
DE ECONOMIST 145, NO. 2, 1997

UNEMPLOYMENT AND CATCHING UP: EUROPE *VIS-À-VIS* THE USA **

BY

HENRI L.F. DE GROOT AND ANTON B.T.M. VAN SCHAIK*

Key words: endogenous growth, catching up, efficiency wages, dual economy

1 INTRODUCTION

After World War II, the European countries drastically increased their productivity levels relative to the United States. In the 1970s and 1980s, however, convergence slowed down and European productivity levels are now stabilizing at some distance from their US counterparts (both on a macroeconomic and a sectoral level).¹ This observation is underexposed in the empirical literature on economic growth. Most of this literature contains multivariate tests of single equation macroeconomic growth models on large cross-country samples. However, these studies all face serious econometric problems of simultaneity, multicollinearity, and limited degrees of freedom. Furthermore, the development of empirical tests to discriminate between existing growth theories has turned out to be a formidable task, given the subtle implications of the theories. The possibilities to draw inferences from international data is therefore limited (*cf.* Mankiw (1995)). The estimation of a single-equation macroeconomic model is thus an activity to which there are now sharply diminishing returns. One way to remedy this would be to test more complete models, not only reduced forms, with a sharper focus on sectoral and institutional structures (*cf.* Fagerberg (1994), and Olson (1996)). This may reveal that the process of catching up with the USA not only depends on the extent of the productivity gap, but also on the interaction of labour market institutions with the sectoral structure of the economy. Comparing the post-war eco-

*↵ Tilburg University and CentER, P.O. Box 90153, 5000 LE Tilburg, The Netherlands.

**↵ We would like to thank Lans Bovenberg, Erik Canton, Theo van de Klundert, Richard Nahujs, Harald Uhlig, and two anonymous referees of this journal for useful comments on an earlier version of this paper. Of course, the usual disclaimer applies.

1↵ Several sources containing empirical data clearly illustrate this point (e.g., Dollar and Wolff (1993), Van Ark and Pilat (1993), OECD (1993), Summers and Heston (PWT 5.6), Maddison (1995), and McKinsey Global Institute (1996)). All these sources point in the same direction, namely the main European countries catching up with the USA in the 1950s and 1960s, but lagging behind since the mid 1970s at levels of approximately 80 percent of US productivity (both total factor productivity and labour productivity).

conomic performances of the European Union and the United States, there are strong indications that labour market institutions do matter very much (e.g., Bean (1994), OECD (1994)). This performance is characterized by historically unprecedented low European levels of unemployment in the 1950s and 1960s, the period of catching up with the USA. In the late 1960s, however, European unemployment started to rise steadily, whereas the US unemployment rate periodically returned to its 'natural rate.'

The answer to the intriguing question of why European countries do no longer increase their productivity level relative to the USA is still a very open one. This paper develops a simple two-region endogenous growth model with tradeable (high-tech) and non-tradeable (traditional) goods, to shed some light on this question. Trade takes place in varieties of a differentiated product, so that the model can be classified under the heading of the 'new trade theory' (e.g., Krugman (1990)). Within this context, the question whether sectoral structures can differ among countries in such a way that they hamper or speed up economic growth is dealt with. Thereby we will mainly focus on the role of unemployment compensations in determining the sectoral allocation of labour. In distinguishing Europe from the USA, it is evident that these systems differ a lot between the two regions, both in duration and in height. It will be argued that the generosity of unemployment compensations in Europe led to a society with relatively few people from the total work force employed in the high-tech tradeables sector of the economy. As, in our model, technological progress stems from this sector, there is a direct link between the generosity of the unemployment compensation system and economic growth. Thereby, we add to the scarce amount of literature on the relation between economic growth and unemployment (e.g., Bean and Pissarides (1993), Aghion and Howitt (1994), and Bean and Crafts (1995)).² All these studies focus on distortions in the demand for labour. In contrast, we focus on distortions in the supply of labour resulting from generous unemployment compensations and non-competitive wage differentials. Furthermore, we model unemployment as resulting from efficiency wage considerations playing a role in one sector only, which allows us, among other things, to address the problem of

2 Most of the studies currently available on the relation between growth and unemployment address the issue from a search perspective. Equilibrium unemployment results from frictions in the process of matching the unemployed with vacancies posted by firms. The most comprehensive study in this field is Aghion and Howitt (1994). In their model, economic growth results in creative destruction and accompanying lay-off of workers. Growth thus increases the rate of job separation and (partially) increases the unemployment rate. However, growth also affects the rate of job finding by (i) increasing the present value of a job match for the firm (the capitalization effect) and (ii) decreasing the average lifetime of a firm. The first effect tends to decrease the equilibrium unemployment rate while the second effect tends to increase it. Bean and Crafts (1995) consider the potential relation between growth and unemployment from a different angle. In their model, a crucial role is played by the so called 'hold-up' problem. The essence of this problem is that firms have an incentive to underinvest in growth promoting activities in the presence of trade unions and in the absence of binding contracts.

unemployment in the context of a dual labour market. The presence of these efficiency wage considerations can be seen as an institutional factor that is the most important in determining the distribution of labour across the sectors of the economy. Another contribution to the literature is that we address the problem in the context of a two-country model, which allows us to look at the potential effects of labour market institutions on the relative performance of countries, both in terms of unemployment and growth.

The introduction of a two-region model raises the question about the external relatedness of sectors, that is, how the productivity of the tradeables sector in one region does affect the productivity of that sector in another region. In general, technological progress can be conceived either as a 'free good,' as a by-product of other economic activities, or as the result of intentional R&D activities in private firms. It is now increasingly accepted that the third source (innovation, as the outcome of intentional activities in private firms) is one of the most important sources of technological progress in OECD economies (*cf.* Dosi (1988), Fagerberg (1994)). Recently, Van de Klundert and Smulders (1996) have incorporated the accumulation of firm-specific knowledge and the idea that firms can learn from each other in a two-sector two-region model, distinguishing traditional and high-tech goods, which can both be traded between regions. We follow these authors by assuming that the backward region can learn from the advanced country, but not the other way around. In other words, the backward region can copy production processes at a relatively low cost and has an opportunity to catch up (*cf.* Krugman (1990), Barro and Sala-i-Martin (1995)). However, in contrast with the usual assumptions in the literature on trade and endogenous economic growth, we allow labour market institutions and unemployment to play a prominent role in our model. In addition, we assume that the production of traditional goods only takes place in the non-tradeables sector. The inclusion of a non-tradeable sector has various reasons. First of all, it is important from an empirical point of view, as sheltered sectors constitute a large part of the economy. Secondly, we want to focus – among other things – on the dual character of the labour market. In order to be able to do so, we need two substantial sectors that make up the economy. Tradeability of traditional goods therefore had to be excluded as this makes full specialization possible (*cf.* Van de Klundert and Smulders (1996)). Finally, the distinction between a tradeables and a non-tradeables sector is important in relation to the knowledge spillovers in our model. It seems reasonable to assume that these spillovers are most prominent in the tradeables sector (see Coe and Helpman (1995) for an empirical study on this issue, confirming the significance of R&D spillovers, which are stronger the more open an economy is to foreign trade). We will take the most extreme position by assuming that there are no spillovers whatsoever in the non-tradeables sector.

We proceed as follows. Section 2 presents the model. Equilibrium unemployment and the allocation of labour over sectors is discussed in section 3. The division of labour over sectors turns out not to depend on the dynamics of the

model. These dynamics will be presented in section 4. The model predicts that (nearly) symmetrical countries, only differing in their initial labour productivity levels in the high-tech sector, will fully converge. However, if sectoral structures differ between countries, this will no longer hold. In this case, there are possibilities for leapfrogging or relative convergence, *i.e.*, steadily lagging behind the leader region. The results will be used to shed some more light on the development of the countries of the European Union *vis-à-vis* the USA in the post World War II period. Thereby, we will focus on differences in the system of unemployment compensations between the two regions. Section 5 contains an evaluation in which we will confront the theoretical analysis in this paper with empirical evidence. We conclude in section 6.

2 A DUAL ECONOMY

The world consists of two almost identical regions with two differences only. Firstly, the backward region (the European Union, labelled region 2) initially has a substantially lower labour productivity in the high-tech sector compared with the leader region (the USA, labelled region 1). The initial positions are inherited from the past. Secondly, the welfare systems (as represented in the model by an exogenous unemployment compensation) differ between both regions. Each region produces two types of goods, *viz.* non-tradeable traditional goods and tradeable high-tech goods. The factors of production are labour, firm-specific knowledge, and firm-specific efficiency of workers. In each region there are n firms ($i = 1, \dots, n$) in the high-tech sector,³ which compete monopolistically on the world market for $2n$ varieties of the high-tech products (n is assumed to be sufficiently large). Each firm is assumed to produce a unique brand.

In the non-tradeables sector there is unitary labour productivity

$$y = L_N, \quad (1)$$

where L_N stands for the number of workers employed in the non-tradeables sector, and y is the production of non-tradeables. Assuming perfect competition in the non-tradeables sector, the price of a non-tradeable good equals labour costs

$$p_N = w_N, \quad (2)$$

³ The number of firms is chosen to be exogenous. We deliberately abstain from the complex issue of entry and exit behaviour and all related strategic considerations. They are interesting in their own right (see for example Van Schaik and De Groot (1995)), but not essential for the issues we want to focus on in this paper. Another reason for this choice is that an exogenously given number of firms with persistent excess profit opportunities matches real world phenomena quite well (see Mueller (1986)).

where p_N denotes the price of non-tradeables, and w_N is the wage rate in this sector.

High-tech firms employ (direct or productive) labour (L_{xi}) for production of goods that has labour productivity h_i , and efficiency e_i , leading to x_i units of output

$$x_i = h_i e_i L_{xi}. \quad (3)$$

The efficiency of a high-tech production worker is a variable that can be affected by the wage-setting behaviour of the firm. The variable h_i on the other hand depends on international forces and the number of workers employed in the Research and Development lab of the firm (h_i will be further explained in section 4). To simplify the analysis, we assume that each firm employs a fixed proportion $\beta(>0)$ of the number of production workers in R&D activities

$$L_{ri} = \beta L_{xi}, \quad (4)$$

where L_{ri} is labour employed in R&D activities.⁴

Total nominal income (I) consists of labour income and profits ($n\pi_i$)

$$I = w_N L_N + n w_{Ti} (L_{xi} + L_{ri}) + n \pi_i, \text{ where} \\ \pi_i = p_{Ti} x_i - w_{Ti} (L_{xi} + L_{ri}).$$

Here p_{Ti} is the price of the tradeable good i , and w_{Ti} the wage rate of firm i . Substituting π_i and Equations (1) and (2) result in⁵

$$I = p_N y + n p_{Ti} x_i. \quad (5)$$

Based on a two-step optimization procedure where consumer preferences are specified according to a Cobb-Douglas consumption index, we derive that con-

4 We thus implicitly assume that firms employ research labour according to some rule of thumb. The main justification for this is that the future fruits of doing R&D are inherently uncertain, not justifying the use of a perfect foresight model to derive R&D inputs. It can thus be argued that the use of rules of thumb for determining R&D input (for example, R&D expenditures being a fixed proportion of profits) is closer to the truth than the use of perfect foresight. There is, however, large debate on the best way of modelling R&D expenditures. Alternatively, in Van Schaik and De Groot (1995), for a closed economy, we explicitly determine the number of research workers on the basis of fully optimizing behaviour of a firm, which explicitly takes into account the fruits of employing R&D labour in terms of increased future productivity. In this case, the firm allocates its labour among production and research in such a way that the marginal productivity of labour in the two activities is equalized. In equilibrium, each firm employs a fixed proportion (β) of its production labour to R&D activities.

5 As there are no international capital flows in the model, trade must be balanced at every moment in time. This requires that the value of spending equals national income.

sumers spend a fraction σ of total nominal income on high-tech (tradeable) goods and a fraction $(1 - \sigma)$ on traditional (non-tradeable) goods. Preferences between traditional and high-tech goods are assumed to be identical across regions. For the non-tradeables it can then be derived that

$$(1 - \sigma)I = yp_N. \quad (6)$$

Preferences over varieties are also uniform across regions and are given by a CES-function (*cf.* Dixit and Stiglitz (1977), with an elasticity of substitution equal to $\epsilon (> 1)$). Consequently, world demand for any variety produced in a region 1 relative to world demand for any variety produced in region 2 (assuming symmetry within a region)⁶ depends on the relative price of these varieties:

$$\frac{x^1}{x^2} = \left(\frac{p_T^1}{p_T^2} \right)^{-\epsilon}. \quad (7)$$

This relation holds for both regions and will only occur once in the fully specified model.

High-tech firms maximize their operating profits,⁷ using labour input and the wage rate as their instruments. This behaviour results in a fixed mark-up over labour costs, and a wage rate that is chosen such that it minimizes labour costs resulting from production (yielding the so called Solow-condition). The mark-up relation is written as:

$$p_T = \frac{\epsilon}{\epsilon - 1} \frac{w_T}{eh}. \quad (8)$$

This relation shows that real wages in the tradeables sector increase with labour productivity h . Unit real labour costs (w_T/ehp_T) equal $(\epsilon - 1)/\epsilon$, and are therefore invariant with respect to labour productivity growth.

In this paper, we assume that the efficiency wage relation is only operating in the high-tech sector.⁸ Empirically, this assumption seems justified. Studies by Brown and Medoff (1989), Gera and Grenier (1994), and Krueger and Summers (1988), have revealed (i) that there is an interindustry wage structure that is sig-

6 Because of this assumption we will omit the brand indices i from this point onwards.

7 See the Appendix for a formal statement and solution of the producers' maximization problem.

8 The basic concept of efficiency wages has been studied widely by – among others – Salop (1979), Akerlof (1982), and Shapiro and Stiglitz (1984). Akerlof and Yellen (1986), Katz (1986), and Layard, Nickell and Jackman (1991) provide good overviews. From this literature it seems fairly well established that efficiency wage considerations play a potentially important role in explaining various labour market experiences in developed countries. What all the basic models have in common is that they contain some reason (either retaining workers (Salop (1979)), recruiting workers (Weiss (1980))

nificant and persistent over time, and (ii) that this wage structure cannot be explained solely on the basis of standard competitive factors like differences in skills, working conditions, etc. High-paying industries seem to contain large, capital-intensive firms with extensive product market power. These are the characteristics that we attach to the high-tech sector.

Following Akerlof (1982), the main reason in our model for the high-tech firms to pay efficiency wages is based on sociological considerations. The idea is that each worker has a certain perception of the amount of effort that a 'fair' employer can ask from him. The employer can affect this fair amount by changing the wage he pays. The more he pays, the higher the notion of the worker of the fair amount of effort to be supplied to the employer. The importance of this type of sociological consideration for explaining various phenomena in the labour market is increasingly acknowledged (see, e.g., Solow (1980), and Kahneman, Knetsch and Thaler (1986)).

With respect to the specification of the effort relation we also follow Akerlof (1982). The efficiency of a worker in the one sector (tradeables) depends on the wage he earns related to the wage of a worker in the other sector (non-tradeables):

$$e = -a + c \left(\frac{w_T}{w_N} \right)^\gamma, \text{ where } \frac{1}{c} < \gamma < 1, a > 0 \text{ and } c - a = 1. \quad (9)$$

This formulation guarantees an interior solution of the profit maximization problem for the firm (see Appendix). Invoking the constraints on the parameters implies that $w_T > w_N$ at the optimum. In this case, the Solow condition reads as:

$$\frac{w_T}{w_N} = \left[\frac{a}{c(1 - \gamma)} \right]^{\frac{1}{\gamma}}. \quad (10)$$

This condition states that the firm will increase its wage as long as a one percent increase in wages leads to a more than one percent increase in effort. It turns out that the model exhibits relative nominal wage rigidity (note that the real wage rate in the traditional sector equals one, so that relative real wages come down to real wages in the tradeables sector). Substitution of Equation (10) in Equation (9) gives the optimal effort by employees in the tradeables sector, *viz.*

$$e^* = a \frac{\gamma}{1 - \gamma}.$$

or motivating workers (Shapiro and Stiglitz (1984), and Akerlof (1982))) for a profit-maximizing firm to pay wages that are in excess of market-clearing wages. The result is the existence of equilibrium unemployment.

The labour market consists of three segments, *viz.* employment in the tradeables sector, employment in the non-tradeables sector and unemployed labour. This leads to

$$L = L_T + L_N + U, \quad (11)$$

where U is the number of unemployed people. We will normalize total (exogenous) labour supply at one ($L = 1$), so that L_T , L_N and U can further be seen as ratios. Total labour allocated in the tradeables sector equals

$$L_T = n(L_x + L_r). \quad (12)$$

We assume that labour is immobile over regions and perfectly mobile within a region. Unemployed people receive a real unemployment compensation equal to b , expressed in terms of the non-tradeable good. Consequently, the nominal compensation equals bp_N . This compensation is paid out of lump-sum taxes on labour income, so that total income available in the economy is still described by Equation (5). It is assumed that the net real wage earned in the non-tradeables sector is higher than the real unemployment compensation, so that the unemployment compensation b must be sufficiently smaller than 1. In principle, all the people being unemployed or working in the non-tradeables sector would like to be employed in the tradeables sector, as this leads to an improvement in their earnings.

With respect to the unemployed we assume that the tradeables sector only recruits workers from the pool of unemployed and that in equilibrium the unemployed are indifferent towards accepting a job in the non-tradeables sector or remaining unemployed⁹ (see, e.g., Bulow and Summers (1986), and Burda (1988) for a similar kind of analysis). If the percentage of jobs which will open up in the tradeables sector is denoted by δ , the probability for an unemployed person of finding a job in the tradeables sector equals $\delta L_T/U$. The numerator of this expression describes the number of jobs that open up in the tradeables sector every period. The denominator gives the number of people that are waiting for a job in this sector. A worker is indifferent towards remaining unemployed or accepting a job in the non-tradeables sector if (note that $p_N = w_N$)

$$w_N = \left(\frac{\delta L_T}{U} \right) w_T + \left(1 - \frac{\delta L_T}{U} \right) bw_N, \text{ where } 0 \leq b < 1. \quad (13)$$

Basically, this relation says that the expected pay-off from accepting a job in the non-tradeables sector (left-hand side) is the same as the expected pay-off from

⁹ This is equivalent to saying that a person employed in the non-tradeables sector is indifferent towards becoming unemployed or remaining at work in the non-tradeables sector. Bulow and Summers (1986) find this assumption to be justified both theoretically and empirically.

waiting until a job in the tradeables sector opens up and remaining unemployed in the meantime (right-hand side).

For each region the model counts 12 equations and 12 unknowns, viz. L_x , L_r , L_T , L_N , x , y , U , e , w_N/p_N , w_T/p_T , w_T/w_N and I/p_N . Equation (7), which determines the terms of trade p_T^1/p_T^2 , applies to both regions. Labour productivity h will be explained in section 4 by two dynamic equations. For the moment we have 25 equations and 25 unknowns in total, so that the model can be solved. According to Walras' Law one equation should be redundant, but we already left one equation out (stating that total income is spent on consumption). The model is only solved for real variables. Real income has been denoted in terms of non-tradeables, but given the solution for all relative prices, real income in terms of tradeables can easily be derived.

3 THE ALLOCATION OF LABOUR

The solution of the model is quite straightforward. After substituting Equation (10) into Equation (13) we get

$$U = \frac{W - b}{1 - b} \delta L_T, \text{ where } W \equiv \left[\frac{a}{c(1 - \gamma)} \right]^{\frac{1}{\gamma}}.$$

Note that $W (= w_T/w_N) > 1$, and by definition $b < 1$, so that U/L_T will rise if one of the parameters a , b , or δ increases. According to this relation, there is a positive correlation between unemployment and high-tech employment. This is a typical feature of dual labour market models of this kind and these models are often criticized for this feature (e.g., Lindbeck and Snower (1991)). Two remarks are important to note here. Firstly, it is not the size of the high-tech sector *per se* that matters, but the number of jobs opening up (δL_T). It is well known from the search literature (e.g., Aghion and Howitt (1994)) that higher growth (resulting from a larger high-tech sector in the underlying model) increases creative destruction and consequently increases the rate of job separation and equilibrium unemployment. Though this mechanism is not explicitly modelled here, it can be used as an argument for the positive relation unemployment and high-tech employment. Secondly, unemployment in our model results from supply distortions and should be conceived as wait unemployment, i.e., more workers deliberately queuing up for high-wage jobs the more of these jobs will become available. It is this difference in institutional setting of Europe vs. the USA that we want to focus on and that we conceive as an important element in distinguishing the unemployment performance of the two regions.

Combining the equation for the number of unemployed people with the labour constraint, Equation (11), yields:

$$L_N = 1 - \left[1 + \frac{\delta(W - b)}{1 - b} \right] L_T. \quad (\text{A})$$

What this equation basically says is that a rise of employment in the high-tech sector and the accompanied increase in the number of unemployed people leaves less workers to be employed in the traditional sector. The second relation between L_N and L_T follows from the other equations of the model:

$$L_N = WS L_T, \text{ where } S \equiv \frac{1 - \sigma}{\sigma} \frac{\epsilon}{\epsilon - 1} \frac{1}{1 + \beta}. \quad (\text{B})$$

Note that $0 < \sigma < 1$, $\beta > 0$ and $\epsilon > 1$, so that $S > 0$. This equation shows that, for the circular flow to be in equilibrium, an increase in employment in the high-tech sector must be accompanied with an increase in employment in the traditional sector.

Equating (A) and (B) gives the solution of the model in terms of L_T . Note that in equilibrium the sectoral allocation of labour over sectors is fixed, i.e., independent of the development of labour productivity (h) over time. This will be explained later on.

The solution of the model can easily be shown in a diagram, which decomposes total labour over employment in the non-tradeables sector, employment in the tradeables sector and unemployment (see Figure 1). The slopes of the curves (A) and (B) are $1 + \delta(W - b)/(1 - b)$ and WS , respectively.

In the figure, we have also drawn the full-employment line, which describes all possible divisions of labour over sectors for $\delta = 0$. In this case, there is no reason for people to remain unemployed as no new jobs will open up in the high-wage sector. If $\delta > 0$, however, there is unemployment as $\delta(W - b)/(1 - b) > 0$. The level of unemployment is determined by confronting the equilibrium of the model, i.e., the intersection of line (A) and line (B), with the full-employment line.

The comparative-static analysis will focus on changes in the parameter b which is a measure for the generosity of the unemployment compensation system, and an exogenous change in labour productivity (h) in the high-tech sector of the follower region. The results are summarized in Table 1, where we look at the

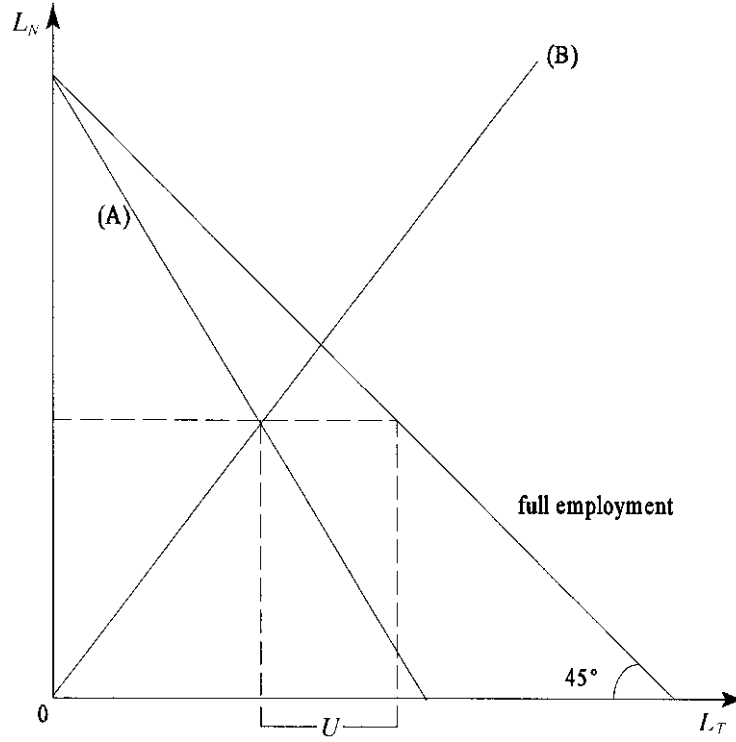


Figure 1 – Goods and labour market equilibrium

effects for region 2. Besides (un)employment levels, we also consider the wage ratio between sectors:

$$\frac{w_T}{w_N} = \left[\frac{a}{c(1-\gamma)} \right]^{\frac{1}{\gamma}},$$

the price ratio between tradeables and non-tradeables:

$$\frac{p_T}{p_N} = \frac{w_T}{w_N} \frac{\epsilon}{\epsilon - 1} \frac{1 - \gamma}{\gamma} \frac{1}{a} \frac{1}{h},$$

and the price ratio in the high-tech sector, i.e., the terms of trade:

$$\frac{p_T^2}{p_T^1} = \left(\frac{x^1}{x^2} \right)^{\frac{1}{\epsilon}} = \frac{w_T^2}{w_T^1} \frac{e^1}{e^2} \frac{h^1}{h^2}.$$

The wage ratio is known from Equation (10). The ratio of prices of high-tech and traditional goods (i.e., the *intraregional* terms of trade) follows from combining Equations (2) and (8) with the optimal efficiency of high-tech workers. The (*interregional*) terms of trade is explained by Equation (7). This equals the price ratio in the high-tech sector, obtained by applying Equation (8) to each region separately and then dividing.

It is important to note that preferences (i.e., the parameter σ) do not show up (directly) in these ratios. Relative prices are determined by relative wages (which in turn are fixed by the parameters of the efficiency wage relation), and the development of relative labour productivity in the course of time. The productivity ratio within a region, i.e., between traditional and high-tech goods, is $1/h$, whereas the productivity ratio in the high-tech sector, i.e., between the backward region and the leader region, is h^2/h^1 . The latter ratio will further be denoted by d .

Another important characteristic of the model follows from the assumption that the regions are symmetrical with regard to the parameters of the efficiency-wage relation (and the strength of competition captured by parameter ϵ), so that relative nominal wages (w_T/w_N) and the effort levels are the same in both regions. This implies that

$$\frac{w_N^2}{w_N^1} = \frac{w_T^2}{w_T^1} = \frac{p_N^2}{p_N^1} = d \frac{p_T^2}{p_T^1}.$$

The interregional wage ratios equal each other and (as $\epsilon > 1$) these ratios will rise if the productivity ratio d increases. These ratios can be rewritten as:

$$d = \frac{p_N^2/p_T^2}{p_N^1/p_T^1} = \frac{w_T^2/p_T^2}{w_T^1/p_T^1},$$

showing that relative productivity levels are fully reflected in both the ratio of the *intraregional* terms of trade and the relative real wage in the high-tech sector. This dichotomous character of the model causes the sectoral allocation of labour to be independent of relative productivity, as the productivity ratio in the high-tech sector is fully reflected in relative real labour costs.

Figure 2 looks at the effects of an increase in real unemployment compensation (b) in region 2. Line (A) turns clockwise around its intercept with the L_N -axis. Higher unemployment compensations make people more willing to wait until a job in the high-tech sector becomes available. This reduces employment in the non-tradeables sector, so that total income diminishes. Accordingly, demand decreases. As a result, unemployment increases. Labour becomes more expensive relative to labour in the other region. The (*interregional*) terms of trade improves so that output and employment in the high-tech sector decrease. Thus a more

TABLE 1 – COMPARATIVE-STATIC RESULTS (FOR REGION 2)

Increase of	Effect on							
	U	L_T	L_N	x	w_T/w_N	p_T/p_N	p_T^2/p_T^1	p_N^2/p_N^1
b^2	+	–	–	–	0	0	+	+
d	0	0	0	+	0	–	–	+

Note: The increase in d is due to an increase in h^2 .

generous unemployment compensation results in higher unemployment and reduced employment in both sectors.

Further, we consider an (exogenous) increase in labour productivity of region 2, which implies a rise of the productivity ratio in high-tech sector (d). The sectoral structure of employment does not change, because there is no incentive to change the demand for labour in the tradeables sector if the productivity ratio increases. (This is due to pricing behaviour of high-tech firms (*cf.* Equation (8)),

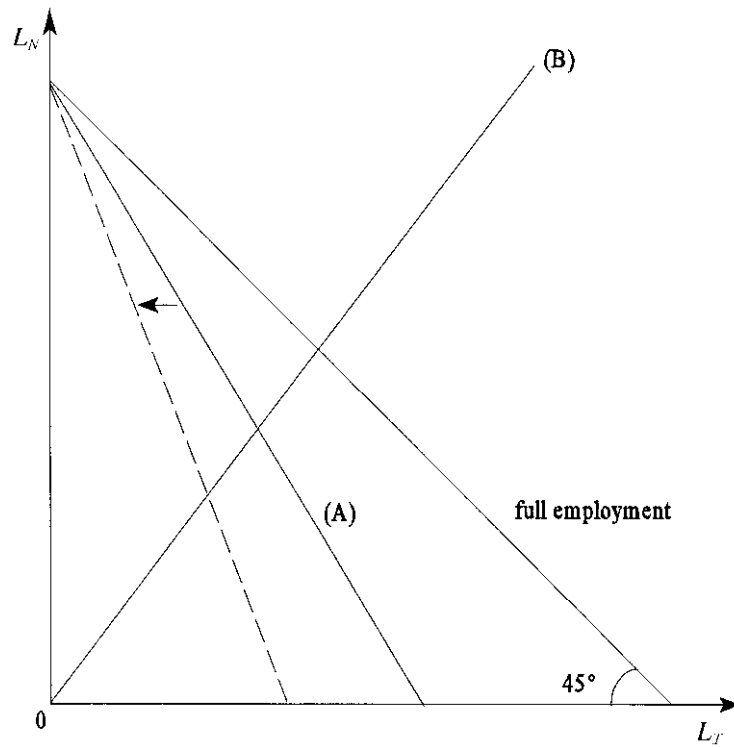


Figure 2 – An exogenous increase in unemployment compensation

which makes unit real labour costs insensitive to productivity changes.) The increase in productivity is followed by a rise of high-tech real wages relative to high-tech real wages in the other region. The terms of trade deteriorates, so that output of the tradeables sector in region 2 increases. Thus, in general, the model predicts that output of the high-tech sector in the backward region grows faster than output of the high-tech sector in the leader region, if the productivity ratio increases. The dynamics behind the process of catching up will be described in the next section.

4 RELATIVE CONVERGENCE

The technology-gap approach to economic growth conceives technological differences as the primary cause for differences in productivity levels across regions. Backward economies may catch up by learning from the experiences of the leader region. As Gerschenkron (1952) has pointed out, catching up is not conceived as being automatic; it requires adequate preconditions to imitate the technological leader, which often contains an element of innovation in its own. A certain level of R&D, for instance, is a necessary condition for successful imitation (*cf.* Fagerberg (1994)). Barro and Sala-i-Martin (1995) describe this leader-follower mechanism as follows (p. 281):

‘The diffusion of technology from leading economies to followers involves costs of imitation and adaptation. We assume that these costs are lower than those for innovation when very little has been copied, but rise as the pool of uncopied ideas gets smaller. This cost structure implies a form of diminishing returns to imitation and thereby tends to generate a pattern of convergence. Follower countries tend to grow faster the greater the gap from the leaders. This process is, however, conditional, in that the growth rate depends, for a given technological gap, on government policies and other variables that influence the rate of return to imitation in a follower economy.’

To model this we follow Krugman (1990, chapter 7), and Van de Klundert and Smulders (1996) and assume that the dynamics of labour productivity in the two regions are given by¹⁰

10 Note that the macroeconomic growth rate is a weighted average of the sectoral growth rates. More concrete, the macroeconomic growth rate (g_m) of region i equals $\sigma^i h^i / h^i$. In terms of the parameters of our model, the macroeconomic growth rate equals

$$g_m^i = \sigma \xi \frac{1}{1 + WS + M} \frac{\beta}{n(1 + \beta)d^{\alpha(i-1)}}, \text{ where } M = \frac{\delta(W - b)}{1 - b}, \text{ and } i = 1, 2.$$

$$\frac{\dot{h}^1}{h^1} = \xi L_r^1, \text{ and} \quad (14)$$

$$\frac{\dot{h}^2}{h^2} = d^{-\alpha} \xi L_r^2. \quad (15)$$

Here, $\xi (> 0)$ stands for an (exogenous) productivity parameter in the R&D labs, and L_r is the number of workers employed in the R&D labs. As total labour L is normalized at one, we can call nL_r the R&D employment ratio. High-tech firms improve their labour productivity by investing in R&D. In addition, firms in the backward region (region 2) can also learn from firms in the other region (region 1), for example by transferring or copying technologies from the leader firms, which do not have to be developed by the followers on their own. Firms in the follower country receive a productivity bonus ($d^{-\alpha}$), which is negatively related to d and positively to α . The parameter α measures the strength of the one-sided spillovers in knowledge between regions. The productivity bonus is highly institutionally determined and contains for instance investments in physical infrastructure, education, the quality of the legal system in the backward region, and the readiness or capability (in terms of, for example, technological congruence) of poor countries to adapt new technologies.

Subtracting Equation (14) from Equation (15) yields:

$$\frac{\dot{h}^2}{h^2} - \frac{\dot{h}^1}{h^1} \equiv \frac{\dot{d}}{d} = \xi \left(\frac{L_r^2}{d^\alpha} - L_r^1 \right). \quad (16)$$

This equation shows that the productivity ratio may increase, decrease or remain constant, depending on the respective amounts of labour employed in the R&D labs, the strength of spillovers, and the initial productivity ratio. Thus the model can explain that an initial leading region becomes a backward region (compare this with the leapfrogging idea of Brezis, Krugman and Tsiddon (1991)), that regions diverge, or that there is a tendency for regions neither to converge nor to diverge. In the latter case (a constant productivity ratio) the wealth of nations measured in absolute productivity levels still increases, because high-tech productivity is (steadily) growing. All these cases are relevant from an empirical

From this we derive the following results:

$$\frac{\partial g_m^i}{\partial \sigma} > 0; \frac{\partial g_m^i}{\partial W} < 0; \frac{\partial g_m^i}{\partial b} < 0; \frac{\partial g_m^i}{\partial n} < 0; \frac{\partial g_m^i}{\partial \beta} > 0; \frac{\partial g_m^i}{\partial \epsilon} > 0; \frac{\partial g_m^i}{\partial \xi} > 0; \frac{\partial g_m^2}{\partial d} < 0.$$

point of view, as has been widely documented in the literature (*cf.* Maddison (1995)).

The process of catching up will come to an end if $\dot{d} = 0$. The associated steady-state locus is (using Equations (3), (4), (7), (8) and (16)):

$$\frac{w_T^2}{w_T^1} = d^{\frac{\epsilon-1-\alpha}{\epsilon}}. \quad (\text{SSL})$$

To investigate the dynamics of the model the steady-state locus should be confronted with the temporary equilibrium locus, which reads (after combining Equations (3), (4), (7) and (8)) as:

$$\frac{w_T^2}{w_T^1} = d^{\frac{\epsilon-1}{\epsilon}} \left[\frac{L_r^1}{L_r^2} \right]^{\frac{1}{\epsilon}}. \quad (\text{TEL})$$

Behind the dynamics of the model is the mechanism of international trade. It is important to realize that according to mark-up pricing, the terms of trade depends positively on the wage ratio in the tradeables sectors and negatively on the productivity ratio, *viz.*

$$\frac{p_T^2}{p_T^1} = \frac{1}{d} \frac{w_T^2}{w_T^1}.$$

The follower country initially faces a productivity ratio smaller than one and lower wages than in the leader country. However, the lower wage ratio cannot fully compensate for the difference in labour productivity, so that the price of the high-tech good of the follower country is higher than the price of the high-tech good of the leader country. The follower country will experience an increase in market share in the world market for high-tech goods if it is able to increase the productivity ratio and thus to lower the terms of trade. As Figure 3 reveals, this will always be the case if $\alpha > \epsilon - 1$. In this case the SSL is sloping downwards, so that the model is stable.¹¹ A relatively high value of α implies more international spillovers, so that there is more room for price decreases in the follower country. A relatively low value of ϵ indicates that the (bundle of) product varieties supplied by the follower country are substantially differentiated from those supplied by the leader country, so that the follower country can relatively easily compete on the world market for high-tech goods (despite lower productivity and higher prices compared to the leader country).

¹¹ The SSL is upward-sloping if $\epsilon - 1 > \alpha$. A relatively high value of ϵ implies small differences in varieties, so that there is much competition by prices. In this case the model is stable if TEL intersects SSL from below.

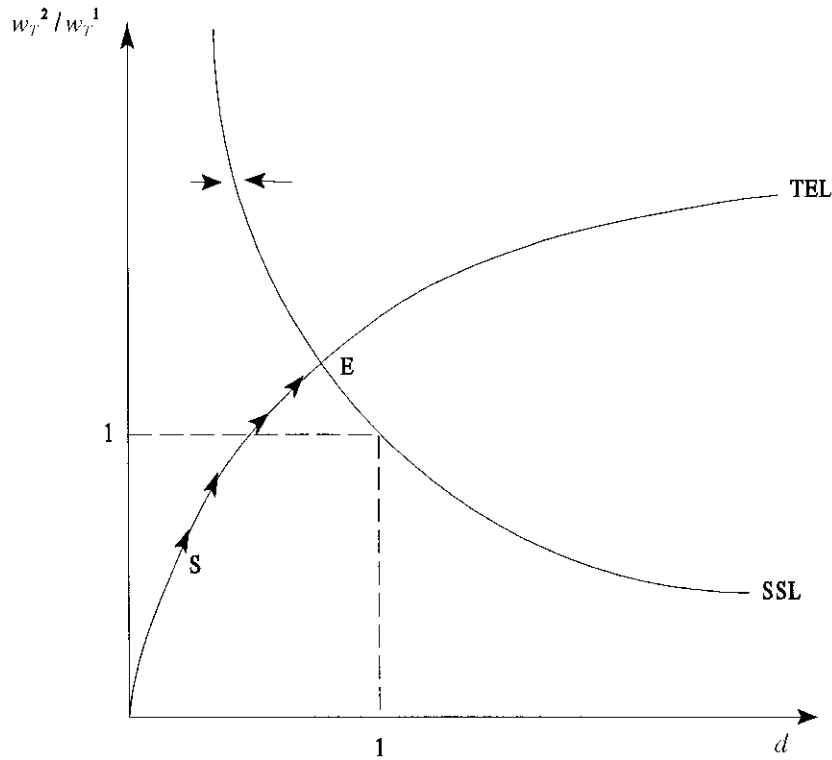


Figure 3 – The dynamics of the model

Figure 3 depicts the dynamic evolution of two regions that differ in two respects. Region 2 initially lags behind region 1. Furthermore, region 2 is characterized by a more generous unemployment compensation system, resulting in high unemployment and a relatively low number of people employed in the R&D labs. The growth rate of region 1 only depends on its research intensity and is thus constant (given constancy of the R&D employment ratio over time). The development of productivity in region 2 relative to region 1 is driven by two factors. It is positively affected by its ‘backwardness,’ and negatively by its relatively small research department. In the diagram, the positive ‘backwardness’ effect dominates initially, resulting in catching up. Ultimately, a steady state is reached in which the positive ‘backwardness’ effect is exactly offset by the negative ‘relative research intensity’ effect. Starting from some initial productivity ratio (point S), the economy will move along the temporary equilibrium locus towards the point where SSL and TEL intersect (point E). In the steady state the two regions will grow at the same pace, but at different levels. In the figure the follower country has a smaller R&D employment ratio than the leader country, implying

that in the steady state wages are higher and productivity is lower than in the leader country. The steady-state productivity level comes down to¹²

$$d^* = \left(\frac{L_r^2}{L_r^1} \right)^{\frac{1}{\alpha}} = \left(\frac{L_T^2}{L_T^1} \right)^{\frac{1}{\alpha}}.$$

This result shows that persisting differences in productivity levels between regions can be explained by persisting differences in employment shares of the tradeables sectors. As we have seen in the previous section, interregional differences in high-tech employment shares (and consequently in R&D employment ratios) crucially depend on differences in the social welfare system. Higher unemployment compensations decrease the fraction of workers in the high-tech sector relative to the total labour force, so that there is less R&D.

5 EMPIRICAL ISSUES

The model developed in this paper stresses the role of high-tech and high-wage sectors in trade between countries with similar tastes, which predominantly exchange very similar, substitutable products. The significance of high-tech firms and industries for macroeconomic development has been explored extensively in recent theoretical and empirical literature on technology and employment. An example is the analysis in the *OECD Jobs Study* (1994). The premises of this comprehensive study are in line with the model developed above. In the same way, the OECD stresses the coincidence of imperfect competition in product markets and wage differentials in labour markets¹³: ‘The duality of the labour market under these circumstances also introduces frictions in the workings of the market mechanism: the unemployed may prolong their job search in the hope of getting into ‘high-wage’ firms and sectors, and displaced workers from the ‘high-wage’ firms and sectors may have very high replacement rates and hence reservation wages when compensations are based on previous earnings.’

The *OECD Jobs Study* extensively explores the relation between ‘high-tech’ and ‘high-wage’ sectors. Starting point is the empirical ‘stylized fact’ that production and sales of manufactured goods takes place in conditions of more or less imperfect competition. R&D spending is increasingly seen as a major source of sunk costs, and therefore of imperfect competition. Product differentiation advantages arise from buyers’ preferences for a specific variety of very similar substitutable products. (Possible reasons are network externalities and investment in information gathering before using the near substitute.) Moreover, there is grow-

¹² Notice that we deal with nearly symmetrical countries and that the only difference we allow for (apart from an initial productivity ratio smaller than one) is $b^2 > b^1$.

¹³ *OECD Jobs Study* (1994), part II, section IV, The effect of imperfect product market competition on wages and employment.

ing evidence that competition in the product market is insufficient to prevent persistent 'supernormal' profits. Rents come about because competitors cannot enter and eliminate supernormal profits. The *OECD Jobs Study* presents empirical evidence on rent-sharing, strongly suggesting that wages differ considerably across broad sectors, even after controlling for age, education, occupation, and gender and that wage premia are relatively stable across time. Manufacturing is the sector paying a relatively high wage premium, whereas the service sectors are generally 'low-wage' sectors (with the exception of the banking sector). The *OECD Jobs Study* distinguishes two main reasons for rent-sharing: union pressure and efficiency wages. These two factors may be operating at the same time, but for the purpose of our paper we have chosen to incorporate only efficiency wage considerations into the analysis.

An important problem in the (empirical) studies on technology and employment is that there are numerous definitions of high-technology industries. The most commonly used are industries which have the highest R&D intensity (for instance defined as the number of workers spending the majority of their time on R&D, or as the ratio of business-enterprise R&D to production) in the OECD area as a whole. This definition excludes those industries which do little R&D even when they are (major) users of technologically sophisticated equipment. To remedy this, the definition can be broadened by taking into account the proportion of high-technology inputs embodied in final products. Applying this concept eliminates all intermediate products and resolves each final product into its ultimate constituent elements: labour and knowledge. This procedure resembles the concept of vertically integrated industries as proposed by Pasinetti (1981). Total research labour 'embodied' in a final product is then decisive for its classification under high-tech or traditional goods.

The *OECD Jobs Study* (part I, Annex 4.A) has grouped manufacturing industries according to technology and wages. A distinction has been made between high, medium, and low-technology groups on the one hand and high, medium, and low-wage groups on the other hand. It appears that most high-technology industries indeed pay high wages. The OECD also shows trends in high-technology industries across countries, for example in Table 4.1 (part I), which shows the development of an international specialization index for high, medium and low wage/technology industries between 1970 and 1992.¹⁴ The table reveals that 'the group of European Community countries have become increasingly specialized in low-wage and low-tech products as compared to the USA and Japan. Between 1970 and 1989, manufacturing employment in Japan increased by 4 per cent overall, in the USA by 1.5 per cent, while in the EC it declined by about 20 percent.' This evidence (in addition to the evidence on total factor productivity

14 The specialization (or revealed comparative advantage) index for a particular type of industry is its share in a country's total manufacturing exports divided by the same share for all OECD countries taken together.

and labour productivity¹⁵) thus suggests that Europe is lagging behind the USA. However, further empirical research will be needed to identify the high-tech sector of an economy and to adequately measure research labour embodied in final products.

6 CONCLUSION

The model developed in this paper suggests various (hypothetical) reasons for the intriguing empirical fact that European countries were catching up with the USA in the fifties and the sixties and stayed behind afterwards. Crucial is the recognition that the sectoral structure of economies and institutions on the labour market is important to understand the development of relative productivity levels among countries. The model predicts that 'backwardness' and relatively high employment shares of manufacturing were the driving forces behind European economic growth in the fifties and sixties. In Europe, a generous unemployment system emerged in the late sixties. This change in system led to an increase in unemployment rates in the European countries, and reduced employment shares in the manufacturing sector. The accompanied adverse effect on the number of people working in Research and Development can explain the subsequent lagging behind (relative convergence) of Europe.

As argued in the introduction, macroeconomic growth empirics seems to have reached a dead end. The great majority of the 'new growth' models are essentially one-commodity models, with no structural change, no transitional dynamics, and lack of attention to institutions. A promising way to breathe new life into growth empirics seems to us the development and testing of multi-commodity models with a sharper focus on sectoral structures, international differences in technical knowledge, and institutional factors. The model of this paper contributes to this type of endogenous growth models. The model ends up with a dynamic equation for relative productivity growth, which explains the process of catching up in terms of relative R&D intensities and initial productivity ratios. Empirical research might take this equation as a starting point. A more extended estimation equation is obtained after expressing the R&D intensities in terms of the parameters of the model. Important institutional determinants of the sectoral structure (and thus of R&D intensities) are, among other things, wage differences between sectors, and the generosity of the compensation system. It should be noticed that, just as in neo-classical growth empirics, the estimation equation is deduced from a consistent framework, which serves as a disciplinary device to avoid testing without theory. Thus, by regressing economic growth more directly on institutional factors of the labour market, new empirical regularities might be detected, which will increase our understanding of the complex process of the development of the wealth of nations.

15 See footnote 1.

APPENDIX

In this appendix we will describe the behaviour of the firm operating in the high-tech sector. Each firm maximizes its operating profits by choosing w_{Ti} and L_{xi} optimally. Formally, this problem can be written as:

$$\max_{L_{xi}, w_{Ti}} \Pi = p_{Ti} e_i \left(\frac{w_{Ti}}{w_N} \right) h_i L_{xi} - L_{xi} w_{Ti}.$$

subject to the efficiency wage relation (9) and the demand function for the variety the firm produces. The first-order conditions for this optimization problem are:

$$\frac{\partial \Pi}{\partial L_{xi}} = \left(\frac{\epsilon - 1}{\epsilon} \right) p_{Ti} h_i e_i - w_{Ti} = 0, \text{ and} \quad (\text{A})$$

$$\frac{\partial \Pi}{\partial w_{Ti}} = p_{Ti} h_i L_{xi} \frac{\partial e_i}{\partial w_{Ti}} \left(\frac{\epsilon - 1}{\epsilon} \right) - L_{xi} = 0. \quad (\text{B})$$

From (A) we can derive the mark-up relation

$$p_{Ti} = \frac{\epsilon}{\epsilon - 1} \frac{w_{Ti}}{h_i e_i}.$$

Combining Equation (B) with (A) yields the familiar Solow condition

$$\frac{\partial e_i}{\partial w_{Ti}} \frac{w_{Ti}}{e_i} = 1.$$

If we now use the Akerlof specification as has been specified in the text (Equation (9)) for the efficiency-wage relation (and the symmetry assumption) we arrive at:

$$\frac{w_T}{w_N} = \left[\frac{a}{c(1 - \gamma)} \right]^{\frac{1}{\gamma}}.$$

REFERENCES

- Aghion, Ph. and P. Howitt (1994), 'Growth and Unemployment,' *Review of Economic Studies*, 61, pp. 477-494.
- Akerlof, G.A. (1982), 'Labor Contracts as Partial Gift Exchange,' *Quarterly Journal of Economics*, 97, pp. 543-569.
- Akerlof, G.A. and J.L. Yellen (1986), 'Introduction,' in: G.A. Akerlof and J.L. Yellen (eds.), *Efficiency Wage Models of the Labor Market*, Cambridge, Cambridge University Press, pp. 1-21.
- Ark, B. van and D. Pilat (1993), 'Productivity Levels in Germany, Japan, and the United States: Differences and Causes,' *Brookings Papers on Economic Activity: Microeconomics*, 2, pp. 1-64.
- Barro, R.J. and X. Sala-i-Martin (1995), *Economic Growth*, New York, McGraw-Hill.
- Bean, Ch. and N. Crafts (1995), *British Economic Growth since 1945: Relative Economic Decline ... and Renaissance?*, CEPR Discussion Paper 1092, London.
- Bean, Ch. and Chr. Pissarides (1993), 'Unemployment, Consumption and Growth,' *European Economic Review*, 37, pp. 837-859.
- Bean, Ch.R. (1994), 'European Unemployment: A Survey,' *Journal of Economic Literature*, 32, pp. 573-619.
- Brezis, E., P. Krugman, and D. Tsiddon (1991), *Leapfrogging: A Theory of Cycles in National Technological Leadership*, NBER Working Paper 3886, Cambridge, MA.
- Brown, Ch. and J. Medoff (1989), 'The Employer Size-Wage Effect,' *Journal of Political Economy*, 97, pp. 1027-1059.
- Bulow, J.I. and L.H. Summers (1986), 'A Theory of Dual Labor Markets with Application to Industrial Policy, Discrimination, and Keynesian Unemployment,' *Journal of Labor Economics*, 4, pp. 376-414.
- Burda, M. (1988), '"Wait Unemployment" in Europe,' *Economic Policy*, 7, pp. 391-425.
- Coe, D.T. and E. Helpman (1995), 'International R&D Spillovers,' *European Economic Review*, 39, pp. 859-887.
- Dixit, A. and J.E. Stiglitz (1977), 'Monopolistic Competition and Optimum Product Diversity,' *American Economic Review*, 67, pp. 297-308.
- Dollar, D. and E.N. Wolff (1993), *Competitiveness, Convergence, and International Specialization*, Cambridge, MA, MIT Press.
- Dosi, G. (1988), 'Sources, Procedures, and Microeconomic Effects of Innovation,' *Journal of Economic Literature*, 26, pp. 1120-1171.
- Fagerberg, J. (1994), 'Technology and International Differences in Growth Rates,' *Journal of Economic Literature*, 32, pp. 1147-1175.
- Gera, S. and G. Grenier (1994), 'Interindustry Wage Differentials and Efficiency Wages: Some Canadian Evidence,' *Canadian Journal of Economics*, 27, pp. 81-100.
- Gerschenkron, A. (1952), 'Economic Backwardness in Historical Perspective,' in: B.F. Hoselitz (ed.), *The Progress of Underdeveloped Areas*, Chicago, University of Chicago Press.
- Kahneman, D., J.L. Knetsch, and R. Thaler (1986), 'Fairness as a Constraint on Profit Seeking: Entitlements in the Market,' *American Economic Review*, 76, pp. 728-741.
- Katz, L.F. (1986), 'Efficiency Wage Theories: A Partial Evaluation,' in: S. Fischer (ed.), *NBER Macroeconomics Annual 1986*, pp. 235-289.
- Klundert, Th. van de and S. Smulders (1996), 'North-South Knowledge Spillovers and Competition. Convergence versus Divergence,' *Journal of Development Economics*, 50, pp. 213-232.

- Krueger, A.B. and L.H. Summers (1988), 'Efficiency Wages and the Inter-industry Wage Structure,' *Econometrica*, 56, pp. 259-293.
- Krugman, P.R. (1990), *Rethinking International Trade*, Cambridge, MA, MIT Press.
- Layard, R., St. Nickell, and R. Jackman (1991), *Unemployment, Macroeconomic Performance and the Labour Market*, Oxford, Oxford University Press.
- Lindbeck, A. and D.J. Snower (1991), *Segmented Labour Markets and Unemployment*, CEPR Discussion Paper 523. London.
- Maddison, A. (1995), *Monitoring the World Economy 1820-1992*, Paris, OECD Development Centre Studies.
- Mankiw, N.G. (1995), 'The Growth of Nations', *Brookings Papers on Economic Activity*, 22, pp. 271-326.
- McKinsey Global Institute (1996), *Capital Productivity*, McKinsey and Company, Washington D.C.
- Mueller, D.C. (1986), *Profits in the Long Run*, Cambridge, Cambridge University Press.
- OECD (1993), *The International Sectoral Database*, Paris.
- OECD (1994), *The OECD Jobs Study; Evidence and Explanations*, parts I and II, Paris.
- Olson, M. (1996), 'Big Bills Left on the Sidewalk: Why Some Nations are Rich, and Others Poor,' *Journal of Economic Perspectives*, 10, pp. 3-24.
- Pasinetti, L.L. (1981), *Structural Change and Economic Growth, A Theoretical Essay on the Dynamics of the Wealth of Nations*, Cambridge, Cambridge University Press.
- Salop, S.C. (1979), 'A Model of the Natural Rate of Unemployment,' *American Economic Review*, 69, pp. 117-125.
- Schaik, A.B.T.M. van and H.L.F. de Groot (1995), *Unemployment and Endogenous Growth*, CentER Discussion Paper 9575, Tilburg.
- Shapiro, C. and J.E. Stiglitz (1984), 'Equilibrium Unemployment as a Worker Discipline Device,' *American Economic Review*, 74, pp. 433-444.
- Solow, R.M. (1980), 'On Theories of Unemployment,' *American Economic Review*, 70, pp. 1-11.
- Summers, R. and A. Heston (1991), 'The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988,' *Quarterly Journal of Economics*, 106, pp. 327-368.
- Weiss, A. (1980), 'Job Queues and Layoffs in Labor Markets with Flexible Wages', *Journal of Political Economy*, 88, pp. 526-538.

Summary

UNEMPLOYMENT AND CATCHING UP: EUROPE VIS-À-VIS THE USA

This paper develops a two-region two-sector endogenous growth model with a dual labour market based on efficiency wages. Growth is driven by research done in the (high-tech) tradeables sector. The follower region tends to catch up in terms of labour productivity with the leader region. Differences in unemployment compensation systems can lead to relative convergence, i.e., a steady state with the backward region lagging behind the leader region. The reason for this is that high social welfare compensations generate high unemployment and reduce the amount of labour employed for R&D purposes.