

THE DETERMINANTS OF FDI FLOWS INTO CZECH MANUFACTURING INDUSTRIES: Theoretical Background for an Empirical Study

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ABSTRACT

The purpose of this paper is to assess the determining factors representing the causal side of FDI entry into Czech Republic. Our aim is to provide a descriptive analysis of Czech manufacturing in 1994, based on hypotheses derived from the theory of investments for small open economies. The econometric tests have been applied on data for 91 industries. The variable of FDI per total capital stock in given industry is regressed on a list of 8 main theoretically based explanatory variables characterising the input side and the market structure of industries. Because the pace of restructuring did not proceed in all industries at the same speed, our data were subject to conflicting patterns of behaviour in many industries. As an aftermath, the ordinary least squares technique did not lead to efficient estimates of the over-all sample and the majority of explanatory variables were not statistically significant. Therefore we had to adopt a special technique of estimation based on trimmed least squares and a leverage point. Thus we could unveil the correlation between FDI and the behaviour of producers subject to their different attitudes to factor usage. The experiments with this very complicated model will continue during whole 1998.

1. The Role of Investment

Taken from a point of view of the macroeconomic theory there are several roles in which the foreign investment effects the host economy (Kenen [1994]):

$$X-M = -I_f \quad [1]$$

where $X-M$ is the current account balance and I_f (so called „foreign investment“) is the balance of the capital account. In case there is a net increase in foreign investment flows, and the reserves of CNB do not change, the country can afford to increase its imports over exports by the same amount. That means, a surplus on the FDI account, accompanied by a balance of trade and services deficit, does not

necessarily imply a threat of external disequilibrium. Even the opposite can be true: it creates favourable conditions for further development of the country by allowing increased imports of machines, technology, patents, etc. A real danger is if the flows of incoming I_f might suddenly fall in the future. If the increased imports have a consumer orientation (instead of investments), it is a sign that I_f have low spillover effects and one of crucial chances for an accelerated domestic development was wasted. The analysis of Czech FDI, imports and spillovers for 1992-96 shows that the increased imports had a consumer destination (Prokop [1997]) and that the spillovers into the indigenous sector were close to zero (Holland, Pain [1998]).

Another important macroeconomic view is revealed by the following equation from the national accounting:

$$-I_f = (S-I) + (T-G) \quad [2]$$

As was discussed in our first paper (Benacek, Visek [1998]), the gap for foreign investment, formed by a deficit between savings and domestic investment, was too narrow and a large part of foreign capital was „invested“ into reserves of the CNB. If considered as macroeconomic conditions for FDI, large domestic savings (e.g. over 28% of GDP), large long-term credits from abroad and large portfolio investments into the Czech economy competed keenly with the FDI and helped in crowding it up in a final outcome.

The most revealing insight on the role of FDI in a domestic economy can be found in an analysis of foreign investment on GDP. After adjusting and combining the identities and equations from national accounts we can arrive at the following causal links for the development of GDP (dY):

$$dY = 1 / (s + m) * [(dI^a - dS^a) + (dG - dT) - (S^f dr - I^f dr) + (dX^a - dM^a) + m^* dY^*] \quad [3]$$

where:

s, m = marginal propensity to save and to import

dI^a = autonomous (exogenous) increase in investment (e.g. due to increased green field FDI)

$I^f dr$ = an endogenous increase in investment caused by a (dr) due to $I_f > 0$ ¹

dS^a = autonomous increase in domestic saving (i.e. saving unrelated to interest rate or income)

$S^f dr$ = decrease in saving induced by a decrease in interest rate due to incoming I_f

$dG - dT$ = the budget surplus or deficit (unimportant in the Czech case)

dX^a = autonomous increase in exports (e.g. due to higher export openness of FDI)

dM^a = autonomous increase in imports (e.g. due to higher imports of machines and material inputs of firms with FDI)

$m^* dY^*$ = foreign marginal propensity to import related to a change in foreign GDP.²

In equation [3] the links related to FDI are marked in bold. We can see that except for direct effects there is also a multiplier effect related to $s+m$. Unfortunately in the Czech Lands both propensities are very high and the multiplier is only around 15%. When talking about positive direct effects, both the increase in autonomous investment and in autonomous exports due to FDI are very important determining factors of the GDP growth, especially in small economies. A stimulation of endogenous domestic investment due to lower interest rate i caused by foreign capital inflows is also an important factor.

Last but not least, when searching for determining factors of FDI, let us turn our attention to production functions in an implicit form:

¹ Here we assume that the inflow of foreign investment of all kinds lowers the domestic interest rate. This is a spillover effect of a tendency to equalise the interest rates in a world economy, provided the domestic capital market is liberalised (i.e. the capital account of the balance of payments is fully convertible).

² Foreign import propensity may be an overlap with the autonomous increase in exports. FDI generates not only a push-effect for more exports (e.g. through marketing networks of the foreign investor) but also a pull-effect arising from a better image and quality of the products coming from Eastern Europe.

$$Y = f(L, N, K, T, E)$$

[4]

where:

L = labour, N = natural resources, K = physical capital stock

T = human capital (including R&D, image, marketing network and know-how of better management)

E = exogenous factors of growth (X-efficiency, increasing returns to scale, pollution, institutional conditions, transaction costs, etc.).

$dY > 0$ if the positive effects of dK , dT and dE on the growth of Y are not more than offset by negative effects of a decrease in employment, depletion of natural resources and negative externalities in E . For analysing the causes of FDI one should turn in the first place to such primary conditions like endowments of labour, natural resources, physical capital and human capital. Some (other) causes can be intertwined with effects: high human capital breeds new human capital, potential for increasing returns (as a cause) generates high concentration ratios and monopolistic competition (as an effect), spillover effects of FDI are concentrated in the variables T and E , etc.

2. The Selection of Endogenous Variables Describing FDI

In this paper we will deal with the part of FDI which is associated with the production factors. Though we will not use production functions, our econometric analysis will be based on the intensity of factor usage (physical capital, labour, natural resources and human capital), their efficiency, economies of scale, transaction costs and also with some IO aspects, such as market power and competition.

The first set of problems to be solved is to define the exogenous variable to be „explained“. The most natural approach would be to use a FDI penetration index, defined as: FDI_i / K_i , i.e. by a stock of FDI assets (in a strict definition of IMF) normalised by the size of all assets in a given industry i . The problem here is that Czech FDI is not available in a suitable breakdown into industries. For that purpose we have constructed our own data base of FDI into 250 largest firms which comprises approximately 80% of all FDI. Unfortunately, the strict definition of FDI by IMF is not valid in this case because the firms can include into „FDI“ the payments promised for the future or their goodwill or investments disbursed from domestic credits. Our first experiments were based on these data.

A third alternative, supported by the Czech Statistical Office, is to substitute FDI_i by a stock of all physical capital under the foreign ownership control (i.e. K_i^f) relative to K_i . K^f is a wider concept, because here we get the capital irrespective of the origin of financing (e.g. capital financed by domestic credit or capital acquired by an indigenous partner), what is even less theoretically pure than our previous data set. However, this alternative offers a better estimate of the potential of capital which the foreign ownership has under its command.

Normalising the stock of FDI by the size of the total stock of K requires that also the explanatory variables reflect **relative** intensities (such as labour per value added), excluding thus all size effects. It is then expected that the volume of FDI_i is given as a linear function of the total capital endowments K_i , i.e. $(FDI_i/K_i)*K_i$.

3. Theoretical Considerations for Empirical Testing

Our task will be to specify a set of hypotheses which are supported by theories of behaviour of producers in their decision-making about physical capital investment. We will model a small open economy which has no impact on world prices or world supply. The behaviour of investors in a small open economy should be subject to the same laws, irrespective of the origin of investors (indigenous or foreign). They both are profit maximisers and institutional arrangements cannot discriminate between them. However, there are two significant differences between foreign and indigenous investors. The former are less constrained in their availability of financial funds for investments because the world economy is larger. The technical parameters of foreign investments can be superior to the parameters of indigenous investments (Leamer [1994]), what can be described by unit-value isoquants of production functions at Figure 1:

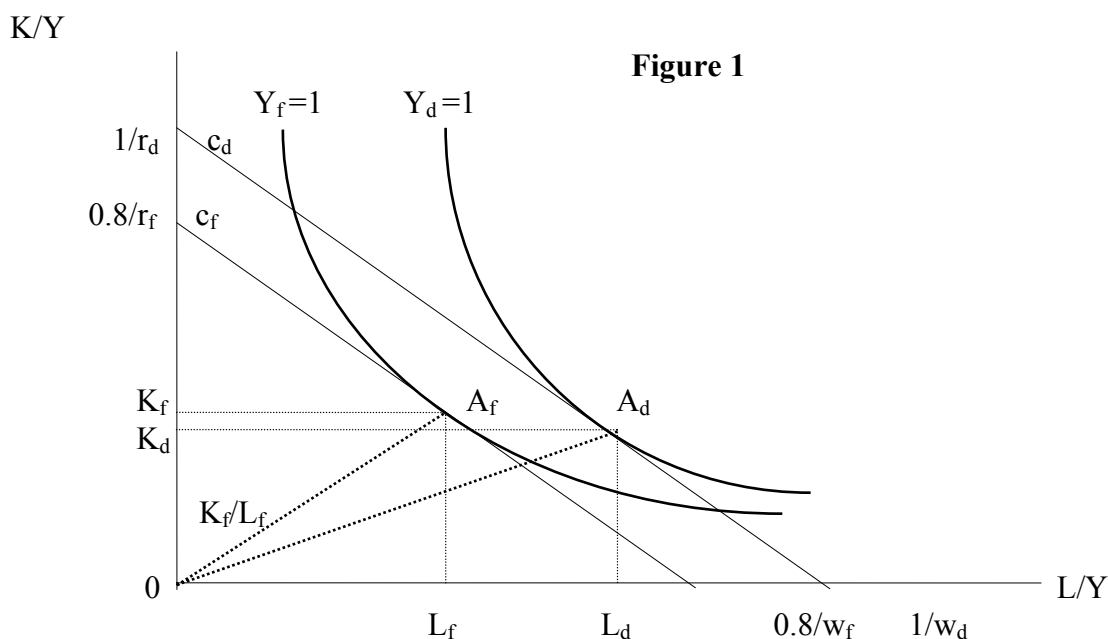


Figure 1 describes the situation of two competing investors: domestic (d) and foreign (f). The FDI investor has an advantage of a more advanced technology, the isoquant of which is Y_f . While both investors must pay the same unit factor costs (w for labour and r for capital), the more antiquated domestic technology allows for only normal implicit profit because its isocost line c_f is equal to the price (both 1 mil Korunas). The FDI investor's yield is 0.2 mil Korunas per each 1 mil Korunas of sales because her isocost line for a production of 1 mil Kc of sales is equal to 0.8 mil Korunas.

The following conclusions can be deduced from our figure:

- It will be the FDI investor who will invest in this industry because she is more efficient
- The efficiency gain of the FDI investor is encoded in her better technical (capital) endowments - her K/L ratio is higher than the K/L ratio of an indigenous firm. The other advantage can be a better price per physical unit due to better image, quality or distribution network.
- In case both investors would invest in parallel, the indigenous investor would be out-competed in the long run.
- Indigenous investor can succeed only in an industry where the difference in technical efficiency relative to the FDI competition is much lower.³ It can happen that this industry need not be very profitable (though a situation of high profitability of both investors cannot be excluded).
- The relative position of the domestic unit-value isoquants for various industries is NOT relevant for the foreign investors. What matters is the relative position of a foreign isoquant relative to an isoquant of indigenous competitors. Surprisingly, FDI can be directed to an industry which shows high inefficiency in the domestic production !

Our last conclusion is of crucial importance. It reveals that investment advantages need not be visible if one analyses only the **relative domestic input conditions** of production. Unfortunately, the analysis of domestic unit-value cost relative to FDI unit-value cost is very difficult ex-ante. No FDI investor is willing to release such an information. We can even turn the argument upside down: once we reveal an existence of high FDI investments into a sector with inefficient indigenous enterprises we can test a hypothesis that it is this industry which reveals its comparative advantage. Thus, instead of a relationship between exports and imports in the industry, we can use an indicator of FDI intensity for discovering the long-term dynamic sources of comparative advantages.

³ In another words, where the gap between competing isocost lines is much less than $1/r - 0.8/r$. An alternative measurement can be by using the coefficient of total factor productivity which is the coefficient A from a Cobb-Douglas function: $Y = A L^b K^{1-b}$. It is evident that we cannot support a condition that the technologies are the same in all countries. Instead of Heckscher-Ohlin assumptions a Ricardian approach to investment location should be applied.

Industry A

Figure 2

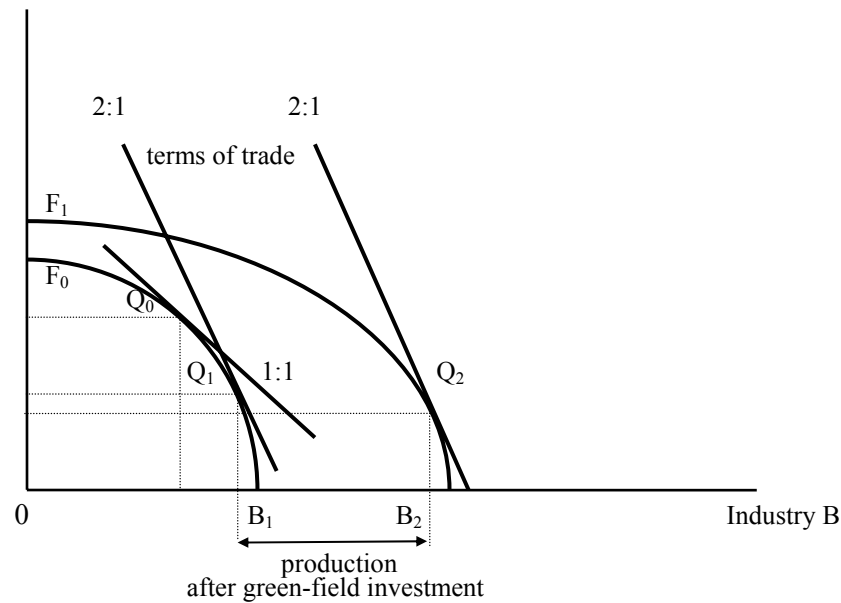


Figure 2 describes a situation where the comparative advantages matter. However, we are not sure if they would be revealed already when they had opened up or only after the FDI entry. The production possibility frontier F_0 of a closed economy allocates the production into Q_0 where a half of the resources is used for production of A and a half for B. The terms of trade (i.e. relative prices A:B) are given as 1:1. After the opening up the world prices prevail and the commodity in industry B is „revealed“ as one with a comparative advantage. The domestic reallocation of resources would be from Q_0 to Q_1 . Because the profits earned in B are high after the price changes, a further reallocation of production from Q_1 to Q_2 can now proceed. The production of B sharply rises while production of A slightly decreases. Provided that technologies of B are the same in all countries and the production of B is capital-intensive, both indigenous and foreign entrepreneurs have the same chances for investments into B. In case the production of B is labour-intensive, the expansion of production is to a large extent barred by a shortage of labour. The FDI would have a chance only with a take-over bid for a production of $0-B_1$. Thus in this case we could see only portfolio FDI and no green-field FDI.

However, a complication arises if the technologies coming with FDI are more efficient than the domestic ones. If the amount of new production B_2-B_1 can be produced with a help of FDI for half of the resources used for domestic production $0-B_1$, then only the FDI green-field investment can succeed. On top of it, FDI will also try to expand by take-overs of indigenous firms. This expansionary strategy would follow even if the production in B would be labour-intensive ! With a move similar to one described in our Figure 1, FDI entry to indigenous firms can crowd-out a great deal of (inefficient hoarded) labour (see L_d-L_f) and replace it by a small increase in capital. The K/L ratio would increase substantially and all „domestic“ entrepreneurs would disappear from industry B, irrespective if the production is labour or capital-intensive.

Figure 2 can also help us to describe a paradox, the relevance of which is very important for countries in transition. Let us assume that the terms of trade do NOT change after the opening up. The reason can be that the image, good-will or quality are not accepted by world demand. Commodities in B are judged as inferior products with rock-bottom prices, while similar „Western“ products have prices 2 to 5-times higher.⁴ Another reason for sustained low prices comes from industrial organisation side. After the opening up the firms in emerging market economies find themselves in a marketing

⁴ This is a feature common for all emerging market economies. Their outsider products compete in separate segments of the market and they are not accepted as substitutes or competitors for („haute couture“ or „hi-tech“ or „trade mark“) Western products. Mistaken conclusions are often drawn that an introduction of PPP can throw a better light on these countries. In case of mixing PPP with exports the result is always a shocking misunderstanding.

vacuum. Their distribution network is frail, they are not a part of a strategic trade policy and/or they are challenged by various oligopolistic and oligopsonistic organisations. As such, also their potential for increasing returns to scale cannot get a foothold. A mere entry of FDI into such firms and industries can improve the terms of trade - i.e. to change the tangency of PPF from a slope of 1:1 to 2:1. An analysis of the comparative advantages before the FDI entry would not reveal any reasons why this industry should be of interest for any foreign investor.

Therefore two caveats must be made before we proceed to an empirical analysis of the determining factors of FDI. Though the classical comparative advantages stemming from endowments and costs remain a foundation for analysing the industrial investment decisions in a small open economy, one must be very cautious in interpreting their meaning. In a world where human capital, industrial organisation and institutional barriers play a dominant role in competition and where the know-how in pre-production, production and post-production stages are not distributed evenly among all countries, the traditional methods of analysis can lead to most unexpected paradoxes. Their enigma can be unveiled only if one has full information - what is seldom an easy task to fulfil.

The second caveat stems from the former. Once the investment decisions are so complicated in an environment which is subject to so many unpredictable changes (like in transforming economies), many decisions can be wrong. Because the FDI investors into CEECs must calculate with a costly premium for risk and uncertainty, their volume of investments must be always smaller than to stabilised countries. But also those CEECs, which succeed in decreasing the level of risk and uncertainty for investment decision-making of all agents,⁵ will earn an additional bonus by attracting higher volumes of FDI than their less fortunate competitors.

4. Selection of Explanatory Variables for Empirical Tests of FDI

Our study is to a large extent different from previous studies devoted to the structure of FDI. The breakdown into 91 NACE 3-digit industrial categories concentrated on one single country make the choice of explanatory variables different from the approach in studies analysing the determining factors of FDI in a cross-country environment (see Lansbury et al. [1996] or Barrell, Pain [1997]).

It follows from the theoretical hypotheses discussed in the previous section that the empirical testing of FDI in the industrial breakdown should be based on the principles which guide the investment decision-making of small open economies, where exports and comparative advantages are the most important guidelines. The interdependence of trade and FDI for small countries in Central Europe was analysed by Naujoks and Schmidt [1995], Altziger [1998], Eichengreen and Kohl [1998]. In principle, a foreign investor does not enter into an industry which has no comparative advantage, where returns are low and where the foreign competition can bring her venture to bankruptcy. There can be exceptions to this rule:

- a hostile take-over aiming to eliminate the indigenous competition, increase own exports to the host economy and to increase later the price
- effects of increasing returns add a new edge to the common production in both countries
- a market power in the given country offers an investor a monopoly rent
- the industry without comparative advantage has a high import barrier and it is better to produce in the host country than to export to her
- high transportation costs preclude the trade.

All these exceptions notwithstanding, we will use the standard tests of comparative advantages for our point of departure. In our basic model we will commence with the tests of factor usage (in accordance to Heckscher-Ohlin-Vanek theorems): capital and labour intensities of production, human

⁵ *One can inquire what instruments can help in decreasing the risk and uncertainty. The Czech „liberal“ government thought during 1990-97 that free markets will provide the service automatically. Only recently it was (partially) admitted that visible hands of oligopolistic markets do the opposite. Under these conditions the only alternative seems to be a viable public administration which upholds the (free) markets and guarantees low transaction costs of their institutional arrangements. That means it must not get entangled in its own bureaucracy and regulation. FDI Promotion Organisations and FDI support schemes can be a part of the deal, provided that competition is not eliminated in this process.*

capital requirements and requirements of natural resources in the industry where FDI can enter. Because FDI is not only subject to a „correct“ factor endowment criteria but also it should minimise the cost of production.⁶ Therefore a test for total factor productivity or a factor cost will be added to the list of variables. Tests for intra-industry trade and a proxy variable for market power should be also included since both factors represent the „alternative theories“ of trade. The last test concerns the Stolper-Samuelson theorem: the changes in relative prices after the opening- up can lead to extensive changes in the allocation of resources and investments.

5. List of Determining Factors and Hypotheses Tested

The following explanatory variables were used in our tests:

1. Labour per unit of net production (value added) L/PH: all previous studies of Czech trade have confirmed that labour was a statistically significant variable with a positive sign: the higher is the labour intensity of production, the more attractive may be the industry for FDI.
2. Physical capital per unit of net production (value added) K/PH: as a substitute to labour intensity we should expect its statistically significant negative sign. A functioning non-antiquated capital is a scarce and too expensive factor in this country - thus production in capital-intensive industries ought not to be competitive, what discourages the FDI
3. Depreciation: this should follow the same pattern as the previous factor.
4. Capital per labour (K/L): as a combination of the variables no. 1 and 2, this should result in its high statistical significance with a negative sign. This should be our crucial variable.
5. Productivity of labour (as an alternative to variable no. 1): according to Heckscher-Ohlin theorem, a labour abundant country should use labour more intensively in production for exports than in production for import-substitution or for domestic use. The productivity of labour in export intensive industries must be therefore lower than in industries with high capital requirements.
6. Wages per labour: a higher profitability in industries with FDI could spill over to higher wages, especially if there is an inelastic labour supply because of low mobility due to a shortages of flats.
7. Unit labour cost (ULC): it is argued that it is a combined influence of wages and productivity what matters for the competitiveness of industries based on high labour intensities. A positive correlation between FDI and ULC is expected.
8. Profits: the profits in industries attracting FDI should be greater than profits in industries with indigenous enterprises, at least up to a medium-term.
9. Costs of labour and capital per unit of production: according to Ricardo and Haberler, comparative advantages should be based on production which has lower costs (relative to other industries). A negative sign is expected.
10. Total factor productivity (TFP). We have used it as a proxy for efficiency of factor usage: the higher is TFP, the lower volume of factors is necessary to produce a unit-value of output. Thus a positive sign associates high efficiency of factor usage with high attraction of FDI. A negative sign would imply a paradox which we have tried to explain above in the theoretical part of this paper.
11. Investments. Although high investment activity in an industry can be also an effect of FDI, we can also assume that a high indigenous investment can be a sign of expected profitability - a fact which must also attract FDI. Unfortunately if all investments would come from abroad then this variable would cause multicollinearity. Also the differences in K/L requirements by industries can cause bias in this variable.
12. Exports per sales. This variable is reflecting directly our main approach to FDI: the higher is the export orientation the more efficient the industry is relative to competition abroad. Thus a positive relationship between export competitiveness and incoming FDI should be significant.
13. Debts. This is a controversial variable: if the debts are caused by credits accompanying high investment activities the sign should be positive. If, however, the debts reflect problems with liquidity and sales, the sign can be negative.

⁶ *Though this may sound a duplicate condition for a stabilised market economy, it need not to be the case for an economy in transition, where the restructuring has not been completed.*

14. Increasing returns to scale: a dummy variable derived from CES production functions (Barry [1997] and Pratten [1988]). It is expected that high FDI is positively correlated with increasing returns (a strategy ascribed to multinationals).
15. Concentration ratio (CR3): a characteristics related either to market power (with an orientation to large domestic market) or to increasing returns and exports. CR3 was calculated as a share of three largest firms in a given industry on the total output of the industry and a positive sign is expected. According to Konings [1996] imperfect competition and oligopolistic interactions between a limited number of foreign strategic investors is the more appropriate approach to follow in explaining the FDI location than the traditional factor-related approach.
16. Balassa index of inter-industrial specialisation (BAL): a tendency to relate FDI with high export specialisation of industries is well observed, even though some high export FDI firms can be also important importers (Altzinger [1998]). Thus we should be able to test a hypothesis what kind of revealed comparative advantage (Vollrath [1991]) is associated with FDI. Thus a positive relationship between FDI and BAL can be tentatively expected.
17. Grubel-Lloyd index of intra-industrial specialisation (GL): this index is closely related to Balassa index. It tests if high FDI penetration is positively related with high intra-industry trade. It means that we test whether industries with high FDI are intensive importers of inputs which are processed and then re-exported. (Here high inter-industrial specialisation in export as well as in import are treated as equally „irrelevant“, having the value of GL index close to zero.)
18. Change of nominal prices in time (DP): it is assumed that the difference in indices of the industrial inflation in 1991-1994 reflects the narrowing of the gap between the world prices and former prices under central planning. The higher is the index of DP, the more advantageous are the new relative prices in the industry. This is also closely related with the improvements in industrial terms of trade which should attract more FDI.
19. Energy intensity: in our tests we will use four different energy requirements - coal, gas, oil and electricity. High energy requirements were observed in the historical pattern of Czech exports to the West (in 1977-87). After 1990 the imported abundance of cheap energy has ended, thus comparative advantages should not be now associated with this indicator.
20. Kilogram prices or Czech exports. It is argued that kilogram prices reflect the intensity of natural resources embodied in the product. These are products at low stage of processing with low value added. Since Czechia does not have a comparative advantage in natural resources a negative sign can be expected.
21. Kilogram prices or Czech exports relative to kilogram prices of EU exports. This variable is a proxy for relative prices of physical units which represent the differences in quality. The higher is this index the lower is the gap in quality and the higher FDI we can expect.
22. Waste by-products with negative externalities: some experts argue that Czech products gained a comparative advantage in technologies which are highly toxic or otherwise damaging (due to loopholes in Czech legislation and high environmental costs in EU countries). Therefore a positive coefficient for this variable should be expected.
23. Research and development: R&D expenditure is testing the influence of high value added. High R&D is also a sign of an intensive use of human capital and resulting high quality. In case Czechia does not have a comparative advantage in human capital, this factor should have a negative sign.
24. Human capital (VS/PH): the employment of university educated employees per value added is just another indicator of the previous factor. The role of education was found important in the study of Barrell, Lansbury and Pain [1997] or Holland and Pain [1998].

The intensities of FDI stock relative to the total capital endowments in industry i (FDI_i / K_i , used as exogenous variable) lie within the interval of $\langle 0, +1 \rangle$. Its structure for all industries $i = 1, 2, \dots, n$ will be „explained“ by a list of variables, e.g. individual factor intensities (i.e. production input requirements). A non-linear model with one exogenous factor j is illustrated in Figure 3. For example, if the horizontal axis represents such a factor intensity like labour per capital, then the fitted line FF' would suggest that the intensity of absorption of FDI in the given country is high in production orientated to labour-intensive commodities. The rationale for such a pattern of FDI can be that the analysed host country has relatively higher endowment of labour than abroad. Its labour is therefore relatively cheaper, and thus the production of labour-intensive commodities is more efficient and profitable than the production of capital-intensive goods.

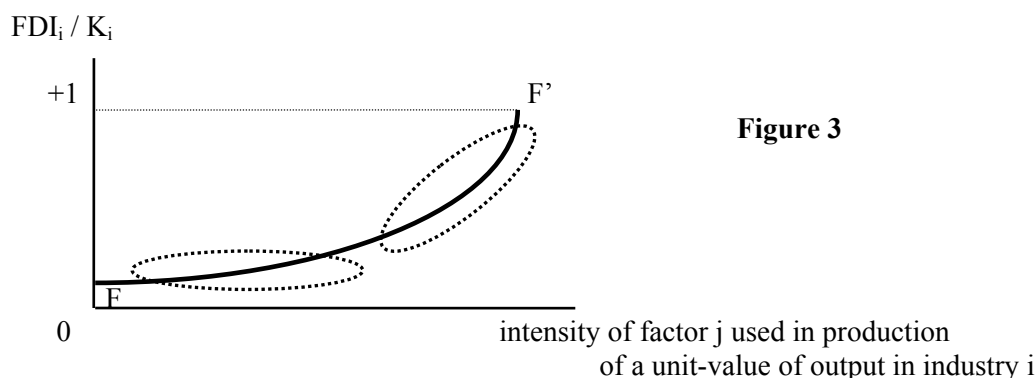


Figure 3

The following functional relationship will be therefore econometrically tested:

$FDI_i / K_i = F(f_1, f_2, \dots, f_m)$, where f_j are individual explanatory variables $j=1, 2, \dots, m$.

The exponential nature of functional relationship is caused by a fact that the pattern of distribution of FDI is not linearly regular. There are two dominant set of industries: those which have been nearly avoided by FDI and then those favourite ones with very high FDI. Two ellipses plotted in Figure 3 point to the areas of high concentration of our FDI population. The problem with non-linear relationships can be solved by using an exponential function F for estimation, or by taking logarithms of the values of FDI intensities.

6. Problems with Czech Statistics and with the Traditional Technique of Estimate

Our next step would be to test empirically the simple model described above. Czech statistics are seemingly well equipped for such a task: the database of enterprises in manufacturing industries in a time series of 1990-1996 looks very promising. The breakdown of firms by OKEC (NACE) three-digit classification, with a variety of numerous input characteristics would offer a good representation of a mix of sufficient number of products (i.e. 93 industries). Unfortunately, the crucial problem is that the database lacks the statistics on FDI. The only resource - the CNB statistics of FDI by firms - is strictly confidential. Because the official figures in breakdown into 10 sectors (of which 5 are manufacturing) are of no use for any analytical purposes we have built our own database of 235 enterprises with FDI.⁷

The other problem was that since 1995 the database lacks the statistics on exports which are of crucial interest for our analysis. On top of that, the data after 1994 narrow the population of firms to those ones with over 100 employees only. Thus in 1995 and 1996 there was a loss of more than a half of the FDI firms reported for 1994. Therefore we were forced to concentrate in our analysis on data for 1994. Though it meant a loss of the latest information provided now for 1996, the data for 1994 fit better to our purposes and within 6 months we could make a comparison with the latest data for 1997 which will contain again the data about exports and even imports which were missed since 1992.

Our first experiments with OLS technique of estimate confirmed our intuition that the results would not be statistically significant. The fit improved after we had introduced a non-linear relationship between exogenous and endogenous variables. Nevertheless, the coefficient of determination around 0.24 could through little light on what was going on with FDI. The problem was that our list of explanatory variables was not able to explain the complexity of behaviour of foreign investors. That means, the pattern of their behaviour was not uniform - what we were trying to explain in our previous chapters. We had to use some more sophisticated technique of estimate than OLS in order to separate and figure out conflicting patterns of behaviour. From various alternatives (instrumental variables, factor and cluster analysis, node analysis) we have concentrated on the trimmed least squares with a leverage point - a technique of robust statistics which was developed by Ruppert and Carrol [1980] and later applied on econometric estimates which worked with data amalgamating two or more

⁷ The collection was based on data from Czechinvest, newspaper announcements and from our own questionnaire sent to firms. We are aware that many figures do not distinguish between incoming foreign payments for FDI and the local financing, and between effected payments and promises to pay (though we have deducted that whenever it was known). For the list of enterprises with FDI see our first paper (Benacek, Visek [1998]).

different populations. This technical problem, which had a far-reaching impact on our results and conclusions, is described in the next chapter.

7. Robust Method of Estimate

Robust methods of estimation of regression coefficients have been recently designed especially for solving the problems of heterogenous patterns in data sets. The reason why these methods were not much used in the past was given by the extreme requirements of the method on both the memory and the speed of computers. Even now, when the Pentium processors offer a great computing comfort, the speed of one estimate prolongs to approximately 20 minutes. In the paper we have applied our own variant of a robust technique, namely the least trimmed squares. The corresponding estimator allows to adjusting breakdown point⁸ and hence it is flexible for the pre-processing of data, as well as for their final study. First of all, let us recapitulate the method of the estimator. We shall consider the following linear regression model:

$$Y_i = X_i^T \beta^0 + \varepsilon_i, \quad i = 1, 2, \dots, n$$

where Y_i is the value of response variable for the i -th case, $X_i \in R^p$ is the vector of factors (or, if you want to call them explanatory variables for the i -th case), β^0 is the vector of regression coefficients and finally ε_i is the random fluctuation (for the i -th case). Then for an arbitrary $\beta \in R^p$ we shall denote by $r_i(\beta) = Y_i - X_i^T \beta$ the i -th residual at β . Further, we shall use $r_{(i)}^2(\beta)$ for the i -th order statistics among the squared residuals, i.e. we will have $r_{(1)}^2(\beta) \leq r_{(2)}^2(\beta) \leq \dots \leq r_{(n)}^2(\beta)$. Finally, let us define the *least trimmed squares* estimator of regression coefficients by the extremal problem:

$$\beta^{\{LTS\}} = \arg \min \left\{ \sum_{i=1}^h r_{(i)}^2(\beta) \right\} \quad (1)$$

where $n/2 \leq h \leq n$ and the minimisation is performed over all $\beta \in R^p$ (see e.g. Rousseeuw and Leroy [1987]). In other words, in this extremal problem we are looking for such an argument $\beta \in R^p$ for which sum of h smallest squared residuals is minimal, however, it is given only implicitly which indices have been taken into account. In a similar way, i.e. by an appropriate extremal problem, practically all robust estimators with high breakdown point (as the *least median of squares* ($\beta^{\{LMS\}}$), *S-estimator*) are defined. We shall, however, restrict ourselves on $\beta^{\{LTS\}}$. It follows immediately from (1) that $\beta^{\{LTS\}}$ takes into account only h observations and the rest of them come into the game only through the fact that they have to have the squared residuals larger or equal to $r_{(h)}^2(\beta^{\{LTS\}})$. Under rather general conditions $\beta^{\{LTS\}}$ is consistent and asymptotically normal (see Rousseeuw and Leroy (1987) or Višek (1999)).

It is intuitively clear that to carry out the minimisation in (1) is possible only in some (simple) cases, e.g. when the number of observations is approximately than 20. In all other cases we try to find an approximation to the precise solution of (1). It appeared that the algorithm, which was based on

⁸ The breakdown point is a characteristic of statistical estimators which indicates how large part of data may represent contamination without breaking the estimator, i.e. without causing a very large (or in the case of estimating the scale, very small) value of estimator. E.g. using arithmetic mean as the estimator of location we would assume that it gives a value somewhere at the centre of the cloud of data. Nevertheless, it is easy to see that single (very) large value among the data may cause an arbitrary large deviation of the arithmetic mean from the centre of (the bulk of) data; compare this behaviour with the behaviour of median.

deriving this approximate solution over the residuals of $\beta^{\{LMS\}}$ ⁹, need not give good results¹⁰. Nowadays we have at hand an algorithm for evaluation of $\beta^{\{LTS\}}$ which proved to be more reliable. Moreover, it allows to create an idea how much the structure of data is intricate (see again Višek (1996)). Of course there is a question how to select h . Rousseeuw and Leroy (1987) showed that putting $h = [(n+1)/2] + [p/2]$ (where $[a]$ denotes the integer part of a), we obtain maximal breakdown point, namely $(((n-p)/2)+1)/n$. However, in practice it appears that we do not need maximal breakdown point and we can select h (much) larger. We usually select h "sufficiently" small to reach acceptable determination of model (say R^2 about 60%).

Sometimes, the situation is such that when we record scale estimates for different values of h , we notice that rapid decrease of scale estimate for decreasing h at one point stops or the decrease becomes mild with respect to the initial steep one. If, moreover, the h_0 which was selected according to these two rules, is such that for h 's nearby this h_0 the models are stable in coefficients, we can assume that we have separated data on the proper part and something else which may be considered to be contamination or another population, governed by another model, if any. Of course, the boundary is usually vague and only exceptionally sharp.

8. Traditional Empirical Tests with OLS Method of Estimate

Our empirical results are based on data for 91 manufacturing industries in the year 1994. FDI relative to the stock of physical capital (FDI_i / K_i) in manufacturing industries i is taken as a dependent variable in our. The list of explanatory variables in our basic equation was selected on grounds of theories of production location in a small open economy (factor usage, comparative costs and intra-industrial exchange) and industrial organisation (market power):

- The measures of factor intensities were defined as L_i/PH_i and K_i/PH_i , where L_i is total labour, K_i is the total stock of physical capital, and PH_i is the value added in industry i . We also use the variable K_i/L_i as an alternative measure of factor intensity.
- For each industry i , total factor productivity (TFPW), as a proxy for efficiency and costs, is defined as:

$$TFPW_i = \frac{PH_i}{K_i^a (w_i L_i)^{1-a}},$$

where the coefficient a is set to 0.3 (in accordance with the coefficients from aggregate production function of the Cobb-Douglas type) and w_i is wage rate. TFP is thus equal to an imaginary constant A_i assigned to the unit-value isoquant of industry i if its real values of L_i , K_i per output PH_i are fitted into the equation.

- The price change between years 1990 and 1994 defined as an index of inflation (DP_i).
- The measure of concentration in each industry ($CR3_i$) as a proxy for market power is defined as the share of three largest firms in the industry i on total output of that industry.
- Balassa index (BAL_i) of intra and inter-industry exchange is defined in the form:

$$BAL_i = \frac{X94_i - M94_i}{X94_i + M94_i},$$

where $X94_i$ ($M94_i$) denotes total exports (imports) of the industry i in the year 1994. $X94_i$ and $M94_i$ are from customs statistics.

With the theoretical considerations done in the previous part of the paper, our empirical work is based on a semi-logarithmic specification of the basic equation:

$$\ln(FDI_i/K_i) = b_0 + b_1*(L_i/PH_i) + b_2*(K_i/PH_i) + b_3*CR3_i + b_4*TFP_i + b_5*BAL_i + b_6*DP_i$$

⁹ In accordance with Rousseeuw and Leroy (1987) and program PROGRESS or S-PLUS (which was for a long time assumed to be efficient),

¹⁰ See Hettmansperger and Sheather (1992) and Višek (1994) and (1996).

where $i=1, 2, \dots, 91$ are manufacturing industries in NACE 3-digit nomenclature. The exogenous variables represent basic theoretical instruments for explaining the pattern of investments where comparative advantage is the point of departure: the influence of factor proportions (Heckscher-Ohlin relative endowments), the market power (CR3), the Ricardo-like minimisation of factor inputs per a unit-value of specialised output (TFP), the influence of inter-industrial trade (BAL) and the price developments (DP).

For the empirical tests we have applied the OLS estimation on cross-sectional data set. Since we had a very large list of explanatory variables, we first tested for the presence of the most destructive problem in this context: the presence of multicollinearity among the exogenous variables. Our test did not identify any symptoms confirming the presence of multicollinearity in the model, even though, in a perfect market environment, there could be expected a high correlation between K and L. However, after examination of the residuals, we found the model to be plagued with heteroscedasticity. It means that OLS estimates of standard errors are inconsistent. Therefore, we used White correction to adjust the variance-covariance matrix of the estimated coefficients for purposes of inference. Thus, the results are robust with respect to arbitrary forms of heteroscedasticity in the error structure.

Table 1 reports the estimation results of OLS regressions. We must admit from the start that the model brought results which, without any adjustments, did not show any sign of statistical significance. First we had to exclude two industries - electricity and tobacco ¹¹ - because the graphical analysis of their variables has shown that these were two outliers „sitting“ in two different corners far away from the data set. The results after this adjustment were as follows:

Table 1 (89 industries): variables:	Model 1					
	L/PH	K/PH	CR3	BAL	TFPW	DP
slope coefficients	62.40	-0.142	-0.202	-0.649	1.020	0.013
t-statistics (slope coefficients)	0.456	-2.207	-0.209	-1.129	1.257	2.818
probability of 0 hypothesis	0.6357	0.0301	0.8349	0.2623	0.2124	0.0061
R-squared	0.2236					
significance (regr. equation)	0.0016					

The first two variables deal with the Heckscher-Ohlin explanation of investment due to comparative advantages given by country's relative endowments and factor requirements in production. It has been accepted by all previous studies of Czech trade that Czechia had a comparative advantage in the use of labour. From this fact it was implicitly inferred that it was due to relatively better domestic endowments of labour than of capital. It has been visible after 1990, when the market economy commenced to function, that the previous enormous accumulation of physical capital stock (measured in purchasing prices unadjusted for depreciation) was found antiquated and widely inefficient. At the same time there surged a demand for expensive imported physical capital for the financing of which there was an enormous shortage of liquidity. Thus it is not surprising that the usage of physical capital stock has a negative sign and it becomes our key explanatory variable.

Investments shunning off from the capital intensive industries were at the same time avoiding to be involved in industries the expansion of which would require a large financial investment into their capital revamping. A cheaper alternative would be if they started their export expansion in the labour intensive industries. Surprisingly, this strategy was not confirmed by our estimation because the coefficient for labour per value added has low statistical significance (though its sign was correct). We were not able to explain this paradox at this stage of our computations.

The variable of DP, measuring the intensity of price changes during 1990-96, has the second statistically significant coefficient. The higher is the inflation in an industry relative to average, the more attractive it becomes because its unit prices rise. This fact can be closely related to the improvements in terms of trade. It would be in line with conclusions of both the Ricardian and the Stolper-Samuelson theorems after the opening up: industries with comparative advantage should

¹¹ *Electricity generation is a government monopoly with enormous ratio K/L, with negligible FDI due to regulation and extremely high profits. Tobacco is a monopoly of Philip Morris with enormous inflow of FDI and also with extremely high profits.*

benefit from an increase in relative prices when their domestic prices adjust to the level of the world prices which must be higher. The investments, according to Stolper-Samuelson, are then attracted to these industries. Industries without a comparative advantage should have an adverse development of prices (i.e. inflation rates lower than average). We found that this relationship was present in the pattern of Czech FDI but, due to low R-squared, this characteristics was generally quite weak.

The remaining variables dealing with inter/intra-industrial specialisation in trade, total factor productivity and market power (measured by concentration index CR3) did not reveal any importance in deciding about FDI. Probably some industries behave in an untypical way. In the worse case we can say that FDI have no important determining factor or the data were unreliable and contaminated with errors in measurement. Before proceeding so far we tried to exclude some other important factors which were reported in other studies. Zemplerova [1998] had come to a conclusion that FDI in Czechia is closely correlated with high exports. Therefore we have included the variable exports per total sales (X_i/S_i), unfortunately without any success:

Table 2: (89 industries - exports added):

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP	X/S
slope coefficients	23.01	-0.107	-0.518	-0.792	1.145	0.013	1.733
t-statistics (slope coefficients)	0.176	-1.555	-0.500	-1.358	1.455	2.738	1.135
probability of 0 hypothesis	0.8610	0.1239	0.6182	0.1784	0.1496	0.0076	0.2596
R-squared	0.2360						
significance (regr. equation)	0.0021						

Even though we may admit that firms with FDI are highly export-oriented, our estimate did not confirm that FDI was particularly attracted by industries which were open to export either before the FDI entry or even after the FDI entry - when FDI was not intensive enough to influence the openness of the whole industry. In the next step we have tried to uncover the potential role of natural resources and human capital. We have therefore added into the list of explanatory variables the energy-intensity (ENR) of production, R&D requirements and the toxic waste by-products (WST) contents of a unit of value added (PH). The results are indicated in Table 3.

Table 3: (89 industries - energy, R&D and waste added):

statistics	L/PH	K/PH	BAL	TFPW	DP	ENR/PH	R&D/PH	WST/PH
slope coefficients	106.9	-0.167	-0.675	1.343	0.013	0.056	-0.528	-9.604
t-statistics (slope coeff.)	0.828	-1.619	-1.226	1.803	2.445	0.6125	-0.076	-1.873
probab. of 0 hypothesis	0.410	0.1093	0.2237	0.0751	0.017	0.5426	0.9393	0.0648
R-squared	0.241							
significance (regr. eq.)	0.007							

The results have changed only marginally. The only new variable which would deserve a comment is the contents of toxic waste characterising the social costs of pollution. We can see that FDI has been directed to industries friendly to environment. Unfortunately this specification of the model slashed with the variable of capital usage. Waste and capital were most probably highly correlated.

9. Empirical Tests with Least Trimmed Squares Method of Estimate

Since attempts of models given in tables 1, 2 and 3 were not successful we have applied the robust approach on the same data. The program for the least trimmed squares was used and results are again gathered in tables. The following three sets of estimations, each of which comprises of five tables, gives an idea which explanatory variables used in models 1, 2 and 3 may be really relevant, provided we re-arrange the data set into two populations showing identical behavioural characteristics. In order to describe our method we have varied the number of industries in such a way that it would be discernible how it influences the explanatory power of the model. Our robust estimate in fact ranks industries in accordance how their FDI behaves as a function of the given specification of the model (irrespective of the signs of coefficients). Therefore smaller number in the set of industries has always higher R-squared and its coefficients are more significant.

Robust diagnosis of the previous Model 1:

Table 4a (45 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP
slope coefficients	-1.237	0.360	-5.840	-1.137	1.048	1.318
t-statistics (slope coefficients)	-2.632	7.300	-15.73	-5.679	3.666	7.978
probab. of 0 hypothesis	0.0122	0.000	0.000	0.0000	0.0007	0.0000
R-squared	0.9184					
significance (regr. equation)	0.0000					

When we break down our data set into two halves, one half can show a nearly perfect fit, with all chosen variable being significant. Surprisingly, the signs for the impart of L, K and CR3 are reversed from what we have theoretically assumed. This is a first sign that our sample can be rather heterogeneous. Though we can hardly judge that it is just these industries which behave perfectly in accordance with our model (for that we would have to test our sample in a time-series and confirm their stationary behaviour), what matters is to analyse how the sample changes its properties when we extend its size. Is the model robust enough to show a stationary behaviour of the whole population ? While the extension to 50 industries leads no important differences, the change to 55 industries reveals drastic changes. The signs in the variables for K, CR3 and TFP is reversed.

Table 4b (50 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP
slope coefficients	-1.207	0.299	-5.229	-1.295	0.813	1.394
t-statistics (slope coefficients)	-2.070	4.860	-11.46	-5.140	2.245	6.898
probab. of 0 hypothesis	0.444	0.0000	0.0000	0.0000	0.0300	0.0000
R-squared	0.8513					
significance (regr. equation)	0.0000					

Table 4c (55 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP
slope coefficients	-2.860	-0.117	1.546	-0.026	-2.305	0.255
t-statistics (slope coefficients)	-4.539	-3.151	2.820	-0.080	-5.801	1.041
probab. of 0 hypothesis	0.0000	0.0028	0.0070	0.9370	0.0000	0.3032
R-squared	0.6709					
significance (regr. equation)	0.0000					

Table 4d (60 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP
slope coefficients	-2.875	-0.086	1.135	0.190	-1.842	0.407
t-statistics (slope coefficients)	-4.010	-2.084	1.956	0.521	-4.219	1.492
probab. of 0 hypothesis	0.0002	0.0420	0.055	0.605	0.0001	0.1417
R-squared	0.5567					
significance (regr. equation)	0.000					

Table 4e (65 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP
slope coefficients	0.234	0.249	-3.49	-0.592	1.104	1.493
t-statistics (slope coefficients)	0.267	2.576	-5.34	-1.670	1.901	4.970
probab. of 0 hypothesis	0.7907	0.0126	0.000	0.1003	0.0622	0.000
R-squared	0.5527					
significance (regr. equation)	0.0000					

By increasing the number of industries in our analysed sample to 60 and 65, practically all our previous results become unstable and still inconsistent with the estimate for the original sample of 89 industries. We must take the results from our largest (nearly full) sample the most credible from all our estimates because the process of pre-selection was minimal. The only universal conclusion which we can say at this stage of analysis is that we have to proceed to further analytical study if we would like to generalise our results. The behaviour of FDI is much less predictable than, for example, in Czech exports which we have analysed previously (Benacek, Visek, Jarolim [1998]).

A similar conclusion can be drawn if the same steps are exercised on our previous model 2.

Robust diagnosis of the previous Model 2:

Table 5b (50 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP	X/S
slope coefficients	-1.409	0.315	-5.760	-1.139	1.011	1.357	1.595
t-statistics (slope coefficients)	-2.442	5.295	-12.61	-4.641	2.795	6.865	2.368
significance of coefficients	0.0189	0.0000	0.0000	0.0000	0.0078	0.000	0.0225
R-squared	0.8699						
significance (regr. equation)	0.0000						

Table 5d (60 industries)

statistics	L/PH	K/PH	CR3	BAL	TFPW	DP	X/S
slope coefficients	0.955	0.249	-4.735	-0.486	2.781	1.527	2.649
t-statistics (slope coefficients)	1.204	3.154	-8.022	-1.609	5.942	6.031	3.172
significance of coefficients	0.2340	0.0027	0.0000	0.1138	0.0000	0.0000	0.0025
R-squared	0.7434						
significance (regr. equation)	0.0000						

Similar controversial results can be received with our previous Model 3. We also cannot exclude a case that our specification of the model was incorrect because some variables can be in a mutual conflict and their multicollinearity can be revealed only at some steps of the process indicated above. Nevertheless, we have already information which regressors (out of the full list of 22 tested) may be relevant for the explanation of $\ln(\text{FDI}_i/\text{K}_i)$ and that it will be possible, after a simpler and theoretically more robust specification of the model, to explain approximately a large part of data in a more consistent manner. In other words, results given in the previous text give a hope that there is a subset of industries, containing about 70 industries which can be governed by an acceptable model. Results are presented in the following tables 6.

Model 4

Table 6c (55 industries)

statistics	K/PH	IRS	DP	WST/PH	R&D/PH	TFPW
slope coefficients	-0.251	3.905	0.427	-0.051	0.188	1.316
t-statistics (slope coefficients)	-5.628	14.14	1.882	-1.971	5.126	5.116
significance of coefficients	0.0000	0.0000	0.0660	0.0055	0.0000	0.0000
R-squared	0.8911					
significance (regr. equation)	0.0000					

Since we found out from the experiments that variable WASTE/PH appeared to be in conflict with K/PH, we have dropped it and restricted the model on variables K/PH, IRS, DP R&D/PH and TFPW which are also theoretically quite meaningful. The results are as follows:

Table 6e (65 industries)

statistics	K/PH	IRS	DP	R&D/PH	TFPW
slope coefficients	-0.313	3.837	0.360	0.245	1.356
t-statistics (slope coefficients)	-5.303	10.89	1.227	5.075	4.108
significance of coefficients	0.0000	0.0000	0.2249	0.0000	0.0001
R-squared	0.8009				
significance (regr. equation)	0.0000				

At this stage it is evident that the variable DP (increase in relative prices) brings only a small piece of information which cannot improve considerably our model. Hence we had to drop it. The final model contains only four variables, the role of which is not only easy to understand, but also the whole process of estimation in steps is stable. Since the results for 70 industries gave satisfactory results, both in the significance of regressors and in the determination of the model (see next table), we have decided to perform detailed diagnostics on the size of a subset of industries which we are able to explain by this model.

Table 6f (70 industries)

statistics	K/PH	IRS	R&D/PH	TFPW
slope coefficients	-0.315	3.577	0.246	1.392
t-statistics (slope coefficients)	-4.829	8.889	4.607	3.596
significance of coefficients	0.0000	0.0000	0.0000	0.0000
R-squared	0.7032			
significance (regr. equation)	0.0000			

Table 6g (71 industries)

statistics	K/PH	IRS	R&D/PH	TFPW
slope coefficients	-0.313	3.523	0.244	1.428
t-statistics (slope coefficients)	-4.608	8.440	4.405	3.555
significance of coefficients	0.0000	0.0000	0.0000	0.0007
R-squared	0.6806			
significance (regr. equation)	0.0000			

Table 6h (72 industries)

statistics	K/PH	IRS	R&D/PH	TFPW
slope coefficients	-0.301	3.481	0.238	1.489
t-statistics (slope coefficients)	-4.285	8.040	4.133	3.576
significance of coefficients	0.0000	0.0000	0.0001	0.0007
R-squared	0.6560			
significance (regr. equation)	0.0000			

Table 6i (73 industries)

statistics	K/PH	IRS	R&D/PH	TFPW
slope coefficients	-0.288	3.444	0.230	1.548
t-statistics (slope coefficients)	-3.983	7.706	3.872	3.605
significance of coefficients	0.0002	0.0000	0.0003	0.0006
R-squared	0.6329			
significance (regr. equation)	0.0000			

Table 6j (74 industries)

statistics	K/PH	IRS	R&D/PH	TFPW
slope coefficients	-0.342	2.389	0.242	1.255

t-statistics (slope coefficients)	-4.656	5.734	3.977	3.000
significance of coefficients	0.0000	0.0000	0.0002	0.0038
R-squared	0.5585			
significance (regr. equation)	0.0000			

Table 6k (75 industries)

statistics	K/PH	IRS	R&D/PH	TFPW
slope coefficients	-0.3481	2.554	0.251	1.276
t-statistics (slope coefficients)	-4.620	6.079	4.016	2.973
significance of coefficients	0.0000	0.0000	0.0001	0.0040
R-squared	0.5578			
significance (regr. equation)	0.0000			

The results demonstrate a dramatic decrease of determination of model when we extended the sub-sample in question from 73 industries to 74. So it is probably reasonable to assume that sub-sample of 73 industries (see Table 6i) can be explained by a theoretically determined model given in the last collection of tables. **We have seen that 82 % of industries and 88% of all Czech incoming FDI can be explained at a high level of statistical significance by the following determining factors:**

- Negative approach to capital intensity of production, where FDI is rather reluctant to commit itself to these kind of industries. We can only infer indirectly that labour intensive industries were a probable target for investment.
- Preference for industries with high total factor productivity.
- Preference for industries showing increasing returns to scale (i.e. the potential for future market power and high profitability).
- High requirements of production for R&D.

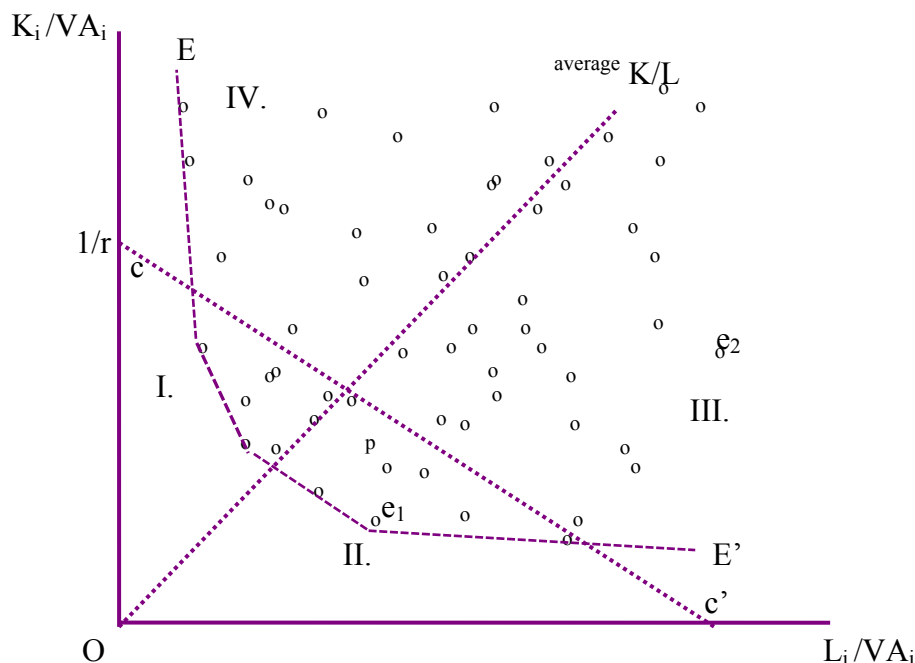
10. Generalisation of the Main Results

Our empirical results are based on data for 91 manufacturing industries in the year 1994. The crucial result of our study concerns the role of labour and capital in locating FDI. Our tests have confirmed that during 1990-94 FDI did not prefer the physical capital-intensive industries. On the other hand, however, we could not find a strong statistical evidence for preferring labour-intensive industries for FDI. In another words, we have found that even though FDI was located mainly under the ray of average K/L ratio, we could not find that a condition of high L/value added (characteristic for by definition for labour-intensive industries) was satisfied. An explanation for this paradox can be that industries in transition in 1994 were not in a Pareto-optimal state. That means, many of them were not technically efficient and the process of their restructuring was not yet completed in 1994. The problem is illustrated in Figure 4:

The points on our scatterplot represent the allocation of average utilisation of capital and labour in individual industries per unit-value of value added (VA_i). The envelope EE' depicts the frontier of Pareto-efficient allocation of resources (Jones [1974])¹². All points above this line are Pareto-inefficient - there could be always found a point of another allocation of K and L where the same unit of production can be achieved with both less K and less L. In a stabilised perfect market economy the allocation of new investment would to industry with relative endowments e_i , because it has the best location relative to the isocost line cc' for budget of unity. The industries with their $\{K_i, L_i\}$ located above the isocost line cc' would not be hot candidates for investment.

¹² An aggregate unit-value isoquant of a production function for the whole economy would be then identical with EE' , what would represent a set of production subject to the most technically efficient criterion (Farrell [1957]).

Figure 4



Speaking theoretically, the stylised facts in Figure 4 (which are not so much different from our real data, sic!) would suggest that the prime target for FDI would be in industries located in area II. Their production is both labour-intensive and cost-efficient. Then would follow area I which is cost-efficient but capital-intensive. Area IV would be the least attractive for FDI. Surprisingly, our empirical tests have assessed area III as the most significant area for FDI. For example, an industry with endowments e_2 could have been even more successful recipient of FDI than e_1 ! This is definitely a paradox, contradicting the theory.¹³ We can proceed with the paradox even further: the low coefficient of determination suggests that there were many exceptions to our rule. Thus the Czech FDI inflows were scattered (with not a wide differences in probability) all over our areas I, II and III.

The tendency to direct the FDI into the labour-intensive industries can lead to another hypothesis. We can speculate that this is not because of higher endowments of labour to capital in Czechia than in EU. Huge investments during 42 years of central planning and extremely high investments throughout the period of transformation could push Czechia among the countries with high K/L endowments. Unfortunately, capital-intensive production is also a production which requires functioning property rights because there is too much financial capital involved. As argued in Olson [1998] capital-intensive equals also „property-rights intensive“. The functioning of banks, contract enforcement, low taxation and political stability are crucial conditions for FDI to come and stay. Czechia, unfortunately, failed to a large extent in these parameters, what became known after 1996. Therefore her problems with FDI will last until the government would not change it to better. After that, the FDI can change its strategy and enter more evenly into both capital and labour-intensive industries.

At this stage of our study we can formulate a more general hypothesis which has to be tested in our further study: since in mere 5 years after the demise of central planning the restructuring in Czech manufacturing industries was still far from being finished, the co-existence of both efficient and inefficient **industries** should be extended to the co-existence of both efficient and inefficient **firms**. With 36 firms in average in an industry we cannot exclude a case that their dispersion inside the industry could be similar as what we have observed among the industrial averages. Therefore we

¹³ Benacek [1997] and Benacek, Shemetilo, Petrov [1997] try to explain this kind of paradoxes. There are many strategies for survival in a transient economy which allow inefficient firms to mimic as efficient firms. They even may show profits while efficient firms under intensive restructuring may have a red bottomline. Transaction costs incurred outside the production process may contaminate the data for production functions and thus bias our picture of inefficiency.

cannot be certain that an FDI coming into an inefficient sector must have been by itself a signal for an inefficient choice. It could have been a case which we have discussed when we commented on Figure 2.

Though restructuring is definitely a process which leads to a more transparent environment for decisions about FDI and thus (as a **cause**) to larger FDI inflows, it can be also an **effect** of FDI. The former case leads to better conditions for competition and thus to wider effects of various spillovers among firms. The latter creates a situation where successful firms with FDI become leaders, while the less successful indigenous firms are left in a hopeless strife for survival. The result is a creation of parallel tiers of firms which do not compete with one another on the same markets. The smaller upper tier with firms with FDI shows high and ever rising productivity, high exports, profits and investments. The larger lower tier contains indigenous firms fighting with ownership issues, bad debts and shortage of capital. The study of Zemplerova [1998] confirmed that this dismal figure and a widening gap between these two tiers may be a realistic description. Then bringing the inefficient firms to bankruptcy and promoting FDI can be, though very costly and painful, the only rational policy for faster development.

Holland and Pain [1998] have also confirmed that spillover effects on productivity from FDI firms to indigenous firms were very difficult to observe in Czechia during 1990-95. This is in line with an assumption about the existence of two isolated tiers of firms. However, even though we agree that two parallel segments of the economy are not an arrangement conducive to high growth and a restructuring with bankruptcies would be necessary, we also cannot assume that the whole economy can be safeguarded by FDI alone. The existence of an indigenous sector, able to co-operate, invest, imitate, innovate and compete with FDI firms, is a condition without which the process of catch-up cannot be started. As an economic policy recommendation, this requires on one hand a functioning legal environment where rent-seeking is not a sufficient condition for survival. On the other hand, the straightening-up of the capital market and improvements in the functioning of banks is another crucial condition so that the domestic savings are transformed into the correct hands and used for correct purposes.

11. CONCLUSIONS

In this paper we have tested econometrically what determining factors could represent the causal side of FDI entry into Czech Republic. Our aim was to provide a descriptive analysis of Czech manufacturing in 1994, based on hypotheses derived from the theory of investments for small open economies. The econometric tests have been applied on data for 91 industries. The variable of FDI per total capital stock in given industry was regressed on a list of 8 main theoretically based explanatory variables characterising the input side and the market structure of industries.

Because the pace of restructuring did not proceed in all industries at the same speed, our data were subject to conflicting patterns of behaviour in many industries. As an aftermath, the ordinary least squares technique did not lead to efficient estimates of the over-all sample and the majority of explanatory variables were not statistically significant. Therefore we had to adopt a special technique of estimation based on trimmed least squares and a leverage point. Thus we could unveil the correlation between FDI and the behaviour of producers subject to their different attitudes to factor usage. Because the usage of robust methods required extensive experimenting with complicated techniques of estimation, a special paper of this project (see Visek and Benacek [1999]) continued further on where we have finished this paper in chapter 9.

We have seen that 72 % of industries and 88% of all Czech incoming FDI can be explained at a high level of statistical significance by the following determining factors:

- Negative approach to capital intensity of production, where FDI is rather reluctant to commit itself to these types of industries. We can only infer indirectly that labour intensive industries were a probable target for investment.
- Preference for industries with high total factor productivity.
- Preference for industries showing increasing returns to scale (i.e. the potential for future market power and high profitability).
- High requirements of production for R&D.

The omitted industries, representing some 12% of FDI flows have shown different properties where the parameters of efficiency were lower. We have formed a hypothesis that the industries refused by the robust estimation were industries with a low level of restructuring. The characteristics of those industries were inclined to reveal behavioural properties reminding the environment of central planning. Unfortunately this fundamental innovative hypothesis, which could help quantify the level of restructuring in various industries, will need more experimenting and testing before we could proclaim it valid.

12. REFERENCES

- Agarwal J. P.: Implications of FDI Flows into the European Transition Economies for Developing Countries. University of Kiel. Paper presented at 10th EEA Congress, Prague, 1995
- Altzinger W.: Does Investment Substitute Exports? Vienna, University of Economics, WP, 1998
- Altzinger W., Winklhofer R.: General Patterns of Austrian FDI in Central and Eastern Europe and a Case Study. *Journal of Int. Relations and Development*, Ljubljana, vol. 1, No. 1, 1998
- Barrell R., Pain N.: FDI, Technical Change and Ec. Growth within Europe. *The Ec. Journal*, vol. 107, p. 1770-86, 1997
- Barrell R., Lansbury M., Pain N.: FDI in Central Europe since 1990: an Econometric Study. NIESR, London, 1997
- Barry F.: The Increasing Returns Sectors in Transition: The EU Periphery, the Czech and Slovak Republics and Romania Compared. EU Phare-ACE Research Paper, Univ. College, Dublin, 1997
- Benacek V.: The Competitiveness and Trade of Industries in Transition: Why Are Their Strategies for Survival So Similar? CERGE, Discussion Paper No. 7, 1997, p. 1-19
- Benacek V., Shemetilo D., Petrov A.: Efficiency under Restructuring from a Microeconomic Perspective. In: *Restructuring Eastern Europe*, Sarma S. (ed.). E. Elgar Publ., Cheltenham, UK, 1997
- Benacek V., Visek J.: Foreign Direct Investment in an Economy of Transition - The Case of the Czech Republic: Evolution, Problems and Policy Issues. Charles University, Prague, 1998
- Benacek V., Visek J., Jarolim M.: Supply-Side Characteristics and the Industrial Structure of Czech Foreign Trade. Working Paper of FSV, Charles University, Prague, 1998
- Blomstrom M., Kokko A.: Home Country Effects of FDI: Evidence from Sweden. NBER Working Paper no. 4639, Cambridge, USA
- Djankov S., Hoekman B.: Determinants of FDI in Czech Firms. World Bank, mimeo, 1998a
- Djankov S., Hoekman B.: Avenues of Technology Transfer: FDI and Productivity Change in the Czech Republic. World Bank and CEPR, 1998b
- Eichengreen B., Kohl R.: The external Sector and Development in Eastern Europe: The Determinants of Differential Performance. *Journal of Int. Relations and Development*, Ljubljana, vol. 1, No. 1, 1998
- Farrell M. J.: The Measurement of Productive Efficiency. *J. of the Royal Statistical Society*, Series A, p. 253, 1997
- Fisher, R. A.: On the mathematical foundations of theoretical statistics. *Philosophical Trans.*, Royal Statistical Society, London, Ser. A 222, 1922, p. 309-368
- Greenaway D., Milner C. R.: *The Economics of Intra-Industry Trade*. Oxford, Blackwell, 1986
- Hampel F. R., Ronchetti E. M., Rousseeuw P. J., Stahel W. A.: *Robust Statistics -- The Approach Based on Influence Functions*. New York: J. Wiley & Sons, 1986
- Hanel P.: Factor Intensity and Composition of Foreign Trade. Czech Republic 1989-94. Discussion Paper of IHS Vienna, 1995
- Hettmansperger T. P., Sheather S. J.: A Cautionary Note on the Method of Least Median Squares. *The American Statistician* 46, 1992, p. 79—83
- Holland D., Pain N.: Accession, Integration and the Diffusion of Innovations: A Study of the Determinants and Impact of FDI in Central and Eastern Europe. Working Paper of NIESR, London, 1998
- Hunya G.: Integration of CEEC Manufacturing into European Corporate Structures via Direct Investment. WIIW, Vienna, Research Report no. 245, 1998
- Jones R.: A Small Country in a Many-Commodity World. *Australian Ec. Papers*, No. 23, 1974

- Konings J.: FDI in Transition Economies. Leuven Inst. For Central and East European Studies, Leuven, 1996
- Krugman P.: International Trade Theory and Policy. In G. Grossman and K. Rogov (eds.), *Handbook of Int. Economics*, vol.III, Elsevier, North Holland, 1992
- Landesmann M.: The Economic Interpenetration between the EC and Eastern Europe: Czechoslovakia. Eur.Economy - Reports and Studies, No. 8, European Commission, 1994
- Leamer E. E.: Models of the Transition in Eastern Europe with Untransferable Eastern Capital. Vienna, Institute for Advanced Studies, Working Paper Series, 1994
- Maronna R.A., Bustos O. H., Yohai V. J.: Bias and efficiency-robustness of general M-estimators for regression with random carriers. In: Smoothing Techniques for Curve Estimation. Eds. T. Gasser and M. Rosenblatt, New York: Springer-Verlag, 1979
- Naujoks P., Schmidt K.-D.: FDI and Trade in Transition Countries: Tracing Links. Kiel Working Papers, IFW Univ. Of Kiel, 1995
- Prokop L.: The Contents of Investment Goods in the Pattern of Czech Imports. Working Paper of Czech National Bank, 1997
- Lansbury M., Pain N., Smidkova K.: The Determinants of FDI in Central Europe by OECD Countries: An Econometric Analysis. In: Czaky, Foti G., Mayes D. (eds): FDI in Transition: The Case of the Visegrad Countries. Institute for World Economy, Budapest, 1996
- Rousseeuw P.J., Leroy A.M.: Robust Regression and Outlier Detection. N. York, J.Wiley, 1987
- Ruppert, D., Carroll, R. J.: Trimmed least squares estimation in linear model. J. of American Statistical Assoc, 75 (372), 1980, p. 828--838
- Stolze F.: Changing Foreign Trade Patterns in Post-Reform Czech Industry (1989-95) - Empirical Evidence. Prague Ec. Papers, No. 4, 1997
- Visek J. A.: A cautionary note on the method of Least Median of Squares reconsidered. Paper of the 12th Prague Conference on Information Theory, Statistical Decision, Functions and Random Processes, Prague, 1994, p. 254 - 259.
- Visek, J. Á .: On high breakdown point estimation. Computational Statistics, vol. 11, Berlin, 1996, p. 137-146
- Vollrath T.: A Theoretical Evaluation of Alternative Trade Intensity Measures of RCA. Weltwirtschaftliches Archiv, No. 2, 1991, p. 265-279
- Zemplinerova A.: FDI in the Czech Manufacturing enterprises - An Empirical Approach. Working Paper of ACE/Phare, CERGE, Prague, 1998