Explaining the Wage Gap: Heckscher-Ohlin, Economic Geography and Services Availability[1]

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Abstract: In the debate on globalisation and wage inequality Heckscher-Ohlin theory has featured prominently. However, a neglected mechanism by which globalisation affects labour market outcomes is through the increased tradability of producer services. By integrating elements of Heckscher-Ohlin theory, the economic geography literature and the literature on producer services linkages, we show that the impact of globalisation on the relative wages is a sophisticated combination of the effects that play a key-role in these models. The most important result we find is that the fall in transportation costs of producer services might indeed have caused the sharp increase in wage inequality. (JEL F1, R1)

Keywords: wage inequality, comparative advantage, economic geography, producer services.

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1 Introduction

It is a well-documented fact that in the 1980s and 1990s, the relative demand for low-skilled workers fell in the advanced countries. In the United States and the United Kingdom, this showed up primarily in a widening of the wage gap between low-skilled and high-skilled workers. In continental-OECD, it took the form of increased unemployment of the low-skilled (e.g. OECD (1997), Nickell and Bell (1996)). Over the same period, manufacturing imports from low-wage countries to the advanced countries increased greatly (e.g. Collins (1998), OECD (1997)). This coincidence of events has triggered a lively debate on the impact of increased trade with low-wage countries — commonly referred to as globalisation — on the labour markets in advanced countries. Theoretically, this debate has been mainly fuelled by insights from the well-known Heckscher-Ohlin factor abundance model of international trade. By predicting that an increase in trade with low-skilled abundant countries will result into a fall in the relative wages of the low-skilled in one's own country, this model supports the notion that globalisation might hurt low-skilled workers in advanced countries. In countries where relative wages are rigid, the declining demand for the low-skilled will instead translate into an increase of unemployment of low-skilled workers (e.g. Davis (1998), Brecher (1974)).

A huge amount of empirical literature has emerged in order to analyse the predictions of the Heckscher-Ohlin model[2]. Generally speaking, there is little decisive evidence which singles out trade as the main culprit for the labour market developments in the advanced countries (Burda and Dluhosch (1998)). Moreover, the finding that the decline in relative wages of low-skilled workers has not lead to a decrease in skill-intensity within industries, has lead some authors to favour skill-biased technological change as the explanation for the deterioration of the labour market position of the

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[2]Recent empirical work includes Haskel and Slaughter (1998), Leamer (1998). See Wood (1998) for a review of the empirical studies.

low-skilled.[3] Other authors less eagerly reject the role of trade in this respect and argue instead that the basic Heckscher-Ohlin framework requires amendation to allow for additional linkages between trade and labour markets.[4]

This paper fits in the latter strand of research as one of our primary aims will be to develop a framework that is more suited to analyse the impact of globalisation on the labour market position of the low-skilled in advanced countries. This is not so much done because of some of the obvious limitations of the basic assumptions of the Heckscher-Ohlin model, but primarily because we think that the changed nature of manufacturing trade warrants a more complex framework to analyse globalisation than the Heckscher-Ohlin model can provide. Especially the rise of intra-industry trade, the increase in the fragmentation or disintegration of production, and the increased international mobility of high-skilled labour are important new aspects of globalisation that need a place in the analytical framework. Manufactured goods are nowadays not only more differentiated than ever before (Krugman (1995)), but the production of these goods also increasingly involves the use of specialised intermediate inputs. Moreover, manufacturing production more and more takes place in a number of different locations. Rather than concentrating production in one location, modern manufacturing firms disintegrate their production and divide their production process over different countries, for instance to exploit such locational advantages as proximity to markets and access to relatively cheap labour.[5] The increased international mobility of high-skilled labour, finally, directly relates to an important side-effect of these developments in manufacturing, which is the notable increase of the use of producer services as an intermediate

[3] For instance, Berman, Bound and Griliches (1994), and Krugman and Lawrence (1993).

[4] This strand of research includes, among others, Borjas and Ramey (1993), Feenstra and Hanson (1996), Davis (1996), Sachs and Shatz (1998), and Wood (1997). In particular, these amendations show that the relation between globalisation and labour markets may not be so straightforward as the basic Heckscher-Ohlin model tells us.

[5] The disintegration of production also results into more intra-industry trade, as intermediate inputs cross borders several times during the manufacturing process. Feenstra and Hanson (1996), for instance, estimate that for the United States the share of imported intermediate inputs of total intermediate purchases has increased from 5.7 percent in 1972 to 13.9 percent in 1990.

input in manufactured production.[6] Whereas the fragmentation of (international) manufacturing production increasingly requires the use of co-ordinating producer services, it is because of the nature of services provision that to perform such tasks internationally commonly requires the temporary cross-border movement of high-skilled workers.[7] It is because of the latter that considering globalisation as only a reduction in the transportation costs of goods, as it is commonly analytically dealt with, is too narrow-minded. In our view, a proper analysis of the effects of globalisation should also take into account a reduction in the transportation costs of producer services.

The purpose of this paper therefore is to analyse the impact of globalisation, as we see it, on the relative wages of low-skilled workers in a framework that also takes heed of these novel features of globalisation. This is not to say that we will abandon the Heckscher-Ohlin framework altogether, but the increased importance of trade in intermediates and producer services and the international fragmentation of production calls for a framework in which also intra-industry trade and the location decisions of firms matter. As such a framework is by and large provided by models of the economic geography literature, the current paper seeks to integrate elements of this literature with some of the insights of Heckscher-Ohlin trade theory. In order to acknowledge the rising importance of producer services, and to analyse the consequences of a reduction in their transportation costs, our model also explicitly incorporates services-related input-output linkages.

This is reflected in the basic set-up of our model, which considers a world in which two regions that differ in their relative endowments of low-skilled and high-skilled labour can both produce different varieties of two distinct manufactured goods. The production process of these goods is depicted as a two-stage process. Whereas in the first stage of production, manufacturing firms construct raw output by using low-skilled labour only, the second stage consists of the transformation of the raw output into final consumption goods by adding a variety of producer services. As producer

[6] See Francois and Reinert (1995) for empirical evidence on this point.

[7] See Burda and Dluhosch (1998) for a clarification on the first point and Stibora & de Vaal (1995) and Wood (1997) for an analysis of the second point.

services are assumed to use high-skilled labour only, this set-up provides a clear link with Heckscher-Ohlin type of mechanisms as goods may differ in their relative use of producer services. The production of raw output and producer services both entail scale economies, which in combination with their respective transportation costs—both raw output and producer services are tradeable—provides a link with well-known mechanisms of the economic geography literature. Finally, by depicting manufacturing production as a two-stage process we not only account for fragmentation of production, but also allow for the explicit incorporation of producer services linkages.

The structure of the paper is as follows. Section 2 presents the model and specifies how producer services enter the production of final consumer goods. In Section 3, we present some analytical notes on the impact of a reduction in the transportation costs of goods *and* producer services. In particular, we will show how relative wages of low-skilled workers in one region depend on each of the mechanisms that are present in our model. In Section 4, we use computer simulations to consider the overall effects of globalisation. The point that stands out from this section is that it is in particular the fall in transportation costs of producer services that can explain the sharp decline in relative wages of the low-skilled during the 1980s. In Section 5 and Section 6 we offer two extensions of our framework. Section 5 discusses how the impact of globalisation is affected when also labour mobility is allowed for between regions. Section 6 considers the impact on the relative wages of low-skilled workers of services trade that requires a local presence in the region of services consumption. Section 7, finally, concludes.

2 The model[8]

We consider a world that consists of two regions, Home and Foreign, which are both capable of producing a homogeneous good A and many varieties of the manufactured goods X and Y. Consumers spend a fixed share of their income on each good, whereas

[8] The basic structure of the model we present in this section stems from de Vaal and van den Berg (1999).

for manufactured goods they also have a taste for variety (modelled in the usual Dixit-Stiglitz way). For a Home consumer this implies the following utility function:

$$U = \left[\prod_{Z=X,Y} C_Z^{\mu_Z} \right]^{(1-\mu_A)} C_A^{\mu_A} = \prod_Z \left[\left(\sum_{N_h} c_{Z_{hh}}^{\theta} + \sum_{N_f} c_{Z_{fh}}^{\theta} \right)^{\mu_Z/\theta} \right]^{(1-\mu_A)} C_A^{\mu_A} \tag{1}$$

where N_h (N_f) is the number of varieties of good $Z = X, Y$ from Home (Foreign).[9] Consumers thus spend a fraction $1-\mu_A$ of their income on the two manufactured goods and μ_A on agricultural products. Of the income spent on manufacturing goods, a fraction μ_Z is spent on Home and Foreign varieties of good Z ($\sum \mu_Z = 1$), which are all imperfect substitutes of each other ($0 < \theta < 1$).[10] By the first order conditions of utility maximization, and given that we take good A as numeraire, it then follows that the consumption ratio of a Home and a Foreign variety is a function of relative prices only, viz.

$$\frac{c_{Z_{hh}}}{c_{Z_{fh}}} = \left(\frac{p_{Z_{hh}}}{p_{Z_{fh}}} \right)^{\frac{1}{\theta-1}} \tag{2}$$

Both regions are endowed with agricultural labour (L_A), low-skilled labour (L) and high-skilled labour (H). Agricultural labour is only used for the production of agricultural products, which takes place under constant returns to scale with a per unit labour requirement of one. Low-skilled labour and high-skilled labour, on the other hand, are used for the production of manufactures. To allow for producer services linkages, manufacturing is modelled as a two-stage process. In the first stage, the manufacturing firm uses low-skilled labour to make an intermediate stage, raw output z_i ($z_i = x_i, y_i$).[11]

[9] The relevance of adding a subscript to distinguish between the origin of the good (the first subscript) and the area where is it consumed (the second subscript) will become clear when we discuss the production processes of manufacturing goods. We refrain from adding subscripts to distinguish between varieties as in equilibrium consumers will be shown to buy equal quantities of Home varieties as well as of Foreign varieties.

[10] We do not allow for sectoral differences in the extent of substitutability (θ) between varieties.

[11] We will use Z to refer to the type of good and z_i to refer to the raw output that is produced by firm i in sector $Z = X, Y$.

Then, in the second stage of production, she adds producer services S (incorporating only high-skilled labour) to turn the raw output into a final consumption good. High-skilled labour therefore enters manufacturing production only indirectly, in the form of producer services, whereas low-skilled labour can be considered as a direct input to the manufacturing firm.

In addition to this specific way of modelling the production process, the production structure has the following features. First, both the production processes of raw output and producer services incur increasing returns to scale. This ensures that each variety of z or S is always produced on one location. Second, the market structure for manufacturing goods and producer services is monopolistic competition with free entry and exit. Firms in both markets will therefore enter or exit until profits are zero. Third, we assume that both z and S are tradeable, be it at different 'iceberg'-type of transportation cost (τ for raw output and ρ for producer services).[12] Consumers can thus enjoy the consumption of manufacturing varieties from both regions, as imported varieties of z will be finished in the region of consumption. Because producer services are also tradeable and because Home and Foreign services are imperfect substitutes, the 'finishing touch' to transform raw output into final consumer goods thus includes Home and Foreign producer services. Fourth, the production structure for manufactures applies to both the X and the Y good ($Z = X, Y$). As we model producer services to take high-skilled labour only—thus taking heed of the relative knowledge-intensity of producer services—this implies that once we assume that both goods differ in services intensity, we in fact assume that both goods differ in skill-intensity.[13] Given this latter assumption, it is immediately clear that our model thus incorporates elements of the standard

[12] Iceberg-type transportation costs imply that transportation costs are modelled such that, due to transportation, part of the good 'melts' away. Though being a quite unrealistic way of modelling transportation costs, the 'iceberg'-assumption prevents the modelling of a separate transportation industry.

[13] This may seem a rather extreme way of taking heed of the relative knowledge-intensity of producer services. It is not, however, if one puts all manufacturing related production activities on a scale that ranges from low-skilled labour intensive to high-skilled labour intensive. The production of the raw product is then extremely low-skilled labour intensive, that of producer services extremely high-skilled labour intensive, whereas the production of final goods takes an intermediate position (including the potential difference between X and Y).

Heckscher-Ohlin framework. In addition, from the economic geography literature we adopt the combination of scale economies and transportation costs. Finally, our model uses insights from the literature on producer services linkages as we characterise the production process of manufactures as a two-stage process.

The production of manufactures can be summarized by (for Home manufacturing firms and for $Z = X, Y$)[14]

$$L_{\bar{z}_h} = F + B\bar{z}_h \tag{3}$$

$$\bar{z}_h = z_{hh} + z_{hf} \tag{4}$$

$$m_{Z_{hh}} = z_{hh}^{\alpha_Z} \left[\sum^{n_h} S_{hh_Z h}^{\gamma} + \sum^{n_f} (\rho S_{fh_Z h})^{\gamma} \right]^{\frac{1-\alpha_Z}{\gamma}} \tag{5}$$

$$m_{Z_{hf}} = (\tau z_{hf})^{\alpha_Z} \left[\sum^{n_h} (\rho S_{hh_Z f})^{\gamma} + \sum^{n_f} S_{fh_Z f}^{\gamma} \right]^{\frac{1-\alpha_Z}{\gamma}} \tag{6}$$

$$H_{\bar{S}_h} = f + b\bar{S}_h \tag{7}$$

$$\bar{S}_h = \sum_Z [N_h(S_{hh_Z h} + S_{hh_Z f}) + N_f(S_{hf_Z h} + S_{hf_Z f})] \tag{8}$$

In these equations $\bar{z}_h$ stands for total raw output of a good $Z = X, Y$ producer, of which z_{hh} (z_{hf}) is used to make the final good for consumers in Home (Foreign). The amount of low-skilled labour needed to produce $\bar{z}_h$ is $L_{\bar{z}_h}$, which consists of a fixed

[14] In describing the model we will confine ourselves to the Home region. The expressions for Foreign can be obtained by analogy.

cost F and marginal cost B. Equivalently, $\bar{S}_h$ denotes the total output of a services firm which is sold to Home and Foreign manufacturing producers of both goods, as indicated by (8). The notation for services is such that $S_{ij_Z k}$ refers to a service produced in region i that is used by a good Z firm from region j to finish its good in region k ($i, j, k = h, f$). The amount of high-skilled labour needed to produce $\bar{S}_h$ is given by (7), where f denotes the fixed cost of services production and b its marginal cost.[15] Finally, consider the production functions (5) and (6) in which $m_{Z_{hh}}$ ($m_{Z_{hf}}$) denotes the amount of the final consumption good a Home producer of good Z makes for consumers in Home (Foreign).[16] Due to transportation costs of raw output ($\tau < 1$), only τz_{hf} can be used to make final consumption goods in Foreign (although the amount z_{hf} is intended for the Foreign market). In a similar way, transportation costs of producer services ($\rho < 1$) are included in the production functions. Note, however, that the transformation of z_i into final consumption goods is performed by all services varieties from Home (n_h) and Foreign (n_f), which are all imperfect substitutes of each other ($0 < \gamma < 1$). Finally, the services intensity of manufacturing production is determined by the parameter α_Z.

Given this production structure and noting from (2)that the price elasticity of demand for manufacturing goods equals $1/(1-\theta)$, profit maximization in the manufacturing sectors yields the following expressions for the prices charged by Home manufacturing firms (we refer to Appendix A for details of the derivation)

$$p_{Z_{hh}} = \frac{C_Z}{\theta} w_h^{\alpha_Z} \tilde{V}_h^{1-\alpha_Z} \tag{9}$$

$$p_{Z_{hf}} = \frac{C_Z}{\theta} \tau^{-\alpha_Z} w_h^{\alpha_Z} \tilde{V}_f^{1-\alpha_Z} \tag{10}$$

[15] Note that the provision of producer services has been modelled such that it takes into account most of the specific features that the provision of producer services is usually associated with. Thus, we have modelled services as high-skilled labour intensive, as involving a fixed cost in production along with some marginal production costs, and as inherently differentiated products. The static nature of our analysis precludes the incorporation of other services specific features such as non-storability and reputation aspects.

[16] Recall that we do not add subscripts to distinguish between different varieties of manufacturing goods (see: footnote 9). The same applies to services varieties. For final goods, subscripts are thus only used to distinguish between the origin of the good (the first subscript) and the region it is consumed (the second subscript). For services, an additional subscript is required to identify the country of origin of the manufacturing producer buying the service (as well as its sector).

with $C_Z = B^{\alpha_Z}\alpha_Z^{-\alpha_Z}(1-\alpha_Z)^{-(1-\alpha_Z)} > 0$ and where w_h denotes the absolute wage of low-skilled labour in Home. $\tilde{V}_i$ is the price index of services in region $i = h, f$ as given by ($i \neq j$):

$$\tilde{V}_i = \left[\sum^{n_i} v_i^{-\frac{\gamma}{1-\gamma}} + \sum^{n_j}\left(\frac{v_j}{\rho}\right)^{-\frac{\gamma}{1-\gamma}}\right]^{-\frac{1-\gamma}{\gamma}} \tag{11}$$

where v_h and v_f, respectively, denote the price of a Home and Foreign service. The price equations thus in fact simply state that for both goods marginal revenue of selling in each market should equal marginal cost. Marginal revenue is a fixed mark-up over the local price, whereas marginal costs depend on the wages of the low-skilled labour of the 'home' region of the manufacturing producer (via w_h), as well as on the cost of services in both regions (via the price index $\tilde{V}_i$).

From the FOC of manufacturing firms in Appendix A we can also derive expressions for the demand for services. This leads to

$$S_{ij_Zk} = \begin{cases} \theta(1-\alpha_Z)p_{Z_{jk}}m_{Z_{jk}}v_i^{-1/(1-\gamma)}\tilde{V}_k^{\gamma/(1-\gamma)} & (\text{for } i = k) \\ \theta(1-\alpha_Z)\rho^{\gamma/(1-\gamma)}p_{Z_{jk}}m_{Z_{jk}}v_i^{-1/(1-\gamma)}\tilde{V}_k^{\gamma/(1-\gamma)} & (\text{for } i \neq k) \end{cases} \tag{12}$$

The demand for the output of a services firm thus depends on its price (v_i), the prices of the other services in the region it sells to ($\tilde{V}_k$), and the sales of the manufacturing firm it sells to ($p_{Z_{jk}}m_{Z_{jk}}$).[17] As we can infer from (12) that the price elasticity of demand for services always equals $1/(1-\gamma)$, profit maximization gives

$$v_h = \frac{b}{\gamma}r_h \tag{13}$$

[17] Note that S_{ij_Zk} is the gross demand for services output. In standard trade terminology: it is the amount f.o.b. The amount of services that can be productively used by manufacturing firms will be the amount c.i.f. though, which explains the premultiplication of S_{ij_Zk} with ρ in the production function of manufactures.

where r_h denotes the absolute wage of high-skilled labour in the Home region. The price a Home services firm charges is therefore a fixed mark-up over its marginal labour cost. Substitution of (13) into (11) gives $\tilde{V}_i = \left[n_i^{-\frac{1-\gamma}{\gamma}} \frac{b}{\gamma} r_i + n_j^{-\frac{1-\gamma}{\gamma}} \frac{b}{\gamma} (r_j/\rho) \right]$ as the simplified price index for services. Note therefore that the tradeability of services implies that the marginal cost of manufacturing production depends on the wages of high-skilled labour of both regions.

Equilibrium on the market for raw output requires that the total sales of one firm equal the total demand (per firm). By using (4) and substituting for z_{hh} and z_{hf} from the FOC of manufacturing firms in Appendix A, this yields:

$$\bar{z}_h = \frac{\alpha_Z \theta}{B} \frac{p_{Z_{hh}} m_{Z_{hh}} + p_{Z_{hf}} m_{Z_{hf}}}{w_h} \tag{14}$$

whereas equilibrium on the market for services per firm requires (by using (12)):

$$v_h \bar{S}_h = \sum_Z (1-\alpha_Z)\theta v_h^{-\frac{\gamma}{1-\gamma}} \begin{bmatrix} \left(N_{Z_h} p_{Z_{hh}} m_{Z_{hh}} + N_{Z_f} p_{Z_{fh}} m_{Z_{fh}}\right) \tilde{V}_h^{\frac{\gamma}{1-\gamma}} + \\ \rho^{\frac{\gamma}{1-\gamma}} \left(N_{Z_f} p_{Z_{ff}} m_{Z_{ff}} + N_{Z_h} p_{Z_{hf}} m_{Z_{hf}}\right) \tilde{V}_f^{\frac{\gamma}{1-\gamma}} \end{bmatrix} \tag{15}$$

By our assumption on free entry and exit of firms on both markets it follows (see Appendix A):

$$\bar{z}_h = \frac{\alpha_Z \theta}{(1-\theta)} \frac{F}{B} \qquad \text{and} \qquad L_{\bar{z}_h} = \frac{1-\theta(1-\alpha_Z)}{(1-\theta)} F \tag{16}$$

$$\bar{S}_h = \frac{\gamma}{1-\gamma} \frac{f}{b} \qquad \text{and} \qquad H_{\bar{S}_h} = \frac{f}{1-\gamma} \tag{17}$$

As similar expressions hold for firms in Foreign, (16) implies that all manufacturing producers produce identical levels of raw output for which they use identical amounts of low-skilled labour. Equation (17) implies the same, mutatis mutandis, for Home and Foreign services firms.

To determine equilibrium we have to specify how the labour market is organized. Recall from the onset of this section that agricultural labour is only used for agricultural production, whereas low-skilled and high-skilled labour are involved in manufacturing production. Recall also that high-skilled labour is used only for the production of producer services and that low-skilled labour is used only for the production of the raw output of manufacturing firms. As is customary in most of the economic geography literature, we will assume that agricultural labour is evenly distributed across regions, but that the distribution of manufacturing labour may vary across regions. Denoting the world endowment of agricultural labour by $\overline{L}^A$, that of low-skilled labour by $\overline{L}$ and that of high-skilled labour by $\overline{H}$, this implies that the full employment conditions are given by

$$Q_h^A = \overline{L}^A/2 \tag{18}$$

$$\sum_Z N_{Z_h} L_{\bar{z}_h} = \lambda_L \overline{L} \equiv L_h \tag{19}$$

$$n_h H_{\bar{S}_h} = \lambda_H \overline{H} \equiv H_h \tag{20}$$

where Q_h^A denotes agricultural output in Home (the unit labour requirement is one) and where λ_L and λ_H respectively denote the share of the Home region in $\overline{L}$ and $\overline{H}$.

The model is closed by specifying the equilibrium conditions for the market of manufactured goods. Given the Cobb-Douglas representation of the demand side this becomes, for the markets in Home

$$(1-\mu_A)\mu_Z I_h = N_{Z_h} p_{Z_{hh}} c_{Z_{hh}} + N_{Z_f} p_{Z_{fh}} c_{Z_{fh}} \tag{21}$$

where $I_h = \overline{L}^A/2 + w_h L_h + r_h H_h$ denotes total income in Home. The trading equilibrium is contained in equations (2), (9) - (10), (14) - (15) and (19) - (21), as well as their foreign equivalents. Together the 26 equations solve for 26 endogenous variables, i.e. w_h, w_f, r_h, r_f, n_h, n_f, N_{Z_h}, N_{Z_f}, $p_{Z_{hh}}$, $p_{Z_{hf}}$, $p_{Z_{ff}}$, $p_{Z_{fh}}$, $m_{Z_{hh}}$, $m_{Z_{hf}}$, $m_{Z_{ff}}$, $m_{Z_{fh}}$

(recognizing that in equilibrium $c_{Z_{ij}} = m_{Z_{ij}},\ i,j = h,f$ and recalling that good A is the numeraire).[18]

3 Analytical Notes on Globalisation and Relative Wages

The central focus of this paper is how the decline of transportation costs of goods and services, which we have dubbed globalisation, affects the relative wages of low-skilled labour. To find out how this relation works, we devote this section to deal with the matter analytically. In the next section, we will use numerical analysis to gain more concrete insight into the matter.

The earnings of both the low-skilled and the high-skilled in a certain region are obviously related to the worldwide consumer expenditures on the final consumer goods produced by that region. Whereas the low-skilled will be rewarded for their efforts in constructing raw output, the high-skilled will be rewarded for making the transformation into final consumption goods. A logical starting point for discussing the relative earnings of both factors of production is therefore to determine the total expenditures on goods from a certain region. This is accomplished by substitution of (2) in the demand equilibrium equation (21), which yields the consumption expenditures on a sector-z good from a region-i producer that is consumed in region j (for $i,j = h,f$):

$$p_{Z_{ij}} m_{Z_{ij}} = \frac{(1-\mu_A)\mu_Z I_j p_{Z_{ij}}^{-\theta/(1-\theta)}}{\sum_i N_{Z_i} p_{Z_{ij}}^{-\theta/(1-\theta)}} \tag{22}$$

Multiplying both sides with the total number of sector-Z goods from region i and recognizing that the denominator of (22) is part of the price index of sector-Z good in region

[18] In the terminology of the economic geography literature, this is the 'short-run' equilibrium. The 'long-run' equilibrium follows when manufacturing labour is allowed to move to other regions. We will pick up on the consequences of cross-border labour mobility in a later section though.

j, which is given by $\tilde{P}_{Z_j} \equiv \left[\sum_{i=h,f} N_{Z_i} p_{Z_{ij}}^{-\theta/(1-\theta)}\right]^{-(1-\theta)/\theta}$, yields[19]

$$s_{Z_{ij}} = (1-\mu_A)\mu_Z N_{Z_i} \left[I_j / p_{Z_{ij}}^{\theta/(1-\theta)}\right] \tilde{P}_{Z_j}^{\theta/(1-\theta)} \tag{23}$$

where $s_{Z_{ij}}$denotes the expenditure of region j on the sector-Z goods from region i. Thus, total regional expenditure on goods depends on the income of the region, the regional price of the goods, and the price of the goods relative to the prices of the same type of goods from the other region (reflected in the sectoral price index).

The earnings of low-skilled labour in region j can now be depicted as the total of expenditures on region j goods, *minus* the required payments to intermediate services:

$$w_j L_j = \sum_Z s_{Z_{jj}} + \sum_Z s_{Z_{ji}} - \sum_Z N_{Z_j}[n_h S_{hjzh} + n_f S_{fjzf} + (n_h S_{hjzf} + n_f S_{fjzh})/\rho] \tag{24}$$

Substituting for S_{ijzk} from (12) and making use of (23) then gives, after some rearranging

$$w_j L_j = \sum_Z [1-\theta(1-\alpha_Z)] s_{Z_{jj}} + \sum_Z [1-\theta(1-\alpha_Z)] s_{Z_{ji}} \tag{25}$$

as the expression that settles the total earnings of low-skilled labour in region j. It basically says that low-skilled labour gets the cost share of raw output in total manufacturing production (which is not surprising given zero profits in manufacturing).

The earnings of high-skilled labour can then be derived by recognizing that regional income should equal regional expenditures, that is

$$\overline{L}^A/2 + w_j L_j + r_j H_j = C_A + \sum_Z (s_{Z_{jj}} + s_{Z_{ij}})$$

[19]Note that the sectoral price indices can be derived from the consumers maximisation problem (see: e.g. Fujita, Krugman and Venables, 1999, p. 46-49).

Substituting for $w_j L_j$ by using (25) and rearranging, we get

$$r_j H_j = \sum_Z \theta(1-\alpha_Z)(s_{Z_{jj}} + s_{Z_{ji}}) + \sum_Z (s_{Z_{ij}} - s_{Z_{ji}}) + (C_A - \overline{L}^A/2) \qquad (26)$$

The remuneration for high-skilled labour in region j thus consists of the cost share of high skilled labour of region j's world wide sales of manufactured goods (the first term), corrected for the services balance of region j, which consists of the sum of the trade balance of manufactured goods (the second term) and agricultural goods (the third term). This correction for the services balance is due, as all services are used as intermediate input in the production of all manufactured goods.

The ratio of (25) and (26) could in principle be used to investigate the impact of globalisation on relative wages. However, as the final outcome will be a combination of Heckscher-Ohlin type of effects, producer services linkage effects and economic geography effects, the interpretation of such analysis is severely hampered. We therefore proceed by finding out how each of these elements affects the relative wage position of low-skilled labour separately and postpone the analysis of the overall effect to the numerical analysis in the next section.

By the Heckscher-Ohlin elements in our model—factor abundance in combination with sectoral differences in services intensity—we would expect that a reduction in transportation costs will favour the relatively abundant production factor in the economy. To see this, we first determine comparative advantage. By using the autarkic versions of the model, we can derive the following expression for the relative goods price in Home (see Appendix B for the derivation):

$$\left(\frac{p_X}{p_Y}\right)_h = \bar{C}\left(\frac{H_h}{L_h}\right)^{\alpha_X - \alpha_Y} H_h^{\frac{1-\gamma}{\gamma}(\alpha_X - \alpha_Y)} \qquad (27)$$

with $\bar{C} \equiv (C_X/C_Y)[f/(1-\gamma)]^{\frac{1-\gamma}{\gamma}(\alpha_Y - \alpha_X)}(b/\gamma)^{\alpha_Y - \alpha_X}\left(\frac{\sum(1-\theta(1-\alpha_Z))\mu_Z}{\sum\theta(1-\alpha_Z)\mu_Z}\right)^{\alpha_X - \alpha_Y}$. This price equation shows that comparative advantage is a combination of a familiar

Heckscher-Ohlin type of comparative advantage (the first term) and a services variety externality effect (the last term)[20]. Home will therefore have a comparative advantage in the good that makes intensively use of its abundant factor, even though the existence of services linkages may turn this comparative advantage into a comparative disadvantage.[21] Applying standard Stolper-Samuelson type of reasoning, a reduction in transportation costs will therefore favour the production factor that is used intensively in the comparative advantage good of the economy (i.e. the abundant factor). The particular type of transportation costs that is reduced is thereby of no relevance.

Relative wages are also affected by the presence of intermediate services linkages and the externality this bestows on manufacturing production. As we have just seen in our discussion on comparative advantage, the unit cost of manufacturing production decreases when more services varieties become available, all other things equal. As a reduction in the transportation costs of services can in fact be interpreted as an increase in the availability of services, such a reduction will increase manufacturing productivity and thereby affect the wages of the low-skilled.[22] Due to the one-way direction of these linkages, the wages of the high-skilled remain unaffected by this channel. In addition, changes in the transportation costs of raw output do not affect the price index of services directly and will therefore not affect relative wages through the services availability channel.

[20] The services variety externality effect relates to the fact that an increase in the number of services will, *ceteris paribus*, lower the costs of producing both final consumption goods (see (9) and (10)). As such, an increase in services variety can be considered a positive externality to manufacturing firms. As in zero-profit equilibrium all services producers use the same amount of labour, the externality effect is directly related to the amount of high-skilled labour in a region.

[21] A relative abundance in, for instance, high-skilled labour is only sufficient for a comparative advantage in the high-skilled labour intensive good (read: services intensive good) if the country is also high-skilled abundant in absolute terms. That is, when Home is relatively abundantly endowed with high-skilled labour, but the absolute number of high-skilled workers is smaller than in Foreign ($\lambda_{LH} < 0.5$), this could overthrow the Heckscher-Ohlin based comparative advantage due to a relatively small services variety externality effect. In Appendix B we derive a condition to settle whether or not this will happen.

[22] This follows also immediately by inspection of the equations: an increase in ρ decreases the price index of services in both regions; as the price index of services is included in the price equations, it follows that an increase in ρ decreases the costs of manufacturing production. *Ceteris paribus*, this should increase the absolute wages of the low-skilled workers in both regions.

The effects on relative wages due to the economic geography elements in our model are less straightforward, as they ultimately depend on a trade-off between the so-called 'home-market' effect and the 'extent of competition' effect.[23] Whereas the size of the home market allows firms in the larger region to offer higher wages as they can save on transportation costs, firms in the smaller region can offer higher wages because transportation costs form a more effective shield against foreign competition.[24]

To deal with the economic geography effects analytically, we consider regional demand for the products that form the basis for the earnings of low-skilled and high-skilled labour—respectively the production of raw output and the production of producer services. Combining the demand function for raw output production (from Appendix A) with (22) yields (for $i, j = h, f$):

$$Bw_i z_{ij} = \alpha_Z \theta \left[\frac{(1-\mu_A)\mu_Z I_j}{p_{Z_{ij}}^{\theta/1-\theta}} \right] \tilde{P}_{Z_j}^{\theta/(1-\theta)} \tag{28}$$

which can be rewritten as, applying (4),

$$Bw_i \bar{z}_i = \alpha_Z \theta \left[\frac{(1-\mu_A)\mu_Z I_i}{p_{Z_{ii}}^{\theta/1-\theta}} \right] \tilde{P}_{Z_i}^{\theta/(1-\theta)} + \alpha_Z \theta \left[\frac{(1-\mu_A)\mu_Z I_j}{p_{Z_{ij}}^{\theta/1-\theta}} \right] \tilde{P}_{Z_j}^{\theta/(1-\theta)} \tag{29}$$

for $i, j = h, f$, $i \neq j$. The earnings of low-skilled labour in region i due to raw output production are therefore a positive function of both regions' income in terms of firm i's

[23] In economic geography models, these two effects, together with the price index effect, are typically applied to give structure to the analysis of the effects of cross-border movement of labour (the long-run equilibrium). We find it useful to apply these effects to analyse the impact of globalisation in the short-run equilibrium as well as in the long-run equilibrium, for reasons discussed below.

[24] In the standard economic geography literature the size of a region refers to the size of the regional labour force. In our set-up however, there are two factors of production, which are unevenly distributed among regions (L and H). Therefore, we will use the 'size of a region' to refer to the total income of a region.

output (the bracketed terms) and the sectoral price index of manufactured goods in both regions.

Proceeding likewise for the earnings of high-skilled labour requires an expression that settles regional demand for the services from a particular region. This is obtained by recognizing that the right-hand side of (15) in fact consists of the summation of demand for region i services ($i = h$ in (15)) by manufacturing firms from both regions. Using 22 to rewrite 15, we get

$$v_i \bar{S}_i = \sum_Z (1-\alpha_Z)\theta \left[\frac{(1-\mu_A)\mu_Z I_i}{v_i^{\gamma/1-\gamma}} \right] \tilde{V}_i^{\frac{\gamma}{1-\gamma}} + \sum_Z (1-\alpha_Z)\theta \left[\frac{(1-\mu_A)\mu_Z I_j}{(v_i/\rho)^{\gamma/1-\gamma}} \right] \tilde{V}_j^{\frac{\gamma}{1-\gamma}} \tag{30}$$

for $i, j = h, f, i \neq j$. As v_i is a constant mark-up over high-skilled wages, this equation basically conveys the same message for high-skilled labour as (29) did for low-skilled labour. Thus, the earnings of high-skilled labour in region i due to services production for region j depend positively on both the income of region j (now in terms of region i services) and the price index of services in region j.

To investigate the economic geography effects in our model, we start by assuming that both regions are equally well endowed with low-skilled and high-skilled labour ($\lambda_l = \lambda_h = 0.5$). From the economic geography literature we know that in this case the relative wages between regions equal one (see f.i. Krugman, 1991). By investigating (29) and (30), it can be seen that this result carries over to our model as well. However, these equations also show that the contribution of a region to the earnings of its 'own' factor of production exceeds the contribution of the other region. This is due to the fact that the transportation costs imply that the prices of products that are sold abroad (either raw output or services) *ceteris paribus* always exceed that of domestically sold products. This holds for both types of labour, but as the equations indicate, τ is the relevant transportation cost parameter in this respect for low-skilled labour (as it determines the difference between p_{ii} and p_{ij}, *ceteris paribus*), whereas ρ performs the same role for high-skilled labour (directly visible in (30)). In other words, for equally sized regions,

transportation costs imply that the 'own' market is more important in determining the wages of the factors of production than the foreign market.

Turning now to the case where the regions are unequal in size, it can be seen directly that also the difference in nominal regional income becomes important for the extent to which a region contributes to the remuneration of labour in either region. Nevertheless, it is still true that due to the transportation costs, the 'own' market is more important in determining the remuneration for the labour force than the foreign market. In our view, the bracketed terms on the right-hand sides of (29) and (30) can therefore be considered as representations of the home market effect. To see this, assume that $I_i > I_j$. Since the contribution of region i to the earnings of its 'own' factors of production exceeds the contribution of region j, and given that $I_i > I_j$, it follows that the larger region i will offer higher wages than the smaller region j ($w_i/w_j > 1$ and $r_i/r_j > 1$). The latter effect is known as the home market effect.

The price indices of goods and services in (29) and (30) proxy the extent of competition effect, as they actually put a lid on the price manufacturing or services producers in region j can ask. To see this, we recall from Section 2 the definitions of both the price indices for manufacturing goods and for services $(i, j = h, f; i \neq j)$:

$$\tilde{P}_{Z_i} = \left[N_{Z_i} p_{Z_{ii}}^{-\theta/(1-\theta)} + N_{Z_f} p_{Z_{fi}}^{-\theta/(1-\theta)} \right]^{-(1-\theta)/\theta}$$

$$\tilde{V}_i = \left[\sum^{n_i} v_i^{-\frac{\gamma}{1-\gamma}} + \sum^{n_j} \left(\frac{v_j}{\rho} \right)^{-\frac{\gamma}{1-\gamma}} \right]^{-\frac{1-\gamma}{\gamma}}$$

Due to the presence transportation costs, these equations imply that the smaller region j—now defined via the labour market, that is by comparing either N or n between the regions—typically has the higher price index as the higher priced imported goods or services get more weight. Firms located in the smaller region are therefore able

to bid higher prices than their counterparts in the larger region, which is good for the earnings of labour in the small region. Still assuming that $I_i > I_j$, this implies that $w_i/w_j < 1$ and $r_i/r_j < 1$. As with the home market effect, however, it should also here be noted that whereas τ is the sole moderator of the extent of competition effect for low-skilled labour, ρ is so for high-skilled labour. Consequently, by the economic geography channels changes in the transportation costs of goods (τ) only exert a direct impact on the earning of low-skilled labour, whereas changes in the transportation costs of services (ρ) only directly influence the remuneration of high-skilled labour.

The latter insight is important for determining the impact of globalisation on the relative position of low-skilled labour. Turning first to the home market effect when τ changes, it appears from (29) that an increase in τ is good for low-skilled labour in both regions, as it *ceteris paribus* increases the demand for one's output in the other region ($I_j/p_{Zij}^{\theta/1-\theta}$ goes up). Note, however, that as the smaller region depends more on exports than the larger region, low-skilled labour in the smaller region benefits most from reductions in τ. With region i being the larger region, it then follows that by the home market effect w_i/w_j falls when τ goes up. An increase in τ thus in fact erodes the advantage the larger market has due to the size of its home market. Turning now to the relative wage of low-skilled workers within one region, recall that an increase in τ has no direct effect on the earnings of high-skilled workers. This immediately settles the impact of globalisation on w/r: due to the home market effect, a rise in τ will increase w/r in both regions.

A similar argument can now be used to determine the impact of changes in ρ on w/r. By (30) we can deduce that an increase in ρ benefits high-skilled labour in both regions, as demand from abroad for one's output increases ($I_j/(v_i/\rho)^{\gamma/1-\gamma}$ goes up when $i \neq j$). As changes in ρ do not directly affect the earnings of low-skilled labour, this implies that by the home market effect a rise in ρ implies a fall in w/r. Moreover, as the smaller region is more dependent on exports that the larger region, an increase in ρ reduces the home market advantage of the larger region. With $I_i > I_j$, it follows that r_i/r_j falls due to the home market effect.

The impact of changes in either τ or ρ via the extent of competition effect requires more intricate reasoning, which starts at taking a look at the relevant price indices ($\tilde{P}_{Z_j}$ when dealing with τ and $\tilde{V}_i$ when dealing with ρ). We then see that an increase in either τ or ρ implies that the price index falls relatively more in the smaller region. As only the prices of imported goods or services decline due to the fall in the transportation costs, the price index equations show that the region that imports most varieties witnesses the largest fall in the price index.[25] Assuming once more that region j is the smaller region, this implies that when τ rises the fall in $\tilde{P}_{Z_j}$ exceeds the fall in $\tilde{P}_{Z_i}$, and when ρ rises $\tilde{V}_j$ goes down more severely than $\tilde{V}_i$. However, in order to say something about the effect on the relative wages between regions we have to address what happens in each region to (29) and (30) upon changes in τ and ρ. To do so, we rewrite these equations to ($i, j = h, f; i \neq j$),

$$\Omega_1 w_i^{\frac{1-(1-\alpha_Z)\theta}{1-\theta}} \overline{z}_i = \left[\frac{I_i}{\tilde{V}_i^{(1-\alpha_Z)\theta/1-\theta}}\right] \tilde{P}_{Z_i}^{\theta/(1-\theta)} + \tau^{\alpha_Z \theta/1-\theta} \left[\frac{I_j}{\tilde{V}_j^{(1-\alpha_Z)\theta/1-\theta}}\right] \tilde{P}_{Z_j}^{\theta/(1-\theta)} \tag{31}$$

$$\Omega_2 v_i^{1/1-\gamma} \overline{S}_i = I_i \tilde{V}_i^{\frac{\gamma}{1-\gamma}} + \rho^{\gamma/1-\gamma} I_j \tilde{V}_j^{\frac{\gamma}{1-\gamma}} \tag{32}$$

where $\Omega_1$and Ω_2 are constants that are defined as $\Omega_1 \equiv B(C_Z/\theta)^{\theta/1-\theta}/[\alpha_Z\theta(1-\mu_A)\mu_Z]$ and $\Omega_2 \equiv [\sum_Z(1-\alpha_Z)\theta(1-\mu_A)\mu_Z]^{-1}$. For both types of labour the impact of a reduction in transportation costs is therefore a weighted average of the impacts on the relevant regional price indices, where the weight attached to the price index of some region is basically given by the income of that region. In the absence of transportation costs, this would imply that changes in the price index of, say, goods in region i, get the same weight in both regions (τ then disappears from the right-hand-side of (31)).

[25] Note therefore that we now measure size by the size of the respective regional labour forces. By the labour market conditions, the larger region in terms of low-skilled (high-skilled) labour also forwards the larger number of goods (services) varieties (see equations (19) and (20)).

But when there are transportation cost, both equations imply that the weight attached to a certain price index is always lower when it relates to goods or services that are imported. Consequently, the wage effect in a region will always be closer to the price index effect in its own region, than to that in the other region. As we have seen above that the smaller region faces the sharpest decline in its price indices, both for goods and services, this implies that wages there will go down most. With region i being (again) the larger region, it then follows that by the extent of competition effect w_i/w_j rises when τ goes up, and r_i/r_j rises when ρ increases. This is intuitively plausible as globalisation reduces the advantage the smaller region has due to a more effective shield against foreign competition. For the relative position for the low-skilled in either region this implies that by the extent of competition effect an increase in τ has a negative impact on the relative wages of low-skilled workers (w/r goes down), whereas an increase in ρ exerts a positive impact on the relative wages of the low-skilled (w/r goes up).

This ends our analysis of the separate channels through which globalisation affects the relative position of low-skilled labour. The overall effect will be an intricate balance of all the effects that play a role, a matter on which the next section will shed more light. We conclude this section by summarizing for each channel how each type of globalisation affects nominal and relative wages (Table 1). Whereas a "+" indicates that we expect globalisation to increase nominal or relative wages; a "–" indicates that we expect a decrease. In constructing the table, we have designated Home as the larger region, which is also relatively abundant in high-skilled labour.

Table 1: Channels of direct wage effects of globalisation[26]

Globalisation of the market for raw output (τ up)

	Heckscher-Ohlin	Home Market	Extent of Competition	Services Availability
w_h	-	+	-	none
r_h	+	none	none	none
w_h/r_h	-	+	-	none

Globalisation of the services market (ρ up)

	Heckscher-Ohlin	Home Market	Extent of Competition	Services Availability
w_h	-	none	none	+
r_h	+	+	-	none
w_h/r_h	-	-	+	+

4 The Impact of Globalisation on Relative Wages

To get insight in the overall effect of globalisation on the relative wage position of low-skilled labour, we discuss in this section the results of computer simulations that were conducted to establish a numerical relation between w/r and either τ or ρ. The point of departure for our simulations is the parameter configuration as given in Table 2 below, which depicts the world as one in which the major share of income is spent on manufactured goods and where the majority of labour is low-skilled. Good X is relatively

[26] The effects given in the table are the direct effects. Due to the general equilibrium nature of our model, there are in addition indirect effects following a fall in transportation costs which are not discussed.

services intensive, whereas the transportation costs for services are higher than for raw output. Home is taken as the larger country and is also relatively high-skilled labour abundant.[27] As the primary focus in the globalisation debate so far has been mainly on the relative wage position of the low-skilled in advanced economies, we will confine the remainder of our analysis to the relative wages in Home. Note that by focusing on relative wages within one region, the results also apply to relative real wages.

Table 2: Parameter configuration base case scenario

$1-\mu_A = 0.95$	$\alpha_X = 0.6$	$\theta = 0.6$	$\rho = 0.6$	$\overline{L} = 400$	$\lambda_L = 0.6$
$\mu_X = 0.6$	$\alpha_Y = 0.8$	$\gamma = 0.6$	$\tau = 0.8$	$\overline{H} = 100$	$\lambda_H = 0.8$
$\mu_Y = 0.4$				$\overline{L}^A = 25$	

The results of our numerical analysis are given in Figure 1 and Figure 2. In Figure 1, we present w/r for Home as a function of either of the transportation cost parameters, while maintaining the level of the other type of transportation cost at its base case level. By way of a sensitivity analysis on τ and ρ, we present in Figure 2 the results on relative wages for all combinations of τ and ρ.[28]

[insert Figure 1 and 2 about here]

Two results stand out from inspection of Figure 1. First, whereas globalisation of the market for raw output (via τ) is always detrimental to the low-skilled in Home, irrespective of the initial level of τ, this is not the case when globalisation concerns the liberalisation of services markets (via ρ). In that case, the initial level of ρ becomes

[27] By making these particular assumptions with respect to the size and the relative abundance of the Home region, Home can be taken to represent the advanced economies of the world. Foreign, in contrast, can taken to represent the newly industrialising countries of South Asia. For empirical estimates on distribution of labour, see World Bank (1995).

[28] We have also performed extensive sensitivity analyses with respect to the other parameters of the model. For brevity's sake, we will only explicitly refer to these results when it is useful for the analysis.

important for gauging the effects of globalising services markets. Whereas at low values of ρ, a reduction in the transportation costs of services decreases the relative wage position of the low-skilled dramatically, the effect of globalisation is less severe at intermediate levels of ρ and becomes even positive at high values for ρ. In other words, when services markets are already fairly globalised, a further reduction in the costs of international services transactions will benefit, rather than hurt, the low-skilled in advanced countries. For globalisation of the market for raw output this is never the case, even though the impact of globalisation is most severe at the initial stages of globalisation (at low τ) and decreases when τ goes up. Figure 2 shows that these patterns hold regardless of the level of globalisation in the other market.[29]

The second point worth noting from Figure 1 is that the impact of globalising services markets in a situation of virtual autarky is much more severe than the impact of a comparable level of globalisation on the market for raw output. This result might help to interpret the developments in the relative income position of the low-skilled in advanced economies during the 1980s. As one can argue that by that time the transportation costs of raw output had already come down considerably, whereas pending technological breakthroughs in telecommunications and information technology the cross-border transaction costs of services were still high,[30] our analysis suggests that it is the globalisation of services markets rather than the further globalisation of goods markets that explains the sharp decline of the wages of the low-skilled during that time. Some support to this view is given by the fact that the severe pressure on the relative wages of the low-skilled in advanced countries coincided with an era in which major advances in telecommunications and information technology helped to bring down the transaction costs of services trade by an considerable extent.

The particular curvature of both relations can be understood by using the analyti-

[29] Except for the effects of an increase in τ when ρ is very low (in fact for $\rho < 0.05$). Then, the relative income position of the low-skilled will instead increase at low levels of τ and decrease at higher levels of τ. A very low ρ is very unlikely, however, and we will therefore ignore it.

[30] See, for instance, Baldwin and Martin (1999) and Siebert (1999) for empirical evidence on this matter.

cal framework of Section 3. Starting with the relation between w/r and τ, we note that in terms of the overall outcome the pattern shown is in line with the standard Heckscher-Ohlin predictions, even though the underlying mechanisms are more diverse. The direct economic geography channels manifest themselves in the explanation of the non-linear curvature of the relation (at low τ the decline in w/r is larger in percentage terms than at high τ). As for the base case parameter configuration, the economic geography elements on balance favour wages in the larger region for changes at low τ, whereas the balance favours wages in the smaller region for high τ,[31] the geography elements will on balance decrease w_h/r_h at low levels of τ, whereas they will increase w_h/r_h at higher levels of τ. This readily explains the decline in relative wages at low τ, as then both the Heckscher-Ohlin-effect and the joint geography effects work in the same direction. For the curvature at high τ, our framework thus suggests that the Heckscher-Ohlin effect is large enough to overcome the advantageous geography effects on w_h/r_h.[32]

To understand the effects of a reduction in ρ on relative wages we note first that by the Heckscher-Ohlin effect an increase in ρ will decrease w_h/r_h. Second, the direct economic geography elements in our model will affect w_h/r_h positively at low levels of ρ and negatively at high levels of ρ (see footnote 31 for the argument). Third, as services availability improves when ρ increases, an increase in ρ will lead to an increase in w_h/r_h. This leads to the conclusion that whereas the Heckscher-Ohlin effect

[31] This is related to the fact that for the parameter configuration chosen, the extent of competition effect dominates the home market effect at low levels of τ, whereas the dominance is reversed for high levels of τ. See Krugman (1991a) for the standard line of reasoning and de Vaal & van den Berg (1999) for the reasoning in the presence of services linkages. Consequently, for low (high) levels of τ a reduction in transportation costs will lower the advantage of the smaller region due to the extent of competition effect more (less) than it lowers the advantage of the larger region due to the home market effect. For our parameter setting, a reduction in transportation costs therefore favours wages in the larger region for low levels of τ whereas it favours wages in the smaller region for higher levels. Combining this with the fact that the economic geography impacts of changes in τ and ρ are labour type specific (see Section 3), this implies that by the direct economic geography channels the relation between τ and w/r becomes a U-shaped form. Alternatively, when depicted as a function of ρ, the relation between ρ and w/r becomes an inverse U-shape.

[32] This can be explained by the fact that the economic geography effects become less important if the transportation costs fall (see e.g. Krugman, 1991). Note also that we can confine our analysis to a discussion of Heckscher-Ohlin and geography effects as changes in τ do not affect services availability (see Table 1).

is apparently large enough to overcome the advantageous direct geography and services availability effects at low levels of ρ, this 'dominance' is taken over by the services availability effect at high levels of ρ (as then also the geography effects exert a negative impact on w_h/r_h). In addition it should be noted that the level of ρ at which the 'switch of dominance' takes place depends on the level of τ, as becomes clear upon close inspection of the data behind Figure 2. It appears that the higher τ, the higher the threshold level for ρ will be. This is plausible as we have seen that increases in τ are always detrimental to the low-skilled in Home. For the position of the low-skilled this implies that once goods markets open up to international trade, they should welcome further liberalisation on the services markets as well.

5 Globalisation and Labour Mobility

So far, we have considered globalisation as a reduction in either the transportation costs of goods or the transportation costs of services. A different aspect of globalisation is, however, the increased international mobility of labour, see for instance IMF (1997) and Stalker (2000). In a standard Heckscher-Ohlin world, factor mobility typically leads to similar effects on relative wages as trade in goods or services, thus rendering factor mobility a substitute for globalisation of goods and services markets. In a world with economies of scale, it may however well be that free trade and factor mobility complement each other, so that factor mobility provides an additional channel through which globalisation may affect relative wages. This section therefore investigates the impact of labour mobility on the relative wage position of the low-skilled in advanced countries. In addition, it will investigate how labour mobility is affected by the fall in the transportation costs of goods and services. The latter allows us to analyse the different aspects of globalisation in a combined setting.

To see how the relative labour market position of low-skilled workers in the advanced countries is affected by labour mobility, we proceed in steps. First, we calculate

for a given distribution of labour across regions the relative real wages between regions. As long as the relative real wages of low-skilled and high-skilled workers between regions are unequal to one, labour has an incentive to move to the region with the highest real wages. Therefore, in the next step we allow labour to move stepwise to the region with the higher real wage. Typically, this gives rise to the agglomerative processes that are so common in economic geography models. Note by the way that as our model includes two factors of production, we consider both the mobility of low-skilled and high-skilled labour. Finally, as we want to deal with the effects on the labour market position of the low-skilled, we compare the labour market outcomes for the low-skilled in the two situations.[33]

The real wages in region $i = h, f$ are obtained by dividing the nominal wages through the economy's overall price index. Hence, the real wage for low-skilled labour is given by $w_i/\tilde{P}_i^{(1-\mu_A)}$, whereas the real wage of high-skilled labour is $r_i/\tilde{P}_i^{(1-\mu_A)}$. $\tilde{P}_i$ denotes the true price index of consumers in region i, as given by

$$\begin{aligned}\tilde{P}_i &= \prod_{Z=X,Y} \left(\tilde{P}_{Z_i}/(1-\mu_A)\mu_Z\right)^{(1-\mu_A)\mu_Z} \\ &= \prod_{Z=X,Y} [(1-\mu_A)\mu_Z]^{-(1-\mu_A)\mu_Z} \left[N_{Z_i} p_{Z_{ii}}^{\frac{\theta}{\theta-1}} + N_{Z_j} p_{Z_{ji}}{}^{\frac{\theta}{\theta-1}}\right]^{\frac{\theta-1}{\theta}} \qquad (33)\end{aligned}$$

for $i, j = h, f;\ i \neq j$. Note therefore that the regional price index $\tilde{P}_i$ is a demand weighted multiplication of the sectoral price indices $\tilde{P}_{Z_i}$. After substitution for $p_{Z_{ij}}$

[33] A complicating factor that we have to deal with in our calculations is the fact that the impact of stepwise adjustments in either of the λ's on sectoral employment levels will typically not be the same. For instance, we can expect that well before all low-skilled labour has moved out of the region with the lower real wage, there will be a value for λ_L at which labour employment in one of the goods sectors has become zero. This implies that from that point onwards we have to continue our calculations with a version of the model in which the regional sector with zero employment no longer exists. Although such model-breaks are awkward from a theoretical point of view— if only because once implemented there is no way back to the original model — they must be implemented to determine the long-run equilibrium. Whenever appropriate, we therefore allow for model breaks in our calculations.

from (9) and (10), the expression reduces to (for $i, j = h, f;\ i \neq j$)

$$\tilde{P}_i = \prod_{Z=X,Y} [(1-\mu_A)\mu_Z]^{-(1-\mu_A)\mu_Z} \frac{C_Z}{\theta} \tilde{V}_i^{1-\alpha_Z} \left[N_{Z_i} w_i^{\frac{\alpha_Z \theta}{\theta-1}} + N_{Z_j} (w_j/\tau)^{\frac{\alpha_Z \theta}{\theta-1}} \right]^{\frac{\theta-1}{\theta}} \tag{34}$$

making the price index a function of Home and Foreign wages of low-skilled and high-skilled workers and the number of both manufacturing and services varieties in both regions.

Given that we know the real wages of either type of labour in each region, it is now possible to calculate the relative real wage between regions of both types of labour. As labour always moves to the region with the highest real wage, the agglomerative patterns show up immediately. For the mobility of low-skilled labour, the results (not shown) imply that the mobility of low-skilled labour always (that is, at every level of transportation costs) results into full agglomeration in the larger region (which is Home in our base configuration). This is not the case, however, when high-skilled labour is assumed to be mobile internationally. For sufficiently high transportation costs of services, mobility of high-skilled workers leads to a stable equilibrium at an intermediate level of λ_H. This is shown in Figure 3, in which the relative real wage of high-skilled workers between regions is plotted as a function of the share of high-skilled workers in Home at different levels of transportation costs of services. Note, by the way, that the stable intermediate equilibrium vanishes immediately after a fall in the transportation costs of services. For higher levels of ρ, all high-skilled workers move to the larger region and full agglomeration is the outcome. Finally, to see whether the agglomerative process of high-skilled workers is influenced by the transportation costs of raw output, we plotted in Figure 4 the relative real wage of high-skilled workers as a function of λ_H at different levels of τ. It follows that for the base case value of ρ, mobility of high-skilled labour results into full agglomeration in the larger region at every level of τ.

[insert Figures 3 & 4 about here]

In order to explain these agglomerative patterns, we have to rely on the economic geography effects discussed earlier on. Recall equations (29) and (30) in which the home market and extent of competition effect are proxied. The important thing to note is that mobility of either type of labour has a direct impact on the home market and extent of competition effect. To see this, consider the impact of an increase in λ_H. Because a rise in λ_H increases the nominal income of Home, *ceteris paribus*, it enlarges the advantage Home has due to its size (home market effect) and therefore increases the relative wage of both types of workers in Home (w_h/w_f and r_h/r_f rise). At the same time, however, a rise in λ_H increases the number of services varieties produced in Home (see (20)), whereas it lowers the number of services varieties produced in Foreign. As the n_i's are crucial in determining the price index of services, it follows that a rise in λ_H decreases (increases) the price index in Home (Foreign), which, as we have seen in section 3, reduces the relative wage of high-skilled workers in Home (r_h/r_f falls). Turning now to Figure 3, it follows that the intermediate stable equilibrium at low levels of ρ is due to the fact that at low levels of ρ the extent of competition effect dominates over the home market effect; when transportation costs of services fall, the balance between the effects is reversed and international mobility of high-skilled workers implies full agglomeration.[34]

We can use the resulting agglomeration patterns to say something on the effects of globalisation on the relative position of the low-skilled in Home when there is also labour mobility. To do so, we present in Table 3 for the parameter configurations that are used in the figures, the relative wages of low-skilled in Home for both the begin situation (the base configuration) and the end situation (when labour has stopped moving). It appears that mobility of low-skilled labour is always unfavourable to the low-skilled, but that the set-back in relative wages is lower the lower transportation costs (of what-

[34] In Figure 4, in contrast, there is always full agglomeration since the transportation costs of services, which is the relevant parameter in this case, is at an intermediate level ($\rho = 0.6$), so that the home market effect dominates over the extent of competition effect.

ever type) are.[35] Another picture emerges with respect to the mobility of high-skilled workers. Whereas mobility of high-skilled workers is good news for the low-skilled at all levels of τ and at medium to high levels of ρ, it is bad news for the low-skilled at low levels of ρ. Moreover, the table shows that the low-skilled workers benefit most when goods markets are less globalized, whereas they benefit least (or lose most) the less globalised services markets are. The latter can be explained by the fact that at a very low level of ρ, many services are being lost in international trade, which reduces the positive impact of increased services availability due to agglomeration. As a very low ρ may also preclude such full agglomeration to take place—at $\rho = 0.1$ mobility of high-skilled labour leads to a stable intermediate equilibrium—this also explains why the set-back in the relative position of the low-skilled is most severe at low levels of ρ.

Table 3: Globalisation and Labour Mobility[36]

Low-skilled labour mobile

	$\tau = 0.2$	$\tau = 0.5$	$\tau = 0.8$ (base case)	$\rho = 0.1$	$\rho = 0.3$	$\rho = 0.6$ (base case)	$\rho = 0.8$
$(w/r)_h$ begin	1.1154	1.0807	1.0601	1.2138	1.0955	1.0601	1.0589
$(w/r)_h$ end	1.0044	1.0044	1.0044	0.9113	0.9592	1.0044	1.0292

High-skilled labour mobile

	$\tau = 0.2$	$\tau = 0.5$	$\tau = 0.8$ (base case)	$\rho = 0.1$	$\rho = 0.3$	$\rho = 0.6$ (base case)	$\rho = 0.8$
$(w/r)_h$ begin	1.1154	1.0807	1.0601	1.2138	1.0955	1.0601	1.0589
$(w/r)_h$ end	1.1615	1.0983	1.0674	1.1420	1.0674	1.0674	1.0674

[35] This is intuitively plausible. Recall that international trade and factor mobility are substitutes in a Heckscher-Ohlin setting which implies that low-skilled mobility towards Home can be interpreted as a relative supply shock deteriorating the relative wages of low-skilled workers. If τ is at a high level, the relative wages of low-skilled workers in Home have decreased already to a considerable extent due to international trade; factor mobility then has a relatively small impact on relative wages.

[36] The 'begin' situation refers to our base case configuration in which λ_l equals 0.6, whereas λ_h equals 0.8. The 'end' situation refers to the long-run equilibrium outcome for λ_l and λ_h. In all but one

6 Subsidiary Trade in Services

The previous sections have considered services trade as taking place in a goods-like sense, that is with the output of services firms crossing regional borders. In the literature on services trade it is widely acknowledged, however, that on many occasions services trade requires the cross-border movement of either the producer of the service, the consumer, or both.[37] In the case of producer services, foreign direct investment is often mentioned as an important mode for services trade. To investigate how this might influence our results, we therefore assume in this section that the nature of service production is such that a services firm can only supply its output in the other region if it establishes a local subsidiary. These subsidiaries are to be operated by local (high-skilled) labour, but do not involve additional fixed costs.[38] A services firm that has its headquarters in, say, Home thus incurs the fixed costs of production in Home and from there supplies both regional markets by adding locally the marginal cost component of services production. Note that this does not alter the way raw output is transformed into final consumption goods. The finishing touch of manufacturing production still takes place in the region of consumption, for which manufacturing firms use the complete range of available services varieties. These are now provided free of transportation costs, however, as services are always supplied locally, either directly from headquarters or through the local subsidiary. Note also that the location of a services firm's headquarters will be in the region with the lowest high-skilled wages. As subsidiaries face an identical elasticity of demand as local firms, and therefore charge the same mark-up over marginal production costs, the regional profits of a services firm are the same regardless of whether the firm supplies the market via a subsidiary or directly from headquarters. To maximize total profits a service firm will then make sure to incur the fixed costs of

case the obtained values are consistent with full agglomeration in Home, i.e. $\lambda_l = 1$ or $\lambda_h = 1$. The exception concerns the stable intermediate equilibrium at ρ = 0.1, in which λ_h equals 0.68.

[37] See, for instance, Sampson and Snape (1985), UNCTAD and World Bank (1994) and Stibora and de Vaal (1995).

[38] One could argue that the fixed costs will increase when a firm has to coordinate international production activities. As this has no qualitative effects on our results, we simply ignore this possibility.

production in the region with the lowest high-skilled wage.

The model changes that are required to deal with subsidiary trade in services are spelled out in Appendix C. Here we go directly to the consequences for the relative wages of subsidiary trade in services. Figure 5 depicts the results of our calculations.[39] It portrays, for the base case configuration, the relative wages of low-skilled in Home as function of τ. For reference, we have also plotted w/r when services trade takes place in a goods-like sense (from Figure 1). As the figure shows, increased tradeability of raw output is also detrimental to the low-skilled in Home when there is subsidiary trade in services. However, the negative impact is less severe than for services trade in a goods-like sense.

[insert Figure 5 about here]

How can we explain the less severe fall in the relative wage in case of subsidiary trade? Recall first that the explanation of the fall in w/r if services are tradeable in a goods-like sense is sought in a combination of Heckscher-Ohlin type of effects and economic geography effects (see Section 3). Subsidiary trade does not change this: again the Heckscher-Ohlin type of effects and economic geography effects are relevant in explaining the fall in w/r. However, subsidiary trade in services increases the services variety externality effect relative to the case where services are tradeable in a goods-like sense. Part of the increased externality effect is due to the fact that there are no transportation costs of services anymore. In effect, we can think of this increase as a rise of ρ to 1, which according to our framework in section 3 increases w/r. The

[39] In the base case configuration, $r_h < r_f$, so that all headquarters are located in Home. When we allow for changes in the parameter setting (here in τ) and wages adjust, this may not longer hold true. In our calculations, we therefore allow for regime switches. While starting with a version of the model that posits all headquarters in Home, we check for each subsequent change in τ whether the equilibrium outcome is still consistent with this presupposition. If this not the case, we switch to a version of the model where headquarters can exist in both regions, that is we calculate equilibrium under the constraint $r_h = r_f$. As further modifications of the parameter configuration then typically lead to an adjustment in the distribution of headquarters over regions, we may reach a point where also this not longer suffices to yield a consistent equilibrium. In that case, we switch to a version of the model where headquarters are located only in Foreign. The regime switches are facilitated by the gams-programme we use for our calculations. An outline of the different versions of the model can be found in Appendix C.

externality is further increased, however, because once headquarters are located in one region only, the number of services varieties rises (in our base case configuration n_h)[40]. The latter decreases the price index of services and therefore leads to a further increase of w/r when compared to trade in services in a goods-like sense.[41]

We also consider the consequences of cross-regional labour mobility when there is subsidiary trade in services. As before, we first analyse the long-run consequences of labour mobility, to compare then the relative income position of the low-skilled in the long-run equilibrium with the initial situation. Figures 6a and 6b facilitate the first step of this investigation. It shows the regional real wage ratio for low-skilled labour (as a function of λ_L) and the regional real wage ratio for high-skilled labour (as a function of λ_H). For the base case configuration, it appears that when low-skilled labour is mobile, low-skilled labour typically ends up in one region (the Home region in our base case configuration). When, however, high-skilled labour becomes mobile, a stable intermediate equilibrium is achieved. As the figure shows, the level of transportation costs of raw output is not of much impact on this pattern.

[insert Figure 6a and 6b about here]

The impact of these long-run processes on the relative wage position of low-skilled in Home is given in Table 4 (which is constructed in the same way as Table 3). In contrast to our results of the previous section, it appears that mobility of labour always worsens the relative income position of the low-skilled. To what extent, however, depends once again on the level of globalisation of goods markets. Whereas the losses

[40] The rise in n_h is due to the fact that the fixed cost of services production (f) are incurred in the region with the lowest high-skilled wages.

[41] In Figure 5, both additional effects can be made visible. As long as the headquarters are in both regions ($\tau < 0.15$), the only difference between the two curves lies in the fact that there are no transportation costs in the subsidairy trade case, whereas these transportation costs are present in case the services are tradeable in a goods-like sense. If $\rho = 1$, both curves would coincide. However, at the point where the regime switches from a situation where services headquarters are present in both regions (for $\tau < 0.15$) to a regime where headquarters are only located in Home, the number of services varieties increase. This increases the w/r ratio even further. In this interval ($\tau > 0.15$), also the $\rho = 1$ curve for services trade in a goods-like sense falls below the curve for subsidiary trade in services.

to the low-skilled increase when τ goes up when they are themselves mobile, an increase in τ instead reduces the negative impact on w/r when high-skilled labour is mobile. To understand why, we refer back to the reasoning employed in section 5.

Table 4: Subsidiary Trade in Services and Labour Mobility

Low-skilled labour mobile

	$\tau = 0.7$	$\tau = 0.8$ (base case)	$\tau = 0.9$
$(w/r)_h$ begin	1.0952	1.0912	1.0876
$(w/r)_h$ end	1.0815	1.0735	1.0618

High-skilled labour mobile

	$\tau = 0.7$	$\tau = 0.8$ (base case)	$\tau = 0.9$
$(w/r)_h$ begin	1.0952	1.0912	1.0876
$(w/r)_h$ end	1.0521	1.0521	1.0521

7 Summary and Concluding Remarks

This paper analyses the impact of globalisation on the labour market position of the low-skilled in the advanced countries. In order to take into account the changed nature of manufacturing trade, we have integrated insights of the Heckscher-Ohlin trade theory with insights from the economic geography literature. In addition, to acknowledge the increasingly important role for producer services we have incorporated insights from the literature on producer services linkages. As such, we have argued that globalisation not only involves a reduction in the transportation costs of goods, but also a reduction

in the transportation costs of producer services.

The main body of our model consists of a two-region world, where each region is capable of producing many varieties of two manufactured goods. These manufactured goods are produced in a two-stage process: first, a tradable raw output is constructed by using low-skilled labour only; in the second stage, a variety of a tradable producer service is added in order to transform the raw output into a final consumption good. The production of producer services requires high-skilled labour. As the two goods may differ in their relative use of producer services, this set-up provides a clear link with the Heckscher-Ohlin type of mechanisms. By depicting the production of goods as a two-stage process we are able to incorporate producer services linkages. Finally, due to scale economies in production of both raw output and producer services, and due to their respective transportation costs, a link is established with the economic geography literature.

Given this set-up, we have first investigated analytically the impact of globalisation on the relative wage of low-skilled workers in the advanced countries. Here it turned out that due to the inclusion of producer services linkages and economic geography elements, the relation between globalisation and labour markets is not as straightforward as the Heckscher-Ohlin model tells us. In particular, we have argued that the impact of globalisation on the relative wages of the low-skilled is a combination of effects that play a key-role in the models employed. The balance of these effects is analytically not clear, as they might work in opposite directions. For instance, whereas a reduction in the transportation cost of producer services is detrimental to the low-skilled by the Heckscher-Ohlin effect and the home market effect, it is good for them because of increased services availability and the extent of competition effect.

To investigate the overall impact of globalisation on the labour market position of low-skilled workers we conducted a numerical analysis by means of computer simulations. A first conclusion from that analysis is that the fall in transportation costs of producer services, instead of the fall in the transportation costs of goods, might have caused the sharp decline in the relative wages of the low-skilled in the advanced countries dur-

ing the 1980s. As the globalisation debate so far has mainly focused on globalising goods markets, our model thus offers a new insight on the nexus between globalisation and labour markets. A second conclusion from the numerical analysis is that whereas liberalising services markets is detrimental to the low-skilled workers during the initial stages of globalisation, further reductions in the transportation costs of producer services will eventually benefit them. As by now services markets are already fairly liberalised, this suggests that the low-skilled in the advanced countries should actually welcome any further efforts to globalise services markets.

Further conclusions can be derived from two extensions we offer. Our first extension relates to an investigation of the impact of cross-border labour mobility on the relative wage position of low-skilled labour in advanced countries. It appears that whereas mobility of low-skilled labour is always unfavourable to the low-skilled, mobility of high-skilled labour is beneficial to them once services markets are fairly globalised. Again we thus see that the liberalisation of services markets is eventually beneficial for the low-skilled. The second extension is related to the nature of services trade. As it is widely acknowledged that cross-border services transactions often require some form of local presence of the services producer, this extension assumes that services firms can only supply their services in the other region by establishing a local subsidiary, which is to be operated by local (high-skilled) labour. We then find that modelling the globalisation of services production in such a way mitigates the detrimental effect on the low-skilled of goods markets globalisation.

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Appendix A Profit maximization manufacturing producers

This section gives the solution of the profit maximization problem of a home-based manufacturing producer when services are tradeable in a goods-like sense. The maxi-

mization problem of a manufacturing producer can be written as:

$$\begin{aligned}
\max \pounds \;=\; & p_{Z_{hh}} m_{Z_{hh}} + p_{Z_{hf}} m_{Z_{hf}} - w_h L_{\bar{Z}_h} - v_h \sum^{n_h} (S_{hh_Z h} + S_{hh_Z f}) \\
& - v_f \sum^{n_f} (S_{fh_Z h} + S_{fh_Z f}) \\
& + \lambda_1 \left\{ z_{hh}^{\alpha_Z} \left[\sum^{n_h} S_{hh_Z h}^{\gamma} + \sum^{n_f} (\rho S_{fh_Z h})^{\gamma} \right]^{\frac{1-\alpha_Z}{\gamma}} - m_{Z_{hh}} \right\} \\
& + \lambda_2 \left\{ (\tau z_{hf})^{\alpha_Z} \left[\sum^{n_h} (\rho S_{hh_Z f})^{\gamma} + \sum^{n_f} S_{fh_Z f}^{\gamma} \right]^{\frac{1-\alpha_Z}{\gamma}} - m_{Z_{hf}} \right\} \\
& + \lambda_3 \left\{ L_{\bar{Z}_h} - F - B(z_{hh} + z_{hf}) \right\}
\end{aligned}$$

where all variables are as defined in the main text. From the FOC we obtain,

$$\lambda_1 = \theta p_{Z_{hh}} \tag{A.1}$$

$$\lambda_2 = \theta p Z \tag{A.2}$$

$$\lambda_1 = \frac{B}{\alpha_Z} \frac{z_{hh}}{m_{Z_{hh}}} w_h \tag{A.3}$$

$$\lambda_2 = \frac{B}{\alpha_Z} \frac{z_{hf}}{m_{Z_{hf}}} w_h \tag{A.4}$$

$$v_h \left[\sum^{n_h} S_{hh_Z h}^{\gamma} + \sum^{n_f} (\rho S_{fh_Z h})^{\gamma} \right] = \lambda_1 (1 - \alpha_Z) m_{Z_{hh}} S_{hh_Z h}^{\gamma - 1} \tag{A.5}$$

$$\frac{v_f}{\rho} \left[\sum^{n_h} S_{hh_Z h}^{\gamma} + \sum^{n_f} (\rho S_{fh_Z h})^{\gamma} \right] = \lambda_1 (1 - \alpha_Z) m_{Z_{hh}} (\rho S_{fh_Z h})^{\gamma - 1}. \tag{A.6}$$

$$\frac{v_h}{\rho} \left[\sum^{n_h} (\rho S_{hh_Z f})^{\gamma} + \sum^{n_f} S_{fh_Z f}^{\gamma} \right] = \lambda_2 (1 - \alpha_Z) m_{Z_{hf}} (\rho S_{hh_Z f})^{\gamma - 1} \tag{A.7}$$

$$v_f \left[\sum^{n_h} (\rho S_{hh_Z f})^{\gamma} + \sum^{n_f} S_{fh_Z f}^{\gamma} \right] = \lambda_2 (1 - \alpha_Z) m_{Z_{hf}} S_{fh_Z f}^{\gamma - 1} \tag{A.8}$$

Substituting (A.3) in (A.1) and (A.5) as well as (A.4) in (A.2) and (A.8) yields, next to the demand expression for raw output as used to derive equation (28) in the main text, after rearranging and by using the production functions for $m_{Z_{hh}}$ and $m_{Z_{hf}}$ as given in (5) and (6):

$$\theta p_{Z_{hh}} = \frac{B}{\alpha_Z} w_h z_{hh}^{1-\alpha_Z} \left(\sum^{n_h} S_{hhz_h}^{\gamma} + \sum^{n_f} (\rho S_{fhz_h})^{\gamma} \right)^{\frac{\alpha_Z - 1}{\gamma}} \tag{A.9}$$

$$\theta p_{hf} = \frac{B}{\alpha_Z} w_h \tau^{-\alpha_Z} z_{hf}^{1-\alpha_Z} \left(\sum^{n_h} (\rho S_{hhz_f})^{\gamma} + \sum^{n_f} S_{fhz_f}^{\gamma} \right)^{\frac{\alpha_Z - 1}{\gamma}} \tag{A.10}$$

$$z_{hh} = \frac{\alpha_Z}{1-\alpha_Z} \frac{v_h}{B w_h} S_{hhz_h}^{1-\gamma} \left(\sum^{n_h} S_{hhz_h}^{\gamma} + \sum^{n_f} (\rho S_{fhz_h})^{\gamma} \right) \tag{A.11}$$

$$z_{hf} = \frac{\alpha_Z}{1-\alpha_Z} \frac{v_f}{B w_h} S_{fhz_f}^{1-\gamma} \left(\sum^{n_h} (\rho S_{hhz_f})^{\gamma} + \sum^{n_f} S_{fhz_f}^{\gamma} \right) \tag{A.12}$$

Substitution of the latter two expressions in the former two yields, after rearranging and by using $\tilde{V}_i = \left[\sum^{n_i} v_i^{-\frac{\gamma}{1-\gamma}} + \sum^{n_j} \left(\frac{v_j}{\rho} \right)^{-\frac{\gamma}{1-\gamma}} \right]^{-\frac{1-\gamma}{\gamma}}$, $i, j = h, f;\ i \neq j$:

$$p_{Z_{hh}} = \frac{C_Z}{\theta} w_h^{\alpha_Z} \tilde{V}_h^{1-\alpha_Z} \qquad \text{and} \qquad p_{Z_{hf}} = \frac{C_Z}{\theta} \tau^{-\alpha_Z} w_h^{\alpha_Z} \tilde{V}_f^{1-\alpha_Z}$$

with $C = B^{\alpha_Z} \alpha_Z^{-\alpha_Z} (1-\alpha_Z)^{-(1-\alpha_Z)} > 0$. The price equations for foreign manufacturing firms are obtained in a likewise fashion.

The market structures for both manufacturing goods and producer services are completed by assuming that firms in both markets will enter and exit until profits are zero. Hence, we require, for $Z = X, Y$:

$$p_{Z_{hh}} m_{Z_{hh}} + p_{Z_{hf}} m_{Z_{hf}} = w_h L_{\bar{z}_h} + v_h n_h (S_{hhz_h} + S_{hhz_f}) + v_f n_f (S_{fhz_h} + S_{fhz_f}) \tag{A.13}$$

$$v_h S_h = r_h (f + b S_h) \tag{A.14}$$

Appendix B Autarkic price ratio

The autarky equilibrium for Home is contained in the following set of equations

$$\frac{m_X}{m_Y} = \left(\frac{p_X}{p_Y}\right)^{\frac{1}{\theta-1}} \tag{B.1}$$

$$p_Z = \frac{C_Z}{\theta} w^{\alpha_Z} \tilde{V}^{1-\alpha_Z} \tag{B.2}$$

$$\bar{z} = \frac{\alpha_Z \theta}{B} \frac{p_Z m_Z}{w} \tag{B.3}$$

$$vS = \theta \left(\tilde{V}/v\right)^{\frac{\gamma}{1-\gamma}} \sum_Z (1-\alpha_Z) N_Z p_Z m_Z \tag{B.4}$$

$$(1-\mu_A)\mu_Z I = N_Z p_Z m_Z \tag{B.5}$$

and the two labour market equations (19) and (17). To derive the autarkic price ratio, we first substitute for $V = (b/\gamma) n^{-\frac{1-\gamma}{\gamma}} r$, yielding

$$\frac{p_X}{p_Y} = C_X/C_Y \left(\frac{w}{r}\right)^{\alpha_X - \alpha_Y} n^{\frac{1-\gamma}{\gamma}(\alpha_X - \alpha_Y)} (b/\gamma)^{\alpha_Y - \alpha_X}$$

Substituting in this equation directly for n_h from (20), while using (**??**) and recognising that in autarky relative wages can be expressed as (from the ratio of the autarky versions of (25) and (26) in Section 3):

$$\frac{w}{r} = \frac{H}{L} \left(\frac{\sum_Z (1-\theta(1-\alpha_Z))(1-\mu_A)\mu_Z}{\sum_Z \theta(1-\alpha_Z)(1-\mu_A)\mu_Z} \right)$$

leads, after some rearranging,

$$\left(\frac{p_X}{p_Y}\right)_h = \bar{C}\left(\frac{H_h}{L_h}\right)^{\alpha_X-\alpha_Y} H_h^{\frac{1-\gamma}{\gamma}(\alpha_X-\alpha_Y)}$$

with $\bar{C} \equiv (C_X/C_Y)[f/(1-\gamma)]^{\frac{1-\gamma}{\gamma}(\alpha_Y-\alpha_X)}(b/\gamma)^{\alpha_Y-\alpha_X}\left(\frac{\sum(1-\theta(1-\alpha_Z))(1-\mu_A)\mu_Z}{\sum\theta(1-\alpha_Z)(1-\mu_A)\mu_Z}\right)^{\alpha_X-\alpha_Y}$. This is equation (27) in the main text. Note that the relative wage ratio above also makes clear that in our model the one-to-one relation between the physical definition and the price definition of factor abundance still holds.

We can use the price ratio to derive a condition that settles when a region has a comparative advantage in a certain good. This yields

$$\frac{(p_X/p_Y)_h}{(p_X/p_Y)f} = \left[\frac{\lambda_H}{1-\lambda_H}\right]^{\frac{\alpha_X-\alpha_Y}{\gamma}} \times \left[\frac{1-\lambda_L}{\lambda_L}\right]^{\alpha_X-\alpha_Y} \lessgtr 1 \qquad \text{(B.6)}$$

where a value lower (higher) than 1 would indicate a comparative advantage of Home in good X (Y). This condition has been derived by dividing the price ratios of Home and Foreign, while implementing our notation concerning the regional distribution of labour. Moreover, we have assumed that all model parameters have equal values in both regions.

Appendix C Subsidiary trade in services

In this appendix we make clear how the model changes when trade in services takes place via foreign direct investment. To do so, we initially suppose that $r_f < r_h$, which implies that all services firms' headquarters are located in Foreign. The production functions of manufactured goods then read, for a Home manufacturing firm

$$m_{Z_{hh}} = z_{hh}^{\alpha_Z}\left[\sum^{n_f} S_{fh_Zh}^{\gamma}\right]^{\frac{1-\alpha_Z}{\gamma}} \qquad \text{and} \qquad m_{Z_{hf}} = (\tau z_{hf})^{\alpha_Z}\left[\sum^{n_f} S_{fh_Zf}^{\gamma}\right]^{\frac{1-\alpha_Z}{\gamma}} \qquad \text{(C.1)}$$

where notation is as before. As there are no transportation costs involved with services trade, the price indices of services become a function of the *local* prices of services varieties:

$$\tilde{V}_i = \left(\sum^{n_f} v_i^{\frac{-\gamma}{1-\gamma}} \right)^{\frac{-(1-\gamma)}{\gamma}} \qquad i,j = h,f \tag{C.2}$$

Whereas the zero-profit conditions for manufacturing remain the same, the zero-profit output of a services firm changes to:

$$S_{ff} = \frac{\gamma}{1-\gamma}\frac{f}{b} - \frac{r_h}{r_f} S_{fh} \tag{C.3}$$

where $S_{ff} = \sum_Z \left(N_{Z_h} S_{fh_i f} + N_{Z_f} S_{ff_i f} \right)$ is the output directly supplied from headquarters to manufacturing firms in Foreign and $S_{fh} = \sum_Z \left(N_{Z_h} S_{fh_i h} + N_{Z_f} S_{ff_i h} \right)$is the output of the subsidiary to manufacturing firms in Home. The claim of a services firm on the labour market is bS_{fh} in Home and $f + bS_{ff}$ in Foreign. Note that when wages are equal in both regions, total output of a services firm is the same as when services are tradeable in a goods-like sense, see (17) in conjunction with (8). By using the FOC of manufacturing firms, equilibrium on the services market requires $(i,j = h,f; i \neq j)$:

$$v_i n_f S_{fi} = \sum (1-\alpha_Z)\theta (N_{Z_i} p_{Z_{ii}} m_{Z_{ii}} + N_{Z_j} p_{Z_{ji}} m_{Z_{ji}}). \tag{C.4}$$

The full-employment conditions for high-skilled labour, finally, become:

$$bn_f S_{fh} = \lambda_H \overline{H} \tag{C.5}$$

$$n_f (f + bS_{ff}) = (1-\lambda_H)\overline{H} \tag{C.6}$$

Equilibrium is contained in (2) - (10), (14), (C.4), (19),(C.5), (21) and their foreign equivalents (including (C.6)).

The main problem in analysing equilibrium is that it should be consistent with the pre-supposition we make regarding the location of the headquarters of services firms. As we have argued, services firms locate their headquarters in the region with the lowest high-skilled wage. This implies that we have to allow for regime switches when the region that is supposed to host services firms' headquarters has the higher nominal wage. Such regime switches are facilitated by GAMS. The model adjustments necessary are as follows. When headquarters are located in Home, the model to be used is simply obtained by reverting the appropriate regional subscripts in the set-up above. When the model should feature headquarters in both regions, the model becomes similar to the one used in the main text, except for (i) the absence of transportation costs in services, (ii) the fact that the services market equilibrium conditions take into account the new way of providing services across borders; (iii) the full employment condition for high-skilled labour becomes like (C.6) for both regions; and (iv) a constraint on the nominal wages of high-skilled labour (which should be equal in both regions).