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Abstract

Recent empirical evidence links migrant remittances and return migration, and stresses the impact of uncertainty on migrant decisions. Theoretical analyses of the motives for remittances generally neglect these features, and do not include alternative strategies such as savings, which potentially have very different implications for both migrants and origin countries. This paper presents a model of endogenous remittances, savings and return decisions under uncertainty. This setting, which applies to long-term international migration, addresses the following questions. Which migrant characteristics affect their remittance-saving portfolio decisions? How do these decisions interact with migration success and return plans? In our framework, migrants make remittance and saving decisions at an early stage of migration, when migration success and return options are uncertain. Over time, information about professional prospects is acquired, and conditionally on past decisions, migrants adjust their return plans. We show that migrants anticipating a large wage in the host country, or a relatively low risk of migration failure are less likely to remit and to return, and more likely to save. These results are in line with recent empirical evidence, such as the large share of non-remitting migrants, the fact that migrants facing higher risks are more likely to remit, and the potentially poor economic performance of returnees. Finally, we provide a rationale for the support by relatives in the sending country of low-skill, illegal migration.

Keywords: remittances; savings ; risk ; return migration

JEL codes: D13, D80, JE

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1 Introduction

Over the last decade, migrant remittances have become a key element of many developing economies. In 2012, remittances represented a quarter of the GDP's of countries such as Moldova, Lesotho and Nepal, and reaching even half of Tajikistan's GDP.[1] Remittances are also important because their growth is both faster and more stable than official aid. For instance, the average annual growth rate of remittances to Sub-Saharan Africa has amounted to 13.9 % over the 1995-2010 period.[2] These transfers help recipients in countries of origin to cope with adverse shocks, and foster investments in various domains, such as education, productive assets and innovative technologies, but also in financial development, housing and social capital.[3]

In the face of such a major phenomenon benefiting recipient countries, economists have analyzed migrants' behavior, and in particular their motivations to send remittances. Migrant altruism towards the family left behind is among the most widely acknowledged motives for remittances. Practically all other motives can be related to the existence of some implicit contract between the migrant and the recipient. Such contracts involve mutual insurance and various forms of investments made by migrants in the country of origin, in human, physical, financial and social capital.

Although this literature is relatively vast, the analysis of the motives for remittances has until recently overlooked important elements of the migrant's decision process. While the link between remittances and return migration plans has recently been observed, theoretical analysis of the motives for remittances under endogenous return migration is scarce. More importantly, empirical studies show strong discrepancies between planned and actual duration of stay in the host country, due to uncertainty about their professional prospects and about their capacity to assimilate in the host country. Yet, theoretical analyses assume perfect foresight by migrants. Finally, a proper analysis of migrants' remittance behavior should include alternative strategies of transferring resources to the future, such as savings, whereas theoretical and empirical studies generally analyze either remittances or savings, but not both. Addressing the following questions may therefore improve our understanding of migrants' remittance and return migration strategies. Are migrants more or less likely to remit or to save under uncertainty? How do prior beliefs in terms of expected gains and risks from migration affect migrants' remittance-saving portfolio? How do these decisions interact with migration success and return plans?

In this paper, we present a model of endogenous remittances, savings and return decisions under uncertainty. Remittances foster investments in the host country, and these investments also benefit the migrant.[4] In our setting, migrants make remittance and saving decisions at an early stage of migration, when both migration success and return options are uncertain. Over time, when information about professional prospects is acquired, and conditionally on past savings and remittances, migrants choose to become either a permanent migrant or a return migrant by comparing the consumption levels they would obtain in each location. It must be noted that this setting is in line with long-term international migration rather than circular migration.[5]

Savings and remittances are two technologies to transfer resources to the future, but they differ in some important aspects. When migrants consider whether to stay in the host country or return, they view savings

[1] Source: Worldbank, Migration and Development Brief #21, 2013.

[2] Source: Migration and remittances factbook (2011), World Bank.

[3] See the literature review below.

[4] The notion of investment in this paper must be interpreted in a very broad sense, encompassing various forms of capital, including physical, financial, human and social capital.

[5] The case of non-EU workers residing in the European Union is a good example of this type of migration.

as completely mobile, in the sense that these may be withdrawn and used in either location. In contrast, remittances lead to investments which have location-specific returns. Indeed, a migrant eventually opting for a permanent stay in the host country will only enjoy part (if any) of the remittance investment. For instance, investments in physical capital (e.g. houses, small businesses, inheritance,...) will incur transaction costs to be repatriated in the host country. Other types of investments in the origin country, for example in social capital (prestige, social status) are simply immobile and illiquid and therefore sunk. These considerations have strong implications in terms of return plans under uncertainty. For instance, we show that migrants who tend to remit large amounts in the early stages of migration have, ceteris paribus, a higher probability of return. Also, ex-ante, returns to remittances are random since they depend on the uncertain final location. In other words, unlike savings, remittances affect the distribution of future consumption through (i) their different returns in each location and (ii) their impact on return migration.

This paper contributes to the literature by providing an original framework to analyze migrants' behavior. It allows us to relate profiles of migrants based on their prior beliefs about migration to various patterns of remittance-saving portfolios. More specifically, we show that migrants forming high expectations about the benefits of migration are less likely to remit and more likely to save.[6] Also migrants whose labor market outcomes are relatively risky in the host coutry are more likely to remit. Combining these prospect and risk characteristics, the model predicts that low-skill, illegal migrants are likely remit, whereas highly-educated and documented migrants are less likely to remit. Intermediate remitters are for instance legal migrants with low levels of education, and student migrants, whose returns from migration are potentially high but risky. Also, the model reproduces a series of recent stylized facts, linked to the determinants of remittance behavior, to the relationship between remittances and return intentions, and to the economic performance of returnees.

First, all empirical analyses of remittance behavior highlight the existence of a large share of non-remitting migrants. Bettin et al. (2012) develop an econometric model which distinguishes various reasons for not remitting, either due to credit constrains, or due to the mere non-willingness to remit. Our framework captures these different possibilities, and explains why some unconstrained migrants may prefer not to remit. Since remittances increase the likelihood of return migration ex ante, and remittances have a higher return in the country of origin, returns to remittances are likely to be convex. This convexity is a first potential source of corner solution in remittances. Also, migrants who ex ante have high expectations about their economic outcomes in the host country are less likely to return. Because of this, they are also more likely to bear transaction costs to repatriate returns to remittances, which limits the attractiveness of such a form of investment. An additional reason for not remitting is related to the location of risks in host and origin countries. Migrants facing relatively low risk in the host country have no incentives to remit, as remitting affects the probability of return, and as a result increases the exposure to risks from the origin country. Conversely, this result is consistent with the observation that migrants facing high uncertainty in the host country are more likely to remit (Amuedo-Dorantes & Pozo (2006) ; Dustmann et al. (2010) ; Sinning (2011)).

The arguments on the impacts of expected gains and risks from migration provide a rationale for the important flows of illegal migration and their support by family members in developing countries. Indeed, these results imply that the relatives who supported low-prospect and/or risky migration are, provided that the initial migration itself is succesful, likely to receive remittances. Interestingly, such migrants are likely to remit independently of any pressure mechanisms, since it is in the own interest to remit.[7] These results are

[6] This result is in line with the numerous empirical papers observing that more educated migrants are less likely to remit.

[7] Illegal migrants also generally rely more on transnational networks, since such networks improve migrants' economic

strongly related in our model to the positive effect of past remittances on the likelihood of return. Dustmann et al. (2010) prove the existence of this "feedback effect" in their thorough analysis of the impact of return plans on remittances. They show that failing to take it into account leads to biased estimates of that impact.

Finally, the empirical literature provides mixed evidence on the economic success of return migrants. Our model provides rationales for this phenomenon, and may explain cases of negative selection of return migrants. For instance, Coulon & Piracha (2005) and Campos-Vazquez (2012) show that the average counterfactual wages of return migrants had they never migrated are lower than the average wages of stayers, despite the existence of a migration premium derived from the human capital accumulated in the host country. In our model, there is first a potential negative selection at the first stage of migration since, as explained above, migrants who have relatively low and risky benefits from migration are the most likely to remit, and therefore are likely to receive support. Second, because of transaction costs, the more migrants remit, the more they are ready to concede low wages in the origin country. Furthermore, the low prospect, high risk migrants are the most likely to remit and are therefore the most susceptible to return and earn low wages.

In line with the explained empirical evidence, this model allows us to identify two distinct types of investment motives for remittances.[8] First, when the expected returns to remittances are larger than the returns to savings, we say that remittances are sent with a "pure investment motive". Second, when the migrant's risk structure across locations is such that remittances reduce the total variance of future consumption, remittances may be sent with a "precautionary investment motive". Illegal migrants are particularly subject to this second motive.

The paper is organized as follows. A review of the recent literature is provided in Section 2. The general setting is introduced in Section 3. The case of risk neutral migrants is presented in Section 4, while the case of risk averse migrants is analyzed in section 5. Concluding remarks are provided in Section 6.

2 Review of the literature

This paper links three fields of the migration literature: the study of (i) the motives for remittances, (ii) return migration plans, and (iii) the role of uncertainty at the early stages of migration.

First, the literature analyzing the motives for remittances has been initiated by Lucas & Stark (1985). Recent surveys of this question are provided by Rapoport & Docquier (2006), Carling (2008) and Stark (2009). Remittances are generally motivated by altruism towards the left behind and/or by the existence of an implicit contract between the migrant and the recipient. This implicit contract can take various forms. Remittances may be part of a mutual insurance arrangement. Indeed, migration allows families to diversify their income sources (Stark & Levhari (1982)) and remittances can be considered as insurance transfers to the family left behind (de la Briere et al. (2002) ; Gubert (2002) ; Choi & Yang (2007)). Remittances may also be seen as the repayment by the migrant of an implicit loan which made the initial migration possible (Poirine (1997)). As previously mentioned, remittances also foster investments in education (Edwards &

prospects and provide them with informal insurance. The counterpart of these networks is that they exert a pressure to remit, which provides an additional reason why origin countries support risky migration.

[8] In order to keep the exposition as simple as possible, the altruism motive is not presented in this model. The inclusion of this motive, even though it would clearly provide an additional incentive to remit, would not qualitatively affect our main results, which describe the effects of remittances on return plans and on the expectation and the variance of the migrant's consumption. Furthermore, as discussed in the conclusion, the altruism motive is difficult to distinguish from a motive of investment in social capital in the origin country.

Ureta (2003) ; Yang (2008) ; Yang (2009) ; Calero et al. (2009) and Alcaraz et al. (2012)), productive assets (Adams (1998)) and innovative production technologies (Mendola (2008)), but also in financial development (Aggarwal et al. (2011)), housing (Osili (2004) ; Adams Jr. & Cuecuecha (2010)) and social capital (Maggard (2004) ; Gallego & Mendola (2009)).

Whether altruism is involved or not in the migrant's decision making process, these investments generally benefit both remittance recipients and migrants themselves, either in terms of physical or social capital. For instance, remittances maintain membership rights in home communities (Osili (2007)) and generate the gratitude from recipients (Stark & Falk (1998)). Remittances may also be sent to migrants' extended family and friends in order to ensure the provision of services, such as the maintenance of migrants' patrimony, cattle and crops (Cox (1987)). Finally, migrants may invest in their future inheritance by sending money to their parents and improve their position against their siblings (the so-called strategic bequest motive, observed by Hoddinott (1994), Schrieder & Knerr (2000) and de la Briere et al. (2002)).

Second, return migration is an important phenomenon. For instance, about 40% of migrants leave the host country after 5 to 7 years of migration (Bijwaard (2010) for the Netherlands, Dustmann & Weiss (2007) for the UK). Return migration has first been explained by location-specific preferences (Hill (1987) ; Djajic & Milbourne (1988)). More recent contributions relate return migration to long term strategies (Borjas & Bratsberg (1996)), motivated either by "lifecycle" or "target earnings" considerations. Migrants caring about lifecycle consumption determine the length of their stay abroad by trading off higher (utility) costs of staying abroad, including differences in purchasing powers, for higher earnings in the host country (Djajic & Milbourne (1988) ; Stark et al. (1997) ; Dustmann (1997) ; Dustmann (2003)). An increase in wages may lead "lifecycle migrants" to stay longer in the host country. In contrast, migrants wishing to invest in their country of origin need to accumulate sufficient "target earnings" before returning (Mesnard (2004), Djajic (2010)). These savings often translate into entrepreneurial activities, which require liquidities and are more profitable if migrants acquired specific skills and human capital in the host country (Dustmann & Kirchkamp (2002), Dustmann et al. (2011)). Compared to lifecycle consumption, "target earnings" considerations provide opposite predictions: higher wages in the host country allow migrants to reach the required level of savings faster, allowing them to shorten their stay in the host country. Yang (2006) uses exchange rate shocks to empirically test both theories and finds a larger support for the lifecycle theory.

As regards remittances, recent empirical evidence highlights the positive link between return intentions and remittances (Dustmann et al. (2010) ; Sinning (2011) ; Piracha & Randazzo (2011)) and between return intentions and asset holdings by migrants in the origin country (Dustmann & Mestres (2011)). Yet to the best of our knowledge, our model is the first to take into account this relation, and in particular the feedback effect of remittances on return plans (Dustmann et al. (2010)).

Third, with regard to uncertainty, most theories analyzing migration duration assume that duration is decided at the beginning of the migration process, under perfect foresight. There is however strong evidence that migrants form erroneous expectations about available opportunities in the host country (Borjas & Bratsberg (1996)) and about the length of their stay, for instance in case of illegal migration and/or of poor economic performance (Tunali (2000)). van Baalen & Müller (2008) follow a sample of migrants from Southern Europe and Turkey over 21 years using the German Socioeconomic Panel. While a mere 2.7% declared their intention to stay more than 20 years in 1984, 39% were still in Germany in 2004. These inaccurate expectations cannot only be attributed to the initial phase of migration, as for each additional year in the host country, about 70% of immigrants revise upward the duration of their stay. At the same time, about 26% of migrants who initially declared their plan to stay permanently in Germany had left by 2004. Labour market trajectories affect return migration, as shown by Kirdar (2009) and Bijwaard (2013) who both find that migrant unemployment has a positive impact on return. In addition to return decisions, recent empirical studies show that uncertainties about income and legal status also positively affect saving and/or remittance behavior (Amuedo-Dorantes & Pozo (2006) ; Dustmann et al. (2010) ; Sinning (2011) ; Piracha & Zhu (2012)). Yet, few theoretical works incorporate uncertainty. Galor & Stark (1991) assume that return itself is random and exogenous and show that the return probability induces migrants to save more than native-born individuals. Dustmann (1997) presents a model of savings and optimal duration under uncertainty. However, these decisions are jointly made ex ante.

Our paper contributes to the three mentioned fields in the following ways. Among the motives for remittances, we focus on the investment motive in various forms, including social capital (membership rights, gratitude, status). Interestingly, a self-interested behavior involving investments of this kind mimics the predictions of the altruism motive (Stark & Falk (1998)), since both altruistic and self-interested migrants benefit more from helping poorer recipients. Regarding the comparison between lifecycle and target earnings theories of return migration, our framework is more in line with lifecycle considerations, since high wages in the host country lower the likelihood of return migration. It is also worth noting that unlike many theoretical analyses previously cited, our model does not require differences in purchasing power or in preferences for consumption between host and home countries in order to motivate return migration. Instead, return migration is motivated here by the fact that for some migrants, remittances may have a higher return than savings, or may decrease future risks. Because of the feedback effect, remittances increase the willingness to return. In other words, return migration in our framework is driven by the comparison between savings and remittances and by the feedback effect. Finally, while the few studies which account for uncertainty preclude any revision of return migration plans when information about the migration outcome is revealed, our setting allows migrants to choose their final location after the revelation of information. This feature is one of the main driving forces of our results.

3 The model

Let us consider a migrant who lives for two periods, noted $t \in \{1, 2\}$. At the beginning of period 1, the migrant has just arrived in the host country h and earns a certain initial wage $w_1 \geq 0$, but faces uncertainty about long term wage prospects, i.e. wages that could be obtained by settling in the host country, or by returning to the origin country o after a migration experience. Formally, at the beginning of period 1, the migrant only knows the joint density function of period-2 wages in the origin and host countries, noted $k(w_o, w_h)$. Also, at this period, the migrant makes decisions on savings s and remittances r. Consumption in period 1 is written:

$$c_1 = w_1 - r - s. \tag{1}$$

Savings, which are placed on a bank account in the host country, produce τs at the beginning of period 2. Remittances are invested in the country of origin in some form of (physical, financial, social) capital.[9] This investment produces a return $R_l(r)$ for the migrant in period 2, which depends on the migrant's location

[9] While remittances need not always have an explicit investment purpose, they generally benefit the migrant by maintaining his/her membership rights, and by improving his/her social status in the community. In this case, they can therefore also be considered as a form of investment.

decision $l \in \{h, o\}$.[10] $R_l(r)$ is location-specific because if migrants choose to stay in the host country, migrants only partially benefit from investments made in the country of origin. The loss incurred in case of permanent migration is either due to transaction costs borne to liquidate the asset (e.g. a house, a small business,...), or simply because some specific types of assets, like social capital, are immobile, illiquid and therefore sunk. As a result, $R_o(r) \geq R_h(r)$. Also, let us define $D_R(r) \equiv R_o(r) - R_h(r)$ as the difference in returns to remittances between temporary and permanent migration, or transaction costs, which increase with the value of the investment: $D'_R(r) > 0$.[11]

At the end of period 1, the migrant observes w_o and w_h. Based on this information, the migrant decides at the beginning of period 2 whether to stay permanently in the host country, or to return to the country of origin. In order to do so, the migrant compares consumption levels in both locations. Period-2 consumption levels if the migrant opts for the origin / host countries are respectively:

$$c_o = w_o + R_o(r) + \tau s, \tag{2}$$

$$c_h = w_h + R_h(r) + \tau s. \tag{3}$$

Note that contrary to remittances and wages, savings are perfectly mobile, since they can be withdrawn and spent in any location.

Summing up, this setting highlights the trade-off between higher expected wages in the host country and higher returns to remittances in the origin country in a context of uncertainty. In the *first period,* the migrant decides on savings and remittances (s, r). In the *second period,* wages in both locations (w_o, w_h) are observed by the migrant, who chooses a location $l \in \{h, o\}$. Solving backwards, we start by analyzing the second period's problem, namely the location choice, and derive its consequences on the (ex ante) likelihood of return migration in period 1 and on saving and remittance decisions.

3.1 Optimal location choice

The migrant chooses the location in which the consumption level is the highest, so that ex-post, period-2 consumption $c_2 = \max\{c_o, c_h\}$. In this simple setting, this choice boils down to comparing the difference in returns to remittances between origin and host countries, $D_R(r) \equiv R_o(r) - R_h(r)$, to the difference in wages between host and origin countries, $D_w \equiv w_h - w_o$.[12] At this stage, note that $D_R(r)$ is certain and depends on a past endogenous variable, whereas D_w is a random variate.

Lemma 1 *In period 2, the migrant returns to the origin country if $D_w < D_R$.*

The condition for return migration simply comes from the comparison between c_o and c_h:

$$c_o > c_h \iff w_h - w_o \equiv D_w < D_R \equiv R_o - R_h.$$

[10] We do not impose specific assumptions on the shape of $R_l(r)$ and keep it general. It is likely however that this shape is affected by the relationship between the sender and the recipient of remittances, and we discuss this point in Section 4.2.

[11] This is obvious in the case of investments in social capital where $R_o(r) = 0$. Then, $D'_R(r) \equiv R'_o(r) > 0$. For other types of investments, this only implies that the larger the investment, the larger the cost to liquidate the asset, for instance in the case of proportional costs. A more complex framework involving a recipient in an agency relationship also leads to $D'_R(r) > 0$ (not presented here but available upon request).

[12] This basic version, which neglects differences in purchasing powers and country preferences, already allows us to reproduce many stylized facts about remittances and return migration plans. The impact of such differences will be discussed further.

Having determined the optimal location condition, we can now start the analysis of the migrant's problem in period 1. In this period, wages, and consequently the wage gap D_w, are treated as random variables. Return migration is therefore uncertain, and depends on the distribution of D_w. Let $f(D_w)$ denote the marginal density of D_w, where $f(D_w) = \int\int k(w_o, w_h)\,\iota(w_h, w_o, D_w)\,dw_o dw_h$, where $\iota(w_h, w_o, D_w) = 1$ if $w_h - w_o = D_w$ and $\iota = 0$ otherwise. The cumulative density function of D_w is noted $F(D_w)$.

Lemma 2 *In period 1, the probability of return migration,* $\Pr(D_w < D_R) = F(D_R)$*, increases with remittances:*

$$\frac{\partial F(D_R)}{\partial r} = f(D_R)\,D_R'(r) > 0.$$

This Lemma provides microfoundations of the "feedback effect" of remittances on return plans (Dustmann & Mestres (2009)).[13] In the next two sections, we will solve the migrant's problem in period 1, i.e. defining optimal remittances and savings under uncertainty, anticipating optimal location decisions in period 2. Since remittances have different returns depending on the location choice, but also affect the probability of return migration, they have complex effects on the distribution of consumption patterns in period 2. These effects pertain to expected consumption on the one hand, and risk on the other hand. For the sake of expositional simplicity, we will separate the cases of risk neutrality and risk aversion in two distinct sections. In order to do so, recall first that the migrant's preferences have two relevant aspects, namely risk aversion and consumption smoothing over time, which standard expected utility does not allow to disentangle.[14] In contrast, the more general non-expected utility theory developed by Selden (1978) and Kreps & Porteus (1978) separates risk aversion and consumption smoothing.[15] Following this approach, the migrant's utility is noted

$$U = u(c_1) + \delta u\left(g^{-1}E(g(c_2))\right), \tag{4}$$

where both $u(\cdot)$ and $g(\cdot)$ are increasing, concave functions. $g^{-1}E(g(c_2)) = \tilde{c}_2$ is the certainty equivalent functional of period-2 consumption, with

$$E[g(c_2)] = F(D_R)\,E(g(c_o)\,|D_w \leq D_R) + (1 - F(D_R))\,E(g(c_h)\,|D_w > D_R), \tag{5}$$

where with probability $F(D_R)$ the migrant returns to the country of origin and enjoys $E(g(c_o)\,|D_w \leq D_R)$, where c_o depends on the realization of w_o. With probability $(1 - F(D_R))$, the migrant stays in the host country and enjoys $E(g(c_h)\,|D_w > D_R)$. While the concavity of $u(\cdot)$ captures the migrant's taste for consumption smoothing, the concavity of $g(\cdot)$ captures the degree of risk aversion. Section 4 and 5 are based on two particular cases of Kreps-Porteus preferences. Section 4 covers the case of risk-neutral migrants having a taste for consumption smoothing, which corresponds to a linear $g(\cdot)$ function and a concave $u(\cdot)$ function. This case allows us to introduce the "pure investment motive" for remittances, which appears when the expected return to remittances dominates that of savings. In Section 5, we introduce risk aversion by posing that $u(\cdot)$ and $g(\cdot)$ are identical. This second case, which corresponds to expected utility, puts forward the "precautionary motive" for remittances: depending on the distribution of wage risks across locations, remittances may decrease the variance of future consumption.

[13] See the introductory section.

[14] For example, assuming risk neutrality under standard expected utility would impose the utility function to be linear. In this case, the migrant has no taste for consumption smoothing either, so that at equilibrium, consumption is always at a corner in one of the two periods.

[15] The models of Kreps and Porteus (1978) and Selden (1978) are equivalent but we use the formulation of Kreps and Porteus which is more intuitive. See Chapter 20 of Gollier (2004) for an introduction to non-expected utility.

4 Risk neutral migrant and the pure investment motive

Following equation (4) and using a linear $g(\cdot)$ function, the risk-neutral migrant's utility is:

$$U = u(c_1) + \delta u(E[c_2]),$$

where c_1 is defined in (1) and c_2 is equal to c_o (2) if $D_w < D_R$, and is equal to c_h (3) otherwise. Since D_w is by definition equal to $w_h - w_o$, it belongs to the same data generating process. Therefore, for a given pair (w_o, w_h) and its corresponding wage gap D_w, the following joint densities have the same values: $k(w_o, w_h) = m(w_o, D_w) = n(w_h, D_w)$, where $m(w_o, D_w)$ and $n(w_h, D_w)$ are joint densities of wages with D_w.[16] Using these notations, we can write the expectation of period-2 consumption by distinguishing the two final possible locations:

$$E[c_2] = \int_{-\infty}^{D_R}\int_{-\infty}^{+\infty} (\tau s + R_o + w_o)\, m(w_o, D_w) dw_o dD_w + \int_{D_R}^{+\infty}\int_{-\infty}^{+\infty} (\tau s + R_h + w_h)\, n(w_h, D_w) dw_h dD_w. \quad (6)$$

Let us first analyze the properties of the remittance technology in the way it affects the expectation of future consumption. Based on these properties, we will study in a second subsection the optimal remittances decision of risk-neutral migrants.

4.1 The impact of remittances on expected consumption

In this subsection, we will analyze the impact of remittances on (i) the expected consumption in each location, and (ii) the total expectation of consumption, taking into account optimal location decisions.

The first analysis will provide interesting results about the economic success of return migrants and of permanent migrants. In order to study the expected consumption in each location conditional, let us rewrite (6) as:

$$E[c_2] = F(D_R)\, E(c_o|D_w \leq D_R) + (1 - F(D_R))\, E(c_h|D_w > D_R), \quad (7)$$

where conditional expectations of consumption in case of return and permanent migration are respectively:

$$\begin{aligned} E(c_o|D_w \leq D_R) &= \tau s + R_o + E(w_o|D_w \leq D_R), \\ E(c_h|D_w > D_R) &= \tau s + R_h + E(w_h|D_w > D_R), \end{aligned}$$

and conditional expectations of wages are:

$$\begin{aligned} E(w_o|D_w \leq D_R) &= \int_{-\infty}^{D_R} \left(\int_{-\infty}^{+\infty} w_o m(w_o|D_w) dw_o \right) \frac{f(D_w)}{F(D_R)} dD_w, \\ E(w_h|D_w > D_R) &= \int_{D_R}^{+\infty} \left(\int_{-\infty}^{+\infty} w_h m(n_h|D_w) dw_h \right) \frac{f(D_w)}{1 - F(D_R)} dD_w. \end{aligned}$$

This decomposition allows us to assess the impact of remittances on the expected consumption in each location separately, taking into account the endogeneity of the location decision. Such an exercise brings two

[16] Note that by definition, $\int_{-\infty}^{+\infty} m(w_o, D_w) dw_o = \int_{-\infty}^{+\infty} n(w_h, D_w) dw_h = f(D_w)$.

interesting findings. First, it allows us to provide an explanation to the poor performance of some return migrants.[17] Second, it shows that remittances, although they are more productive in case of return migration, increase the conditional expectation of consumption of migrants settling in the host country.

Proposition 1 *Conditionally on optimal location decisions in period 2,*

1. *remittances decrease the expected wage $E(w_o|D_w \leq D_R)$, but have an ambiguous impact on the expected consumption in the country of origin:*

$$\frac{\partial E(c_o|D_w \leq D_R)}{\partial r} = R_o'(r) + \frac{\partial E(w_o|D_w \leq D_R)}{\partial r},$$

where $R_o'(r) \geq 0$ but $\frac{\partial E(w_o|D_w \leq D_R)}{\partial r} < 0$.

2. *remittances have a positive impact on the expected wage and consumption in the host country:*

$$\frac{\partial E(c_h|D_w > D_R)}{\partial r} = R_h'(r) + \frac{\partial E(w_h|D_w > D_R)}{\partial r} > 0,$$

where $R_h'(r) > 0$ and $\frac{\partial E(w_h|D_w > D_R)}{\partial r} > 0$.

Proof. See Appendix 1. ■

Remittances have an ambiguous impact on $E(c_o|D_w \leq D_R)$ because, ceteris paribus, migrants who remit more are ready to concede lower wages in the origin country. Indeed, as r increases, so does D_R, so that the condition to return ($D_w \leq D_R$) is easier to satisfy. In other words, return migration is compatible with higher values of D_w, that is, lower (higher) values of w_o (w_h). This result provides a rationale for poor economic outcomes of return migrants: the more migrants remit, the more likely they will return, and the lower the wages they are ready to accept in case of return. Conversely, remittances have a positive impact on $E(w_h|D_w > D_R)$: migrants who remit are less likely to stay, which implies that they will do so only for sufficiently large wages in the host country.

Having analyzed the impact of remittances by location, let us now analyze their global impact on $E[c_2]$. To this end, let us rewrite (6) as:

$$E[c_2] = \tau s + E[R] + E[w], \tag{8}$$

where:

$$\begin{aligned} E[w] &\equiv F(D_R)\, E(w_o|D_w \leq D_R) + (1 - F(D_R))\, E(w_h|D_w > D_R), && (9)\\ E[R] &\equiv F(D_R) R_o + (1 - F(D_R))\, R_h. && (10) \end{aligned}$$

$E[w]$ is the expected wage, based on the distributions of wages in each location conditional on the wage gap D_w. Similarly, $E[R]$ is the total expectation of return to remittances, which also depends on ex-post location decisions. In order to show the impact of remittances on $E[c_2]$, let us first analyze their impacts on $E[w]$ and $E[R]$ separately. The next Lemma shows that migrants who decide to remit anticipate lower expected wages, but higher expected benefits from remittances.

[17] As mentioned in the introduction, there is mixed evidence about the economic success of returnees. Despite the existence of a migration premium derived from the human capital accumulated in the host country, some analyses, such as Coulon & Piracha (2005) and Campos-Vazquez (2012), find a negative selection of return migrants: had they never migrated, the counterfactual wages of return migrants are lower than non-migrants.

Lemma 3 *Remittances have a negative impact on* $E[w]$ *and a positive impact on* $E[R]$*:*

$$\begin{aligned}\frac{\partial E[w]}{\partial r} &= -f(D_R)D_R' D_R < 0,\\ \frac{\partial E[R]}{\partial r} &= f(D_R)D_R' D_R + E[R'(r)] > 0,\end{aligned}$$

where

$$E[R'(r)] \equiv F(D_R)R_o'(r) + (1 - F(D_R))\, R_h'(r) > 0. \tag{11}$$

The first part of the lemma, which states that remittances have a negative impact on expected wages, is explained by the following intuition. Remitting increases the likelihood of return migration by $f(D_R)D_R'$. The global distribution of wages is unaffected by this change, except at the margin where migrants are indifferent between returning and staying, i.e. when $D_w = D_R$. When switching from staying to returning, they renege on w_h to earn a wage w_o instead. Therefore, they suffer a loss D_w at this marginal point, which is precisely equal to D_R.

The second part of the lemma highlights two positive effects of r on $E[R]$. The first effect stems from the fact that, as for $E[w]$, remittances increase the likelihood of return migration at the margin. At this margin, migrants enjoy a return $R_o(r)$ instead of $R_h(r)$: they benefit from a marginal increase equal to D_R. The second and most obvious term accounts for the marginal returns to remittances in each location, $R_o'(r)$ and $R_h'(r)$. Weighting these two marginal returns by their respective probabilities leads to $E[R'(r)]$.

Proposition 2 *The total expectation of future consumption is increasing, and potentially convex in remittances.*

$$\begin{aligned}\frac{\partial E[c_2]}{\partial r} &= \frac{\partial E[R]}{\partial r} + \frac{\partial E[w]}{\partial r} = E[R'(r)] > 0,\\ \frac{\partial^2 E[c_2]}{\partial r^2} &= f(D_R)\left(D_R'(r)\right)^2 + E[R''(r)],\end{aligned} \tag{12}$$

where

$$E[R''(r)] = F(D_R)R_o''(r) + (1 - F(D_R))\, R_h''(r).$$

Combining the two parts of Lemma 3 leads directly to Proposition 2. This proposition shows first that remittances affect $E[c_2]$ through an increase in returns to remittances, but also a decrease in the expected wage, since remittances increase the likelihood of migrating back to the country of origin, where wages are on average lower. However, the net marginal effect of remittances on expected consumption is always positive, and corresponds to the expected marginal return to remittances, $E[R'(r)]$. The following figure illustrates these effects. In this figure, when remittances are close to zero, the probability of return migration is zero, so that $E[R(r)] = R_h(r)$, and $E[w] = E[w_h]$. As remittances increase, the likelihood of return migration becomes strictly positive, and $E[R(r)]$ increases, as it becomes a convex combination of $R_h(r)$ and $R_o(r)$. Also, $E[w]$ decreases, as it depends on the distribution of both w_h and w_o. As stated in the previous proposition, the sum of these two effects is always positive (the blue curve is always increasing in r). As remittances increase further, they become so large that the probability of returning to the origin country becomes equal to 1. In that case, $E[R(r)] = R_o(r)$, and $E[w] = E[w_o]$. Further increases in remittances no longer affect expected wages, while returns to remittances are perceived with certainty in the country of origin.

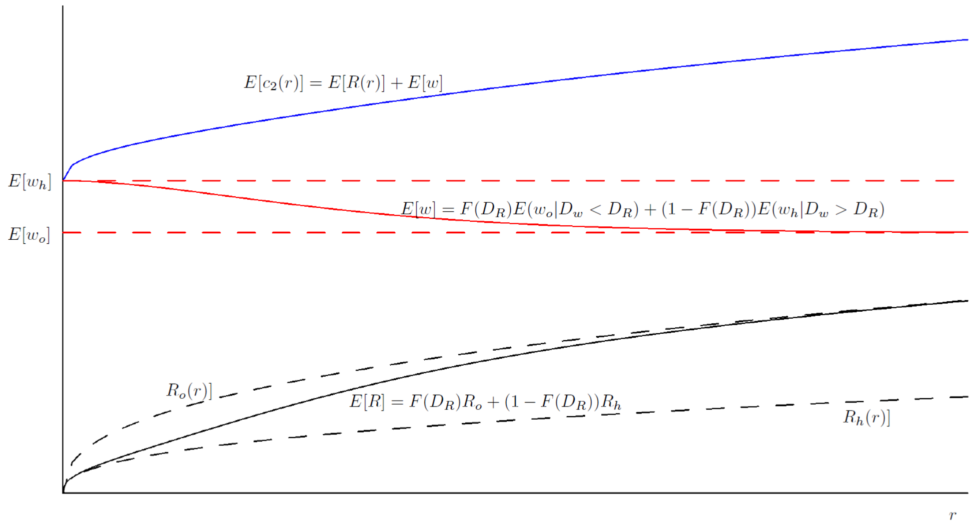

Figure 1: The remittance technology

Secondly, the proposition shows that expected consumption is not only increasing, but may also be *convex* in r. This potential convexity comes from the first term in the right hand side of (12), which is positive and is due to the feedback effect of remittances. Indeed, even if $R_o(r)$ and $R_h(r)$ are not convex, expected consumption may be more and more increasing in remittances because the more the migrant remits, the higher the probability of returning to the origin country, where the benefits of remittances are the highest. In other words, as the migrant remits, $E[R(r)]$ puts more weight on $R_o(r)$, and less on $R_h(r)$. In the following figure, we present a case where $R_o(r)$ and $R_h(r)$ are both linear, so that, following the previous reasoning, returns to remittances are always convex: $\frac{\partial^2 E[c_2]}{\partial r^2} = f(D_R)\left(D_R'(r)\right)^2 \geq 0$. This figure illustrates that as long

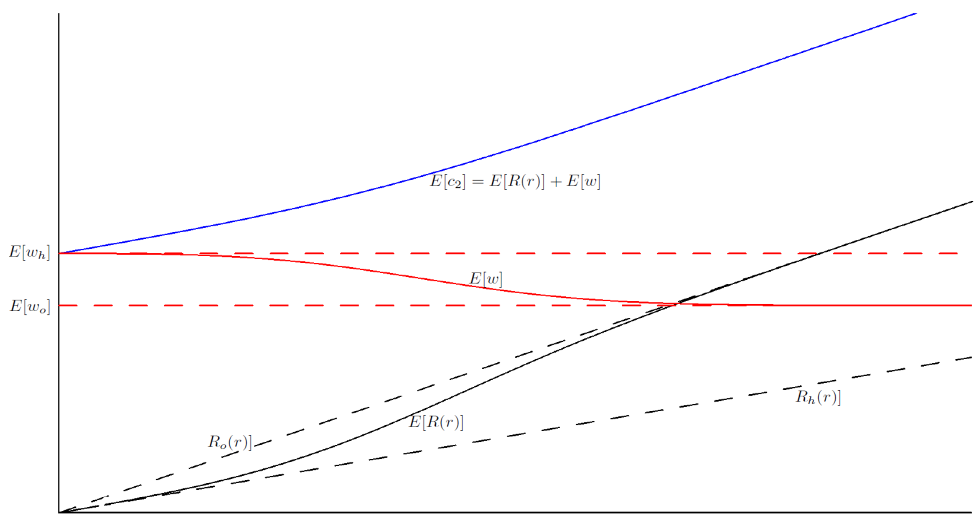

Figure 2: The remittance technology (convex case)

as remittances increase the likelihood of return migration, $E[c_2]$ is always convex in remittances when $R_o(r)$ and $R_o(r)$ are linear.

This possible variety in the "technology" of returns to remittances gives rise to the following questions: (i) which migrant characteristics are likely to lead to high/low or concave/convex returns to remittances, and (ii) how does this affect the migrant's optimal remittances behavior? We address the first question in the next subsection, looking at the impact of migrants' beliefs about migration success in terms of wages and at recipients' characteristics in the country of origin and their use of remittances.

4.2 How migrant characteristics affect the impact of r on $E[c_2]$

In this subsection, we discuss the impact of migrants' and recipients' characteristics on the shape of returns to remittances, both through $\frac{\partial E[c_2]}{\partial r}$ and $\frac{\partial^2 E[c_2]}{\partial r^2}$. While we provide here analytical results and their interpretation, the interested reader can find graphical representations of these results based on calibrations of the model in Appendix 2.

First, we show that the higher migrants' anticipations about migration success in terms of wages, the lower their expected marginal returns to remittances. In order to show this, let us consider that some migrants have higher wage prospects from migration than others following the concept of first order stochastic dominance. A migrant with high (low) wage prospects faces a cumulative distribution of the wage gap between host and origin countries noted $F_{P_h}(D_w)$ ($F_{P_l}(D_w)$). The distribution of the wage gap for migrants with high prospects first-order stochastically dominates that of migrant with low wage prospects: $F_{P_h}(D_w) \leq F_{P_l}(D_w)$ for all D_w. In other words, for any given D_w, the higher the migrant's wage prospects, the lower $F(D_w)$. Note that first order stochastic dominance implies that migrants with higher prospects have a higher expected wage gap: $E_{P_h}(D_w) \geq E_{P_l}(D_w)$.

Lemma 4 *For all r, the higher the migrant's wage prospects, the lower $\frac{\partial E[c_2]}{\partial r}$.*

Proof. One can rewrite $\frac{\partial E[c_2]}{\partial r} = E[R'(r)]$ as $F(D_R(r))D'_R + R'_h(r)$, which clearly increases with $F(D_R(r))$. For a given level of D_R, a migrant with higher migration prospects faces a lower expected marginal return to remittances. See Appendix 2 for a graphical illustration. ■

Let us now discuss how recipient characteristics affect $\frac{\partial^2 E[c_2]}{\partial r^2}$. We have seen that $\frac{\partial^2 E[c_2]}{\partial r^2}$ is the sum of two terms, $f(D_R)(D'_R(r))^2$ and $E[R''(r)]$. While the first is always positive, the second term may also be positive, depending on the way recipients in the origin country use remittances. Indeed, $E[R''(r)]$ is more likely to be positive in poor receiving households than in rich ones. Intuitively, poor families are likely to first allocate remittances to their basic needs. The more the migrant remits, the higher recipients' capacity to switch to more productive investments, which also benefits the migrant. Marginal returns to remittances are therefore negligible for low levels of remittances, and become attractive as recipient households have improved their living conditions. As a result, migrants originating from poor households are more likely to face convex returns to remittances. This reasoning has been illustrated by Adams (1998), which shows that households with a migrant member have a higher marginal propensity to invest.

In the next section, we analyze migrants' optimal saving and remittance decisions, taking into account the potential heterogeneity in the remittance technology across migrants.

4.3 Optimal savings and remittances under risk neutrality

The risk-neutral migrant's objective is:

$$\underset{\{s,r\}}{Max}\ U = u(c_1) + \delta u(E[c_2]),$$

where c_1 and $E[c_2]$ are defined in (1) and (8), and both r and s need to satisfy non-negativity constraints. While remittances can obviously not be negative, borrowing is precluded by the migrant's lack of credibility to repay a loan in case of return migration. As mentioned in Proposition 2, returns to remittances may either be concave, or convex. Let us analyze these two cases separately.

Proposition 3 *Under risk neutrality, if $R_o(r)$ and $R_h(r)$ are sufficiently concave, then $\frac{\partial^2 E[c_2]}{\partial r^2} \leq 0$, and three types of remittance-saving portfolios are possible: $(0, s^*)$, (r^*, s^*) and $(r^*, 0)$, where:*

- *under "high" migration prospects (large $E[D_w]$): $(0, s^*)$ such that $\frac{u_1'}{\delta u_2'} = \tau > E[R'(0)]$,*
- *under "intermediate" migration prospects: (r^*, s^*) such that $\frac{u_1'}{\delta u_2'} = \tau = E[R'(r)]$,*
- *under "low" migration prospects (small $E[D_w]$): $(r^*, 0)$ such that $\frac{u_1'}{\delta u_2'} = E[R'(r^*)] > \tau$.*

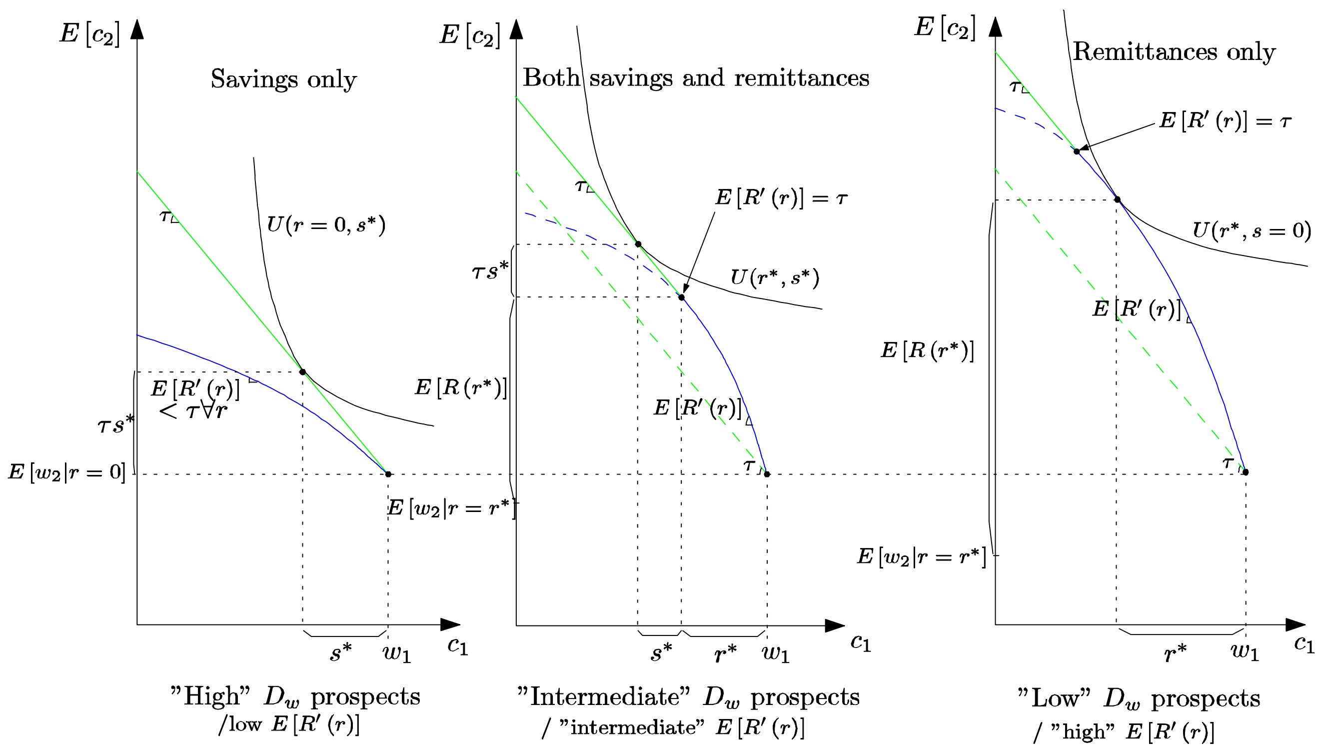

Figure 3: Optimal savings and remittances under concave returns to remittances.

The migrant's optimal strategy of saving/remittance portfolio is determined by the Kuhn Tucker conditions with respect to savings and remittances, which are respectively:

$$
\begin{aligned}
U_s &= -u_1' + \delta u_2' \tau = 0 \text{ and } s > 0, \qquad (13)\\
&= -u_1' + \delta u_2' \tau < 0 \text{ and } s = 0,
\end{aligned}
$$

and

$$
\begin{aligned}
U_r &= -u_1' + \delta u_2' E[R'(r)] = 0 \text{ and } r > 0, \qquad (14)\\
&= -u_1' + \delta u_2' E[R'(r)] < 0 \text{ and } r = 0. \qquad (15)
\end{aligned}
$$

If both first order conditions are satisfied with equality, that is, if there is an interior solution in both r and s, we obtain the following arbitrage condition:

$$E\left[R'(r)\right] = \tau. \tag{16}$$

The marginal returns to both activities must equalize at this double interior solution. However, depending on the migrant's wage prospects, one of these two first order conditions may not hold with equality, leading to a corner solution in either r or s. Following Lemma 4, if prospects are so high that $E\left[R'(0)\right] < \tau$, marginal returns to remittances are too low for the migrant to send remittances ; instead he/she will focus on savings. In contrast, if prospects are low, the optimal level of remittances may still have a marginal return which dominates that of savings: $E\left[R'(r^*)\right] > \tau$. In this case, the migrant has no incentives to save and will only remit. These three cases are illustrated in Figure 3.

It must be noted that the solutions described here are valid if and only if $\frac{\partial^2 E[c_2]}{\partial r^2} < 0$. Intuitively, for the arbitrage condition, $E\left[R'(r)\right] = \tau$, to hold at equilibrium, remittances should have a decreasing expected marginal return. Indeed, remittances below the interior solution should have a higher marginal return than savings, while remittances beyond the interior solution should have a lower return than savings. If, as mentioned in the previous section, remittances have an increasing marginal return, this reasoning does not hold, and a corner solution will prevail. As shown in the next proposition, the case of convex returns to remittances is incompatible with an interior solution in both s and r.

Proposition 4 *If $R_o(r)$ and $R_h(r)$ are not sufficiently concave, then $\frac{\partial^2 E[c_2]}{\partial r^2} > 0$ and the optimal remittance/saving portfolio of the migrant is never diversified. Two remittance-savings portfolios are possible, $(0, s^*)$ and $(r^*, 0)$, where:*

- *under "high" migration prospects: $(0, s^*)$ with $U(0, s^*) > U(r^*, 0)$ and s^* such that $\frac{u_1'}{\delta u_2'} = \tau$,*
- *under "low" migration prospects: $(r^*, 0)$ with $U(r^*, 0) > U(0, s^*)$, and r^* such that $\frac{u_1'}{\delta u_2'} = E\left[R'(r^*)\right]$.*

Proof. See Appendix 3. ■

The main insight of this case is that the optimal remittance/saving portfolio of the migrant is never diversified when returns to remittances are convex. Which of the two assets is chosen depends again on return prospects. If prospects are high (low), marginal returns to remittances are low and the migrant saves (remits).

Figure 4 illustrates why an interior solution in both s and r is impossible under convex returns to remittances. On the left graph, for low values of r, marginal returns to remittances are too low compared to returns to savings, τ. Remitting large amounts in order to enjoy high marginal returns to remittances would distort the migrant's consumption path excessively (insufficient consumption in period 1) compared to the balance offered by savings (point S). The graph in the middle represents the limit case in which the migrant is indifferent between only saving (point S) and only remitting ($U(r^*, 0) = U(0, s^*)$). In this case, due to the convexity of returns to remittances, the migrant needs to remit a larger amount than what he/she would have saved ($r^* > s^*$) in order to reach the attractive portion of returns to remittances.[18] Finally, the last graph illustrates the case in which returns to remittances are large and/or very convex. Since marginal returns to

[18] The migrant therefore modifies his/her consumption path over time, conceding a lower consumption level in period 1 in order to enjoy a higher expected consumption level in period 2.

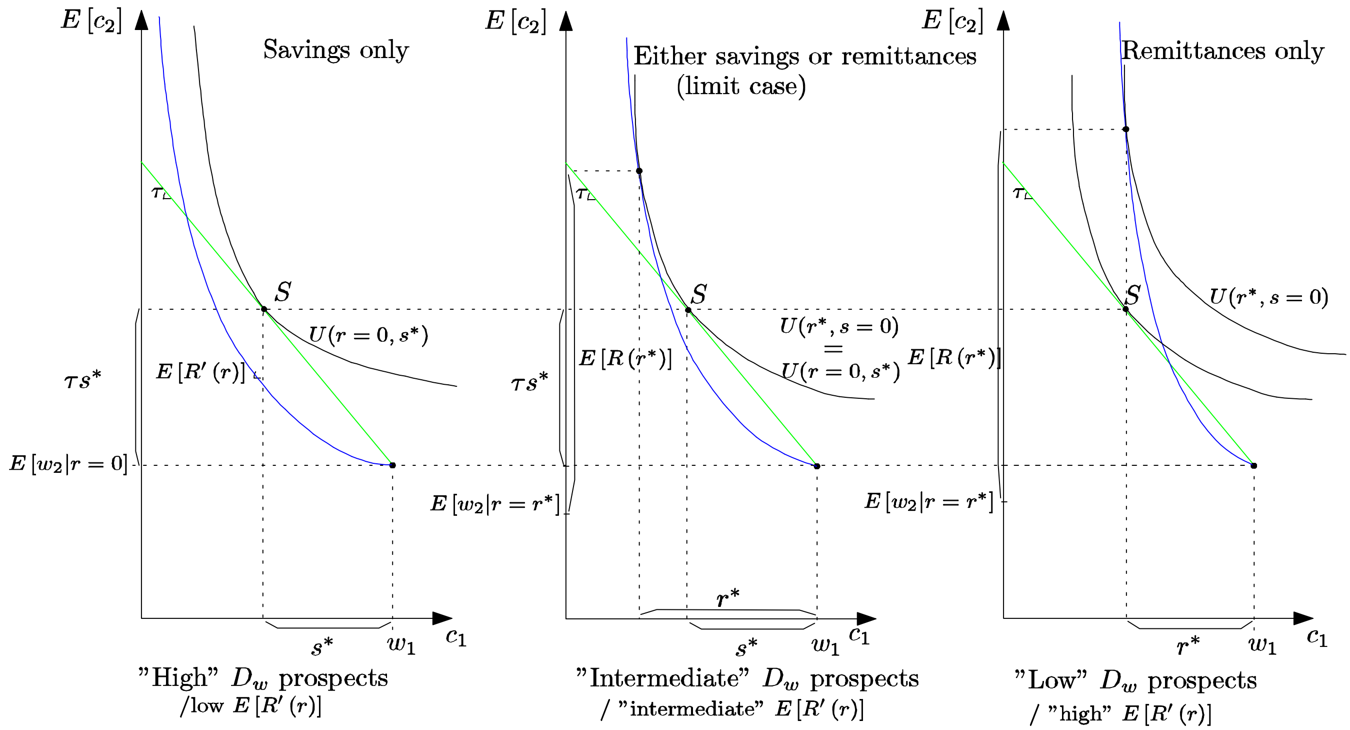

Figure 4: Optimal savings and remittances under convex returns to remittances.

remittances become quickly high, and the migrant only remits. Here, the migrant may consume more in period 1 than he/she would have with savings.

Let us now analyze the risk implications of remittances.

5 Risk averse migrants and the precautionary investment motive

In this section, we generalize migrants' preferences by introducing risk aversion, while maintaining the rest of the model unchanged. As previously mentioned, the migrant's utility function in this section is based on expected utility:

$$U = u(c_1) + \delta E u(c_2), \tag{17}$$

where c_1 is defined in (1) and c_2 is equal to c_o if $D_R > D_w$, and is equal to c_h otherwise, where c_o and c_h are defined respectively in (2) and (3). In this analysis, we will make use of the standard concepts of certainty equivalent and Arrow-Pratt approximation of the risk premium. Let $\tilde{c}_2$ denote the certainty equivalent of c_2, that is, $u(\tilde{c}_2) = Eu(c_2)$. This certainty equivalent can be approximated by

$$\tilde{c}_2 \approx E(c_2) - \frac{\eta}{2} Var(c_2), \tag{18}$$

where η is the migrant's degree of absolute risk aversion. Based on this formula, and since we already studied the effect of remittances on $E(c_2)$, we will focus in this section on the variance of c_2. One can show, as an application of the law of total variance, that $Var(c_2)$ takes the following form:

$$Var(c_2) = E[Var(c_2|D_w)] + Var[E(c_2|D_w)],$$

where

$$E\left[Var\left(c_2|D_w\right)\right] = F\left(D_R\right) Var\left(w_o|D_w \leq D_R\right) + \left(1 - F\left(D_R\right)\right) Var\left(w_h|D_w > D_R\right), \tag{19}$$

and

$$\begin{aligned} Var\left[E\left(c_2|D_w\right)\right] &= F\left(D_R\right)\left(1 - F(D_R)\right)\left[E\left(c_o|D_w \leq D_R\right) - E\left(c_h|D_w > D_R\right)\right]^2 \\ &= F\left(D_R\right)\left(1 - F(D_R)\right)\left[D_R + E\left(w_o|D_w \leq D_R\right) - E\left(w_h|D_w > D_R\right)\right]^2. \end{aligned} \tag{20}$$

Let us describe intuitively the two terms composing the variance of c_2. The first term, $E\left[Var\left(c_2|D_w\right)\right]$, which is decomposed in (19), represents the average variance over the two locations. More precisely, it is the weighted sum of consumption variances by location, where weights are the probabilities of choosing these respective locations. The second term, $Var\left[E\left(c_2|D_w\right)\right]$, which is decomposed in (20), represents the consumption variance which is due to differences in expected consumption across locations. This second term can be interpreted as the risk imposed by the uncertainty about the future location itself.

In the next subsection, we assess the impact of remittances on the aggregate risk faced by the migrant.

5.1 The impact of remittances on consumption variance

In this section, we will provide a rationale, based on risk considerations, to the fact that migrants facing relatively more risks in the host country, such as illegal migrants, are more likely to remit than others. Indeed, the initial distribution of uncertainty is an important determinant of the migrant's ability to use remittances as a precautionary investment. More precisely, we show that if the wage uncertainty is mostly located in the host country labor market, remittances have the property of *reducing* future consumption variance. This argument also provides a rationale for the fact that in developing countries, families provide support for illegal/risky migration. Indeed, it is in the own interest of migrants facing high risk in the host country to send remittances, so that families are likely to receive a return on investment independently of pressure mechanisms, such as migrant networks. This section also allows us to show that the location choice (temporary versus permanent migration) is per se a risk-coping mechanism, used ex post. Remittances, sent ex ante, improve the effectiveness of this ex-post risk-coping device.

The impact of remittances on aggregate risk is highlighted in the following Lemma. The economic intuition follows in the subsequent propositions.

Lemma 5 *The derivative of the total consumption variance is determined by*

$$\begin{aligned} \frac{\partial Var(c_2)}{\partial r} &= 2D_R' F\left(D_R\right)\left(1 - F\left(D_R\right)\right)\left[E(c_o|D_w \leq D_R) - E(c_h|D_w > D_R)\right] \\ &\quad + f\left(D_R\right) D_R'\left[Var\left(w_o|D_R\right) - Var\left(w_h|D_R\right)\right]. \end{aligned} \tag{21}$$

Proof. See Appendix 4. ■

Lemma 5 describes the effect of remittances on the variance of the migrant's future consumption. The sign of this effect depends on two terms. First, remittances are likely to decrease $Var(c_2)$ if the expected consumption is lower in the origin country than in the host country ($E(c_o|D_w \leq D_R) < E(c_h|D_w > D_R)$). Note that these expectations are conditional on the wage gap, and that the distribution of wages across the two locations is in fact a crucial determinant of the sign of this first term. Second, remittances are likely to decrease $Var(c_2)$ if, at the margin where the migrant is indifferent between staying and returning (i.e.

for $D_w = D_R$), the variance of wages in the origin country is lower than the variance of wages in the host country.

In order to provide more insights from this general formula and to highlight the role played by the distribution of wage risks across locations, we need to add more structure on the distribution of wages. To this end, we will assume that wages are drawn from a bivariate normal distribution, with means $E[w_o] = \mu_o$ and $E[w_h] = \mu_h$ and variances $Var[w_o] = \sigma_o^2$ and $Var[w_h] = \sigma_h^2$. We assume without loss of generality that wages are independently distributed across locations, so that $cov(w_o, w_h) = 0$.[19] The reason why we assume a bivariate normal distribution is that this distribution has appealing properties allowing analytical solutions and providing intuitive results. One implication of normality is that the migrant's income variance is minimized for $E(c_o|D_w \leq D_R) = E(c_h|D_w > D_R)$. This is intuitive since, at this point, uncertainty related to the location itself vanishes, given that ex ante the consumption levels are equal in both locations. It has to be noted, however, that if this level is optimal from an insurance perspective (precautionary motive), remittances are also potentially sent to increase the migrant's expected income (pure investment motive). This combination of motives is explored in the section devoted to the migrant's optimization problem.

5.2 How migrant characteristics affect the impact of r on $Var(c_2)$

As in the previous section, let us consider how some migrant characteristic may affect the remittance technology, in term of consumption variance this time. Let us define the relative variance of wages in the host country as

$$\theta_h \equiv \frac{\sigma_h^2}{\sigma_o^2 + \sigma_h^2} \in [0, 1].$$

Clearly, migrants differ in terms of θ_h. For instance, illegal migrants are more likely to face risk in the host country, in which case θ_h is close to one. On the other hand, well established and integrated migrants should face very little risk in the host country, while uncertainty in case of return is higher.

Proposition 5 *Remittances are risk-reducing if the relative host-country wage variance θ_h is sufficiently large:*

$$\frac{\partial Var(c_2)}{\partial r} < 0 \iff \theta_h > \widetilde{\theta}_h, \tag{22}$$

where the threshold $\widetilde{\theta}_h$ depends on $D_R(r)$:

$$\widetilde{\theta}_h \equiv \frac{D_R - E(D_w|D_w \leq D_R)}{E(D_w|D_w > D_R) - E(D_w|D_w \leq D_R))} \in [0, 1].$$

Proof. See Appendix 5. ■

Proposition 5 indicates that remittances decrease the aggregate income risk faced by the migrant if her initial risk is mainly located in the host country (large θ_h). Intuitively, increasing remittances makes return migration more likely, which reduces the exposition to the relatively large risk in the host country. An important implication of Proposition 5 is that $\widetilde{\theta}_h$ is itself a function of the level of remittances. The next proposition states that the impact of remittances on risk is non-monotonic.

[19] While wages for a given individual are independently distributed across locations, this assumption is compatible with the fact that the distribution parameters between the two locations are correlated *accross individuals*. For instance, highly educated agents probably face high expected wage in both locations, while low-educated migrants are likely to face low expected wages in both origin and host countries.

Proposition 6 *$\widetilde{\theta}_h$ is increasing in r. Therefore, $Var(c_2)$ is potentially non-monotonic in r, being decreasing for low r, and increasing for large r.*

Proof. See Appendix 6. ■

This proposition states that low levels of remittances may decrease aggregate risk, as in this case $\widetilde{\theta}_h$ is low and is likely to be smaller than θ_h. Large levels of remittances may on the other hand be risk-increasing, as $\widetilde{\theta}_h$ is then high and will eventually be larger than θ_h.

It must be noted at this stage that the impact of remittances on aggregate risk is largely driven by the fact that our framework accounts for the location choice. More precisely, it can be argued that in this setting, the genuine self insurance device is the migrant's ability to choose her location after information about wages is revealed. Indeed, for any initial geographical distribution of risks, the migrant is protected against low wages by the ability to select the best outcome among both locations. In other words, the migrant is capable of mitigating a negative shock in one location by moving to the other location. Moreover, as we show in the following example, this instrument is most powerful if risk is evenly distributed among locations. Example 1 provides the intuition behind propositions 5 and 6, namely that remittances are risk-reducing if risk is mainly located in the host economy and that transferring too much risk towards the origin country might, at the end, increase the aggregate risk faced by the migrant. In order to illustrate these points, we use a simplified framework where the only decision variable is location.

Example 1 *Suppose an agent can choose between two locations $\{a, b\}$, where wages are random and take the following form:*

$$\begin{aligned} w_a &= w - (1 - \theta_h)\, x, \\ w_b &= w + \theta_h x, \end{aligned}$$

where $x \sim F(x)$ and $E(x) = 0$. Let $\omega \equiv Max\{w_a, w_b\}$ define the wage the agent will obtain in period two after selection of the optimal location. Two results emerge from this example.

1. *The capacity to choose the best location always improves the expected consumption: the expected consumption conditional on optimal location, $E(\omega)$, is larger than the unconditional expected consumption w.*
2. *The consumption variance conditional on optimal location, $Var(\omega)$ is minimized when the initial income risk is identical in both locations, i.e. for $\theta_h = 1/2$.*

Proof. See Appendix 7. ■

As this simplified example illustrates, on the one hand, the location choice allows the migrant to increase expected consumption. On the other hand, it shows that aggregate risk depends on the initial risk composition. More precisely, the more the distribution of wage risks across locations is even ex ante, the lower the variance of consumption conditional on optimal location. If risk is mainly located in the host economy, remittances can be used to improve the balance of risks across locations, so that aggregate risk is reduced. This mechanism provides an explanation to the empirical evidence according to which migrants facing higher risks in the host country are more likely to remit (Amuedo-Dorantes & Pozo (2006), Dustmann et al. (2010)). On the contrary, as stated in Proposition 6, remittances may increase aggregate risk if the origin country is relatively riskier.

5.3 Optimal savings and remittances under risk aversion

The migrant maximizes expected utility with respect to savings and remittances. The first order conditions are given by

$$U_s = -u_1' + \delta u_2' \tau \leq 0, \tag{23}$$

$$U_r = -u_1' + \delta u_2' \frac{\partial \tilde{c}_2}{\partial r} \leq 0, \tag{24}$$

where $\tilde{c}_2$ is defined in equation (18), so that under constant absolute risk aversion,

$$\frac{\partial \tilde{c}_2}{\partial r} \approx \frac{\partial E(c_2)}{\partial r} - \frac{\eta}{2} \frac{\partial Var\,(c_2)}{\partial r},$$

where $\frac{\partial E(c_2)}{\partial r} = E\left[R'(r)\right]$, as described in Proposition 2, and where the impact on the variance is given by equation (21). We are now able to formally take into account both precautionary and pure investment motives. Under risk neutrality, we have shown that returns to remittances are likely to be convex, as discussed after equation (12). In the risk averse case, we need to also take into account the effect of remittances on consumption variance in order to define the concavity or convexity of total returns to remittances. Note that another source of migrant heterogeneity, namely risk aversion η, amplifies this result: the larger η, the larger the impact of r on $Var\,(c_2)$.

Definition 1 *Under risk aversion, total returns to remittances are concave if*

$$\frac{\partial^2 \tilde{c}_2}{\partial r^2} \approx \frac{\partial^2 E\,(c_2)}{\partial r^2} - \frac{\eta}{2} \frac{\partial^2 Var\,(c_2)}{\partial r^2} \leq 0. \tag{25}$$

Whether returns to remittances are convex or concave matters for the optimal migrant portfolio. Indeed, as in the section with risk neutrality, we know that the migrant's objective may admit an interior maximum in both s and r only if total returns to remittances are concave. Although convex total returns to remittances are still possible for risk averse migrants, this possibility is less likely than in the case of risk neutral migrants. The fact that concavity is the more relevant case under risk aversion is due to the impact of remittances on the variance of consumption. By Proposition 6, we know that $\frac{\partial^2 Var(c_2)}{\partial r^2} > 0$. This effect, whose magnitude increases with the degree of absolute risk aversion η, increases the likelihood of concave returns to remittances. As a result, it is likely that risk averse migrants choose strictly positive levels of both savings and remittances. However, one should keep in mind that, even if returns to remittances are concave, the non-negativity constraint on savings may, under some conditions, be binding. As in Proposition 3, this will be the case if the return to savings is low compared to the returns to remittances, which, in the risk averse case, combine potential benefits in terms of both expectation and variance of consumption. For instance, because remittances are risk-reducing for illegal migrants, these migrants are more likely to have no savings, other things being equal.

Proposition 7 *Optimal savings and remittances under risk aversion*

1. *If* $\frac{\partial^2 \tilde{c}_2}{\partial r^2} \leq 0$, *then depending on migration prospects and host-country relative risk* θ_h, *three types of remittance-saving portfolios are possible:*

   - *"high" and "safe" migration prospects (large* $E[D_w]$, *low* θ_h*):* $(0, s^*)$ *such that* $\frac{u_1'}{\delta u_2'} = \tau > \frac{\partial \tilde{c}_2}{\partial r}|_{(r=0)}$,
   - *"intermediate" migration prospects:* (r^*, s^*) *such that* $\frac{u_1'}{\delta u_2'} = \tau = \frac{\partial \tilde{c}_2}{\partial r}|_{r^*}$,
   - *"low" and "risky" migration prospects (low* $E[D_w]$, *large* θ_h*):* $(r^*, 0)$ *such that* $\frac{u_1'}{\delta u_2'} = \frac{\partial \tilde{c}_2}{\partial r}|_{r^*} > \tau$.

2. *If* $\frac{\partial^2 \tilde{c}_2}{\partial r^2} > 0$, *then the optimal remittance/saving portfolio is never diversified:*

   - *"high" and "safe" migration prospects:* $(0, s^*)$ *with* $U(0, s^*) > U(r^*, 0)$ *and* s^* *such that* $\frac{u_1'}{\delta u_2'} = \tau$,
   - *"low" and "risky" migration prospects:* $(r^*, 0)$ *with* $U(r^*, 0) > U(0, s^*)$ *and* r^* *such that* $\frac{u_1'}{\delta u_2'} = \frac{\partial \tilde{c}_2}{\partial r}|_{r^*}$.

The last section provides a taxonomy of the motives for remittances, based on the analysis conducted above.

5.4 Remittances as pure and/or precautionary investment?

Figure 5 provides a taxonomy of investment motives for remittances. This taxonomy is based on the way remittances affect the expectation and variance of consumption at the margin, and is therefore represented in the space $\left(\frac{\partial Var(c_2)}{\partial r}; \frac{\partial E(c_2)}{\partial r}\right)$. Combining the first order conditions presented in equations (23) and (24),

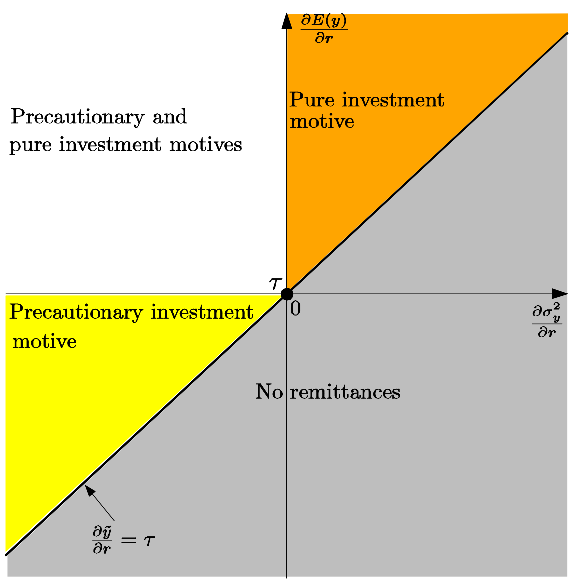

Figure 5: Taxonomy of the investment motives for remittances

we know that, for an interior solution,

$$\tau = \frac{\partial \tilde{c}_2}{\partial r} \approx \frac{\partial E(c_2)}{\partial r} - \frac{\eta}{2} \frac{\partial Var(c_2)}{\partial r}.$$

This equation is represented in Figure 5 by the straight line with positive slope $\frac{\eta}{2}$. All points below this line are such that $\frac{\partial \tilde{c}_2}{\partial r} < \tau$, in which cases it is not in the migrant's interest to remit. For this reason, r^* is at a corner in the grey area in the lower right corner of the graph.

In the upper left part of the figure, remittances are attractive because $\frac{\partial \tilde{c}_2}{\partial r} \geq \tau$. If $\frac{\partial E(c_2)}{\partial r} < \tau$, the investment motive is irrelevant since savings provide a better return. However, the fact that $\frac{\partial \tilde{c}_2}{\partial r} > \tau$ is due to the fact that remittances are risk-reducing at the margin. Therefore, remittances are spent on a precautionary motive in this case, which is represented by the yellow triangle. The opposite case is captured by the orange triangle, in which only the investment motive is relevant, since $\frac{\partial E(c_2)}{\partial r} > \tau$ whereas remittances increase risk: $\frac{\partial Var(c_2)}{\partial r} > 0$. Finally, the white square represents the area where both motives are met since remittances have a higher average return than savings and decrease the aggregate risk.

6 Concluding remarks

In this paper, we present a theory of migrants' decisions on their remittance-saving portfolio under uncertainty about migration success and endogenous return migration. Stylized facts show that migrants have poor information about their professional prospects at the time of arrival in the host country. In our model, beliefs about such prospects affect migrants' remittance and saving decisions at the early stage of migration, and will in turn shape the likelihood of return migration in the future. The model provides insights about the role played by such migrant characteristics on portfolio decisions. Two key results are obtained.

First, the higher the migration prospects (i.e. expected wage gain from migration), the lower the incentive to remit and the higher the incentive to save. This result stems from the fact that ceteris paribus, migrants with high migration prospects are less likely to return to their origin country. As a result, migrants anticipate that they will only partly enjoy the benefits of the investments financed by their remittances in the country of origin (housing, businesses, social capital,...). Therefore, they tend to remit less and to favor savings ex ante. Second, migrants who face a relatively large wage risk in the host country are more likely to remit: remitting allows them to balance future risks across locations as it increases the likelihood of return migration.

Combining these prospect and risk characteristics, the model predicts that low-skill, illegal migrants are likely to remit, whereas highly-educated and documented migrants are less likely to remit. Intermediate remitters are for instance legal migrants with low levels of education, and student migrants, whose returns from migration are potentially high but risky.

These results provide insights to explain the massive flows of low-skill, illegal migrants towards more developed countries. Indeed, it is in the own interest of such migrants to send remittances, independently of pressure mechanisms, such as migrant networks, or altruistic behavior. Therefore, relatives of these migrants anticipate that they are likely to receive remittances if they invest in them by fostering migration, even if their supervision mechanisms are limited.

The model also reproduces other stylized facts. For instance, the diversification of migrants' portfolios depends on the remittance technology, and more precisely on whether returns to remittances are concave or convex. When remittances have convex returns, migrants either save or remit, but do not invest in both assets. This result contributes to explanation of the large share of non-remitting migrants. Also, the model can explain potential cases of negative selection of return migrants through two effects. First, we have seen that family support for migration may not be targeted towards the brightest candidates, since migrants with low and risky wage prospects are more likely to remit. Second, remitting migrants are more likely to return in order to enjoy the benefits of their remittances, which leads them to accept potentially lower wages than if they had not remitted.

Finally, let us discuss some assumptions of the model.

First, the migrant is assumed purely selfish. It must first be noted that, as shown by Stark & Falk (1998), migrants' remitting behavior towards poor recipients may be mistakenly interpreted as altruism, since they may simply be due to the migrant's taste for gratitude from recipients. The impact per monetary unit on gratitude is indeed, ceteris paribus, greater for poor recipients than rich ones. Interestingly, this approach is in line with the investment motive we analyze in this paper. Still, let us briefly discuss the impact of altruism in our model. It must be highlighted that most of our results would not be affected by the introduction of altruism. Indeed, our conclusions on the technological effects of remittances on the expectation and variance of future consumption are independent of the migrant's preferences. Naturally, this does not mean that altruism towards the recipient would not affect the migrant's saving and remitting decisions. Clearly, altruism provides an additional motive to remit, favoring remittances over savings. However, introducing altruism implies the inclusion of the recipient's utility in the migrant's utility function. Because the recipient's utility is concave in remittances, altruism would therefore reduce the degree of convexity of the returns to remittances. Because of this second effect, an interior solution in both remittances and savings is more likely.

Second, the paper does not take into account subjective preferences for one country nor the difference in purchasing powers between the host and the origin countries. On the one hand, country-specific preferences could easily be introduced in the model. Migrants having a strong preference for living in the country of origin would adopt similar strategies as migrants with low migration prospects, i.e. more likely to remit and return. One the other hand, introducing purchasing power differences would make the model more realistic but would considerably complicate the model without qualitatively affecting our results. In this case, all the migrant's income sources, including savings, would have a different impact according to the chosen location. While this complicates the analysis, this effect does not counterbalance our results on remittances, since returns to remittances are also affected by the additional asymmetric effect of purchasing power differences. In other words, the inclusion of different purchasing powers introduces an asymmetry across locations which affects all decision variables in the same way, so that our results would be qualitatively unchanged.

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7 Appendix 1: Proof of Proposition 1

First, recall that

$$E(w_o|D_w \leq D_R) = \int_{-\infty}^{D_R}\int_{-\infty}^{+\infty} w_o \frac{m(w_o, D_w)}{F(D_R)} dw_o dD_w = \frac{1}{F(D_R)}\int_{-\infty}^{D_R} E(w_o|D_w) f(D_w)\, dD_w.$$

Applying Leibniz's rule, and keeping in mind that the only object which depends on r is D_R,

$$\begin{aligned}
\frac{\partial E(w_o|D_w \leq D_R)}{\partial r} &= D_R'\left[\frac{f(D_R)}{F(D_R)} E(w_o|D_R) - \frac{f(D_R)}{F(D_R)^2}\int_{-\infty}^{D_R} E(w_o|D_w) f(D_w)\, dD_w\right] \\
&= -D_R' \frac{f(D_R)}{F(D_R)}\left[E(w_o|D_w \leq D_R) - E(w_o|D_R)\right], \\
&= -D_R' \frac{f(D_R)}{F(D_R)}\left[E(w_o|w_o \geq w_h - D_R) - E(w_o|w_o = w_h - D_R)\right] < 0. \qquad (26)
\end{aligned}$$

Second, similarly,

$$E(w_h|D_w > D_R) = \int_{D_R}^{+\infty}\int_{-\infty}^{+\infty} w_h \frac{n(w_h, D_w)}{1 - F(D_R)} dw_h dD_w = \frac{1}{1 - F(D_R)}\int_{D_R}^{+\infty}\int_{-\infty}^{+\infty} w_h n(w_h|D_w) dw_h f(D_w)\, dD_w.$$

Hence, applying Leibniz's rule again,

$$\begin{aligned}
\frac{\partial E(w_h|D_w > D_R)}{\partial r} &= D_R'\left[-\frac{1}{1 - F(D_R)} E(w_o|D_R) f(D_R) + \frac{f(D_R)}{(1 - F(D_R))^2}\int_{D_R}^{+\infty} E(w_o|D_w) f(D_w)\, dD_w\right] \\
&= D_R' \frac{f(D_R)}{1 - F(D_R)}\left[E(w_h|w_h > D_R + w_o) - E(w_h|w_h = D_R + w_o)\right] > 0. \qquad (27)
\end{aligned}$$

8 Appendix 2: Illustrating the remittance technology

First, the savings technology only relies on τ, which we pose equal to 1. The remittance technology primarily relies on $R_o(r)$, which we specify as $R_o(r; a, b) = b\frac{r^a}{a}$, with a and b positive, so that $R_o(r)$ is concave if and only if $a \leq 1$. Let $\gamma \in [0; 1]$ represent the proportion of R_o spent as transaction costs to repatriate the investment in the host country, so that $R_h(r) = (1 - \gamma) b\frac{r^a}{a}$ and $D_R(r) = \gamma b\frac{r^a}{a}$. Let period-2 wages and the wage gap be normally distributed, with

$$E\begin{bmatrix} w_h \\ w_o \\ D_w \end{bmatrix} = \begin{pmatrix} \mu_h \\ \mu_o \\ \Delta \end{pmatrix} \text{ and } Var\begin{bmatrix} w_h \\ w_o \\ D_w \end{bmatrix} = \begin{pmatrix} \sigma_h^2 & 0 & \sigma_h^2 \\ 0 & \sigma_o^2 & -\sigma_o^2 \\ \sigma_h^2 & -\sigma_o^2 & \sigma^2 \end{pmatrix},$$

where $\Delta = E[D_w] = \mu_h - \mu_o$ and $\sigma^2 = Var(D_w) = \sigma_h^2 + \sigma_o^2$. Under these assumptions, after some computations,[20] one can show that the expected wage (9) can be rewritten as

$$E(w) = \mu_h - \int_{-\infty}^{D_R} D_w f(D_w)\, dD_w,$$

where the density function $f(D_w)$ depends on Δ and σ^2. The parameter μ_h only serves as a scaling parameter, giving a relevant range for Δ, r and s. We will pose $\mu_h = 100$. Summing up, the remittance technology relies on the following set of parameters: $(\Delta, \sigma, a, b, \gamma)$. We start by showing the impact of remittances on $E(R(r)) = F(D_R) R_o + (1 - F(D_R)) R_h$, focusing on the case of concave returns to remittances, with $(\Delta, \sigma, a, b, \gamma) = (30, 10, 0.6, 4, 0.5)$.In this example, returns to remittances in the origin country (the upper

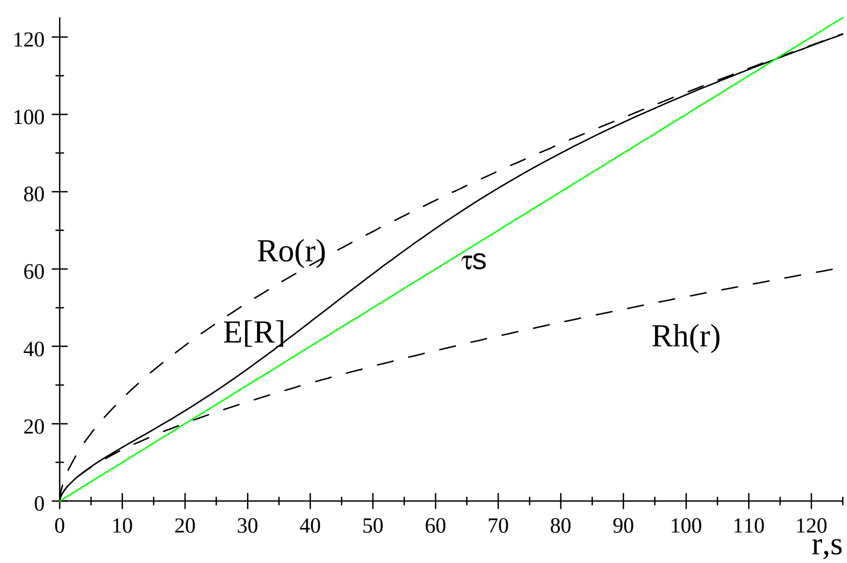


Figure 6: Remittances and savings

shaded curve) dominate returns to savings (the continuous green line), until r reaches very large values.

[20] To see this, note that under normality, we have that $E(w_o|D_w) = \frac{\sigma_h^2}{\sigma_o^2+\sigma_h^2}\mu_o + \frac{\sigma_o^2}{\sigma_o^2+\sigma_h^2}(\mu_h - D_w)$ and $E(w_h|D_w) = \frac{\sigma_h^2}{\sigma_o^2+\sigma_h^2}(\mu_o + D_w) + \frac{\sigma_o^2}{\sigma_o^2+\sigma_h^2}\mu_h$.

Returns to savings dominate returns to remittances in the host country (the lower shaded curve) for r larger than 20. However, it is more interesting to compare τs, the green line, to $E[R]$, the continuous black curve. When r is low, so is D_R and therefore the likelihood of return migration $F(D_R)$. As a result, for $r < 20$, $F(D_R) = 0$ and $E[R] = R_h$: expected returns are simply returns to remittances in case of permanent migration. As r increases, $F(D_R)$ becomes strictly positive, and the blue curve representing $E[R]$ separates from R_h and tends to R_o. When r reaches about 70, $F(D_R) = 1$, that is, return migration is certain, and $E[R] = R_o$. One can see in the example that expected returns to remittances tend to dominate returns to savings for all relevant values of remittances. There is, however, an additional point to take into account: since remittances affect return migration, and wages differ between both locations, remittances negatively affect future expected wages. Combining $E[R]$ and $E[w]$, one can show the total impact of remittances on $E[c_2]$.The red curve represents expected wage conditional on optimal location decisions, $E[w]$. As for $E[R]$,

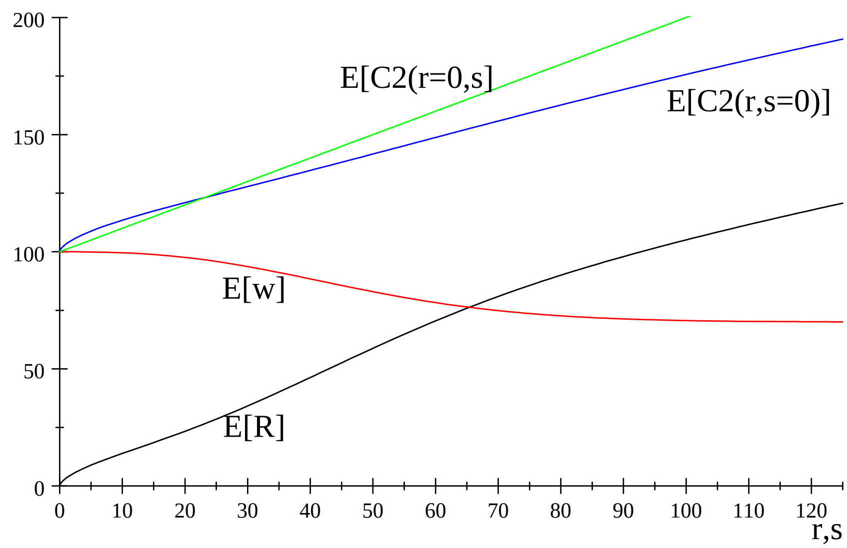


Figure 7: Effects of remittances and savings on future expected consumption

one can see that for very low values of r, the likelihood of return migration, $F(D_R)$, is close to zero, so that $E[w]$ is close to $\mu_h = 100$. As r increases, so does the probability of return migration, until $F(D_R) = 1$ (for about $r = 100$ in this example).

8.1 Comparative statics

We explained that prior beliefs about migration success had an important impact on returns to remittances. The next figure illustrates this point, keeping the same parameter values, except for Δ, which equals 40, 20 and 10 in the black, red and blue curves, respectively (the green line represents returns to savings):

The same exercise is performed for the shape of returns to remittances $R_l(r)$. We compare in the next figure the concave case presented so far to the linear case (the black curve, with $(a, b) = (1, 2)$) and the convex case (the red curve, with $(a, b) = (1.4, 0.8)$).

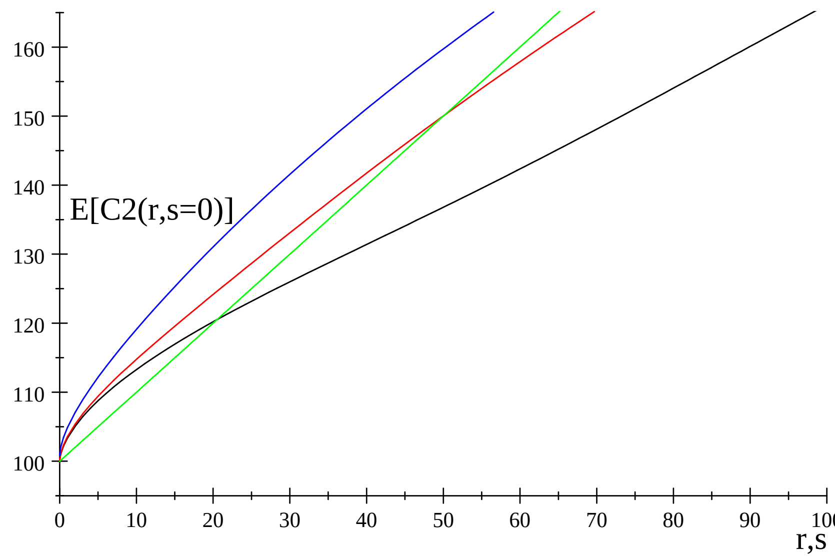


Figure 8: Comparative statics: migration prospects

9 Appendix 3: Proof of Proposition 4

Let us prove by contradiction that convex returns lead the migrant to either save or remit, but not to do both. For the double interior solution to be a maximum, the Hessian of U has to be definite negative, which requires that the determinant of H be positive. The Hessian writes

$$H = \begin{bmatrix} U_{ss} & U_{sr} \\ U_{rs} & U_{rr} \end{bmatrix},$$

where

$$\begin{aligned} U_{ss} &= u_1'' + \delta u_2'' \tau^2 < 0, \\ U_{sr} &= U_{rs} = u_1'' + \delta u_2'' \tau \frac{\partial E\left[c_2\right]}{\partial r} < 0, \\ U_{rr} &= u_1'' + \delta u_2'' \left(\frac{\partial E\left[c_2\right]}{\partial r} \right)^2 + \delta u_2' \frac{\partial^2 E\left[c_2\right]}{\partial r^2}. \end{aligned}$$

By the arbitrage condition (16),

$$\begin{aligned} U_{ss} &= U_{sr} = U_{rs} \equiv \Psi < 0, \\ U_{rr} &= \Psi + \delta u_2' \frac{\partial^2 E\left[c_2\right]}{\partial r^2}, \end{aligned}$$

The determinant of the Hessian is positive if and only if

$$\begin{aligned} U_{ss}U_{rr} - U_{sr}U_{rs} &= \Psi \left(\Psi + \delta u_2' \frac{\partial^2 E\left[c_2\right]}{\partial r^2} \right) - \Psi^2 = \Psi \delta u_2' \frac{\partial^2 E\left[c_2\right]}{\partial r^2} \\ &> 0 \iff \frac{\partial^2 E\left[c_2\right]}{\partial r^2} < 0. \end{aligned}$$

Therefore, we have just shown that if $\frac{\partial^2 E[c_2]}{\partial r^2} > 0$, then the double interior solution is not a maximum. We then need to identify which type of corner solution prevails. Two options must be considered. The first and

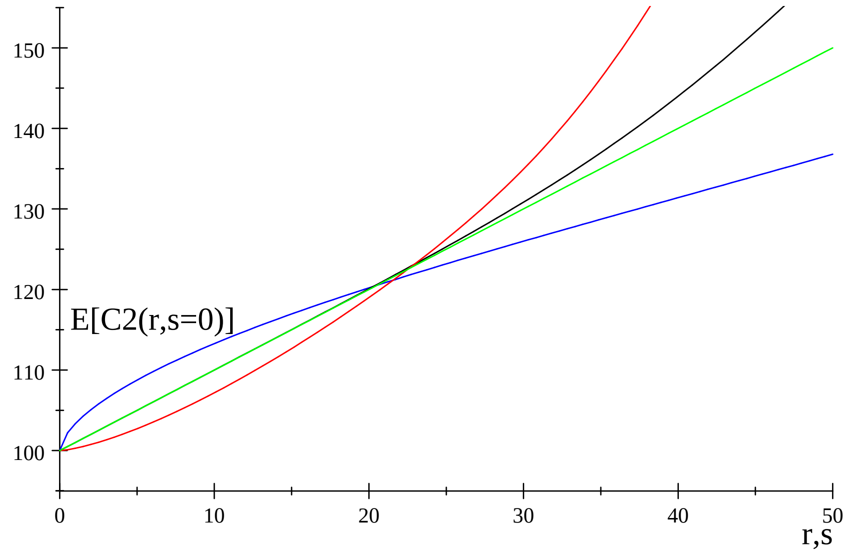


Figure 9: Comparative statics: concave, linear and convex returns R(r)

most obvious case is the corner solution in savings. If sufficient amounts are spent on remittances, their return eventually dominate the return to savings, leading to $s = 0$. This does not imply however that the migrant remits an infinite amount of money since he/she is prevented from borrowing. In fact, an interior solution in remittances is still feasible. Since $s = 0$, the conditions for having a maximum interior in remittances are the first and second order conditions solely on r:

$$\begin{aligned} U_r &= -u_1' + \delta u_2' \frac{\partial E\left[c_2\right]}{\partial r} = 0, \\ U_{rr} &= u_1'' + \delta u_2'' \left(\frac{\partial E\left[c_2\right]}{\partial r}\right)^2 + \delta u_2' \frac{\partial^2 E\left[c_2\right]}{\partial r^2} \leq 0. \end{aligned}$$

The latter condition might be fulfilled even if $\frac{\partial^2 E[c_2]}{\partial r^2} > 0$. Indeed, the more the migrant remits, the more his/her consumption path is distorted at the expense of first period utility. This cost is convex, while the benefit in terms of second period consumption is concave. The second case occurs if, due to liquidity constraints, the migrant is unable to spend enough remittances so as to raise their return to the level of the return to savings, τ. Then, remittances are at a corner and the migrant saves instead.

10 Appendix 4: Proof of Lemma 5

First, let us rewrite the total variance as

$$Var\left[c_2\right] = \Sigma_o + \Sigma_h + \Sigma_{oh}, \tag{28}$$

where

$$\begin{aligned}\Sigma_o &= F(D_R)\,Var(c_o|D_w \leq D_R),\\ \Sigma_h &= (1-F(D_R))\,Var(c_h|D_w > D_R),\\ \Sigma_{oh} &= F(D_R)(1-F(D_R))\left[E(c_o|D_w \leq D_R) - E(c_h|D_w > D_R)\right]^2\\ &= F(D_R)(1-F(D_R))\left[D_R + E(w_o|D_w \leq D_R) - E(w_h|D_w > D_R)\right]^2.\end{aligned}$$

Based this expression, one can write the effect of r on $Var[c_2]$ as the sum of three effects.[21]

We first split the resolution of these three effects in two separate subsections, and then gather them in third subsection.

10.1 The derivatives of Σ_o and Σ_h with respect to r

First, note that

$$\begin{aligned}\Sigma_o &= F(D_R)\int_{-\infty}^{D_R}\int_{-\infty}^{+\infty}(w_o - E(w_o|D_w \leq D_R))^2\, m(w_o|D_w)dw_o \frac{f(D_w)}{F(D_R)}dD_w,\\ \Sigma_h &= (1-F(D_R))\int_{D_R}^{+\infty}\int_{-\infty}^{+\infty}(w_h - E(w_h|D_w > D_R))^2\, n(w_h|D_w)dw_h \frac{f(D_w)}{1-F(D_R)}dD_w.\end{aligned}$$

Applying Leibniz's rule,

$$\begin{aligned}\frac{\partial\Sigma_o}{\partial r} &= D_R' f(D_R)\int_{-\infty}^{+\infty}(w_o - E(w_o|D_w \leq D_R))^2\, m(w_o|D_R)dw_o\\ &\quad -2\int_{-\infty}^{D_R}\int_{-\infty}^{+\infty}\frac{\partial E(w_o|D_w \leq D_R)}{\partial r}(w_o - E(w_o|D_w \leq D_R))\, m(w_o|D_w)dw_o f(D_w)\,dD_w.\end{aligned}$$

Note that, as seen in the previous appendix, $\frac{\partial E(w_o|D_w \leq D_R)}{\partial r}$ does not depend neither on w_o nor on D_w, and can therefore exit from the integrals of the second term. One can then rewrite

$$\begin{aligned}\frac{\partial\Sigma_o}{\partial r} &= D_R' f(D_R)\int_{-\infty}^{+\infty}(w_o - E(w_o|D_w \leq D_R))^2\, m(w_o|D_R)dw_o\\ &\quad -2\frac{\partial E(w_o|D_w \leq D_R)}{\partial r}\overbrace{\int_{-\infty}^{D_R}\int_{-\infty}^{+\infty}(w_o - E(w_o|D_w \leq D_R))\, m(w_o|D_w)dw_o f(D_w)\,dD_w}^{=0}.\end{aligned}$$

[21] Note that since wages are the only source of uncertainty,

$$\begin{aligned}Var(c_o|D_w \leq D_R) &= Var(w_o|D_w \leq D_R),\\ Var(c_h|D_w > D_R) &= Var(w_h|D_w > D_R).\end{aligned}$$

By a similar reasoning,

$$\begin{aligned}\frac{\partial \Sigma_h}{\partial r} &= -D'_R f(D_R) \int_{-\infty}^{+\infty} (w_h - E(w_h|D_w > D_R))^2 n(w_h|D_R) dw_h \\ & \quad -2\frac{\partial E(w_h|D_w > D_R)}{\partial r} \overbrace{\int_{D_R}^{+\infty}\int_{-\infty}^{+\infty} (w_h - E(w_h|D_w > D_R)) n(w_h|D_w) dw_h f(D_w) dD_w}^{=0}.\end{aligned}$$

Summing up,

$$\begin{aligned}\frac{\partial \Sigma_o}{\partial r} &= D'_R f(D_R) \int_{-\infty}^{+\infty} (w_o - E(w_o|D_w \le D_R))^2 m(w_o|D_R) dw_o \\ &= D'_R f(D_R) \left\{E\left[w_o^2|D_R\right] + E(w_o|D_w \le D_R)^2 - 2E(w_o|D_w \le D_R)E\left[w_o|D_R\right]\right\}, \\ \frac{\partial \Sigma_h}{\partial r} &= -D'_R f(D_R) \int_{-\infty}^{+\infty} (w_h - E(w_h|D_w > D_R))^2 n(w_h|D_R) dw_h \\ &= -D'_R f(D_R) \left\{E\left[w_h^2|D_R\right] + E(w_h|D_w > D_R)^2 - 2E(w_h|D_w > D_R)E\left[w_h|D_R\right]\right\}.\end{aligned}$$

10.2 The derivative of Σ_{oh} with respect to r

The derivative of the third term (Σ_{oh}) with respect to remittances is given by

$$\begin{aligned}\frac{\partial \Sigma_{oh}}{\partial r} &= D'_R f(D_R)(1 - 2F(D_R)) \left[D_R + E(w_o|D_w \le D_R) - E(w_h|D_w > D_R)\right]^2 \\ & \quad +2F(D_R)(1 - F(D_R)) \left[\begin{array}{c} \left[D_R + E(w_o|D_w \le D_R) - E(w_h|D_w > D_R)\right] \\ * \left[D'_R + \frac{\partial E(w_o|D_w \le D_R)}{\partial r} - \frac{\partial E(w_h|D_w > D_R)}{\partial r}\right] \end{array}\right],\end{aligned}$$

where $\frac{\partial E(w_o|D_w \le D_R)}{\partial r}$ and $\frac{\partial E(w_h|D_w > D_R)}{\partial r}$ are determined in (26) and (27).

10.3 The derivative of $\Sigma_o + \Sigma_h + \Sigma_{oh}$ with respect to r

Combining those terms, the derivative of the total variance is

$$\frac{\partial Var[c_2]}{\partial r} = \frac{\partial \Sigma_o}{\partial r} + \frac{\partial \Sigma_h}{\partial r} + \frac{\partial \Sigma_{oh}}{\partial r}.$$

After tedious calculations, we end up with equation (21).[22]

11 Appendix 5: Proof of proposition 5

First, let us show that the normality assumption helps obtain analytical results to our problem. Indeed, to assess the distribution of the difference of two random variables, such as $D_w = w_h - w_o$, is generally a very

[22] Those calculations make use of the following relationships:

$$\begin{aligned}Var(w_l|D_R) &= E\left(w_l^2|D_R\right) - E(w_l|D_R)^2, \\ E(w_h|D_R) - E(w_o|D_R) &= E(w_h - w_o|D_R) = D_R.\end{aligned}$$

and are available upon request.

demanding task which makes use of concepts of cross-correlation of distributions and complex conjugate of density functions. Such a distribution does not have an analytical expression in virtually all types of distribution functions, except the normal distribution. In other words, assuming a normal distribution is the unique case which provides an analytical solution to the problem of the determination of D_w's distribution. In this case, D_w, which is a linear combination of two normal random variables, is also normally distributed, with parameters $E\left[D_w\right] = \mu_h - \mu_o$ and $Var\left[D_w\right] = \sigma_h^2 + \sigma_o^2$.

11.1 Conditional expectation

Second, as we already saw in the previous section, we make extensive use of the concept of conditional expectation of wages. In general, the conditional expectation $E\left[w_o|D_w\right]$ is a complex, usually nonlinear, function of D_w, which depends on the joint distribution of w_o and D_w. In the case of the joint bivariate normal distribution, however, the conditional expectation is linear in D_w according to the following general formulation:

$$E\left[w_o|D_w\right] = E\left[w_o\right] + \left(corr\left(w_o, D_w\right)\sqrt{\frac{Var\left[w_o\right]}{Var\left[D_w\right]}}\right)\left(D_w - E\left[D_w\right]\right).$$

Let us develop this expression in order to provide more intuition. Since $cov\left(D_w, w_o\right) = -\sigma_o^2$ and $corr\left(D_w, w_o\right) = \frac{-\sigma_o^2}{\sigma_o\sqrt{\sigma_o^2+\sigma_h^2}} = -\frac{\sigma_o}{\sqrt{\sigma_o^2+\sigma_h^2}}$, we can write:

$$\begin{aligned} E\left[w_o|D_w\right] &= \mu_o + \left(-\frac{\sigma_o}{\sqrt{\sigma_o^2+\sigma_h^2}}\frac{\sigma_o}{\sqrt{\sigma_o^2+\sigma_h^2}}\right)\left(D_w - \left(\mu_h - \mu_o\right)\right) \\ &= \mu_o - \frac{\sigma_o^2}{\sigma_o^2+\sigma_h^2}\left(D_w - \left(\mu_h - \mu_o\right)\right) \\ &= \frac{\sigma_h^2}{\sigma_o^2+\sigma_h^2}\mu_o + \left(1 - \frac{\sigma_h^2}{\sigma_o^2+\sigma_h^2}\right)\mu_h - \left(1 - \frac{\sigma_h^2}{\sigma_o^2+\sigma_h^2}\right)D_w. \end{aligned}$$

Let $\theta_h = \frac{\sigma_h^2}{\sigma_o^2+\sigma_h^2}$ and $\bar{\mu} = \theta_h\mu_o + \left(1-\theta_h\right)\mu_h$. We can finally rewrite $E\left[w_o|D_w\right]$ (and following the same reasoning $E\left[w_h|D_w\right]$) as

$$\begin{aligned} E\left[w_o|D_w\right] &= \bar{\mu} - \left(1-\theta_h\right)D_w, \\ E\left[w_h|D_w\right] &= \bar{\mu} + \theta_h D_w. \end{aligned}$$

11.2 Conditional variance

The conditional variance under normality is based on the following general formula:

$$Var\left[w_h|D_w\right] = \sigma_h^2\left(1 - cor\left(w_h, D_w\right)^2\right).$$

Substituting, one can show that conditional variances of w_h and w_o are equal:

$$Var\left[w_h|D_w\right] = Var\left[w_o|D_w\right] = \frac{\sigma_h^2\sigma_o^2}{\sigma_o^2+\sigma_h^2}.$$

11.3 The effect of remittances on consumption variance

Combining the expressions of conditional expectation and variance with Lemma 5, the second term of (21) vanishes. The effect of remittances on consumption variance boils down to

$$\frac{\partial Var(c_2)}{\partial r} = 2D_R'F\left(D_R\right)\left(1 - F\left(D_R\right)\right)\left[E(c_o|D_w \leq D_R) - E(c_h|D_w > D_R)\right],$$

where, based on the conditional expectation formula, it is straightforward to show that conditional expectations with inequality are:

$$\begin{aligned} E\left[w_o|D_w \leq D_R\right] &= \overline{\mu} - \left(1-\theta_h\right) E\left[D_w|D_w \leq D_R\right] \\ E\left[w_h|D_w > D_R\right] &= \overline{\mu} + \theta_h E\left[D_w|D_w > D_R\right]. \end{aligned}$$

Therefore, $E(c_o|D_w \leq D_R) - E(c_h|D_w > D_R)$ can be rewritten as

$$\theta_h \left(E\left[D_w|D_w \leq D_R\right] - E\left[D_w|D_w > D_R\right]\right) + D_R\left(r\right) - E\left[D_w|D_w \leq D_R\right],$$

so that $\frac{\partial Var(c_2)}{\partial r} < 0$ if and only if

$$\begin{aligned} D_R\left(r\right) - E\left[D_w|D_w \leq D_R\right] &< \theta_h \left[E\left[D_w|D_w > D_R\right] - E\left[D_w|D_w \leq D_R\right]\right] \\ &\Longleftrightarrow \theta_h > \widetilde{\theta}_h\left(r\right). \end{aligned}$$

12 Appendix 6: Proof of Proposition 6

First, recall that

$$\widetilde{\theta_h}\left(r\right) \equiv \frac{D_R - E\left[D_w|D_w \leq D_R\right]}{E\left[D_w|D_w > D_R\right] - E\left[D_w|D_w \leq D_R\right]}.$$

If wages are jointly normally distributed, the following relationships hold:

$$\begin{aligned} E\left[D_w|D_w \leq D_R\right] &= \mu_D - \sigma_D \frac{\phi\left(\frac{D_R-\mu_D}{\sigma_D}\right)}{\Phi\left(\frac{D_R-\mu_D}{\sigma_D}\right)}, \\ E\left[D_w|D_w > D_R\right] &= \mu_D + \sigma_D \frac{\phi\left(\frac{D_R-\mu_D}{\sigma_D}\right)}{1-\Phi\left(\frac{D_R-\mu_D}{\sigma_D}\right)}, \end{aligned}$$

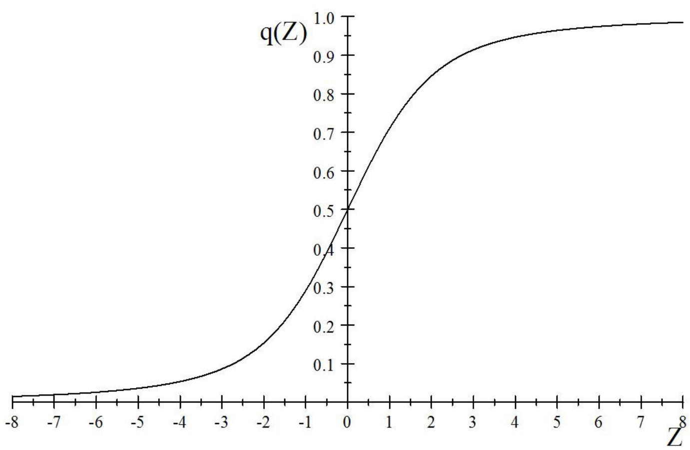
where $\mu_D = E\left[D_w\right] = \mu_h - \mu_o$; $\sigma_D = \sqrt{Var\left[D_w\right]} = \sqrt{\sigma_h^2 + \sigma_o^2}$ and where $\phi\left(.\right)$ and $\Phi\left(\frac{D_R - E[D_w]}{\sigma_D}\right)$ are the marginal and cumulative density functions of a standardized normal distribution, respectively. It follows that $\widetilde{\theta_h}\left(r\right)$ can be rewritten as

$$\widetilde{\theta_h} = q\left(Z\right) = \left(1-\Phi\left(Z\right)\right)\left(1+\frac{Z\Phi\left(Z\right)}{\phi\left(Z\right)}\right),$$

where $Z = \frac{D_R-\mu_D}{\sigma_D}$ and $q\left(\cdot\right)$ is a transformation of standard normal -marginal and cumulative- density functions and, importantly, does not depend on any parameter of the model. This last fact implies that

$$\begin{aligned} \widetilde{\theta_h}'\left(r\right) &= q'\left(Z\right)\frac{\partial Z}{\partial r} = q'\left(Z\right)\frac{D_R'}{\sigma_D} \\ &> 0, \end{aligned}$$

since $q'\left(Z\right) > 0$. Indeed, this transformation of the standard normal distribution is increasing in Z, as displayed in the following figure:



13 Appendix 7: Example 1

We can derive from the example that

$$\begin{aligned} E(w_a) &= E(w_b) = w \\ Var(w_a) &= (1-\theta_h)^2 Var(x) \\ Var(w_b) &= \theta_h^2 Var(x). \end{aligned}$$

Ex ante, taking into account the optimal location choice, the agent's income is given by a random variable with the following definition

$$\begin{aligned} \omega &\equiv Max\{w_a, w_b\} \\ &= \begin{cases} w-(1-\theta_h)x, \text{ if } x<0 \\ w+\theta_h x, \text{ otherwise.} \end{cases} \end{aligned}$$

Let us first mention that, in such a setting, the ability to choose a location after the risk is revealed allows the agent to earn a higher income, on average, than if she was locked in one of the two locations. Indeed,

$$\begin{aligned} E(\omega) &= \int_{-\infty}^{0} [w-(1-\theta_h)x]\,dF(x) + \int_{0}^{+\infty} (w+\theta_h x)\,dF(x) \\ &= w - F(0)E(x \mid x<0) \\ &> w. \end{aligned}$$

This result obviously applies to the more general framework of this paper. Second, let us discuss the impact of the initial risk composition θ_h on the agent's aggregate risk. To this end, we calculate the variance of the agent's income:

$$Var(\omega) = \int_{-\infty}^{0} (1-\theta_h)^2 x^2 dF(x) + \int_{0}^{+\infty} \theta_h^2 x^2 dF(x) - \left[\int_{-\infty}^{0} x dF(x)\right]^2.$$

Note that the third term does not depend on θ_h. Hence, $Var(\omega)$ is minimized for

$$\theta_h^* = \int_{-\infty}^{0} x^2 dF(x) \left[\int_{-\infty}^{+\infty} x^2 dF(x)\right]^{-1} \in [0,1].$$

which, under the sufficient condition that the distribution of x is symmetric, implies that $\theta_h^* = 1/2$.

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