Thema

UMR 8184

THéorie Économique, Modélisation et Applications

Thema Working Paper n°2014-11
Université de Cergy Pontoise, France

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CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

May, 2014

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Key-words: Stolper-Samuelson Theorem, wage bargaining, unionization
Area: International Trade
JEL: F16, J31, J51

Abstract

We build a theoretical model that incorporates unionization in the labor market into a Heckscher-Ohlin-Samuelson (HOS) framework to investigate the impact of unionization on the Stolper-Samuelson Theorem. To capture the American economy case, we assume that unskilled labor in the manufactured goods sector is unionized, and that sector is intensive in skilled labor, and that trade liberalization increases the relative price of manufactured goods. In the HOS model, trade liberalization induces a reallocation of production towards the sector that uses intensively the country's most abundant factor. The resulting change in relative labor demand impacts wage bargaining in the unionized sector, which, in turn, has a dampening effect on the Stolper-Samuelson effect. Moreover, wages of unionized workers are even less responsive to trade liberalization. Through traditional mandated-wages regressions, we show that skilled-wage differentials changes were less pronounced among more unionized sectors in the U.S. economy for the 1979-1990 period.

1 Introduction

Since the late 1970's, the United States has experienced a sharp increase in wage inequality, with a significant increase of the wages of skilled workers with respect to the unskilled. Most of this rise in skill premium has been credited to skill biased technological changes (SBTC) - see, for instance, Acemoglu (2002). A strand of the literature investigated the expressive growth of trade flows with less developed economies as an alternative explanation for this rise in wage inequality, but found only minor effects (Leamer, 1996; Krueger 1997; Baldwin & Cain, 1997; Slaughter, 2000; Feenstra & Hanson,1997; and Haskel & Slaugther, 2000). More recently, however, there have been growing evidence that, since the early 2000's, the contribution of trade to the rise in wage inequality in the U.S. is large and is getting larger over time (Krugman, 2008; Haskel et al., 2012).

We argue that the the decrease in unionization rates in the U.S. that occurred during that period is one possible explaination for the increase in the importance of trade to wage inequality. In fact, private sector union membership in the U.S. declined from 34 to 8% for men and from 16 to 6% for women between 1973 and 2007 (see Western and Rosenfeld, 2011). Acemoglu et al. (2001) investigate how the fall on unionization rates affects the channel of SBTC on wage inequality. However, the literature on how deunionization affects the trade - wage inequality mechanism is still scarse.

This paper investigates the impact of unionization on the relation between trade liberalization and skill premium. We proceed in two steps. First, in a theoretical framework, we incorporate unions and wage bargaining in a standard Heckscher-Ohlin-Samuelson (HOS) model to study how the presence of unions changes the model predictions. Then, through traditional mandated-wages regressions, we empirically investigate the role of unionization on the impact of trade in the U.S. We show that changes in skilled-wage differentials induced by price changes are positive and large only in less unionized sectors in the U.S. economy for the 1979-1990 period. For unionized sectors, those with unionization rates above the mean, skilled-wage differentials associated with price changes are actually slightly negative. Hence, the empirical findings are in line with the model's predictions.

Our empirical exercise focuses on the period 1979-1990 since it is generally found that, in that period, trade only had very small effects on skilled-wage differentials, if any. Moreover, that is also the period when unionization was larger in the U.S. One of the difficulties of examining how changes in unionization affect the implications of the HOS model using a longer period is that the fall in unionization is probably endogenous which makes it hard to disentangle competing explanations for the rise in wage inequality.

The impact of trade openness on wage inequality is traditionally explained by the Stolper-Samuelson Theorem. According to its two-goods-two-factors version, trade openness increases the relative wage of the relatively abundant production factor, which is used intensively in the production of the export good. In the theoretical part of the paper, we derive a new version of the Stolper-Samuelson Theorem relaxing the hypotheses of perfect competition and wage flexibility. We assume that one sector of the economy faces imperfect competition in the goods' market. We also assume that in this sector wages of unskilled workers are set through collective bargaining, as in the right-to-manage model (Nickell and Andrews, 1983). The model predicts that the impact of trade openness on wage differentials is dampened when there is unionization in at least one of the sectors. Moreover, this dampening effect is even larger in the unionized sector itself.

There are a few papers that consider the effect of unionism in open economies, such as Johnson and Stafford, 1999 (see Helpman et al., 2011, for a review of recent papers on how labor market frictions affect trade impacts on wages). However, their motivation is different from ours, since they are concerned with the impact of exogenous changes in the bargaining power of workers on wages, comparing open and closed economies. More specifically, they assume that wages of unionized workers are equal to the one prevalent in the rest of the economy times an exogenous parameter greater than one. They study the impact of changes in this parameter on relative wages. Conversely, this paper explicitly models the bargaining process between workers and firms, that is, the wage wedge caused by bargaining is made endogenous. We are, then, able to derive the impact of openness on the wage negotiated through collective bargaining, and, consequently, on wage differentials.

In the empirical part of the paper, we estimate mandated-wages regressions for sectors with 1986 unionization rates below and above the mean. We show that skilled-unskilled wage differentials induced by price changes are positive and significant only when we use sectors below the unionization rate mean. That is, we find that the Stolper-Samuelson Theorem is valid only for sectors with a low degree of unionization. For unionized sectors, those with unionization rates above the mean, skilled wage differentials induced by price changes are actually negative. This effect is even larger when a dummy for the computer industry is used. Our results confirm the existence of the dampening effect of unionization on wage differential changes induced by trade. These results are in line with recent evidence in Autor et al. (2013) that show that rising import competition from China caused significant employment reductions particularly in the manufacturing sector.

The article is organized as follows. In the next section, we develop a general equilibrium trade model with wage bargaining. Section 3 presents the results of mandated-wages regressions for sectors of the U.S. economy below and above the unionization rate mean. Section 4 concludes.

2 The model

This section builds a general equilibrium model which considers the impact of wage bargaining in the relationship between trade openness and wage inequality. More specifically, we incorporate the right-to-manage model of wage bargaining into the Heckscher-Ohlin-Samuelson (HOS) framework. There are two important features of the right-to-manage model that are attractive to our assessment of this problem. First, the model allows us to work with decentralized negotiations. Second, wages are the result of the bargaining process between firms and unions, while firms still determine the level of employment. The result is compatible with the observed paths of employment and wages in the US economy, with employment being much more volatile than wages (see, for example, McDonald and Solow, 1986).

There are three fundamental conflicting hypotheses in the HOS and the right-to-manage models which should be made compatible. First, the existence of unions in the right-to-manage model generates distinct wages among workers of similar qualification in different industries, whereas in the HOS model wages are equal across sectors. Second, the HOS model allows for different production factors' intensities in each industry, while the right-to-manage usually only models the production technology for the unionized sector. The modelling of sectors with different technologies is extremely important in the HOS model, since they are key (along with the relative abundance of factors) for the existence of international trade among countries. Finally, models of wage bargaining consider imperfections in the markets for goods, while the HOS model assumes perfect competition. Note that imperfections in the goods market are essential to the bargaining process since it requires the existence of positive rents to be shared between firms and unionized workers.

The model developed in this section considers that wages of unionized workers are distinct across sectors, as in the models of wage bargaining, and that technologies are different across sectors, as in the HOS. The model also incorporates imperfections in the markets for goods, by assuming the existence of transportation costs in the economy, with firms competing in prices. This modelling strategy allows us to maintain the assumption of constant returns to scale in production, which is necessary to derive the equilibrium in a HOS setup (see, for example, Krugman, 1980 and Helpman and Krugman, 1985).

2.1 Model Setup

Consider a small open economy that produces two types of goods: manufactured goods (M) and food (F). Their production technology presents constant return to scale, using two factors of production, skilled labor (S) and unskilled labor (U), which are perfectly mobile across sectors and in fixed supply. More specifically, we assume Cobb-Douglas production functions, defined as:

$$Q_k^M = A\left(U_k^M\right)^{\alpha}\left(S_k^M\right)^{1-\alpha} \text{ and} \tag{1}$$

$$Q_l^F = B\left(U_l^F\right)^{\beta}\left(S_l^F\right)^{1-\beta}\ , \tag{2}$$

where parameters $\alpha \in (0,1)$ and $\beta \in (0,1)$, Q_i^J is the amount of good J, $J = M, F$, produced by each firm i. U_i^J and S_i^J are the amount of unskilled and skilled labor, respectively, used in firm i of sector J. We assume that production of manufactured goods uses skilled labor intensively, whereas food production is intensive in unskilled labor, which implies $\beta > \alpha$.

All firms in the food sector produce a homogenous good, and they are under perfect competition. Manufactured goods, on their turn, are subject to transport costs. More specifically, we assume that the economy is divided into K regions, or neighborhoods. There are transportation costs between these regions of the iceberg type, that is, only a fraction $t,\ t \in (0,1)$ of the product reaches the final destination. There is only one firm producing manufactured goods in each region and they compete in prices, as in the Hotteling model.[1]

We assume that all unskilled workers in the manufactured goods sector are unionized. In the bargaining process, the union and the firms jointly determine wages. Once wages are determined, the firm chooses the employment level. After describing the wage bargaining process, we present the profit maximizing choices of the firm. Finally, the equilibrium of the economy is characterized.

2.2 Wage bargaining

Each firm k of sector M has to negotiate wages with unskilled workers. Under the right-to-manage model, wage is determined jointly by the firm and unionized workers, while employment is unilaterally set by the firm. During wage negotiations, workers take into account the expected labor demand by the firm and the probability of layoffs. The alternative income in the case of dismissal depends on the probability of being employed by another firm in the same sector, or by a firm in the food sector, where wages are competitively. It is important to note that workers' options after layoffs are different than those usually found in the bargaining models literature, since here, there is an alternative sector which always employ all the excess labor supply.

The wage bargaining problem between unskilled unionized workers and firm k is given by

$$\max_{w_k^M} \ \Omega = \left(W_k^M - \overline{W}_k^M\right)^{\delta} \left(\Pi_k^M - \overline{\Pi}_k^M\right) \tag{3}$$

$$\text{s.t} \ \ W_k^M - \overline{W}_k^M \geq 0$$

$$\Pi_k^M - \overline{\Pi}_k^M \geq 0$$

where W_k^M represents the utility of a representative unionized worker in firm k of sector M, Π_k^M is the firm's profit, $\overline{W}_k^M$ and $\overline{\Pi}_k^M$ are the fall-back utilities in case they are not able to reach an agreement. δ is the union's bargaining power, assumed to be the same for all firms in the sector, and w_k^M is the wage of the unskilled worker in firm k.

[1] It is important that there is only one firm in each region, otherwise price competition among them would be given by the Bertrand model where, in equilibrium, each firm's profit is zero.

Labor union

The union in each firm maximizes expected utility of its representative member, which is given by

$$W_k^M = \lambda_k^M w_k^M + \left(1 - \lambda_k^M\right) A^M, \tag{4}$$

where A^M is the alternative expected income and λ_k^M is the probability of an unskilled unionized worker to keep his (or her) job in firm k, sector M. This probability equals $\lambda_k^M = \frac{U_k^M}{\overline{U}}$, where U_k^M is the employment level in the firm and $\overline{U}$ is the endowment of unskilled labor in the economy.

To simplify the algebra, we assume that the fall-back utility $\overline{W}_k^M$ is equal to alternative income A^M. In this model, there is no unemployment since the worker that loses his (or her) job in the manufactured goods firm is automatically employed by the food sector. Therefore, we do not consider income maintenance mechanims provided by the union in case the bargain does not succeed, such as a strike fund. Using equation (4) and the assumption $\overline{W}_k^M = A^M$, the first term of equation (3) becomes

$$W_k^M - \overline{W}_k^M = \lambda_k^M \left(w_k^M - A^M\right). \tag{5}$$

Firm

The firm hires skilled workers before the bargaining process with the union, based on its anticipation of the bargaining results. Hence, the firms' profit function considered at the moment of the bargain is given by:

$$\Pi_k^M = p_k^M Q_k^M - w_k^M U_k^M - s\overline{S}_k^M, \tag{6}$$

where p_k^M is the price of the good sold by firm k, s is the skilled worker wage and $\overline{S}_k^M$ is the number of skilled workers already hired by the firm.

Taking $\overline{S}_k^M$ as given, and using the production function defined in equation (1), the profit-maximizing choice of unskilled labor is given by:

$$U_k^M = \overline{S}_k^M \left(\frac{\alpha A p_k^M}{w_k^M}\right)^{\frac{1}{1-\alpha}}. \tag{7}$$

Substituting the production function (1) and the employment equation (7) into the profit equation (6), we get:

$$\Pi_k^M = \overline{\alpha}\overline{S}_k^M \left(\frac{A p_k^M}{\left(w_k^M\right)^{\alpha}}\right)^{\frac{1}{1-\alpha}} - s\overline{S}_k^M, \tag{8}$$

where $\overline{\alpha} \equiv \alpha^{\frac{\alpha}{1-\alpha}} - \alpha^{\frac{1}{1-\alpha}}$.

The fallback utility of the firm is equal to the loss incurred in having previously hired skilled workers, that is:

$$\overline{\Pi}_k^M = -s\overline{S}_k^M. \tag{9}$$

Equations (8) and (9) yield:

$$\Pi_k^M - \overline{\Pi}_k^M = \overline{\alpha}\overline{S}_k^M \left(\frac{Ap_k^M}{\left(w_k^M\right)^{\alpha}} \right)^{\frac{1}{1-\alpha}}. \tag{10}$$

Bargaining result

Substituting equations (5) and (10) into equation (3), we get the function to be maximized at the moment of the bargain:

$$\max_{w_k^M} \ \Omega = \left[\lambda_k^M \left(w_k^M - A^M\right)\right]^{\delta} \overline{\alpha}\overline{S}_k^M \left(\frac{Ap_k^M}{\left(w_k^M\right)^{\alpha}} \right)^{\frac{1}{1-\alpha}}, \tag{11}$$

where, using equation (7), we have that $\lambda_k^M = \frac{U_k^M}{\overline{U}} = \frac{\overline{S}_k^M}{\overline{U}} \left(\frac{\alpha A p_k^M}{w_k^M} \right)^{\frac{1}{1-\alpha}}$.

The unskilled worker's wage that maximizes equation (11) is equal to

$$w_k^M = \overline{\phi} A^M, \tag{12}$$

where $\overline{\phi} \equiv \frac{\alpha}{\alpha - \delta(1-\alpha)}$. Note that $\overline{\phi} > 1$, that is, the salary of the unskilled worker in sector M is greater than the alternative income A^M. According to equation (12), the wages of unskilled workers is the same in all firms of sector M, that is, $w^M \equiv w_k^M \ \ \forall k$. Also, in the symmetric equilibrium, all firms hire the same number of workers. We then drop the firm subscript henceforth.

Finally, let us derive the alternative income A^M, following a similar procedure used in Layard et al. (1991). The rate of return for each sector is given by:

$$rV^M = w^M + \lambda^F \left(V^F - V^M\right), \text{ and} \tag{13}$$

$$rV^F = w^F + \lambda^M \left(V^M - V^F\right), \tag{14}$$

where $\lambda^J \equiv \frac{U^J}{\overline{U}}$ is the probability of working in sector J for next period, for $J = M, F$. Note that, since we assume full employment, $\lambda^M + \lambda^F = 1$.

Solving the system of equations (13) and (14), we get that:

$$A^M = rV^F = \left(1 - \frac{\lambda^M}{1+r}\right) w^F + \frac{\lambda^M}{1+r} w^M. \tag{15}$$

Substituting equation (15) into equation (12), we finally get the relation between wages in the two sectors:

$$w^M = \phi w^F, \tag{16}$$

wher $\phi \equiv \frac{\overline{\phi}\left(1+r-\lambda^M\right)}{1+r-\overline{\phi}\lambda^M}$. It is straightforward to see that $\phi > 1$, so that, as a result of the wage bargaining, the wage in the manufactured goods sector is higher than the wage in the food industry.

2.3 Profit maximization

Factor demand

A firm's profit is given by:

$$\Pi^J = p_i^J Q_i^J - w^J U_i^J - sS_i^J, \tag{17}$$

where p_i^J is the price of the good sold by firm i in sector J, $J = M, F$, w^J is the wage of an unskilled worker and s that of a skilled worker. Notice that, due to unionization in the manufactured goods sector, wages of unskilled workers may differ across sectors, while skilled workers receive the same wage wherever he or she works.

Food sector Given the production function in equation (1), the optimal factor choice in the food sector is given by:

$$\frac{U^F}{S^F} = \left(\frac{\beta}{1-\beta}\right)\left(\frac{s}{w^F}\right). \tag{18}$$

We ommit the firm subscript, since all firms hire the same number of workers and pay the same wages in the competitive market of the food sector.

Manufactured goods sector For the manufactured goods sector, we use the production function in equation (1) to get the optimal factor choice. It satisfies the following equation:

$$\frac{U^M}{S^M} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{s}{w^M}\right), \tag{19}$$

where w^M is the result from the bargaining process that described in the previous section, defined in equation (16). Here, we also ommit the firm subscript since in the symmetric equilibrium all firms hire the same number of workers.

Pricing

In this small open economy, goods prices are exogenously determined in the international markets. Domestic prices are equation to international prices plus import tariffs and/or export subsidies. Profit maximization conditions relate the exogenous goods prices to factor prices, as follows.

Food sector The food sector is a perfectly competitive market. Therefore, its price p^F is equal to the marginal cost of production, as in:

$$p^F = \frac{1}{B}\left(\frac{w^F}{\beta}\right)^{\beta}\left(\frac{s}{1-\beta}\right)^{1-\beta}. \tag{20}$$

Manufactured goods sector Each firm k of sector M decides the price of goods that maximizes profit, taking into consideration possible actions to be taken by other firms. The price determination of each firm results from a simultaneous non cooperative game played by K identical firms with symmetric information. The following proposition summarizes the solution of this problem.

Proposition 1 *There exists a Nash Equilibrium in which firms equalize their prices to their average costs divided by the share of products that reaches their destination, t:*

$$p^M = p_k^M = t^{-1} c^M \left(w^M, s\right) = t^{-1} \frac{1}{A} \left(\frac{w^M}{\alpha}\right)^{\alpha} \left(\frac{s}{1-\alpha}\right)^{1-\alpha}, \tag{21}$$

where $c^M \left(w^M, s\right) \equiv \frac{1}{A} \left(\frac{w^M}{\alpha}\right)^{\alpha} \left(\frac{s}{1-\alpha}\right)^{1-\alpha}$ represents the average cost, which is identical across firms.

Proof. Since strategies with $p_k^M < c^M \left(w^M, s\right)$ lead to negative profits, they are strictly dominated by strategies $p_k^M \geq c^M \left(w^M, s\right)$. Hence, the firm chooses a price p_k^M in the interval $\left[c^M \left(w^M, s\right), \infty\right)$. Now, suppose that firm k chooses a price $p_k^M > t^{-1} c^M \left(w^M, s\right)$. Each opponent k^* can obtain a non-negative profit with price $p_{k^*}^M$, such that $p_k^M > p_{k^*}^M \geq t^{-1} c^M \left(w^M, s\right)$. Moreover, they would attract all consumers of firm k, which, in its turn, would have zero profits. Therefore, the firm will chose a price $p_k^M \leq t^{-1} c^M \left(w^M, s\right)$. On the other hand, if $p_k^M < t^{-1} c^M \left(w^M, s\right)$, the firm would face a smaller profit with the same demand compared to the case with $p_k^M = t^{-1} c^M \left(w^M, s\right)$, given that the price does not compensate transportation costs to attract consumers that live in other neighborhoods. Therefore, $p_k^M = t^{-1} c^M \left(w^M, s\right)$ is the optimal strategy for each firm k. ■

The price in equation (21) generates profits equal to $(1-t)\, p^M Q_k^M$ for each firm k.

2.4 Equilibrium

The equilibrium of this economy is represented by seven equations. We have the wage bargaining equation (16), that relates the wage of unskilled workers in the two sectors, the otimal factor choices in equations (18) and (19), and the price equations (20) and (21). Finally, the full employment condition for both factors of production completes the model. Demand equals supply of factors when:

$$U^M + U^F = \overline{U}, \text{ and} \tag{22}$$

$$S^M + S^F = \overline{S}. \tag{23}$$

With these seven equations, it is possible to determine the equilibrium value for the seven endogenous variables, three wages and the four categories of employment: w^M, w^F, s, U^M, U^F, S^M and S^F.

Figure 1: Equilibrium

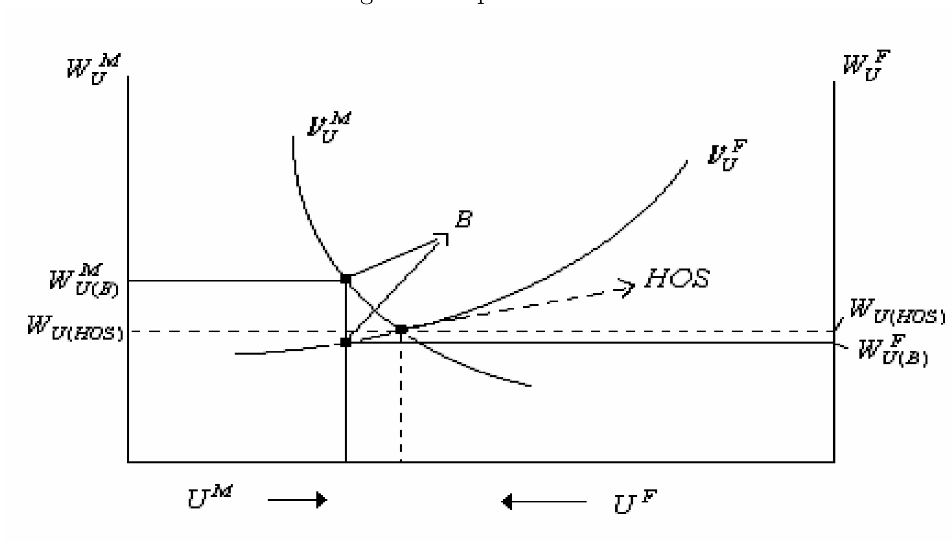

Figure 1 ilustrates the equilibrium wages and employment of unskilled workers and how they compare to the usual HOS equilibrium values. The horizontal axis represents unskilled workers employment, with the distance between the two vertical axis corresponding to the total endowment of unskilled labor, which is taken as fixed in the model. The vertical axis on the left hand side represents wages in manufacture while wages in the food sector is represented on the axis to the right. The two downward schedules V_U^M and V_U^F represent the value of marginal productivity of labor in the manufactured goods and food sectors, respectively. In the HOS model, with competitive wages in both sectors, employment allocation between sectors will be such that the marginal poductivity of labor is the same in the two sectors, hence with equal wages. the equilibrium in given by the HOS point in the figure.

In our model with unionized workers in the manufactured goods sector, the wage in that sector $w^M_{U(B)}$ is determined by a bargaining process as described in section 2.2, and employment level in the sector will be set accordingly. Wage in the food sector will adjust so as to absob all remaining unskilled workers. As we can see in the figure, $w^M_{U(B)} > w_{HOS} > w^F_{U(B)}$, that is, unionized workers in the manufactured goods sector have higher wages compared to wages under the HOS model, while the contrary is true for non-unionized workers in the food sector.

2.5 The impact of trade openness

Trade openness can be represented in this model by an exogenous variation in the relative price of goods. Hence, in order to analyze the impact of trade openness, it suffices to investigate the impact of exogenous changes in goods prices. The analysis is based on the total differential of the log-linearized equilibrium equations. Define $\widehat{x} \equiv \frac{dx}{x}$.

From the factor demand equations (18) and (19), we have:

$$\widehat{U}^M - \widehat{S}^M = \widehat{s} - \widehat{w}^M, \text{ and} \tag{24}$$

$$\widehat{U}^F - \widehat{S}^F = \widehat{s} - \widehat{w}^F. \tag{25}$$

From price equations (21) and (20), it follows that:

$$\widehat{p}^M = \alpha \widehat{w}^M + (1-\alpha)\,\widehat{s}, \text{ and} \tag{26}$$

$$\widehat{p}^F = \beta \widehat{w}^F + (1-\beta)\,\widehat{s}. \tag{27}$$

The equilibrium equations in the markets for factors (22) and (23) lead to:

$$\widehat{U}^M = -\frac{U^F}{U^M}\widehat{U}^F, \text{ and} \tag{28}$$

$$\widehat{S}^M = -\frac{S^F}{S^M}\widehat{S}^F. \tag{29}$$

Finally, differentiation of the log-linear version of the unskilled workers' wage equation (16) in the manufactured goods sector results in:

$$\widehat{w}^M = \widehat{w}^F + \Phi \widehat{U}^M, \tag{30}$$

where $\Phi \equiv \frac{(\phi-1)\lambda^M}{1+r-\lambda^M}$, and we used the fact that $\widehat{\lambda}^M = \widehat{U}^M$ It is straightforward to check that $\Phi \geq 0$, that is, a higher probability of getting a job in the manufactured good sector increases wages in that sector.

Solving the system of equations (26) to (30), we get a set of equations that show how changes in prices affect factor returns. In order words, we have a new version of the Stolper-Samuelson Theorem for an economy with an unionized sector. We have that:

$$\widehat{w}^M = \left(\frac{1-\alpha}{\beta-\alpha}\right)\widehat{p}^F - \left(\frac{1-\beta}{\beta-\alpha}\right)\widehat{p}^M + \beta\Phi\left(\frac{1-\alpha}{\beta-\alpha}\right)\widehat{U}^M \tag{31}$$

$$\widehat{w}^F = \left(\frac{1-\alpha}{\beta-\alpha}\right)\widehat{p}^F - \left(\frac{1-\beta}{\beta-\alpha}\right)\widehat{p}^M + \alpha\Phi\left(\frac{1-\beta}{\beta-\alpha}\right)\widehat{U}^M \tag{32}$$

$$\widehat{s} = -\left(\frac{\alpha}{\beta-\alpha}\right)\widehat{p}^F + \left(\frac{\beta}{\beta-\alpha}\right)\widehat{p}^M - \Phi\left(\frac{\alpha\beta}{\beta-\alpha}\right)\widehat{U}^M \tag{33}$$

$$\widehat{U}^M = \frac{\overline{\mathrm{S}}/\mathrm{S^F}}{(\beta-\alpha)\left(\frac{S^M}{S^F} - \frac{U^M}{U^F}\right) + \left(\alpha + \beta\frac{S^M}{S^F}\right)\Phi}\left(\widehat{p}^M - \widehat{p}^F\right). \tag{34}$$

Notice that all terms in brackets in the system of equations (31) to (34) are positive: given the assumption that the manufactured sector in skilled labor intensive, we have that $\beta > \alpha$ and $\frac{S^M}{S^F} > \frac{U^M}{U^F}$.

Let us analyze the impact of trade openness in a developed country, such as the United States, that is relatively better endowed with skilled labor. To that end, we assume that trade openness causes an increase in the relative price of manufactured goods, which is more intensive in skilled labor. As in the Stolper-Samuelson Theorem, the first two terms of equations (31) and (32) indicate that a higher relative price of manufactured goods depresses wages of unskilled labor in both sectors, while, according to the first two terms of equation (33), it increases wages of skilled labor.

Unionization adds an extra effect related to employment changes, in the third term of equations (31) to (33). According to equation (34), a higher relative price of manufactured goods increases employment of unskilled labor in that sector, which, in turn, has a positive impact on unskilled labor wages and a negative one on wages of skilled labor. Intuitively, with higher relative price of manufactured goods, the production in this sector expands and attracts both skilled and unskilled workers, while the production in the food sector falls. The higher demand for unskilled labor in the manufactured goods sector increases the negotiated wage, dampening the direct negative impact of the price change on wages unskilled workers. Hence, unionization attenuates the impact of trade openness on wages. Moreover, this dampening effect is stronger on wages of unionized workers.

For non-unionized labor, the employment effect is always smaller than the direct effect of price changes, as shown in the appendix. It means that the employment effect does not reverse the traditional Stolper-Samuelson prediction for those workers. For unionized workers, however, the employment effect may outweight the direct price effect, so that their wages increase with higher prices of manufactured goods. This could happen if manufactures uses skilled labor very intensively compared to the food sector, and depending on parameter values. It is not possible to determine the sign of the impact of prices on wages of unionized unskilled workers without more specific and restrictive assumptions on parameter values. Nevertheless, we cannot rule out this possibility

The results obtained with this model indicate that the existence of wage bargaining reduces the impact of trade openness in the economy. This is due to the particular adjustment of wage and employment given wage negotiations in the unionized sector. In particular, wages of unionized workers respond less to price changes compared to non-unionized ones. Moreover, the impact of price changes on wages of unionized workers may be in contradition with the standard Stolper-Samuelson effect for sector that uses the non-unionized labor very intensively.

3 Empirical analysis

In this section, we use data from Leamer (1996) for the period 1979-1990 to study how the degree of unionization across sectors affects the test of the traditional Stolper-Samuelson-Theorem. The NBER database for 445 U.S. manufacturing sectors reveals significant differences between wages paid to unskilled workers (measured here by blue-collar workers): in 1979, for example, average wages in the lowest-paying sector corresponded to 22% of the average wages paid in the highest-paying sector. For white-collar workers, wage dispersion across sectors was much less pronounced: the Pearson variation coefficient of the wages series was 0.30 for unskilled workers and 0.17 for skilled workers.

One can also observe a strong positive correlation between average wages of blue-collar workers and their degree of unionization across sectors. This correlation is 0.57 when we use data from the NBER *Immigration, Trade and Labor Markets*, obtained from Abowd (1990). For skilled workers, on the other hand, we do not find a positive correlation between wages and the degree of unionization.

These results suggest that unions are important in the determination of wages of less skilled workers. In the next sub-section, we further investigate how unionization affects the test of the Stolper-Samuelson theorem through mandated-wages regressions.

3.1 Mandated-wages regressions and unionization

In order to illustrate the empirical relevance of unions for analyzing the Stolper-Samuelson Theorem, we initially estimate mandated-wages regressions using the 445-sector NBER data for the 1979-1990 period. As in Leamer (1996), we regress average log-changes in sectoral prices from 1979 to 1990 on initial (1979) expenditures shares on four factors of production (unskilled and skilled labor, capital and intermediate goods).[2]

The regressions are estimated for three groups of sectors: i) the whole sample of 445 sectors (colum 1 in Table I); ii) those sectors with degrees of unionization of unskilled workers below the mean, with and without including a dummy for the computer sector, justified by the presence of an outlier in its price change (columns 2 and 3); and iii) those sectors with degrees of unionization above the mean (column 4).

Table I presents the results. When we test the Stolper-Samuelson theorem using all sectors (column 1), we observe a very small difference in the growth rate of wages of 0.3 percentage points in favour of more skilled workers (5.8% compared to 5.5%). A test does not reject the hypothesis that the two coefficients are equal to each other. This result is not compatible with the predictions of the Stolper-Samuelson Theorem and is consistent with the general findings of the literature that trade was not relevant for explaining the observed increase in skilled-wage differentials in the 1980's.

Regressions 2 to 4, however, illustrate how different the results are when we break the sample according to the degree of unionization. For less unionized sectors, those with unionization rates below the 1986 mean, the estimated skilled wage differential growth is much higher, reaching 5.8 percentage points when we include the computer sector dummy (column 3). For the more unionized sectors

[2]Possible heteroscedasticity problems are corrected using a White-consistent heteroscedastic covariance matrix.

(column 4), on the contrary, prices seem to have slightly favoured the growth of wages of unskilled workers (6.5% compared to 6.3% of skilled workers), although one can not reject that these two coefficients are equal to each other.

In order to verify whether the econometric results we found actually correspond to the different unionization degrees across sectors, we run several robustness checks (not shown here). First, we calculate the main statistics and correlations of the variables for each sub-group of the sample. Second, we split the 445 observations into two groups, with the same number of observations in each group as above, but with observations now chosen randomly. The idea is to evaluate the mandated-wage regressions for these groups and compare them with the ones shown in Table I.

We find that the rates of changes in prices and wages - for both unskilled and skilled workers - are statistically similar among groups as well as the average intensity usage of unskilled labor (measured by the ratio of unskilled labor over total employment). This means that the two groups of observations are similar with respect to the key variables necessary to evaluate the predictions of the HOS.

The correlations of price changes with the intensity of labor have signs consistent with the Stolper-Samuelson effect in the U.S. economy, without any relevant differences across groups of observations. When price changes are correlated with the intensity of unskilled labor, correlation signs are negative. When price changes are correlated with the intensity of skilled labor, correlation signs are positive. This shows that it does not exist any selection bias in the choice of the groups of observations that would result in a different impact of trade openness on wage inequality than the one we found in Table I.

The estimation of mandated-wages regressions for several alternative subgroups of the sample reveal some important results. First, all groups of observations that do not include the computer sector (outlier) present coefficients consistent with the Stolper-Samuelson effect. Second, the econometric estimation for the other groups are in general sensitive to the inclusion of the computer sector dummy. When the dummy is included, the results are also favourable to the Theorem.

The several random sub-groups of observations illustrate the small probability of finding similar results to those described in Table I. In particular, the inconsistency of the mandated-wage estimation with the Stolper-Samuelson effect for the group of more unionized industries sectors seems to be an actual feature of this group and not an artificial result.

The results presented in this section confirm that an alternative version of the HOS model that takes into account the presence of unions, a sthe one we presented in the previous section, could be relevant for the analysis of the importance of trade in explaining the evolution of skilled wage differentials in the U.S.

4 Conclusion

This work intends to contribute to the debate about the effects of trade openness on wage differentials by skill under the predictions of the HOS model. We studied the impact of wage bargaining between firms and unions for the Stolper-Samuelson Theorem, by building a theoretical model that incorporates imperfections in labor and goods markets.

The model predicts that the impact of trade openness on wage differentials is smaller in the presence of unionization. With unions, part of the impact of price changes in absorbed by employment changes, thereby dampening the effect on wages.

The model derived here and the empirical results show that, when imperfections in the factor markets are important in the economies (or in some segments of the economies), the effects of trade openness go beyond those predicted by the HOS model. In particular, the existence of wage bargaining between firms and workers is able to explain the reduced effect of trade on wage inequality in the U.S. over the 1980's.

5 Appendix

In this appendix we show that the direct impact of price changes on wages is stronger than the indirect one through its effect on employment. Without loss of generality, we model the increase in the relative price of manufactured goods as an increase in its own price, while the price of food remains unchanged, that is: $\widehat{p}^M > 0$ and $\widehat{p}^F = 0$. In this case, the system of equation (31) to (34), with some manipulation, become:

$$\widehat{w}^M = \left(\frac{1-\beta}{\beta-\alpha}\right)\left(-\widehat{p}^M + \beta\left(\frac{1-\alpha}{1-\beta}\right)\Phi\widehat{U}^M\right) \tag{35}$$

$$\widehat{w}^F = \left(\frac{1-\beta}{\beta-\alpha}\right)\left(-\widehat{p}^M + \alpha\Phi\widehat{U}^M\right) \tag{36}$$

$$\widehat{s} = \left(\frac{\beta}{\beta-\alpha}\right)\left(\widehat{p}^M - \alpha\Phi\widehat{U}^M\right) \tag{37}$$

$$\widehat{U}^M = \frac{\overline{\mathrm{S}}/\mathrm{S}^\mathrm{M}}{(\beta-\alpha)\left(1-\frac{U^M}{U^F}\frac{S^F}{S^M}\right)+\left(\alpha\frac{S^F}{S^M}+\beta\right)\Phi}\widehat{p}^M. \tag{38}$$

Substituting equation (38) on equation (37), we have that:

$$\widehat{s} = \left[\frac{\beta\left(1-\frac{U^M}{U^F}\frac{S^F}{S^M}+\Phi\right)}{(\beta-\alpha)\left(1-\frac{U^M}{U^F}\frac{S^F}{S^M}\right)+\left(\alpha\frac{S^F}{S^M}+\beta\right)\Phi}\right]\widehat{p}^M. \tag{39}$$

Combining equations (18) and (19), we have that $\frac{U^M}{U^F}\frac{S^F}{S^M} = \frac{\alpha(1-\beta)}{\beta(1-\alpha)}\left(\frac{w^F}{w^M}\right)$. Since, by assumption, $\beta > \alpha$, and using the result in equation (16), we have that $\frac{U^M}{U^F}\frac{S^F}{S^M} < 1$, both the numerator and the denominator of equation (39) are positive. Hence, an increase in the relative price of manufacured goods increases wages of skilled labor.

It is straighforwad to see that an increase in p^M will then decrease w^F. Since the second parenthesis in equation (37) is the negative of the corresponding term in equation (39), the the impact of changes in p^M on w^F is the opposite of its impact on s.

Concerning w^M, note that the term that multiplies $\Phi\widehat{U}^M$ in equation (35) is larger than the corresponding one in equation (37), that is, $\beta\left(\frac{1-\alpha}{1-\beta}\right) > \alpha$. It is then possible that an increase in p^M result in higher wages for unskilled labor in manufacture.

From the analysis in the previous paragraph we know that $\left(-\widehat{p}^M + \alpha\Phi\widehat{U}^M\right) < 0$. Hence, there will be a range of β for which we will also have $\left(-\widehat{p}^M + \beta\left(\frac{1-\alpha}{1-\beta}\right)\Phi\widehat{U}^M\right) < 0$. However, when $\beta \to 1$, that is, the production function in food sector tends to use only skilled labor, we have that the wage of unskilled workers in the unionized sector increase after a rise in the relative price of manufactured goods. To see that, we substitute equation (38) into equation (35) to get:

$$\widehat{w}^M = -\left[\frac{(1-\beta)\left(1-\frac{U^M}{U^F}\frac{S^F}{S^M}\right) - \Phi\left(\frac{S^F}{S^M}+\beta\right)}{(\beta-\alpha)\left(1-\frac{U^M}{U^F}\frac{S^F}{S^M}\right) + \left(\alpha\frac{S^F}{S^M}+\beta\right)\Phi}\right]\widehat{p}^M.$$

When $\beta \to 1$, wages tend to: $\widehat{w}^M \to -\left[\frac{-\Phi\left(\frac{S^F}{S^M}+1\right)}{(1-\alpha)\left(1-\frac{U^M}{U^F}\frac{S^F}{S^M}\right)+\left(\alpha\frac{S^F}{S^M}+1\right)\Phi}\right]\widehat{p}^M$. Moreover, $\frac{S^F}{S^M} \to 0$, which implies $\widehat{w}^M \to \frac{\Phi}{\Phi+(1-\alpha)}\widehat{p}^M$, where Φ is defined in equation (30). Hence, wages of unskilled labor in the manufacturing sector increase after an increase in $\widehat{p}^M$.

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