Institute of Economic Studies, Faculty of Social Sciences
Charles University in Prague

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Pavel Ryska
Jan Průša

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Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

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Efficiency Wages in Heterogenous Labour Markets

Pavel Ryska*
Jan Průša#

* IES, Charles University Prague
E-mail: pavel_ryska@volny.cz

IES, Charles University Prague
E-mail: jan.prusa@ies-prague.org

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Abstract:
In this paper we tackle two shortcomings of present efficiency wage models. Firstly, they do not fully account for labour heterogeneity, thus implying that high-effort and low-effort units of labour are interchangeable. Secondly, building on this assumed homogeneity of labour, the models derive involuntary unemployment from effort decisions of workers, which are patently voluntary.
We offer a consistent reformulation of the theory: Each of the effort or quality levels is regarded as a separate market which has its own clearing quantity and price. As such unemployment is a result of workers' reluctance to adjust to the prevailing market conditions on the respective labour sub-market.
To further clarify heterogeneity in labour markets, we propose to employ the demand for workers' characteristics instead of the demand for workers. This microeconomic approach shows that in standard equilibrium employers will not choose among all workers but only select specific characteristic-types. Therefore to become attractive, an unemployed worker has to significantly alter either his wage or the bundle of offered characteristics.
Both these modifications reinforce our central claim that free market interaction cannot lead to unemployment other than voluntary.

Keywords: labour market; efficiency wages; involuntary unemployment; demand for heterogeneous goods.

JEL: J64, J20.

1 Introduction

To understand why there is unemployment and whether it may be involuntary is an important and long-lasting goal of the economic profession. Since the 1980s, the efficiency-wage theories have occupied a prominent place in labour market research. Their appeal rests in two features. First, efficiency-wage considerations derive the occurrence of involuntary unemployment only from simple profit maximization of the firm. Second, they explain why wages are observed to vary relatively little and employment to vary a lot.

In the present paper, we take issue with the main conclusions of efficiency-wage models. In our view, these models incorrectly specify the labour market as a homogeneous one, while they implicitly model a situation of heterogeneous labour. This is why they necessarily lead to a non-Walrasian outcome and imply involuntary unemployment. We show that if labour markets are modelled as fully heterogeneous — an approach that we support — then the existence of involuntary unemployment does not follow. Specifically, we analyze the two most common efficiency-wage models: the Solow (1979) model, in some literature called the 'generic' efficiency wage model, and the Shapiro-Stiglitz (1984) 'shirking' model. Although the two models differ in the degree of wage rigidity they lead to, they both imply involuntary unemployment and are both based on the same microeconomic approach to labour markets. We offer an alternative approach, and for this purpose we invoke the rather little known contribution of Lancaster (1966, 1971) to show that the conclusion about involuntary unemployment does not hold.

It is important to stress that while our paper does not dispute the existence of unemployment in general, we object to the claim that *involuntary* unemployment is caused by market optimization of firms. Therefore the main purpose of our paper is to contribute to logically consistent theory and model building.

This paper is structured as follows. In Section 2, we describe the two major efficiency models (Solow and Shapiro-Stiglitz) and for each provide critical analysis of its conclusions. In this part, we focus on the particular layout of the model at hand. In Section 3, we generalize our findings and show their deeper implications (subsection 3.1) and then provide a formal microeconomic setting (Lancaster's approach) which is adequate to address the problems and which reinforces our case (subsection 3.2). Section 4 concludes the paper.

2 Two Efficiency-Wage Models

2.1 Solow's Model

2.1.1 The Standard Layout

Solow (1979) was one of the first to formulate an efficiency-wage model that would imply wage rigidity and therefore involuntary unemployment. Here we use the most common version of the model as presented in Romer (2006) to maintain the familiar notation.

There is a large number of identical competitive firms that maximize profits. To simplify the analysis, only one input — labour — is assumed. The contribution of labour to output of the firm depends positively on effort e that workers exert. This effort is assumed to enter the

production function multiplicatively with labour. The production function is therefore

$$Y = F(eL) \tag{1}$$

where $F'(\bullet) > 0$, $F''(\bullet) < 0$. The key element of the model is the assumption that higher wages induce higher effort on worker's part, i.e. that $e = e(w)$, where $e'(\bullet) > 0$. Since firms are free to choose both the wage and amount of employment, their optimisation problem is

$$\max_{L,w} \{F(e(w)L) - wL\}.^{1} \tag{2}$$

The first-order conditions are

$$F'(e(w)L)e(w) - w = 0$$

and

$$F'(e(w)L)Le'(w) - L = 0.$$

Assuming that second-order conditions are satisfied, the two equations yield the solution to optimal choices of the firm. Their combination gives

$$e'(w^*) = \frac{e(w^*)}{w^*}. \tag{3}$$

The interpretation is straightforward. The firm wants to find such w^* so as to minimize the cost per unit of effective labour $w/e(w)$ or, equivalently, maximize effort per dollar $e(w)/w$. This happens at w^* where average effort equals marginal effort which is the condition in (3).[2] This equation therefore gives the optimal wage w^*, which can then be plugged into either of the two first-order conditions to find optimal employment L^*.

The essential message of equation (3) is that optimal wage w^* is completely independent of the labour market. What drives wages is not standard supply of labour and demand for labour, but only the effort function $e(w)$ that workers have and that firms know about. Therefore, the implication of the Solow model is that if the entry of effort into the production function is labour-augmenting (i.e. e multiplies L rather than other potential inputs), then the optimal wage can be completely rigid. This has important consequences. First, because all firms are identical, each chooses w^*, which implies a potential disequilibrium on the labour market. Whenever w^* exceeds the Walrasian equilibrium wage w_{eq}, involuntary unemployment results. This is depicted in Figure 1. Second, because the wage is given by (3) and thus is unresponsive to labour demand, swings in the labour demand curve only affect the amount of labour hired, not the wage level. Therefore, the model seems to explain the empirically observed large movements in employment as compared to the relatively small movements in wages.

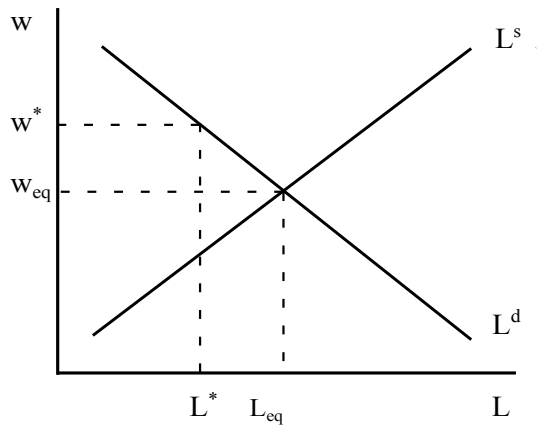
[1] We assume that output price is normalized to one, i.e. output is the numéraire.

[2] Minimizing real wage costs can be formally written as

$$w^* = \arg\min_{w} \left\{ \frac{w}{e(w)} \right\}.$$

Differentiating with respect to w and assuming that regularity conditions are satisfied, this yields the same solution as in (3).

Figure 1: Optimal wage w^* in the Solow model



2.1.2 A Closer Look at Assumptions

The above Solow model is striking in that it does not produce disequilibria due to obstacles for market functioning, due to market imperfections or non-maximizing behaviour, but precisely *because of* profit-maximizing behaviour. The very goal to maximize profits leads firms to disregard the market when setting wages. Solow's model has received repeated references (Yellen, 1984) and extensions (Summers, 1988), and also relatively few criticisms (e.g. Bellante, 1994). However, to the best of our knowledge, the most problematic (and hidden) assumptions in the model have not been discussed.

First, Solow (1979) assumes that the effort function is a fixed, given relationship that cannot be changed by the worker. However, this is not consistent with any conceivable idea of the effort function, nor with definitions of effort by other authors. Second, Solow introduces only one labour market, although he assumes from the very beginning that there are different types (efforts or qualities) of labour. We discuss these two points in the next two parts, respectively.

2.1.3 The Nature of the Effort Function

The effort function represents the assumption that effort of workers varies with wage, but non-linearly. It is necessary to clarify at the outset that both wages and labour output are flow variables measured per unit of time. Therefore hourly effort $e(\bullet)$ (leading to certain hourly output) is a non-linear function of hourly wage w.

It seems reasonable to assume that marginal effort $e'(\bullet)$ will be decreasing from some point. No matter how high the offered hourly wage, there is an upper limit on how much a human can perform. The assertion of increasing marginal effort at lower wages is more disputed, but can also be justified on grounds of (mal)nutrition in developing countries or motivation in developed countries.

As was shown above, the firm then sets the optimal wage w^* to satisfy the unit wage elasticity of effort in (3). Following this condition, efficiency wage models proceed to assert

that this generates downward wage rigidity. Workers cannot offer lower wages in order to find a job: In the region where marginal effort is increasing, lower wage $w < w^*$ would violate the optimum condition of cost minimization for the firm and thus decrease its profitability.

This however contradicts the nature of the effort function. Ever since Shapiro and Stiglitz introduced in their seminal paper "the effort decision of a worker" (1984, p. 435), effort $e(\bullet)$ is considered to be endogenous to the worker.[3] If the worker is not successful at finding a job paying certain desired wage per unit of effort, he receives a clear market signal that his services are too expensive. The worker then has to offer a lower price — that is, he has to turn his effort function upwards around the point of origin. Such a matching process is not only possible, but in our opinion also often observable.

To avoid misunderstanding, we are far from claiming that the concept of effort function is flawed or unusable. On the contrary, it provides at least two important insights into the functioning of the labour market. First, the effort function embodies the notion that labour as a productive input has more dimensions than man-hours. Second, it implies that optimisation of firms and workers is accordingly multidimensional and that a firm can employ more of low-intensity man-hours or less of high-intensity man-hours.[4]

Nevertheless, what we do question is the conclusions about market disequilibrium drawn from effort functions. The most important consequence of condition (3) is that firms cannot be expected to set wage primarily in terms of hours. Instead they will optimize production in such a way that unit wage (in money per effort) will be set equal to the marginal product of effort, and the final hourly payment will then be determined by the amount of effort exerted. The firm will plan the amount of effort units it requires. It will then hire the respective amount of labour which will supply this amount of effort, that is, either a lot of cheap low-effort workers or few costly high-effort workers. Let us recall that the price per unit of effort (i.e. 'effort wage') in which workers can compete is a voluntary decision of workers based on their preferences. At this point we can already conclude: Given that the effort function is fully determined by workers' preferences, there exists no room for involuntary unemployment.

So far we stressed the voluntary, preference-driven character of the effort function. In the following section we will turn to another crucial implication of the efficiency wage models: the multidimensionality of labour.

2.1.4 Heterogeneous Labour Markets

The production function in (1) has only one input — labour. Usually, the simplification to model only one labour market with labour L and one capital market with capital K is justified. This is because we often assume from the very beginning that there is only one type of labour and one type of capital. Then, the maximization of profit in the standard textbook form $\Pi = F(K, L) - r_K K - wL$ does not pose any problems for analysis.

We suggest, however, that the situation with efficiency-wage models is fundamentally different. In these models, one deals *by definition* with different types of labour. Specifically, in the above model Solow introduces the possibility of different effort levels e, which implies labour of varying quality. Yet, Solow still models the labour market as a single one with homogenous

[3] The case of malnutrition is excluded from our consideration as it does not concern developed economies.

[4] As a result, it shows that the solution to the profit maximization problem may have more than one solution.

labour L: See the right-hand term wL in (2). This is in our opinion a serious contradiction that prevents standard economic analysis — and standard results accordingly. In what follows we show that this assumption of a homogenenous labour market, which has gone unnoticed in efficiency literature so far, is the necessary element that allows Solow to derive the existence of involuntary unemployment.

In contrast to the production function (1), let us now define that each level of effort e constitutes a different type of labour. That is, we now distinguish between labours of different qualities according to the effort that the worker puts into it. The more effort is put into work, the higher quality of labour follows. For ease of notation, let us also assume that the number of types (qualities) of labour is finite, i.e. ranging from some inferior labour L_1 to top-quality labour L_N. Solow's production function $Y = F(eL)$ now becomes

$$Y = F(L_1, ..., L_N). \tag{4}$$

At first sight, effort e is absent in the production function in (4). This is because its meaning is now subsumed under different *types of labour* L_1,..., L_N. L_i corresponds to effort level e_i, which in turn corresponds to wage w_i.[5] Therefore, we have preserved the link between wages and effort — the main idea of efficiency wage models — but we model different efforts in the form of different types of labour. Putting these considerations together, the firm now faces the problem

$$\max_{L_1,...,L_N} \{F(L_1, ..., L_N) - w_1 L_1 - ... - w_N L_N\}. \tag{5}$$

The optimisation problem in this form clarifies why the treatment of labour matters crucially. Now, the firm still chooses effort (efficiency) by choosing wage, but formally does it by choosing a specific labour market L_i. The pairs (w_1, L_1), ..., (w_N, L_N) represent the particular labour markets, assorted by the quality of labour that is traded on them. Importantly, w_i is the *Walrasian equilibrium wage* prevailing on market for labour of type L_i. As a result, in the optimisation problem (5) the firm does not explicitly choose w as in (2), but does it implicitly by choosing labour of quality L_i with its corresponding price w_i.

2.1.5 Equilibrium on the Heterogeneous Market

The implications of this reformulation are far-reaching. Firms still maximize profits by choosing the optimal effort level, but since we now view labour markets as heterogenous, firms do so by choosing the optimal labour market where to hire labour. Finding and setting the optimal wage therefore amounts to choosing a labour market and paying its Walrasian *equilibrium* wage. This means, however, that no disequilibrium wage can occur. Any wage chosen is an equilibrium wage on *some* market — and this market is chosen. The effort function $e(w)$ can then be understood as a set of N wage-quality pairs traded on N markets.

By defining labour as heregeneous, we have reached a different perspective on the problem at hand: firms choose between types (qualities) of labour L_1,..., L_N just as they may choose

[5] It is crucial to note that index i does *not* correspond to workers: more workers can be of the same type L_i and one worker can alter his type from L_i to L_j, as we show in section 2.1.3. We return to this point in the next section.

between types (qualities) of capital K_1,..., K_N. Our reformulation, in contrast to Solow's treatment, is therefore a general one. We have shown that different efficiencies (efforts) can be simply modelled as different types of labour, each of which has its own market. This is a parallel to different types of capital having their own market. Solow, by contrast, assumes that labour of different efficiencies is traded on a single market at some *uniform* price. This is why he inevitably derives a non-standard situation in which the wage is independent of demand and supply, and hence where involuntary unemployment exists. By contrast, defining labour properly as heterogenous shows that there is no room for disequilibrium situations and involuntary unemployment.[6] This refutes the idea of the Solow model that labour is a peculiar, special input that causes standard market equilibrium to fail.

The confusing feature of labour is that one and the same physical person may exert different efficiencies and therefore be present on multiple labour markets. In economics, however, markets are abstract concepts, not physical places. Thus it does not pose any problem to model different efforts of the same person as different markets. We therefore see no reason for abandoning standard neoclassical economic analysis, contrary to what is done in the Solow (1979) model.

To clarify that what matters more is services offered by inputs rather than their physical definition, in section 3 we introduce an alternative microeconomic approach, using Lancaster's characteristic-space model.

2.2 Shapiro-Stiglitz Model

2.2.1 The No-Shirking Condition

In a second very known version of efficiency-wage models, Shapiro and Stiglitz (1984) elaborated on early literature to include imperfect information. Their basic idea was that when firms cannot perfectly monitor workers' effort, they may choose to pay higher wages to discourage workers from shirking. The point of Shapiro-Stiglitz model is not that higher wages simply induce higher effort, which sufficed as reason in the basic Solow (1979) model. Here, non-Walrasian wages play the role of creating involuntary unemployment, which in turn works as a 'worker discipline device': if there was no involuntary unemployment, argue Shapiro and Stiglitz, then shirking would entail no costs, because after being caught and fired, workers would immediately find new jobs. Only involuntary unemployment can 'discipline' workers by incurring costs of losing jobs. Therefore, Shapiro and Stiglitz understand non-Walrasian wages as an economy-wide equilibrium solution to the possibility of shirking.

The model assumes that there are only two effort levels: working and shirking. As a result, one can inspect three value functions V_E^N, V_E^S and V_U that stand for the present value of (a) being employed and working, (b) being employed and shirking, and (c) being unemployed, respectively. Defining these and then imposing the condition under which workers do not shirk ($V_E^N \geq V_E^S$) yields the well known no-shirking condition

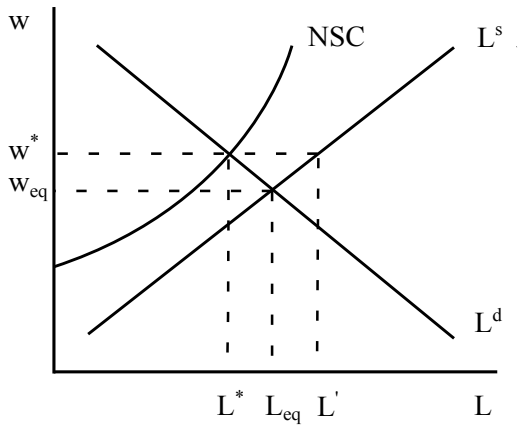
$$w \geq e + \bar{w} + \frac{e}{q}\left(\frac{b}{u} + r\right) \equiv \hat{w}, \tag{6}$$

[6]Equilibrium must be attained insofar as neoclassical assumptions on the individual submarkets i are met. This is not to say that other frictions on these markets do not exist. We merely show that effort or quality variations of labour *per se* do not generate disequilibrium.

where e is effort (disutility from working), $\bar{w}$ the unemployment benefit (i.e. alternative wage in case of getting fired), q the probability of being caught shirking, b the probability of termination of working post (exogenous, with no relation to effort), u the unemployment rate, and r the rate of interest used for discounting future to present value.

Wage $\hat{w}$ makes workers just indifferent between working and shirking. Any wage higher than $\hat{w}$ ensures that given the current unemployment rate and the parameters of the model, costs of shirking outweigh its benefits. The appealing feature of the model is that the minimum no-shirking wage $\hat{w}$ depends on the unemployment rate in the economy — that is, on other firms' wage decisions — and therefore can be plotted as a function in the labour market diagram. Higher employment L (equivalent to lower unemployment rate u) lowers workers' costs of getting fired for shirking. Therefore, according to (6), to discourage them from shirking, firms have to pay them higher wages. This results in the upward-sloping no-shirking condition (NSC) in Figure 2.[7] The optimal wage that the firm sets is w^*, given by the intersection of the labour-demand curve and the no-shirking condition. This time, unlike the Solow model, labour demand matters for the optimal wage. However, labour supply is still irrelevant in setting of w^*, giving again rise to involuntary unemployment.[8]

Figure 2: Optimal wage w^* in the Shapiro-Stiglitz model



2.2.2 A Play with Words to Prove Involuntary Unemployment

This conclusion about involuntary unemployment was criticized by Carmichael (1985). He suggested that those workers who want to work at w^* but are not hired can simply 'buy' the job. That is, they offer to pay an 'entrance fee' or a 'bond' to the firm for giving them the

[7] Figure 2 is not exactly the one shown in Shapiro, Stiglitz (1984). The authors use a figure with a vertical labour supply curve at the maximum employment N. We prefer to use a more general version with an upward-sloping labour supply curve which nevertheless fully maintains the idea of the Shapiro-Stiglitz model.

[8] More accurately, in the Shapiro-Stiglitz model it results *necessarily*, because it is precisely the involuntary nature of unemployment that disciplines workers and keeps them from shirking. In the Solow model, by contrast, involuntary unemployment is a possibility, but not a necessity.

job. This reduces their value from the job to the point where they are indifferent between working and being unemployed. Therefore, unemployment is no longer involuntary. Although Carmichael's point made an impact[9], there is a more serious problem in the model.

Shapiro and Stiglitz give the following reasoning:

> "From the worker's point of view, *unemployment is involuntary*: those without jobs would be happy to work at w^* or lower, but cannot make a credible promise not to shirk at such wages." Shapiro & Stiglitz (1984), p. 438, emphasis original.

In our view, Shapiro and Stiglitz are involved in an outright contradiction. On one hand, they claim that the workers would be 'happy to work at w^* or lower'. On the other, they assert that at such wages 'they cannot make a credible promise not to shirk'. One would like to ask the authors the question: 'At w^*, would the employees work or shirk?' It appears as if Shapiro and Stiglitz used a terminological trick on the reader to make their case. The situation in the model is as follows: One can be either employed or unemployed; further, if one is employed, he can work or shirk. If one shirks, he does not work at all and thus does not exert any effort. However trivial this may sound, it matters crucially for the conclusions. Shapiro and Stiglitz have us believe that at w^*, $L' - L^*$ people in fact offer to do *something* for the potential employer, but somehow cannot get the job. However, as the authors themselves write, they do not offer to work — they instead *offer to shirk*. Therefore, there cannot be involuntary unemployment. When Shapiro and Stiglitz call unemployment involuntary, they in fact pity workers for not getting paid for *not* working.[10]

The confusion of words is caused by the use of the category 'employed, but shirking'. For economic analysis, it does not matter whether one is idly sitting at home and is called 'unemployed', or whether he is idly sitting at work (shirking) and is called 'employed, but shirking'.[11] The economic meaning of the two categories — the employed but shirking and the unemployed — is identical in the model: the person does not produce anything. Yet, in Shapiro's and Stiglitz's logic, when one offers to shirk at w^* and firms, knowing this, do not offer him the job, he is called 'involuntarily unemployed'. If Shapiro and Stiglitz had not used the term 'employed' for those who do not work at their job, they could never have reached this conclusion.

2.2.3 Labour Supply versus the No-Shirking Condition

Shapiro and Stiglitz chose to introduce the simplest case where the only two options are $e > 0$ for working and $e = 0$ for shirking. Let us broaden the model to a more general case with

[9] See Shapiro's and Stiglitz's (1985) reaction in which they retreated somewhat from their claim about involuntary unemployment.

[10] Similar self-contradictory statements like that of Shapiro and Stiglitz above can be found in Yellen (1984, p. 202) and Romer (2006, p. 455).

[11] There is no difference between 'unemployed' and 'employed, but shirking' in the model since Shapiro and Stiglitz allow only two effort levels in their model: $e > 0$ for working and 0 for shirking. Thus, shirking at work amounts to zero output just as being unemployed does.

As a side note, we add that 'employed' in economics has always meant 'utilised'. Therefore, 'employed, but shirking' is a confused connection that the authors fail to explain. See terms such as 'employed shirker' in Shapiro, Stiglitz (1984, p. 436.)

$0 < e_1 < e_2$, where e_1 is the shirking state[12] and e_2 the working state. It is easy to show, however, that this does not change anything about the failure of the model to prove involuntary unemployment. It suffices to inspect carefully the definitions of the NSC and the labour supply curve.

In order to construct the no-shirking condition, Shapiro and Stiglitz first had to empty the meaning of the labour supply curve. The labour supply curve, in all economic works since the curve was conceived, has always *meant precisely the no-shirking condition.* The condition of working at a given effort level — as the opposite of shirking (i.e. failing to reach this effort level) — is exactly the idea of the labour supply curve: one is offering to supply labour of given quality in exchange for reward on the labour supply curve, and not to supply this quality beyond the supply curve. Therefore, Shapiro and Stiglitz necessarily have to redefine the labour supply curve away from its original meaning in order to move its content into their newly conceived 'no-shirking condition'. Hence, in their model, the labour supply curve also comprises those who in fact do not want to supply the labour of given quality. Only then can the authors come up with the NSC curve to denote those who will 'really' work. We stress that the invalidity of the model does not rest on whether effort levels are defined as $e_1 = 0$ and $e_2 > 0$ or $0 < e_1 < e_2$. The reason is that the borderline between working and shirking is given by the definition of what L means on the respective market.

At a closer look, the root of the problem just described is the same as that of the Solow model identified in Section 2.1.4: labour L on the horizontal axis in Figure 2 is not always measured in the same units. Labour used in the non-shirking condition is something completely different from 'labour' (i.e., not labour but shirking in any form) ascribed by Shapiro and Stiglitz to the labour supply curve. Then the horizontal axis has two alternating meanings, and hence the figure cannot be used for standard microeconomic analysis. We explain deeper problems of this practice in Section 3.

For now, we conclude that there is no involuntary unemployment in the Shapiro-Stiglitz model. Workers voluntarily choose their effort level at any wage. If firms know that with a certain wage and certain level of employment additional workers would shirk at work, and for this reason do not offer them work, then nothing of involuntary nature occurs. The NSC curve in reality *coincides with* the correct labour supply curve.[13]

2.2.4 Firm Optimisation

The central claim of the Shapiro-Stiglitz model is that firm optimisation leads to involuntary unemployment, and that this in turn represents market inefficiency which needs to be corrected. Still the model leaves the interaction of firms on the market largely undefined. Let us therefore analyze the production side in more detail.

The model assumes that there are M identical firms which have aggregate production func-

[12] Shirking from the point of view of the firm is any positive effort lower then what was agreed in the employment contract, i.e. any positive effort lower than the marginal product equivalent to the agreed wage.

[13] To avoid misunderstanding, we do not claim that due to imperfect monitoring the wages offered by firms cannot be higher than what would be the case under perfect monitoring. We only claim that those unemployed are unemployed voluntarily and that the distinction between the NSC curve and the labour supply curve is erroneous.

tion (see Shapiro & Stiglitz (1984), footnote 9):

$$Y = F(L) \equiv \max_{L_i} \sum_{i=1}^{M} f_i(L_i) = \max_{L_i} \{M \cdot f(L_i)\}$$

where by symmetry $L_i = \frac{L}{M}$. Most strikingly the model is missing an analysis of competition in the sense of how M is determined and who stands behind these firms. This raises the question why the economy does not end in one of the extreme states: either there might be just one producer or each labourer might be self-employed. Recall that all producers are identical and that production function has the standard property of decreasing returns of scale, then the following inequality holds:

$$M \cdot f\left(\frac{L}{M}\right) > f\left(M \cdot \frac{L}{M}\right).$$

This means that the latter case where firms are dissolved completely should be preferable.

In order to resolve this issue, we must consider yet another confusing point made by Shapiro & Stiglitz. They dispute the efficiency of market equilibrium by stating that

> "The natural unemployment rate is too high." Shapiro & Stiglitz, *ibid*, p. 440.

They find that workers are paid their marginal product MPL, and claim that higher employment could be financed from the producer surplus of average product APL over MPL (see the feasibility constraint in equation 12, Shapiro & Stiglitz 1984). Most importantly Shapiro & Stiglitz do not offer any reason why producer surplus should be redistributed: they simply claim that it belongs to workers.[14]

There is a stark contradiction in their argument: On the one hand, Shapiro & Stiglitz claim that the whole product belongs to workers. On the other hand, they insist on workers being employed not on their own but *in firms*. The solution can be seen easily: If Shapiro & Stiglitz want workers to earn a wage equal to APL, workers should become self-employed and cash in this benefit. Otherwise, if existence of M firms is assumed — as is indeed the case in real economies —, there exists a certain value added in firms which naturally belongs to the organizer of the firm.[15]

3 Generalization: Alternative Microeconomic Approach

3.1 Deeper Problems of Homogeneous Markets

We have shown that modeling labour as heterogeneous when efficiency is studied results in fundamentally different conclusions as compared to the single-market approach practised in Solow and Shapiro-Stiglitz models. In this part, we suggest reasons why the heterogeneous

[14] This is in effect a direct attack on the marginal revolution in economics, which surprisingly did not receive much attention in subsequent literature. We note that Shapiro's and Stiglitz's proposed solution of redistribution of the surplus APL over MPL is based on nothing else than Karl Marx's surplus value theory.

[15] This value added lies especially in investing the time necessary for the production process, gathering required fixed investments (capital) and managing highly advanced processes of production. These complicated procedures are called *roundabout methods of production* and their distinctive feature lies in investing funds now to consume their products later, instead of enjoying the funds for immediate consumption.

labour approach should be strongly preferred. As the reference model, we take the basic Solow (1979) model from section 2.1, but all of our arguments below apply just as well to the Shapiro-Stiglitz model.

The goal of the demand-supply analysis in economics is to study the relationship between prices and quantities. A precondition for this to be possible is to define precisely the good or service whose quantity and price is to be studied. Solow's model, however, violates this requirement. The idea of the model is that higher wages increase workers' effort, for which reason firms may choose to pay above-equilibrium wages and thus create involuntary unemployment. Yet, this very idea implies that by offering higher wages, firms demand *different* type of labour than with lower wages. This means, however, that labour L on the horizontal axis changes its own definition while wage moves. This is a situation that standard microeconomic theory does not allow. The consequences are serious — comparative statics cannot be conducted.

For instance, to compare the amount of employment with the Walrasian equilibrium wage w_{eq} and with Solow model's optimal wage w^*, we would want to know the difference $L_{eq} - L^*$. Yet, we cannot subtract these two numbers since each of them stands for labour of different quality.[16] This point cannot be overemphasized. In fact, the varying definition of L on the horizontal axis even prevents the use of demand and supply curves. The entire demand-supply analysis is built on the assumption of ceteris paribus. If labour is being continually *redefined* when wage is changing, then the ceteris paribus condition is violated: what changes is not only quantity of labour, but also its quality — i.e. the very definition of labour itself. We borrow a statement from Rothbard:

> "The definition of a *good* is that it consists of an interchangeable supply of one or more units. Therefore, every unit will always be valued equally with every other." Rothbard (2004 [1962]), p. 320, emphasis original.

The endogeneity of labour quality on wage causes Solow's model to violate this condition. As a result, it cannot use the standard demand-supply analysis and thus cannot claim to demonstrate involuntary unemployment. In fact, Solow's theory does not model any meaningful market.[17]

[16] Take a parallel with the firm buying capital equipment — say, trucks. It can buy an expensive, top-quality truck from Mercedes-Benz, or it can buy a cheap, low-quality truck from Daihatsu. However, to subtract the number of Mercedes's from the number of Daihatsus bought does not make any sense. The two trucks have different characteristics despite both of them being trucks. By the same token, it makes little sense to subtract the number of high-quality, expensive bricklayers from the number of low-quality, cheap bricklayers. Certainly, the difference is that one and the same bricklayer can exert different efforts and thus be a high-quality bricklayer at one time and a low-quality one at another. This surely does not hold for trucks. However, this is still not a reason for modeling this situation as one labour market. Markets are abstract concepts defined according to characteristics of goods, not according to the physical fact that two types of goods can be produced by one and the same person. The fact that one single person can do different jobs or exert different efforts is economically irrelevant. What matters is the characteristic of the resulting goods or services.

[17] Later on, in a presidential address delivered for the American Economic Association, Solow himself called for a heterogeneous approach to labour markets:

> "(...) That fact of life merely reminds us that 'labour' is not a well-defined homogenenous factor of production." Solow (1980), p. 4.

Yet, Solow never changed his 1979 efficiency-wage model to incorporate this view. We have shown that this statement of Sollow effectively invalidates the conclusions of his own efficiency-wage theory.

In conclusion, if labour is heterogeneous due to model assumptions (effort considerations), then to model it in one homogeneous labour market is not only self-contradictory, but it makes impossible the entire demand-supply analysis that one needs to derive results about market equilibrium. We suggest that the homogeneous labour approach should be replaced by multiple heterogeneous labour markets, differing by the quality of labour offered on them.[18] This is the direction of current research, among existing papers we refer to research by Bagger, Christensen & Mortensen (2010). In the next section, we offer a formal setting for the heterogeneous market approach.

3.2 The Characteristics Model

3.2.1 Lancaster's Model

Although mainstream economic textbooks tend to ignore the problem of goods' heterogeneity, this issue was understood by many economists and it was even modelled by some.

Perhaps the most complex theoretical model was developed by Lancaster (1966, 1971). In standard consumer theory preferences are defined on the space of goods, i.e. consumer utility function takes a vector of goods as its argument. In contrast, Lancaster postulates that consumers in fact choose between goods according to their characteristics, i.e. consumer utility function takes a vector of characteristics as its argument. The link between goods and characteristics is established by means of two axiomatic principles stemming from everyday experience:

1. A single good may possess several different valuable characteristics.

2. A number of different goods may have some of their characteristics exactly the same.

In formal terms Lancaster (1971) defines the transformation from the goods space ($\mathcal{G}$-space)

[18] It is interesting to note that the term efficiency-wages was not born in the rich literature of the 1970s and 1980s that claimed the existence of involuntary unemplyoment. Already Alfred Marshall (1964 [1920], p. 456) used the term 'efficiency-wages' to explain that wages in the same profession tend to converge to one value (i.e. confirm the law of one price) *after efficiency of the worker is taken into account*. He stated:

> "Competition tends to make weekly wages in similar employments not equal, but proportionate to the efficiency of the workers." Marshall (1964 [1920]), p. 454.

Thus Marshall realized that workers within the same profession differ in efficiency of their work. And he went further:

> "... it is not an uncommon saying (...) that he is the best business man who contrives to pay the highest wages." Marshall (1964 [1920]), p. 457.

This is a strong indication that Marshall, some 60 years before efficiency wage literature appeared, understood that higher wages bring higher effort and thus higher efficiency of labour. But apparently, he saw different efficiencies as different markets. This is why, unlike Solow, Shapiro or Stiglitz, he made no mention of involuntary unemployment.

to characteristics space ($\mathcal{C}$-space):

$$\begin{aligned} \boldsymbol{z} &= \mathbb{B}\boldsymbol{x}, \\ \mathbb{B} &\in M(r \times n), \\ \text{where } z_i &= \sum_{j=1}^{n} b_{ij} x_j, \end{aligned} \tag{7}$$

where b_{ij} is the quantity of the i-th characteristic possessed by a unit amount of the j-th good, z_i is the quantity of the i-th characteristic, x_j is the quantity of j-th good, r is the number of characteristics and n is the number of goods. $\mathbb{B}$ is the consumption technology matrix with elements b_{ij} and it describes all goods on the market in terms of their characteristics. Note that equation (7) is based on two further assumptions:

1. *Linearity.* $z_p = b_{pj} x_j$.
2. *Additivity.* $z_q = b_{qj} x_j + b_{qk} x_k$.

The consumer optimisation problem then takes the form:

$$\begin{aligned} \max_{\boldsymbol{x}} \; & u(\boldsymbol{z}) \\ \text{s.t. } \boldsymbol{z} &= \mathbb{B}\boldsymbol{x} \\ \boldsymbol{x} &\geq \mathbf{0} \\ \boldsymbol{p}'\boldsymbol{x} &\leq Q \end{aligned} \tag{8}$$

where the last line is the budget constraint. The choice variable is still the vector of goods $\boldsymbol{x}$ but it enters the objective function only through the consumption technology transformation. The vector of characteristics $\boldsymbol{z}$ is what matters to the consumer.

We need to highlight the separation mechanism between $\mathbb{B}$ and $u(\bullet)$. The consumption technology matrix $\mathbb{B}$ is assumed to be objectively observable at least in theory.[19] $\mathbb{B}$ represents information that all consumers can agree on: area of a flat, engine power of a car, or weight of a laptop. Subjective perceptions about goods, that is how individual characteristics are relatively valuable to a given consumer, are still contained in the utility function $u(\bullet)$.

Since in a general case $r = n$ cannot be guaranteed, properties of a solution to (8) are not straightforward. In particular, it appears reasonable to assume that $r < n$, since producers will try to develop goods combining various characteristics to satisfy as many consumers as possible.

In this case Lancaster (*ibid*) shows that consumer with utility function $u(\bullet)$ will not consume all n goods but at most r goods and often even less than r goods. In other words, some of the goods will not be purchased at all by this consumer. They will be those goods which do not have an attractive combination of price-discounted characteristics so as to satisfy the given preferences. Lancaster explains that corner solutions to the optimisation problem become general, as compared to textbook consumer theory. Another important property of the characteristics framework is that small changes in prices of goods that are not consumed do not affect equilibrium choice of $\boldsymbol{x}^*$.

[19] This is equivalent to producer theory where production technology is assumed to be hypothetically observable by all producers.

Below we show that both properties have important implications when we approach the labour market in a similar way.[20]

3.2.2 Market for Labour Characteristics

It is both a straightforward and, as far as we know, hitherto unexplored idea to extend Lancaster's approach to the labour market, which we propose in line with our analysis in the previous sections.

In our opinion, the characteristics model easily accommodates the main features of labour markets which can be observed in practice: Above all the advanced level of workers' specialization and the elaborate screening during job matching process for the majority of vacancies.

Assume that x_j's represent n labourer *characteristic-types* who offer their work on the market, and each of the workers has r characteristics z_i. Again it seems natural to assume that $r < n$, since firms generally look for a limited bundle of knowledge and skills. Thus employers solve the optimisation problem in (8).

The two important properties of any solution to (8) described in section 3.2.1 apply. Given workers' characteristics captured in $\mathbb{B}$, firms will not consider all candidates for their vacancies but rather search for those with the most favourable combination of desired characteristics discounted by their prices.

We illustrate this in Figure 3 with $n = 3$ and $r = 2$, where the budget constraint in $\mathcal{G}$-space is transformed by $\mathbb{B} \in M(2\times3)$ to $\mathcal{C}$-space. On the left hand side (LHS), the tetrahedron represents combinations (consumption bundles) of three characteristic-types of labourers $(x_1, x_2, x_3)'$ which the firm can afford given budget Q. Since the firm is interested in characteristics, it projects the tetrahedron into $\mathcal{C}$-space. In terms of geometry, the four vertices on the LHS correspond to the four vertices on the RHS in Figure 3. The tetrahedron is convex, hence the four vertices determine the envelope of the convex quadrilateral on the RHS, which is the budget constraint in $\mathcal{C}$-space.

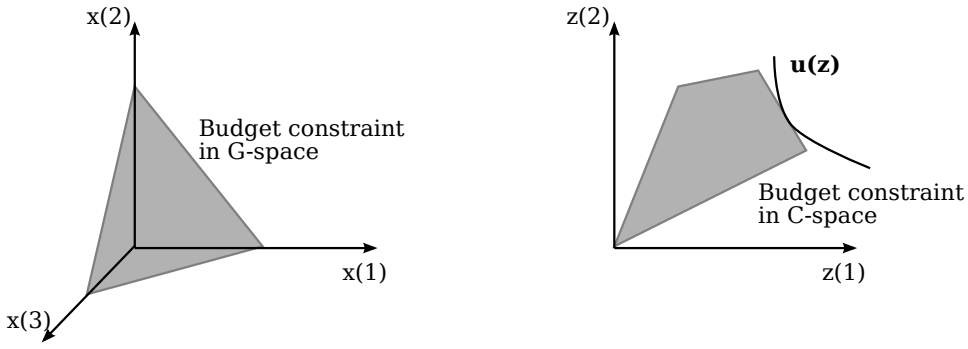
The optimum of an employer with $u(\boldsymbol{z})$ as depicted conditional on budget constraint Q lies on one of the edges of the quadrilateral, so that a combination of two out of the three characteristic-types of candidates will be chosen for the job. Going back to $\mathcal{G}$-space, the optimum will lie on one of the edges, say between x_1 and x_2, while labourers of characteristic-type 3 will not be considered ($x_3 = 0$). As is apparent from the $\mathcal{C}$-quadrilateral, the characteristic-type corresponding to the leftmost nonzero vertex is not competitive because his price-discounted combination of characteristics is too expensive.

The crucial conclusion of the model concerns the importance of relative prices of labour

[20] It is useful to mention that when it comes to recognizing the importance of product heterogeneity, empirical economics seems to be one step ahead of theory. The characteristics model has been applied in frequently cited empirical studies on demand systems for differentiated products. Perhaps the most influential is the paper by Berry, Levinsohn & Pakes (BLP 1995) who estimated demand parameters in the U.S. automobile market.

In order to make the concept of characteristics operational and econometrically sound, BLP worked with observed and unobserved characteristics of cars and estimated the respective demand slopes for the observed (or better: measured) ones. BLP enhanced their model by second choice data (BLP 2004). Other papers include Bresnahan, Stern & Trajtenberg (BST 1997), who estimate the demand system for personal computers. These studies demonstrate that heterogeneity of products is a relevant and recognized fact in empirical economics, but much less so in theoretical economics.

Figure 3: An illustrative transformation of budget constraint from $\mathcal{G}$-space to $\mathcal{C}$-space



characteristics: If a low-effort or low-skilled worker is unemployed, either he must lower his wage significantly (this shifts the vertex of the $\mathcal{G}$-tetrahedron away from the origin), or he must change the characteristic offered to high effort or high skill as expressed by coefficients of matrix $\mathbb{B}$. Geometrically both changes will turn edges of the $\mathcal{C}$-quadrilateral in Figure 3. Another option for the worker is to look for an employer with a different utility function.

The possibility of involuntary unemployment is excluded, since unemployment stems simply from wage-characteristic mismatch. As long as workers are willing to adjust, the unemployment gap can easily be bridged.

4 Conclusions

The theory of "efficiency wages" is a popular argument used to show that rational market interaction generates downward wage rigidity and involuntary unemployment. We identify two crucial fallacies of this idea. For one, efficiency wage models ignore the most important feature of labour markets: labour heterogeneity. Thus high-effort and low-effort units of labour are viewed as completely interchangeable, which however from the viewpoint of the firm they surely cannot be. For two, efficiency wage papers are plagued with a significant inner inconsistency: The resulting unemployment is classified as involuntary although it results from the effort decision of the worker where there is nothing rigid other than the worker's very own preferences.

To remove these contradictions we reformulate the theory in a more accurate way. Each of the effort or quality levels has to be viewed as a separate market which has its own clearing quantity and price. As such unemployment is a result of workers' reluctance to adjust to the prevailing market conditions on the respective narrow labour sub-market.

Alternatively, the labour market can be modelled by means of characteristics possessed by workers, as was originally proposed for the goods market by Lancaster (1966). This approach is based on a more complex analysis yet leads to the same conclusions. When some worker is unemployed he finds himself in a corner solution of the market optimisation. As a result he has

to either significantly alter his wage or significantly alter the bundle of provided characteristics. This way he can turn the corner solution to his side and become employed.

Both these modifications reinforce our central claim that free market interaction cannot lead to unemployment other than voluntary.

A Application: Did Henry Ford Pay Efficiency Wages?

In a well-known empirical paper, Raff and Summers (1987) ask whether efficiency wage theories can be applied to notable historical episodes of wage increases. As an exemplary case, they take Henry Ford's automobile factory in Detroit in years before World War I. They conclude that Ford's move to increase wages significantly and the subsequent job queues confirm the existence of involuntary umemployment.

Ford Motor Company saw skyrocketing growth of sales and high profitability since its foundation in 1903. However, mass production based on standardised, repetitive work in unpleasant factory conditions gradually caused dissatisfaction on workers' part. As Raff and Summers document,

> "... worker dissatisfaction took visible form. In 1913, annual turnover at the Ford plant reached 370%. Ford had to hire 50,448 men during the course of the year in order to maintain the average labor force at 13,623. (...) At the same time that turnover became so alarming, Ford also faced and epidemic of absenteeism. In 1913, the company suffered a 10% daily absenteeism rate." Raff and Summers (1987), pp. 63–64.

Ford even complained about workers' 'soldiering', i.e. deliberate (but hidden) boycott of production without declaration of an official strike. The problems became so grave that Ford first responded by increasing wages across-the-board by 15% in October 1913. This move helped only temporarily and problems of similar nature returned very shortly. Hence, in January 1914, Ford ordered a wage increase of more than 100%, raising the daily wage from USD 2.34 to USD 5.00. The measure was accompanied by a reduction of working hours from 9 to 8 hours a day.

Using this example, Raff and Summers aim to confirm the two major assertions of efficiency wage theories: (a) that the productivity improvement at Ford's plant more than offset higher wages, thereby leading to increased profits, and (b) that the higher wages caused disequilibrium on the labour market, creating involuntary unemployment.

As regards the first claim, Raff and Summers offer plenty of evidence that the wage increase paid off to Ford. Between 1913 and 1914, the turnover rate fell from 370% to 54%; the company had to lay off 6 times fewer workers in 1914 than in 1913; better work discipline allowed the company to significantly lower material costs; thanks to higher productivity, it could reduce average workforce by 11%. Even with fewer workers and shorter working hours, the plant increased the number of produced cars by 15% year-on-year. The overall effect was that Ford's net profit grew, in real terms, by 15% between 1913 and 1914.

We do not find this result surprising. Ford found that he may well achieve higher profits with more expensive, but higher-quality labour rather than with cheap, but low-quality labour.

As we noted in Section 2.1.5, this is a standard, profit-maximizing choice of inputs, be it labour or capital.

However, Raff and Summers then attempt to prove the second claim, i.e. that the new, higher wage was a disequilibrium one. In their view, this is demonstrated by the job queues that appeared in front of Ford's factory. They quote colourful newspaper reports from the days following the pay rise:

> "Twelve thousand men, more than congregated around the plant on any other day last week celebrated the [five-dollar day] with a rush on the plant which resulted in a riot and turning of a fire hose on the crowd in weather but little different from zero." Raff and Summers (1987), p. 73. Brackets original.

They further document that the wage increase was not meant to attract more highly skilled workers, given the fact that production techniques at Ford's factory did not require more qualified labour than before. Altogether, these considerations lead Raff and Summers to conclude that "Ford's wage surely exceeded his workers' opportunity cost and put him in the position of rationing jobs." (p. 83).

In our opinion, Raff and Summers fall in the trap of defining types of labour too narrowly. In Section 2.1.4 we made the case that labour must be understood fully heterogeneously, taking account of all possible differences. In contrast, Raff and Summers only see differences in types of labour when it comes to qualification and skills. They assert that Ford was not looking for different type of labour when he raised wages because he still demanded the same qualifications and skills. Hence, they see an above-equilibrium wage on the job market after the pay rise. On the contrary, we suggest that Ford in fact *was* looking for a different type of labour because he wanted more reliable, more disciplined and more vigorous labour. These characteristics are no less a 'type' of labour than formal skill or qualification. Therefore, Ford went to another market to hire labour, and paid the correspondingly higher wage to obtain it.[21]

The fact that Ford decided to raise wages dramatically after serious problems with absenteeism, boycotts, low morale and poor discipline only corroborates our case. Ford could no longer afford to pay a low-quality input, and decided instead to pay a better one. As we stressed in Section 3.1, when one increases his effort, discipline and reliability in response to higher wage, we are moving from one market to another because the definition of labour L is changing. Therefore, involuntary unemployment does not follow.

The large job queues outside Ford's plant do not make the case for involuntary unemployoment either. The fact that a number of applicants show up for a job recruitment is not a proof that all of the applicants have the characteristics that the firm is looking for. Our application of Lancaster's model (Section 3.2.2) shows that unemployment stems from wage-characteristic mismatch. It is not surprising that after the announcement of a 100% pay rise, thousands of candidates came to apply for jobs. Yet, Ford was looking for a certain combination of characteristics that the recruitment event was to reveal, and surely only some applicants had them. In other words, it is only *during* the recruitment process — not before it — that the applicant

[21] As we pointed out in footnote 5, it is crucial to understand that different *types* of labour may well be represented by the very same labourer. Thus Ford did not necessarily have to hire different labourers, but just had to induce them to exert higher effort.

finds out what exact labour market the firm is targeting and whether he fits in it. Therefore, the mere fact that there are more applicants than the firm is willing to take on can never prove the existence of involuntary unemployment.[22]

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[22] We find it peculiar that Raff and Summers could use the observation of a job queue as a proof of involuntary unemployment. Anyone who has ever applied for a job in a publicly announced recruitment would confirm that there are often more applicants than the number of posts offered. However, few people would call it a proof of the existence of involuntary unemployment, because during the job interview many applicants are revealed to be *outside* the targeted market. Raff and Summers completely disregard the fact that recruitment is a matching process which reveals the heterogeneity of the labour market.

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