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Institut für Volkswirtschaftslehre

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## Volkswirtschaftliche Diskussionsreihe

Capital/Labor Substitution, Capital Deepening,  
and FDI

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# Capital/Labor Substitution, Capital Deepening, and FDI

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## **Abstract**

Empirical studies show that the elasticity of substitution between capital and labor is larger than one in developed countries but smaller in developing countries. This paper develops a production function which allows for this structure in the elasticity of substitution. The case of a falling real interest rate and capital deepening in the developed countries in the presence of FDI flows from the developed to the developing country is analyzed. It is shown that this structure in the elasticity of substitution can be responsible for a U-shaped relationship between the capital intensity of the developed country and the relative capital intensity of the developing country. This carries over to an inverted U-shaped relationship between the capital intensity of the developed country and FDI profitability.

*Keywords:* Capital/Labor Substitution, FDI, Capital Deepening

*JEL Classification Number:* E23, F21, O11

# 1 Introduction

While current research in explaining FDI patterns is heavily focussed on heterogeneity of firms and industries with respect to productivity and sector or firm size (see e.g. the recent review of the literature in Helpman 2006), this paper looks from a more macroeconomic point of view onto the phenomenon of FDI. Its main argument relies on the heterogeneity of the elasticity of substitution between capital and labor among different countries and the development of the real interest rate. When looking at developed and less developed countries (see e.g. Duffy and Papageorgiou 2000 or Pereira 2002) it seems that more developed countries are characterized by an elasticity of substitution above one while developing countries have an elasticity below one. This together with a falling real interest rate and capital deepening<sup>1</sup> in the developed country over a longer time horizon can give rise to an inverted U-shaped pattern in FDI flows as will be argued below.

Working out the determinants of FDI from the theoretical point of view, Helpman (2006) broughtly distinguishes between reasons related to productivity heterogeneity and incomplete contracts. The latter is not the focus of the present paper. Regarding the first argument, the main theoretical contribution to the literature is the Melitz (2003) model with monopolistic competition and heterogenous firms on which a large strand of the subsequent literature is build on<sup>2</sup>. Subsequent developed models took account of more complex firm strategies involved in FDI as horizontal and vertical integration strategies or export platform structures<sup>3</sup> (e.g. Yeaple 2003). This literature points on several issues touching upon the firm's decision of whether to pursue FDI or not. From this theoretical point of view, the main results are that more productive and larger firms are engaged in trade and FDI compared to firms

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<sup>1</sup>With capital deepening an increase in the ratio of capital and labor used in production is meant here.

<sup>2</sup>E.g. Helpman, Melitz and Yeaple (2004) or Grossmam, Helpman and Szeidl (2005).

<sup>3</sup>Horizontal FDI corresponds to the situation where a firm serves the foreign market by producing the final good in an own foreign facility, whereas vertical FDI means that intermediate input factors for production of the final good are produced in an own foreign facility. Export platform FDI involves production in a foreign country to serve other countries with products.

which serve only their domestic market. This finding is concordance with empirical findings. The knowledge capital model developed by Markusen, Venables, Eby-Konan and Zhang (1996) and Markusen (1997) added to the literature by focusing on factor proportions in a two factor model economy. Also, a rich environment of different types of FDI was included. Solving these and subsequent models by simulations provided insights into the relationship between FDI and factor proportions<sup>4</sup>, i.e. how differences in factor proportions favor different types of FDI<sup>5</sup>.

A recent review of empirical studies searching for determinants of FDI can be found in Blonigen (2006). He broughtly groups these into two categories. Firm level studies trying to find correlations between firm specific characteristics and firm specific FDI behavior and more macro economic oriented general equilibrium studies trying to find correlations between country or region characteristics or exogenous macro economic variables and FDI inflows. Firm level studies point to the importance of own intangible assets and access to other's intangible assets as well as firm size and productivity (Helpman, Melitz and Yeaple 2004). Macroeconomic general equilibrium studies point to the importance of exchange rates, taxes, uncertainty, agglomeration effects and tariffs as noted by Markusen and Maskus (2001) (For a list of references see Markusen and Maskus 2001).

It seems remarkable that capital is absent in almost all the papers and articles cited above, the only factor of production considered by these models is labor. Also the The issue of heterogeneity in factor substitutability and the interest rate seem to be hardly recognized by the literature on FDI.

The model below therefore aims to add to the theoretical literature on determinants of FDI by taking account of the difference in the elasticity of substitution between capital and labor across developed and developing countries. The case analyzed in this paper is that of a falling real interest rate over a longer period of time and a thereby induced increase in the capital/labor ratio, i.e. capital deepening. The lower

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<sup>4</sup>Factors that are recognized are skilled and unskilled labor, capital however is not present in these models.

<sup>5</sup>The knowledge capital model was subsequently tested empirically in Carr, Markusen and Maskus (2001).

degree of substitutability of capital and labor in developing countries implies, *ceteris paribus*, a slighter increase in the capital/labor ratio. However, different products in the model are not perfect substitutes and the declining relative capital/labor ratio in the developing country induces increasing prices for goods produced there. This counteracts the above effect and even dominates it from some point in time inducing convergence between countries. Therefore a U-shaped relationship between the capital/labor ratio of the developed country and the relative capital/labor ratio of the developing country emerges. There are two kinds of investments analyzed in this paper. The first is portfolio investment by which investment flows by ordinary investors are meant which are subject to local productivity in creating capital goods for production. The local relative productivity is assumed to be lower in the developing country. The second is foreign direct investment originating from the developed country which refers to the situation where a particular firm can create its own capital goods for investment abroad by using its relatively higher productivity. The aforementioned U-shaped profile in the relative capital intensity of the developing country drives a wedge between the marginal product of portfolio and direct investments which can cause an inverted U-shaped relationship in FDI profitability. It also has serious implications for inequality across countries.

Desroches and Francis (2007) among others have documented that during at least the last 15 years the real interest rates in developed countries were falling. During the same period of time FDI inflows around the world grew heavily (see e.g. UNCTAD 2006) by more than GDP did. Also this evidence might be only suggestive, the paper might be of general interest because a falling interest rate accompanied with a rising capital intensity are the general characteristics of the adjustment process to a steady state in the growth process of an economy (see e.g. Barro and Sala-i-Martin 2003).

The basic framework is somewhat similar to the one presented in Helpman (1985) where differentiated products can be produced by MNEs either in the home or the host country and are sold simultaneously in both markets. Helpman (1985) terms this as “horizontally integrated multinationals” but Markusen and Maskus (2001)

point to the difference of this setup to what is usually referred to as horizontal FDI. The model in this paper does not aim to give a contribution on the question why horizontal FDI between similar countries occurs. Instead the focus is only on different countries motivated by the observation that less developed countries poses a lower elasticity of substitution between capital and labor. Exactly this observation is the motivation for this paper and, hence, this paper elaborates on isolated effect of this difference which can only be observed between different countries on FDI flows.

The model thus fits more into the category of early contributions to the FDI literature which tries to explain FDI behavior by differences in factor proportions starting with the contribution of Helpman (1984).

## 2 Theoretical Background

The CES function developed in Arrow et al. (1961) as a solution to the partial differential equation defining the constant elasticity of substitution

$$\sigma = \frac{f'(k)[f(k) - kf'(k)]}{-kf''(k)f(k)}$$

takes the form

$$f(k) = \gamma_1[k^{\frac{\sigma-1}{\sigma}} + \gamma_2]^{\frac{\sigma}{\sigma-1}}.$$

$k$  is defined as capital per efficiency unit of labor,  $k = \frac{K}{AL}$ , where  $K$  is the capital stock,  $L$  is raw labor and  $A$  might be interpreted as human capital or the state of a purely labor augmenting technology.  $f(k)$  is the intensive form of a constant returns to scale production function for final output  $Y$ ,  $Y = F(AL, K)$ .  $f'(k)$  and  $f''(k)$  denote first and second derivatives with respect to  $k$ . Finally  $\gamma_1$  and  $\gamma_2$  are arbitrary constants of integration. De la Grandville (1989) introduced the normalized CES function through determination of these two constants from initial conditions on production. It is important to note that “initial” is not to be interpreted in terms of time, but in terms of some baseline values for production. If the economy departs from this baseline, the elasticity of substitution is given by  $\sigma$ . The initial

condition were given by  $k_0$ ,  $\mu_0$  and  $y_0$ , i.e. the baseline capital intensity, the baseline marginal rate of substitution between labor and capital and the baseline production per efficiency unit of labor. For  $\gamma_1$  and  $\gamma_2$  this implies

$$\begin{aligned}\gamma_1 &= y_0 \frac{k_0^{\frac{1}{\sigma-1}}}{k_0 + \mu_0}, \\ \gamma_2 &= \mu_0 k_0^{-\frac{1}{\sigma}}, \\ \mu_0 &= \frac{f(k_0) - k_0 f'(k_0)}{f'(k_0)}.\end{aligned}$$

The resulting normalized production function in intensive form is then given by

$$f(k) = y_0 \left( \frac{k_0^{\frac{1}{\sigma}} + \mu_0}{k_0 + \mu_0} \right)^{\frac{\sigma}{\sigma-1}} \left( \frac{k_0^{\frac{1}{\sigma}}}{k_0^{\frac{1}{\sigma}} + \mu_0} k_0^{\frac{\sigma-1}{\sigma}} + \frac{\mu_0}{k_0^{\frac{1}{\sigma}} + \mu_0} \right)^{\frac{\sigma}{\sigma-1}}.$$

This production function was subsequently used by, among others, Klump and De la Grandville (2000), Klump and Preissler (2000), Miyagiwa and Papageorgiou (2003) and Aquilina, Klump and Pietrobelli (2006).

An innovative production function can be obtained from these result by explicitly specifying  $\mu_0$  and  $y_0$ . The economic intuition behind this that the baseline values of production correspond to a situation where the economy is in an optimal position to use the available technology, i.e. if the capital intensity equals  $k_0$ , production possibilities are better than with  $k \neq k_0$ . One way to formalize this idea is to use the specifications:

$$\begin{aligned}\mu_0 &= \frac{\alpha}{1-\alpha} k_0^{\frac{\sigma-1}{\sigma} - \frac{\tilde{\sigma}-1}{\tilde{\sigma}}}, \\ y_0 &= \left[ (1-\alpha) k_0^{\frac{\tilde{\sigma}-1}{\tilde{\sigma}}} + \alpha \right]^{\frac{\tilde{\sigma}}{\tilde{\sigma}-1}}.\end{aligned}\tag{1}$$

This results in the production function

$$f(k) = \left[ (1-\alpha) k_0^{\frac{\tilde{\sigma}-1}{\tilde{\sigma}}} + \alpha \right]^{\frac{\tilde{\sigma}}{\tilde{\sigma}-1} \left( 1 - \frac{\tilde{\sigma}-1}{\tilde{\sigma}} \frac{\sigma}{\sigma-1} \right)} \left[ (1-\alpha) \left( \frac{k}{k_0} \right)^{\frac{\sigma-1}{\tilde{\sigma}}} k_0^{\frac{\tilde{\sigma}-1}{\tilde{\sigma}}} + \alpha \right]^{\frac{\sigma}{\tilde{\sigma}-1}}\tag{2}$$

in intensive form<sup>6</sup>. If  $k$  equals  $k_0$ , this function reduces to  $y_0$  given by (1) above. This implies that at  $k = k_0$  the elasticity of substitution equals  $\tilde{\sigma}$  and for  $k \neq k_0$  it is given by  $\sigma$ .

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<sup>6</sup>A somehow related production function appears in Jones (2003), where the baseline production is restricted to the Cobb-Douglas case. For the empirical relevance of this specific function see also Antony (2008).



### 3 The Model

This section uses the production function (2) to construct an economy consisting of two countries, one developed and one developing. The developed country is assumed to set the technology standard defined by the production technology. There is a continuum of differentiated products and producers located in the developed country can contract out production to the developing country or engage via FDI in producing in the developing country. Contracted out production is pursued by a local producer who uses capital goods produced with local productivity using portfolio investments while FDI financed production can make use of capital goods produced by direct investors using the higher productivity of the developed country. The rate of return to portfolio investments equals the interest rate obtained from ordinary investments in the developing country while the rate of return to direct investments is higher due to the assumption that only one firm active in the developed country has the knowledge to provide the developing country with direct investments. Since goods are imperfect substitutes this firm is in the position of a monopolist who faces competition only from portfolio investors who have a comparative disadvantage in producing capital goods. The rate of return on portfolio investments is assumed to be exogenously given and the reaction of the model economy to changes in the interest rate is analyzed.

#### 3.1 Production

A firm  $i$  in the developed country is faced with the production possibilities given by the production function in (2), where  $k_i$  is the capital intensity of the  $i$ th firm given by  $\frac{K_i}{A_i L_i}$ .  $K_i$  denotes the capital stock and  $L_i$  the labor input of firm  $i$ .  $A_i$  is a labor augmenting factor which is assumed to be identical for all firms in the developed country, i.e.  $A_i = A$ .

The firm faces an exogenous interest rate of  $r$  and can choose among production possibilities by choosing the value of  $k_0$ , the base line value for the capital intensity in production. Since at the point  $k_i = k_0$  the elasticity of substitution is larger than elsewhere it is cost minimizing to choose this value for  $k_0$ . As  $A_i$  is identical

for all firms in the developing country, they will all choose the same  $k_0$ . Henceforward,  $k_0$  denotes the capital intensity of the developed country which is exogenously determined by the interest rate. The price for the good produced by the firms is normalized to one and thus  $r$  represents the measure for the real interest rate in terms of the developed country good<sup>7</sup>. This interest rate determines  $k$  and in turn  $k_0 = k$  which are identical for all firms in the developed country. Following the empirical evidence, it is assumed that  $\tilde{\sigma} > 1 > \sigma$ , and hence the firms in the developed country operate at an elasticity of substitution above one. Due to symmetry between firms  $i$ ,  $K_i = K$  and  $L_i = L$ .

A firm can decide to also produce in the developing country by either contracting out its production or by investing directly into that country and building up an own production unit. However, the goods produced in the developing country are not perfect substitutes for the goods produced in the developed country. It is assumed that consumers have preferences over the different goods given by

$$U = \left( \int_0^{\frac{1}{2}} y_i^\delta di + \int_{\frac{1}{2}}^1 y_j^\delta dj \right)^{\frac{1}{\delta}}, \quad (3)$$

where  $\xi = \frac{1}{1-\delta} > 1$  measures the elasticity of substitution between different goods. Goods are not perfect substitutes but neither variant is essential for the consumers. There is a set of measure  $\frac{1}{2}$  goods produced in the developed country and a corresponding mass of  $\frac{1}{2}$  produced in the developing country indexed by  $j$  reflecting the above assumption that each producer can produce via FDI or contracting out in the developing country.

The developing country differs from the developed country with respect to the labor augmenting factor. Labor is less productive there so that every firm has a specific augmenting factor  $A_j < A$  in producing the corresponding good  $j$  in the developing country. The capital intensity for the firm  $j$  in this country is therefore defined analogously as in the developed country as  $\frac{K_j}{A_j L_j}$ .

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<sup>7</sup>This simplifies the analysis. Alternatively one could define the real interest rate by dividing by a price index over developed and developing countries' goods according to the consumption index below with the same results.

There is a difference whether this good is produced by a local firm under contract with the producer in the developed country or when production takes place after this producer has directly invested in the developing country. This difference is with respect to the capital goods which form  $K_j$  used in production. Denote investments directed to firm  $j$  by  $I_j$  made by consumers from foregone consumption. Then capital goods are produced according to  $K_j = \frac{A_j}{A} I_j$  in the case of contracting out. This reflects that if local producers have to build up the necessary facilities meeting the technical standard of the developed country they face frictions caused by the lower labor augmenting factor of their workers, i.e. they have difficulties in producing capital goods that are in conjecture with the technology standards. However, if the firm  $i$  from the developed country does this investment, it does not have these difficulties. This firm can use its specific knowledge to produce the necessary capital goods according to its local production function  $K_j = I_j$  and can invest them into the local facility in the developing country. This is similar as in Acemoglu et al. (2006) where the difference in the ability of producing capital goods is determined by differences in technology and the distance to the technology frontier. From a broader perspective this assumption implies that direct investors have a comparative advantage compared to portfolio investors.

This structure implies that in the first case the local producer as an contractor has to pay an effective interest rate of  $\frac{A}{A_j} r$  if investments yield the same return in both countries. If capital is employed up to the point where its marginal product equals the effective interest rate, the capital intensity is determined by

$$r = p_j \frac{A_j}{A} f'(k_j), \quad (4)$$

where  $p_j$  is the price for good  $j$  and  $f'(k_j)$  is the first derivative of (2) at the point  $k_j$ . If  $p_j \frac{A_j}{A}$  differs from one,  $k_j$  is unequal to  $k = k_0$  and the local producer is not at the base line value of production implying an elasticity of substitution of  $\sigma < 1$ .

In the second case, the producer of the capital goods  $K_j$  can directly invest them in the developing country by lending them to the local facility. Since the elasticity of substitution between capital and labor falls short of one in all cases where  $k_j = k_0$ , he will charge a price as high as possible. The limit price is  $\frac{A}{A_j} r$  at which the

local facility will be indifferent between being the contractor or the object of FDI. However, to be able to invest directly the investor needs a local representative, e.g. to observe its local investments, which causes fixed costs in terms of local labor. Let these fixed costs be given by  $\mu w_j$ , where  $w_j$  is the wage paid in the developing country and  $\mu$  is a positive parameter. Thus net profits for the direct investor are given by

$$\pi_i = p_j \left( \frac{A}{A_j} - 1 \right) r k_j A_j L_j - \mu w_j. \quad (5)$$

### 3.2 Capital Deepening

This section draws attention to the scenario where real interest rates are falling and hence the capital intensity in the developed country increases. This can be directly read off the marginal product condition for all firms in the developed country,  $r = f'(k_0)$ . No arbitrage in the investment sector of the economy implies together with (4)

$$f'(k) = p_j \frac{A_j}{A} f'(k_j). \quad (6)$$

Whether the capital intensity  $k_j$  increases depends on the development of the price  $p_j$ . Assume that prices equal marginal cost, the first order condition for wages

$$w_j = p_j A_j (f(k_j) - f'(k_j)k_j), \quad (7)$$

can be used together with (4) and the production function (2) to compute the price as

$$p_j = \frac{p}{A_j}, \quad (8)$$

with

$$p = \left[ (1 - \alpha) k_0^{\frac{\sigma-1}{\sigma}} + \alpha \right]^{-\frac{\sigma}{\sigma-1}} \times \left[ (1 - \alpha)^\sigma \left( A k_0^{1 - \frac{\sigma}{\sigma-1}} r \right)^{1-\sigma} + \alpha^\sigma (w_j)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

Since  $p$  is identical for all firms  $j$ , prices in the developing country differ only by the factor  $\frac{1}{A_j}$ . Labor is assumed to be perfectly mobile between firms within a country

yielding a wage rate that is equal for all firms. (7) and (8) imply that all firms  $j$  will choose the same capital intensity. The last result is due to the fact that the local facility pays the same effective interest rate regardless whether it is the object of contracting out or FDI. The costs and hence the price for producing one unit of a particular good in the developing country is not guaranteed to be lower than in the developed country. However, for reason of plausibility, the case of an initially lower price is analyzed in the following.

With these results at hand, the no arbitrage condition (6) yields the relative capital intensity of the developing country as

$$\frac{k_j}{k_0} = \left[ \frac{1 - \alpha}{\alpha} k_0^{\frac{\sigma-1}{\sigma}} \frac{1 - \left(\frac{p}{A}\right)^{\sigma-1}}{\left(\frac{p}{A}\right)^{\sigma-1}} + \frac{1}{\left(\frac{p}{A}\right)^{\sigma-1}} \right]^{-\frac{\sigma}{\sigma-1}}, \quad (9)$$

which depends on the price measure  $p$  of the developing country. To determine this price measure one has to take account of substitution effects due to the consumption index (3)

$$\frac{p}{A} = \left(\frac{k_0}{k_j}\right)^{\frac{1}{\xi-\sigma}} \left(\frac{A}{A_j}\right)^{\frac{1-\xi}{\xi-\sigma}} \left(\frac{L}{L_j}\right)^{\frac{1}{\xi-\sigma}}. \quad (10)$$

From this equation it can be seen as long as developed and developing country's goods are more substitutable than capital and labor in the developing country, a rising relative capital intensity of the developed country increases the price of the developing country's good in terms of developed country's goods. If, as assumed above,  $\xi > 1$ , this is the case here. What also can be seen from this expression is that for  $\frac{p}{A}$  to be equal for all firms  $j$ , the relative employment of capital for two different firms  $m$  and  $n$  in the developing country has to fulfill  $\frac{K_m}{K_n} = \left(\frac{A_m}{A_n}\right)^\xi$ , which characterizes a stable equilibrium in capital allocation in the developing country. Wage equalization between firms in the developing country leads to the above mentioned result that the capital intensity in all firms is identical.

From these results it can now be seen how the relative capital intensity of the developing country reacts to changes in the capital intensity in the developed country, i.e. if it were to rise as the real interest rate falls. Building the total differential of (9) with respect to  $\frac{k_j}{k_0}$  and  $k_0$  and taking account of the change in the price measure

$\frac{p}{A}$  via (10) gives

$$\frac{d\frac{k_j}{k_0}}{dk_0} = -\frac{\sigma-1}{\sigma} \left(\frac{k_j}{k_0}\right)^{\frac{2\sigma-1}{\sigma}} \frac{\frac{\sigma-1}{\sigma} \frac{1-\alpha}{\alpha} \frac{1-\tilde{p}}{\tilde{p}} k_0^{-\frac{1}{\sigma}} - \frac{1}{\tilde{p}^2} \frac{\partial \tilde{p}}{\partial k_0} \left(\frac{1-\alpha}{\alpha} k_0^{\frac{\sigma-1}{\sigma}} + 1\right)}{1 + \frac{\sigma}{\sigma-1} \left(\frac{k_j}{k_0}\right)^{\frac{2\sigma-1}{\sigma}} \frac{1}{\tilde{p}^2} \frac{\partial \tilde{p}}{\partial \frac{k_j}{k_0}} \left(\frac{1-\alpha}{\alpha} k_0^{\frac{\sigma-1}{\sigma}} + 1\right)}, \quad (11)$$

$$\tilde{p} = \left(\frac{p}{A}\right)^{\sigma-1} > 1,$$

$$\frac{\partial \tilde{p}}{\partial \frac{k_j}{k_0}} = -\frac{\sigma-1}{\xi-\sigma} \tilde{p} \frac{k_0}{k_j} > 0,$$

$$\frac{\partial \tilde{p}}{\partial k_0} = \frac{\sigma-1}{\xi-\sigma} \tilde{p} \frac{1}{k_j} < 0.$$

Although (11) is a quite complex expression, some clear insights about the behavior of the relative capital intensity of the developing country in reaction to an increase in the capital intensity of the developed country can be gained. The denominator of (11) is always positive, while the numerator is negative for small values of  $k_0$  but becomes positive if  $k_0$  is large enough<sup>8</sup>. This results in a U-shaped profile for the relative capital intensity of the developing country,  $\frac{k_j}{k_0}$ . At the beginning of the capital deepening process, the lower elasticity of substitution between capital and labor leads to weaker growth of the capital intensity in the developing country than in the developed country. However, during this development, relatively more developed country goods are produced, inducing an increase in the relative price of the developing country goods and hence an increase in the marginal product of capital there which attracts capital into the developing country. At some point the last effect dominates the first from which the relative capital intensity of the developing country increases until it reaches the value of one where both countries enjoy the same capital intensity.

### 3.3 FDI

The last subsection emphasized the U-shaped profile of the relative capital intensity of the developing country. This U-shaped profile has direct implications for the direct investments mentioned above. The interest rate equals the marginal product

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<sup>8</sup>This can be seen from (11) since the first term in the numerator is negative and monotonic increasing in  $k_0$  while the second term is positive and monotonic increasing in  $k_0$ .

of investments in the developing country and wages equal the marginal product of labor

$$\begin{aligned}
r &= p_j \frac{A_j}{A} f'(k_j) \\
&= p_j \frac{A_j}{A} \left( (1 - \alpha) k_0^{\frac{\tilde{\sigma}-1}{\sigma}} + \alpha \right)^{\frac{\tilde{\sigma}}{\tilde{\sigma}-1} \left( 1 - \frac{\tilde{\sigma}-1}{\tilde{\sigma}} \frac{\sigma}{\sigma-1} \right)} \times \\
&\quad \times \left( (1 - \alpha) \left( \frac{k_j}{k_0} \right)^{\frac{\sigma-1}{\sigma}} k_0^{\frac{\tilde{\sigma}-1}{\sigma}} + \alpha \right)^{\frac{1}{\sigma-1}} (1 - \alpha) k_0^{\frac{\tilde{\sigma}-1}{\sigma} - \frac{\sigma-1}{\sigma}} k_j^{-\frac{1}{\sigma}} k_0^{\frac{\tilde{\sigma}-1}{\sigma} - \frac{\sigma-1}{\sigma}}, \\
&= p_j \frac{A_j}{A} f(k_j)^{\frac{1}{\sigma}} f(k_0)^{\frac{\sigma-1}{\sigma} - \frac{\tilde{\sigma}-1}{\tilde{\sigma}}} (1 - \alpha) k_j^{-\frac{1}{\sigma}} \\
w_j &= p_j A_j (f(k_j) - f'(k_k) k_j) \\
&= p_j A_j \alpha f(k_j)^{\frac{1}{\sigma}} f(k_0)^{\frac{\sigma-1}{\sigma} - \frac{\tilde{\sigma}-1}{\tilde{\sigma}}}.
\end{aligned}$$

It then follows that net profits from FDI are positive if

$$\frac{1 - \alpha}{\alpha} \frac{1}{\mu} \left( \frac{A}{A_j} - 1 \right) \left( \frac{k_j}{k_0} \right)^{\frac{\sigma-1}{\sigma}} k_0^{\frac{\tilde{\sigma}-1}{\sigma}} L_j > 0. \quad (12)$$

The number of workers employed by firm  $j$  can readily be computed by observing that the price measure (10) must be identical for all firms  $j$ . This implies that relative employment of firms  $m$  and  $n$  is given by

$$\frac{L_m}{L_n} = \left( \frac{A_m}{A_n} \right)^{\xi-1}, \quad (13)$$

implying that the firm with the higher labor augmenting factor has also a higher absolute employment if  $\xi > 1$ . Returning to the net profits from FDI it can be seen from condition (12) that the U-shaped relationship between  $\frac{k_j}{k_0}$  and  $k_0$  has important implications for the question whether to contract out production or to directly invest in the developing country. As capital deepens in the developed country as the interest rate falls the net profits from FDI first strictly increase. This means that at this early stage of development the incentive to prefer FDI over contracting out first gains but eventually falls when the capital intensity of the developed country is high. The incentive is higher if the gap in the labor augmenting factor between the developed and the developing country is high, i.e. if the comparative advantage for direct investments over traditional investments is large. However, if the firm in the

developing country has a high labor augmenting factor it attracts much labor at the going wage rate, increasing the net profits. Thus there is a trade off between a low labor augmenting factor, and a high gap to the developed country, and high labor augmenting factor and high employment. Thus at least a decreasing marginal profitability from capital deepening occurs if profitability is not inverted U-shaped, meaning that first more and more firms find it profitable to pursue FDI and might be switching back later to contracting out.

### 3.4 Inequality

There are some implications of the production function (2) for inequality in several economic figures. First, as already mentioned there might be a U-shaped development of the relative capital intensity as just shows. Second, this pattern has implications for other figures such as relative wages or per capita production.

Relative wages, in terms of the developed country's good, for the developing country,  $\frac{w_j}{w}$  can be computed using (6) as

$$\begin{aligned}\frac{w_j}{w} &= \frac{p_j A_j (f(k_j) - f'(k_j)k_j)}{A(f(k_0) - f'(k_0)k_0)} \\ &= \left(\frac{k_j}{k_0}\right)^{\frac{1}{\sigma}}.\end{aligned}$$

Thus, the U-shaped relationship carries over to the relative wage from the same reasons as above.

Relative per capita production in terms of the developed country's good,  $\frac{p_j A_j f(k_j)}{A f(k_0)}$  is given by

$$\begin{aligned}\frac{p_j A_j f(k_j)}{A f(k_0)} &= \frac{k_j}{k_0} p_j^{1-\sigma} \left(\frac{A}{A_j}\right)^\sigma \\ &= \left(\frac{k_j}{k_0}\right)^{\frac{\xi-1}{\xi-\sigma}} \left(\frac{A_j}{A}\right)^{\frac{(1-\sigma)(\xi-1)}{\xi-\sigma}} \left(\frac{L_j}{L}\right)^{\frac{\sigma-1}{\xi-\sigma}}.\end{aligned}$$

If, as assumed,  $\xi > 1$ , the U-shaped profile also applies to per capita production during a phase of capital deepening in the developed country. Together with (13) it can be seen that per capita production across firms in the developing country is identical.



## 4 Conclusion

The motivation for this paper came from the empirical observation that the elasticity of substitution between capital and labor is significantly larger than one for developed and smaller for developing countries. Economic intuition already implies that this has implications for inequality in the capital intensities of both types of countries, i.e. that if the capital intensity of the developed country increases it can not do this in developing countries that much.

The paper proposed a production function which can account for two different elasticities of substitution between capital and labor. Due to choice of technology, the developed country can enjoy the higher elasticity of substitution while the developing country can not. This has important implications for a variety of economic issues. The paper's focus is on direct investments of firms active in the developed country for which the relative capital intensity of the developing country is very important. The reason for the inverted U-shaped profile of net profits for FDI in the developing country is the deteriorating effect of capital deepening in the developed country for the ratio of the interest rate to wages in the developing country. The relative decline in capital intensities lets the wage decrease relative to the interest rate which are basis for profits of FDI while the former determine the costs of FDI. This makes FDI more profitable so that more and more firms engage in FDI. From some point on this relationship turns around and FDI gets less profitable.

It has also been shown that capital deepening has initially adverse effects via the lower elasticity of substitution in the developing country onto relative wages and relative per capita production which are driven by the decline in the relative capital intensity. However also this relationship has a turning point and therefore inequality vanishes again over time.

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