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## Efficiency wages, unemployment and welfare: A trade theorists' guide

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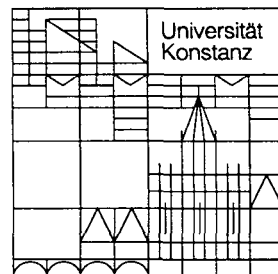
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**Sonderforschungsbereich 178**  
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Juristische  
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Fakultät für Wirtschafts-  
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Jürgen Meckl

**Efficiency Wages, Unemployment  
and Welfare:  
A Trade Theorists' Guide**

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**Efficiency Wages, Unemployment and Welfare:  
A Trade Theorists' Guide**

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## **Abstract**

The paper incorporates the efficiency–wage theory into an otherwise standard trade model. The model accounts for sector-specific job rents and involuntary unemployment while preserving decisive properties of the competitive full-employment approach. The key results from the literature can be derived from special cases; e.g., raising minimum wages can reduce unemployment. Additionally, we derive new, counterintuitive results: (a) Emigration can raise home employment. (b) Immigrants might not only find employment but also raise employment for non-immigrants. (c) Investment can reduce employment. (d) Raising unemployment benefits can reduce unemployment.

# 1 Introduction

Incorporating efficiency wages into otherwise standard trade models has become increasingly popular in the recent trade literature. There are two general reasons for choosing this special framework. First, in the eyes of many authors efficiency-wage theories are one of the most promising approaches to explain involuntary unemployment (cf. Blanchard & Fischer 1989). Second, these theories seem to explain some observed regularities and provide some new theoretical insights. Concerning the second point, we have listed below what we view as the *key results* of the different efficiency-wage models (EWMs). Both points explain why efficiency-wage approaches have been substituted for the the minimum-wage approaches dominating the discussion of unemployment and welfare effects of trade and commercial policies in the trade literature of the seventies and early eighties (cf. Brecher 1974, Schweinberger 1978, Neary 1985).

The following key results seem to cover the most important effects of efficiency wages in open economies.

1. Efficiency wages help to explain the observed stability of intersectoral wage differentials (Bulow & Summers 1986, Krueger & Summers 1988, Katz & Summers 1989).
2. Social welfare and aggregate unemployment can be positively correlated (Brecher 1992, Agell & Lundborg 1995).
3. Trade liberalization can reduce social welfare (Agell & Lundborg 1995, Copeland 1989). In fact, it can even reduce welfare for all trading partners.
4. Trade liberalization can reduce unemployment for all trading partners (Matusz 1996). In a fully competitive two-by-two Heckscher-Ohlin model, trade reduces unemployment in the labor-abundant country (Hoon 1991).
5. Protection of high-wage sectors can be welfare-improving (Matusz 1994, Bulow & Summers 1986, Katz & Summers 1989).
6. Raising minimum wages can reduce unemployment (Manning 1995).

These results have been derived from different versions of EWMs. Some are multisector models, some not. In some of them, efficiency wages do not generate

unemployment due to the existence of a secondary labor market. Most are quite complicated to analyze.

Subsequently, we develop a *simple* EWM which allows to obtain all these different results, and more, from a unified framework. Specifically, we will add to the list two closely related results that seem to be worth mentioning.

7. Immigration from abroad (or an exogenous increase in the home labor force) can raise employment among the home labor force. Under other circumstances, emigration can raise employment among the home labor force. By essentially the same mechanism, inflows of other factors (e.g., investment) can lead to increases in unemployment.
8. Raising unemployment benefits can reduce unemployment.

The simplified efficiency–wage approach we use is an extension of Solow’s (1979) model: Wages affect the productivity of labor in the production process and therefore are an argument in the production function. When it comes to the details, however, we combine arguments from two strands of the efficiency–wage literature.

Concerning the motivation of workers, we use the fair–wage approach of Akerlof (1982) and Akerlof & Yellen (1990). These authors assume that workers, in determining their effort, compare their wage with other factor prices in the same sector. If they receive relatively high wages, they reciprocate by exerting high effort at work. While this is the basic idea, other variables like the rate of unemployment also have an influence on effort.

The difference between our approach and the one of Akerlof and Yellen is that in our model the standard of fairness is not provided by intra–firm comparisons with other factor prices but by a comparison with one’s own opportunities outside the firm. In this respect, we follow the approach of Summers’ (1988), who assumes labor productivity to depend on relative wages that reflect the relative attractiveness of opportunities outside the firm. Taking up this idea, we assume that workers’ concern with fairness links labor productivity to the wage paid by the firm relative to average labor income across the economy.<sup>1</sup>

This leads to a model that preserves an important feature of standard trade models: The equilibrium allocation maximizes income under slightly modified lin-

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<sup>1</sup>A less general version of such a model has already been explored by Albert & Meckl (1997).

ear resource constraints. Despite the fact that there is involuntary unemployment, a transformation surface exists, and the equilibrium allocation is determined by a point of tangency between this surface and an iso-income hyperplane.

This feature, which gives rise to the useful envelope properties of the GDP function, is absent from most EWMs. This explains why these other models are so difficult to analyze: They include more distortions than necessary. With the model presented here, it is possible to focus on the one distortion we are interested in, namely, unemployment, without having to buy into further distortions that destroy the envelope properties of the GDP function.

The fact that our model allows to derive the above-mentioned key results demonstrates that the additional distortions are inessential in terms of results. Of course, the transmission of changes in exogenous variables to changes in unemployment differ between our model and the models in which the key results have originally been found. Insofar as the interest in the models derives from an interest in the results, however, this should not be a disadvantage of the present approach.

In many respects, the production side of our model behaves like a standard general equilibrium (GE) model of production. Well-known properties of special structures like the Heckscher–Ohlin (HO) or specific-factors (SF) model directly carry over; comparative-static effects need only minor reinterpretation. The derivation of the EWM key results uses much of the well-known mechanics of simple general equilibrium models of production. The present variant of the efficiency-wage approach can therefore be regarded as a workhorse model of trade and unemployment: Unemployment can be introduced in many important traditional contexts with minimum costs in terms of algebra.

The paper is organized as follows. Section 2 develops the basic model of efficiency-wage induced unemployment in a standard trade model and derives key result 1 in passing. As an application to traditional problems, section 3 analyzes the effects of trade in the presence of unemployment (key results 2 to 5). Section 4 considers the effects on unemployment of factor movements and minimum wages (key results 6 to 8), demonstrating that these results are intimately connected. Section 5 offers some concluding remarks.



## 2 A Simple General–Equilibrium Model of Production and Unemployment

### 2.1 Fair Wages

On the basis of our version of the efficiency–wage model is the idea of Akerlof and Yellen (cf. Akerlof 1982, Akerlof & Yellen 1990) that firms and workers implicitly exchange gifts: If firms set higher wages in relation to some reference wage, workers reciprocate with higher effort. The source of this behavior is that workers respect a fairness norm. There are two alternative views of such a norm. The norm can be viewed as a constraint, restricting optimizing behavior. The other view is that a norm comes with a definition of a degree of norm violation, and that people choose an optimal degree of norm violation. Both views yield identical consequences. We use the norm–as–constraint presentation but derive it from the optimal–norm–violation framework.

Let us consider a simple specification of consumers' utility functions: Consumers derive utility from consumption and derive disutility from effort at work. The individual and aggregate labor supply is fixed; workers, if they are not unemployed, can only adjust their effort. Effort is adjusted according to a fairness norm. We consider a utility function  $u(c, |\epsilon - \epsilon_n|, \epsilon)$ , where  $c$  is consumption and  $\epsilon$  is effort at work while  $\epsilon_n$  is the effort required by a fairness norm. We will come back to the question how  $\epsilon_n$  is determined; for now, we just assume that it is given.  $\epsilon - \epsilon_n$  then is the extent of norm violation. We assume that overcompliance  $\epsilon > \epsilon_n$  and undercompliance  $\epsilon < \epsilon_n$  both generate discomfort; for simplicity, we assume that the effects are symmetric which makes the absolute value  $|\epsilon - \epsilon_n|$  the relevant argument. Both norm violation and effort have a negative marginal utility. From this, it immediately follows that effort will never be higher than required by the norm since in the case of  $\epsilon > \epsilon_n$ , the same extent of norm violation,  $|\epsilon - \epsilon_n|$ , could be generated by less effort. Assuming interior solutions, utility maximization on the basis of given income implies that effort is an increasing function of  $\epsilon_n$ . We simplify our model by assuming separation properties of the utility function leading to an indirect utility function of the form  $v(\mathbf{p}, y) - h(\epsilon_n)$ , where  $\mathbf{p}$  is the vector of prices of consumer goods,  $y$  is income, and  $\epsilon = h(\epsilon_n)$  is the optimal level of effort depending on the effort  $\epsilon_n$  required by the fairness norm.

We further simplify the analysis by assuming homothetic preferences over consumption goods; specifically, we choose  $u$  to be linearly homogenous in  $\mathbf{c}$ , which implies  $v(p, y) = y/e(\mathbf{p})$  with  $e(\mathbf{p})$  as a non-decreasing, linearly homogenous and concave price-index function. Such an indirect utility function might be derived from a constant degree of optimal norm violation as it follows from a quasi-linear utility function in  $|\epsilon - \epsilon_n|$  and  $\epsilon$ . For instance, the specification

$$u(\mathbf{c}, |\epsilon - \epsilon_n|, \epsilon) = \bar{u}(\mathbf{c}) - (\epsilon - \epsilon_n)^2 - \epsilon,$$

where  $\bar{u}$  is any linearly homogenous utility function, fulfills all our requirements.

We assume that the effort  $\epsilon_n$  required by the fairness norm depends on the employer's wage offer  $w$  and the reference wage  $\bar{w}$ . We assume that  $\bar{w}$  is average labor income. Thus workers, in determining how much effort is required by fairness considerations, compare their wage with the average labor income in the economy, including the labor income of the unemployed, which might either be zero or determined by unemployment benefits. We will refer to  $\bar{w}$  as the reference wage. The reference wage, defined in this way, is equal to the expected labor income of a worker drawn randomly from the population. It therefore reflects the different alternatives of workers, including unemployment. Labor-market conditions affect the reference wage through the proportion of workers receiving no labor income or unemployment benefits.

On a technical level, we assume

$$\epsilon = \epsilon(w/\bar{w}) \stackrel{\text{def}}{=} h[\epsilon_n(w/\bar{w})],$$

where  $\epsilon' > 0$  because  $\epsilon_n$  is increasing in  $w/\bar{w}$ . The function  $\epsilon(w/\bar{w})$  is called the effort function. Later, we consider an affine effort function since even this simple specification allows for all the cases we are interested in.

It is, of course, an enormous simplification to assume that workers, in determining the effort due to their employer, just compare the wage they receive with the expected or average labor income. But, as we will see, this simple approach has the advantage of explaining the rigidity of intersectoral wage differentials (key result 1). In the absence of direct evidence, we think that this is enough to justify the assumption in a macroeconomic context, where no more can be done than to highlight key variables and account for a few stylized facts.

To summarize, a worker's utility as a function of prices and income is

$$\nu(\mathbf{p}, w, \bar{w}, a) \stackrel{\text{def}}{=} \frac{w + a}{e(\mathbf{p})} - \epsilon\left(\frac{w}{\bar{w}}\right), \quad (1)$$

where  $a$  is non-labor income. Of course, the wage  $w$  will be sector specific. Unemployed workers will either receive only non-labor income or—in one version of the model—non-labor income plus unemployment benefits. In either case, they will exert no effort. We assume that the indirect utility functions of all workers are identical. Note that the notation no longer indicates whether the effort function is a constraint or the result of optimization.

## 2.2 Participation Constraint and Job Rent

The indirect utility function (1) allows us to derive a participation constraint restricting cost-minimizing wage setting of the firm. A worker will decline employment in a sector where the real wage  $w/e(\mathbf{p})$  is lower than the disutility of effort  $\epsilon(w/\bar{w})$ , i.e. where there is a negative job rent  $w/e(\mathbf{p}) - \epsilon(w/\bar{w})$ .

Let us write the wage set by the firm as a markup on the reference wage:  $w = (1 + q)\bar{w}$ , where we will find later that  $q > 0$ . With the definitions

$$\begin{aligned} R(q) &\stackrel{\text{def}}{=} (1 + q) \frac{\bar{w}}{e(\mathbf{p})} \\ E(q) &\stackrel{\text{def}}{=} \epsilon(1 + q), \end{aligned} \tag{2}$$

we can write the participation constraint as

$$R(q) \geq E(q). \tag{3}$$

The LHS of the inequality is the real wage paid by the firm, i.e. the wage defined by a markup  $q$  on the reference wage and deflated by the relevant price index. The RHS is the effort. We consider both variables as functions of the markup  $q$  because this simplifies the exposition.

There is no clear economic intuition concerning the properties of an effort function. At least for some relevant range, any behavior seems possible. Since we do not aim at completeness, we simplify matters and assume that the effort function is affine in the relevant range:

$$E(q) = a + b(1 + q) \quad a, b > 0 \tag{4}$$

Note, however, that this specification is used only for purposes of illustration. Nothing really depends on it.

We then distinguish between two cases where the two graphs intersect each other. The first case is illustrated in fig. 1.  $E(q)$  is flatter than  $R(q)$ . The vertical

difference between the the graph of  $R(q)$  and the graph of  $E(q)$  is the job rent. Thus, the job rent rises with the markup  $q$  and therefore with the wage paid, being negative before and positive after the intersection point of  $R(q)$  and  $E(q)$ . Firms must be careful to set the markup on the reference wage  $q$  at least equal to the value  $q^*$  at the intersection point where the job rent is just zero. If the real reference wage  $\bar{w}/e(\mathbf{p})$  rises, the minimal markup  $q^*$  falls. In other words: If the real reference wage is higher, a lower markup is sufficient to compensate workers for the effort. If one considers several firms setting different markups, it follows in this case that wages and job rents are *positively* correlated.

Insert fig. 1 here!

In the second case (not illustrated),  $E(q)$  is steeper than  $R(q)$  and, accordingly, the job rent falls with the markup  $q$  and therefore with the wage paid. Firms must then be careful to set the markup on the reference wage  $q$  not higher than some value  $q^*$ , beyond which the job rent becomes negative. The intuition is that, beyond  $q^*$ , fairness considerations would force workers to work so hard that their extra income cannot compensate them. The maximum markup  $q^*$  increases with a rise in the real reference wage. In other words: If the real reference wage is higher, a higher markup is tolerable. If one again considers several firms setting different markups, it follows in this case that wages and job rents are *negatively* correlated.

In the present paper, we will not consider other cases than those of a clearly positive or a clearly negative correlation between wages and job rents, although other cases could easily be relevant. However, these two clearcut cases already yield the key results we are interested in.

Subsequently, we will always assume that the participation constraint is not active, which implies that the cost-minimizing value of the markup  $q_j$  is on the admissible side of  $q^*$ . Since it will turn out that the cost-minimizing markups are constant, inactivity of the participation constraint translates into the assumption that the real reference wage is low or high enough. If the participation constraint were active, unit-cost minimization would imply  $q_j = q^*$ . Unit costs, then, would depend on goods prices since  $q^*$  depends on the real reference wage. We will ignore this possibility since it is of no special interest for our purposes. With an inactive participation constraint, job rents are positive in all sectors. With even

one positive job rent, unemployment is involuntary. Furthermore, the assumption of positive job rents obviously implies that the reference wage is non-zero.

## 2.3 Cost Minimization

Consider the problem of a representative firm in sector  $j$ . The firm's wage offer influences workers' effort and thereby the efficiency of labor. While the reaction of workers' effort to changes in the wage offer is identical across industries, the increase in efficiency resulting from the same effort differs across industries: In some jobs, effort makes all the difference, and a highly motivated person can easily replace two less motivated ones. In other jobs, effort does not matter much as long as it does not fall short of some minimum. To capture this idea, we assume that labor input in efficiency units is an increasing function of effort:

$$G_j(\epsilon)L_j, \quad G'_j > 0 \quad (5)$$

$L_j$  is the physical labor input in sector  $j$ . As already stated above, workers' effort  $\epsilon$  is an increasing function of  $w_j/\bar{w}$ . Average labor income  $\bar{w}$  is a parameter for the firm while its own wage offer  $w_j$  can be set optimally. Let us denote the function mapping  $w_j/\bar{w}$  to efficiency of labor by

$$g_j\left(\frac{w_j}{\bar{w}}\right) \stackrel{\text{def}}{=} G_j\left[\epsilon\left(\frac{w_j}{\bar{w}}\right)\right]. \quad (6)$$

Consider a competitive firm that faces a given reference wage  $\bar{w}$  and given prices  $\mathbf{r}$  for other factors of production. If the firm produces with the help of a linearly homogenous production function  $f_j$ , it will minimize unit costs:

$$\min_{w_j, L_j, \mathbf{v}^j} \left\{ w_j L_j + \sum_{i=1}^m r_i v_i^j : f_j(g_j(w_j/\bar{w})L_j, \mathbf{v}^j) \geq 1, \quad L_j, v_i^j, w_j \geq 0 \right\}. \quad (7)$$

The outcome of problem (7) is well-known and can be derived by elementary computations. The wage rate  $w_j$  is determined by the condition that the elasticity of the efficiency function  $g_j$  is equal to unity. Assuming that  $g_j$  is a strictly concave function with  $g_j(\bar{x}) = 0$  for some  $\bar{x} > 0$ , this condition leads to a unique solution for  $w_j/\bar{w}$ . Efficiency-wage induced unemployment results if this solution is greater than one, which we will assume to be the case for all sectors. Thus we find as a solution for the sectoral wage rate  $w_j = (1 + q_j)\bar{w}$  with some constant

$q_j > 0$ . As already mentioned before, the cost-minimizing wage is determined by a fixed markup on the reference wage. Subsequently, we write  $\bar{\epsilon}_j$  for the fair value  $\epsilon(1 + q_j)$  of effort,  $\bar{g}_j$  for the optimal value of labor efficiency  $G_j(\bar{\epsilon}_j)$ , and  $\bar{L}_j$  for efficient labor  $\bar{g}_j L_j$ .

Thus, the intersectoral wage differential between industries  $i$  and  $j$  is given by  $(q_i - q_j)/(1 + q_i)$ , independently from unemployment or relative prices and therefore constant over time. This is key result 1. As remarked in the introduction, this result is a key result because empirical studies find significant wage differentials that are quite stable over time. The theoretical explanations of this stylized fact advanced in these studies, although based on efficiency wages, abstract from unemployment. Those models featuring unemployment, on the other hand, are based on more complicated versions of the efficiency-wage theory, e.g. Matusz' (1994) version of the shirking approach. In these complicated models, intersectoral wage differentials are not independent from other variables like unemployment. The present approach gives the most simple explanation in terms of efficiency wages of both, unemployment and stable intersectoral wage differentials.

Given the optimal values  $q_j$  and  $\bar{g}_j$ , we can define the unit-cost functions by

$$b_j(\bar{w}, \mathbf{r}) \stackrel{\text{def}}{=} \min_{L_j, \mathbf{v}^j} \left\{ \bar{w}(1 + q_j)L_j + \sum_{i=1}^m r_i v_i^j : f_j(\bar{g}_j L_j, \mathbf{v}^j) \geq 1, L_j, v_i^j \geq 0 \right\}. \quad (8)$$

A comparison of first-order conditions of (7) and (8) shows that both minimization problems describe the same behavior. The only difference is that we have already used part of the solution in the definition of (8).

Applying the envelope theorem to (8) implies

$$\begin{aligned} \frac{\partial b_j(\bar{w}, \mathbf{r})}{\partial \bar{w}} &= (1 + q_j) a_{L_j}(\bar{w}, \mathbf{r}) \\ \frac{\partial b_j(\bar{w}, \mathbf{r})}{\partial r_i} &= a_{ij}(\bar{w}, \mathbf{r}), \end{aligned} \quad (9)$$

where  $a_{L_j}$  and  $a_{ij}$  are the input coefficients of the respective factors. We will use these unit-cost functions to determine the equilibrium allocation in the usual way.

## 2.4 Labor Absorption and Unemployment

The reference wage  $\bar{w}$  is the average labor income, where the average includes the labor income of the unemployed, which is either zero or equal to unemployment benefits. There are several assumptions concerning unemployment benefits that are consistent with our simple model. One is that there are no such benefits; instead, workers own other factors of production from which they derive income. In this case, the reference wage is

$$\bar{w} \stackrel{\text{def}}{=} \sum_{j=1}^n w_j L_j / L, \quad (10)$$

where  $L$  is the national labor supply, which we assume to be given. Substituting in (10) the solutions  $w_j = (1 + q_j)\bar{w}$  for the sectoral wages yields the following restriction for employment:

$$\sum_{j=1}^n (1 + q_j) L_j = L \quad (11)$$

Since we have assumed  $q_j > 0$  for all  $j$ , this means that any allocation yields unemployment.

Let us look at the same result in a slightly different way. The wage in each sector is given by a markup on average labor income  $\bar{w}$ . Thus, for every worker employed in this sector, there must be a matching number of workers who are unemployed in order to bring average labor income down to  $\bar{w}$ . Let us call the number of workers employed in the sector plus the number of unemployed required to make average earnings equal to  $\bar{w}$  the amount of labor *absorbed* by the sector. Let us denote labor absorbed by sector  $j$  by  $N_j$ . Then the relation we have just explained reads  $w_j L_j / N_j = \bar{w}$ . Substituting  $w_j = (1 + q_j)\bar{w}$ , we find  $N_j = (1 + q_j)L_j$ . In other words: Sectoral labor absorption is given by a fixed markup on sectoral employment; the markup is the same as the one determining the wage rate with reference to average labor income. The employment constraint (11) just tells us that aggregate labor absorption must equal the national labor supply. Moreover, this consideration squares with the equation  $\partial b_j / \partial \bar{w} = (1 + q_j)a_{Lj}$ : The derivative of the unit-cost functions w.r.t. the reference wage is the labor-absorption-coefficient of the respective sector. These considerations imply that the results of the standard models concerning sectoral employment carry over to sectoral labor absorption.

Since the effect of effort on labor efficiency is sector-specific, i.e. the  $q_j$ 's vary across industries, the level of unemployment varies with sectoral employment. This is the most important feature of models combining efficiency wages with a multi-sectoral structure, and the source of all the counterintuitive results derivable from them.

## 2.5 Unemployment Benefits

It is possible to introduce unemployment benefits and still preserve the simplicity of the model. We just have to assume that benefits are financed by a proportional tax on wage incomes, while tax revenues are distributed equally among the unemployed. This is quite a crude approximation to real-world benefit systems. Still, it allows us to discuss possible incentive effects of these benefits.<sup>2</sup>

Given our assumptions, the reference wage has to take after-tax wage incomes and unemployment benefits into account, where both components are weighted by the rates of employment and unemployment, respectively. With

$$\mu = \frac{L - \sum_{j=1}^n L_j}{L}$$

as the rate of unemployment, the reference wage is defined as

$$\bar{w} \stackrel{\text{def}}{=} \frac{(1-t) \sum_{j=1}^n w_j L_j}{\sum_{j=1}^n L_j} (1-\mu) + \frac{t \sum_{j=1}^n w_j L_j}{L - \sum_{j=1}^n L_j} \mu. \quad (12)$$

Obviously, the reference wages defined by (10) and (12) are identical. Incentives, however, may be different if such a system of unemployment benefits exists. Given positive unemployment benefits, the question arises whether the fairness norm considers before-tax or after-tax wages. Probably, a mixture of both is more realistic than either of the extremes. Such a mixture could easily be considered; however, we are content to spell out the consequences of the extreme cases.

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<sup>2</sup>Our assumptions imply that benefits depend on the extent of unemployment. Many benefit systems, however, fix benefits in relation to some point of reference. However, at least at the point where tax increases encounter strong political opposition, there is usually a strong tendency to cut benefits if unemployment increases. Thus, a system of the kind envisaged in the text is not completely out of the world.



If  $w_j = (1 + q_j)\bar{w}$  as before (before-tax wage is relevant), nothing changes in comparison with the case of zero unemployment benefits. That is, if the labor supply is fixed, unemployment benefits do not necessarily affect incentives; we can have a case where they amount to a pure redistribution among workers.<sup>3</sup>

If, on the other hand,  $(1 - t)w_j = (1 + q_j)\bar{w}$  (net wage is relevant), the employment restriction takes on the form

$$\sum_{j=1}^n (1 + q_j)L_j = (1 - t)L. \quad (13)$$

That is, there is a second component of unemployment not depending on sectoral structure but on taxation. Firms, in determining the optimal wage, have to pay more on account of the tax since workers ignore—unfairly, as capital owners might complain—the before-tax wage rates in trading off the disutility of effort against compliance with the fairness norm. The effect is the same as the effect of reducing the overall labor supply. Concerning the effects of the latter, however, we are in for a surprise; we will come back to this point.<sup>4</sup>

## 2.6 The Equilibrium Allocation

We now consider the equilibrium conditions of the model with the employment constraint (11). All we have to say holds *mutatis mutandis* for a model using (13) instead of (11).

Obviously, the usual zero-profit conditions must hold for all goods:

$$b_j(\bar{w}, \mathbf{r}) \geq p_j, \quad x_j \geq 0 \quad \text{w.c.s.} \quad j = 1, \dots, n \quad (14)$$

“w.c.s.” stands for “with complementary slackness”. We assume that factors other than labor are also in fixed supply. Factor markets must clear for all factors except labor; for labor the condition (11) replaces the standard constraint. As already mentioned, the participation constraint requires a certain level for  $\bar{w}$ ; in

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<sup>3</sup>Even with an endogenous labor supply, the conclusion need not be different. If it is necessary to be registered as unemployed in order to get job offers, unemployment benefits will not change the incentives to register.

<sup>4</sup>If labor is taxed differently in different sectors, as it is implied, e.g. by the treatment of earnings from night shifts in some countries, we could without great difficulty introduce sector specific tax effects.

assuming that this condition is met, we have implicitly ruled out the possibility that (11) holds as an inequality rather than an equality.

The factor–market–clearing conditions then take on the following form:

$$\begin{aligned} A(\bar{w}, \mathbf{r})\mathbf{x} &\leq \mathbf{v}, \quad \mathbf{r} \geq \mathbf{0} \quad \text{w.c.s.} \\ \sum_{j=1}^n (1 + q_j) a_{Lj}(\bar{w}, \mathbf{r}) x_j &= L \end{aligned} \quad (15)$$

It is well-known that equilibrium conditions of this form can be derived from the following optimization problem (cf. Dixit & Norman 1980: ch. 2):

$$\begin{aligned} y(\mathbf{p}, \mathbf{v}, L) &\stackrel{\text{def}}{=} \\ \min_{\bar{w}, \mathbf{r}} \quad &\{ \bar{w}L + \sum_{i=1}^m r_i v_i : b_j(\bar{w}, \mathbf{r}) \geq p_j, \quad r_i \geq 0, i = 1, \dots, m \} \end{aligned} \quad (16)$$

Since we have assumed constant returns to scale, product exhaustion holds, and  $y(\mathbf{p}, \mathbf{v}, L)$  is the GDP function. It has all the usual properties: It is (i) non-decreasing, convex and linearly homogenous in output prices, (ii) non-decreasing, concave and linearly homogenous in factor endowments, (iii) the derivatives with respect to output prices are the outputs, and (iv) the derivatives with respect to the factor endowments are the factor prices. In the case of labor, the relevant factor price is the reference wage  $\bar{w}$ ; sectoral wages are determined by the fixed markups on the reference wage. Since the equilibrium allocation can be described by an ordinary GDP function, there exists a modified transformation surface such that equilibrium production occurs where the price vector is normal to this surface. The transformation function  $g(\mathbf{x}, \mathbf{v}, L)$  can be defined by an optimization problem based on the GDP function:<sup>5</sup>

$$g(\mathbf{x}, \mathbf{v}, L) \stackrel{\text{def}}{=} \max_{\mathbf{s}} \left\{ \sum_{j=1}^n s_j x_j - y(\mathbf{p}, \mathbf{v}, L) : \sum_{j=1}^n s_j^2 = 1, \quad \mathbf{s} \geq \mathbf{0} \right\} \quad (17)$$

Problem (16) is the dual to the problem of income maximization on the basis of

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<sup>5</sup>Cf. Albert (1994: 294-5) for an analysis of this optimization problem.

the transformation function:<sup>6</sup>

$$y(\mathbf{p}, \mathbf{v}, L) \equiv \max_{\mathbf{x}} \left\{ \sum_{j=1}^n p_j x_j : g(\mathbf{x}, \mathbf{v}, L) \leq 0, \mathbf{x} \geq \mathbf{0} \right\} \quad (18)$$

All the well-known comparative-static properties for special structures like the HO or SF model can be derived as well. Any results involving intensities and sectoral labor inputs apply if labor absorption instead of labor inputs and labor-absorption coefficients instead of labor-input coefficients are used. Any other results apply anyway.

While the maximum-income property is a consequence of the simplicity of our efficiency-wage approach, we do not think that we oversimplified since, as we are going to demonstrate, the key results from more complicated approaches can still be derived. After all, it is not the fact that income is not at its maximum that is in the center of interest: Unemployment is the distortion we want to focus on, and in this context all other distortions, although possibly important on their own, just distract from the main point. By preserving the maximum-income property, our model is as close as possible to standard competitive trade models. This feature is especially important for empirical work. For instance, the only additional requirement for the calibration of a CGE trade model with unemployment is data on sectoral wages and unemployment. Similarly, regression analyses based on GDP functions could easily incorporate the slight technical differences between the present and traditional trade models.

## 2.7 Relaxing Assumptions

Before we turn to the derivation of further key results, we shortly discuss the effects of relaxing some of our simplifying assumptions.

**Endogenous markups.** The maximum-income property is easily lost if more complicated efficiency-wage approaches are used, as the shirking model used by Matusz (1994) illustrates. The upshot of his eq. (16) is that  $\bar{g}_j = 1$  and  $q_j =$

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<sup>6</sup>Cf. Dixit & Norman (1980: ch. 2). We approach the maximization problem via its dual because the Kuhn–Tucker conditions for the standard maximum problem, which uses production functions and resource constraints, are ill-defined. For an explanation of the difficulty and well-defined first-order conditions for the standard problem, see Albert (1995).

$1 + e(\mathbf{p})\gamma_j w_0/\bar{w}$ , where  $\gamma_j$  is a sector-specific constant and  $w_0$  is the monetary equivalent of the marginal disutility of effort (assumed to be constant). This implies that the markup becomes endogenous. The same happens in our model once the participation constraint becomes active for some sector.

With endogenous markups, the GDP as a function of commodity prices and factor endowments loses its maximum-value character. Or in other words: Markets are no longer able to guarantee maximal income. This implies the non-vanishing second-order effects in Matusz' (1994) eqs. (7), which drive his results. Schweinberger's (1995) model, in contrast, is closer to ours; he also uses envelope properties of the equilibrium allocation.

**Dual labor markets.** Markups also become endogenous, and the maximum-income property is destroyed, in cases where wages do not affect labor productivity in some sectors. Workers in those sectors cannot realize positive job rents, and therefore these secondary sectors absorb all labor not employed in the primary sectors where positive job rents prevail. Since labor is always fully employed, opportunity costs of producing different goods are not reflected by market prices. This is the essence of the dual-labor-market approaches used by Bulow & Summers (1986), and Katz & Summers (1989). In terms of our model, we would find that for a sector without efficiency wages,  $q_j$  would be negative and adjust such that full employment is guaranteed.

**Harris-Todaro structures.** There is an exception to the rule that including sectors without efficiency-wage setting destroys the envelope properties of the model. Consider a Harris-Todaro type of model where labor migrates between an urban and a rural sector (Harris & Todaro 1970, Khan 1980). The urban sector is characterized by unemployment while the rural sector is not. Both sectors produce different goods. In the simplest case, no other factors of production move between rural and urban areas. We then might model the urban sector by a GDP function  $y^u(\mathbf{p}^u, \mathbf{v}^u, L^u)$  that is based on an employment restriction

$$\sum_{j=1}^n (1 + q_j) L_j^u = L^u$$

and incorporates unemployment. The rural sector, on the other hand, is characterized by a traditional GDP function  $y^r(\mathbf{p}^r, \mathbf{v}^r, L^r)$  based on an employment

restriction

$$\sum_{j=n+1}^k L_j^r = L^r ,$$

implying full employment of the rural labor supply. Thus, we assume that urban labor, in judging the fairness of the wage, is not concerned with the rural wage rate: Urban workers adjust their standards of fairness to their new environment.

According to the basic Harris–Todaro assumption, labor migrates until the expected urban labor income, which in our case is endogenous and equal to the marginal value product of labor according to  $y^u$ , is equal to the rural wage rate. Thus, equilibrium is described by the following equations:

$$\begin{aligned} \bar{w} &\stackrel{\text{def}}{=} \frac{\partial y^u}{\partial L^u} = \frac{\partial y^r}{\partial L^r} \\ L^u + L^r &= L \end{aligned} \tag{19}$$

Again,  $L$  denotes the national labor supply. The whole economy then can be described by a GDP function

$$\begin{aligned} &y(\mathbf{p}^u, \mathbf{p}^r, \mathbf{v}^u, \mathbf{v}^r, L) \stackrel{\text{def}}{=} \\ &\max_{L^u, L^r} \{y^u(\mathbf{p}^u, \mathbf{v}^u, L^u) + y^r(\mathbf{p}^r, \mathbf{v}^r, L^r) : L^u + L^r = L\} . \end{aligned} \tag{20}$$

The first-order conditions of (20) are just the equilibrium conditions (19). By collecting the equilibrium conditions behind the two GDP functions used in (20) and combining them with (19), we find that the overall GDP function  $y$  is of the efficiency-wage type if we allow some of the markups to be equal to 0. That is, we find that the Harris–Todaro employment restriction is

$$\sum_{j=1}^n (1 + q_j) L_j^u + \sum_{j=n+1}^k L_j^r = L .$$

In our framework, the difference between Harris–Todaro structures and dual labor markets is that with the latter, the sectors without efficiency-wage setting are still relevant for the fairness standard.

Note that, in our framework, the Harris–Todaro assumption of equalization of rural wage rate and expected urban labor income is plausible only if there are information problems that lead workers to concentrate on labor income instead of utility. The equilibrium described by (19) will in general not equalize utilities, which—beyond the real wage—must take the disutility of effort into account. If

real wages are equalized, expected welfare will, due to unemployment, be greater in the urban area as compared with the rural area.<sup>7</sup>

If, on the other hand, the markups in the urban sector are interpreted as the result of unionization, there is no need to assume that worker efficiency is related to utility. In this case, migration will equalize expected real wages even under the assumption of full information, and the present analysis will apply without qualifications.<sup>8</sup>

**Fairness defined by comparison with other factors.** As mentioned in the introduction, our approach extends Solow's (1979) model and is close to Summers' (1988) efficiency-wage theory where worker productivity depends on the relative attractiveness of opportunities outside the firm. The latter feature is the decisive difference between the present approach and that of Akerlof & Yellen (1990). These authors assume workers to choose their effort depending on whether the wage they receive is high relative to *other* factor prices paid within the *same* firm or sector. We shortly comment on the kind of results that come out of such models since they cannot be replicated in our model.

To fix ideas, consider two types of labor, skilled and unskilled, and assume that skilled workers exert effort depending on the relative wage of skilled vs unskilled labor in the same sector. This approach can explain stable wage differentials between skill groups, which Krugman (1995) claims to be responsible for the relatively high unemployment rates in Europe as compared to the US. This approach also has some striking implications. We give an example that we have not yet seen in the literature. Assume sectoral production functions of the form  $f_j [K_j, g(L_j^s, L_j^u)]$ , where  $j$  is a sector index,  $K$  denotes capital,  $L^s$  skilled labor, and  $L^u$  unskilled labor. Both  $f_j$  and  $g_j$  are linearly homogenous production functions. Thus, we have simplified the model by assuming separability w.r.t. labor inputs. This implies that stable wage differentials between both types of labor fix the ratio of skilled to unskilled labor in each sector. With fixed ratios, it depends on, among others, relative labor endowments whether skilled or un-

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<sup>7</sup>See also the welfare analysis in the next section, which might be applied here to derive, as a full-information equilibrium condition, the equation  $w^r - \bar{w}^u = b\mu e(\mathbf{p}^r, \mathbf{p}^u)$ . This equation is based on the affine effort function as specified above.  $\mu$  is the urban rate of unemployment.

<sup>8</sup>On the envelope properties of Harris-Todaro models in which employment or unemployment as such is not welfare relevant, see Marjit & Beladi (1997).

skilled labor will be unemployed in equilibrium. Thus, if efficiency wages are paid to skilled labor, the result might nevertheless be full employment of skilled and unemployment of unskilled labor.

Agell & Lundborg (1995) combine the Solow–Summers and the Akerlof–Yellen approach and assume that fairness considerations take account of both, wages paid by other firms or sectors *and* prices of other factors. Additionally, they assume that effort depends on the rate of unemployment, which acts as a measure of the probability of becoming unemployed.<sup>9</sup> Given their specification, unemployment can only occur for the factor that receives efficiency wages. Our example above suggests that this is not true in general.

Thus, we expect an even richer set of surprising results from generalizing the effort function. At the present stage, however, we aim at clear structures that allow us to state easily understandable transmission mechanisms generating the key results.

### 3 Welfare, Trade, and Unemployment

In this section, we introduce a social welfare function that reflects the possibility of achieving Pareto improvements. Simplifying the model by coming back to the case of an affine effort function already discussed in section 2, we derive a general proposition concerning the ambiguity of welfare effects. On this basis, we derive key result 2 that welfare and aggregate unemployment can be positively correlated. We then go on to show that trade may reduce welfare for all trading countries (key result 3) and to derive results concerning the effect of trade on unemployment (key result 4). The section concludes with key result 5 concerning the effects of protection on welfare.

#### 3.1 A Social Welfare Function

Since we have assumed identical and homothetic preferences over consumption goods and additive separability of the disutility of effort, we can legitimately consider the utility of a representative consumer. The resulting social welfare

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<sup>9</sup>In our model, the unemployment rate directly enters the measure of outside opportunities only if wages are equal across sectors, which is a possible special case. In all other cases, the influence of labor–market conditions cannot be summarized by just one variable.

function (SWF)

$$W(\mathbf{p}, \mathbf{v}, L) = \frac{y(\mathbf{p}, \mathbf{v}, L)}{e(\mathbf{p})} - \sum_{j=1}^n \bar{\epsilon}_j L_j(\mathbf{p}, \mathbf{v}, L) \quad (21)$$

increases if and only if it is possible to achieve a Pareto improvement by lump-sum transfers. Thus, the welfare analysis proceeds as in the simple standard models of trade theory. The SWF is easy to interpret. Welfare rises *ceteris paribus* if real income rises; this is the first term. Welfare falls *ceteris paribus* if aggregate effort goes up; this is the second term.

As can be seen from (11), a shift of workers from low-wage to high-wage sectors requires that some workers drop out, which implies a rise in unemployment. The question is whether job rents are lost in the aggregate. In general, this depends on, among others, the correlation between wages and job rents. In the case of an affine effort function, where we have  $\bar{\epsilon}_j = a + b(1 + q_j)$  with  $a, b > 0$  (cf. eq. (4) above), all the relevant relations become much simpler, although, as shown in section 2, job rents can still be positively or negatively correlated with wages. Subsequently, we work with this affine specification because no further complications are needed in order to derive the key results.

The point of the affine effort function is that aggregate effort depends on employment alone. With the affine effort function, we have

$$\sum_{j=1}^n \bar{\epsilon}_j L_j = \sum_{j=1}^n [a + b(1 + q_j)] L_j, \quad (22)$$

which due to

$$\sum_{j=1}^n \frac{(1 + q_j) L_j}{L} = 1 \quad (23)$$

(from the employment restriction (11)) simplifies to

$$\sum_{j=1}^n \bar{\epsilon}_j L_j = aL^e + bL, \quad (24)$$

where  $L^e \stackrel{\text{def}}{=} \sum_{j=1}^n L_j$  denotes aggregate employment. Thus, the SWF can be written as

$$W(\mathbf{p}, \mathbf{v}, L) = \frac{y(\mathbf{p}, \mathbf{v}, L)}{e(\mathbf{p})} - aL^e(\mathbf{p}, \mathbf{v}, L) - bL. \quad (25)$$

A shift of labor from low-wage to high-wage sectors leads to a *decrease* in aggregate effort due to increasing unemployment. The simplified form (25) of



the SWF implies that, as usual in efficiency–wage models, rising unemployment with constant real income means an improvement in welfare since effort reduces welfare. This does of course not mean that individual workers profit from unemployment. It just means that, as long as real income is constant, they could be fully compensated for their losses by lump-sum transfers without anybody else being worse off than before the rise in unemployment. This is possible since some people must have gained in terms of income if real income is constant despite rising unemployment.

Affine effort functions allow us to derive welfare results from the comparative statics of employment. The constant  $a$  in the SWF (25) can have any positive value. Consider a case where real income and employment move in the same direction. We can always assume that  $a$  is so small that the income effect dominates or that  $a$  is so big that the employment effect dominates. We call this the central ambiguity proposition.

**CAP:** *The welfare effect of any disturbance that results in a positive correlation between real income and employment can take on any sign.*

We will several times refer back to CAP in order to derive the key results that are concerned with welfare. At this point, we note that CAP already implies key result 2, which says that welfare and unemployment can be positive correlated.

CAP is not a new result. Agell and Lundborg (1995) also attribute the ambiguity of welfare effects of trade to fairness considerations. However, they completely abstract from the direct welfare impact of changes in aggregate effort; instead, they emphasize the indirect effect of prices on effective labor supply. In contrast, the welfare-reducing effects of trade in our model must always be caused by the fact that the employed have to work harder in the aggregate. Copeland's (1989) results rely on a similar mechanism.

The possibility of exogenous shocks generating welfare gains through their negative effect on aggregate employment has moreover been emphasized by Brecher (1992). However, in his model this—as he calls it—paradoxical result does not stem from changes in unemployment per se but from a reduction of monitoring costs. Due to his specifications of the effort functions and resource-consuming monitoring activities, the welfare gain from effort reduction is always dominated by the welfare loss due to reduced labor employment in the consumption–good

sectors.<sup>10</sup> However, an additional welfare gain is generated by the positive correlation of employment and resource input into monitoring activities to detect shirking. A reduction in aggregate employment sets free resources (capital) in the production of non-consumable monitoring activity which can be employed in the consumption-good sectors. This latter effect may be decisive for the sign of the welfare impact. Our analysis shows that an increase in unemployment can generate positive welfare effects even if monitoring costs are negligible.

### 3.2 Free Trade and Employment

Consider a group of countries, where each country can be described in terms of our model, moving from autarky to free trade. Real income never falls for any of the trading partners; under standard assumptions, all partners will unambiguously experience rising real incomes. This is a consequence from the fact that the welfare effects resulting from changes in effort are just side effects that do not feed back into the allocation and the consumption of goods. Thus, we can make the usual revealed-preference argument in order to demonstrate that the utility from consumption rises unambiguously.

If we look at a two-goods, two-factors, two-country version of this model and assume identical GDP function but different relative factor endowments, we find that employment will move in different directions in both countries. Assume that sector 1 is the high-wage sector in both countries, i.e.  $q_1 > q_2$ . If the home country exports good 1, it will specialize (not necessarily completely) on the production of this good. This means that labor absorption rises in sector 1, which implies less employment since  $q_1 > q_2$  means that, in relation to sector 2, a higher percentage of labor absorbed by sector 1 is unemployed. Since the foreign country specializes on good 2, labor absorption in sector 1 will fall and employment will rise. Since both countries experience a rise in real income, welfare results according to CAP are ambiguous only for the foreign country. Generally, in a two-goods, two-factors version of the model, there will always be one country that gains from trade.

However, it would be a mistake to generalize this result to a world with

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<sup>10</sup>This is different in Matusz (1994), where—due to sector-specific effort functions—the second effect may dominate the first. In Matusz' framework, however, an increase of employment raises welfare.

more goods. Trade may reduce welfare for all trading countries even if they have identical technologies and identical preferences that are moreover homothetic over goods. The reason is that, in general, trade may cause employment to increase in all countries. The following example of a two-country model with three goods illustrates the point. We give an intuitive account while a footnote contains a model specification. Assume that the three goods are fish, pork, and beef. Due to restriction on resources, the home country in autarky produces fish and pork, while the foreign country produces fish and beef. The rates of transformation between fish and meat in both countries is greater than one and, for simplicity alone, assumed to be constant. That is, fish is relatively expensive in both countries. Consumers live on stews that always contain two of the goods. The proportions in a stew depend on prices. The stews are perfect substitutes; so the cheapest stew is preferred. If trade is opened up, all consumers realize that the cheapest stew now is pork and beef; the fish production goes to zero. If fishing is the high-wage sector, while the other two sectors have equal wages, employment must rise in both countries because, relatively to the fishing industry, a higher percentage of labor absorbed is employed in pork and in beef production. Thus, real income and employment are positively correlated in both countries, and according to CAP welfare might fall.<sup>11</sup> Thus, there exist constellations where all countries prefer autarky to free trade. This is key result 3.

Since we can alternatively assume in the stew example that fishing is the low-wage industry, an analogous argument demonstrates one part of key result 4, namely, that trade liberalization can reduce unemployment in all trading countries. Matusz (1996) proves the same result in a one-sector efficiency-wage model with intrasectoral trade in differentiated products. The other part of key result 4, referring to a Heckscher–Ohlin model with efficiency wages, will be derived in the next section. However, the result is already indicated at the beginning of this subsection, where we made plausible that in a two-goods model employment in two countries starting to trade will move in opposite directions.

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<sup>11</sup> Assume a utility function  $c_1^{\frac{1}{2}}c_2^{\frac{1}{2}} + c_2^{\frac{1}{2}}c_3^{\frac{1}{2}} + c_1^{\frac{1}{2}}c_3^{\frac{1}{2}}$  for three consumption goods. The production side may be described by the transformation functions  $x_1 + \alpha x_2 = 1$  in country  $h$  and  $x_3 + \beta x_2 = 1$  in country  $f$ , where  $\alpha$  and  $\beta$  are arbitrary constants greater than 1. Good 2 will not be produced in a free-trade equilibrium.

### 3.3 Industrial Targeting

Let us now derive key result 5 that promotion of high-wage sectors (by import tariffs or export subsidies) can be welfare-improving. Without unemployment, this result follows from the existence of sector-specific job rents. On this basis, Bulow & Summers (1986), and Katz & Summers (1989) argue in favor of targeting high-wage sectors. Since the composition of employment changes as workers are shifted to high-wage/high-rent industries, GDP and hence welfare rises. Assuming export sectors to be the high-wage/high-rent sectors, as it is plausible for the US or other highly industrialized countries, this reasoning justifies subsidization of export sectors.

This argument for industrial targeting may break down if unemployment is considered (cf. Matusz 1994). In general, every change in the *composition* of employment is then accompanied by a change in the *level* of employment. The welfare effects of the latter may work against the composition gain and even overcompensate it. This can be shown in a two-sector small open economy version of our model.

In a small open economy, the effects of protection on real income are negative. In order to apply CAP, we therefore have to show that the employment effects can also be negative. This is again a trivial exercise. In a two-goods, two-factors model, labor absorption in the protected sector must rise and labor absorption in the other sector must fall. So much follows from the fact that standard production theory still holds for labor absorption. If we assume that the protected sector is the high-wage sector, it always follows that employment declines since, relatively to the low-wage sector, a higher proportion of absorbed labor is unemployed.

## 4 Factor Movements, Minimum Wages, and Unemployment

In this section, we derive the outstanding key results from a two-by-two HO-type model. We call this model the HO<sub>e</sub> model, where the index “e” indicates that the model assumes efficiency wages.<sup>12</sup>

We call the second factor “capital” and denote sectoral capital inputs by  $K_j$ ,

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<sup>12</sup>The analogously defined SF<sub>e</sub> model has been analyzed by Albert & Meckl (1997).

$j = 1, 2$ . Capital supply is assumed to be fixed at a level of  $K$ . The GDP function then is  $y(p_1, p_2, K, L)$ .

In HO-type models, comparative-static effects depend on factor intensities. We therefore define capital intensities

$$\bar{k}_j(\bar{w}, r) \stackrel{\text{def}}{=} \frac{\partial b_j(\bar{w}, r)/\partial r}{\partial b_j(\bar{w}, r)/\partial \bar{w}}, \quad j = 1, 2.$$

These intensities yield sectoral capital inputs per unit of labor *absorbed* by the sector. Capital inputs per unit of labor employed are

$$k_j(\bar{w}, r) \stackrel{\text{def}}{=} (1 + q_j)\bar{k}_j(\bar{w}, r).$$

Since sectoral wages differ, we know that factor intensities defined as relative factor cost shares might become relevant. Capital intensities according to that definition are

$$\psi_j(\bar{w}, r) \stackrel{\text{def}}{=} \frac{r\bar{k}_j(\bar{w}, r)}{\bar{w}} = \frac{rk_j(\bar{w}, r)}{w_j}.$$

Obviously, it depends on the value of the markups  $q_j$  whether the intensity ranking of the sectors in the cost-share sense and in the physical sense agrees or disagrees. We will find that this question—whether those two rankings agree or not—plays an important role for comparative-static effects.

In order to derive the effects that are of interest in connection with key results 6 to 9, it suffices to look at factor-market clearing under the assumption of diversification. We find the following equations under the assumption that the factor-supply constraints are active:

$$\begin{aligned} k_1 L_1 + k_2 L_2 &= K \\ (1 + q_1)L_1 + (1 + q_2)L_2 &= L \end{aligned}$$

Note that these are the well-known standard equations from the HO model once we recognize that traditional results hold for labor absorbed rather than labor employed. This becomes apparent if we rewrite the equations using the definition  $N_j = (1 + q_j)L_j$  of labor absorption:

$$\begin{aligned} \bar{k}_1 N_1 + \bar{k}_2 N_2 &= K \\ N_1 + N_2 &= L \end{aligned}$$

However, since we are interested in employment effects, we prefer the former instead of the latter system. Solving for employment  $L^e = L_1 + L_2$  yields

$$L^e = \frac{1}{(1 + q_1)(1 + q_2)} \left( \frac{k_1 - k_2}{\bar{k}_1 - \bar{k}_2} L - \frac{q_1 - q_2}{\bar{k}_1 - \bar{k}_2} K \right). \quad (26)$$

Given that changes in factor supplies are not so large that they enforce specialization, factor prices will not react to factor-supply changes. Thus we find that changes of factor supplies can have any effect on employment, depending on the factor intensities and the markups. Specifically, we find the following rather surprising result (key result 7).

- Let sector 1 be relatively capital intensive in the physical sense and sector 2 relatively capital intensive in the cost-share sense (rankings disagree). This requires  $q_1 < q_2$ , i.e., the capital-intensive sector has the lower wage. This is not implausible when we compare, for instance, high-quality services to manufacturing. Then  $dL^e/dL < 0$ . That means: For every worker who emigrates (and thus reduces unemployment), additional employment is created in the economy.
- Consider the same scenario as before with the difference that the difference in capital intensities in the cost-share sense is positive (rankings agree). Let moreover  $\bar{k}_1 - \bar{k}_2$  be much smaller than the difference in the physical sense. This still implies  $q_1 > q_2$ . However, now we can have  $dL^e/dL > 1$ . That means: Every worker who immigrates finds employment and moreover creates employment for other non-immigrant workers. Note that this dramatic difference in results might be due to tiny differences in the markups  $q_j$  if  $\bar{k}_1 - \bar{k}_2$  is near zero. That is, two countries differing a little bit with respect to fairness norms might have completely different experiences with immigration and emigration.

It is easy to see that independently from the sign of  $dL^e/dL$ , an inflow of capital can have any effect on employment. These results can be illustrated in a simple diagram showing the linear equations that determine employment in  $L_j$ -space (fig. 2).

Insert fig. 2 here!

We use the above model to derive key result 8 that an increase in unemployment benefits can increase employment. In order to derive this result, we assume the version of the model (discussed in section 3) where unemployment benefits lead to a modification of the employment restriction, namely,

$$(1 + q_1)L_1 + (1 + q_2)L_2 = (1 - t)L,$$

where  $t$  is the tax rate on wages used to finance unemployment benefits. Given that we stay in the diversification cone, raising  $t$  implies an increase in unemployment benefits since factor prices and therefore all wages stay constant. Thus, an increase in  $t$  is equivalent to a change in  $L$ . By the same reasoning used to derive key result 7 above, we can conclude that, depending on factor intensities and markups, an increase in benefits reduces unemployment.

Given these results, it is no further problem to derive the last of the outstanding key results, namely, that an increase in minimum wages can lead to an increase in employment (key result 6). Manning (1995) has shown the validity of this result for an Salop-type labor-turnover EWM (Salop 1979). In his macroeconomic one-sector context, the result fails to hold for an Solow-type EWM, where the wage enters the production function. Our results, however, show that key result 6 is not tied to Salop-type EWMs.

We extend the  $HO_e$  model by adding a third sector, e.g., agriculture, which produces with the help of labor and a sector-specific factor, e.g., land. Let us assume that this third sector, which is assumed to have the same efficiency-wage structure as the other sectors and affects the employment restriction in the same way, pays the lowest wages in equilibrium ( $q_3 < q_j$ ,  $j = 1, 2$ ). If a minimum wage is introduced, it can be binding for sector 3 alone.

Formally, we can describe the extended model with the help of a GDP function for the  $HO_e$  model,  $y^{HO}(p_1, p_2, N, K)$  (where  $N$  denotes labor absorption in the  $HO_e$  part), and a GDP function for the third sector, which is of course very simple since this sector consists of firms with the same production functions:

$$y_3(p_3, L_3, S) \stackrel{\text{def}}{=} p_3 f_3(\bar{g}_3 L_3, S)$$

Here,  $S$  denotes the given quantity of the sector-specific factor. The following

aggregate GDP function then describes the allocation:

$$y(p_1, p_2, p_3, L, K, S) \stackrel{\text{def}}{=} \max_{N, L_3} \left\{ y^{\text{HO}}(p_1, p_2, N, K) + y_3(p_3, L_3, S) : N + (1 + q_3)L_3 = L \right\} \quad (27)$$

The correctness of this representation can easily be verified by a glance at the first-order conditions. This technique of building up a model around a HO “nugget” (or, in our case, a HO<sub>e</sub> nugget) is due to Marjit (1990).

Given that the HO<sub>e</sub> nugget remains fully diversified, the minimum wage does not affect the reference wage  $\bar{w}$ , which is still determined by the zero-profit conditions of sectors 1 and 2. The minimum wage, then, just raises the markup and generates an employment reduction in sector 3. Hence, we have two counteracting effects on labor absorption in sector 3: the markup rises but employment falls. Depending on the elasticity of factor substitution in sector 3, the employment effect can be weak or strong, letting labor absorption in sector 3 either rise or fall.

With given factor prices, the effect of a rise or fall in sector 3’s labor absorption is equivalent to an emigration from or an immigration to the HO<sub>e</sub> nugget. Thus, the minimum wage affects employment in the HO<sub>e</sub> nugget in exactly the same way as a change in labor supply discussed above affects employment in the HO<sub>e</sub> model. Obviously, then, the overall effect can be an increase in employment. If both factor-intensity rankings agree and  $\bar{k}_1 - \bar{k}_2$  is near zero, the employment-creation effect in the HO<sub>e</sub> nugget can be as large as we want it to be, dominating any loss of employment in sector 3.

Finally, our results concerning the effect of trade on unemployment in the HO<sub>e</sub> model can differ qualitatively from the results derived from models that do not allow for intersectoral wage differentials (cf. Hoon 1991). Abstracting from wage differentials, trade equalizes unemployment rates between countries which are completely identical except for relative factor endowments by reducing employment in the capital abundant country and increasing it in the labor abundant country (key result 4). With wage differentials, however, trade cannot equalize unemployment rates. This can be seen by inspection of (26). Furthermore, trade raises employment in the labor abundant country only if wages are higher in the sector which produces labor intensively according to the cost-share definition. In that country, the labor-intensive sector expands as trade is opened up



whereas the capital-intensive sector shrinks. Only if wages are relatively high in the declining sector, aggregate employment goes up.<sup>13</sup>

## 5 Conclusions

This paper has presented a model incorporating the fair-wage hypothesis into otherwise standard trade models. This model can explain stable intersectoral wage differentials for homogeneous labor found in the empirical literature. Due to the simplicity of our approach, almost all properties of the competitive model with full employment are preserved. This enables the analysis of unemployment problems in isolation of other distortions. Furthermore, it can be implemented empirically along the lines of the competitive model with full employment necessitating only a calibration of intersectoral wage differentials.

Our model is quite general. The key results of efficiency-wage models found in the literature can be derived by appropriate specification of the effort function and choice of parameters. Additionally, results do not hinge on low model dimensionality.

Eventually, our multisectoral model explains why, contrary to conjectures deriving from one-sector efficiency-wage macromodels, capital accumulation and technological progress do not eliminate unemployment over time. As long as capital accumulation and technological progress are sufficiently biased towards the high-wage sectors, these dynamic processes should drive up unemployment over time. In a multisectoral model, wealth effects (as considered by Phelps 1994) are not necessary to reconcile the theory with the trends in the development of the real wage and the rate of unemployment observed in most industrialized economies. While one may argue that in a more complicated specification of the model, wealth effects will come into play anyway, it is surely important to know that they do not have to bear the burden of explanation, as they do in Phelps analysis.

This leads to the more general question of whether unemployment should be viewed as a macro or as a micro phenomenon.

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<sup>13</sup>Note that the rankings of sectors according to physical intensities resp. cost shares disagree for sufficiently high wage differentials. Hence, it is possible that trade generates an expansion of the sector that is relatively capital intensive in the physical sense while at the same time raising aggregate employment.

In our model, the effect of effort on labor efficiency is sector-specific, which means that the markups  $q_j$  vary across industries. Since the markups determine sectoral labor absorption, the level of unemployment varies with sectoral employment. This is the most important feature of models combining efficiency wages with a multi-sectoral structure, and the source of all the counterintuitive results derivable from them. Efficiency-wage unemployment is *not* a pure macro phenomenon but turns out to depend on relative prices and relative factor endowments.

This view is not in line with the argument by Krugman (1993) and Mussa (1993) that changes in the sectoral structure of the economy have little *net* effect on unemployment.<sup>14</sup> From a *theoretical* point of view, there are no restrictions on the size of these net effects. Thus, the view that unemployment is a macro phenomenon must be construed as an *empirical* claim, for which, unfortunately, Krugman (1993) and Mussa (1993) fail to provide any evidence. Any such evidence, namely, that relative prices have a zero net effect on unemployment, should be considered as strong evidence against the efficiency-wage theory of unemployment in general since, according to this theory, such zero net effects are extremely implausible. They presuppose either an extraordinary high level of similarity between sectors or a very special change in exogenous variables.

In the introduction, we have been stressing the simplicity of our model as compared with many other efficiency-wage models in the literature. This simplicity originates from the fact that in our model, the allocation still maximizes income under a slightly modified employment constraint. In this connection, we would like to remind readers of an interesting parallel. The rise of GE models in trade theory began with Haberler's (1930) simplification of previous, rather sterile GE approaches by the assumption that the equilibrium allocation maximizes income at current prices of outputs. On the basis of this assumption, prices of inputs can easily be determined as marginal value products, which in turn can be computed from a GDP function that is a maximum-value function for the problem of income maximization under the restriction of given quantities of productive factors. The *realism* of Haberler's assumption had been attacked from the beginning by Viner (1932) in the famous real-cost debate. In effect, Viner argued that different job characteristics in different industries might give rise to preferences of workers

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<sup>14</sup>Cf. also Matusz (1996, p. 71).

over these jobs and therefore to compensating wages. This usually destroys the envelope properties that trade theorists, following the ideas of Samuelson, have since used with great effect. Nevertheless, Viner had of course been right: We should expect wages to compensate for job characteristics. However, the added complication of compensating-wage models has in general not been judged worth the effort in terms of the derivable theorems. In the present context, we face a similar choice. In full employment models, compensating wages can destroy the envelope properties because wages are no longer equal to marginal value products. In models with involuntary unemployment, efficiency wages can destroy the envelope properties for the same reason. However, they need not. The question is whether added realism pays in terms of additional insights. The present paper argues that we can explain a lot with simple arguments. Moreover, our model lends itself quite easily to calibration and other empirical exercises. Future research might use the model as a kind of benchmark: If something cannot be explained in our simple way, this is a good argument in favor of complications that actually yield an explanation. However, if nothing speaks against an explanation along the lines of our model, why work harder?

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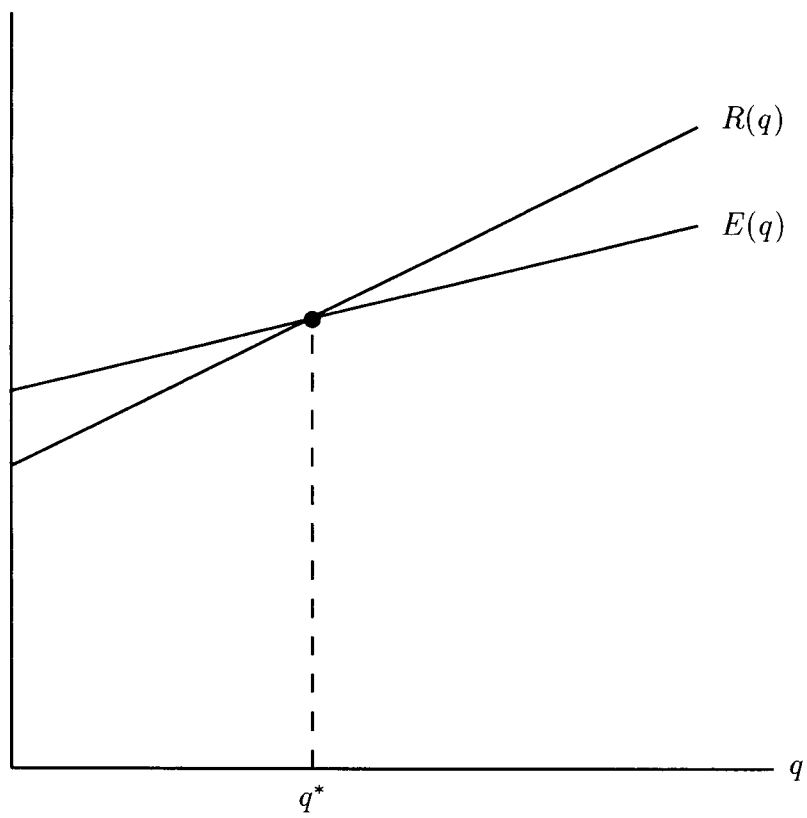
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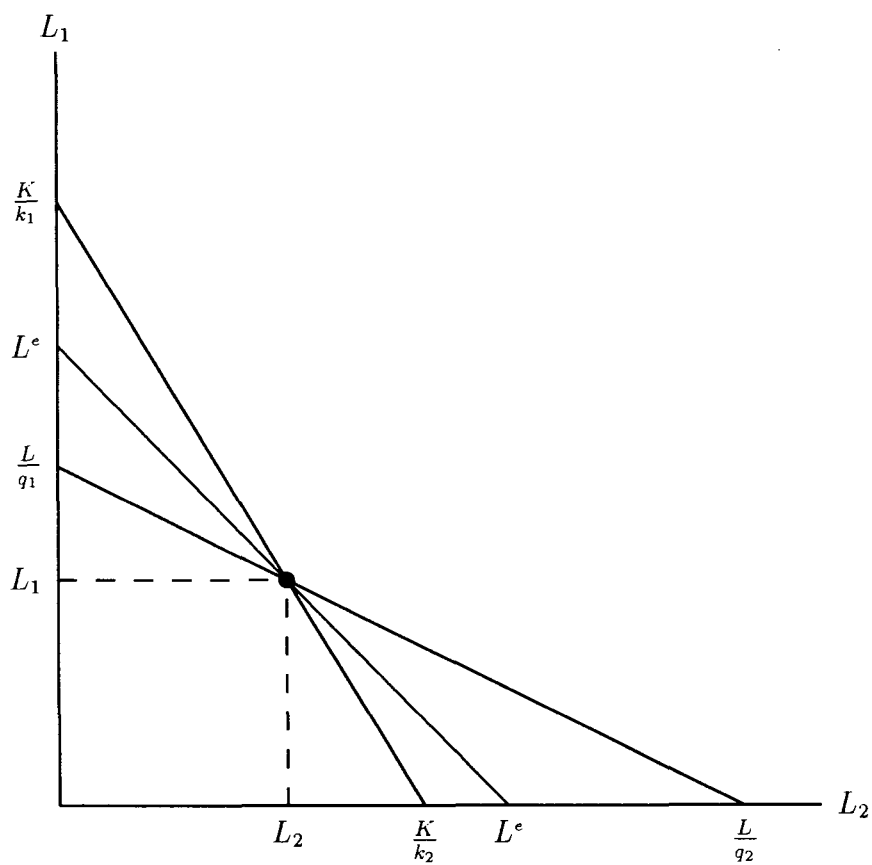
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**Fig. 1**



**Fig. 2**