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Abstract:

This paper analyzes the impact of remittances sent by altruistic migrants on the labor supply of residents. The model is cast as a two-period game with asymmetric information about the residents' real economic situation. The optimal transfer depends on wages of both the donor and the recipient. Residents subject to a good economic situation may behave as if they were in a poor economic situation only in order to manipulate remitters' expectations. The latter, being aware of this risk, reduce the transferred amount accordingly. Therefore, in the equilibrium, residents who really are victims of the bad economic outlook, are penalized as compared to the perfect information set-up. In some circumstances, they can signal their type by drastically cutting working hours, thus further enhancing their precarity.

Key words: Altruism, Development, International Economics, Labor Economics, Labor Supply, Migrants, Perfect Bayesian Equilibrium, Signaling

Résumé :

L'article étudie l'impact des transferts monétaires effectués par les migrants vers les pays d'origine sur l'offre de travail des résidents. Si les derniers ont la possibilité de manipuler les anticipations des migrants, les migrants peuvent réduire le montant du transfert, pénalisant ainsi les résidents les plus démunis.

Mots-clés : Altruisme, Développement, Économie du travail, Économie internationale, Émigrants, Équilibre Bayesien Parfait, Offre de travail, Signalisation, Transferts

JEL Classification: D82; F22; J22; O15

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INTERNATIONAL REMITTANCES AND RESIDENTS' LABOUR SUPPLY IN A SIGNALING MODEL

Claire Naiditch* **et Radu Vranceanu**†

Abstract

This paper analyzes the impact of remittances sent by altruistic migrants on the labor supply of residents. The model is cast as a two-period game with asymmetric information about the residents' real economic situation. The optimal transfer depends on wages of both the donor and the recipient. Residents subject to a good economic situation may behave as if they were in a poor economic situation only in order to manipulate remitters' expectations. The latter, being aware of this risk, reduce the transferred amount accordingly. Therefore, in the equilibrium, residents who really are victims of the bad economic outlook, are penalized as compared to the perfect information set-up. In some circumstances, they can signal their type by drastically cutting working hours, thus further enhancing their precarity.

Mots-clef: Migrants, Remittances, Perfect Bayesian Equilibrium, Labour Supply, Signaling, Altruism.
JEL Classification: D82, F22, J22, O15.

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1 Introduction

Often the decision to migrate from a developing to a developed country is guided by economic considerations; in general, migrants are able to get better economic opportunities in the host country than at home. The left home relatives may also benefit from the migrants' successful integration. Indeed, once they found a job abroad, migrants tend to send a significant part of their income to their families back home. Over the past fifteen years, international migrant remittances have become increasingly prominent - exceeding $232 billion in 2005, with more than 70% of this amount going to developing countries. In 2004, remittances were the second largest source of external financing of the developing world after foreign direct investment, and amounted to more than twice the size of official aid.

Such a substantial amount of external funding must have an impact on the macroeconomic equilibrium of developing countries. Several authors studied the impact of remittances on inequalities and poverty in receiving countries (Adams, 2006; Adams and Page 2005; Lopez-Cordoba, 2004; Adams, 2004). They show that remittances contributed to fighting poverty (measured by the account index) and especially to reducing the "depth of poverty" (measured by the poverty gap index) and the "severity of poverty" (measured by the squared poverty gap).

While this positive effect on poverty reduction should not be underemphasized, remittances may also bring about some unpleasant consequences. In particular, remittances can create income dependency by undermining recipients' incentives to work, which, in turn, would slow down economic growth. The usual suspect for such a disappointing outcome is the asymmetric information between the remitter and the recipient. For instance, Chami et al. (2003) analyze the impact of remittances when the resident, who gets these resources, is able to hide his effort to the remitter. In their model, the migrant is altruistic: his utility depends on the utility of his left home family. They shows that remittances bring about two contradictory effects: on the one hand, an increase in remittances will reduce recipients' work effort because they become less concerned about the risk of getting a small income from work; on the other hand, firms react to additional opportunism by increasing the dispersion of wages in order to stimulate work effort. Since the feed-back effect cannot offset the direct one, remittances have a negative net impact on output.[1] Azam and Gubert (2005) analyze the migration of a family member as part of a diversification strategy that seeks to protect households from income uncertainty specific to agricultural production. Residents are assumed to get remittances only if their income falls below a given threshold. The authors highlight a moral hazard problem: households that can receive remittances tend to decrease their work effort, thus the probability that the output falls below the critical threshold increases.

This paper analyses the impact of remittances on recipients' labor supply in the presence of moral hazard. The model is cast as a two-period game between a migrant who makes a transfer and a resident who benefits of the transfer, given asymmetric information about the real situation of the recipient. Both the migrant and the resident maximize their intertemporal utility. The model builds on the classical signaling methodology developed by Spence (1973).[2] As in the paper by Chami et al. (2003), migrants are altruistic: their utility depends to some extent on the resident's utility. By contrast, in our model income from work is endogenous: residents and migrants are subject to an elementary leisure/consumption trade-off that determines their hour supply. The optimal working time depends on their wages and other autonomous gains, including remittances. The migrant's wage is common knowledge: he is supposed to be paid the same wage as other (migrant) workers in the same sector, which is public information in developed countries. On the other hand, the resident's wage is private information. The migrant observes the resident's working hours during the first period; he can use this information to upgrade his expectations about the recipient's wage. This sequence of decisions opens the door for manipulating information: the resident subject to a good economic situation can behave as if he were in a bad situation only in order to make the donor believe that he is doing badly, and extract more remittances. In an equilibrium with manipulation, when the resident works only a small amount of hours, the migrant cannot tell without ambiguity whether he made this choice because he gets a small wage or because he is trying to manipulate him. Given this uncertainty, the migrant will chose a smaller

[1] This formalization is much in line with those used in models of altruistic transfers within families (Barro, 1974; Becker, 1974; Laferrère and Wolff, 2006; and especially Gatti, 2000).

[2] See also Spence (2001) and Vickers (1986). The model chosen here is close to that developed by Besancenot and Vranceanu (2005).

amount of remittances as compared to the perfect information set-up. As an upshot of all these, imperfect information imposes a real cost on recipients who really are victims of a poor economic outlook. To avoid this outcome, they can choose to signal their type by strongly reducing their working hours during the first period. Consequently, their income precarity edges up, and output in the receiving country declines accordingly.

One interesting feature of this model is its ability to describe the complex relationship between the level of remittances and the migrant's wage in case of asymmetric information: on the one hand, a raise in the migrant's wage implies an increase in the amount of remittances, and, on the other hand, the more acute moral hazard problem calls for a reduction in the amount of remittances. So far this link between remittances and the wage of the migrant (not the resident) has not been emphasized by existing analyses.[3]

The paper is organized as follows. The first section introduces the basic assumptions and the rule of the game. Section 2 analyses the equilibrium when an explicit signaling strategy cannot be implemented. Section 3 comments on the welfare properties of the hybrid equilibrium and analyses the relationship between the migrant's wage and the level of remittances. Section 4 studies the equilibrium when the resident subject to a poor economic is able to signal his type by drastically cutting working hours. The final section presents the conclusion.

2 Main assumptions

The problem is cast as a game between the migrant (or remitter) and the resident. The two agents live over two periods: the first period starts at time $t = 1$ and ends at time $t = 2$, the second starts at time $t = 2$ and ends at time $t = 3$[4] . Thereafter, the two periods will be denoted by index t, which represents the beginning of each period ($t \in \{1, 2\}$). To keep formalization as simple as possible, we assume that during each time period, the two agents consume all of their available resources (i.e., they do not save). Both the migrant and the resident have a job: their income from work depends on their wages and working hours. In addition, the migrant is altruistic: at

[3] Empirical studies on migrations from agricultural to urban areas of the same country have analyzed the relationship between the migrant wage and the resources transferred to the left home family, without reaching a clear cut conclusion (Johnson and Whitelaw, 1974; Rempel and Lobdell, 1978; Hoddinott, 1994).

[4] The migrant and the resident can for example be a couple, with one emigrating and the other left at home.

the beginning of the second period, he commits to remitting part of his income to the resident, depending on his own income and on his perceived economic situation of the resident.

Let s denote the wage of the migrant and let w^i denote the resident's wage. Total working time will be normalized to unity, hence s and w^i should be interpreted as the one-period wage income to be obtained by a worker who would work the maximum working time.

While the migrant's wage is public information, the resident's wage is private information. In order to keep the problem as simple as possible, we assume that the resident's economic situation can be either good, and then he gets a (H)igh wage, $w^i = w^H$, or bad, and then he gets a (L)ow wage, $w^i = w^L$, with $w^L < w^H$ and $w^H < s$.

At the beginning of the game ($t = 1$), the migrant does not know the recipient's real economic situation, but knows the probability of occurrence of the good (or the bad) economic situation. Let $\Pr[w^H]$ denote his *prior* subjective probability that the resident gets a high wage, and $\Pr[w^L] = 1 - \Pr[w^H]$ the *prior* subjective probability that the resident gets a low wage. In order to keep the problem simple, we assume that $\Pr[w^H] = \Pr[w^L] = 0.5$.[5]

- The *basic sequence of decisions* goes as follows:

- At $t = 1$, at the very beginning of the first period, Nature chooses the resident's wage, either w^L or w^H;

- Right after, an exogenously given public aid A is granted to the resident for the period in progress;

- Finally, the resident and the migrant each decide how much they want to work during the first period (h_1 and τ_1 respectively).

- At $t = 2$, at the beginning of the last period, the migrant has observed the resident's working hours during the first period (h_1). He can then upgrade his beliefs about the resident's economic situation;

- Right after, he commits on the amount of remittances T he will send to the resident to *replace* the public aid.[6] He also decides on his own working hours during the second period, τ_2;

[5] Any other values could be considered, provided that $\Pr[w^H] \in]0, 1[$.

[6] In an alternative formulation, remittances could be *added* to public aid. The structure of the problem structure

- Finally, the resident receives the remittances and reveals his real economic situation by choosing his working hours, h_2; the game is over.

- The two players' *objectives*.

a. The resident

At each period $t \in \{1, 2\}$, the *resident's one period utility* is:

$$U_t = U(c_t, h_t) = c_t(1 - h_t), \tag{1}$$

where c_t denotes the resident's consumption; the maximum duration of work is standardized to the unit and h_t denotes the resident's working hours.[7]

Let R denote the resident's non-earned income. His budget constraint is:

$$c_t = w^i h_t + R_t, \qquad \text{with } i \in \{L, H\} \tag{2}$$

where, during the first period, the non-earned income is public aid, $R_1 = A$ and, during the second period, the non-earned income is the amount remitted by the migrant, $R_2 = T$. We assume thereafter that $A < w^L$: public aid is lower than the income of a resident who would work the maximum working time (normalized here to 1) and is paid the low wage. (This plausible constraint will allows us to rule out a negative labor supply.)

The *resident's intertemporal utility* Z can be written simply using an additive form:[8]

$$Z = U_1 + U_2 = U(c_1, h_1) + U(c_2, h_2). \tag{3}$$

b. The migrant

Let x_t denote the migrant's consumption, and we denoted by τ_t his working hours during period t. We assume that his elementary leisure/consumption preferences are the same as the resident's; we thus can define the utility he derives from consumption and work by:

$$V(x_t, \tau_t) = x_t(1 - \tau_t). \tag{4}$$

would not change, but the formula would be unnecessarily complicated.

[7] The Cobb-Douglas function conveys in a simple way the neoclassic assumptions about the convexity of leisure/consumption preferences.

[8] The problem would not change much if we introduce a discount factor.

The migrant is altruistic, so his total utility depends to some extent on the resident's utility. This assumption leads us to define the *migrant's one-period utility* W_t:

$$W_t = W(x_t, \tau_t, c_t, h_t) = [V(x_t, \tau_t)]^{(1-\beta)} [U(c_t, h_t)]^{\beta} \tag{5}$$

where β denotes the degree of altruism, with $\beta \in [0, 1]$. When $\beta = 0$, the migrant is selfish: the resident's welfare does not matter to him. For $\beta > 0$, the migrant can be said to be altruist.

The migrant also seeks to maximize his *intertemporal utility* Σ. It takes an additive form:

$$\Sigma = W_1 + W_2 = [V(x_1, \tau_1)]^{(1-\beta)} [U(c_1, h_1)]^{\beta} + [V(x_2, \tau_2)]^{(1-\beta)} [U(c_2, h_2)]^{\beta}. \tag{6}$$

Finally, for $t \in \{1, 2\}$, the migrant's budget constraint is:

$$x_t = s\tau_t + B_t \tag{7}$$

with his non-earned incomes $B_1 = 0$ and $B_2 = -T$; during the first period, the migrant receives no exogenous income and, during the second period, he transfers resources to the resident.

- The players' *strategies*

The resident seeks to maximize Z, the migrant seeks to maximize Σ.

The resident's strategy ($\mathcal{S}^r$) can be represented by his choice of working hours at each period, given his wage (which is private information): $\mathcal{S}^r(i) = \{(h_1, h_2)|w^i$, with $i \in \{H, L\}\}$.

The migrant decides how much he is going to remit (T) and how long he is going to work during the two periods (τ_1 and τ_2), given his income and his expectations about the resident's wage. At the beginning of the game, the migrant's beliefs are given. The migrant's hours supply during the first period (τ_1) is independent from the resident's behavior. At the beginning of the second period, the migrant chooses his remittances and working hours for the second period (τ_2) after having observed the resident's working hours (during the first period). Any forecasting error implies an (ex-post) utility loss for the migrant. Thus, his strategy ($\mathcal{S}^m$) is made up of his rational guess about the resident's wage; at $t = 1$ his expectations build on his prior beliefs, and at $t = 2$, his expectations take into account the resident's working hours during the first period, h_1. In a compact form, we can write: $\mathcal{S}^m = (E[w^i|I_1], E[w^i|I_2])$ where $E[-]$ is the expectation operator and I_t is the information set at time t, with $t \in \{1, 2\}$.[9]

A Bayesian equilibrium of the game is a situation in which the resident's strategy $\mathcal{S}^r$ maximizes his utility given the migrant's beliefs, and the migrant's beliefs $\mathcal{S}^m$ are correct given the optimal strategy of the resident. In the following, we will analyze only equilibrium situations. Thus, notations can be simplified if we state, according to the *rational expectation* hypothesis, that objective and subjective probabilities are the same (at $t = 1$ and $t = 2$).

In the next Section we analyze the equilibrium of the game when the resident subject to a bad economic situation cannot signal his type by undercutting working hours below the lowest working time that would prevail with perfect information, i.e. cannot recourse to strategic signaling. This assumption will be relaxed in Section 5. It will then be shown that in some cases, even if the resident can signal his type by drastically reducing his working hours, he will not choose to do so because this strategy is dominated. Therefore, the equilibrium developed in the next section is not only an interesting benchmark, but has its own economic meaning.

3 Equilibrium without strategic signaling

3.1 The resident's choice of working hours during the last period

Following the standard methodology, this sequential game is solved by backward induction. At the beginning of the second period the resident has already received the remittances T. Thus, he can decide his optimal working hours h_2^i, given his wage w^i, without any strategic consideration.

To determine his optimal working hours during the second period, the resident maximizes his second-period utility given his budget constraint $c_2 = w^i h_2 + T$:

$$\max_{h_2} \left\{ U(c_2(h_2), h_2) = \left(w^i h_2 + T\right)(1 - h_2) \right\}.$$

The first order condition is: $dU(,)/dh_2 = 0$. Thus, his optimal working hours are:

$$h_2^i = 0.5\left(1 - T/w^i\right), \qquad \text{with } i \in \{H, L\}. \tag{8}$$

[9] In this simple problem, at the outset of the game the expected value of resident's wage is: $E[w^i|I_1] = \Pr[w^H]w^H + \Pr[w^L]w^L = 0.5(w^H + w^L)$.

The resident's second-period labor supply increases with his wage and decreases with the amount remitted.

Finally, replacing the expression of his labor supply in the utility function, we can write the resident's indirect second-period utility as a function of his wage and remittances: $U_2^* = u_2(T, w^i) = \max\{U(c_2(h_2), h_2)\}$, with the explicit form:

$$u_2(T, w^i) = \frac{0.25}{w^i}\left(T + w^i\right)^2 \qquad \text{with } i \in \{H, L\}. \tag{9}$$

3.2 The migrant's choice of remitted amount and working hours during the last period

At the beginning of the second period ($t = 2$), the first-period migrant's utility (W_1) has already been realized. Therefore his decision problem of maximizing $\Sigma = W_1 + W_2$ is truncated: his choices will have an impact only on his second-period utility. Hence, he is concerned only about maximizing W_2. Given that he does not know the resident's wage, he decides on the amount of remittances according to his wage estimate, which depends on the information available at the beginning of the second period (I_2). The expected wage was denoted by $E[w^i|I_2]$.

The migrant must take into account the fact that once the resident gets his remittances, he is going to decide his second-period working hours such as to maximize his utility. Hence the migrant's optimal choice takes the form of a standard Stackelberg decision problem (where the migrant is the "leader" and the resident is the "follower"). Let $E[U_2^*|I_2]$ denote the migrant's estimate of the resident's utility maximum, given his expectations about the resident's wage (Eq 9). The migrant's decision problem can be stated as:

$$\max_{T,\tau_2}\left\{W_2 = [V(x_2,\tau_2)]^{(1-\beta)}\left(E[U_2^*|I_2]\right)^{\beta}\right\}$$

$$\begin{aligned} \text{with (1)} \quad &: \quad x_2 = s\tau_2 - T \\ \text{and (2)} \quad &: \quad E[U_2^*|I_2] = u_2(T, E\left[w^i|I_2\right]) = \frac{0.25}{E\left[w^i|I_2\right]}\left(T + E\left[w^i|I_2\right]\right)^2 \end{aligned}$$

where the constraint (1) is the second-period budget constraint and (2) is the indirect utility of the resident as expected by the migrant.

To solve the problem, we carry out necessary substitutions and denote by ω_2 the logarithm of

W_2:

$$\begin{aligned}\omega_2 &= (1-\beta)\ln\left[(s\tau_2 - T)(1-\tau_2)\right] + \beta\ln\left[\frac{0.25}{E\left[w^i|I_2\right]}\left(T + E\left[w^i|I_2\right]\right)^2\right] \\ &= (1-\beta)\ln(s\tau_2 - T) + (1-\beta)\ln(1-\tau_2) + 2\beta\ln\left(T + E\left[w^i|I_2\right]\right) + Const. \end{aligned} \quad (10)$$

The first order conditions yield:

$$\frac{d\omega_2}{d\tau_2} = \frac{s(1-\beta)}{s\tau_2 - T} - \frac{1-\beta}{1-\tau_2} = 0 \quad (11)$$

$$\frac{d\omega_2}{dT} = -\frac{1-\beta}{s\tau_2 - T} + \frac{2\beta}{T + E[w^i|I_2]} = 0 \quad (12)$$

Thus, the optimal amount remitted is:

$$T^*(s, E\left[w^i|I_2\right]) = \beta s - (1-\beta)E\left[w^i|I_2\right]. \quad (13)$$

The amount remitted decreases with the resident's wage (as anticipated by the migrant) and increases with the migrant's wage and degree of altruism. In addition, our problem implies that $T^* \geq 0$ (remittances cannot be negative). Thereafter, to keep the analysis as simple as possible, we will assume thereafter that, whatever the resident's wage, the optimal amount remitted is strictly positive. Since T^* decreases with $E\left[w^i|I_2\right]$ and is strictly positive for all the possible values of $E\left[w^i|I_2\right]$, it has to be positive for the largest possible value of $E\left[w^i|I_2\right]$, i.e. w^H, which implies:

$$\beta s - (1-\beta)w^H > 0 \Leftrightarrow \beta > \hat{\beta} \equiv \frac{w^H}{s + w^H}. \quad (14)$$

Within our analysis framework, the existence of remittances thus implies a minimum degree of altruism. From now on, we will assume that $\beta > \hat{\beta}$ (since $s > w^H$, a sufficient but not necessary condition is $\beta > 0.5$).

We can also determine the migrant's labor supply during the second period:

$$\tau_2^* = 0.5\left[(1+\beta) - (1-\beta)\frac{E\left[w^i|I_2\right]}{s}\right], \quad (15)$$

which increases with the migrant's wage s, and decreases with the expected value of the resident's wage $E\left[w^i|I_2\right]$.

3.3 How is $E[w^i|I_2]$ determined knowing h_1?

Notice that when there is *perfect information* about his wage, the resident cannot aim at manipulating expectations, and must choose his first-period working hours with the only objective of maximizing his first-period utility ($U_1 = U(c_1, h_1)$), given his first-period budget constraint $c_1 = A + w^i h_1$. The resident's optimal working hours would then simply be $h_1^i = 0.5(1 - A/w^i)$. In this case, if his wage were high ($w^i = w^H$), he would work a lot, $h_1^i = h_1^H$ with $h_1^H \equiv 0.5\left(1 - A/w^H\right) > 0$ and if his wage were low ($w^i = w^L$), he would work less, $h_1^i = h_1^L$, with $h_1^L \equiv 0.5\left(1 - A/w^L\right) > 0$.

In this first part of the analysis, we assumed that the resident cannot undercut working hours below h_1^L in order to signal his type. Thus, his strategy is $\mathcal{S}^r(i) = \{(h_1^L, h_2^L), (h_1^H, h_2^L), (h_1^L, h_2^H), (h_1^H, h_2^H)\}$.

At the beginning of the game, information available to the migrant about the resident's economic situation is summarized by his prior beliefs: $\Pr[w^H] = \Pr[w^L] = 0.5$.

At the beginning of the second period, the migrant knows the resident's working hours during the first period. He can then upgrade his beliefs which can be written as conditional probabilities:

$$\Theta = \begin{cases} \Pr[h_1^L|w^L] \\ \Pr[h_1^L|w^H] \end{cases}$$

with $\Pr[h_1^H|w^L] = 1 - \Pr[h_1^L|w^L]$ and $\Pr[h_1^H|w^H] = 1 - \Pr[h_1^L|w^H]$.

Remember that the amount remitted decreases with the resident's expected wage. Thus, when the resident's economic situation is truly bad, he has no incentive to behave as is his situation was good (by choosing $h_1^i = h_1^H$), because, not only he incurs a first period utility loss, but also he will get a smaller amount of remittances. On the other hand, if he gets the high wage, in case of asymmetric information, the resident may decide to work less as if his wage were low, in order to make the migrant believe that he is in a bad economic situation. In that case, the migrant would remit a higher amount and the resident's second-period utility might be higher. Let q denote the share of residents who choose this manipulating strategy.[10] The *migrant's beliefs* can then be

[10] Or, alternatively, the objective probability for all (high wage) residents of randomizing between the manipulating and the fair strategy.

written (in the equilibrium situation):

$$\Theta = \begin{cases} \Pr[h_1^L | w^L] = 1 \\ \Pr[h_1^L | w^H] = q, \text{ with } q \in [0,1] \end{cases}$$

By observing the resident's working hours, the migrant is able to revise his *ex ante* probabilities $\Pr[w^H]$ and $\Pr[w^L]$. More precisely:

a) If the resident chooses to work h_1^L, Bayesian calculation of probabilities yields:

$$\begin{aligned} \Pr[w^H | h_1^L] &= \frac{\Pr[h_1^L | w^H] \Pr[w^H]}{\Pr[h_1^L | w^H] \Pr[w^H] + \Pr[h_1^L | w^L] \Pr[w^L]} \\ &= \frac{pq}{pq + (1-p)} = \frac{q}{1+q} \end{aligned} \tag{16}$$

and thus:

$$\begin{aligned} \Pr[w^L | h_1^L] &= 1 - \Pr[w^H | h_1^L] \\ &= \frac{1-p}{pq + (1-p)} = \frac{1}{1+q}. \end{aligned} \tag{17}$$

The information set I_2 used by the migrant when $t = 2$ to revise probabilities includes as the single salient piece of information the resident's working hours during the first period, $I_2 = \{h_1\}$. The expected value of the resident's wage conditional on I_2, $E\left[w^i | I_2\right]$, can then be written:

$$E[w^i | h_1^L] = \frac{q}{1+q} w^H + \frac{1}{1+q} w^L \tag{18}$$

with $E[w^i | h_1^L] \in [w^L, 0.5(w^L + w^H)]$.

The expected value of the resident's wage increases with the probability of adopting the strategy of manipulating expectations:

$$\frac{dE[w^i | h_1^L]}{dq} = \frac{w^H - w^L}{(1+q)^2} > 0, \tag{19}$$

to reach its highest value for $q = 1$ (when everybody works h_1^L, the migrant cannot revise prior probabilities, therefore $\Pr[w^H | h_1^L] = \Pr[w^L | h_1^L] = p$).

b) If the resident chooses to work h_1^H, conditional probabilities can be written:

$$\Pr[w^H | h_1^H] = \frac{\Pr[h_1^H | w^H] \Pr[w^H]}{\Pr[h_1^H | w^H] \Pr[w^H] + \Pr[h_1^H | w^L] \Pr[w^L]} = \frac{p(1-q)}{p(1-q) + 0} = 1 \tag{20}$$

$$\Pr[w^L | h_1^H] = 0. \tag{21}$$

The expected value of the resident's wage is simply:

$$E[w^i|h_1^H] = w^H. \tag{22}$$

Thus, the optimal amount of remittances (Eq. 13) is bigger if the resident chooses $h_1 = h^L$ than if he chooses $h_1 = h^H$.

3.4 The resident's choice of working hours during the first period

Given former developments, it turns out that when the resident is in a poor economic situation ($w^i = w^L$), he will always choose to work the small amount of time ($h_1 = h_1^L$) : he does not want the migrant to believe that he is well paid because he would then get less remittances. On the other hand, if the resident is in a good economic situation ($w^i = w^H$), he will manipulate migrant's anticipations by choosing to work h_1^L with probability q, and will be honest by choosing to work h_1^H with probability $1-q$.[11] Extreme cases $q = 0$ or $q = 1$ correspond to pure strategies. In the following, we focus on the mixed strategy case $q \in [0, 1]$, which encompasses the two pure strategies as particular situations.

The mixed strategy $q \in [0, 1]$ is implemented if the "rich" resident ($w^i = w^H$) is indifferent between playing h_1^H or h_1^L:

$$Z(h_1^H, w^H) = Z(h_1^L, w^H). \tag{23}$$

In a first step, we estimate $Z(h_1^L, w^H)$. Knowing that $h_1^L = 0.5(1 - A/w^L)$, we can write the resident's first-period utility as: $U_1 = U(c_1(h_1^L), h_1^L) = u_1(h_1^L, w^H)$ with:

$$u_1(h_1^L, w^H) = (w^H h_1^L + A)(1 - h_1^L) \tag{24}$$

$$= 0.25(1 + A/w^L)[w^H(1 - A/w^L) + 2A]. \tag{25}$$

Then, we know that $E[w^i|h_1^L] = w^H \frac{q}{1+q} + w^L \frac{1}{1+q}$. Thus, optimal remittances (Eq. 13) are:

$$T^* = \beta s - (1-\beta)\left[w^H \frac{q}{1+q} + w^L \frac{1}{1+q}\right] \tag{26}$$

[11] The probability q is endogenous.

so, the second-period indirect utility function can be written (Eq. 9):

$$u_2(T^*(E[w^i|h_1^L]), w^H) = \frac{0.25}{w^H}\left\{\beta s - (1-\beta)\left[w^H\frac{q}{1+q} + w^L\frac{1}{1+q}\right] + w^H\right\}^2$$
$$= \frac{0.25}{w^H(1+q)^2}[\beta s(1+q) - (1-\beta)w^L + (1+\beta q)w^H]^2. \quad (27)$$

In a second step, we calculate $Z(h_1^H, w^H)$. We know that $h_1^H = 0.5(1 - A/w^H)$, thus, $U_1 = U_1(c_1(h_1^H), h_1^H) = u_1(h_1^H, w^H)$, with:

$$u_1(h_1^H, w^H) = (w^H h_1^H + A)(1 - h_1^H)$$
$$= \frac{0.25}{w^H}(A + w^H)^2. \quad (28)$$

Knowing that $E[w^i|h_1^H] = w^H$ and $T^* = \beta s - (1-\beta)w^H$, the second-period utility function (Eq. 9) becomes:

$$u_2(T^*(w^H), w^H) = \frac{0.25}{w^H}\left(T^* + w^H\right)^2$$
$$= \frac{0.25\beta^2}{w^H}\left(s + w^H\right)^2. \quad (29)$$

Taking into account these two expressions, the indifference condition (23) becomes:

$$u_1(h_1^H, w^H) + u_2(T^*(w^H), w^H) = u_1(h_1^L, w^H) + u_2(T^*(E[w^i|h_1^L]), w^H) \quad (30)$$
$$\Leftrightarrow (1+q)^2\left(w^H - w^L\right)\frac{A^2}{(w^L)^2} = (1-\beta)[2\beta s(1+q) - (1-\beta)w^L + (1+2\beta q+\beta)w^H]. \quad (31)$$

The latter equation implicitly defines q as a function of the various parameters. It can be shown that q is an increasing function in the migrant's wage s. For so doing, condition (31) is written as:

$$s = \frac{1}{2\beta(1+q)}\left[\frac{\left(w^H - w^L\right)(1+q)^2 A^2}{(1-\beta)(w^L)^2} + (1-\beta)w^L - (1+2\beta q+\beta)w^H\right]. \quad (32)$$

Differentiating this expression, we get:

$$\frac{dq}{ds} = \frac{2\beta(1+q)^2(1-\beta)}{\left(w^H - w^L\right)[(A/w^L)^2(1+q)^2 + (1-\beta)^2]} > 0. \quad (33)$$

Furthermore, by setting $q = 0$ and respectively $q = 1$, we get the inferior and superior wage thresholds that separate the three types of equilibria:

$$q = 0 \Rightarrow s_0 \equiv \frac{1}{2\beta}\left[\frac{\left(w^H - w^L\right)A^2}{(1-\beta)(w^L)^2} + (1-\beta)w^L - (1+\beta)w^H\right] \quad (34)$$
$$q = 1 \Rightarrow s_1 \equiv \frac{1}{4\beta}\left[\frac{4\left(w^H - w^L\right)A^2}{(1-\beta)(w^L)^2} + (1-\beta)w^L - (1+3\beta)w^H\right]. \quad (35)$$

with $s_1 > s_0$. If $s_0 > w^H$, depending on s, one of the three situations depicted in Figure 1 can occur:

When $s \in [w^H, s_0]$, it turns out that $Z(h_1^H, w^H) > Z(h_1^L, w^H)$: it is not beneficial for residents in a good economic situation to manipulate information ($q = 0$). The equilibrium is *separating*: each type of resident implements a specific action, either h_1^L or h_1^H, and this action signals his type without ambiguity.

When $s \in [s_0, s_1]$, there can be manipulation ($q \in [0, 1]$), the equilibrium is *hybrid*: while the action h_1^H signals the migrant's type, the action h_1^L does not.

When $s > s_1$, it can be shown that $Z(h_1^H, w^H) < Z(h_1^L, w^H)$: all residents in a good economic situation find it beneficial to manipulate information ($q = 1$). The equilibrium is of the *pooling* type: all residents, whatever their wage, choose the same action h_1^L, migrants can infer no information from observing first period working time h_1.

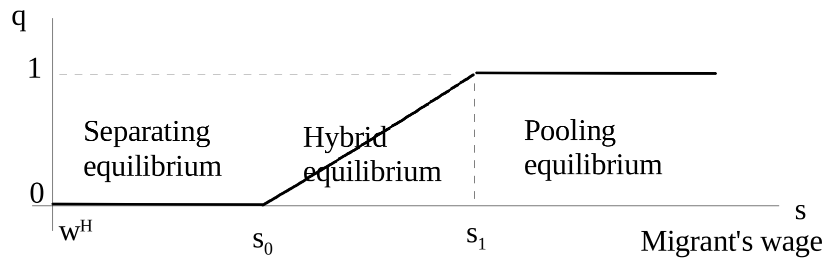

Figure 1: Types of equilibria and the manipulation probability with respect to s

If $s_0 < w^H < s_1$, the separating equilibrium cannot occur. If $s_1 < w^H$, the only possible equilibrium is the pooling one. In order to develop on the most general case, in the following we assume that $s_0 > w^H$.

3.5 The migrant's choice of working hours during the first period

In order to conclude the analysis of individual strategies, we can analyze the migrant's choice of working hours during the first-period. His decision problem is:

$$\max_{\tau_1} \left\{ \Sigma = [V(x_1, \tau_1)]^{(1-\beta)} \left[U(E[c_1|I_1], h_1)\right]^{\beta} + [V(x_2, \tau_2)]^{(1-\beta)} \left[U(E[c_2|I_1], h_2)\right]^{\beta} \right\}$$

$$\begin{aligned} \text{with } \forall t, \quad x_t &= s\tau_t + B_t, \text{ and } B_1 = 0, B_2 = -T \\ \text{with } \forall t, \quad E[c_t|I_1] &= E[w^i|I_1]h_t + R_t, \text{ and } R_1 = A, R_2 = T \\ \text{and } E[w^i|I_1] &= 0.5(w^H + w^L). \end{aligned}$$

In this simple problem, it is easy to check that the optimal solution is $\tau_1^* = 0.5$. Given the assumption that the migrant gets no exogenous income ($B_1 = 0$), the migrant's working hours do not depend on his expectations about the resident's wage as determined at the beginning of the game, $E[w^i|I_1]$. Since the latter is a constant, $E[w^i|I_1] = 0.5(w^H + w^L)$, this simplification does not modify the basic structure of the game.

4 Properties of the hybrid equilibrium

4.1 A welfare comparison

This subsection aims at providing a comparison in terms of welfare between the perfect and the imperfect information case. In the case of perfect information, the resident subject to the good economic situation cannot manipulate information because the migrant knows his wage. Therefore, like in the separating equilibrium, each type of resident has a specific first-period strategy: if $w^i = w^L$ then $h_1 = h^L$ and if $w^i = w^H$ then $h_1 = h^H$. In this case, the poor resident's utility would be:

$$Z^{\mathcal{P}}(h_1^L, w^L) = u_1(h_1^L, w^L) + u_2(T^*(w^L), w^L). \tag{36}$$

where exponent $\mathcal{P}$ stands here for perfect information.

In the case of imperfect information, we have shown that some rich residents may implement the manipulation strategy. In the hybrid equilibrium (and the pooling one as well), the poor resident's utility is:

$$Z^{\mathcal{I}}(h_1^L, w^L) = u_1(h_1^L, w^L) + u_2(T^*(E[w^i|h_1^L]), w^L). \tag{37}$$

where exponent $\mathcal{I}$ indicate imperfect information. The utility loss (in absolute value) of the poor resident due to the the imperfection of information can be written:

$$Z^{\mathcal{P}}(h_1^L, w^L) - Z^{\mathcal{I}}(h_1^L, w^L) = u_2(T^*(w^L), w^L) - u_2(T^*(E[w^i|h_1^L]), w^L). \tag{38}$$

We know that:

$$\begin{aligned} u_2(T^*(w^L), w^L) &= \frac{0.25}{w^L}(T^*(w^L) + w^L)^2 \\ &= \frac{0.25\beta^2}{w^L}(s + w^L)^2 \end{aligned} \tag{39}$$

and, given the expression of optimal remittances (Eq. 13) and the expected wage of the resident (Eq. 18), we get:

$$\begin{aligned} u_2(T^*(E[w^i|h_1^L]), w^L) &= \frac{0.25}{w^L}(T^*(E[w^i|h_1^L]) + w^L)^2 \\ &= \frac{0.25}{w^L}\left[\beta s - (1-\beta)\left[w^H\frac{q}{1+q} + w^L\frac{1}{1+q}\right] + w^L\right]^2. \end{aligned} \tag{40}$$

Since $T^{\mathcal{I}*} = T^*(E[w^i|h_1^L]) < T^{\mathcal{P}*} = T^*(w^L)$, it is easy to see that:

$$\begin{aligned} u_2(T^*(w^L), w^L) &> u_2(T^*(E[w^i|h_1^L]), w^L) \\ Z^{\mathcal{P}}(h_1^L, w^L) &> Z^{\mathcal{I}}(h_1^L, w^L). \end{aligned}$$

To sum up, under imperfect information, the resident subject to a bad economic situation ($w^i = w^L$) (who cannot signal his type), undergoes a utility loss compared to the perfect information case.

After some calculations presented in Appendix 1, the welfare loss due to imperfect information can be expressed according only to q:

$$Z^{\mathcal{P}}(h_1^L, w^L) - Z^{\mathcal{I}}(h_1^L, w^L) = q\frac{\left(w^H - w^L\right)^2}{4w^L}\left[\frac{A^2}{\left(w^L\right)^2} - \frac{1-\beta^2}{1+q}\right] > 0. \tag{41}$$

We note an important condition on the parameters:

$$\frac{A^2}{\left(w^L\right)^2} - \frac{1-\beta^2}{1+q} > 0. \tag{42}$$

Finally, without going into details, we notice that imperfect information would generate a utility gain for the rich resident (who get a higher amount of remittances than in the case of perfect information) and an *ex post* welfare loss for the migrant, because he makes his decisions based on an inaccurate expected value of the resident's wage; he would remit too much to a "rich" resident, and too little to a "poor" one.

4.2 The equilibrium relationship between remittances and the migrant's wage

According to Eq. (13), optimal remittances depend on the migrant's wage and on his evaluation of the resident's wage. But the probabilities that enable him to determine the resident's expected wage depend on his own wage, since the latter has a bearing on the resident's behavior. More precisely, a raise in the migrant's wage s generates two opposite effects: on the one hand, there is a wealth effect such that the migrant, richer, wishes to increase his remittances; on the other hand, the rise in the amount remitted causes an increase in the probability of manipulation and thus in the resident's wage as expected by the migrant, who is then prompted to reduce his remittances.

These complex links can be better highlighted by studying the formal relationship between T and s. From the expression of optimal remittances, $T^* = \beta s - (1-\beta) E\left[w^i | h_1^L\right]$, we can write:

$$\frac{dT^*}{ds} = \beta - (1-\beta) \frac{dE\left[w^i | h_1^L\right]}{dq} \frac{dq}{ds}. \tag{43}$$

We replace by the expressions (19) and (33) to get:

$$\frac{dT^*}{ds} = \beta \frac{\frac{A^2}{(w^L)^2} - \frac{(1-\beta)^2}{(1+q)^2}}{\frac{A^2}{(w^L)^2} + \frac{(1-\beta)^2}{(1+q)^2}}. \tag{44}$$

The sign of $\frac{dT^*}{ds}$ is the same as the sign of $\frac{A^2}{(w^L)^2} - \frac{(1-\beta)^2}{(1+q)^2}$. This term is positive. Indeed, according to Condition (42) $\frac{A^2}{(w^L)^2} - \frac{1-\beta^2}{1+q} > 0$. Yet, it is easy to see that $\frac{A^2}{(w^L)^2} - \frac{(1-\beta)^2}{(1+q)^2} > \frac{A^2}{(w^L)^2} - \frac{1-\beta^2}{1+q}$ $\forall(\beta, q)$. Remittances are an increasing function of the migrant's wage: in this model, the wealth effect overrides the moral hazard effect.

Finally, note that the resident's working hours during the second period are a decreasing function of remittances. Thus, the effect of a raise in the migrant's wage on the resident's hours supply is negative.

5 Equilibrium with strategic signaling

The former welfare analysis shows that when residents cannot reduce working hours h_1 below the perfect information lowest working time (h_1^L) such as to signal their type, a poor resident incurs a welfare loss as compared to a situation with perfect information. In this section we relax the constraint on working hours, and allow the resident to adjust working hours strategically. Indeed, according to the traditional argument (Vickers, 1986; Spence, 2002), the poor resident may try to signal his real situation (unfavorable) by undercutting working hours and accepting a degradation of his utility during the first period, provided that the reduction will not be implemented by a possible manipulator. If this form of strategic signaling is effective, then the separating equilibrium prevails.

Here, we are interested in signalization possibilities when rich residents do tend to cheat, i.e. when $s > s_0$ (and $q \in [0, 1]$). In order to study this problem formally, let us denote by $\bar{h}_1$ the working hours which allow signalization, with $\bar{h}_1 < h_1^L$. If this policy of working hour reduction exists, it must comply with two conditions.

Condition 1 or incentive constraint: signalization has to be effective; in other words, it has to dissuade the manipulator (who is inevitably in a favorable situation, w^H) from choosing the same strategy as the poor resident. A manipulator does not find it beneficial to work $\bar{h}_1$ and, under the separating conditions, to be considered without ambiguity as a poor resident, if his gains are higher when he is honest (he then works h_1^H and signals his type):

$$Z(\bar{h}_1, w^H) \quad < \quad Z(h_1^H, w^H) \tag{45}$$

$$u_1(\bar{h}_1, w^H) + u_2(T^*(w^L), w^H) \quad < \quad u_1(h_1^H, w^H) + u_2(T^*(w^H), w^H). \tag{46}$$

Condition 2 or participation constraint: signalization has to be profitable for the poor resident. If he undergoes the cost of reduced working hours during the first period, his intertemporal utility with signalization must nevertheless be higher than in the absence of signalization (and thus without cost during the first period):

$$
\begin{aligned}
Z(\bar{h}_1, w^L) &> Z(h_1^L, w^L) && (47)\\
u_1(\bar{h}_1, w^L) + u_2(T^*(w^L), w^L) &> u_1(h_1^L, w^L) + u_2(T^*(E[w^i|h_1^L]), w^L). && (48)
\end{aligned}
$$

Appendix 2 shows that Condition 1 is satisfied if:

$$\bar{h}_1 \leq h_1^H - \sqrt{z_1} \tag{49}$$

where :

$$z_1 \equiv \frac{(1-\beta)(w^H - w^L)[2\beta(s + w^L) + (1+\beta)\left(w^H - w^L\right)]}{4\left(w^H\right)^2} > 0. \tag{50}$$

Threshold z_1 depends on s, but not on q, because in the separating equilibrium, q is null. Rational residents will choose the highest working hours that guarantees signalization:

$$\bar{h}_1 = h_1^H - \sqrt{z_1}. \tag{51}$$

In Appendix 2, we prove that when $s > s_0$, $\bar{h}_1$ is always strictly inferior to h_1^L. It implies that, in this game, signalization by reduction of his working hours is always a possible strategy for a resident in an unfavorable economic situation.

As for Condition 2, it is satisfied if (see Appendix 2):

$$\bar{h}_1 > h_1^L - \sqrt{z_2}, \tag{52}$$

with :

$$z_2 \equiv q\frac{\left(w^H - w^L\right)^2}{4\left(w^L\right)^2}\left[\frac{A^2}{\left(w^L\right)^2} - \frac{1-\beta^2}{1+q}\right] > 0. \tag{53}$$

(Condition (42) enables us to make sure that $z_2 > 0$ and $dz_2/dq > 0$).

Knowing that $\bar{h}_1 = h_1^H - \sqrt{z_1}$, we conclude that there is a signalization strategy by reduction of the first-period working hours which is effective *and* profitable if and only if:

$$
\begin{aligned}
h_1^H - \sqrt{z_1} &> h_1^L - \sqrt{z_2} && (54)\\
\Leftrightarrow \sqrt{z_1} - \sqrt{z_2} &< h_1^H - h_1^L, \text{ with } h_1^H - h_1^L = \frac{A\left(w^H - w^L\right)}{2w^H w^L} > 0. && (55)
\end{aligned}
$$

If there are cases where this condition is met, we can also highlight cases where it is impossible.

For instance, when remitters are very altruistic ($\beta \to 1$) the threshold z_1 is close to 0, while z_2 is positive. Condition (55) is then met. The equilibrium with signalization prevails.

When $\beta < 1$, we can study several significant cases.

1st case : s close to s_0.

When s is close to s_0, $q = 0$ and thus $z_2 = 0$. The previous condition becomes: $h_1^L < h_1^H - \sqrt{z_1} = \bar{h}_1$ which is impossible because it was shown that $\bar{h}_1 < h_1^L$. Thus, signalization by modulating working hours is not profitable when foreign wages are close to s_0. This result seems quite logical: when s is close to s_0, nobody is cheating; then, signalization is unnecessary.

2nd case : s close to s_1.

When $s = s_1$, $q = 1$. Replacing s by s_1 (Eq. 35) in Eq. (50), threshold z_1 becomes :

$$[z_1]_{s=s_1} = \frac{(w^H - w^L)^2}{4\left(w^H\right)^2}\left[\frac{2A^2}{(w^L)^2} + 0.5(1-\beta)^2\right] \tag{56}$$

and threshold z_2 becomes:$[z_2]_{q=1} = \dfrac{\left(w^H - w^L\right)^2}{4\left(w^L\right)^2}\left[\frac{A^2}{(w^L)^2} - 0.5(1-\beta^2)\right]$.

Inequality (55) can be written:

$$\left[\frac{2A^2}{\left(w^L\right)^2} + 0.5(1-\beta)^2\right]^{1/2} - \frac{w^H}{w^L}\left[\frac{A^2}{\left(w^L\right)^2} - 0.5(1-\beta^2)\right]^{1/2} < \frac{A}{w^L}. \tag{57}$$

The left term is decreasing in w^H. Therefore, above a certain threshold, i.e. for w^H high (compared to w^L), signalization is possible and profitable for a resident in a difficult economic situation.

3rd case : $s > s_1$.

When $s > s_1$, $q = 1$; threshold z_2 reaches its maximum in $[z_2]_{q=1}$ (because z_2 is an increasing function in q), while z_1 is an increasing function in s. Even if the condition is satisfied for s_1, a higher wage will prove it wrong. When the migrant is paid a very high wage, signalization is not longer profitable for the resident in a difficult economic situation. Remittances are so high that everyone will always find it beneficial to cheat.

6 Conclusion

While several empirical studies have highlighted the positive effect of migrants' remittances on poverty reduction in developing countries, some studies stressed out the fact that these remittances could bring about adverse effects on recipients' work effort (Chami et al., 2003; Azam and Gubert, 2005). Our paper belongs to this strand of literature. It analyzes the impact of remittances on residents' labour supply in a signaling framework.

The model is cast as a two-period game between an altruistic migrant and a resident who receives remittances, under the assumption of imperfect information concerning the resident's economic situation. In the Hybrid Bayesian Equilibrium, a resident in a good economic situation can try to manipulate the migrant's expectations by adopting the same behavior as the resident subject to a bad economic situation. The imperfection of information is prejudicial to the poor resident, because, not being able to signal his type, he receives a reduced amount of remittances. It is also prejudicial to the altruistic migrant who remits less (more) than he would like to a poor (rich) resident. Therefore manipulation leads to a fall in the labor supply of the receiving country that harms economic growth in the long run, if time saved by cheaters is not used in a productive way (investment in human capital). It was shown that in some cases, a poor resident can implement an expensive signaling strategy, which consists in drastically reducing his labor supply. This strategy is likely to reinforce the income precarity of residents right when they meet the worst economic outlook.

The model is based on several assumptions, and some of them are simplifying. In particular, we did not take into account the possibility for the migrant to save resources during the first period which he could consume during the second period. The problem that integrates the intertemporal choice of consumption would require an even more complex formalization. Moreover, we did not consider the possibility for the resident to be altruistic, possibility that should contain the scope for manipulation without fully eliminating it. Finally, it could be interesting to study the virtues of alternative contracting mechanisms between the migrant and the resident. For instance, if the migrant could commit on the amount of remittances at the beginning of the first period, this would dissuade the rich resident from cheating. Yet this contract might be dominated, since it implies less insurance for the poor resident.

Simplifications used in this paper are the price to pay to get a straightforward analysis of the influence of imperfect information on the amount remitted on the one hand, and on labor supply on the other hand. Compared to existing theoretical models, this model submits an explanation of remittances linked not only to the resident's wage but also to the migrant's wage. This relationship between the migrant's wage and the amount remitted is complex, because the traditional wealth effect can be partly offset by the reinforcement of the incentive to cheat for the recipients. The impact of international remittances on economic growth is also clearly identified, insofar as the model builds on a traditional arbitrage between consumption and leisure, that allows us to bring into the picture the optimal working time.

If it is difficult to draw strong conclusions in terms of economic policy from a model which remains very stylized, results call for a cautious assessment of the macroeconomic impact of private intrafamily remittances. In the light of our analysis, any element which reduces the asymmetry of information between migrants and recipients should contribute to improve the situation of the poorest residents.

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A Annexe 1. Utility loss in case of imperfect information

When information is perfect, the poor resident's utility is:

$$Z^{\mathcal{P}}(h_1^L, w^L) = u_1(h_1^L, w^L) + u_2(T^*(w^L), w^L)$$

When information is imperfect, in the hybrid equilibrium the poor resident's utility is:

$$Z^{\mathcal{I}}(h_1^L, w^L) = u_1(h_1^L, w^L) + u_2(T^*(E[w^i|h_1^L]), w^L)$$

Knowing that:

$$\begin{aligned} u_2(T^*(w^L), w^L) &= \frac{0.25}{w^L}(T^* + w^L)^2 \\ &= \frac{0.25}{w^L}(\beta s - (1-\beta)w^L + w^L)^2 = \frac{0.25\beta^2}{w^L}(s + w^L)^2 \end{aligned} \quad \text{(A.58)}$$

and that, according to Eq. (13):

$$\begin{aligned} u_2(T^*(E[w^i|h_1^L]), w^L) &= \frac{0.25}{w^L}(T^* + w^L)^2 \\ &= \frac{0.25}{w^L}(\beta s - (1-\beta)\left[w^H \frac{q}{1+q} + w^L \frac{1}{1+q}\right] + w^L)^2, \end{aligned} \quad \text{(A.59)}$$

we can write the resident's loss depending on q:

$$\begin{aligned} Z^{\mathcal{P}}(h_1^L, w^L) - Z^{\mathcal{I}}(h_1^L, w^L) &= \frac{0.25\beta^2}{w^L}(s + w^L)^2 - \frac{0.25}{w^L}(\beta s - (1-\beta)\left[w^H \frac{q}{1+q} + w^L \frac{1}{1+q}\right] + w^L)^2 \\ &= \frac{0.25}{w^L}(1-\beta)\frac{q}{1+q}\left(w^H - w^L\right)\left[2\beta s + (\frac{2\beta + q + \beta q}{1+q})w^L - \frac{q - q\beta}{1+q}w^H\right] \\ &= \frac{0.25}{w^L}(1-\beta)\frac{q}{1+q}\left(w^H - w^L\right)\{H\} \end{aligned} \quad \text{(A.60)}$$

However, in the hybrid equilibrium:

$$s = \frac{1}{2\beta(1+q)}\left[\frac{(1+q)^2 A^2}{(1-\beta)(w^L)^2}\left(w^H - w^L\right) + (1-\beta)w^L - (1 + 2\beta q + \beta)w^H\right] \quad (61)$$

Thus:

$$\begin{aligned} H &= 2\beta s + \frac{1}{1+q}\left[(2\beta + q + \beta q)w^L - (q - q\beta)w^H\right] \\ &= \frac{1}{1+q}\left[\frac{(1+q)^2 A^2}{(1-\beta)\left(w^L\right)^2}\left(w^H - w^L\right) + (1-\beta)w^L - (1 + 2\beta q + \beta)w^H - (q - q\beta)w^H\right] \\ &= \frac{(1+q)A^2}{(1-\beta)}\frac{w^H - w^L}{\left(w^L\right)^2} + \frac{1}{1+q}\left[(1+\beta)(1+q)w^L - (1+\beta)(1+qw^H\right] \\ &= (w^H - w^L)\frac{(1+q)}{(1-\beta)}\left[\left(\frac{A}{w^L}\right)^2 - \frac{1-\beta^2}{1+q}\right]. \end{aligned} \quad \text{(A.62)}$$

Difference between the two utilities is:

$$Z^{\mathcal{P}}(h_1^L, w^L) - Z^{\mathcal{I}}(h_1^L, w^L) = q\frac{\left(w^H - w^L\right)^2}{4w^L}\left[\frac{A^2}{\left(w^L\right)^2} - \frac{1-\beta^2}{1+q}\right]. \quad (63)$$

B Annexe 2. Signaling conditions

B.1 Condition 1

We study if signalisation by the poor resident through reduction of his first-period labour supply is possible.

We calculate:

$u_1(\bar{h}_1, w^H) = (w^H\bar{h}_1 + A)(1-\bar{h}_1)$

$u_1(h_1^H, w^H) = \frac{0.25}{w^H}(A + w^H)^2$

$u_1(\bar{h}_1, w^L) = (w^L\bar{h}_1 + A)(1-\bar{h}_1)$

$u_1(h_1^L, w^L) = \frac{0.25}{w^L}(A + w^L)^2$

Knowing that:

$u_2 = \frac{0.25}{w^r}(T^* + w^r)^2$

$T^* = \beta s - (1-\beta)E[w^i|h_1^L]$

$E[w^i|h_1^L] = w^H\frac{q}{1+q} + w^L\frac{1}{1+q}$

we get:

$u_2(T^*(w^L), w^H) = \frac{0.25}{w^H}(\beta s - (1-\beta)w^L + w^H)^2$

$u_2(T^*(w^H), w^H) = \frac{0.25\beta^2}{w^H}(s + w^H)^2$

$u_2(T^*(w^L), w^L) = \frac{0.25}{w^L}(T^* + w^L)^2 = \frac{0.25}{w^L}(\beta s - (1-\beta)w^L + w^L)^2 = \frac{0.25\beta^2}{w^L}(s + w^L)^2$

$u_2(T^*(E[w^i]), w^L) = \frac{0.25}{w^L}\left\{\beta s - (1-\beta)\left[w^H\frac{q}{1+q} + w^L\frac{1}{1+q}\right] + w^L\right\}^2$

We can then rewrite *Condition 1 :*

$$\begin{aligned}
u_2(T^*(w^L), w^H) - u_2(T^*(w^H), w^H) &\leq u_1(h_1^H, w^H) - u_1(\bar{h}_1, w^H) \\
\frac{0.25}{w^H}(\beta s - (1-\beta)w^L + w^H)^2 - \frac{0.25\beta^2}{w^H}(s + w^H)^2 &\leq \frac{0.25}{w^H}(A + w^H)^2 - (w^H\bar{h}_1 + A)(1-\bar{h}_1) \\
(1-\beta)(w^H - w^L)[2\beta s - (1-\beta)w^L + (1+\beta)w^H] &\leq [(w^H - A) - 2w^H\bar{h}_1]^2 \\
(1-\beta)(w^H - w^L)[2\beta s - (1-\beta)w^L + (1+\beta)w^H] &\leq (2w^H)^2(\frac{w^H - A}{2w^H} - \bar{h}_1)^2 \\
(1-\beta)(w^H - w^L)[2\beta(s + w^L) + (1+\beta)(w^H - w^L)] &\leq 4(w^H)^2(h_1^H - \bar{h}_1)^2, \quad (B.64)
\end{aligned}$$

where $h_1^H - \bar{h}_1 > 0$.

Let us denote:

$$z_1 = \frac{(1-\beta)(w^H - w^L)[2\beta(s+w^L) + (1+\beta)(w^H - w^L)]}{4(w^H)^2} > 0 \tag{65}$$

Thus, separation is possible if there is a $\bar{h}_1 \in]0, h_1^L[$ such that:

$$(h_1^H - \bar{h}_1)^2 \geq z_1 \iff \bar{h}_1 \leq h_1^H - \sqrt{z_1}. \tag{66}$$

The resident chooses the highest working hours possible:

$$\bar{h}_1 = h_1^H - \sqrt{z_1}.$$

Important : we check that $\bar{h}_1 < h_1^L$.

$$\begin{aligned}
h_1^H - \sqrt{z_1} &< h_1^L \\
\left(h_1^H - h_1^L\right)^2 &< \frac{(1-\beta)(w^H - w^L)[2\beta(s+w^L) + (1+\beta)\left(w^H - w^L\right)]}{4\left(w^H\right)^2} \\
\frac{A^2}{4}\left(\frac{w^H - w^L}{w^H w^L}\right)^2 &< \frac{(1-\beta)(w^H - w^L)[2\beta(s+w^L) + (1+\beta)\left(w^H - w^L\right)]}{4\left(w^H\right)^2} \\
\left(w^H - w^L\right)^2\left(\frac{A}{w^L}\right)^2 &< (1-\beta)(w^H - w^L)][2\beta(s+w^L) + (1+\beta)\left(w^H - w^L\right)] \equiv Y(s)
\end{aligned} \tag{B.67}$$

In this inequality, the right term denoted $Y(s)$ is a function increasing in s.

We calculate $Y(s_0)$, with $s_0 = \frac{1}{2\beta}\left[\frac{A^2}{(1-\beta)(w^L)^2}(w^H + w^L) + (1-\beta)w^L - (1+\beta)w^H\right]$.

$$Y(s_0) = (w^H - w^L)^2 \frac{A^2}{\left(w^L\right)^2} \tag{68}$$

In the hybrid equilibrium, $s > s_0$. Thus:

$$\left(w^H - w^L\right)^2 \frac{A^2}{\left(w^L\right)^2} = Y(s_0) < Y(s),\ \forall s \Leftrightarrow \bar{h}_1 < h_1^L, \forall s. \tag{69}$$

B.2 Condition 2

We study if signalisation by the poor resident through reduction of his first-period labour supply is profitable to him.

$$\begin{aligned}
u_1(\bar{h}_1, w^L) + u_2(T^*(w^L), w^L) &> u_1(h_1^L, w^L) + u_2(T^*(E[w^r]), w^L) \\
4w^L(w^L\bar{h}_1 + A)(1-\bar{h}_1) + \beta^2(s+w^L)^2 &> (A+w^L)^2 + [\beta s - \frac{1-\beta}{1+q}(qw^H + w^L) + w^L]^2 \\
-4w^L w^L(\bar{h}_1)^2 + 4w^L\bar{h}_1(w^L - A) + [4w^L A - (A+w^L)^2] &> [\beta s - \frac{1-\beta}{1+q}(qw^H + w^L) + w^L]^2 - \beta^2(s+w^L)^2 \quad \text{(B.70)}
\end{aligned}$$

However, $(w^L - A) = 2h_1^L w^L$, thus:

$$\begin{aligned}
-4(w^L)\left[\left(\bar{h}_1\right)^2 - 2\bar{h}_1 h_1^L + \left(h_1^L\right)^2\right] &> \left[\beta s - \frac{1-\beta}{1+q}(qw^H + w^L) + w^L\right]^2 - \beta^2(s+w^L)^2 \\
4(w^L)^2\left(h_1^L - \bar{h}_1\right)^2 &< (\beta s + \beta w^L)^2 - \left[\beta s - \frac{1-\beta}{1+q}(qw^H + w^L) + w^L\right]^2
\end{aligned}$$

$$\begin{aligned}
4(w^L)^2\left(h_1^L - \bar{h}_1\right)^2 &< \left\{-(1-\beta)w^L + \frac{1-\beta}{1+q}(qw^H + w^L)\right\}\left\{2\beta s + (1+\beta)w^L - \frac{1-\beta}{1+q}(qw^H + w^L)\right\} \\
4(w^L)^2\left(h_1^L - \bar{h}_1\right)^2 &< \left\{q\frac{1-\beta}{1+q}(w^H - w^L)\right\}\left\{2\beta s - \frac{1}{1+q}\left[(1-\beta)qw^H - (2\beta + q + \beta q)w^L\right]\right\} \quad \text{(B.71)}
\end{aligned}$$

However, in the hybrid equilibrium, $s = \frac{1}{2\beta(1+q)}\left[\frac{\left(w^H - w^L\right)(1+q)^2 A^2}{(1-\beta)(w^L)^2} + (1-\beta)w^L - (1+2\beta q + \beta)w^H\right]$.

We can then rewrite *Condition 2*:

$$\begin{aligned}
4(w^L)^2\left(h_1^L - \bar{h}_1\right)^2 &< q\frac{1-\beta}{(1+q)^2}(w^H - w^L)\left\{\frac{\left(w^H - w^L\right)(1+q)^2 A^2}{(1-\beta)(w^L)^2} - (1+\beta)(1+q)(w^H - w^L)\right\} \\
4(w^L)^2\left(h_1^L - \bar{h}_1\right)^2 &< q(w^H - w^L)^2\left\{\frac{A^2}{(w^L)^2} - \frac{(1+\beta)(1-\beta)}{(1+q)}\right\} \quad \text{(B.72)}
\end{aligned}$$

Let us denote:

$$z_2 = q\frac{\left(w^H - w^L\right)^2}{4\left(w^L\right)^2}\left\{\frac{A^2}{\left(w^L\right)^2} - \frac{1-\beta^2}{1+q}\right\} \quad (73)$$

Knowing that, according to Condition 1 (42), $z_2 > 0$, and that $h_1^L - \bar{h}_1 > 0$, Condition 2 can be rewritten:

$$\left(h_1^L - \bar{h}_1\right)^2 < z_2 \Leftrightarrow h_1^L - \sqrt{z_2} < \bar{h}_1. \quad (74)$$

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