INTERNATIONAL FRAGMENTATION: BOON OR BANE FOR DOMESTIC EMPLOYMENT?

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Abstract

In this paper, we introduce the fairness approach to efficiency wages into a standard model of international fragmentation. This gives us a theoretical framework in which wage inequality and unemployment rates are co-determined and therefore the public concern can be addressed that international fragmentation and outsourcing to low wage countries lead to domestic job-losses. We develop a novel diagrammatic tool to illustrate the main labour market effects of international fragmentation. We also explore how preferences for fair wages and the size of unemployment benefits govern the employment effects of outsourcing and critically assess the role of political intervention that aims to reduce unemployment benefits under internationally fragmented production.

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Keywords: international fragmentation, unemployment, fair wages.

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1 Introduction

International fragmentation is a key aspect of modern industrial production and has therefore sparked a lot of interest in the academic literature and the popular press. Krugman (1995, p. 331) notes that "it is hard to argue that the sheer volume of trade (...) marks a qualitative difference from previous experience". Rather it is the composition of trade in general and the share of intermediate goods in particular that makes the recent wave of globalisation so different from globalisation a hundred years ago (Feenstra and Hanson, 2004). Grossman and Helpman (2005, p. 115) articulate the common view by stating: "We live in an age of outsourcing".[1]

The public debate on international fragmentation has so far predominantly focused on outsourcing of labour intensive production processes to low wage countries in Asia or Eastern Europe and its adverse effects on unskilled workers in industrialised countries. This phenomenon has revived the discussion among economists on whether it is technical progress or some form of globalisation that can explain recent labour market developments observed in the Western Europe and the U.S. Empirical findings in Feenstra and Hanson (1999, p. 938) "(...) support the idea that both foreign outsourcing and expenditures on computers have played a role in the increase of the relative wage for nonproduction workers". Moreover, they stress that "trade in intermediate inputs can have an impact on wages and employment that is much greater than for trade in final consumer goods" (2004, p. 147), since much of the recent growth of trade is attributable to outsourcing of component production and transactions of intermediate goods. When trade takes this form, it substantially changes the process of home production, with labour market consequences, which are similar to those observed under (factor-biased) technical change (ibid, p. 177). These insights have stimulated a theoretical discussion on the labour market ef-

[1] Throughout this paper, we use the two terms "international fragmentation" and "outsourcing" synonymously. For empirical evidence on the magnitude and growth of intermediate goods transactions associated with international fragmentation, see Hummels et al. (2001) and Yeats (2001). In a seminal paper, Yi (2003) calibrates a two-country dynamic Ricardian model of vertical specialisation to highlight the relevance of international fragmentation in explaining the growth of world trade after World War II.

fects of international fragmentation. Interestingly however, although in the perception of the general public it is the employment effects rather than the wage effects of international fragmentation that are important, almost all theoretical studies on outsourcing have built upon the assumption of perfectly competitive factor markets.[2] A framework that allows for co-determination of the skill premium and the unemployment rate is so far missing in the literature. To close this gap is the purpose of this paper.

There is a bulk of literature dealing with the relative factor price effects of international fragmentation. While Feenstra and Hanson (1996a) have pointed to a factor bias effect of outsourcing in a one-sector model, Arndt (1997) has shown in a two-sector framework that outsourcing of labour intensive activities may be beneficial for unskilled workers if it occurs in the sector with labour intensive production. This indicates a sector bias in the wage effects of international fragmentation. Indeed a number of different outcomes can be generated, including "some curious cases" (Venables, 1999). In the following years, economists have tried to identify a general principle which is at work, when international fragmentation affects factor prices. Egger and Falkinger (2003) point to the interaction of a cost-saving and a factor-intensity effect, which together determine the production pattern under outsourcing and the distributional consequences of international fragmentation. Independently of them, Kohler (2003) has drawn a similar conclusion from a multi-sector model.

Empirical evidence supports the common view that international fragmentation has substantial effects on relative wages in favour of skilled workers. Feenstra and Hanson (1996b, 1999) identify a positive impact of international fragmentation on the skill premium in the U.S., while Hijzen et al. (2002) and Hijzen (2003) provide similar results for the U.K. Even in continental European countries with strong labour market institutions, outsourcing may exhibit significant relative wage effects. Geishecker and Görg (2004) use the German Socio-Economic Household Panel to show that international fragmentation reduces the real wage for workers in the lowest skill categories, while it increases real wages

[2]The focus of the public debate on unemployment rather than wages clearly follows from casual observation of the popular press on both sides of the Atlantic. For more evidence in the case of the U.S., see Scheve and Slaughter (2001).

for (highly) skilled workers.

There is also (at least indirect) support for the public concern that international fragmentation may have detrimental employment effects (see, e.g., Egger and Egger, 2003a), a phenomenon that cannot be addressed in orthodox models of international fragmentation with perfectly competitive factor markets. However, to the best of our knowledge, the existing studies focus on employment in manufacturing industries, while a rigorous assessment of the nexus between international fragmentation and (economy-wide) unemployment rates is so far missing in the literature.[3] Despite the lack of well documented empirical evidence, it is this nexus which dominates the public discussion on outsourcing and therefore requires a better understanding of the main economic mechanisms at work.

International fragmentation can only impact on the unemployment rate if there are imperfections in the labour market. From a theoretical point of view, different sources of such imperfections can be distinguished: insider/outsider or trade union models, minimum or efficiency wages, etc. To our knowledge, there are three studies that analyze international fragmentation in a setting with imperfect labour markets, all of which focus on the role of trade union activities. Gaston (2002) investigates how outsourcing opportunities affect the nature of collective bargaining. Access to international fragmentation raises the outside options of firms and thereby worsens the bargaining position of unions. But international fragmentation does not occur in the bargaining equilibrium analyzed in this paper. Egger and Egger (2003a) consider bargaining on unskilled wages in a one-sector model but their analysis builds upon an ad hoc representation of the wage-setting curve without any details of the wage determination process. Skaksen (2004) presents a model of international fragmentation in the presence of trade unions. However, two restrictive assumptions are imposed. First, there is only one sector of production, which rules out any sector bias in the employment level effects and, second, there is only one type of labour,

[3]In the 1990s almost all Western European countries were characterized by a sharp increase of international fragmentation, mainly in the form of outsourcing to low-wage Central and Eastern Europe (Egger and Egger, 2003a; 2003b). However, at the same time, these countries experienced quite different developments in their unemployment figures. While unemployment rates increased in Italy and Germany, they declined in Denmark and the Netherlands, and remained rather stable in Austria (OECD statistics).

so that skill premium and unemployment effects cannot be addressed simultaneously.

Motivated by strong microeconometric and experimental evidence, we choose a different approach and consider a variant of the efficiency wage model, where the efficiency wage is derived from a *fairness* constraint (see Solow, 1979; Akerlof, 1982, and Akerlof and Yellen, 1988, 1990).[4] In this case, worker effort depends on the perceived fairness of the wage, i.e. on the wage paid by the firm relative to the wage workers consider to be fair. The fair wage is a weighted average of the income attainable outside the job and the wage of the other skill group. It is an important implication of this framework that the fairness constraint is binding for the unskilled workers, giving rise to unemployment of this group, while skilled labour is fully employed in equilibrium.

We combine the fair wage model with the outsourcing framework suggested by Jones (2000) and Jones and Kierzkowski (2001). This accounts for three potential sectors of production and two primary factor inputs (skilled and unskilled labour).[5] The model gives us a powerful tool to investigate the impact of international fragmentation on both the skill premium and the unemployment rate. Moreover, it allows us to disentangle cost-saving and factor-intensity effects of outsourcing and to address non-marginal effects that change the output mix in the economy of interest.[6] Following most of the theoretical literature on international fragmentation, we consider a small open economy and rule out any adjustments in final goods prices.

The remainder of the paper is structured as follows. Section 2 presents a model of fair wages and international fragmentation and characterises the unemployment effects

[4]Fehr et al. (1993) remark that their "two-stage market experiment may be viewed as (...) a test of Akerlof and Yellen's efficiency wage approach" (p. 438) and, when summarizing their findings, they conclude that the "results provide evidence for the validity of the fair wage-effort hypothesis" (p. 453). See Howitt (2002) and Bewley (2002) for an overview on further evidence.

[5]For an application of the fair wage model in a setting with more than one production sector, see Agell and Lundborg (1995), Grossmann (2000), and Kreickemeier and Nelson (2005).

[6]In this respect, Jones and Kierzkowski (2001, p. 28) argue that "the process of fragmentation is definitely not a marginal phenomenon." And in explaining why the standard Heckscher-Ohlin logic fails when thinking about the distributional consequences of international fragmentation, Jones (2000) emphasizes that foreign outsourcing of component production changes the production pattern of an economy.

of outsourcing. Section 3 discusses how the effects of international fragmentation differ in egalitarian and non-egalitarian economies. Section 4 looks at the effects of changing unemployment benefits on wages and employment and compares these effects for the cases of integrated and internationally fragmented production. Section 5 concludes.

2 A Model of Fragmentation and Unemployment

2.1 Integrated production

We look at a small open economy potentially producing the three goods X, Y and Z. Product markets are perfectly competitive, and production functions in all sectors exhibit constant returns to scale. For simplicity, the production technology in all sectors is assumed to be Leontief. Furthermore, good X is the good with the highest skill intensity and good Z the one with the lowest skill intensity. There are two factors of production, skilled labour H and unskilled labour L, both of which are supplied inelastically. Let w_L denote the wage of unskilled labour, w_H the wage of skilled labour, and P_i the price of good i. In equilibrium, unit costs cannot be smaller than goods prices, i.e.

$$c_X(w_L, w_H) \geq P_X \qquad c_Y(w_L, w_H) \geq P_Y \qquad c_Z(w_L, w_H) \geq P_Z, \tag{1}$$

where the strict equality holds for those goods that are produced in equilibrium.

The conditions for non-positive profits are conveniently visualised using the Lerner-Pearce (LP) diagram in figure 1. X, Y and Z denote unit-value isoquants for the respective goods, i.e. combinations of H and L that give one Euro worth of output. The unit isocost line tangent to X and Y gives combinations of H and L that cost one Euro and are therefore compatible with zero profits in both sectors X and Y. The inverses of the resulting factor prices are given by the intersection points of the unit isocost line with the respective factor axis. Analogous reasoning allows us to determine the factor prices compatible with zero profits in the production of Y and Z.

The convex hull of X, Y and Z, known as the Hicksian composite unit-value isoquant, together with the relative skill-to-labour endowment would suffice to determine production

patterns and factor prices in the full employment model: For endowment ratios strictly between the skill intensities of X and Z, goods X and Y (Y and Z) are produced if the endowment ratio is higher (lower) than the skill intensity of Y, and factor prices can be read off the respective part of the Hicksian composite unit-value isoquant. Endowment ratios more extreme than the factor intensities of X or Z lead to full specialisation in the production of the respective good, while full specialisation on Y occurs if the endowment ratio coincides with the skill intensity of Y. This well-known standard reasoning has to be modified here due to the existence of unemployment.

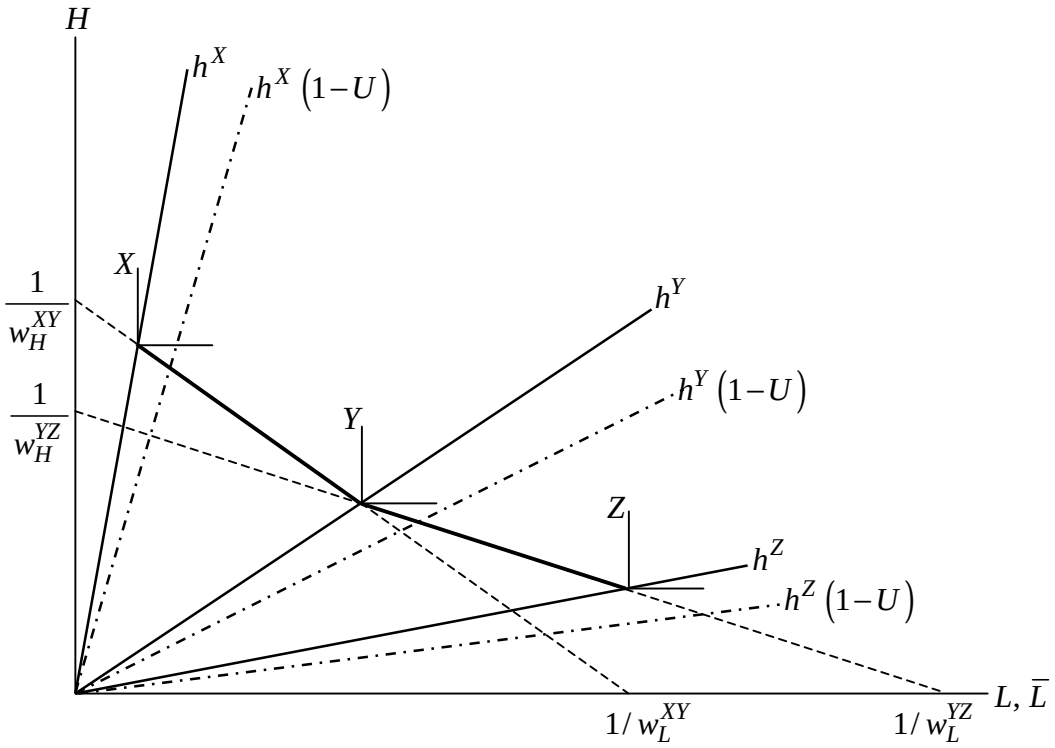

Figure 1: Unemployment in the LP diagram

In order to illustrate how the LP diagram can be used in the present context, define $\bar{h} \equiv \bar{H}/\bar{L}$ as the endowment ratio between skilled and unskilled labour and h as the respective employment ratio. As set out in the introductory section, the equilibrium of

the present model is characterised by full employment of skilled labour, while there is unemployment of unskilled labour. Let the unemployment rate for unskilled labour be denoted by U. Then, the relation between $\bar{h}$ and h is given by

$$h = \frac{\bar{h}}{1-U}, \tag{2}$$

and therefore we have $h > \bar{h}$ if $U > 0$. Denote the skill intensity of good-i production by $h^i, i = X, Y, Z$. Then, the economy produces X and Y if $h^X(1-U) > \bar{h} > h^Y(1-U)$, and it produces Y and Z if $h^Y(1-U) > \bar{h} > h^Z(1-U)$. For endowment ratios of $h^X(1-U)$ or higher ($h^Z(1-U)$ or lower) the economy specialises in the production of good X (good Z). The economy specialises on producing good Y if the endowment ratio equals $h^Y(1-U)$. No assumption has been made so far on how U is determined and whether it is constant across regimes. For illustrative purposes however, assume for the moment an exogenous level of U that is constant for all equilibrium factor prices. Using this assumption, the boundaries between production patterns are depicted in figure 1. In comparison with the full employment model, they are rotated clockwise with the extent of rotation depending on the rate of unemployment. We now move to showing how in our model U is determined in general equilibrium.

Following Kreickemeier and Nelson (2005), involuntary unemployment is generated by a variant of the fair wage mechanism used by Akerlof and Yellen (1990). Both types of workers are able to choose their effort ε at work. In doing so, they take into account the effort norm ε^n. For a worker of group k, we assume the additively separable utility function

$$\nu = v(X, Y, Z) + \Delta\varepsilon_k \tag{3}$$

where $\Delta\varepsilon_k \equiv -|\varepsilon_k - \varepsilon_k^n|$ is the degree of norm violation. Hence, for all consumption bundles a worker of type k maximises utility by choosing $\varepsilon_k = \varepsilon_k^n$. Workers' effort norms are determined by

$$\varepsilon_k^n = \min\left(\frac{w_k}{w_k^*}, 1\right) \qquad\qquad k = L, H \tag{4}$$

where w_k^* denotes the fair wage for workers of group k. Together, (3) and (4) imply that workers provide the normal level of effort, which is normalised to one, if they are paid at least their fair wage.[7]

Firms are wage setters but they are assumed to treat the fair wage, which is determined in general equilibrium, parametrically. Under this assumption, profit maximisation can be thought of as a two-stage process, just as in the standard efficiency wage model of Solow (1979). In step one, firms set the wage rate for each type of labour k to minimise the wage paid for an efficiency unit, which is w_k/ε_k. In step two, they hire workers up to the point where the value marginal product of labour is equal to the wage set in step one. It can be seen from (4) together with $\varepsilon_k = \varepsilon_k^n$ that the wage rate for an efficiency unit of labour (skilled or unskilled) stays constant (at w_H^* and w_L^*, respectively) if a firm pays a wage below the fair wage. We can therefore safely assume, following Akerlof and Yellen (1990), that firms choose to pay wages at least as high as the fair wage for the respective factor.

For each of the two groups, the fair wage has two determinants: first the market wage of the respective other group, and second the remuneration they could expect outside their own job, taking into account that they might be unemployed with a probability that is

[7]Equations (3) and (4) build upon two assumptions, which are essential for all fair wage-effort models. First, workers punish wages lower than those considered to be fair by providing lower effort, a behaviour which is often referred to by the term *negative reciprocity*. There is strong support for the reciprocity of workers by experimental evidence (Fehr and Gächter, 2000) and surveys on manager interviews (Bewley, 2002). Second, workers do not increase their effort in response to *overpayment*. This hypothesis has been studied in psychological experiments. The respective findings can be summarized in the words of Akerlof and Yellen (1990): "These experimental results are consistent with the hypothesis that overpayment does not increase input" (p. 258). Bewley (2002) also gives (at least indirect) support to the second assumption by concluding from survey results that "productivity and morale do not increase with pay levels though they can be hurt by pay reductions." (p. 9)

equal to the factor-specific rate of unemployment.[8] Hence, we have

$$w_L^* = \theta w_H + (1-\theta)(1-U_L)w_L \tag{5}$$

$$w_H^* = \theta w_L + (1-\theta)(1-U_H)w_H \tag{6}$$

where U_L and U_H are the factor-specific rates of unemployment, and θ is the weight attached to the remuneration of the other skill group in one factor's determination of its fair wage. Equations (5) and (6) do not account for payments to the unemployed. The impact of redistributive measures like unemployment benefits is analysed in detail in Section 4.

We assume that in a perfectly competitive labour market the wage for skilled workers would be higher than the wage for unskilled workers. Under this condition it is straightforward to see that the following must be true in equilibrium:

$$U_L > U_H = 0 \tag{7}$$

$$w_H > w_H^* > w_L = w_L^* \tag{8}$$

$$\varepsilon_L = \varepsilon_H = 1 \tag{9}$$

i.e., there is a strictly positive rate of unemployment $U = U_L$ for unskilled workers but full employment for skilled workers, the fair wage is binding only for unskilled workers, and both types of workers provide the normal effort.[9]

According to (7) and (8), equation (6) is not binding. By setting $w_L = w_L^*$ in (5) and solving for $\omega \equiv w_L/w_H$, we get

$$\omega = f(U,\theta) \equiv \frac{\theta}{\theta + (1-\theta)U}. \tag{10}$$

Following Akerlof and Yellen (1990), the equilibrium relationship between the wage differential and the rate of unemployment in (10) is called the *fair wage constraint*. For a

[8] Instead of the expected wage rate, Akerlof and Yellen (1990) use the (hypothetical) market clearing wage rate of the respective group as the second determinant of the fair wage. The two approaches yield similar results as in the presence of involuntary unemployment for the respective factor both its expected wage and its market clearing wage lie below the actual wage. The approach used here is more straightforward to apply in a multi-sector model.

[9] These results are the same as in the model of Akerlof and Yellen (1990).

given value of θ, the fair wage constraint describes equilibrium combinations between the rate of unemployment of unskilled workers and the relative wages of skilled and unskilled workers. Partial differentiation gives

$$\frac{\partial f}{\partial U} = \frac{-\theta(1-\theta)}{(\theta+(1-\theta)U)^2} < 0 \qquad \text{and} \qquad \frac{\partial^2 f}{\partial U^2} = \frac{2\theta\,(1-\theta)^2}{(\theta+(1-\theta)U)^3} > 0,$$

and hence the fair wage constraint is negatively sloped and convex in $\omega - U$-space, i.e. higher rates of unemployment for unskilled workers lead firms to paying them relatively lower wages. This is because with higher rates of unemployment, the fair wage needed to elicit normal effort from unskilled workers is lower. Considering the extreme cases $U = 0$ and $U = 1$, we have $f(0,\theta) = 1$ and $f(1,\theta) = \theta$, respectively. Hence, wages can vary over the range $[\theta, 1]$, and the model gives us an intermediate case between full wage flexibility and a fixed wage differential.[10] For future reference, we introduce the *inverse fair wage constraint*. It follows from (10) as

$$U = \tilde{f}(\omega,\theta) \equiv \frac{\theta}{1-\theta}\frac{1-\omega}{\omega}. \tag{11}$$

In order to describe the equilibrium production structure for the fair wage model in the case of integrated production, in figure 2 we introduce a novel four-quadrant diagram that merges a graphical representation of the fair wage constraint with the LP diagram of figure 1. The LP diagram is shown in the first quadrant, with the Hicksian composite unit-value isoquant traced out in bold.

Quadrant II depicts the function mapping the wage differential ω into $1/w_H$. Trivially, it is a linear function with slope w_L. Note however that w_L, which can be determined as illustrated in figure 1, is specific to the specialisation pattern, so that a change in the specialisation pattern rotates this function. Quadrant III shows the fair wage constraint, while the linear function $L = \bar{L} - \bar{L}U$ in the fourth quadrant relates the level of employment for unskilled labour to the unemployment rate, for a given endowment $\bar{L}$. Together, quadrants II to IV allow us to depict both endowment and employment quantities in the LP diagram of quadrant I.

[10] With perfectly competitive markets for both types of labour, ω can vary between 0 and 1, assuming – as we did – that under perfect competition skilled workers are paid the higher wage.

Note that factor prices in equilibrium have to be compatible with both the zero profit conditions and the fair wage constraint. Factor prices leading to zero profits in the production of Y and Z are compatible with the fair wage constraint for an unemployment rate equal to $U_1 = \tilde{f}(\omega_{YZ}, \theta)$, where ω_{ij} is the relative wage rate compatible with zero profits in the production of goods i and j. Hence, the economy specialises in the production of Y and Z if $h_1 = h^Y(1 - U_1) > \bar{h} > h^Z(1 - U_1)$.

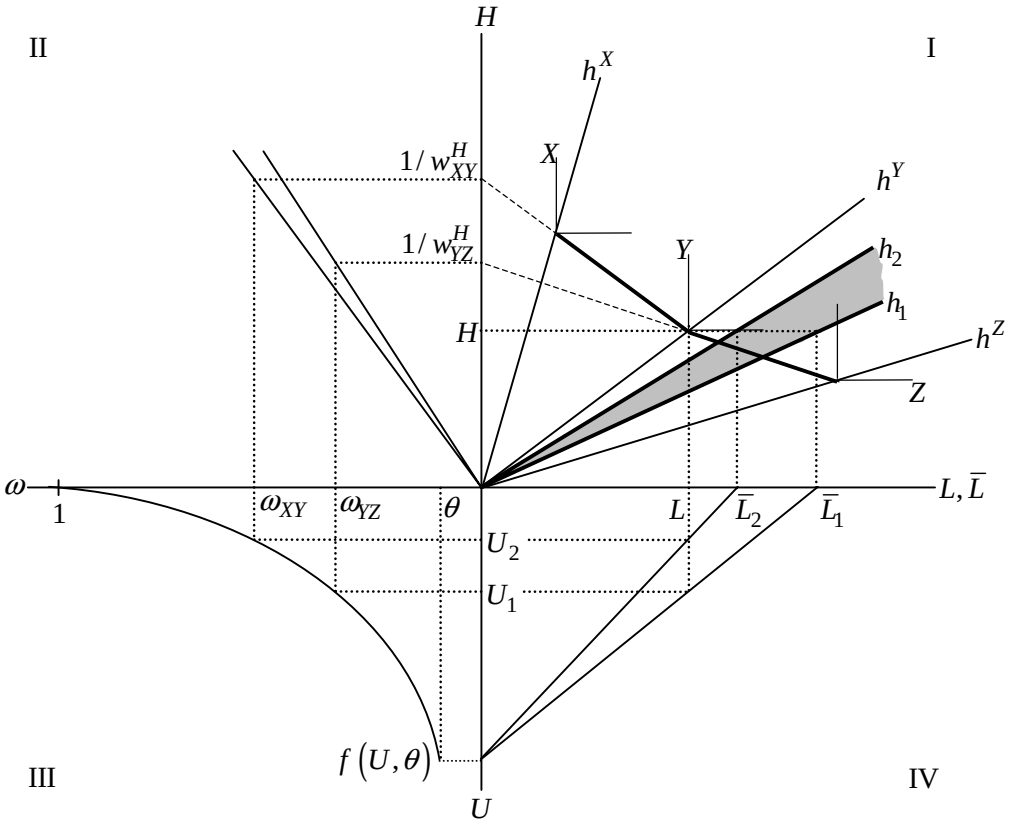

Figure 2: Equilibrium under integrated production

On the other hand, with specialisation in the production of X and Y, the unemployment rate is equal to $U_2 = \tilde{f}(\omega_{XY}, \theta) < U_1$.[11] Consequently, the economy produces these

[11] With a more skill intensive production mix, zero profit conditions require a higher relative wage of unskilled workers, and hence a lower rate of unemployment is needed to make this relative wage compatible with the fair wage constraint.

two goods whenever $h^X(1-U_2) > \bar{h} > h^Y(1-U_2) = h_2$. For endowment ratios between h_1 and h_2 the economy specialises in the production of Y. We call this region of specialisation on the good with intermediate skill intensity, which is shaded in figure 2, the *cone of non-diversification* (NDIV cone).[12] Inside the NDIV cone, for each endowment ratio the equilibrium unemployment rate $\bar{U}$ follows from (2) as $\bar{U} = 1 - (\bar{h}/h^Y)$, and the wage differential is given by $\omega = f(\bar{U}, \theta)$, according to (10).

The existence of an NDIV cone as defined here is guaranteed only for sufficiently low values of the fairness parameter θ, which – as shown earlier – is the lower bound of the wage differential compatible with the fairness constraint. More precisely, the NDIV cone exists if and only if θ is smaller than ω_{YZ} (see figure 2). For $\omega_{XY} > \theta > \omega_{YZ}$, there is an NDIV *region* (which is not a cone). The economy will in this case specialise in the production of Y for $\bar{h} < h_2$. For $\theta > \omega_{XY}$, not even an NDIV region exists, and the economy specialises in the production of good X for all relative factor endowments.

The fact that, irrespective of the relative skill endowment, labour-intensive production processes may become infeasible (if θ is sufficiently high) is an important feature of the fair wage model. However, since we are interested in the full set of general equilibrium interactions between endowments and production patterns, we ignore the latter two cases by assuming that θ is sufficiently small to guarantee the existence of an NDIV cone.

2.2 Fragmented Production

Now we assume that the production process for Y, the good with the intermediate skill intensity, can be split up into the production of components A and B, which in turn can be assembled without incurring an additional cost.[13] In our three-good setup, focusing on the fragmentation in the production process of good Y – rather than the "extreme" goods X or Z – is arguably the most interesting case because it allows us to distinguish between two situations of diversified production: one where the fragmented production process as

[12] In the full employment model with Leontief production functions this cone would have measure zero. This is true as well for a model with a constant rate of unemployment, as illustrated in figure 1.

[13] Assuming that international fragmentation occurs only in one sector is meaningful, as from an empirical point of view outsourcing opportunities are not (equally) prevalent in all industries.

a whole is more skill intensive than the other good produced ($h^Y > h^Z$), and one where it is less skill intensive ($h^Y < h^X$). As it will turn out, this distinction is crucial for many of the results in this paper.[14]

Let the world market prices for the two components be denoted by P_A and P_B, respectively. In analogy to the integrated production case, the absence of positive profits requires

$$c_i(w_L, w_H) \geq P_i \quad \forall i \in \{A, B, X, Y, Z\} \tag{12}$$

where again the strict equality holds for those goods or components that are produced in equilibrium. In analogy to the other production processes, Leontief technology is assumed for the production of components A and B. We restrict our analysis to the situation where

(i) production of one of the two components is retained domestically,

(ii) for relevant (zero-profit consistent) factor prices, fragmented production technology is strictly preferred over integrated production technology, once it is available,

(iii) both X and Z production remain viable for some h,

(iv) the skill intensity of the domestically produced fragment lies between h^X and h^Z, and

(v) good Y is produced in the pre-fragmentation equilibrium.

Conditions (i) to (v) serve the purpose of concentrating on what are arguably the economically interesting cases. In principle, it would be easy to specify world market prices for the two components such that the economy produces both or neither of them (see, e.g., Jones 2000). By condition (i) we exclude these cases from the analysis, as from the point of view of the home country neither of them involves international fragmentation of

[14] This distinction refers to the so-called sector bias of international fragmentation (see Arndt, 1997; and Egger and Falkinger, 2003).

production, the phenomenon we are interested in.[15] Condition (ii) excludes the borderline case of two technologies surviving in the Y sector (Egger and Falkinger, 2003). Condition (iii) says that technology and price for the fragment produced domestically must not be such that either X or Z production is infeasible for all values of h.

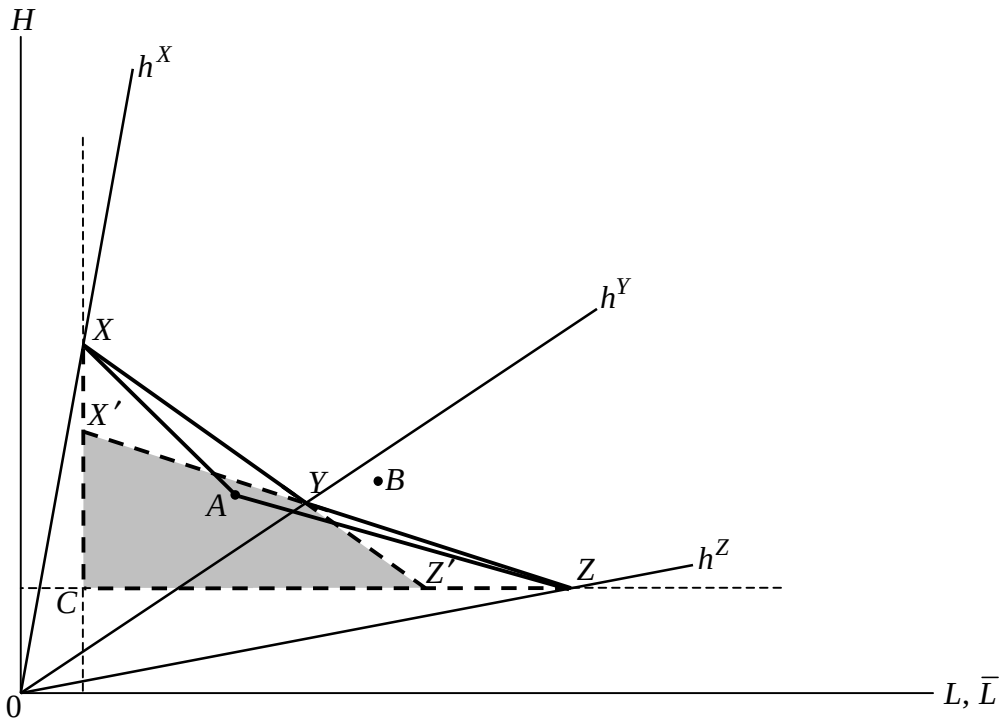

Figure 3: Fragmentation in the LP diagram

Condition (iv) rules out the possibility of a change in the factor intensity ranking of sectors (Egger and Falkinger, 2003), so that production of good X (Z) is the most (least) skill-intensive activity under both integrated production and international fragmentation of Y-manufacturing. Finally, the opportunity of international fragmentation may make

[15] Of course, one may hypothesize costless assembling at home if production of both components is outsourced to a foreign economy. Such a scenario would be in line with Feenstra and Hanson's (1996b) measure of outsourcing, which includes "... goods that are produced entirely by subcontractors, with the U.S. manufacturer attaching its brandname to the finished product"(p. 242). In contrast, we speak of outsourcing if some (residual) production is provided at home.

production of component A profitable although integrated production of Y is unprofitable (see Egger and Falkinger, 2003). However, given assumption (iv) it is obvious that in the case of full specialization on skill-intensive good X (labour-intensive good Z) in the pre-fragmentation equilibrium, international fragmentation and domestic production of one component of Y would reduce (raise) overall employment ratio h and therefore decrease (increase) the rate of unemployment. Since this result is straightforward, we exclude this scenario in the following analysis.

The restrictions that conditions (i) to (v) impose can be seen graphically in figure 3. For concreteness, we label as A the component for which production is retained domestically. Then point A, giving the efficient combination of H and L to produce one Euro worth of fragment A, lies in the shaded area $X'YZ'C$, and the analogous point B for the other fragment lies strictly above XAZ, the Hicksian composite unit value isoquant under fragmentation.[16]

The equilibrium with international fragmentation is depicted in figure 4, which is constructed analogously to figure 2. The figure is drawn for a case where the skill intensity of fragment A is higher than the skill intensity of the integrated production of good Y. The NDIV cone for the fragmentation scenario (NDIV^F), bounded by h_3 and h_4, is given by the shaded area. For comparison, the NDIV cone from the integrated production scenario (NDIV^I) is replicated as the region bounded by h_1 and h_2. It can be seen that diversified production of X and A yields a lower skill premium $1/\omega$ and a lower rate of unemployment than diversified production of X and Y in the pre-fragmentation equilibrium. On the other hand, diversified production of A and Z yields a higher skill premium and a higher rate of unemployment than diversified production of Y and Z in the pre-fragmentation equilibrium.

This observation alone implies that fragmentation decreases unemployment for sufficiently high employment ratios (those that lead to production of XA after fragmentation) and increases unemployment for sufficiently low employment ratios (those that lead to

[16] Areas XYX' and YZZ' are ruled out by assumption (ii), while area $XCZ0$ is ruled out by assumption (iii). Factor intensities above h^X and factor intensities below h^Z contradict assumption (iv). The position of point Y below the line connecting X and Z follows from assumption (v).

production of AZ after fragmentation).[17] While this result is useful as a first insight, it leaves a lot to be desired. First, it is stated in terms of employment ratios that are themselves endogenous. Second, it is not informative for the case of full specialisation on fragment A. Third, it gives no insight in the role – if any – played by the skill intensity of A.[18]

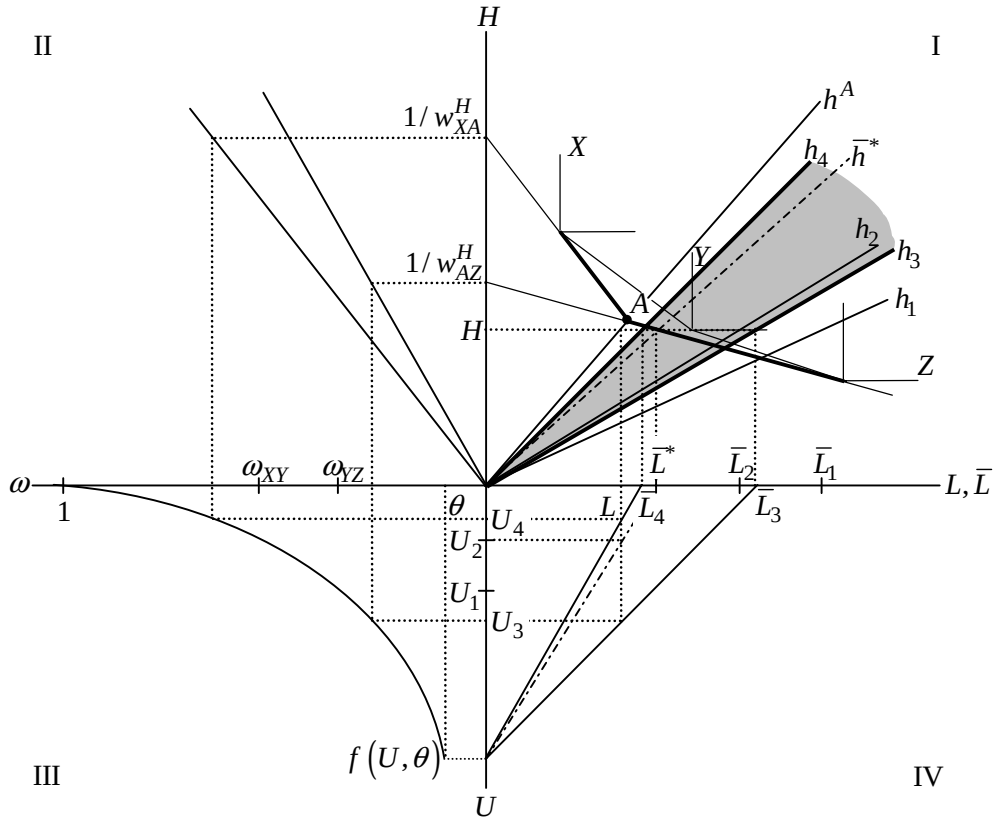

Figure 4: Equilibrium under fragmented production

Further insights into these questions can be gained by writing the unemployment rates under integrated and fragmented production, U^I and U^F, as a function of the endowment ratio $\bar{h}$. Considering $\theta < \omega_{XA}$ (i.e., assuming that an NDIV cone under integrated and

[17] Of course, this result extends to a scenario with full specialization on X or Z in the pre-fragmentation equilibrium, which has been ruled out by assumption (v).

[18] Kohler (2003) shows that under full employment the particular factor market effects of international fragmentation depend on the factor intensities of the remaining domestic activities.

fragmented production exists), and noting assumptions (i)-(v), this gives:

$$U^I = \begin{cases} \tilde{f}(\omega_{XY}, \theta) & \text{for} \quad \bar{h} \geq h^Y(1 - \tilde{f}(\omega_{XY}, \theta)) \\ 1 - \dfrac{\bar{h}}{h^Y} & \text{for} \quad h^Y(1 - \tilde{f}(\omega_{XY}, \theta)) > \bar{h} > h^Y(1 - \tilde{f}(\omega_{YZ}, \theta)) \\ \tilde{f}(\omega_{YZ}, \theta) & \text{for} \quad \bar{h} \leq h^Y(1 - \tilde{f}(\omega_{YZ}, \theta)) \end{cases} \tag{13}$$

$$U^F = \begin{cases} \tilde{f}(\omega_{XA}, \theta) & \text{for} \quad \bar{h} \geq h^A(1 - \tilde{f}(\omega_{XA}, \theta)) \\ 1 - \dfrac{\bar{h}}{h^A} & \text{for} \quad h^A(1 - \tilde{f}(\omega_{XA}, \theta)) > \bar{h} > h^A(1 - \tilde{f}(\omega_{AZ}, \theta)) \\ \tilde{f}(\omega_{AZ}, \theta) & \text{for} \quad \bar{h} \leq h^A(1 - \tilde{f}(\omega_{AZ}, \theta)) \end{cases} \tag{14}$$

It is easily verified that both U^I and U^F are weakly decreasing in $\bar{h}$ and continuous. Furthermore, we have

$$\tilde{f}(\omega_{AZ}, \theta) > \tilde{f}(\omega_{YZ}, \theta) > \tilde{f}(\omega_{XY}, \theta) > \tilde{f}(\omega_{XA}, \theta), \tag{15}$$

irrespective of the relative size of h^Y and h^A. This implies that there is a critical level of $\bar{h}$, labelled $\bar{h}^*$ and not necessarily unique, that separates endowment ratios for which international fragmentation increases unemployment from those where it decreases unemployment. In deriving a more specific result, the following observation is useful:

Lemma 1. *The critical endowment ratio $\bar{h}^*$ lies inside NDIV^F.*

Proof. From (15), U^I lies between $\tilde{f}(\omega_{YZ}, \theta)$ and $\tilde{f}(\omega_{XY}, \theta)$. From (14), U^F can only fall in this range if it is determined by $1 - (\bar{h}^*/h^A)$. This in turn is true if and only if $\bar{h}^*$ lies inside NDIV^F. □

In view of lemma 1, we can describe the properties of the critical endowment ratio $\bar{h}^*$ in more detail:

Proposition 1. *The critical endowment ratio $\bar{h}^*$ is unique if and only if $h^Y \neq h^A$. For given h^Y, a higher h^A is associated with a higher $\bar{h}^*$.*

Proof. We have to distinguish three possible regimes, namely the ones where $\bar{h}^*$ lies above, below, and inside NDIV^I. For $\bar{h}^*$ to be above NDIV^I, we must have $1 - (\bar{h}^*/h^A) =$

$\tilde{f}(\omega_{XY}, \theta)$ and hence $\bar{h}^* = h^A(1 - \tilde{f}(\omega_{XY}, \theta))$. From (13), this implies $h^A > h^Y$. Analogously, we get $\bar{h}^* = h^A(1 - \tilde{f}(\omega_{YZ}, \theta))$ for $\bar{h}^*$ below NDIV^I, with $h^A < h^Y$ in this case. In both regimes, $\bar{h}^*$ can be seen to be unique and increasing in h^A. With $\bar{h}^*$ inside NDIV^I, we have $1 - (\bar{h}^*/h^A) = 1 - (\bar{h}^*/h^Y)$ and hence $h^A = h^Y$. In this case, $\bar{h}^*$ is not unique but can take on any value inside NDIV^I. All $\bar{h}^*$ values consistent with $h^Y = h^A$ are strictly higher (lower) than $\bar{h}^*$ values consistent with $h^Y > h^A$ ($h^Y < h^A$). □

Concerning the unemployment effects of fragmentation, we can state the following result:

Proposition 2. *International fragmentation increases (decreases) unemployment for endowment ratios lower than (higher than)* $\bar{h}^*$.

Proof. Proposition 2 follows from (13)-(15) and proposition 1. □

The intuition for propositions 1 and 2 can be illustrated by means of figure 4, which depicts the critical endowment ratio $\bar{h}^*$ for the case where h^A exceeds h^Y. As shown in the proof to proposition 1, it is given by $\bar{h}^* = h^A(1 - U_2)$, where $U_2 = \tilde{f}(\omega_{XY}, \theta)$. As $\bar{h}^*$ lies above NDIV^I, the economy specialises on X and Y under integrated production. With the implied unemployment rate U_2, the average skill intensity of production is equal to h^A. Under fragmentation, as $\bar{h}^*$ lies in NDIV^F, the economy specialises in the production of A, and hence the skill intensity of production in this case is h^A as well. This implies that the two unemployment rates are equal. For skill intensities exceeding $\bar{h}^*$ but still inside NDIV^F, the average skill intensity under integrated production exceeds h^A, while it is equal to h^A under fragmented production. Hence, fragmentation in this case decreases the average skill intensity of production and unemployment of unskilled workers. Other cases can be illustrated using analogous reasoning. Note that decreasing h^A rotates NDIV^F clockwise and leaves NDIV^I unchanged. As long as $h^A > h^Y$, $\bar{h}^*$ lies above NDIV^I.

In a next step, we use our diagrammatic tool presented in figures 2 and 4 to investigate two policy issues of general public interest. In section 3, we address the role of egalitarian and non-egalitarian attitudes towards wage inequality to get insights into how fairness preferences can affect the implications of international fragmentation for the rate

of unemployment. Unemployment benefits as an indicator of the generosity of the welfare state are at the agenda in section 4.

3 International Fragmentation in Egalitarian and Non-Egalitarian Economies

It is a view held by many economists that strong preferences for an egalitarian wage schedule are an important determinant of high European unemployment rates. However, the theoretical debate on the labour market implications of international fragmentation is usually based on the assumption of perfectly competitive labour markets, which makes a formal analysis of this factor impossible. Since wages and unemployment rates are co-determined in our model, we can address the interaction between international fragmentation and the attitude towards wage inequality and investigate its labour market consequences. To do this, we consider different values of the fairness parameter θ. From (10) we have $\partial f/\partial\theta > 0$, which says that given the rate of unemployment a marginal increase of θ increases the value of ω which is needed in order to elicit the normal effort from unskilled workers. Hence, an increase in θ pivots the fair wage constraint outwards. By alternatively looking at the inverse fair wage constraint, we have $\partial\tilde{f}/\partial\theta > 0$, saying that a higher rate of unemployment is needed to support a given ω if θ is higher.

In order to isolate the impact that θ variations have in our model, we look at two small open economies that are identical in every respect but their preferences towards fairness. The economy that has a high value for θ (θ^e) is labelled *egalitarian*, while the economy with a low θ (θ^{ne}) is referred to as *non-egalitarian*. Using figure 4 it is easily verified that increasing θ, by rotating the fair wage constraint clockwise, rotates both NDIV^I and NDIV^F clockwise as well. Hence, loosely speaking, a given endowment ratio is more likely to lie above NDIV^I and NDIV^F and therefore lead to specialisation on more skill intensive production in the egalitarian economy than in the non-egalitarian economy. This is so because at each relative factor price the egalitarian economy has higher unemployment of unskilled workers and therefore a higher employment ratio h. Hence, international

fragmentation should more likely be beneficial in the egalitarian economy.

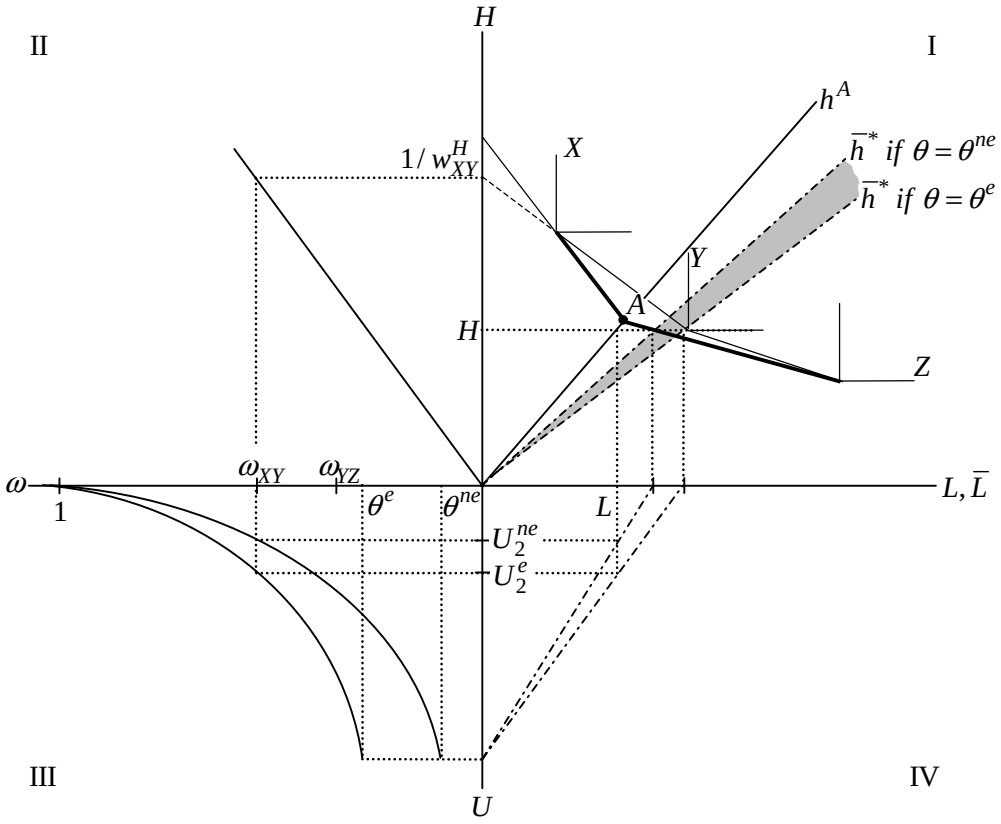

Figure 5: International fragmentation in egalitarian and non-egalitarian economies

This presumption can be substantiated by using the critical endowment ratio $\bar{h}^*$ introduced in the previous section.

Proposition 3. *With $h^A \neq h^Y$ (and θ sufficiently small) there is a non-empty interval of endowment ratios for which international fragmentation leads to increased unemployment in the non-egalitarian economy and to decreased unemployment in the egalitarian economy.*

Proof. It has been shown above (in the proof to proposition 1) that $\bar{h}^*$ is a function of θ, assuming $h^A \neq h^Y$. More specifically, in this case we have $\partial \bar{h}^* / \partial \theta = -h^A(\partial \tilde{f}/\partial \theta) < 0$,

and therefore $\bar{h}^*(\theta^e) < \bar{h}^*(\theta^{ne})$, given $\theta^e < \omega_{AZ}$. Hence, if $\bar{h}$ satisfies

$$\bar{h} \in (\bar{h}^*(\theta^{ne}), \bar{h}^*(\theta^e)) \tag{16}$$

international fragmentation increases unemployment in the non-egalitarian economy, while it decreases unemployment in the egalitarian economy. □

As unemployment is higher in the egalitarian economy, we find that if $\bar{h}$ lies in the interval specified in (16) international fragmentation leads to unemployment convergence between the egalitarian and the non-egalitarian economy. At the same time, there is international divergence in relative factor prices: In the egalitarian economy, international fragmentation compresses the wage differential, whereas the wage differential is widened in the non-egalitarian economy.[19] Figure 5 illustrates these results for the case where $h^A > h^Y$. The construction of the critical endowment ratios follows the reasoning described in section 2. In order to avoid clutter, the NDIV cones have been omitted.

To conclude this section we briefly discuss the borderline case where the skill intensities of A and Y are identical, and which has been excluded in proposition 3. The intuition that a higher preference for fairness increases unemployment ceteris paribus, and thereby makes specialisation on skill intensive goods more likely, applies to this case as well. Therefore, the above statement that fragmentation is "more likely" to decrease unemployment in the egalitarian economy is still valid. However, proposition 3 does not apply here because, from proposition 1, $\bar{h}^*$ is not unique if $h^A = h^Y$.

4 International Fragmentation and the Welfare State

In the derivation of the fair wage constraint (10), it has been assumed that unemployment benefits are equal to zero. For the analysis in the previous sections, this is just

[19] This is consistent with empirical evidence that in rather non-egalitarian economies (like the U.S. or the U.K.) the wage differential has widened in the process of international fragmentation. See our short discussion on this issue in the introductory section. However, our theoretical insights make clear that the respective wage and employment effects may be quite different in egalitarian Western and Northern European countries, for which, to the best of our knowledge, conclusive empirical evidence on the factor market effects of foreign outsourcing is so far missing.

a convenient normalisation that does not involve any loss in generality as long as it is made sure that unemployment benefits are lower than the wage rate. In this section, we introduce strictly positive unemployment benefits the size of which is intended to capture in a rudimentary way the size of the welfare state. This allows us to address an issue raised by many European policy makers, namely the argument that globalisation in the form of international fragmentation makes the generous welfare state of Western European economies unsustainable. According to this argument, high unemployment benefits, by leading to higher wages, foster international fragmentation and thereby lead to domestic job losses. The policy aimed at benefiting unskilled workers might therefore end up harming them. However, as pointed out above, the intuitively appealing idea that international fragmentation and outsourcing of labour-intensive parts of the production chain imply higher unemployment rates may be misleading from a general equilibrium perspective. It is therefore warranted to analyse the effect of unemployment benefits more formally.

Assuming that unemployment benefits are a fraction $\gamma \in (0,1)$ of the wage for each skill group, we can reformulate the fair wages of unskilled and skilled workers and obtain

$$w_L^* = \theta w_H + (1-\theta)[(1-U_L) + \gamma U_L]w_L \tag{17}$$

$$w_H^* = \theta w_L + (1-\theta)[(1-U_H) + \gamma U_H]w_H, \tag{18}$$

according to (5) and (6), respectively. And, accounting for (7) to (9), the fair wage constraint, which for $\gamma = 0$ was determined by (10), becomes

$$\omega = g(U,\theta,\gamma) \equiv \frac{\theta}{\theta + (1-\theta)(1-\gamma)U}. \tag{19}$$

Comparing (10) and (19), we can conclude that a higher replacement ratio γ has qualitatively similar implications as a higher preference for an egalitarian wage schedule in that both pivot the fair wage constraint outwards. Formally, from (19) we get $\partial g/\partial\gamma > 0$, which says that given the rate of unemployment a marginal increase in the replacement ratio increases the value of ω which is needed in order to elicit the normal effort from unskilled workers. Conversely, a higher rate of unemployment is needed to support a given ω if the replacement ratio is higher.

In writing down equations (17) to (19) it is implicitly assumed that the *financing* of unemployment benefits does not impact on the determination of the fair wage of unskilled workers. This is correct under two alternative scenarios. Either the idea of workers on what constitutes a fair wage is related to gross wages, not net wages, or unemployment benefits are financed by a proportional tax on all workers, with the replacement ratio γ defined in terms of net wages. However, if workers' fair wage idea relates to net wages *and* the tax is levied to different extents on workers of different skill (i.e. income) levels, the analysis has to be modified. Consider the extreme case where unemployment benefits are paid for by a tax on skilled workers only. The government budget constraint in this case becomes $tw_H H = \gamma w_L U \bar{L}$, which can be rewritten as $t = \gamma\omega U/\bar{h}$. Ceteris paribus, an increase in the replacement ratio decreases the net wage of skilled workers $(1-t)w_H$. If the net wage enters the determination of w_L^* in (17), the modified fair wage constraint is given by[20]

$$\omega = g(U, \theta, \gamma) \equiv \frac{\theta}{\theta + \left[(1-\theta)(1-\gamma) + \frac{\theta\gamma}{\bar{h}}\right] U}. \tag{19'}$$

It is now readily checked that $\partial\omega/\partial\gamma > 0 \Leftrightarrow \bar{h} > \theta/(1-\theta)$, and therefore the above result goes through if the relative number of skilled workers is sufficiently large: With many skilled workers, a given increase in the replacement ratio is accompanied by a relatively small increase in the wage tax, and therefore the net effect on the fair wage is positive. Given the rather extreme assumptions needed to reverse the result $\partial\omega/\partial\gamma > 0$, it is justified to work with fair wage constraint (19) instead of (19′) in the following analysis, by assuming a proportional tax on all workers.

A high value of γ may consequently imply specialisation on skill-intensive goods X and Y for a country that would have specialised in the production of labour-intensive goods in the presence of a low replacement ratio. In direct analogy to our discussion of θ differentials above, international fragmentation in sector Y may then have beneficial employment

[20] Consider $w_L = w_L^*$ and substitute $t = \gamma\omega U/\bar{h}$ into $w_L = \theta w_H(1-t) + (1-\theta)[(1-U_L+\gamma U_L)]w_L$. Rearranging terms and using $U_L = U$ gives $w_L\left\{1-(1-\theta)[(1-U)+\gamma U] + \theta\gamma U/\bar{h}\right\} = \theta w_H$, which can ultimately be transformed into (19′). Furthermore, we can note that (19′) implies $(1-t)w_H > w_L$. This confirms that the fair wage constraint is binding for unskilled (but not for skilled) workers.

effects in the high γ country and detrimental employment effects in the country with a low replacement ratio. Because of the analogy between γ and θ in the present model, figure 5 can also be used to discuss the issue of unemployment benefits, where a decrease in γ rotates the fair wage constraint counter-clockwise. Hence, there is an interval of endowment ratios for which international fragmentation increases unemployment in a country with low unemployment benefits while it would decrease unemployment in an otherwise identical economy with a high replacement ratio.[21]

While the analysis so far has revealed similarities in the effects of θ and γ in the present model, an important difference lies in the fact that γ is a policy variable. Therefore, it is meaningful to discuss the effect of varying it, given the organisation of production. This is to what we turn next.[22] Under diversification (i.e. production of either XY, YZ, XA or AZ) reductions of γ that do not change the production mix leave relative factor prices constant and decrease the rate of unemployment. Conversely, in the case of full specialisation on Y or A, a marginal decrease in γ has no impact on the unemployment rate but increases the skill premium. Finally, reductions in the replacement ratio that are sufficiently large to impact on the mix of goods being produced reduce the unemployment rate and increase the skill premium.

To compare the effects of a γ change under integrated production with the respective effects under international fragmentation, let us focus on the case of diversified production before and after the variation in γ. For the comparison, we define in analogy to section 2 the inverse fair wage constraint

$$U = \tilde{g}(\omega, \theta, \gamma) \equiv \frac{\theta}{(1-\theta)(1-\gamma)} \frac{1-\omega}{\omega}, \tag{20}$$

according to (19). In view of our discussion above we can distinguish two cases, namely

[21] This result offers an economic intuition behind the observation that a country like Italy, with relatively low unemployment benefit entitlements, suffered from an increase of unemployment in the globalization process of the 1990s, while countries like Belgium or Denmark, with generous compensation schemes, experienced a decline in their unemployment rates.

[22] In principle, one could imagine that γ and θ interact, rather than being treated as independent parameters as in the present paper. See Alesina and Angeletos (2004) for an example where the preference for fairness explains cross-country differences in the choice of redistributive policies.

small γ changes that leave the pattern of production unaffected and γ reforms that have an impact on the output mix. Let us first consider γ variation, which does not affect the production pattern. If the country produces two goods (XY, YZ, XA or AZ), the first derivative of the unemployment rate with respect to the replacement ratio is given by

$$\frac{\partial \tilde{g}(\cdot)}{\partial \gamma} = \frac{U}{1-\gamma}, \tag{21}$$

taking into account that relative factor prices are constant as long as production remains diversified on the same set of goods. The unemployment effect in (21) depends on the size of γ and the unemployment rate: the more generous the unemployment compensation scheme and the higher the (pre-reform) unemployment rate, the more effective is a marginal reduction of the replacement ratio.[23]

Consider next changes in the replacement ratio that lead to a switch in the output mix. If production is diversified before and after the change in γ (i.e., if there is a switch from XY to YZ and from XA to AZ, respectively), it turns out that reducing γ has a stronger relative wage effect and a smaller unemployment effect under fragmentation. While the result on comparison of the relative wage effects is easily verified by inspecting the difference in slopes of the respective Hicksian composite unit value isoquants in figure 5, the result on the relative strength of the unemployment effects is less obvious – and perhaps more surprising. To see why it must hold, observe that for a given value of γ a switch from XY production to XA production decreases unemployment, while a switch from YZ production to AZ production increases unemployment. Combining this observation with the fact that a γ-induced move to the less skill intensive production mix under a given regime (fragmentation/pre-fragmentation) decreases unemployment, we can deduce that the unemployment-reducing effect of a given decline in γ is less pronounced under fragmented production. Hence, in contrast to perceived wisdom, in a world with internationally fragmented production reductions in unemployment benefits may lose part of their effectiveness in mitigating the unemployment problem.

Of course, a change of the replacement ratio may also have an impact on the number of

[23]The *elasticity* of the unemployment rate with respect to the replacement ratio follows from (21) as $\gamma/(\gamma-1)$, and is therefore independent of the unemployment rate.

production processes undertaken at home. Moreover, since the two NDIV cones ($NDIV^I$ and $NDIV^F$, respectively) are not congruent, a certain γ-reduction can change the pattern of integrated production but leave the pattern of fragmented production unaffected. Also the opposite may be true. It has been elaborated above that for some parameter values (with full specialisation on Y or A) a marginal reduction of γ has no effect on the employment level, while for other parameter values (with diversification on XY, YZ, XA or AZ) a marginal decline of γ mitigates the unemployment problem. Overall, no general result can be derived on whether reforms of the unemployment compensation system are more effective under integrated or fragmented production. However, our analysis makes clear that γ-changes, which lead from diversification on skill-intensive production to diversification on labour-intensive production, definitely exhibit lower employment effects in the case of international fragmentation.

Finally, as the position of the fair wage constraint is jointly determined by the preference for fairness and the level of unemployment benefits, the model illustrates that even substantial reductions in unemployment benefits may render it impossible for an egalitarian economy ("Europe") to reach the low unemployment rates of a less egalitarian economy ("America").

5 Concluding Remarks

The public debate in industrialised economies on the international fragmentation of production is mainly driven by the fear of domestic job-losses. In contrast, the academic literature so far has analysed the effects of international fragmentation using a theoretical framework in which the assumption of competitive labour markets leads to full employment in equilibrium. Therefore, the concerns of the general public cannot be addressed in the standard model. In this paper, we have tried to bridge the gap between the policy debate and the theoretical analysis of international fragmentation by using a framework where labour market imperfections lead to involuntary unemployment in equilibrium.

Applying a novel diagrammatic tool that builds on the well-known Lerner-Pearce diagram, we have shown how the employment effects of international fragmentation are jointly

determined by relative factor endowments, the skill intensity of the component for which production is retained domestically, preferences towards wage equality and the level of unemployment benefits. Contrary to common views but in line with earlier findings in the academic literature, our model suggests that international fragmentation and outsourcing of labour intensive production processes do not necessarily harm unskilled workers. In particular, if home production is skill intensive, international fragmentation mitigates the unemployment problem and at the same time reduces the skill premium. In our model, there are three possible reasons for a high skill intensity of domestic production: A high relative skill endowment, a high preference for fairness, and high unemployment benefits. While for a given skill intensity of domestic production the level of unemployment clearly depends on which of these three reasons applies, the impact of fragmentation on unemployment does not depend on it. Therefore, fragmentation can lower unemployment in economies with high or low unemployment rates.

Finally, we have shown that the effectiveness of policy reforms that scale down unemployment compensation schemes may be influenced by whether there is international fragmentation of production or not. In particular, when lowering unemployment compensation leads the economy to move to a more labour intensive production mix, such policy reforms may exhibit smaller employment effects under fragmented production than under integrated production. This result should be of particular interest to policy makers who redesign the size and structure of the welfare state with the aim to make it sustainable in a global economy.

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