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Labour mobility and the redistributive effects of trade integration

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Abstract This paper addresses the role of mobility costs in shaping the effects of trade integration on wage inequality and welfare. We present a three-factor, two-sector model in which the production technology exhibits capital-skill complementarity and the cost of moving across sectors differs between unskilled and skilled workers. Results show that trade integration increases aggregate welfare, but it also raises wage inequality, both within and across skill categories. We also model a public re-training program, financed by a proportional tax levied on skilled workers, which reduces the mobility cost of unskilled workers. We show that even if the re-training programme entails some welfare losses, it can reduce both within and between wage inequality, while still making free trade Pareto superior with respect to the no-trade regime.

Keywords Capital-skill complementarity · Wage inequality · Trade integration · Re-training programme

JEL Classification E24 · J31 · R23

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1 Introduction

One of the most topical issues raised by trade integration concerns its redistributive effects. While opening to free trade is generally agreed upon to increase welfare, it is also considered a major cause of the increase in wage inequality occurred in the last decades in most countries. Moreover, free trade does not entail welfare gains for all, but it typically rewards some groups while harming others; this explains why liberalizing trade often meets strong political opposition.

This paper addresses the role of intersectoral labour mobility in shaping the redistributive effects of trade integration. To this end we model a two-sector small competitive economy in which each sector produces a single good combining capital, skilled labour and unskilled labour. Capital is internationally mobile; skilled and unskilled workers can move across sectors. We introduce workers' heterogeneity by allowing the mobility cost to differ between skill categories, and by adopting a production technology which exhibits capital-skill complementarity. The interaction between mobility costs and capital-skill complementarity turns out to be important in order to address the labour market effects of trade integration and, to the best of our knowledge, it has never been explored before.

The role of mobility costs in shaping the relations between trade integration and inequality calls for the analysis of specific policies that, by reducing mobility costs, can tackle inequality at (possibly) some welfare cost. In order to address this issue, we model a public re-training program, intended at reducing the mobility cost of unskilled workers and financed by a proportional tax levied on skilled workers. We explore the redistributive and welfare effects of changes in the tax rate under alternative assumptions on the effectiveness of the program.

We characterize both the no-trade and the free trade equilibrium. We study the effects of trade integration in terms of aggregate welfare—measured by an utilitarian social welfare function—and both across and within group wage inequality. We show that if the mobility cost of unskilled workers is high enough to prevent mobility, trade integration has a positive effect on aggregate welfare, but it increases both across and within group inequality. We also show that a lower mobility cost for unskilled workers implies both higher welfare and a lower wage inequality. The novelty of our model is that frictions in the reallocation of unskilled workers during the trade integration process might indeed cause an increase in both across and within group inequality. In our set-up, the imperfect mobility of unskilled workers is the main source of the increase in within-group inequality induced by trade integration, whereas capital-skill complementarity is the main cause of the rise in across-group inequality. The two factors are self-reinforcing. Our framework allows for analyzing the interrelations between these two dimensions. Notice that the mechanism explored in this paper does not require any difference in skill intensity between sectors and it is at work independently from the level of development of the country.

We also show how a simple redistributive mechanism may help in absorbing the increase in both within-group and across-group inequality induced by trade integration. A public re-training program aiming at lowering the moving cost for unskilled workers would indeed enhance their reallocation, thus reducing inequality. We show

that even if the public training programme entails some welfare losses, it still makes trade integration Pareto superior with respect to the no-trade regime.

The paper is organized as follows: in Sect. 2 we briefly review the literature on the effects of trade liberalisation on inter-industry (and intra-industry) labour reallocation. In addition, we discuss the evidence concerning the different level of mobility between sectors and firms of educated and less educated workers. Section 3 provides the basic economic set-up and Sect. 4 analyzes the effects of trade liberalisation on aggregate welfare and both within and across group wage inequality. It also studies the effects of the introduction of a public training scheme. Section 5 concludes.

2 Related literature

The literature on wage inequality and international trade is, by now, extremely vast. The interest in the field has been largely motivated by the dramatic increase in both across and within-skill group wage inequality, which has occurred in several developed countries (DCs) and, remarkably, in the US during recent decades (see Katz and Autor 1999).

The benchmark theoretical linkage between trade integration and across group wage inequality is the Stolper-Samuelson theorem: since DCs are assumed to have a comparative advantage in skilled-intensive productions, it follows that the process of specialization induced by trade integration implies an increase in the relative demand for skilled workers, thereby rising the skill premium. A specular pattern of specialization would also entail a reduction of wage inequality in less developed countries (LDCs). However, existing evidence suggests that several LDCs experience rising wage inequality after trade liberalisation episodes (see, *inter alia*, Harrison and Hanson 1999; Arbache et al. 2004). Recent contributions try to solve this puzzle, proposing different linkages between trade integration and wage inequality—see for example Acemoglu (2003), Xu (2003), Epifani and Gancia (2008) and Verhoogen (2008) and references cited therein.[1]

A second, important prediction of classical trade models is that, when a country opens to international trade, factors reallocate across sectors and firms. Indeed, it is this factor reallocation that allows the country to exploit its comparative advantages and to reap the benefits of trade integration. Nevertheless, if the labour market is characterised by imperfect mobility, the benefits of trade integration cannot be fully exploited and, at the same time, within group inequality (between similar workers employed in different sectors) would increase. Empirical evidence suggests that the imperfect mobility of workers is a relevant issue, implying that labour reallocation after trade integration is in general low—see Papageorgiou et al. (1991) and Wacziarg and Wallack (2004). Lately, a few contributions address the issue linking the effects

[1] In particular, great attention has been paid to the interaction between trade, skill-biased technological change and increasing returns to scale and how these may be simultaneous causes of both the process of skill upgrading and increase in inequality (Goldberg and Pavcnik 2004). The comparative static approach, here adopted to make tractable the model, does not allow for technological change and our analysis should be interpreted as capturing only the *direct* effect of opening to free trade on inequality.

of trade integration to job security regulations, which is often maintained to be the major sources of frictions in the labour market—see Andersen and Skaksen (2003).

Remarkably, the joint effect of trade integration and intersectoral labour mobility on both dimensions of inequality—within and across group inequality—can hardly be addressed in existing theoretical models and, to the best of our knowledge, it has never been addressed before. The existing models are not suitable to explore this effect since they either assume that workers are sector specific, as in Acemoglu (2003), or, when they allow for intersectoral labour mobility, they adopt a specification of the production technology which implies that the average skill premium is constant (i.e. a Cobb-Douglas production function in capital and aggregate labour).

Here is where our paper tries to contribute to the existing literature. We develop a theoretical model which allows us to study the interplay between trade integration, (imperfect) labour mobility and wage inequality, both across and within skill categories. Two features of the model are crucial in our analysis: moving costs can differ between categories of workers and the production technology exhibits capital-skill complementarity. Both features involve some notion of heterogeneity between skill categories and deserve a brief discussion.

First, we assume that the cost of moving across sectors is higher for unskilled workers than for skilled workers. The idea behind this assumption is that skilled workers have more general abilities, which can be easily transferred between occupations and sectors; on the contrary, less skilled workers are characterized by less transferable abilities. Existing evidence seems to support the hypothesis of higher internal mobility (across industry, sectors and geographical areas) of more educated workers: it has been shown that high educated workers possess more ability in the job search and lower transaction costs—see, for instance, Greenwood (1975); Bednarzik (1993) and Helwing (2001)—they can more easily learn and implement new tasks and technology—see Nelson and Phelps (1966) and Bartel and Lichtenberg (1987)—and they exhibit an higher propensity to voluntarily change their job—Magnani (2001) and Tomkins and Twomey (2000). Furthermore, there is some evidence that more educated workers spend less time without a job when they are displaced (Bednarzik 1993; Helwing 2001), suggesting that higher education is positively correlated with the ability to learn and perform new tasks. This hypothesis properly fits the different degrees of workers' mobility in those sectors affected by technological changes of a general purpose nature in last decades.[2] As pointed out by Aghion et al. (2002), a more general technology allows for a larger degree of transferability of skills across different sectors, implying a higher intersectoral mobility of skilled workers. Here we stress that the assumption does not need to hold for the whole spectrum of qualifications, and indeed it is possible to provide examples of less qualified workers performing more generic tasks which might well change industry or sector more easily than more educated workers. With more than two skill groups we could intersect formal qualifications (unskilled vs. skilled) and tasks (sector specific vs. generic) and address more carefully the relative mobility of the resulting groups. In our simplified framework,

[2] Bresnahan and Trajtenberg (1995) coined the term 'general purpose technologies' (GPT) to describe certain drastic innovations (e.g. computers) that have the potential for pervasive use and application in a wide range of sectors in the economy.

with only two types of workers, we conform to a standard notion in the literature of education and overlap formal qualification and generic, more easily transferable, abilities.

Second, the constant return to scale production technology exhibits capital skill complementarity: i.e. capital better substitutes unskilled labour than skilled (Griliches 1969; Krusell et al. 2000; Caselli 1999). This assumption has received strong empirical support[3] and it has been shown to be crucial in order to establish a link between internal mobility and across group wage inequality.[4]

As a final remark, notice that in our model the production function is the same in both sectors. This assumption has two main advantages. First, it allows us to focus exclusively on the effect of trade integration on wage inequality occurring through the channel addressed in this paper, disregarding the traditional explanation based on the different skilled-intensity between sectors, as discussed above. Of course, the two channels are not in contradiction. Second, and related to the previous point, the forces highlighted in this paper are at work in any economy experiencing a trade liberalisation process, independently of its level of development. Indeed, our results can offer a complementary explanation to the puzzle of increasing wage inequality in both DCs and LDCs which follows trade integration.

3 The model

We consider a small economy populated by three types of agents: skilled workers, unskilled workers and capitalist-entrepreneurs. The number of skilled and unskilled workers is fixed; they cannot save and supply their labour services in a competitive labour market. The capitalist-entrepreneurs take the saving-investment decisions and hold production. There are two sectors, x and y, each producing a single good, which is sold in a competitive market. Production requires both types of labour and capital. We assume that capital is perfectly mobile between sectors and internationally. It follows that the marginal productivity of capital in each sector is equal to the exogenously fixed world interest rate and we can disregard the explicit analysis of capitalist-entrepreneurs' optimization problem.[5]

Skilled and unskilled workers can move across sectors, but they cannot migrate abroad. We introduce workers' heterogeneity by adopting a production technology which exhibits capital-skill complementarity and by allowing the mobility cost to differ between skill categories. We next detail the production technology and the workers/consumer maximization problem.

3.1 Production

In each sector a representative firm produces a single good $Q = \{X, Y\}$ using the following neoclassical production function:

[3] See Casarico and Devillanova (2008) for references.

[4] See Devillanova (2004).

[5] See Devillanova (2004).

$$Q = f\left(L_q, H_q, K_q\right) = z_q\left[b\left(K_q\right)^{\alpha} + (1-b)\left(L_q\right)^{\alpha}\right]\left[H_q\right]^{1-\alpha} \tag{1}$$

where Q is the quantity of good produced, $q = \{x, y\}$ is an index for the sector, K_q, L_q and H_q are, respectively, the quantities of physical capital, unskilled labour and skilled labour used to produce $Q, \alpha,\ b \in [0, 1]$ are constants and z_q is a multiplicative parameter allowing for different productivities in the two sectors.

The production function (1) captures in a very convenient way the presence of capital skill complementarity. Indeed, the elasticity of substitution between capital and unskilled labour is $\frac{1}{1-\alpha}$, which, for $\alpha > 0$, is greater than the elasticity of substitution between capital and skilled labour, which is one. An easy to verify implication of capital skill complementarity is that $\frac{\partial \pi_q}{\partial K_q} > 0$, where $\pi_q = \frac{f_{Hq}(L_q, H_q, K_q)}{f_{Lq}(L_q, H_q, K_q)}$ is the *skill-premium*—the ratio of skilled to unskilled workers' productivity—in sector q and where $f_{H,q} = \frac{\partial f(L_q, H_q, K_q)}{\partial H_q}$ and $f_{L,q} = \frac{\partial f(L_q, H_q, K_q)}{\partial L_q}$ are, respectively, the marginal productivity of skilled and unskilled workers in sector q. In words, the more capital is employed in a sector, the higher in that sector is the marginal productivity of skilled workers relative to the marginal productivity of unskilled workers.

Two other features of this framework are worth to be emphasized. First, in (1) skilled and unskilled labour are complementary production factors, with elasticity of substitution equal to one. Therefore, the marginal productivity of unskilled workers is going to be positively affected by the amount of skilled workers in the sector, and vice versa. Second, the production function is the same in both sectors, apart from the multiplicative parameter z_q, and the skilled/unskilled intensity in the two sectors is going to be endogenously determined at equilibrium.

3.2 Workers

The economy is populated by a continuum of skilled workers of measure $\bar{H}$ and by a continuum of unskilled workers of measure $\bar{L}$. Agents inelastically supply their time endowment, which is normalized to one, in a competitive labour market. The utility function is:

$$U\left(C_x, C_y\right) = \left[\gamma C_x^{\frac{\theta-1}{\theta}} + (1-\gamma)\, C_y^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{2}$$

where C_x and C_y denote individual's consumption of the two goods, $\gamma \in [0, 1]$ and $\theta \in [0, \infty]$ determines the (constant) elasticity of substitution between goods. Agents maximize (2) subject to the following budget constraint:

$$p_x C_x + p_y C_y + p_x c_j \leq w_{jq} \tag{3}$$

where p_x and p_y are, respectively, the price of good X and good Y, $j = H, L$ is an index of qualification, w_{jq} is the wage of type j labour in sector q. c_j is the individual's moving cost, which we next specify, expressed in units of good X. Normalizing $p_x = 1$, (3) can be written as:

$$C_x + p_y C_y \leq m_{jq} \tag{4}$$

with $m_{jq} = w_{jq} - c_j$ being the consumer's income net of the mobility cost (or disposable income, for brevity), which varies across sectors and qualifications.

Agents solve the individual problem by choosing how much to consume and in which sector to work. Both types of workers can move across sectors bearing some costs of reallocation; they cannot internationally migrate. Their indirect utility function is:

$$V\left(p_y, m_{jq}\right) = \left[\gamma^\theta + (1-\gamma)^\theta p_y^{1-\theta}\right]^{\frac{1}{\theta-1}} m_{jq} \tag{5}$$

Equation (5) highlights that, for given p_y, indirect utility is increasing in m_{jq}. Each agent chooses to work in the sector that allows for obtaining the highest disposable income. If an agent changes sector, he/she pays a mobility cost c_j, allowed to differ between skilled and unskilled workers.[6] An agent chooses to move from sector x to sector y if:[7]

$$w_{jy} - c_j \geq w_{jx} \tag{6}$$

Reallocation of workers occurs until (6) holds with equality. Notice that, in the absence of moving costs, wage equalization between the two sectors would be always reached. The generic expression for c_j is:

$$c_j = f_j + \xi M_j \tag{7}$$

where M_j, is the number of movers of qualification j. The component ξM_j captures the costs of congestion associated to labour mobility, with $\xi > 0$. In particular (7) implies an aggregate mobility cost which is quadratic in M_j. In our framework, a marginal cost increasing in M_j is needed in order to get an interior solution in the free trade regime. $f_j > 0$ represents the fixed costs of mobility due to the imperfect adaptability of skills. We assume $f_L > f_H = 0$, capturing higher mobility of skilled, as discussed in Sect. 2.

3.3 Equilibrium

Equating the marginal productivity of capital in each sector to the world interest rate, solving for capital and substituting into (1), we get:

$$Q = f\left(H_q, L_q, z_q\right) = z_q^{\frac{1}{1-\alpha}} p_q^{\frac{\alpha}{1-\alpha}} b \left(\frac{\alpha b}{\bar{r}}\right)^{\frac{\alpha}{1-\alpha}} H_q + z_q (1-b) L_q^\alpha H_q^{1-\alpha} \tag{8}$$

[6] Disposable income is going to depend on the public training system too, which is introduced in the next section.

[7] For each category of workers, mobility costs are symmetrical between sectors, i.e. the cost of moving from sector x to sector y is equal to the cost of moving from sector y to sector x.

Notice that, *ceteris paribus*, an increase in z_q and/or p_q, attracts new investment in the sector, increases physical production and affects, via capital-skill complementarity, the relative marginal productivity of skilled and unskilled workers in the sector. Competitive wages of skilled and unskilled workers are:

$$w_{Hq} = p_q \frac{\partial f\left(H_q, L_q, z\right)}{\partial H_q} = z_q^{\frac{1}{1-\alpha}} p_q^{\frac{1}{1-\alpha}} d + z_q g l_q^{-\alpha} \tag{9}$$

$$w_{Lq} = p_q \frac{\partial f\left(H_q, L_q, z\right)}{\partial L_q} = p_q z_q \varphi l_q^{1-\alpha} \tag{10}$$

where $d = b\left(\frac{\alpha b}{\bar{r}}\right)^{\frac{\alpha}{1-\alpha}}$, $g = (1-\alpha)(1-b)$ and $\varphi = \alpha(1-b)$ are positive constants and $l_q = \frac{H_q}{L_q}$ indicates the skill intensity in the sector, determined by the mobility choices of workers. Full employment implies:

$$H_x + H_y = \bar{H} \tag{11}$$

$$L_x + L_y = \bar{L} \tag{12}$$

For notational convenience, and recalling that $p_x = 1$, in what follows we denote with $p = \frac{p_y}{p_x}$ the relative price of commodity Y. In equilibrium, the set of wages $(w_{Hy}, w_{Hx}, w_{Ly}, w_{Lx})$, the commodity price p and the distribution of workers between sectors (H_x, H_y, L_x, L_y) is such that agents solve their consumption and location decisions, firms maximize profits and markets clear. From (11) and (12), H_y and L_y uniquely determine the distribution of workers between sectors: thus there are seven unknown endogenous variable (w_{Hy}, w_{Hx}, w_{Ly}, w_{Lx}, p, H_y and L_y). Given p, the four equations for wages (9) and (10), $q = x, y$, and the two conditions for migration (6), $j = H, L$, determine wages and the workers' distribution.

In order to close model, we have to distinguish between the no-trade and the free trade regime.

No-trade regime In the absence of international trade, p is determined by market clearing conditions in the commodity markets. By the properties of the CES utility function we get:

$$\begin{aligned} p_A &= \frac{p_y}{p_x} = \frac{1-\gamma}{\gamma}\left(\frac{\widetilde{C}_y}{\widetilde{C}_x}\right)^{-\frac{1}{\theta}} \\ &= \left(\frac{1-\gamma}{\gamma}\right)\left[\frac{z^{\frac{1}{1-\alpha}} p_A^{\frac{\alpha}{1-\alpha}} b\left(\frac{\alpha b}{\bar{r}}\right)^{\frac{\alpha}{1-\alpha}} H_y + z(1-b) L_y^{\alpha} H_y^{1-\alpha}}{b\left(\frac{\alpha b}{\bar{r}}\right)^{\frac{\alpha}{1-\alpha}} H_x + (1-b) L_x^{\alpha} H_x^{1-\alpha}}\right]^{-\frac{1}{\theta}} \end{aligned} \tag{13}$$

where the subscript A indicates the no-trade regime.

Free trade In the free trade regime, both goods are exchanged internationally. Under the small country assumption, the free trade relative price p_{FT} is exogenously given.

We assume that $p_{FT} > p_A$, implying that Home country has a comparative advantage in sector y.

Notice that in (3) we specify the mobility cost as an expenditure in good X. This modelling assumption guarantees that in aggregate (and at the individual level too) the value of total expenditures (consumption of good X and Y plus total mobility costs) equals total earnings. Under CRS production technology (8), it follows that the value of total expenditures exhausts that of total production. The identity between expenditures and production, and the assumption of small open economy, ensure that the balance trade condition is always satisfied in this model.

3.4 Public re-training program

We also model a public re-training program, intended at reducing the mobility cost of unskilled workers, financed by a proportional tax levied on skilled workers. Specifically, we assume that the training expenditures are targeted to all unskilled workers in the sector with comparative disadvantage and that they reduce the fixed component of their mobility cost. The relevant cost for unskilled workers becomes:

$$\hat{c}_L = f_L - e + \xi M_L \tag{14}$$

where e indicates per capita training expenditures. The idea behind (14) is that if workers' reallocation cost is affected by the adaptability of their skills—which, in our simplified framework, maps into the distinction between skilled and unskilled workers—it can be reduced by programs aimed at providing more adaptable skills.

The introduction of the training program requires only few marginal adjustments to the previous set-up. The relevant wage for skilled workers is now the after tax wage:

$$\hat{w}_{Hq} = (1 - t) w_{Hq} \tag{15}$$

where t is the tax rate. We impose the balance budget constraint for the re-training program:

$$E = t\left[\widetilde{H}_y w_{Hy} + H_x w_{Hx} + \left(\widetilde{H}_x - H_x\right)\left(w_{Hy} - c_H\right)\right] \tag{16}$$

where E are total expenditures in training and $\widetilde{\cdot}$ denotes variables at their initial equilibrium. Once t is fixed, total expenditures are uniquely determined by (16). We assume that total expenditures are distributed equally among all the unskilled workers in the sector, hence per worker expenditure is $e = \frac{E}{L_x}$, where we are using the fact that if any reallocation of workers occurs, it is going to take place from sector x to sector y. Notice that the choice to spread out on all workers the expenditures for the re-training programme is conservative with respect of the results of the model.

Once we replace (7) for unskilled workers with (14) and (9) with (15), the equilibrium of the economy is defined as in Sect. 3.3, except that now we have one free variable t. Next, we characterize the equilibrium of the economy as a function of the tax rate.

4 Results

In this section we study the effect of trade integration on both within and across group wage inequality, and on aggregate welfare. More specifically, we focus on four main outcomes: within group wage inequality $\frac{w_{Ly}}{w_{Lx}}$ and $\frac{w_{Hy}}{w_{Hx}}$; across group pre-taxes wage inequality in each sector (which, under the assumption of competitive labour market, is given by the skill premium π_q); aggregate across group wage inequality; aggregate welfare, measured by an utilitarian social welfare function W. Notice that the choice of an utilitarian welfare function is clearly reductive, since it does not depend on inequality, but it is conservative from the point of view of our results.

To focus on essentials, the following analysis assumes that the two sectors have identical productivities, i.e. $z_y = z_x = 1$—and that the utility function is symmetric in the two goods. Even in this case, the presence of mobility costs implies a multiplicity of equilibria, depending on the initial allocation of labour across sectors. Here, for expositional convenience, we impose a symmetric no-trade equilibrium, implying that workers are equally distributed between sectors, the equilibrium relative price is $p_A = 1$, within group inequalities are null and the wage premium is the same in the two sectors. The assumption of a symmetric no-trade equilibrium is a useful reference point in order to focus on factor reallocation solely driven by trade integration.[8]

4.1 Free trade

When the Home country opens to international trade, the reallocation of workers, if any, is going to take place from sector x to sector y since we consider the case $p_{FT} > p_A$. Furthermore, by perfect international capital mobility, it also follows that the increase in the relative price attracts new capital in the y sector, delivering a higher level of physical capital in the economy.[9] In this case, the social welfare function is:

$$W = \left[H_x V_{Hx} + \widetilde{H}_y V^s_{Hy} + (\widetilde{H}_x - H_x) V^s_{Hy} \right] + \left[L_x V_{Lx} + \widetilde{L}_y V^s_{Ly} + \left(\widetilde{L}_y - L_x\right) V^m_{Ly} \right]$$

where V_j is the indirect utility function of workers of type j and the superscript m and s denotes, respectively, movers, who bear the reallocation cost, and stayers. For instance, in the the first bracket, which refers to skilled workers, $\widetilde{H}_y V^s_{Hy}$ denotes the total indirect utility of skilled workers who were in y at the initial equilibrium and who do not bear any reallocation cost; $H_x V_{Hx}$ is the indirect utility of skilled workers who remain in x; $(\widetilde{H}_x - H_x) V^s_{Hy}$ is the indirect utility of movers from x to y. Since the conditions characterizing the equilibrium of the economy are highly non linear,

[8] At the same time, it must be acknowledged that the specific path of adjustment from the no-trade to the free trade regime depends on the initial equilibrium. Although the main mechanisms here highlighted do not depend on this assumption, different adjustment trajectories may affect the qualitative results of the paper. We leave this issue for future research.

[9] For the sake of simplicity and without loss of generality we assume that any additional capital stock in the free trade equilibrium with respect to the level of no-trade is provided by foreign investors.

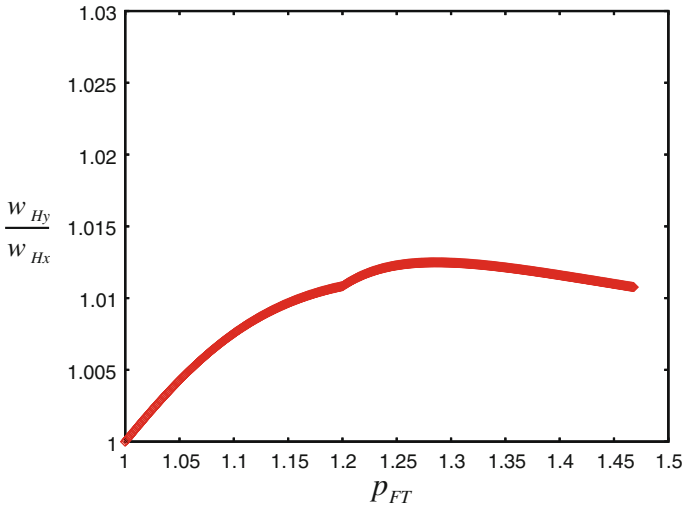

Fig. 1 Skilled wage ratio for different levels of the free trade price

we are unable to provide a closed form solution and we have to compute numerically the model.[10]

4.1.1 The effect of different levels of free trade price

Here we study the effect of different levels of the free trade relative price on the four outcomes of interest. First, notice that, in order to address the mobility of unskilled workers, what is crucial is the level of p_{FT} relative to the mobility cost. In Figs. 1, 2, 3, 4, and 5, the mobility cost is held constant and the endogenous variables are plotted for different levels of p_{FT}. To facilitate the analysis of Sect. 4.1.3, we set the level of the fixed mobility cost for unskilled workers at $f_L = 0.205$: this is the level for which, when $p_{FT} = 1.2$ (the free trade price we use in that section), none of them finds it optimal to move.

When the Home country opens to free trade skilled workers react to the wage differential between sectors and reallocate toward sector y. At the same time, international mobile capital accrues to sector y. The overall effect is an increase of the skilled wage in both sectors. However, because of reallocation costs, $\frac{w_{Hy}}{w_{Hx}}$ slightly increases—see Fig. 1.

Given the level of the fixed cost f_L, unskilled workers reallocate if $p_{FT} > 1.2$—the level of the free trade price for which (6) is positive. For $p_{FT} = 1.469$ reallocation is complete and the economy is at the corner solution where only sector y produces. The effect on within group inequality for unskilled workers is shown in Fig. 2. It is worth

[10] The model has been solved using *FORTRAN77*. The program code are available upon request. We have extensively checked the qualitative robustness of the results to all the admissible ranges of the parameters of the model and we only discuss this issue when results are sensitive to the parameter specification. All figures are plotted using the following values for the parameters: $b = 0.4$, $\bar{r} = 0.1$, $\alpha = 0.5$, $\xi = 0.05$, $\theta = 1.1$, $\gamma = 0.5$, $\overline{L} = 2$ and $\overline{H} = 1$.

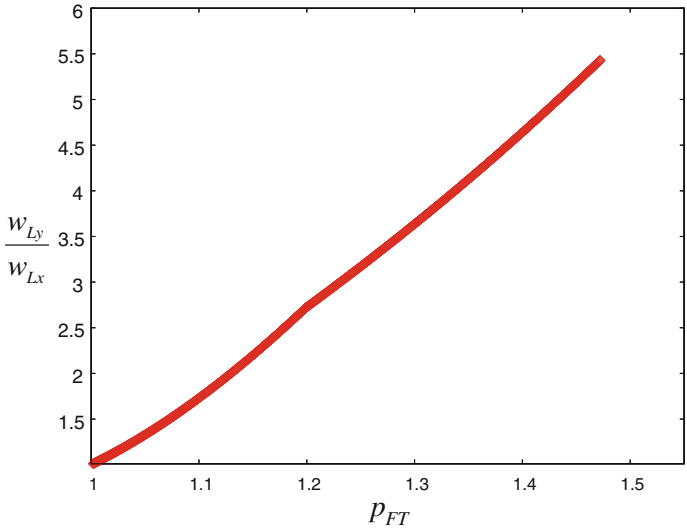

Fig. 2 Within group inequality for different levels of the free trade price

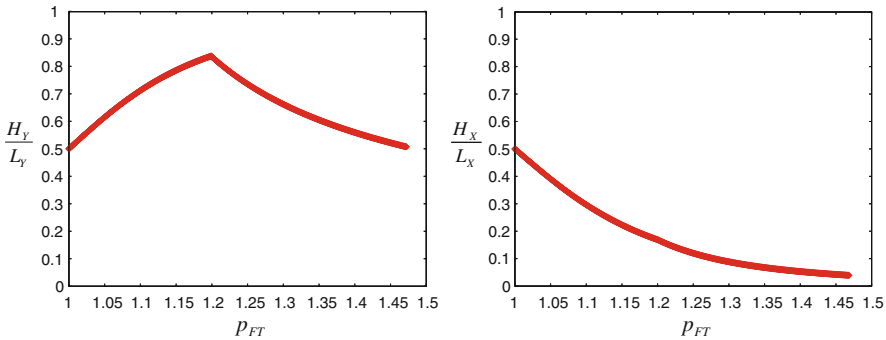

Fig. 3 Skill intensity in sector y $(left)$ and sector x $(right)$ for different levels of the free trade price

noting that within group inequality is strictly increasing in p_{FT}. For $p_{FT} < 1.2$, this is a general result, due to the complementarity between the two types of labour and to the fact that unskilled workers do not move. For $p_{FT} > 1.2$ the relative mobility of skilled and unskilled workers matters. In particular, in our numerical example, at $p_{FT} = 1.2$ most skilled workers have already moved to sector y; for higher levels of p_{FT} the skill intensity l_q is smaller (Fig. 3) and unskilled wages is lower[11] (Fig. 4) in both sectors.

As aggregate across-group inequality is concerned, Fig. 5 shows that the relationship is non monotonic. Let consider first the two limit cases. When $p_{FT} = 1$, the economy is perfectly symmetric, the sectoral skill intensities (see Fig. 3) and the sectoral skill-premia are identical. Consider instead the level of p_{FT} such that the

[11] Wages of unskilled workers increases in sector y if the congestion cost for skilled workers is high enough.

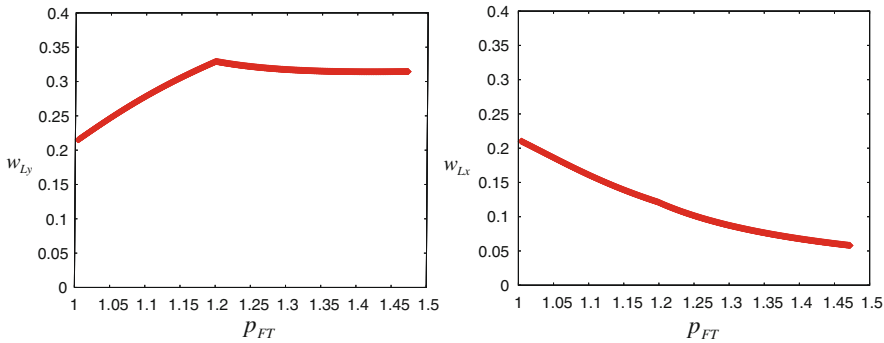

Fig. 4 Unskilled wage in sector y (*left*) and sector x (*right*)

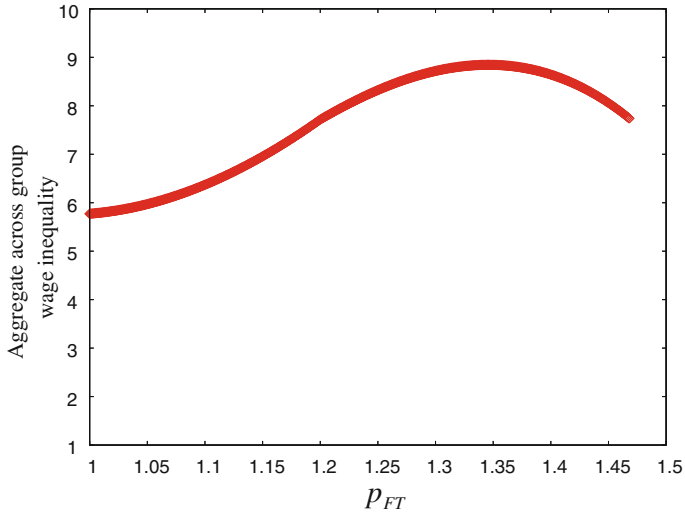

Fig. 5 Aggregate average across group wage inequality

economy is completely specialized: the skill intensity in sector y is the same as in the no-trade regime, but, as Fig. 5 highlights, across-group wage inequality is now higher. This is due to capital-skill complementarity: namely, a higher p_{FT} attracts more capital in the economy, rising the skill premium; when the economy specializes in production of Y, this unambiguously rises across-group inequality in that sector. The behavior of aggregate across-group wage inequality in between these two extreme points is more tricky to be analysed. Let we first focus on sector x. In Fig. 3, skill intensity in the sector x decreases, unambiguously increasing the wage premium in the sector. In sector y two forces are at work: the (non monotonic) behaviour of the skill intensity in the sector, which should first reduce and then increase the skill premium; the arrival of new capital, which, by capital-skill complementarity, rises the wage premium. The average wage premium captures both the behaviour of (the level of) wage inequality in x and y and changes in the relative weights of

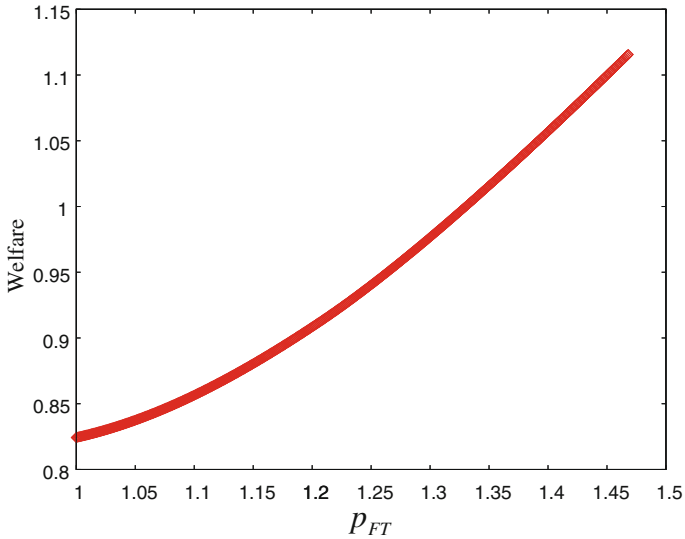

Fig. 6 Aggregate welfare for different levels of the free trade price

the two sectors. In particular, for p_{FT} that assumes values between 1 and 1.2, the dramatic increase in wage inequality in x more than compensate the reduction of wage inequality in y. For higher values of p_{FT}, inequality increases in sector y too. However, factor reallocation progressively lowers the weight of sector x in determining aggregate wage inequality. The latter reaches a maximum at $p_{FT} = 1.346$ and is lower for higher values of the free trade price. Remarkably, average across-group wage inequality is always higher in free trade with respect to the no-trade regime. Finally, aggregate welfare increases with p_{FT} (Fig. 6). Indeed an higher p_{FT} implies that more (international) capital enters sector y and a higher reallocation of labour.

Summing up, the analysis of this section shows that the trade liberalisation causes an increase in aggregate welfare, but also an increase in across, within group and aggregate (average) wage inequality. We next study the effect of the reallocation cost on these variables.

4.1.2 The effect of fixed cost

In order to better understand the role of the training program, we now study the equilibrium of the model when, for given p_{FT}, the level of the fixed cost f_L varies.

We consider a free trade relative price $p_{FT} = 1.2$. For $f_L > 0.205$ unskilled workers do not move because the sectoral wage differential is lower than the fixed cost f_L. When $w_{Ly} - w_{Lx} > f_L$ some unskilled workers in x move toward sector y. Skilled workers and capital follow the reallocation of unskilled workers toward sector y. Figure 7 shows the effect of f_L on the within group inequality. The graph stops when all workers are reallocated in sector y. As Fig. 7 illustrates, the lower f_L, the lower the equilibrium within group inequality. It is worth stressing that this result is due to the complementarity between skilled and unskilled workers. The second important result

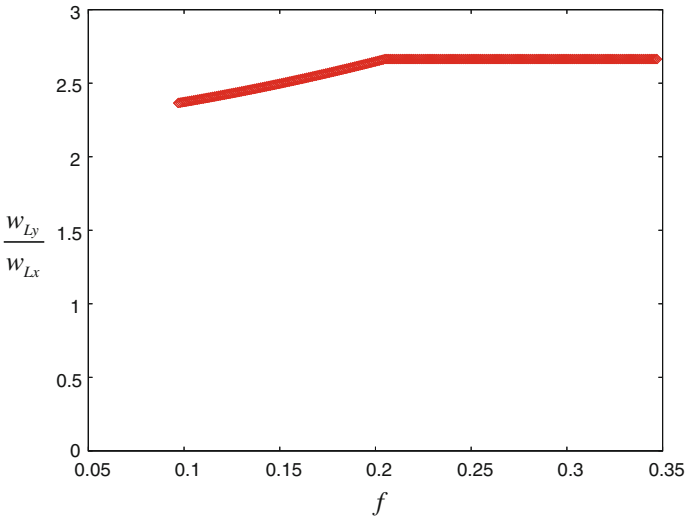

Fig. 7 Within group inequality for different levels of the fixed cost

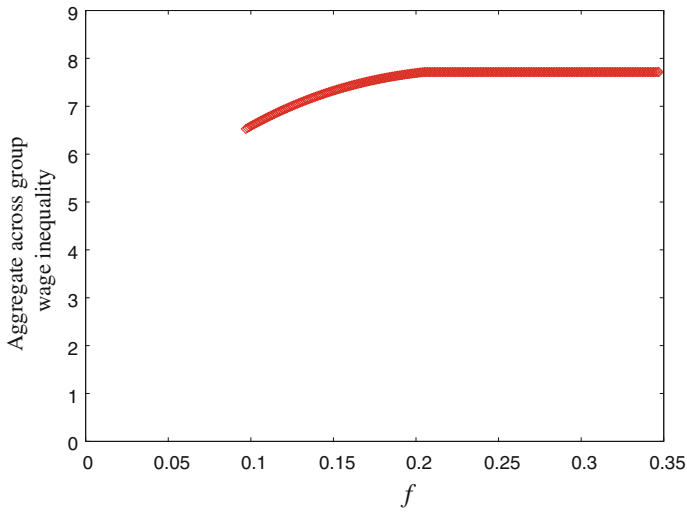

Fig. 8 Aggregate average across group wage inequality and fixed cost

is that a lower fixed cost f_L implies a lower aggregate wage inequality (Fig. 8). The intuition behind this result is that, for given p_{FT}, with lower f_L unskilled workers can move from a highly unequal sector to a less unequal sector. Notice that sectoral inequality is driven, among other factors, by the skill intensities (see Fig. 9), whose behaviour depends, as we have already stressed, by the particular value of mobility cost. Notice also that, specularly to the case analysed in the previous section, the emergence of lower aggregate wage inequality when fixed cost are lower is accompanied by a higher wage premium in both sectors. This result highlights how mobility costs for unskilled

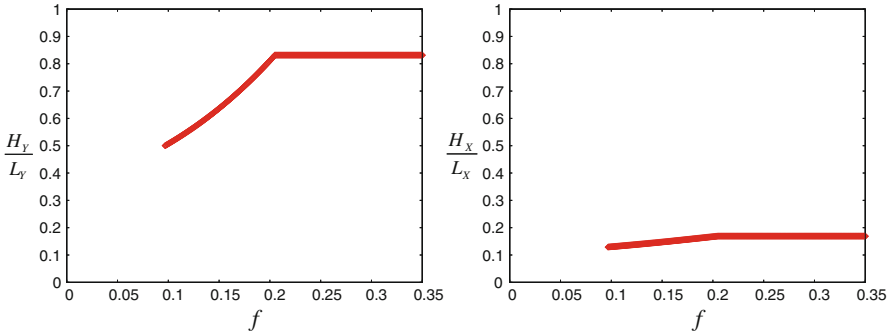

Fig. 9 Skill intensity in sector y (*left*) and sector x (*right*) for different levels of the fixed cost

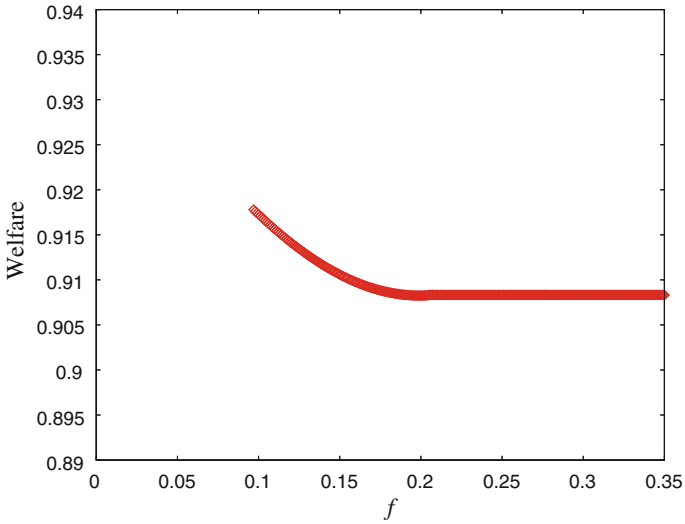

Fig. 10 Aggregate welfare for different levels of the fixed cost

workers represent a further factor fostering the increase in wage premium induced by the presence of capital-skill complementarity during the reallocation process.[12]

The third important result is that when f_L is lower, aggregate welfare is higher (see Fig. 10). The reason is, trivially, that the moving cost does not enter the individuals' utility function and it limits the profitability of the reallocation of the production factors. This implies that the lower these costs are, the more a country can exploit its comparative advantages for any given level of the free trade price.

[12] Moreover it is possible to show that the degree of capital-skill complementarity (captured by the parameter α) affects not only the level of across-group inequality, but also the degree of within group-inequality.

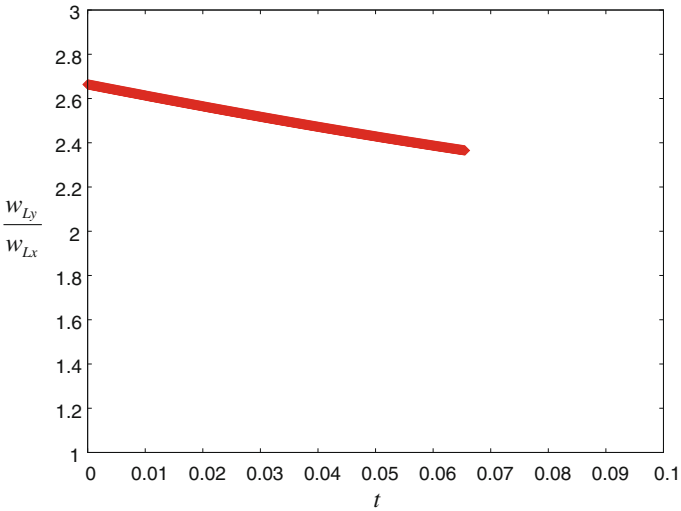

Fig. 11 Within group inequality for different levels of the tax rate

4.1.3 Taxation and the retraining program

The previous sections highlights that: i) trade integration increases welfare; ii) it also increases both across and within group wage inequality; iii) a lower unskilled workers' mobility cost reduces both across and within group wage inequality. Here we explore the possibility of using (part of) the welfare gain i) in order to reduce inequality ii), by using a re-training program, as described in Sect. 3.4, to lower unskilled workers mobility cost.[13] As before, we fix $p_{FT} = 1.2$ and consider a situation in which, with no training program, unskilled workers would not move ($f_L = 0.205$). It follows that, for $t = 0$, unskilled workers are equally allocated in the two sectors (i.e. $\widetilde{L}_x = \widetilde{L}_y = 1$).

Results show that an increase in t, by lowering the reallocation cost of unskilled workers through (14) and (16), reduces both within and across group wage inequality (see Figs. 11 and 12). At the same time, aggregate welfare decreases as t increases (see Fig. 13). The reason is that an increase in t reduces skilled workers' disposable income and consumption and tax revenues are used to finance the re-training expenditures. The related reduction in aggregate consumption more than compensates the positive effect of factor reallocation on efficiency. We are in the presence of a trade-off: the re-training program reduces inequality but at the same time decreases aggregate welfare.

Is it possible to exploit the welfare gain induced by trade integration in order to make all agents better off (with respect to the no-trade regime)? In order to answer

[13] There exists a vast literature on Pareto gains from trade, which looks at the possibility compensating those who lose from free trade using public redistribution in the presence of informational constraints—see Facchini and Willmann (2001) and references therein. Here we abstract from asymmetric information. This simplification is partly justified by the fact that the policy instrument we study (a training program provided to each worker in the comparatively dis-advantaged sector) excludes money transfers and is targeted on individual's observable characteristics.

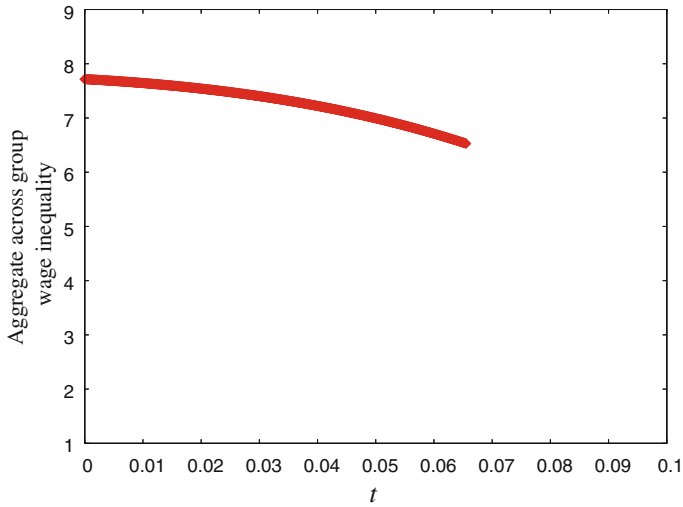

Fig. 12 Average across group wage inequality for different levels of the tax rate

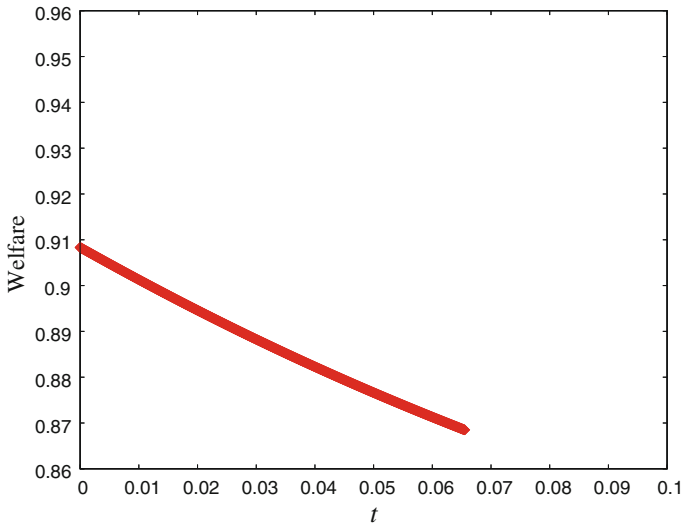

Fig. 13 Welfare effect of taxation: aggregate welfare for different levels of the tax rate

this question, Table 1 compares the no-trade equilibrium with the free trade one. The first two columns show that, when $t = 0$, trade integration has a positive effect on aggregate welfare, but it hurts unskilled workers in sector x. For $t = 6.6\%$ all workers reallocate to sector y and the economy is fully specialised. However, unskilled movers would have been better off in the no-trade regime. If, however, we further increase t, unskilled workers' indirect utility can be increased, by reducing their fixed mobility cost. In particular, given our parametrization, a level of taxation higher than $t = 14.1\%$ allows to obtain an equilibrium which is Pareto superior to the no-trade

Table 1 Pareto gains from trade

	No-trade	Free trade $t = 0$	Free trade $t = 0.66$ *(full reallocation)*	Free trade $t = 0.141$	Free trade $t = 0.155$
Aggregate welfare	0.824	0.908	0.868	0.868	0.868
Utility skilled in y	0.612	0.706	0.708	0.650	0.640
Utility skilled in x/movers	0.612	0.698	0.697	0.640	0.630
Utility unskilled in y	0.106	0.150	0.116	0.116	0.116
Utility unskilled in x/movers	0.106	0.056	0.049	0.106	0.116

one. In sum, even when the public re-training program entails some welfare losses, it can make trade integration Pareto improving. Notice that, from the point in which the economy is completely specialized, changes in t have no effect on the aggregate welfare, because now the retraining program acts simply as an (indirect) redistributive mechanism. Notice, finally, that the condition $E \leq f_L$ is always satisfied. The last column of Table 1 ($t = 0.155$) consider the case where e fully covers the unskilled workers' mobility cost.

As a final remark, notice that the interaction between labour mobility and wage inequality explored in this paper is at work also in closed economies. This observation seems to suggest the opportunity of a re-training mechanism in closed economy too. However, in the no-trade regime the optimality of such a program is jeopardized by two considerations. First, prices are now endogenously determined by (13). It follows that a positive productivity shock to, for instance, sector y, by increasing the relative supply of y, reduces the relative price p_y/p_x. The magnitude of the price effect crucially depends on the elasticity of substitution in the utility function—which plays no role in the case of free trade. In other words, the scope for labour reallocation is lower in closed economy. Second, as we have already noticed, $t > 0$ entails some welfare losses. In the absence of a welfare gain induced by trade integration, the trade-off equity/efficiency becomes more stringent and no Pareto superior policy is available.

5 Conclusions

The discussion over welfare and distributional effects of trade integration is by now a long standing one. In this paper we suggest a new channel through which trade integration can affect these variables, which relies on workers' heterogeneity. In particular, we allow the mobility cost to differ between skill categories, and we adopt a production technology which exhibits capital-skill complementarity. We also study the role of a costly re-training program, intended at reducing individuals' intersectoral mobility costs, in shaping the effects of trade integration

Two are the main contributions of our study. First, the model proposed here is able to account for the effect of trade integration on both across and within skill categories wage inequality when workers are (imperfectly) inter-sectorally mobile. This is, to the best of our knowledge, new to the literature. Second, we show that even under the

conservative assumption of a re-training program entailing some welfare losses, its implementation can make trade integration Pareto improving.

Several recent contributions have stressed the role of employment protection legislation (EPL) and other institutional settings in preventing labour mobility and thus the full exploitation of the possible gains from trade. If EPL are believed to be the only/main source of low mobility, labour reallocation could be reached by reducing job security regulations, at no cost. One of the main points of our paper is that, in fact, mobility costs due to the imperfect adaptability of the skills constitute a further important source of friction in the labour market, other than the EPL. This observation is crucial in order to evaluate the instruments available to the policy maker to enhance labour reallocation. In particular, if the adaptability of workers to new tasks is a major concern, changes in EPL would not have the expected effect; at the same time, policies aimed at increasing mobility become costly and their optimality cannot be given for granted. This model shows that a training program can, under certain conditions, reduce inequality, foster efficiency and compensate the losers from free trade.

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