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A North-South Model of Trade with Search Unemployment

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Abstract

In this paper I build a North-South model of international trade, economic growth and search-frictional unemployment in the North. Growth is driven by a process of creative destruction in the North followed by imitation in the South. I study the effects of intellectual property rights protection and trade liberalization on unemployment and welfare in the North. Intellectual property rights protection decreases unemployment and increases welfare. Trade liberalization increases welfare but has an ambiguous effect on unemployment. It decreases unemployment if workers in the North have a high outside option and increases it if their outside option is low. I provide empirical evidence in support of the last result using data for 20 OECD countries.

Zusammenfassung

In diesem Artikel wird ein Nord-Süd Modell mit internationalem Handel, endogenem Wachstum und Sucharbeitslosigkeit im Norden entwickelt. Schöpferische Zerstörung ist der Wachstumsmotor im Norden und wird von Imitation im Süden gefolgt. Ich untersuche die Effekte des Schutzes des geistigen Eigentums und der Handelsliberalisierung auf Arbeitslosigkeit und Wohlfahrt im Norden. Starker Schutz des geistigen Eigentums reduziert die Arbeitslosigkeit und erhöht das Wohlfahrtsniveau. Handelsliberalisierung erhöht das Wohlfahrtsniveau, während die Wirkung auf die Arbeitslosigkeit nicht eindeutig ist. Die Arbeitslosigkeit fällt, wenn Arbeitnehmer im Norden den Wert der Freizeit hoch schätzen, andernfalls steigt sie. Diese theoretische Schlußfolgerung wird empirisch anhand von Daten aus 20 OECD Staaten unterstützt.

JEL classification: F12, F16, F43, J63, O31, O34, O41.

Keywords: Creative destruction, search, unemployment, trade liberalization, intellectual property rights, North-South trade.

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1 Introduction

In this paper I develop a North-South model in which I study the response of unemployment in the North to trade liberalization and changes in intellectual property (IP) rights protection. While the effect of stronger IP protection is straightforward and leads to lower unemployment, the same can not be said about lower trade barriers. I show that the outside option of workers in the North matters for the effect of trade liberalization on unemployment. A high outside option of workers means that more trade decreases unemployment in the North, while with a low outside option unemployment increases.

There is a lively debate within the North-South trade and IP rights literature on how trade liberalization and imitation affect innovation, growth and ultimately welfare. The first general equilibrium model that explores those issues is developed in Helpman (1993). Helpman shows that imitation and innovation are positively correlated, meaning that stronger IP rights embodied by a lower imitation rate in the South translate into lower innovation and a lower growth rate. In the long run stronger IP rights protection unambiguously makes the Southern consumer worse off. The Northern consumer is also made worse off if the imitation rate is low to begin with, but better off otherwise. Dinopoulos and Segerstrom (2010) show that for the relation between imitation and innovation it is crucial how one models technology transfer. If it happens through FDI, then more imitation can lead to less innovation.

The papers in this debate present models of full employment and this lack of attention to the role of unemployment is surprising. We know that it matters for welfare, we know that it is connected to innovation and growth and there is a sizeable literature by now, both theoretical and empirical, on the connection between international trade and long-run unemployment[1]. Those are all points that are of importance for the results in the North-South literature. It is therefore necessary to incorporate long-run unemployment in an asymmetric country setting first to better understand how labor markets respond to globalization and then to see whether and how the already known results on innovation, growth and welfare change.

I build here an endogenous growth model with search unemployment in the North in which I am able to study how IP protection and trade liberalization affect the long-run unemployment level and welfare in the North. Since the model does not feature unemployment in the South, reporting a Southern welfare measure is possible but not very useful to the extent to which it would not be comparable to the Northern one. I therefore report welfare only in the North and focus most of the analysis on unemployment.

I contribute to the North-South growth literature by adding endogenous search unemployment. The contribution relative to the trade and unemployment literature is to explore the

[1] Davidson, Martin and Matusz (1999), Helpman and Itskhoki (2010), Felbermayr, Prat and Schmerer (2011a) study open economies with unemployment generated by search and matching frictions in the labor market. A number of empirical papers find a connection as well: Dutt, Mitra and Ranjan (2009), Felbermayr, Prat and Schmerer (2011b), Hasan Mitra, Ranjan and Ahsan (2012), Autor, Dorn and Hanson (2013). In this literature there is little work that incorporates economic growth (Sener 2001 and Stepanok forthcoming) and there is even less work on North-South trade and growth (Arnold 2002).

question from an asymmetric country point of view. A few interesting and perhaps some of them unexpected results come out of the analysis. Both stronger IP rights protection and trade liberalization have a positive effect on welfare in the North. Stronger IP rights protection decreases unemployment. The South imitates less, therefore more product varieties are produced in the North, which increases demand for Northern workers and decreases unemployment. The result is quantitatively strong and robust for many parameter specifications.

Trade liberalization has a more ambiguous effect on long-run unemployment. If the outside option of Northern workers is high, trade liberalization decreases unemployment. If the outside option of workers is low, trade liberalization increases unemployment. The outside option is important for the wage of the Northern worker. A higher outside option means a higher wage, which in turn increases consumption expenditure in the North and the relative size of the Northern market.

With an iceberg trade cost, trade liberalization decreases the need for Northern workers to service the Southern market. Fewer goods are lost on the way to sell one unit in the South. This decreases demand for workers in the North. At the same time lower trade costs affect the price of Northern goods in the North. Southern firms act as a competitive fringe to Northern firms and trade liberalization makes Northern firms decrease their prices on the Northern market to keep Southern firms away. This increases demand for Northern goods in the North and therefore also demand for Northern workers. This latter effect dominates when the Northern market is relatively large (high outside option for workers) and trade liberalization leads to lower unemployment.

I build on the data and empirical specification from Felbermayr, Prat and Schmerer (2011b, FPS) and provide empirical support for the above theoretical result. FPS find a significant negative effect of trade openness on long-run unemployment. One of the control variables that they include is a wage distortion index, which contains the average replacement rate. The latter corresponds to the outside option of a jobless person in the theory. Using their 20-country OECD specification I build an interaction variable between openness and the average replacement rate and am able to show that the sign of the coefficient on real openness changes from negative to positive and the sign of the interaction variable is as expected negative. This corresponds exactly to a situation in which openness has a negative effect on unemployment for a high outside option of workers and a positive effect when the outside option of workers is low.

The paper closest to mine is that of Arnold (2002). It builds a model of North-South trade with an exogenous duration of unemployment and without any variable trade costs, thus effectively making the model not suitable to study unemployment itself[2] or the effect of trade liberalization[3]. The focus in Arnold (2002) is to show that labor market frictions can reverse

[2] Unemployment is not exogenous in Arnold (2002), but making the duration to find work exogenous removes an important channel through which trade and other policy variables affect the unemployment rate.

[3] Arnold writes about gains from trade but in his model more trade is the result of a higher imitation level, or alternatively formulated, lower IP rights protection. This does not seem to be the case in the context of a WTO membership for instance where the dissolution of trade barriers is coupled with an IP rights protection agreement like TRIPs. In reality more trade is coupled with more stringent IP rights meaning lower imitation rates.

the relation between imitation and innovation as described in Helpman (1993). Countries with more flexible markets show a positive relation between imitation and innovation. When labor market flexibility is reduced however this relation can change and more imitation can lead to less innovation. Arnold (2002) conjectures that endogenizing unemployment duration will not alter this result and my model confirms this. In my model I endogenize unemployment duration, introduce iceberg trade costs and remove the growth scale effect present in Arnold (2002).

The paper is organized in five sections: the next section describes the main ingredients of the model. In section three I solve the model for a steady state equilibrium. Section four presents empirical evidence to support the main result on the workers' outside option and its importance for how trade liberalization affects unemployment. Section five concludes and an appendix with some more involving derivations is made available in the end.

2 The Model

I develop a North-South model of international trade that features population growth, endogenous economic growth and search-frictional unemployment in the North. Growth comes from a creative destruction process in the North, where follower firms do R&D and when successful introduce higher quality products on the market that replace those of old incumbents. R&D is done with final goods and there is no need to hire workers in order to be able to innovate. The R&D process becomes more difficult with time, which removes a potential scale effect of population size on the growth rate.

Firms that hold the patent for a new product have to announce vacancies and wait before they find the necessary workers to produce. Once the firm has found the workers to produce, it enters its home (North) and the foreign (South) market. In order to be able to ship to the South it has to incur an iceberg trade cost.

Once a new product is discovered it can be imitated. Imitation is costless and the rate at which it happens is exogenous. If a product is imitated it immediately starts to be produced by a competitive fringe firm in the South. There is no unemployment in the South and firms there do not have to wait to hire workers. They supply the Southern and Northern markets at marginal cost and make no profit. Of course they also incur the iceberg trade cost for shipping goods abroad.

Unemployment enters the model in a more or less standard way. Firms have to wait to find workers and workers have to wait to find jobs and there is no on-the-job search. Vacancy announcement is costless and the bargaining process is simplified as in Mortensen (2005) applying a Rubinstein bargaining game in which matched firms and workers continuously bargain for a wage. In such a bargaining game the outside option for workers, effectively not agreeing and remaining on the bargaining table, is the value of leisure. The benefit of a firm from postponing the conclusion to the bargaining game is non-production, in other words zero.

People in the South work in production. People in the North either work in production or are

unemployed. A firm produces until it gets replaced by a new quality leader or an imitator in which case its workers become unemployed. I study steady state equilibria of the model.

2.1 Consumers

The population in the North is L_{Nt} and in the South L_{St}, both grow at a rate n. World population at any period in time would be $L_t = L_{Nt} + L_{St}$. In each country people are members of a fixed number of identical households that optimize the following intertemporal utility function:

$$U_i \equiv \int_0^\infty e^{-(\rho-n)t} \left(log\left(y_{it}\right) + u_{it}k\right) dt,$$

where $i \in \{N, S\}$. The parameter ρ denotes the consumer's subjective discount rate, u_{it} is the share of unemployed people within the household and k is the utility from leisure. There is no unemployment in the South, which means that $u_{St} = 0$.

The number of products available for consumption is infinitely high and of mass one. Utility from comsumption at time t of a single member of a household can be written as

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

$d(j,\omega,t)$ denotes how much is consumed of product ω, quality j at time t. The step-size of each innovation is $\lambda > 1$ and j is a positive integer, which means that higher quality levels of a product bring higher utility.

The consumer problem is standard and follows three steps of optimization. They determine which quality level is used from the possibilities available within product ω, how much of each specific product ω is used versus other products and how consumption expenditure is distributed in time.

Within each product variety consumers have the option to choose from all discovered quality levels. They find it optimal to buy that quality version that offers them the lowest quality-adjusted price $p(j,\omega,t)/\lambda^j$, where $p(j,\omega,t)$ is the price of quality j of product ω at time t. If two different quality versions happen to be offered at the same quality-adjusted price, I assume that the higher quality version is used.

The next optimization step is to find demand for product ω relative to all other product varieties. Having per capita expenditure E_{it}, I obtain:

$$d_i(\omega,t) = \frac{E_{it}}{p_i(\omega,t)},$$

where I shorten the expression for demand and the price by omitting j, since it is already established that consumers buy only the quality level that offers the best quality-adjusted price.

The intertemporal optimization determines the allocation of consumers' expenditure in time. The result is the usual Euler equation $\dot{E}_{it}/E_{it} = r_{it} - \rho$. As in Grossman and Helpman

(1991) I set consumption expenditure in the South to be the numeraire, thus $E_{St} = 1$ for all t. From this follows that the real interest rate in the South $r_{St} = \rho$ is identical for all t. In order to have a balanced growth equilibrium with a constant consumption expenditure also in the North, the real interest rate there should be constant as well, meaning $r_{Nt} = \rho$ for all t.

2.2 Innovation and Imitation

Innovation is endogenous and driven by Northern follower firms, which innovate to discover higher qualities of existing products. Incumbent firms can and do innovate as well, but they try to improve on other quality leaders' products. They do not find it optimal to innovate on their own state-of-the-art goods because they would be replacing themselves and it is always preferable to replace another firm instead. I assume that it becomes common knowledge how to produce the one-step-lower quality level once the highest quality of a product is discovered.

The input to the innovation process is a basket of all produced and available goods. Let $l_i(\omega^*, \omega, t)$ be the amount of good ω^* used for the improvement of good ω at time t by firm i. I assume that the R&D technology is based on a Leontief function, which results in the usage of equal amounts of each variety as an input to the R&D process. With this in mind the technology used by innovating firms can be written as

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

where $a_I > 0$ is an innovation parameter, and $I_i(\omega, t)$ is the Poisson arrival rate of a higher quality version of variety ω at time t. I divide by $X(\omega, t)$, which increases with time, to signify that improving on product ω becomes more difficult for more developed products. The expression in the denominator $\int_0^1 \lambda^j(\omega) d\omega$ is the average quality of products available on the market and similar to R&D difficulty $X(\omega, t)$ grows with time and makes R&D more difficult. Given the Leontief R&D technology, the above expression can be reduced to

$$I_i(\omega, t) = a_I \frac{l_i(\omega, t)}{X(\omega, t)},$$

where $l_i(\omega, t) \equiv \int_0^1 l_i(\omega^*, \omega, t) d\omega^*$ is the amount of each variety ω^* available on the market used for the improvement of variety ω at time t.

So far the discussion has been about the R&D efforts of individual firms. The innovation technology aggregates to

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

where $I = \sum_i I_i$ and $l(\omega, t) = \sum_i l_i(\omega, t)$. I assume that the innovation rate is identical across products ω and independently distributed across firms, varieties and time.

Southern firms imitate on Northern products. Imitation is exogenous and costless and happens at the rate I_M. I assume that the imitation rate is identical across products and time. Once a specific product quality is imitated, all firms know how to produce it.

2.3 Producers

The producer optimization problem can be studied separately from the wage bargaining problem due to the fact that the optimal product price is the result of a limit pricing strategy. In the absence of competitive fringe firms, a product leader in the North would find it optimal to increase the price to infinity and sell the smallest possible amount of the good. This comes from the Cobb-Douglas form of the utility function. Firms therefore set prices in such a way that they would keep a potential competitive fringe out of business in order not to loose market share. For a more general version of a C.E.S. utility function the standard optimal pricing strategy would be possibly determined jointly with the wage bargain[4]. Given the monopolistically competitive environment there would be an overhiring externality, meaning that firms would hire more people in order to reduce their wage. In the chosen setup here with limit pricing however, this is not the case. One can approach product pricing and wage bargaining separately.

A Northern producer would set the price in the North at $p_{NN} = \lambda \tau w_S$ and in the South at $p_{NS} = \lambda w_S$. In both cases it is the Southern competitive fringe, which can immediately start producing the one-step-lower quality of the same product. There is no unemployment in the South and Southern competitive fringe firms can start production immediately.

A Northern producer's profit from selling in the North and the South is

$$\pi_{Nt}(j) = (p_{NN} - w_N)\, d_{NNt} L_{Nt} + (p_{NS} - \tau w_N)\, d_{NSt} L_{St} + (p_{NN} - w_N)\, \frac{I x_t}{a_I} L_{Nt},$$

where d_{NNt} is demand in the North for a Northern product and d_{NSt} is demand for a Northern product in the South. In addition to consumption demand I also include demand for the good that comes from its usage for innovation in the North $\frac{I x_t}{a_I} L_{Nt}$. The parameter $x_t \equiv X(\omega, t)/L_{Nt}$ is a key variable in the model and denotes relative R&D difficulty. It is a measure of how difficult it is to do R&D relative to a measure of the the size of the market L_{Nt} over which the costs of the innovation process can be spread if an innovating firm is successful[5].

Southern competitive fringe firms do not make any profit and price at marginal cost.

2.4 Firm Value Functions

Investing in an innovating follower firm has to yield a return, which in expectation equals the risk-free rate r. The Bellman equation of a Northern follower doing R&D is therefore

$$r v_{NF}(j) = \max_{l_i} -l_i(\omega, t)(n_S p_{SN} + n_N p_{NN}) + I_i v_{NP}(j+1) + \dot{v}_{NF},$$

where v_{NF} is the value of a Northern follower and v_{NP} is the value of a Northern leader that holds the patent for a state-of-the-art quality of a product but has not hired workers for

[4] Limit pricing by firms might still be optimal depending on the size of the innovation step relative to the price of a monopolist.

[5] The combined market size of the North and South is L_t and L_{Nt} is a proportional part of it.

production yet. The expression $n_S p_{SN} + n_N p_{NN}$ is a price index of all products available on the market in the North and therefore also the average price of a unit of the bundle used for R&D. The equation shows that the return to an investment in such a firm should equal the expected benefit. Free market entry dictates that $v_{NF} = 0$ and using in addition the innovation technology allows me to find that

$$v_{NP}(j) = \frac{X(\omega, t)}{a_I}(n_S p_{SN} + n_N p_{NN}). \tag{1}$$

Investing in a firm with a patent but without workers should also yield the risk-free rate:

$$r v_{NP} = z_N v_N - (I + I_M) v_{NP} + \dot{v}_{NP}. \tag{2}$$

z_N is the instantaneous probability for the firm to fill its vacancies and to become a producing leader and v_N is the value of such a leader. A product faces the risk of imitation immediately after it gets discovered. Once the patent in the North is out, the information is published and available. If innovation or imitation occur, the firm holding the patent and searching for workers loses its value, because the product starts to be immediately produced by the Southern competitive fringe. In the case of imitation this is obvious, in the case of innovation, remember that one-step-lower quality becomes common knowledge and can be produced by anyone.

Further, the return from investing in a producing leader should equal profits minus the probability that the product gets imitated or innovated, in which case the firm loses its value. One should of course also take into consideration the increase in firm value with time:

$$r v_N = \pi_{Nt} - (I_M + I)\, v_N + \dot{v}_N. \tag{3}$$

Solving for v_N yields

$$v_N = \frac{\pi_{Nt}}{r + I + I_M - n},$$

where $\dot{v}_N / v_N = n$.

I substitute the above into (2) and obtain the value of a product leader, which has not hired yet:

$$v_{NP} = \frac{\pi_{Nt} z_N}{(r + I + I_M - n)^2}. \tag{4}$$

Combining (1) and (4) gives the R&D equation:

$$\frac{x}{a_I}(n_S p_{SN} + n_N p_{NN}) = \frac{\pi_{Nt}}{L_{Nt}} \frac{z_N}{(r + I + I_M - n)^2}, \tag{5}$$

where I have divided both sides by L_{Nt}. The R&D equation is one of the main equations used to solve the model and shows that investment in innovation can be justified only if there is a sufficiently high demand and profits from a product. For the left-hand side of the equation to be constant in steady state, the relative R&D difficulty parameter x has to be constant, which is why I drop the subscript t.

2.5 The product groups

Some products are produced in the North, they are of mass n_N. Those are product qualities that are state-of-the-art and have not been imitated or improved on. If imitation or innovation occur, production moves to the South and Southern competitive fringe firms take over. In the case of innovation, the South takes over until the innovator finds workers for the newest product. Varieties produced in the South are of mass n_S. The measure of all industries equals unity

$$n_N + n_S = 1. \tag{6}$$

Let n_{SI} denote the mass of those Southern produced varieties that have been improved on by a Northern follower firm, but are still sold by the South, since the Northern firm has not managed to hire yet. n_{SO} are all remaining Southern-produced varieties for which there is no better version discovered in the North yet

$$n_S = n_{SO} + n_{SI}. \tag{7}$$

The inflow and outflow from n_{SO} can be described by:

$$n_N I_M + n_{SI} I_M = n_{SO} I. \tag{8}$$

Not all n_N products go into the n_{SO} group when a product moves to the South. When innovation occurs, those products join directly the n_{SI} group and only imitated products join the n_{SO} group. When a product is produced in the South and is part of the n_{SI} group (a firm with a patent of the better version of the product is looking for workers in the North) its non-produced higher quality version can get imitated as well. This is the second term on the left-hand side of the above equation. Outflow from the n_{SO} group happens when innovation occurs. Those products remain in Southern production but now as n_{SI} products.

The inflow and outflow from and into the group of Southern produced products n_S is depicted by:

$$n_{SI} z_N = n_N (I_M + I). \tag{9}$$

Every product, which has a higher quality version in the North moves to the North when the innovating firm there finds workers. This happens at a rate z_N. At the same time products that are manufactured in the North move for production to the South as soon as they get imitated or improved on.

There are four unknowns n_N, n_S, n_{SI}, n_{SO} and four equations to solve for them (6), (7), (8), (9). I solve for the unknowns in the appendix.

2.6 Unemployment and the Labor Market

Employment in the North is dedicated to production. The production itself is used for consumption and R&D, which is what the following equation depicts:

$$(1-u_{Nt})L_{Nt} = \int_{n_N} \left(d_{NNt}L_{Nt} + \tau d_{NSt}L_{St} + \frac{Ix_t}{a_I}L_{Nt} \right) d\omega.$$

The equation transforms into

$$1 - u_N = n_N \left(\frac{E_N}{\tau \lambda w_S} + \tau \frac{E_S}{\lambda w_S} \frac{L_{St}}{L_{Nt}} + \frac{Ix}{a_I} \right). \tag{10}$$

This is the Northern labor equation, where I have removed the time subscripts from the variables that are constant in steady state.

There is no unemployment in the South and everyone works in production, which is also used for consumption and R&D. The labor market in the South can be described by the following equation:

$$L_{St} = \int_{n_S} \left(\tau d_{SNt}L_{Nt} + d_{SSt}L_{St} + \tau \frac{Ix_t}{a_I}L_{Nt} \right) d\omega.$$

Transforming yields:

$$\frac{L_{St}}{L_{Nt}} = n_S \left(\frac{E_N}{w_S} + \frac{E_S}{w_S} \frac{L_{St}}{L_{Nt}} + \tau \frac{Ix}{a_I} \right). \tag{11}$$

This is the Southern labor market equation, in which I have divided both sides by L_{Nt}. Again, the variables that are constants in steady states are without the time subscript.

Unemployment in the North is the result of search and matching frictions in the labor market. The matching function is of the following form: $m_{Nt}(U_{Nt}, V_{Nt}) = \phi U_{Nt}^{\gamma} V_{Nt}^{1-\gamma}$. It is a standard constant returns to scale matching function, where the number of matches depends on the number of unemployed people $U_{Nt} = u_{Nt}L_{Nt}$ and the number of vacancies announced $V_{Nt} = v_{Nt}L_{Nt}$. The efficiency of the matching process is determined by the parameter $\phi > 0$ and γ determines the elasticity of the matching function. There is no on-the-job search in this model.

The flow of the unemployed in the North is described by the following equation:

$$\dot{U}_{Nt} = nL_{Nt} + (I_M + I) \int_{n_N} \left(d_{NNt}L_{Nt} + \tau d_{NSt}L_{St} + \frac{Ix_t}{a_I}L_{Nt} \right) d\omega - m_{Nt}.$$

All newly born are unemployed. The employees of firms whose products get imitated or innovated on also become unemployed, since the Southern competitive fringe starts to produce immediately. The number of unemployed is reduced by the number of matches m_{Nt}.

After combining the equation on the flow of the unemployed with the Northern labor market equation and writing $m_t(U_{Nt}, V_{Nt}) = p_{Nt}U_{Nt}$, I am able to derive an expression for unemployment in the North:

$$u_N = \frac{n + I_M + I}{p_N + n + I_M + I}. \tag{12}$$

The parameter p_N is the rate at which the unemployed find a job and is constant in steady state. The details of the derivation can be found in the appendix. The rate of unemployment increases with the population growth rate n, the imitation rate I_M and the innovation rate

I, and decreases with the rate at which unemployed people find work p_N. Using the matching function it is possible to show that $v_N = \phi^{\frac{1}{\gamma}} u_N z_N^{-\frac{1}{\gamma}}$. It is also possible to show that $p_N = \phi^{\frac{1}{\gamma}} z_N^{1-\frac{1}{\gamma}}$, which shows the relation between p_N and z_N and is needed when solving the model.

2.7 Wage Bargaining

I adopt the approach used by Mortensen (2005) when describing the wage bargaining problem. Mortensen in turn follows Binmore et. al. (1986). A key aspect of the noncooperative Rubinstein bargaining game is that when negotiating the parties do not search. The result of this is that the outside option for a worker is leisure and not the value of unemployed search and the outside option for a firm is zero. Bargaining power in the North equals $0 < \beta < 1$ for a firm and $1 - \beta$ for a worker.

As previously discussed the prices $p_{NN} = \tau\lambda w_S$ and $p_{NS} = \lambda w_S$ are determined by the threat points that each price-setting firm faces on each market. Those threat points are in both cases determined by the Southern competitive fringe. Instead of optimizing over p_{NN}, p_{NS} and w_N, the optimization problem simplifies to:

$$w_N = \underset{w_N}{argmax} \left\{ \left((\tau\lambda w_S - w_N) \left(d_{NN} L_{Nt} + \frac{I x_t}{a_I} L_{Nt} \right) + (\lambda w_S - \tau w_N) d_{NS} L_{St} \right)^{\beta} (w_N - k)^{1-\beta} \right\}.$$

This can be further rewritten as

$$w_N = \underset{w_N}{argmax} \left\{ ((\tau\lambda w_S - w_N)Q + \lambda w_S - \tau w_N)^{\beta} (w_N - k)^{1-\beta} \right\},$$

where $Q \equiv \frac{d_{NN} L_{Nt} + \frac{Ix}{a_I} L_{Nt}}{d_{NS} L_{St}} = \left(\frac{E_{Nt}}{\tau E_{St}} + \frac{\lambda w_S \frac{Ix}{a_I}}{E_{St}} \right) \frac{L_{Nt}}{L_{St}}$ is relative Northern demand for a Northern good. Solving yields

$$w_N = (\tau Q + 1) \lambda w_S \frac{1 - \beta}{Q + \tau} + \beta k. \tag{13}$$

In order for Southern competitive fringe firms to be able to drive out of business a Northern incumbent with the same quality level product, their price and effective marginal cost on the Northern market has to be lower than the marginal cost of the incumbent $w_N > p_{SN} = \tau w_S$. If this holds then it is clear that the Southern competitive fringe firms will be able to price lower in the South where they would not have to pay the iceberg trade cost, which on the other hand Northern firms would have to pay. Combined with the condition that the markup of a Northern quality leader has to be positive when selling at home and abroad, one has to take into consideration two more inequalities $w_N < p_{NN} = \lambda\tau w_S$ and $\tau w_N < p_{NS} = \lambda w_S$. If the latter holds, the former will also hold.

A setup in which Southern savers do not save in Northern companies would be in line with the evidence in Feldstein and Horioka (1980), who report that domestic savings flow mostly into domestic investment. An alternative specification in which Southern workers

save in Northern companies is of course also possible. In the current setup however, since all Southern companies are competitive fringe firms and have zero value, the Southerner effectively does not save. From this follows that Southern consumption expenditure is equal to the Southern wage and since the former is the numeraire we would have $E_{St} = w_S = 1$. With this in mind I can write the admissible bound for w_N as

$$\frac{\lambda}{\tau} > w_N > \tau. \tag{14}$$

3 The Steady State Equilibrium

In a fully-endogenous growth model R&D difficulty $X(\omega, t)$ depends on the size of the population $X(\omega, t) = mL_{Nt}$, where $m > 0$ is a parameter, which determines how the cost to R&D increases with the Northern population level. In this type of growth model trade costs and IP protection will have an effect on the innovation rate and on growth. From the expression of R&D difficulty, it is straightforward to find relative R&D difficulty $x = m$. The unknowns of the model are z_N, E_{Nt}, I, u_{Nt}, w_N. I find those with the help of the R&D condition (5), the Northern labor equation(10), the Southern labor equation (11), the unemployment equation (12) and the wage equation (13). One has to solve numerically.

I also find and report the steady state welfare of the Northern consumer[6]. The welfare measure does not include any transitional dynamics and is therefore a somewhat simplistic measure of welfare. Using the expression for the static utility of a Northern consumer I can write

$$log(y_{Nt}) + u_{Nt}k = \int_{n_N} log\left(\frac{E_{Nt}}{\tau\lambda ws}\right) d\omega + \int_{n_S} log\left(\frac{E_{Nt}}{\tau ws}\right) d\omega + \int_0^1 log(\lambda^j) d\omega + u_{Nt}k.$$

Welfare depends on how much is consumed of both Northern and Southern produced goods, taking into consideration also their quality levels. It depends in addition on the share of unemployed people in the household and their value of leisure. The above expression can be transformed into

$$log(y_{Nt}) + u_{Nt}k = n_N log\left(\frac{E_{Nt}}{\tau\lambda ws}\right) + n_S log\left(\frac{E_{Nt}}{\tau ws}\right) + \Phi(t) log(\lambda) + u_{Nt}k,$$

where $\Phi(t) = \int_0^t I(s)ds$. I can calculate welfare at any point in time in order to compare steady states but for simplicity I will do that for $t = 0$, where $\Phi(t) = I$. One has to solve for I numerically and then substitute in the welfare expression.

[6] It is possible to report also the welfare level of Southern consumers. I do not do that, given that the welfare measure would not be comparable to the Northern one to the extent that there is by construction no unemployment in the South.

3.1 Numerical Solution

In order to solve the model I use the following parameters: $L_{Nt} = L_{St} = 1$, $n = 0.018$, $\lambda = 1.7$, $\beta = 0.5$, $\gamma = 0.5$, τ changes from 1.1 to 1, I_M changes from 0.02 to 0.01, $a_I = 0.5$, $m = 5$, $\phi = 0.6$. The model is calculated for two values of the leisure parameter $k = 1.2$ and $k = 0.8$.

I set for simplicity the population in the North equal that of the South. The population growth rate in the North and the South is set according to the world population growth rate for the 1980s reported in Kremer (1993). The choice of λ implies a markup of Northern firms selling in the North $\frac{\lambda\tau}{w_N}$ of about 17% to 47%, which is within range of the markups reported in Morrison (1990), and for selling in the South $\frac{\lambda}{\tau w_N}$ of about 5% to 36%. The choice of λ and τ is in addition dictated by (14).

The bargaining power of firms is frequently set equal to the elasticity of the matching function $\beta = \gamma = 0.5$ with the motivation that this choice yields an efficient equilibrium (Hosios 1990). The Hosios condition is however derived for a perfectly competitive goods market. In a monopolistically competitive setting there is usually an overhiring externality and the equilibrium is no longer Pareto optimal at $\beta = \gamma$ (see the discussion in Felbermayr et al. 2012). In my setting the market of goods is monopolistically competitive but there is no overhiring externality. Arguing however whether the equilibrium is Pareto optimal or not is beyond the scope of this paper. I simply set the bargaining power of firms equal to this of workers and respectively also equal to the elasticity of the matching function. The value of leisure k is chosen in such a way that in equilibrium it has to be lower than the Northern wage w_N. An imitation rate $I_M = 0.02$ means that one in 50 Northern products is imitated annually by the South.

Given the individual's static utility I can substitute for demand and differentiate with respect to time to arrive at an expression for the steady state economic growth rate $g = I \ln \lambda$. With this in mind I set $m = 5$ and $a_I = 0.5$ in order to arrive at a growth rate close to 2%, which would comply with the evidence for the US per capita growth rate for the period 1950-1994 (see Jones 2005). The parameter ϕ determines how severe labor market frictions are and has been set to arrive at a reasonable steady state unemployment rate.

Table 1 describes an equilibrium with a value of leisure $k = 1.2$. I look at increasing IP protection, which in my model is the same as decreasing the imitation rate I_M. The effect can be seen by comparing columns 2 and 3. The table also shows the effect of trade liberalization, going from column 3 to column 4, where the iceberg trade cost decreases from 1.1 to 1.

Stronger IP rights protection (lower I_M) decreases the innovation rate I as expected. A lower innovation rate translates into a lower growth rate g, which decreases from 2.67% to 1.82%. Unemployment responds quite sharply decreasing from 6.99% to 2.67%. The intuition behind this effect is straightforward, lower imitation keeps more product varieties in the North. This increases demand for Northern workers and decreases unemployment.

IP protection improves welfare in the North through the lower unemployment rate and the

$k = 1.2$	$\tau = 1.1$, $I_M = 0.02$	$\tau = 1.1$, $I_M = 0.01$	$\tau = 1$, $I_M = 0.01$
I	0.0503	0.0343	0.0343
g	0.0267	0.0182	0.0182
u_N	0.0699	0.0267	0.0261
x	5	5	5
E_N	0.8387	1.1560	1.1679
Welfare N	-0.4695	-0.2212	-0.1147
w_N	1.4693	1.4697	1.4500
n_N	0.5819	0.6052	0.6018
n_S	0.4181	0.3948	0.3982
p_N	1.1754	2.2693	2.3298
z_N	0.3063	0.1586	0.1545

Table 1: Effects of Lower Imitation and Trade Liberalization, High Outside Option

higher consumption expenditure. The lower innovation rate puts a negative pressure on welfare as well as the lower share of Southern produced goods, which are cheaper.

The effect of trade liberalization (lower τ) can be seen by comparing the third and fourth columns of Table 1. First of all, trade liberalization improves welfare of the Northern consumer, because prices of all varieties, produced both in the North and in the South, decrease. Innovation and growth are not really affected[7], the wage in the North w_N and unemployment decrease.

Lower trade costs decrease the price of Northern goods in the North $p_N N = \lambda\tau$, which in turn increases demand for Northern goods in the North. This increases demand for Northern workers. Covering demand for goods in the South requires on the other hand fewer workers because with lower τ fewer goods are lost on the way. This decreases demand for workers in the North. The first effect is stronger in this specification and trade liberalization leads to lower unemployment in the North. It turns out that the effect of trade liberalization on unemployment can be also positive and it depends on the value of leisure k.

I order to study the importance of the value of leisure for the results I solve for an equilibrium with $k = 0.8$ and report the results in Table 2. By comparing the effect of trade liberalization, keeping the imitation rate I_M constant, one can see that in an economy where workers have a higher outside option (Table 1) trade liberalization decreases unemployment (Table 1) and in an economy with a lower outside option $k = 0.8$ trade liberalization increases unemployment (Table 2).

The outside option of workers affects the steady state through its influence on the Northern wage. A higher value of leisure for workers means a higher wage, visible in equation (13). This in turn leads to a higher consumption expenditure in the North and a relatively larger

[7] Innovation and growth do change, but the change is too small to show at the fourth decimal place in the table.

$k = 0.8$	$\tau = 1.1$, $I_M = 0.02$	$\tau = 1.1$, $I_M = 0.01$	$\tau = 1$, $I_M = 0.01$
I	0.0690	0.0540	0.0560
g	0.0366	0.0286	0.0297
u_N	0.0681	0.0328	0.0332
x	5	5	5
E_N	0.5621	0.8457	0.8533
Welfare N	-0.8823	-0.5211	-0.4131
w_N	1.2709	1.2709	1.2500
n_N	0.5691	0.5901	0.5857
n_S	0.4309	0.4099	0.4143
p_N	1.4651	2.4184	2.4465
z_N	0.2457	0.1489	0.1472

Table 2: Effects of Lower Imitation and Trade Liberalization, Low Outside Option

Northern market.

As described, trade liberalization decreases the amount of labor that Northern firms need to service the Southern market. The price does not change since it is independent of τ. The price of Northern firms in the North $p_N = \lambda\tau w_S$ decreases however, since they have to make sure to keep away Southern competitive fringe firms with a one-step-lower quality of the same product. This lower price in the North increases demand and therefore also the need for workers. In addition the R&D intensity is also affected by trade liberalization.

Which effect is stronger and whether ultimately the Northern firm needs more or less workers depends on the relative size of the Northern market, which in turn depends on population size and consumption expenditure and on the response of R&D expenditure. In an economy with a higher value of leisure (higher k) the higher consumption expenditure in the North leading to higher demand for goods in the North offsets the lower need for workers to service the Southern market. The response of the investment in innovation is relatively small to play a decisive role. In such an economy trade liberalization leads to a higher demand for workers by Northern firms. This in turn will lead to a lower unemployment level in the North u_N as seen in Table 1. In an economy with a lower value of leisure trade liberalization leads to a higher steady state level of unemployment.

There is a threshold k for which trade liberalization does not affect unemployment. Decreasing the technology parameter a_I, increasing the R&D difficulty parameter m, increasing the imitation rate I_m, decreasing the bargaining strength of the Northern firm β or decreasing the relative size of the South L_S/L_N decreases the threshold k for which the effect of trade liberalization on unemployment changes.

4 Empirical Support

In this section I build on the data and empirical specification in FPS to test the importance of the value of leisure for the connection between trade liberalization and unemployment. FPS run a panel regression on 20 OECD countries, where the quality of the unemployment data is high. The period is 1980 to 2003. They estimate the following equation:

$$u_{i,t} = \alpha + \beta_1 T_{i,t} + \beta_2 WD_{i,t} + \beta_3 EPL_{i,t} + \beta_4 UD_{i,t} + \beta_5 HC_{i,t} + \beta_6 PMR_{i,t} + \beta_7 POP_{i,t} + \beta_8 GAP_{i,t} + v_t + \epsilon_{i,t},$$

where subscript i denotes the country and t the time period. The dependent variable u is the unemployment rate for people between the ages of 15 and 64. The measure for openness T is real total trade openness from Alcala and Ciccone (2004). The parameter WD is a wage distortion index, which is the sum of the average wage tax burden and an average replacement rate (social benefits if unemployed) to represent the "total fiscal burden imposed on the worker." EPL denotes employment protection legislation, UD is union density, HC is high corporatism, PMR is product market regulation, POP is the logarithm of population and GAP is the output gap. In order to get rid of business cycle effects the data is grouped and averages are taken for five periods, four five-year periods and one four-year period with v being the coefficient on the period dummy. Finally ϵ is the error term.

I am also interested in the coefficient of the openness measure that FPS use, but I want to test whether the sign of this coefficient changes depending on the size of the outside option people have. The value of leisure in my setup would correspond to the average replacement rate in the FPS data. Although I do not explicitly model unemployment insurance, both the value of leisure in the theory and the average replacement rate in the data represent the outside option of a worker searching for a job.

I make two changes to the original regression in FPS. First, I keep the wage distortion index from FPS but create an interaction variable, which multiplies the average replacement rate (still contained in the wage distortion index) with the real openness measure.

Second, from the theory I know that the importance of the average replacement rate for the interaction between trade and unemployment depends on the size of the technology parameter a_I but also on the R&D difficulty parameter m. Both of those parameters determine the size of R&D demand in the North $\frac{Ix_t}{a_I} L_{Nt}$, which would in turn also determine the share of R&D expenditures in total production. My expectation is therefore that the size of the R&D sector might play a role for the importance of the combined effect of openness and that controlling for it can increase the precision of the results if R&D is correlated with unemployment and with openness.[8] I therefore add log R&D expenditures as a share of

[8] I find in the numerical section that a higher m and a lower a_I decrease the threshold value of k at which the effect of trade liberalization on unemployment changes sign. A higher m and a lower a_I correspond to a higher share of R&D expenditures in GDP, a larger R&D sector.

total country GDP for the 20 OECD countries which I am studying[9].

The theory suggests that in an economy with a high workers' outside option k (Table 1), trade liberalization decreases unemployment. In an economy with a low workers' outside option k (Table 2), trade liberalization would increase unemployment[10]. With this theory in mind one would expect in a regression a positive coefficient for the openness variable and a negative coefficient for the interaction variable of openness and the average replacement rate. This is indeed what the results show.

FPS show both fixed and random effects regressions, but report that running a Hausman test suggests random effects to be more appropriate. I show results from the random effects regressions and reproduce the original FPS regression in column 1 of Table 3. This regression does not have an interaction variable between openness and the average replacement rate. As discussed in FPS, openness has a negative and significant effect on unemployment. Adding the mentioned interaction variable however and the share of the R&D sector changes the sign of the coefficient on openness (column 2 of Table 3), it becomes positive and is statistically significant at five percent. The interaction variable is negative and statistically significant at one percent. The coefficients on openness and the interaction variable are jointly significant at five percent. The signs of the coefficients go in the direction suggested by the theory[11]. A pooled OLS in column 3 confirms the random effects result, while the coefficients of interest on openness and the interaction are jointly significant at one percent.

5 Conclusion

I build a fully endogenous growth model of North-South trade with iceberg trade costs, intellectual property rights protection and a search-frictional labor market in the North. I find that stronger IP protection reduces unemployment and increases welfare in the North. Trade liberalization unambiguously improves welfare in the North. I also find that trade liberalization can either increase or decrease unemployment in the North depending on the size of the outside option of workers. It decreases unemployment in a North where the outside option of workers is high. In an economy with low outside option for workers, trade

[9] I use gross domestic expenditure on R&D as a percentage of GDP from the OECD Main Science and Technology Indicators. The data is available from 1981.

[10] The model that I am using here is a fully endogenous growth model, which means that the innovation and growth rates are affected by exogenous policy variables like the iceberg trade cost. Unemployment is positively related to the innovation rate and negatively related to the rate at which workers find a job. The latter increases with trade liberalization and unemployment goes down. The innovation rate can either increase or decrease. It increases in an economy where the outside option k is lower and not only that but it can offset the effect of the higher rate at which workers find jobs. The overall effect on unemployment is positive, unemployment increases with trade liberalization. In a semi-endogenous growth model, where the evolution of R&D difficulty X does not depend on population size but on the innovation rate, e.g. $\dot{X}(\omega,t)/X(\omega,t) = \mu I(\omega,t)$, instead of $X(\omega,t) = mL_{Nt}$, the innovation and growth rates in steady state are independent of the variable cost to trade. In that case unemployment would always depend only on the rate at which workers find a job. Unless k changes the effect of trade liberalization on the rate at which workers find a job, trade liberalization would decrease unemployment for both high and low values of k.

[11] Given the coefficients on openness and the interaction variable one should note that the effect of openness on unemployment becomes negative for an average replacement rate higher than 29.6. The average replacement rate in the data set is a value that ranges from 0.62 to 62.79 with a mean at 28.4 and a standard deviation of 12.73.

Table 3: The Effect of Openness on Unemployment

Dependent Variable: Unemployment rate (15-64 years old)			
	(1) RE	(2) RE	(3) Pooled OLS
Total trade openness, real	-0.076*** (0.022)	0.089** (0.040)	0.174*** (0.057)
Interaction		-0.003*** (0.001)	-0.005** (0.002)
R&D share		-1.982 (1.263)	-4.870*** (1.413)
Wage distortion (index)	0.103*** (0.028)	0.184*** (0.034)	0.223*** (0.063)
Employment protection legislation	-0.969 (0.822)	-1.264* (0.749)	-1.584** (0.625)
Union density	0.009 (0.028)	0.004 (0.024)	-0.009 (0.025)
High corporatism	-1.805*** (0.675)	-1.905*** (0.606)	-0.533 (0.914)
Product market regulation	0.835 (0.560)	0.765 (0.499)	0.414 (0.637)
Population (log)	0.141 (0.610)	0.845* (0.451)	1.711*** (0.433)
Output gap	-0.626*** (0.091)	-0.600*** (0.084)	-0.690*** (0.108)
Countries	20	20	20
Obs	100	100	100
Rsq within	0.608	0.617	
Rsq			0.662

Note: * significance at 10%, ** significance at 5%, *** significance at 1%. In brackets showing robust standard errors. In the pooled OLS regression (3) the standard errors are clustered at the country level. For more details and descriptive statistics of the variables see Felbermayr, Prat and Schmerer (2011b).

liberalization increases steady-state unemployment. Extending an existing study on trade openness and unemployment for 20 OECD countries yields empirical support for the last result.

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