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FDI and Unemployment, a Growth Perspective

Ignat Stepanok

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Ignat Stepanok (IAB)

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Abstract

North-South foreign direct investment (FDI) is frequently viewed as a process in which jobs relocate from the North to the South. I build a growth model with two asymmetric trading economies, the North where firms innovate and the South where Northern firms invest to take advantage of lower wages. Contrary to expectation, I find that lower FDI costs increase unemployment both in the North and in the South. There are two effects of FDI on unemployment, a direct positive one which contributes to the turnover of firms parallel to innovation. The indirect effect appears through innovation and growth: more FDI means higher innovation, this intensifies firm turnover and increases the unemployment rates in both countries even further. I solve the model analytically without trade costs and imitation of products in the South. For the version with trade costs and imitation I offer a numerical solution in which I also look at the effect of FDI on welfare and find a positive relation. In addition to FDI, I explore how intellectual property (IP) rights protection affects unemployment and welfare. Both are higher in a steady state with stricter IP protection.

Zusammenfassung

Nord-Süd Direktinvestitionen werden oft als ein Prozess der Verlagerung von Jobs vom Norden in den Süden betrachtet. In diesem Papier wird ein Wachstumsmodell mit zwei asymmetrischen Ländern entwickelt; der Norden, wo Firmen in Forschung und Entwicklung investieren, und der Süden, in den sie später aufgrund niedriger Kosten Ihre Produktion verlagern. Ein Ergebnis des Modells ist, dass entgegen der Erwartung niedrigere Kosten für ausländische Direktinvestitionen die Arbeitslosigkeit sowohl im Norden als auch im Süden steigern. Die Direktinvestitionen erhöhen die Arbeitslosigkeit durch zwei Effekte: erstens tragen sie direkt, parallel mit der Innovationsrate, zu dem Eintritt und Austritt von Firmen bei; zweitens, indirekt durch Forschung und Entwicklung, in dem sie die Innovationsrate und dadurch die schöpferische Zerstörung von Produkten erhöhen, was am Ende die Arbeitslosigkeit noch weiter steigert. Wohingegen das Modell ohne Imitation von Produkten im Süden und ohne Handelskosten analytisch gelöst werden kann, wird die Version mit Imitation im Süden und mit Handelskosten numerisch gelöst. In dieser numerischen Version untersuche ich nicht nur die Wirkung von ausländischen Direktinvestitionen auf Arbeitslosigkeit, sondern auch auf das Wohlfahrtsniveau, dabei finde ich einen positiven Zusammenhang. Zusätzlich untersuche ich die Wirkung des Schutzes geistigen Eigentums auf Arbeitslosigkeit und Wohlfahrt. Es zeigt sich, dass beide in einem Gleichgewicht mit stärkerem Schutz höher ausfallen.

1 Introduction

The public debate is full of examples pointing at outward FDI as a culprit for domestic job losses in developed countries. At the same time developing countries have been focusing on providing good investment conditions to attract multinationals in order to create jobs. Actually attracting inward FDI is a popular argument for fighting unemployment also in developed countries.

While it can be true that outward FDI leads to job losses and inward FDI to job gains, it is a short-run story, which does not have to hold if we take a long-run dynamic perspective. I argue in this paper that when one looks at FDI as part of a creative destruction process, and at the movement of production from the North to the South as part of the product life cycle described in Vernon (1966), then both outgoing and incoming FDI contribute to higher levels of unemployment. New goods are introduced in the North and later moved for production to the cheaper South, where after some time they find themselves to be obsolete and replaced by newer varieties in the North. A more accessible and cheaper FDI process makes also innovation more profitable and quickens creative destruction.

There has been a lot of discussion about globalization and labor markets, needless to say FDI given its growth in recent decades has played an important role. In addition to the direct effect it has on jobs, it is a major channel for knowledge spillovers, which in turn affect labor markets indirectly through productivity improvements and growth.

The main focus of the current paper is to study theoretically the connection between FDI and unemployment in a growth context. I build a model in which I show that FDI increases unemployment, but also welfare, both in the North and in the South. Northerners fearing job losses have a point, but nevertheless the dynamic effect of FDI increases their welfare, because it makes available goods of higher quality. Southerners on the other hand face higher unemployment with more FDI, which is a surprising result given that incoming FDI is expected to decrease and not to increase unemployment. The overall effect of FDI on welfare is however positive due to technological spillovers and economic growth.

The model in this paper features quality-ladders endogenous growth with two asymmetric countries (regions), the North which innovates and the South where wages are lower so that Northern firms have an incentive to move production there to save on costs. Workers have to search before finding a job, I work with the simplification that the duration of unemployment is exogenous and country-specific. With this model I am able to study the connection between FDI and unemployment both in the North and in the South[1]. I first solve analytically a simplified version of the model without trade costs and in which the South does not imitate the state-of-the-art products of the North. I then add trade costs and exogenous costless imitation and solve the model numerically. FDI has a direct and positive effect on unemployment in both countries. In the North plants are closed to move production to the South, in the South higher FDI creates a larger base of firms whose products can be imitated. Imitation means that subsidiaries of Northern firms in the South

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[1] The model is limited to the extent to which it features only outgoing FDI in the North and incoming FDI in the South, it does not look at North-North or South-South FDI.

close and production is taken over by the competitive fringe there. The direct effect of FDI on Southern unemployment works in combination with imitation. The indirect effect works through innovation, FDI increases innovation and through that the steady state turnover of firms. The higher firm turnover rate raises unemployment in both countries even further[2].

While the FDI literature is quite large, few papers focus on its connection to aggregate unemployment. Schmerer (2014) presents a Ricardian model of trade with search and matching frictions in the labor market, which generate unemployment. Starting from dis-equilibrium amounts of capital in the two countries and allowing for adjustment leads to outflow of capital from the one country to the other. The country from where capital flows out loses product varieties and faces lower labor demand, which respectively leads to lower wages and higher unemployment there. Schmerer shows empirically with OECD data that if a country is a net recipient of FDI, then it tends to have lower unemployment levels. Schmerer's model is however a static one and does not account for FDI's connection to innovation and growth.

A related literature is the one dealing with offshoring and employment. Strictly speaking one should compare this paper with the part of the offshoring literature, where a firm moves tasks or parts of its business to a subsidiary abroad[3]. FDI is about subsidiaries where the parent has controlling rights and is distinguished from portfolio investment, which in the data is usually taken to be ownership of less than ten percent. Nevertheless one can draw parallels between the FDI story here and the offshoring literature, regardless of whether the latter looks at production abroad within or outside of the boundary of the firm.

Parallels between the current model and the offshoring literature can be drawn also if one were to look at vertical value chains, one can extend the horizontal model I develop here to a setting with intermediate products or tasks that are bundled together by final good producers as in a value chain. What is important is that in both the horizontal and the vertical case we look at the movement of production capabilities to the South motivated by cost savings. Static models assume that the South has the capability or advantage to produce some goods or provide some tasks, wile the dynamic story in a quality-ladders growth model focuses on frontier technology switching back and forth from the North to the South.

A number of papers study offshoring and employment (or unemployment) both empirically (see Hummels et al. 2014, Moser et al. 2015, Munch 2010, Geischecker 2008, Bachmann and Braun 2011, Becker and Muendler 2008, Harrison and McMillan 2011) and theoret-ically (see Davidson et al. 2008, Mitra and Ranjan 2010, Ranjan 2013, Unel 2018) and propose a mixed connection between the two depending on the underlying setup. Chang (2005) studies the relation between FDI, economic growth, trade and unemployment in a VAR model using data from Taiwan. No relation is found between incoming FDI and un-

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[2] In the version of the model without imitation, FDI has only an indirect effect on Southern unemployment.

[3] There are definitions of offshoring where the intermediate input can come from an entity outside the firm. Hummels et al. (2014) define the offshoring activity of domestic manufacturing firms as the usage of imported inputs, those most likely originate from other companies abroad and not necessarily from affiliates. Grossman and Rossi-Hansberg (2008) define offshoring as tasks performed abroad, which could come both from a subsidiary or a foreign supplier.

employment[4]. Kovak et al. (2017) show a small positive effect of offshoring on firm-level but also industry and regional employment, Slaughter (2000) finds no effect. Desai et al. (2009) show that U.S. multinationals investing abroad tend to invest more at home and that this result applies to firm employment as well.

In addition to FDI, the model is suitable to study IP rights protection, which is described as a lower imitation rate in the South. I report how it affects welfare and unemployment in both countries, but also how it interacts with FDI.

In the next section I develop the model without trade costs and imitation and offer an analytical solution. In section three I add iceberg trade costs and an exogenous imitation rate for Northern products manufactured in the South, I solve numerically because the analysis quickly becomes computationally complicated.

2 The Model: No Imitation and Free Trade

The model is an extension of Helpman (1993), with several notable differences: it is a vertical growth model without a scale effect of country size on economic growth and features unemployment in both the North and the South. The unemployment rates are endogenous, but the duration of an individual's unemployment spell is exogenously given. FDI is costly as in Dinopoulos and Segerstrom (2010) with Northern firms interested in moving production to the South. Moving production is not immediate and comes at the end of a successful adaptation process, which is done in the South and uses Southern savings. In this section I solve the model analytically for the case in which there is no imitation in the South and trade is free.

2.1 Consumers and Producers

Populations in the North and South, denoted by L_{Nt} and L_{St}, both grow at the exogenous rate n. The intertemporal utility of a representative household from period $t = 0$ to infinity is defined as $U_{it} \equiv \int_0^\infty e^{-(\rho-n)t} log(y_{it}) dt$, where $i \in \{N, S\}$ stands for North and South and the time discount factor $\rho > 0$ is identical for all individuals in both countries. The static utility of a consumer at time t is defined over an infinity of product varieties of mass one, where each variety ω has its own quality ladder:

$$log(y_{it}) \equiv \int_0^1 log \left(\sum_j \lambda^j d_i(j, \omega, t) \right) d\omega. \tag{1}$$

The parameter j is a positive integer and shows the level of a product's quality, $\lambda > 1$ is the step size of innovation and measures the perceived quality difference between an old

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[4] I would not see this as a contradiction to the result that I find in this paper. Ideally one would prefer to see evidence from more than one country and if possible a mix of developed and developing countries. What is more, Chang (2005) looks at inward and outward FDI for Taiwan, in which variables very likely North-North flows are a significant portion. In the current model I look at Northern outgoing FDI to the South and Southern incoming FDI from the North.

and a new version of the same product and $d_i(j, \omega, t)$ is the amount of quality j of product ω consumed at time t.

It is important to note that households redistribute resources equally to household members, which means that each person enjoys the same level of consumption expenditure regardless of whether he or she is unemployed or not.

Optimization is standard, within a variety ω it results in people consuming only the quality that gives them the lowest quality-adjusted price $p(j, \omega, t)/\lambda^j$, which in equilibrium will also be the highest available quality. People's choice between varieties results in demand which equals $d_i(\omega, t) = E_{it}/p(\omega, t)$ with E_{it} denoting per capita consumption expenditure. I drop j from the notation, since the discussion will be always for that quality level, which gives the lowest quality-adjusted price. The last step of consumer optimization deals with allocating expenditure over time, and leads to the usual Euler equation $\dot{E}_{it}/E_{it} = r_{it} - \rho$, with r_{it} being the real interest rate. In order to have a balanced growth equilibrium I solve for a steady state in which $r_{Nt} = r_{St} = \rho$, meaning that consumption expenditure in the North and in the South is constant in steady state.

The production function is linear and one unit of labor is required to produce one unit of any good and any quality both in the North and in the South. Quality leaders in the North set prices to keep competitors out of business, which means that they can charge only λ times what the most viable competitor can offer for the one-quality-step lower version of the same product. Once a product quality is discovered, I assume that the lower quality level of the same product becomes common knowledge and can be produced both in the North and in the South by any firm.

In this version of the model I assume that there are no trade costs between the North and the South and I normalize the wage in the South to be equal to one. A competitive fringe firm from the North would price at marginal cost, which would be the Northern wage w_N. A Southern competitive fringe firm would also price at marginal cost, which is the wage in the South. The wage in the South is lower $w_S = 1 < w_N$, which means that the Southern competitive fringe firms will be the viable threat point for Northern quality leaders. The price of a Northern producer is therefore $p_N = \lambda$ in the North and in the South, Southern affiliates of Northern firms would also price at $p_A = \lambda$ in both countries. Southern competitive fringe firms act only as a threat and do not produce in equilibrium. In a model without imitation or trade costs, only product leaders and their affiliates produce and sell with a markup. This means that the price index in the North and in the South equals λ, the step size of innovation.

2.2 Innovation and FDI

Northern firms, both existing quality leaders but also follower firms, invest in improving existing products, the investment consists of a basked of all goods available on the market. Producing firms do not have an incentive to improve on their own varieties because they would be replacing themselves, but they have the incentive to improve on other incumbent's products. When an innovating firm is successful and discovers a better quality of a given

product, it takes over the market and becomes a monopolist both in the North and in the South. Let $I_i(\omega, t)$ be the instantaneous arrival rate of knowing how to produce the higher quality of product ω, where the subscript i here denotes the innovating firm. The arrival rate depends on the inputs to R&D in the following way:

$$I_i(\omega, t) = a_I \frac{\int_0^1 \lambda^j(\omega^*) l_i(\omega^*, \omega, t) d\omega^*}{X(\omega, t) \int_0^1 \lambda^j(\omega) d\omega}.$$

The parameter a_I is exogenous and $l_i(\omega^*, \omega, t)$ is the amount of good ω^* used for the improvement of good ω. I assume that the R&D function is Leontief and it requires identical amounts of every input variety ω^* in order to affect the chance for innovation. $X(\omega, t)$ is R&D difficulty and with time it grows, to show that it becomes incrementally more difficult to do R&D for every product variety ω. This growth in R&D difficulty is instrumental in removing the scale effect of population size on economic growth, which was characteristic for earlier endogenous growth models. To retain the same success rate of discovery $I_i(\omega, t)$ the amount of goods dedicated by each firm to innovation has to increase at the same rate as R&D difficulty $X(\omega, t)$, the evolution of which I will describe further below. The expression in the denominator $\int_0^1 \lambda^j(\omega) d\omega$ has the same meaning as R&D difficulty, but cancels out with the one in the numerator. The R&D function simplifies to $I_i(\omega, t) = a_I l_i(\omega, t)/X(\omega, t)$, with $l_i(\omega, t) \equiv \int_0^1 l_i(\omega^*, \omega, t) d\omega^*$ denoting how much of each variety is used in the innovation process for ω at time t. The R&D efforts of all individual firms improving on the quality of product ω aggregates to

$$I = a_I \frac{l_I(\omega, t)}{X(\omega, t)},$$

with the instantaneous innovation rate for a single product $I = \sum_i I_i$ being the sum of the arrival rates for all individual firms, and the aggregate investment for product ω being also the sum of investments of all individual firms $l(\omega, t) = \sum_i l_i(\omega, t)$. As is standard in this literature, the number of firms i trying to improve on a single good ω remains undetermined. It is necessary for a balanced growth equilibrium to assume that the innovation rate $I(\omega, t)$ is identical across products ω but also independently distributed across time, firms and products, which is why I drop ω from the innovation rate I and R&D difficulty X_t.

Northern firms can choose to move their production to the South due to lower wages there. Moving production to the South happens after a successful adaptation process, success occurs at the instantaneous arrival rate $I_A(\omega, t)$ and requires an investment again in a basket of all available goods:

$$I_A(\omega, t) = a_A \frac{\int_0^1 \lambda^j(\omega^*) l_A(\omega^*, \omega, t) d\omega^*}{X(\omega, t) \int_0^1 \lambda^j(\omega) d\omega}.$$

The parameter a_A is exogenous, $l_A(\omega^*, \omega, t)$ is the amount of good ω^* invested in the adaptation of good ω for production in the South. Note that this is the effort of an individual firm and there is no aggregation of the efforts of multiple firms as was the case for innovation. I again work with a Leontief function where the same amount of every input good ω^* has to be used in order to increase the chances of success, the above expression then simplifies

to

$$I_A = a_A \frac{l_A(\omega, t)}{X(\omega, t)},\tag{2}$$

with $l_A(\omega, t) = \int_0^1 l_A(\omega^*, \omega, t)d\omega^*$. The adaptive R&D is done in the South, this choice matters to the extent to which the price indexes in the North and in the South can differ once I introduce trade costs. Of course a solution where adaptation is done in the North is easily implementable as well. Once a product is successfully adapted, it starts to be produced in the South, Dinopoulos and Segerstrom (2010) call the adaptation rate an "FDI intensity" rate. This is also how I describe FDI in the analysis that follows, a higher adaptation rate I_A corresponds to more FDI.

2.3 Firm Profits and Value Functions

Firms which produce the state-of-the-art quality of a product sell with a markup and make profits. The profit of a Northern firm producing in the North amounts to

$$\pi_{Nt} = (\lambda - w_N)\left(d_{NNt}L_{Nt} + \frac{Ix_t}{a_I}L_{Nt} + d_{NSt}L_{St} + n_N\frac{I_Ax_t}{a_A}L_{Nt}\right),$$

which is the markup times demand in the North and in the South. Demand comprises of two parts, goods that are used for consumption, $d_{NNt}L_{Nt}$ in the North and $d_{NSt}L_{St}$ in the South, and goods that are used for R&D, innovation in the North $\frac{Ix_t}{a_I}L_{Nt}$ and adaptation in the South $n_N\frac{I_Ax_t}{a_A}L_{Nt}$. The new parameter $x_t \equiv X_t/L_{Nt}$ denotes relative R&D difficulty and is a combination of R&D difficulty X_t and population size in the North L_{Nt}. Larger economies have the capacity to spread R&D costs over a bigger market, this relative measure is useful to look at how innovative an economy is in steady state. What is important to note is that $\frac{Ix_t}{a_I}L_{Nt}$ is demand for the product by firms innovating on a single variety ω, but also demand for that product by all firms innovating on all varieties. The expressions are identical because the mass of all varieties is one and there is innovation happening for all product varieties at any period in time. It is different for the process of adaptation, where only Northern quality leaders make an attempt to move the product to the South, hence the term n_N in the expression for demand for a given good to cover the needs of all adaptation processes running at a given time.

The profit of a Northern affiliate producing in the South features a higher markup, since the wage in the South is lower than the one in the North.

$$\pi_{At} = (\lambda - 1)\left(d_{ANt}L_{Nt} + \frac{Ix_t}{a_I}L_{Nt} + d_{ASt}L_{St} + n_N\frac{I_Ax_t}{a_A}L_{Nt}\right),$$

where d_{ANt} is per capita demand for consumption on the Northern market and d_{ASt} on the Southern market. Given that prices of Northern firms and affiliates are identical, $d_{ANt} = d_{NNt}$ and $d_{ANt} = d_{NNt}$ should hold, with this in mind I can conclude that affiliates have higher profits $\pi_{At} > \pi_{Nt}$.

With profits already described, I can go ahead and write out the value functions of producing firms. Northern consumers save in a market aggregate asset that contains all innovating and producing Northern firms, which yields the riskless real interest rate r. Investing in a

follower firm doing R&D should in expectation yield r, the value of such a follower should therefore satisfy the following equation

$$rv_F(j) = \underset{l_i}{argmax} - l_i(\omega, t)\lambda + I_i v_N(j+1) + \dot{v}_F. \tag{3}$$

Firm i invests in R&D $l_i(\omega, t)$ units of a basket of all goods available on the market, which has the per unit price in the North λ, the follower has success with probability I_i and becomes a leader with value v_N.

The return from investing in a Northern leader equals the stream of profits minus the probability I that a better quality of the same product is discovered, and plus the probability that the Northern leader moves production to the South I_A, in which case the firm's value increases to v_A. The Northern leader invests in adapting its product to Southern production and optimizes over the intensity of this process. Adaptation is done in the South, the cost of the basket of goods used is the Southern price index, which also equals λ.

$$rv_N(j) = \underset{l_A}{argmax} - l_A(\omega, t)\lambda + \pi_{Nt} - I v_N + I_A (v_A - v_N) + \dot{v}_N \tag{4}$$

One should take into consideration the fact that the value of a Northern leader grows at the population growth rate $\dot{v}_N/v_N = n$. Optimization leads to the intuitive result that the expected gain in value from moving production to the South equals the cost of adaptation:

$$v_A - v_N = \lambda \frac{X_t}{a_A}. \tag{5}$$

Substituting for (5) into (4) gives an expression for v_N:

$$v_N = \frac{\pi_{Nt}}{r + I - n}. \tag{6}$$

Free market entry means that any firm can become a follower and do R&D, which in turn means that the value of a follower is zero $v_F = 0$. I can use this in (3) and after combining with (6), I obtain

$$\frac{\pi_{Nt}}{r + I - n} = \lambda \frac{X_t}{a_I}, \tag{7}$$

which is the Northern R&D condition. The main message it carries is that high innovation costs described on the right-hand side can be supported only with high expected profits.

The value of an affiliate is based on its profits and the probability that innovation takes place, in which case the affiliate goes out of business and loses its value:

$$rv_A = \pi_{At} - I v_A + \dot{v}_A,$$

which after solving gives $v_A = \pi_{At}/(r + I - n)$. This in combination with (6) substituted into (5) yields the Southern adaptation condition:

$$\frac{\pi_{At}}{r + I - n} - \frac{\pi_{Nt}}{r + I - n} = \lambda \frac{X_t}{a_A}. \tag{8}$$

The meaning of the equation is again to equate the expected gains (left-hand side) to

the costs (right-hand side) of adaptation. The Northern R&D condition and the Southern adaptation condition are two of the main equations in the model that will help me define the steady state equilibrium.

As already mentioned, the total mass of goods in the world equals unity. One product per firm implies that the mass of the different firm types has to also equal one $n_N + n_A = 1$, where n_N is the mass of Northern quality leaders and n_A the mass of affiliates in the South. Any product that is adapted moves to the South and any product that is innovated on either changes hands between firms in the North or moves from the South to the North. The flow of firms from the North to the South should equal the reverse flow in steady state $I_A n_N = I n_A$. Combining this with the equation stating that the mass of all firms equals one, allows me to find the values $n_N = I / (I_A + I)$ and $n_A = I_A / (I + I_A)$. Clearly more innovation means that more products are produced in the North and a higher adaptation rate means that more varieties are produced by affiliates in the South.

2.4 The Labor Market

I need to describe the labor markets and the inflow and outflow from the groups of the unemployed in the North and in the South. Northern workers find a job with an instantaneous probability β_N. The parameter is exogenous and along with a similar exogenous probability for workers to find a job in the South β_S, makes sure that the model remains tractable. Let's for brevity write demand for labor of a single Northern firm to be equal to $D_N \equiv d_{NN t} L_{N t} + \frac{I x_t}{a_I} L_{N t} + d_{N S t} L_{S t} + n_N \frac{I_A x_t}{a_A} L_{N t}$, this contains the amounts the firm sells both in the North and in the South. The group of unemployed people in the North changes according to the following equation:

$$\dot{U}_N = n L_{N t} + (I + I_A) n_N D_N - \beta_N U_N. \tag{9}$$

On the left-hand side of the equation we have the change in the absolute number of unemployed people in the North, which should equal the difference between all people becoming unemployed and those that find a job. All new-born members of households are in the beginning unemployed, this increases the size of the group of the unemployed. All Northern firms whose products face innovation go out of business and their workers lose their jobs, adaptation also translates into job loss in the North. The group of the unemployed in the North is reduced by the people who find a job, their number is $\beta_N U_N$.

All employed workers on the other hand are busy with production:

$$(1 - u_N) L_{N t} = n_N D_N. \tag{10}$$

I combine the Northern unemployment equation (9) with the labor equation (10) and obtain the rate of unemployment in the North

$$u_N = \frac{n + I + I_A}{n + I + I_A + \beta_N}. \tag{11}$$

The above expression shows that unemployment in the North increases in the population

growth rate n, in the innovation rate I and in the adaptation rate I_A, while it decreases in the rate at which Northern workers find a job β_N.

Let's again for brevity shorten the expression for demand for labor of a Southern affiliate of a Northern firm $D_A \equiv d_{ANt}L_{Nt} + \frac{Ix_t}{a_I}L_{Nt} + d_{ASt}L_{St} + n_N \frac{I_A x_t}{a_A}L_{Nt}$. With this in mind I can write out the dynamics of the group of unemployed individuals in the South:

$$\dot{U}_S = nL_{St} + In_A D_A - \beta_S U_S.$$

Same as in the North, all new-born household members in the South are unemployed. Innovation moves products to the North, which means that affiliates in the South cease production and lay off their workers, the number of the unemployed is reduced by the number of people who find jobs in the South $\beta_S U_S$.

The labor equation of the South shows that all employed workers are active in production and work for the affiliates of Northern firms:

$$(1 - u_S)L_{St} = n_A D_A. \tag{12}$$

Combining the above two equations gives the Southern unemployment rate:

$$u_S = \frac{n + I}{n + I + \beta_S}. \tag{13}$$

The unemployment rate in the South is positive in the population growth rate n and in the innovation rate I and negative in the rate at which workers find a job β_S. The adaptation rate I_A acts indirectly through the innovation rate I. In what follows I will show how I_A and I are related in steady state and will be able to say more on the effect of FDI liberalization on unemployment in the South.

2.5 The Steady State

I describe the solution of a fully-endogenous growth model where policy variables have a permanent effect on economic growth, the constantly increasing R&D difficulty is defined to be function of the growing population $X_t = mL_{Nt}$, where $m > 0$ is an exogenous parameter. One could of course define the evolution of R&D difficulty to be a function of world population or Southern population, but this would not make a qualitative difference to the results, since the population values are proportionate. From the evolution of X_t one can immediately pin down relative R&D difficulty $x \equiv X_t/L_{Nt} = m$. To have a balanced growth equilibrium x must be constant, which in turn means that R&D difficulty X_t and population L_{Nt} should grow at the same rate.

To complete the model I need to write out the expression for the Northern per capita consumption expenditure and to find that I start with the budget constraint of the entire population in the North: $\dot{A}_{Nt} = (1 - u_N)L_{Nt}w_{Nt} + rA_{Nt} - E_{Nt}L_{Nt}$. Changes in the asset position of all Northerners depend positively on their total wages and interest earnings on those investments. Naturally consumption expenditure, which is identical

to every Northerner regardless of employment status, reduces assets. The asset positions of people living in the North $A_{Nt} = \int_{n_N+n_A} v_N d\omega$ are the sum of the values of all Northern firms, but also a share of the values of their affiliates in the South. In steady state we should have $\dot{A}_{Nt} = nA_{Nt}$, since firm values grow at the rate n. From this follows that $E_{Nt}L_{Nt} = (1 - u_N)L_{Nt}w_{Nt} + (r - n)\int_{n_N+n_A} v_N d\omega$, or in per capita terms $E_{Nt} = (1 - u_N)w_{Nt} + (r - n)\frac{1}{L_{Nt}}\int_{n_N+n_A} v_N d\omega$. Substituting for v_N using (6) and (7) results in the following expression for Northern per capita consumption expenditure

$$E_N = (1 - u_N)w_N + (r - n)\lambda\frac{x}{a_I}. \tag{14}$$

The unknown variables are E_N, E_S, I, I_A, u_N, u_S, and w_N, and one can use the following equations to solve for them: (7), (8), (10), (11), (12), (13) and (14). I will focus on showing the effect of FDI liberalization on unemployment in the North and in the South, where FDI liberalization corresponds to an increase in the adaptation parameter a_A. From the adaptation technology (2) one can see that with a higher a_A a firm needs to invest less in adaptation in order to achieve the same rate of success I_A. A higher a_A, which is an exogenous parameter, will lead to a higher FDI rate I_A.

From $d_{ANt} = d_{NNt}$ and $d_{ANt} = d_{NNt}$ follows that $D_N = D_A$. I can then combine (10) and (12) and obtain $(1 - u_N)L_{Nt} = n_N(1 - u_S)L_{St}/n_A$. I substitute for n_N and n_A and for the unemployment rates using (11) and (13) and arrive at

$$\frac{n + I + \beta_S}{n + I + I_A + \beta_N}\frac{I_A}{I} = \frac{\beta_S}{\beta_N}\frac{L_{St}}{L_{Nt}}. \tag{15}$$

The right-hand side is a constant, so any changes in I_A and I on the left-hand side must offset each other. The left-hand side increases in I_A and decreases in I, from this follows that both endogenous variables have to move in the same direction.

I then use (8) and substitute for profits $(\lambda - 1)D_N - (\lambda - w_N)D_A = (r + I - n)L_N\lambda x/a_A$. From $D_N = D_A$ follows that

$$(w_N - 1)D_N = (r + I - n)L_N\lambda\frac{x}{a_A}. \tag{16}$$

I combine this expression with (7) and solve for the wage

$$w_N = \frac{\lambda a_I + a_A}{a_I + a_A}. \tag{17}$$

I take this expression for the wage, substitute for D_N from (12) and for I_A from (15) and use all three in (16)

$$(\lambda - 1)\frac{a_I a_A}{a_I + a_A}\frac{\beta_S}{n + I + \beta_S}\left(\frac{n + I + \beta_S - I\frac{\beta_S}{\beta_N}\frac{L_{St}}{L_{Nt}}}{n + I + \beta_N}\frac{\beta_N}{\beta_S}\frac{L_N}{L_S} + 1\right) - (r + I - n)\frac{L_N}{L_S}\lambda x = 0$$

The only unknown in this equation is the innovation rate I, FDI liberalization $a_A \uparrow$ increases the left-hand side. This has to be offset by an increase in I, which decreases the left-hand side. I can summarize the results in the following

Proposition 1. *FDI liberalization $(a_A \uparrow)$ leads to a higher intensity of FDI $(I_A \uparrow)$, a higher innovation rate $(I \uparrow)$ and through that higher unemployment rates both in the North $(u_N \uparrow)$ and in the South $(u_S \uparrow)$.*

Why cheaper FDI leads to higher FDI intensity is relatively straightforward. Production moves to the South more quickly as Northern firms learn how to produce there on average sooner. This decreases the Northern wage as can be seen in equation (17), a higher a_A is accompanied by a lower w_N. Lower wages in the North in turn increase the markups and profits of Northern firms, which increases the incentives for innovating firms to become quality leaders, hence the higher innovation rate I. It is clear from equations (11) and (13) that the unemployment rates in the North and in the South increase with the higher innovation and adaptation rates.

3 The Model: Imitation and Costly Trade

In this section I add two more features to the model, costly trade and an imitation rate, and check how and whether the results change. The standard North-South growth literature features imitation in the South (Helpman 1993, Dinopoulos and Segerstrom 2010), at the same time trade costs affect both the innovation and adaptation rates and make the model more complete. The disadvantage of the added complexity is that I have to solve numerically.

Once a product starts to be manufactured in the South it is open to imitation. The imitation rate in the South I_M is exogenous and represents an uncertain and costless process which moves production from the hands of the affiliates of Northern firms producing in the South to the competitive fringe also in the South. Similar to the innovation and adaptation rates, I_M represents the instantaneous probability that imitation takes place at a given point in time. Trade costs come in the form of the usual iceberg cost assumption that $\tau > 1$ units have to be shipped from the one country to the other in order for one unit to be sold on the foreign market.

The consumption optimization remains the same, the producer pricing strategy changes however. For the Southern competitive fringe to still be the viable threat to Northern firms on the Northern market, I have to assume that $\tau w_S < w_N$. The marginal cost of a Southern competitive fringe firm on the Northern market, which takes into consideration now the trade cost, has to be lower than the marginal cost of a Northern firm, namely the Northern wage. With this in mind, the price of a Northern producer will be $p_{NN} = \lambda \tau w_S$ in the North and $p_{NS} = \lambda w_S$ in the South, Southern affiliates of Northern firms would also price at $p_{AN} = \lambda \tau w_S$ in the North and $p_{AS} = \lambda w_S$ in the South. As a result of the new prices, profits of a Northern quality leader change to

$$\pi_{Nt} = (p_{NN} - w_N)\left(d_{NNt}L_{Nt} + \frac{Ix_t}{a_I}L_{Nt}\right) + (p_{NS} - \tau w_N)\left(d_{NSt}L_{St} + n_N\frac{I_A x_t}{a_A}L_{Nt}\right).$$

If the firm operates through a subsidiary in the South the profit would be

$$\pi_{At} = (p_{AN} - \tau w_S)\left(d_{ANt}L_{Nt} + \frac{Ix_t}{a_I}L_{Nt}\right) + (p_{AS} - w_S)\left(d_{ASt}L_{St} + n_N\frac{I_A x_t}{a_A}L_{Nt}\right).$$

With $p_{NN} = p_{AN}$ and $p_{NS} = p_{AS}$, it is clear that affiliates still have higher profits. For the markups of Northern firms to be positive $\lambda w_S > \tau w_N$ should hold. Combining this inequality with the one ensuring that Southern imitators can be competitive on the Northern market gives the range for the Northern wage $\frac{\lambda}{\tau}w_S > w_N > \tau w_S$, which I assume holds.

Given this new setup, there are some changes with the firm value functions. The value functions of followers and leaders in the North remain largely the same, what changes is the price of the basket of goods used for innovation and adaptation. The price for innovation is the price index in the North and for adaptation, the price index in the South since this is where adaptation takes place. In the absence of competitive fringe firms, which would price at marginal cost, and also without trade costs both price indexes were equal to λ. The picture is a bit more elaborate now, in addition to the mass of Northern leaders n_N and the mass of their Southern affiliates n_A, there are the Southern competitive fringe firms n_{CF}. The price index in the North is $P_N \equiv n_N p_{NN} + n_A p_{AN} + n_{CF} p_{SN}$, where $p_{SN} = \tau w_S$ is the price of the 'Southern competitive fringe firms on the Northern market. The price index in the South equals $P_S \equiv n_N p_{NS} + n_A p_{AS} + n_{CF} p_{SS}$, with $p_{SS} = w_S$ being the price of the competitive fringe in the South. Equations (7) and (8) change to

$$\frac{\pi_{Nt}}{r + I - n} = P_N \frac{X_t}{a_I}. \tag{18}$$

and

$$\frac{\pi_{At}}{r + I + I_M - n} - \frac{\pi_{Nt}}{r + I - n} = P_S \frac{X_t}{a_A}. \tag{19}$$

Of course as previously the total mass of goods in the world equals one. Adapted products move to the South, innovation moves products to the North or leads to a change in hands between firms in the North, imitation moves products from an affiliate in the South to the competitive fringe also in the South. In steady state the mass of firms leaving the North for the South should equal the mass of firms going back $I_A n_N = I(n_A + n_{CF})$. The group of n_A firms should also remain constant in steady state, meaning that the outflow of firms should equal the inflow $I_A n_N = (I + I_M)n_A$. Using those two relations with the equation showing that the mass of all firms equals one, allows me to solve for the values $n_N = I/(I_A + I)$, also $n_A = n_N I_A/(I + I_M)$ and $n_{CF} = I_M I_A/((I + I_M)(I + I_A))$. More innovation means that more products are produced in the North, a higher adaptation rate means that more varieties are produced by affiliates in the South and more imitation increases the share of goods manufactured in the South by the competitive fringe.

The equation for the flow of people into and out of unemployment (9) remains the same, with the qualification that demand for labor of a single Northern firm takes into consideration the new prices and the trade cost $D_N \equiv d_{NNt}L_{Nt} + \frac{Ix_t}{a_I}L_{Nt} + \tau d_{NSt}L_{St} + \tau n_N\frac{I_A x_t}{a_A}L_{Nt}$. The equation describing the Northern labor market (10) remains the same with the updated D_N, and as a result so does the expression for Northern unemployment (11). Unemployment in the North as previously increases in the innovation and adaptation rates and de-

creases in the rate at which people find a job. The population growth rate also puts an upward pressure on Northern unemployment.

Demand for Northern firms is different with trade costs and imitation, but so is demand for labor for the affiliate of a Northern firm in the South $D_A \equiv \tau d_{ANt} L_{Nt} + \tau \frac{Ix_t}{a_I} L_{Nt} + d_{ASt} L_{St} + n_N \frac{I_A x_t}{a_A} L_{Nt}$. There is in addition the demand for labor of a Southern competitive fringe firm $D_{CF} \equiv \tau d_{SNt} L_{Nt} + \tau \frac{Ix_t}{a_I} L_{Nt} + d_{SSt} L_{St} + n_N \frac{I_A x_t}{a_A} L_{Nt}$, which I need to describe the Southern labor market. The dynamics of the group of unemployed individuals in the South changes to

$$\dot{U}_S = n L_{St} + I\left(n_A D_A + n_{CF} D_{CF}\right) + I_M n_A D_A - \beta_S U_S.$$

Newly-born household members are unemployed, innovation moves products to the North, which means that affiliates in the South but also Southern competitive fringe firms cease production and lay off their workers. Imitation of adapted products also means unemployment for the workers of the affiliate firms. The last term shows that the number of the unemployed decreases by the people who find jobs $\beta_S U_S$.

The labor equation of the South takes into consideration now the different demand quantities faced by the different types of firms there:

$$(1 - u_S) L_{St} = n_A D_A + n_{CF} D_{CF}. \tag{20}$$

The above two equations give a slightly new Southern unemployment rate, affected not only by innovation but directly by imitation and the FDI rate:

$$u_S = \frac{n + I + I_M n_A D_A \frac{1}{L_S}}{n + I + \beta_S}. \tag{21}$$

The role of the innovation and population growth rates remains unchanged, the rate at which workers find a job as previously enters the denominator. The rate of adaptation increases long-run unemployment in the South and enters through n_A, which I have not written out for brevity. It is important to note that this direct effect of FDI depends also on the rate of imitation, since it is imitation that makes affiliates in the South go out of business in favour of competitive fringe firms which take over production. A larger group of affiliates that face higher demand for their products means that more Southern workers are exposed to unemployment through imitation.

3.1 Steady State and the Numerical Solution

In this section I present the main results from solving numerically for steady state equilibria of the model. I set the Southern wage again to be the numeraire, R&D difficulty remains unchanged in its dependence on Northern population $X_t = m L_{Nt}$. Consumption expenditure in the North now takes into consideration the fact that Northern firms and their affiliates are no longer the entire set of producing firms but only part of it

$$E_N = (1 - u_N) w_N + (r - n)\left(n_N + n_A\right) P_N \frac{x}{a_I}. \tag{22}$$

The unknown variables are E_N, E_S, I, I_A, u_N, u_S, and w_N, the equations used for the solution are (18), (19), (10), (11), (20), (21) and (22).

I calculate and report welfare of the Northern Ω_N and Southern Ω_S consumer, where $\Omega_N \equiv \int_0^\infty e^{-(\rho-n)t} log(y_{Nt}) dt$ is defined as the discounted present value of expected utility over an infinite horizon. Some individuals in the North are unemployed, but households re-distribute and each household member enjoys the same utility regardless of whether they work or not. Substituting for static utility gives the following expression

$$(\rho - n)\Omega_N = \int_{n_N + n_A} log\left(\frac{E_{Nt}}{\tau \lambda w_S}\right) d\omega + \int_{n_{CF}} log\left(\frac{E_{Nt}}{\tau w_S}\right) d\omega + \frac{I}{\rho - n} log(\lambda).$$

Welfare of the Northern consumer depends on consumption of Northern and Southern goods and is of course influenced also by the quality level of those goods. Simplifying the expression gives

$$(\rho - n)\Omega_N = log\left(E_N\right) - log(\tau) - (n_N + n_A) log(\lambda) + \frac{I}{\rho - n} log(\lambda).$$

Welfare in the South can be identically written as $\Omega_S \equiv \int_0^\infty e^{-(\rho-n)t} log(y_{St}) dt$. In the South welfare is also a function of the consumption of Northern and Southern goods taking into consideration their quality level:

$$(\rho - n)\Omega_S = \int_{n_N + n_A} log\left(\frac{E_S}{\lambda w_S}\right) d\omega + \int_{n_{CF}} log\left(\frac{E_S}{w_S}\right) d\omega + \frac{I}{\rho - n} log(\lambda).$$

Solving the integrals leaves us with the expression

$$(\rho - n)\Omega_S = log\left(E_{St}\right) - (n_N + n_A) log(\lambda) + \frac{I}{\rho - n} log(\lambda).$$

The last variable that I need to find is economic growth, which occurs due to the constant quality improvement of products. Using the static utility of the individual consumer (1) and differentiating with respect to time gives the expression for economic growth $g = I log(\lambda)$, growth is proportionate to the innovation rate I and the step-size of innovation λ.

The main exercise I focus on is the effect of cheaper FDI ($a_A \uparrow$) on unemployment and welfare in the North and in the South, I show the results in Table 1. I also look at stronger IP protection ($I_M \downarrow$) and its effect on unemployment, FDI and welfare in Table 2.

The parameters that I work with are in some instances chosen directly to match what is considered to be standard from the data, like the real interest rate for instance, or they form in combination with other parameters a variable for which there is also a consensus in the literature and which I aim to match. A good example of the latter case is the economic growth rate, which is a function of the innovation rate I and the step size of innovation λ. In my choice of m, a_I and λ, I make sure the model generates values for the growth rate close to what is observed as standard in the data.

The step-size of innovation which I set at $\lambda = 1.7$ determines along with the Northern wage the markup of Northern producers in the North $\frac{\lambda \tau}{w_N}$. The markup is between 53 and 77

Table 1: Liberalizing FDI

	$L_S/L_N = 1$		$L_S/L_N = 2$	
	$a_A = 5$	$a_A = 10$	$a_A = 5$	$a_A = 10$
I	0.0272	0.0324	0.0553	0.0621
g	0.0145	0.0172	0.0293	0.0330
I_A	0.0211	0.0258	0.1058	0.1211
u_N	0.0622	0.0708	0.1519	0.1675
u_S	0.0517	0.0571	0.0793	0.0855
E_N	1.5186	1.4746	1.3064	1.2618
E_S	0.9623	0.9505	0.9341	0.9214
w_N	1.3310	1.2881	1.2160	1.1778
Welfare N	20.9005	24.8807	44.5704	50.1505
Welfare S	8.4475	13.2066	37.6094	44.1501
n_N	0.5635	0.5574	0.3432	0.3390
n_A	0.2517	0.2738	0.4823	0.5000
n_{CF}	0.1848	0.1688	0.1745	0.1610

Source: own calculation.

percent and within range of what is reported in Morrison (1990). The technology parameter $m = 8$ is important for determining relative R&D difficulty but along with $a_I = 1$ affects the innovation rate I. Given the step-size of innovation I chose such values for m and a_I, so that I arrive at annual economic growth rates $g = I log(\lambda)$ close to two percent, which is the relevant number for the US for the period 1950-1994 according to Jones (2005). The instantaneous probability of a Northerner to find a job is $\beta_N = 1$ and of the Southerner $\beta_S = 1$, I have made this choice in order to arrive at reasonable unemployment rates in the two regions. Population growth is $n = 0.018$ and corresponds to the world population growth rate in the 1980s according to Kremer (1993). McGrattan and Prescott (2005) report a real interest rate of four percent, which is why I set $\rho = r = 0.04$. I set the iceberg trade cost at $\tau = 1.2$ and keep it fixed throughout. The imitation rate is $I_M = 0.02$, which means that a product manufactured by a subsidiary in the South is imitated successfully on average after fifty years. This of course if one treats the time difference between $t = 0$ and $t = 1$ as one year.

The first exercise in Table 1 describes FDI liberalization, the variable that changes is the adaptation parameter a_A, and it moves from $a_A = 5$ to $a_A = 10$. I explore in the context of two different relative sizes of the South, first is the case where the South equals in population the North, in the second case I look at a South twice as large as the North.

Increasing $a_A \uparrow$ makes product adaptation cheaper and therefore increases the FDI rate I_A. This moves production to the South and decreases the Northern wage w_N, which in turn translates into higher markups and profits of Northern firms. Higher profits of Northern firms imply that follower firms doing R&D have more to gain if they are successful and they step up their efforts and innovate more. Looking at the Northern expression for unemployment (11) it is obvious that higher I and I_A will unambiguously increase the unemployment rate u_N. Similarly in the South unemployment u_S (13) increases as well, where both in-

creasing innovation and adaptation act positively on unemployment. Adaptation I_A enters through the mass of affiliates in the South n_A, which is positively related to the adaptation rate I_A. FDI does not lead just to jobs moving from the North to the South, this is a static story. In the long run, FDI is part of a creative destruction process, if this process becomes more intensive it increases unemployment both in the North and in the South.

The connection between welfare and FDI is less straightforward, ultimately higher unemployment both in the North and in the South would mean fewer goods are produced and consumed. If one looks at the expression for Northern consumption expenditure (22), one can see that it decreases in the unemployment rate. A similar expression can be found for Southern consumption expenditure and indeed in Table 1, cheaper FDI leads to lower E_N and E_S.

The share of Southern competitive fringe firms n_{CF} decreases with a higher I_A, which means that more of the product varieties are sold by monopolists who charge a markup. Higher prices to consumers decrease welfare in both countries. What acts positively on the levels of welfare is the higher innovation rate, which leads to higher qualities of the goods being available on the market. In the specifications that I look at, the effect of higher innovation dominates and Northern and Southern welfare both increases with cheaper FDI.

In the next Table 2, I show the effects of IP rights protection $I_M \downarrow$ (the imitation rate decreases from $I_M = 0.02$ to $I_M = 0.01$) while I hold $a_A = 5$ fixed. Lower imitation increases the incentive of Northern firms to adapt their products for Southern manufacturing, since then firms can expect a longer incumbency there, so the FDI rate increases $I_A \uparrow$. The higher FDI rate moves production to the South and suppresses the Northern wage, this means that markups and profits of Northern firms are higher. Innovating firms have a greater incentive to invest in the R&D process if the expected gains are larger, this can be seen in the Northern R&D condition (18). The innovation rate goes up $I \uparrow$, which automatically means also that economic growth increases[5].

Increasing innovation and adaptation unambiguously increase the Northern unemployment rate $u_N \uparrow$, the imitation rate does not enter the expression for Northern unemployment (11). The effect on Southern unemployment is on the other hand not unambiguous, since the imitation rate enters directly into the expression for unemployment (13). Lower I_M decreases Southern unemployment, higher I and I_A on the other hand act in the opposite direction and increase it: in the numerical specification which I have chosen the overall effect of IP rights protection is to increase unemployment in the South as well.

Despite the fact that IP protection decreases the mass of competitive fringe firms n_{CF} and

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[5] In Helpman (1993) it is shown that higher imitation leads to higher innovation in the long run $\frac{\partial I}{\partial I_M} > 0$, this is the case because the higher imitation rate moves production to the cheaper South and frees up resources in the North which can be used for innovation. The relation between innovation and imitation reverses once one adds costly FDI as shown in Dinopoulos and Segerstrom (2010). Given that FDI is costly in the current model, $\frac{\partial I}{\partial I_M} < 0$ holds. In this context it is important to mention the model in Arnold (2002) where the connection between imitation and innovation depends on the flexibility of the labor market. Arnold (2002) builds a North-South growth model without FDI, with an exogenously given probability for unemployed workers in the North to find a job. For high values of this probability the relation between imitation in innovation is positive as in Helpman (1993), for low values or in other words for less flexible labor markets the relation turns negative.

Table 2: Stricter IP rights protection

	$L_S/L_N = 1$		$L_S/L_N = 2$	
	$I_M = 0.02$	$I_M = 0.01$	$I_M = 0.02$	$I_M = 0.01$
I	0.0272	0.0372	0.0553	0.0648
g	0.0145	0.0198	0.0293	0.0344
I_A	0.0211	0.0326	0.1058	0.1359
u_N	0.0622	0.0807	0.1519	0.1795
u_S	0.0517	0.0586	0.0793	0.0833
E_N	1.5186	1.4540	1.3064	1.2656
E_S	0.9623	0.9625	0.9341	0.9336
w_N	1.3310	1.2440	1.2160	1.1593
Welfare N	20.9005	27.8210	44.5704	51.5397
Welfare S	8.4475	17.3543	37.6094	45.9952
n_N	0.5635	0.5334	0.3432	0.3229
n_A	0.2517	0.3678	0.4823	0.5866
n_{CF}	0.1848	0.0988	0.1745	0.0905

Source: own calculation.

therefore the set of goods sold at a low price, despite also the fact that unemployment rates in both regions increase, the welfare levels in the North and in the South increase. This is again due to the higher innovation rate and ultimately the availability of product varieties of higher quality in both markets.

4 Conclusion

In this paper I build an asymmetric country model of endogenous growth driven by vertical innovation that features unemployment in the North and in the South. I focus on two exercises, FDI liberalization and IP rights protection and look at how unemployment and welfare in the North and in the South are affected. More FDI leads to higher unemployment rates both in the North and in the South and increases the welfare of consumers in both countries. Stronger IP protection also increases unemployment and welfare in the North and in the South.

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For further inquiries contact the author:

Ignat Stepanok
Phone +49.911.179.8160
E-mail Ignat.Stepanok@iab.de