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KEYWORDS

diaspora, fluctuations, income volatility, migration, portfolio choice, remittances

1 | INTRODUCTION

Over the last three decades, developing economies have consistently intensified and diversified their connections to the global economy. As a consequence, they have become increasingly exposed to macroeconomic volatility imported through external shocks (Aghion, Bacchetta, & Banerjee, 2004; Kose, Prasad, Rogoff, & Wei, 2009; Prasad, Rogoff, Wei, & Kose, 2007).[1] Recent episodes of crisis have demonstrated how brutally capital can fly out of emerging economies, thereby obstructing any countercyclical fiscal policy aimed at limiting the shock's macroeconomic cost (Arze del Granado, Gupta, & Hajdenberg, 2013; Edwards, 2004).[2] In this context of increased vulnerability to external shocks, migrants' remittances have come to be considered as a potential factor of microeconomic and macroeconomic risk sharing in developing countries. Indeed, since Stark and Bloom (1985), we know that remittances constitute an efficient tool of microeconomic risk diversification in the home country. By smoothing income fluctuations, migrant transfers reduce the instability of consumption, investment and fiscal revenues (Balli & Rana, 2015; Bugamelli & Paterno, 2011; Hakura, Chami, & Montiel, 2009) or they improve resilience against shocks (Mohapatra, Joseph, & Ratha, 2012).[3] As they prove less volatile than other financial flows (De, Islamaj, & Yousefi, 2015), remittances are also supposed to have countercyclical effects for the home country in the event of crises in the home country (Frankel, 2011; Kapur, 2004).[4]

However, not all geographical distributions of a country's diaspora will similarly mitigate microeconomic and macroeconomic risks home. This paper provides formal and empirical

[1]Macroeconomic volatility is a great concern for developing countries as it drags economic growth prospects (Loayza, Rancière, Servén, & Ventura, 2007; Ramey & Ramey, 1995; Rodrik, 1999) and worsens poor households' vulnerability (Aizenman & Pinto, 2005; Guillaumont-Jeanneney & Kpodar, 2011).

[2]Internal factors like policy shifts also explain output instability in emerging market economies, as evidenced by Aguiar and Gopinath (2007).

[3]Additionally, transfers promote financial development in the recipient country (Aggarwal, Demirgüç-Kunt, & Pería, 2011), thereby improving household resilience through a wider access to credit (Bettin, Presbitero, & Spatafora, 2017; Combes, Ebeke, Etoundi, & Yogo, 2014).

[4]Various studies find that the impact of remittances on macroeconomic stabilisation is not linear, countries receiving larger amounts of transfers being less likely to implement efficient economic policies (Hakura et al., 2009).

evidence that the impact of remittances on risk sharing in home country[5] is in fact conditional on the way its diaspora is distributed across different destinations. More specifically, the more diversified and stable the diaspora's locations, the less unstable the remittances to the home country and the less unstable the home country's GDP growth. In order to strengthen our argument that diaspora's location matters, we develop a model of migration portfolio risk combining the aggregate level and volatility of remittances sent by the diaspora, both weighted by the host country's share in the home country's diaspora. This simple framework enables decomposing the overall volatility risk generated by one country's diaspora as the sum of the contagion risk, related to the business cycle of host countries, and of the concentration risk, related to the extent to which the locations of the diaspora are geographically diversified or not.

Transposing the financial portfolio model (Markowitz, 1952; Merton, 1972) to the context of productive diversification and macroeconomic volatility, Lucas (1977) claimed that shocks to individual productive sectors have no effect on aggregate volatility in sufficiently diversified economies.[6] Transposed to remittances, the portfolio diversification argument states that when the geographical location of a country's diaspora is diversified, each independent shock to migrant's earnings in host countries would become inconsequential as the number of independent and identically distributed shocks increases in the country's migration portfolio. By showing that the volatility of remittances increases when a country's diaspora is located in destination countries that are more volatile and in a less diversified set of destination countries, our estimations confirm the existence of the contagion and concentration risks for a large panel of developing countries over 1995–2015. We provide empirical evidence that, by making remittances more volatile, the concentration of the diaspora has an indirect impact on aggregate volatility in the home country, impact that holds after other potential channels of volatility transmission are accounted for. Our results point to particularly high levels of risks for countries that are, at the same time, highly dependent on remittances and have their diaspora located in excessively concentrated or risky destination countries. For countries exposed to the two risks, the adverse effect of remittances on macroeconomic stability would be mitigated by a more diversified structure of labour migration by destination countries and by promoting more stable destinations.

As was argued by Carling (2008), by paying excessive attention to the microeconomic foundations of migration and migrant transfers, the literature on remittances has under-investigated the determinants of their variation that are related to source countries. Although the present paper is the first one to have addressed the impact of the diaspora's localisation on the volatility of remittances and on the resulting instability of home economy's GDP in the set-up of a migration portfolio model, it is connected to several other papers or recent streams of literature in various respects.

First, our measurement of macroeconomic volatility in host countries is close to Cooray and Mallick (2013), which computes the weighted average of real GDP growth volatility of all host countries from where a country receives remittances, with the weight attached to a host country being determined alternatively by its share of the total remittance inflows to the home country and by its share in the home country's stock of migrants. By estimating a dynamic panel data model using the system-GMM estimator over the period 1970–2007, Cooray and Mallick (2013) document that the level of remittance inflows increases with output volatility in host countries,

[5]In the rest of the paper, we will use the terms "home" and "origin" to name the country of origin of migrants and the terms "host" or "destination" to name the country of destination of migrants.

[6]As the number of independent and identically distributed shocks increases, each independent sectoral shock would become inconsequential according to the law of large numbers. Only aggregate shocks—affecting many economic sectors in the same way—are important to explain economic volatility in diversified productive systems.

especially for middle-income countries. Their finding is consistent with the assumption that the insurance motive of migrant workers prevails when host countries are riskier (Galor & Stark, 1990), and with the evidence provided by Amuedo-Dorantes and Pozo (2006) for remittances from US to Mexico. Still, neither are Cooray and Mallick (2013) interested by the impact of diaspora's concentration, nor do they document migrant's remittance volatility.

In a recent paper focusing explicitly on diaspora's concentration, Balli and Rana (2015) have provided evidence that the contribution of migrants' transfers to risk sharing in the origin country is larger when migrants' destinations are well diversified or more distant from the origin country. Although their result partially connects to ours, their framework is different as they focus more on remittance levels than on remittance volatility. Moreover, attention is mainly put on the mitigation of consumption volatility in the home country and not on the geography of diasporas, as we do in this paper. Not only our findings confirm that diaspora concentration matters to explain growth volatility in home countries, but also the portfolio set-up we use allows providing empirical evidence as to how the concentration risk articulates with the contagion risk to transmit volatility through remittances. It is worth noticing that although diaspora's concentration increases macroeconomic volatility home, it is not always detrimental to developing countries' economic development. By studying remittances to 50 developing countries from 2002 to 2007, Vaaler (2013) shows, for example, that diaspora's concentration abroad stimulates the discovery of venture opportunities back home. To our knowledge, this is the single study, with Balli and Rana (2015), that has addressed issues linked to diaspora concentration.

Second, this paper complements the now extensive literature on the smoothing hypothesis basically testing whether remittances are countercyclical with respect to income in worker's home country and procyclical with respect to income in the migrant's host country. Time series evidence was first provided that remittances from Germany to Turkey were either a-cyclical Sayan (2004) or pro-cyclical (Akkoyunlu & Kholodilin, 2008) with respect to the host country's business cycle, before Frankel (2011) confirmed the procyclical pattern on a larger sample of countries. We show in the present paper that the stability of remittances is driven by business cycles in host countries: to be able to remit to the origin country, migrants must in the first place make stable earnings, whatever altruistic or selfish are their motivations. Our findings also contribute to explain the pro-cyclical remitting pattern with respect to home economy's business cycle that is observed in the previous literature (Lueth & Ruiz-Arranz, 2006, 2007; Sayan, 2006; Sayan & Tekin-Koru, 2012). Indeed, when home and host economies are strongly integrated through migration, trade and FDI flows, business and remittance cycles are more synchronised; this could explain the procyclical behaviour of remittances with respect to both the home and host countries' income level.

Lastly, our focus on the concentration of diaspora echoes the prolific literature that has provided evidence that a more diversified trade structure helps reducing growth volatility, notably in resource-rich countries (Balavac & Pugh, 2016; Joya, 2015; Malik & Temple, 2009). di Giovanni and Levchenko (2009) or Kim, Lin, and Suen (2016) have, for example, shown that countries following their comparative advantage tend to exhibit higher growth instability in the long run because their export structure is excessively concentrated. Likewise, geographical diversification of trade allows reducing aggregate growth volatility (Caselli, Koren, Lisicky, & Tenreyro, 2015) and microeconomic export volatility (Kramarz, Martin, & Mejean, 2016). Other papers have paid attention to the transmission of external volatility through international flows of finance. Trade is an essential vector of volatility transmission at both firm and aggregate levels (di Giovanni, Levchenko, & Mejean, 2014, 2018). Apart from trade, fluctuations of foreign capital inflows also tend to exacerbate business cycles in developing countries through pro-cyclical effects (Kaminsky, Reinhart, & Végh, 2005).

Nicet-Chenaf and Rougier (2014, 2016) have, for example, shown that the level of FDI flowing in developing countries is highly dependent on macroeconomic conditions in source countries. Nonetheless, they do not consider concentration of the sources of FDI in their analysis.

The paper is structured as follows. Section 2 motivates the paper's focus on contagion and concentration risks. Section 3 presents the migration portfolio set-up underlying our empirical analysis. Section 4 exposes the estimation results and a series of robustness checks. Section 5 exposes some policy issues.

2 | REMITTANCE VOLATILITY, THE CONTAGION RISK AND THE CONCENTRATION RISK: STYLISED FACTS

2.1 | Remittance volatility and the contagion risk

We argue in the present paper that developing countries with large diasporas are exposed to a risk of volatility contagion through the remittances sent by their migrants. Although there are potentially various channels of volatility transmission linked to migration that are documented below, we adopt a restrictive definition of the contagion risk where output volatility in the economies in which the diaspora is located, as well as their co-movement, might contaminate the home economy through the volatility of remittances.

One critical channel through which diaspora transmits host country's volatility is via the remittances sent by migrants to their home country. As documented by various recent works, the level of remittances flowing to developing countries is strongly correlated to the business cycle of destination countries—mostly developed countries (Balli & Rana, 2015; Cooray & Mallick, 2013). Figure 1 provides an illustration of this correlation for four economies featuring large diasporas abroad. Economic recession in host countries traditionally translates into higher unemployment levels and lower wages, with these adjustments affecting more intensively migrant workers which are chiefly hired in precarious jobs and sectors. Le Heron and Yol (2019) shows, for example, that remittances received by Moldova dropped by 30% after the 2008 financial crisis and by 25% after the 2015 Russian crisis, which triggered recession in the former country.[7] Indeed, as shown by Figure 2, shortage of remittance leads to lower consumption levels in home country, possibly prompting a drop of tax revenue and pro-cyclical fiscal consolidation policies further worsening the contagion effect (Asatryan, Bittschi, & Doerrenberg, 2017).

A second and more indirect channel of volatility contagion is related to the positive effect of migration on trade and financial flows between the host and the home country. It is well established that migration spurs exports from the home to the host country through "nostalgia trade" and network effects (Boly, Coniglio, Prota, & Seric, 2014; Gould, 1994; Head & Ries, 1998). Consequently, home and host country's business cycles are connected through export fluctuations. In fact, economic conditions in the host country will simultaneously determine the levels of remittances and exports revenues flowing to the origin country. Taking the example of Moldova and Mexico again, we can see in Figure 3 that the level of remittances received by these two countries is strongly correlated with the level of their exports. This might not be surprising as Mexican migrants are mainly located in the US, the first trading partner of Mexico, while Moldovan migrants principally live in Russia and in the euro area, which are the main importers of Moldova's products. Such patterns might also be observed in countries featuring less concentrated diasporas.

[7]Mexico also experienced a sharp drop in remittances sent from the US following the estate bubble crisis. Between 2007 and 2008, remittances sent by Mexican migrants decreased by 850 million dollars.

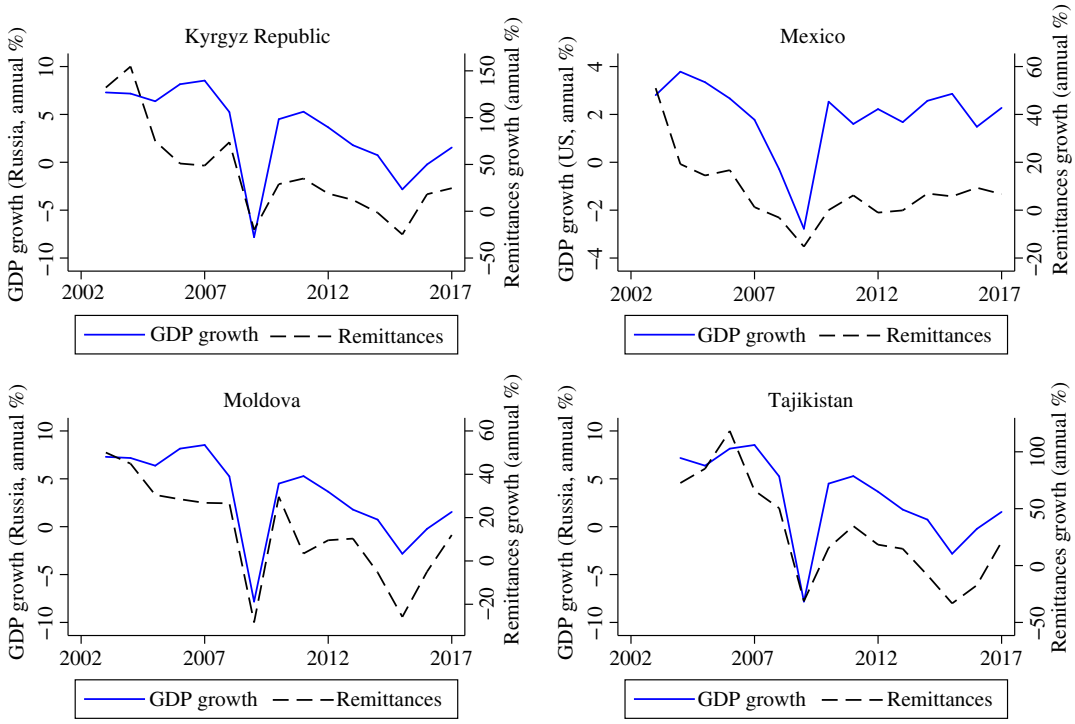

FIGURE 1 Remittances growth and main host country GDP growth.

Sources: World Bank and IMF [Colour figure can be viewed at wileyonlinelibrary.com]

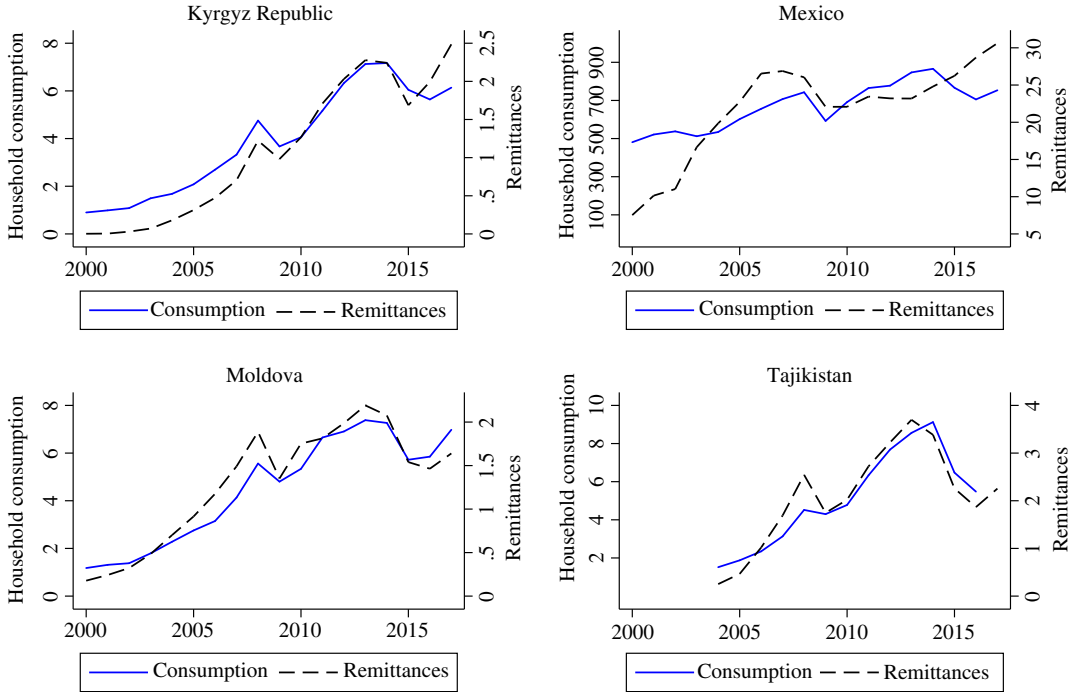

FIGURE 2 Remittances and households' consumption in home country.

Sources: World Bank and IMF. Current billion $US [Colour figure can be viewed at wileyonlinelibrary.com]

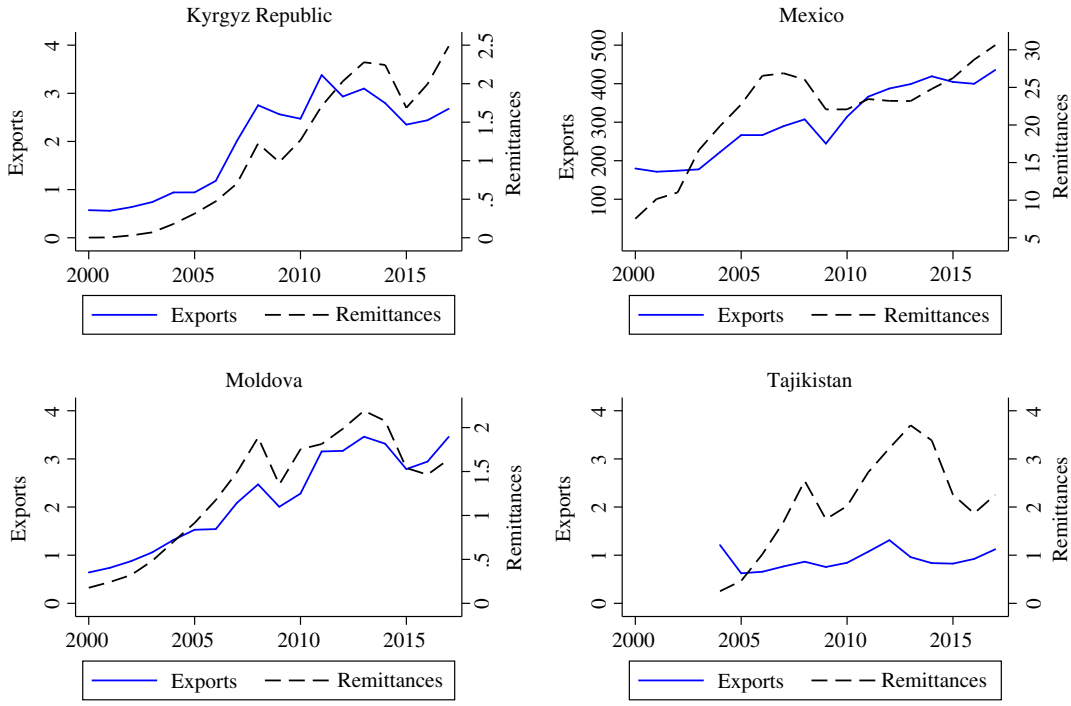

FIGURE 3 Remittances and exports in home countries.
Sources: World Bank and IMF. Current billion $US [Colour figure can be viewed at wileyonlinelibrary.com]

Income volatility prevailing in the countries where the diaspora is located might also contaminate home country through the fluctuations of financial flows, such as loans or FDI, going from the former to the latter. By mitigating information bias about the origin country of migrants, a large diaspora contributes to reducing the transaction costs faced by the host country's firms wishing to invest in the home economy (Kugler, Levintal, & Rapoport, 2018; Kugler & Rapoport, 2007). Insofar as they also are subject to the host economy's business cycle, financial flows will tend to co-move with remittances and exports, generating pro-cyclical effects in the origin country. Once again, although less obviously than for exports, parallel fluctuations of FDI and remittances to Mexico, mainly originating from the US, and in the Kyrgyz Republic, Moldova and Tajikistan, mostly originating in Russia, depicted by Figure 4 provide a good illustration of this phenomenon. Financial flows suffer from volatility along the business cycle of the economy where migrants are located, exactly as remittances do. As a consequence, these parallel sources of volatility transmission must be acknowledged if one wishes to correctly identify the responsibility of the remittance channel in the transmission of volatility from host to home country.

2.2 | Remittance volatility and the concentration risk

The concentration risk results from a lack of diversification of the destinations where one given country's migrants are located abroad. In the extreme case where a country's diaspora is concentrated in a single destination country, any economic downturn in this country will lead to a drop of migrants' transfers to their origin country that might not be compensated by the remittances sourced in more stable destinations. In other words, the more geographically concentrated the diaspora of a country, that is the less diversified the "portfolio" of destination countries, the more volatile the aggregate

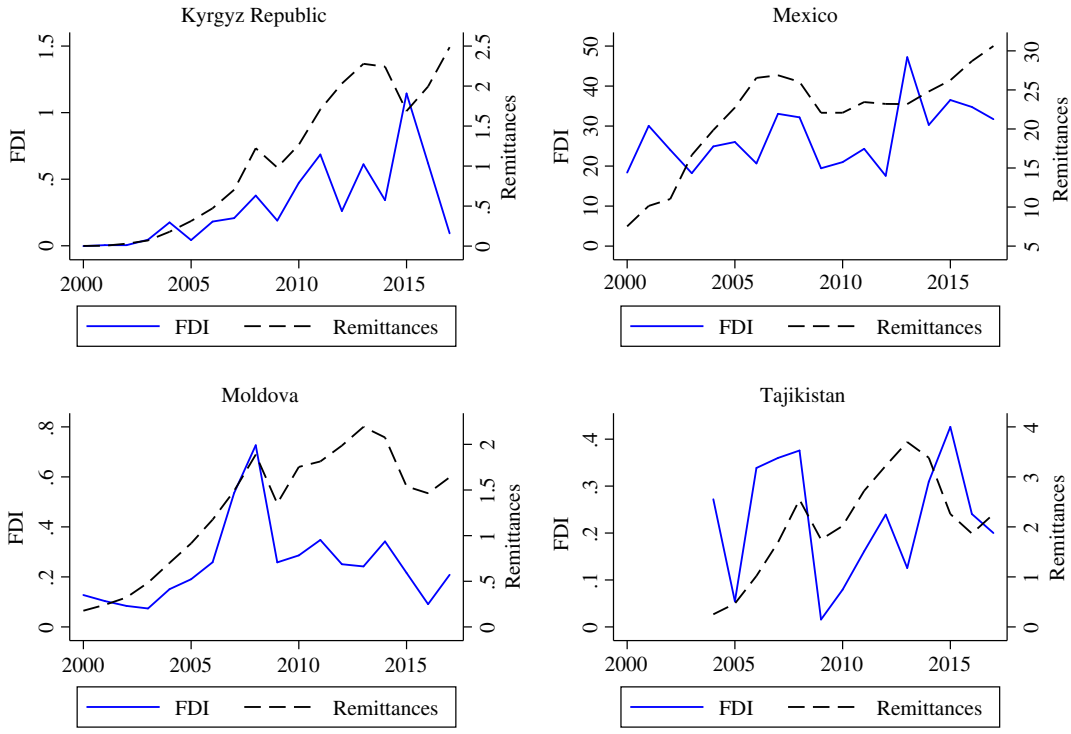

FIGURE 4 Remittances and FDI inflows in home countries.
Sources: World Bank and IMF. Current billion $US [Colour figure can be viewed at wileyonlinelibrary.com]

flows of remittances flowing back to the home economy. One straightforward way to describe the diversification mechanism would be to consider the risk that all migrants from a given origin will be exposed to a shock in the destination country and to show that this risk decreases with the number of destinations. Let the probability θ_j of a shock in the host country j be equal to $1/\alpha$, with this probability being similar for all countries j for the sake of simplicity. The risk that the entire diaspora, that is, all groups of migrants, will be hit by a shock in host countries is given by:

$$\cap_{i=j}^{n}\theta_j = \frac{1}{\alpha^n}, \tag{1}$$

with n standing for the number of host countries. It is straightforward from Equation (1) that the probability that all migrants will be exposed to a shock in their host country goes down when the number of destination countries n increases, that is, when the diaspora is less concentrated.

As an illustration, Mexican households were quickly and strongly affected in 2008 by the sharp drop of remittances consecutive to the financial crisis originating in the US, the main destination of the country's diaspora since 97.8% of Mexican migrants were located in the US in 2015 according to the United Nations. The result was a severe recession in Mexico the following year (−4.7%). One important observation here is that, although not to such extreme extent as it is for Mexico, developing countries' diasporas tend to be fairly concentrated in a few host countries. Although migrants should be dispersed over a large number of countries for the law of large number to apply, the distribution of the stocks of migrants is frequently fat-tailed, with diasporas tending to be concentrated in a few host countries. This pattern of geographical concentration of diasporas is confirmed by Table 1 showing for the sample of home countries used in the present

TABLE 1 Share of migrants taken into account (% stock) considering the main host country (left) and the four main host countries (right)

	Main destination country			Four main destination countries		
	Minimum	**Maximum**	**Average**	**Minimum**	**Maximum**	**Average**
1995	10.00	99.85	52.53	33.51	100	80.06
2000	11.46	99.91	51.50	35.33	100	82.48
2005	10.39	99.90	50.19	33.31	100	81.20
2010	10.69	99.93	49.21	32.71	100	80.71
2015	9.40	99.90	48.65	32.22	100	80.37

Source: United Nations data, authors' calculations. The sample is reported in Appendix 2.

paper that the four countries with the largest stocks of migrants account for a substantial part, at least 80% on average, of their diaspora. It should also be noticed that, on average, the first destination country alone accounted for a large share of 50% of the whole national diasporas during the 2010s.[8]

Various mechanisms have been put forward by the recent literature on migrations to explain diaspora's concentration. Migrant workers do not select their destination randomly (Mayda, 2010; Pedersen, Pytlikova, & Smith, 2008) as they tend to migrate in priority to countries already hosting national fellows. Migrant national communities already installed in the host country favour the arrival of new national migrants by reducing the cost of migration and facilitating their integration into the labour market (Chort, 2017; Colussi, 2015; Munshi, 2003). Likewise, network effects in the destination country help migrants to diversify their portfolio of insurance mechanisms by associating informal diaspora-based insurance and formal mechanisms of social protection (Sabates-Wheeler & Waite, 2003). The constitution of a diaspora of fellow migrants in a foreign country is therefore a dynamic and self-sustaining phenomenon, with network effects generating chain migration to this country at the expense of other destinations featuring more limited diasporas (Beine, 2013). According to Beine, Docquier, and Özden (2011), the size of diasporas exerts one of the most important quantitative impacts on the size and the composition of migration flows, once other factors are accounted for.[9] Relying on the cross-country gravity estimations of the determinants of bilateral migration flows of Beine and Parsons (2015) and Bertoli and Moraga (2012), Beine (2013) reports estimations of the elasticity of migration flows to the size of the diaspora of about 0.4 for all mixed-up flows (0.7 for the flows to OECD countries). Although rational at individual level, such behaviour might lead to a higher concentration risk at aggregate level, as remittances received by the origin country rely on a narrow set of destination economies.

[8]Consistently, we will restrict the list of destinations to the four main destination countries in our empirical work. We believe it will not bias the results as the other destinations only accounting for a limited share of the diaspora, their weight used in the overall risk computation would have been very weak.

[9]Recent empirical evidence shows that network effects are reinforced by various factors like common history (Geis, Uebelmesser, & Werding, 2013; Westmore, 2015), common language (Pedersen et al., 2008), linguistic and ethnic proximity (Fafchamps & Shilpi, 2013), cultural diversity in host countries (Wang, Graaff, & Nijkamp, 2016), geographical distance (Mayda, 2010), selective policies (Ortega & Peri, 2009) or wage differential (Grogger & Hanson, 2011; Rosenzweig, Irwin, & Williamson, 2006). On the determinants of migration, see Sjaastad (1962), Mincer (1978), Stark (1991), Borjas, Bronars, and Trejo (1992), Rotte and Vogler (1998), Chiswick (2000). For a general review, see Hagen-Zanker (2008).

3 | THE MIGRATION PORTFOLIO SET-UP

The theoretical intuitions supporting our empirical analysis can be conveniently formulated in the unique set-up of a portfolio model applied to the set of a country's diaspora locations. In this section, we adapt the simple model of migration destination choice of Beine, Docquier, and Özden (2015) in order to provide micro-foundations to the migration portfolio set-up used in the present paper. This enables to establish that, although families choose rationally destination countries featuring a large diaspora or lower volatility risks, the aggregation of these individually rational choices can create adverse macroeconomic risks for the origin country that may eventually be harmful for migrants' families stayed home in case of repeated shocks in host countries.

3.1 | Micro-foundations: The choice of migration destinations

Families in host country i decide whether to keep all of their members in their home country i or to send their migrants to destinations j ($j = 1, \ldots, J$), each destination being characterised by a specific return/risk ratio.[10] Households assess these return/risk ratios by considering (1) the host country's expected wage level w_j, (11) the probability π_j to find a job in the host economy, which depends on the pace of GDP growth and/or the adequacy of the skill demand structure and (111) the probability β_j that the migrant worker, through her wages and through remittances for her family, will have to face earnings instability in host economy, with this probability being determined by income volatility in host country.

As in recent migration models (Beine et al., 2015; Grogger & Hanson, 2011), the family individual utility is linear in income and includes migration costs as well as positive and adverse characteristics of the country of residence. The utility obtained when a s-type individual migrates to location j is given by:

$$u_{ij} = w_j + A_j - C_{ij} + \zeta_{ij}, \tag{2}$$

where C_{ij} stands for the migration costs from country i to country j, and ζ_{ij} is a random component representing individually heterogeneous influences on migration decisions related to occupational characteristics, abilities or preferences that are not included in the model.[11] As is traditional in the literature on determinants of migration (Beine et al., 2011; Bertoli & Fernández-Huertas Moraga, 2013; Munshi, 2003), migration costs C_{ij} are assumed to increase with the distance d_{ij} between countries i and j and to decrease with the size of the home country i's diaspora network in host country j (D_{ij}) measured by the total number of people born in country i living in country j:[12]

[10]Obviously, all individuals (or families) have not the same type (skill, preferences, social capital, etc.) and the probability to migrate, as well as the destination of migration, will depend on these deterministic parameters that could be summed up by a state vector. However, for the sake of simplifying notations, we have not reported the subscript specifying the type of individuals or families in equations. For a model in which individuals feature heterogeneous skill types, see Beine et al. (2015).

[11]In a standard fashion, this latter variable is assumed to be independent and identically distributed across locations and across periods and independent of the state variables explaining migration in the model.

[12]Contrary to Beine et al. (2015), we consider that there are no administrative costs related to visa obtention. The reason is that we focus on the influence of diaspora's size and host country's volatility characteristics and not on the determinants of migration as in Beine et al. (2015).

$$C_{ij} = C(d_{ij}, D_{ij}) \text{ with } C'd > 0 \text{ and } C'D < 0. \tag{3}$$

As for the deterministic component, utility A_j denoting various host country j's characteristics can be rewritten as in Equation (4):

$$A_j = A\left(\alpha_j, \frac{\pi_j}{\beta_j}\right) \text{ with } A'_{\alpha} > 0 \text{ and } A'_{\frac{\pi}{\beta}} > 0. \tag{4}$$

Equation (4) suggests that country j's potential to attract migrant workers increases with amenities like the level of public spending in destination country j, noted α_j, or with the probability π_j to find a job in the host economy, conditional on the pace of GDP growth in host country, and decreases with the probability β_j that the migrant, and by extension her family through private transfers, will undergo income instability in the host country.

Symmetrically to Equation (2), the utility of the same s-type individual born in country i and staying in country i (not migrating) is given by:

$$u_{ii} = w_i + A_i + \zeta_{ii}, \tag{5}$$

where ζ_{ii} is a random factor of individual influences on the decision not to migrate from country i that are not included in the model. As in standard migration models (Fafchamps & Shilpi, 2013), households in country i will therefore decide whether they send one migrant abroad, and where they send her, by optimising the utility difference between the different destinations, including home country (that would mean not migrating), with respect to the different parameters of their utility function and in function of their preference with respect to risks.[13] Aggregation of individual utility-maximising choices leads to various proportions N_{ij} of the home country's total population within the age of migration N_i having migrated in different locations j abroad or having not migrated and remaining in i.[14] In line with recent models of migration destination choice (Beine et al., 2015; Kennan & Walker, 2013), we suppose that the random variable ζ_{ij} is drawn from (type I) extreme value distribution and use results by McFadden (1973) and Rust (1987) to conveniently write the probability that an individual born in country i will move to location j as:

$$Pr(u_{ij} = max_k\ u_{ik}) = \frac{N_{ij}}{N_i} = \frac{e^{(w_j + A_j - c_{ij})}}{\sum_k e^{(w_k + A_k - c_{ik})}}. \tag{6}$$

As in Beine et al. (2015), the ratio of country i's migrants to country j to country i's non-migrants (residents of i) is drawn from (6) and can be expressed as:

$$\frac{N_{ij}}{N_{ii}} = \Omega_{ij} = \frac{e^{(w_j + A_j - c_{ij})}}{e^{(w_i + A_i)}}. \tag{7}$$

Replacing by Equations (3) and (4) in Equation (7) gives the expression of the ratio of the number of country i's workers located in country j to country i's population of non-migrants as a function of the country i's diaspora size in host country j (D_{ij}), the probability of finding a job (π_j) and the probability of being exposed to income volatility (β_j) in host country j, and the other amenities provided by host country j (α_j):

[13]Their budget constraint is determined by the fact that migration costs should be at least covered by incomes generated by it.

[14]Another optimisation constraint is that the total number of individuals of migration age in country i equals the sum of the migrants located in all destination countries abroad and of the individuals of migration age who stay home. More formally: $N_i = \sum_k N_{ik}$

$$\frac{N_{ij}}{N_{ii}} = \Omega_{ij} = \frac{e^{[w_j + A(\alpha_j, \frac{\pi_j}{p_j}) - c(d_{ij}, D_{ij})]}}{e^{(w_i + A_i)}}. \tag{8}$$

With $\Omega'_{Dij}>0$, $\Omega'_{\alpha j}>0$, $\Omega'_{\pi_j}>0$ and $\Omega'_{\beta j}<0$.

From (7), we can easily draw the expression of the share of the country i's total diaspora located in country j:

$$\phi_{ij} = \frac{N_{ij}}{\sum_{j=1}^{n} N_{ij}} = \theta_i \Omega_{ij} \text{ where } \theta_i = \frac{N_{ii}}{\sum_{j=1}^{n} N_{ij}} \text{ for } j \neq i. \tag{9}$$

The share of country i's migrants to country j in country i's total stock of migrants noted ϕ_{ij} has similar functional characteristics as the ratio of country i's migrants in country j to non-migrants (Equation 8).

As the result of the optimisation process, each country can be associated, at equilibrium, with a n-set of equilibrium destination vectors including, inter alia, the relative size ϕ_{ij} of the country i's diaspora in each country j (with the value of ϕ_{ij} being potentially null for some destinations j), the expected level R_{ji} of remittances from country j to i determined by the expected level of country's GDP growth, and the expected risk of remittance r_j determined by the expected volatility of GDP growth in host country j noted γ_j.

3.2 | Migration portfolio, contagion risk and concentration risk

Let the migration portfolio p_i of the labour-exporting country i be characterised by the n-set of equilibrium destinations (ϕ_{ij}, R_{ji}, r_j). For each origin country i, the expected return of the migration portfolio p_i is given by Equation (10):

$$E(R_{pi}) = \sum_{j=1}^{n} \phi_{ij} E(R_j). \tag{10}$$

The aggregate risk of country i's migration portfolio σ_{pi} is given by Equation (11), where $\sigma_{\gamma j}$ is the standard deviation of the return from migration from the country i to the country j, which positively depends on γ_j, the income volatility in host country j, and $\rho_{\gamma jk}$ is the covariance between country i's migrants' remittances originating from host countries j and k, which also depends positively on the covariance between γ_j and γ_k:

$$\sigma_{pi} = \left(\sum_{j=1}^{n} \phi_{ij}^2 \sigma_{\gamma j}^2 + \sum_{j=1}^{n} \sum_{k=1}^{n} \phi_{ij} \phi_{ik} \rho_{\gamma jk} \right)^{\frac{1}{2}}. \tag{11}$$

It is straightforward that the level of risk σ_{pi} associated with the migration portfolio p_i increases with the cumulated variance of GDP growth in all destinations j, measured by the first component $\sum_{j=1}^{n} \phi_{ij}^2 \sigma_{\gamma j}^2$, as well as with the business cycle co-movement between all pairs of destinations j and k, measured by the covariance term $\rho_{\gamma jk} = \sigma_j^2 \sigma_k^2 Corr(\gamma_j, \gamma_k)$. We call contagion risk the sum of these two components.

As mentioned in the previous section, the first four locations of country i's diaspora account on average for 80% of the total diaspora. Accordingly, we will limit our computations of the portfolio risk indicator, and of its two subcomponents, to the first four locations of country i's diaspora:

$$\sigma_{pi} = \left(\sum_{j=1}^{4} \phi_{ij}^2 \sigma_{\gamma j}^2 + \sum_{j=1}^{4} \sum_{k=1}^{4} \phi_{ij} \phi_{ik} \rho_{\gamma jk} \right)^{\frac{1}{2}}. \tag{12}$$

With the first component, the weighted average of individual host countries' volatility is computed as:

$$Volatility_j = \left(\sum_{j=1}^{4} \phi_{ij}^2 \sigma_{\gamma j}^2\right)^{\frac{1}{2}} = (\phi_{i1}^2 \times \sigma_{\gamma 1}^2 + \phi_{i2}^2 \times \sigma_{\gamma 2}^2 + \phi_{i3}^2 \times \sigma_{\gamma 3}^2 + \phi_{i4}^2 \times \sigma_{\gamma 4}^2)^{\frac{1}{2}}, \tag{13}$$

and with the second component, the weighted average of host countries' volatility covariance is computed as:

$$\begin{aligned} Co - movement_{jk} &= \left(\sum_{j=1}^{4}\sum_{k=1}^{4} \phi_{ij}\phi_{ik}\rho_{\gamma jk}\right)^{\frac{1}{2}} \\ &= (\phi_{i1} \times \phi_{i2} \times \rho_{\gamma 12} + \phi_{i1} \times \phi_{i3} \times \rho_{\gamma 13} + \phi_{i1} \times \phi_{i4} \times \rho_{\gamma 14} + \phi_{i2} \times \phi_{i3} \times \rho_{\gamma 23} \\ &\quad + \phi_{i2} \times \phi_{i4} \times \rho_{\gamma 24} + \phi_{i3} \times \phi_{i4} \times \rho_{\gamma 34})^{\frac{1}{2}}. \end{aligned} \tag{14}$$

The portfolio theory (Markowitz, 1952; Merton, 1972) demonstrates that, given the parameters γ_{ij}, $\sigma\gamma_{ij}$ and for $-1<\rho_{jk}<1$—that is as long as $Corr(\gamma_j, \gamma_k)$, the correlation between business cycles in locations j and k is less than one—the standard deviation of the migration portfolio is lower than the weighted average of the standard deviation of the individual destinations. Put differently, any combination of risky destinations, implying that all ϕ_{ij} are different from one generates a lower risk than that of a single destination, and there is a unique set of ϕ_{ij} that minimises the overall portfolio risk.

The migration portfolio therefore conveys a second source of risk, that we call the concentration risk, that is captured by the distribution of weights ϕ_{ij}. Indeed, it is easy to see that the aggregate portfolio risk σ_p decreases with a less concentrated diaspora as the sum $\sum_{j=1}^{n} \phi_{ij}^2$ is minimal when all ϕ_j are equal. The sum of squared weights $\sum_{j=1}^{n} \phi_{ij}^2$ corresponds to the Hirschman–Herfindahl index of concentration, which tends towards zero as the number of countries with equal weights increases. Put differently, the more uneven the distribution of weights ϕ_{ij} across the n destinations, the more concentrated country i's diaspora (the larger the Herfindahl index of diaspora concentration) and the higher the overall portfolio risk, other things being set equal.

For the sake of clarity, the contagion and concentration risks can be better illustrated in the simplified set-up of a two-country portfolio. Let consider n individuals migrating from one given origin country to two destination countries A and B in the respective proportions of ϕ and $1 - \phi$. Then, the expected overall return and risk of the migration portfolio p is the weighed sum of the average individual remittance level from countries A and B:

$$\pi_p = \phi\pi_A + (1 - \phi)\pi_B, \tag{15}$$

and the risk of the migration portfolio p is the weighed sum of the standard deviation of GDP growth in countries A and B:

$$\sigma_p = [\phi^2\sigma_A + (1 - \phi)^2\sigma_B + (\phi)(1 - \phi)\rho_{AB}]^{\frac{1}{2}}. \tag{16}$$

Let us first assume that the entire set of n migrants had the same and unique destination country in which the country's diaspora is exclusively located in country A ($\phi = 1$). The covariance ρ_{AB} is null and the portfolio risk is equal to σ_A. The same would hold for a diaspora located exclusively in B ($\phi = 0$) where the portfolio risk is equal to σ_B. Equation (16) shows that any combination of non-null diasporas in A and B ($0 < \phi < 1$) would lead to a diversified migration portfolio and a reduction of its expected risk as $\sum_{j=1}^{n} \phi_j^2 = \phi_A^2 + \phi_B^2$ is maximal when $\phi_A = 1$ or $\phi_B = 1$ Consistently, the

former sum is minimal when the diaspora is evenly distributed across the two destinations, that is, when $\phi_A = \phi_B = 0.5$.[15] Transcribed to migration, the portfolio diversification theory implies that any combination of destination countries is less risky than the concentration of the diaspora in a single one and that there exists an optimal distribution of a country's diaspora for any given set of expected idiosyncratic returns and risks and of covariance between these idiosyncratic risks. From this result, we can infer that the risk associated with a given migration portfolio increases with the idiosyncratic volatility of destination countries, with the geographical concentration of the diaspora's location—an inflation of the weight of a limited number of destination countries in the distribution of the diaspora—and with the co-movement of these locations' business cycles.[16]

4 | EMPIRICAL APPROACH AND RESULTS

Section 4.1 first presents reduced-form estimations enabling to assess the extent to which income fluctuations in the countries hosting the diaspora are "imported" by home countries. Then, Section 4.2 investigates more precisely the channel of volatility transmission that goes through migration by identifying how the contagion and concentration risks defined in the previous section impact remittance volatility. Finally, a structural model is estimated in Section 4.3 confirming that the contagion and concentration risks are transmitted to the home country through the channel of remittance volatility. We use a large panel of developing countries and data from various sources such as IMF or World Bank.[17] Variables measuring contagion and concentration risks are computed as described by Equations (12), (13), (14) and (18).

4.1 | Host countries' volatility and its transmission to home country: Reduced-form estimations

This section highlights the transmission of volatility from host countries to migrants' origin countries, which can result from exports, remittances, FDI or other financial inflows. We do not focus on a particular variable so far, while the next two sections will investigate the role of remittances more particularly. The reduced-form model that is estimated is presented by Equation (17):

$$\sigma_{it}^{\Delta GDP^c} = \theta_1 + \theta_2 \sigma_{it-1}^{\Delta GDP^c} + \theta_3 \sigma_{pit} + \theta_4 X_{it} + \theta_5 DIASP_{it} + \theta_6 (\sigma_p \times DIASP)_{it} + \eta_i + \mu_t + \varepsilon_{it}. \quad (17)$$

In Equation (17), $\sigma^{\Delta GDP^c}$ is the volatility of per capita GDP in migrants' origin country, σ_{pi} is the contagion risk experienced by migrants' origin countries, and X is a set of additional controls discussed below. The contagion risk is computed following Equation (12), i.e., as the sum of the

[15]A simple numerical example based on Equation (16) better illustrates this case. Let the shares of a country's diaspora be $\phi = 1 - \phi = 0.5$ and let them be 0.9 and 0.1 for another country, and the idiosyncratic country risks be $\sigma_A = \sigma_B = \sigma$. It is straightforward to check that the portfolio risk will be higher if the diaspora gets more concentrated, as in the latter country as $0.5^2 + 0.5^2 \times \sigma < 0.9^2 + 0.1^2 \times \sigma$.

[16]Various bilateral mechanisms could also differentiate the set (π_{ij}, σ_{ij}) of risk and return associated with migrating from i to j, like the nature of political relationships and migration controls, past common history and current common language, job opportunities for migrants, taxes or incentives on remittances or exchange rate instability and controls. Still, to make the presentation more tractable, we suppose that all (π_{ij}, σ_{ij}) are equal for each given destination country j, whatever the origin country i, the probability θ_i of a shock in the migrant's destination country being similar for all countries i.

[17]The list of countries included in the panel is available in Appendix, as well as data sources.

risks related to weighed average idiosyncratic volatility and co-movement of migrants' host countries. In order to identify which dimension of the contagion risk matters the most to explain the volatility in home economies, the two components of the σ_{pi} variable (i.e., the average host countries' idiosyncratic volatility and average co-movement) are separately tested in Equation (17). However, country *i*'s contagion risk is related, in the first place, to the relative size of country *i*'s diaspora. The smaller the country *i*'s diaspora, the weaker the contagion risk through remittances, as the size of revenues and financial flows sent from the host country will be smaller. Accordingly, the size of the diaspora relative to the country *i*'s population (*DIASP*) and its interaction term with the interest variable are included in the estimated equation.

Equation (17) is estimated on a panel of 93 countries and four non-overlapping time periods (1995–2000, 2000–05, 2005–10 and 2010–15). In line with the empirical literature on economic volatility, the dependent variable $\sigma^{\Delta GDP^c}$ is computed as the 5-year standard deviation of GDP per capita starting in 1995 and ending in 2015. Time-invariant country characteristics such as localisation that might drive higher vulnerability to external shocks are controlled for by country fixed effects. Likewise, global shocks happening in 1995, 2000 and 2008 that can explain volatility are accounted for by time-varying factors common to all countries. Because the current level of GDP volatility might depend on its lagged value, we use the generalised method of moments which allows the introduction of lagged dependent variable as a regressor. Lastly, the estimation of Equation (17) may be biased because of endogeneity issues, notably with respect to our two variables of interest *DIASP* and σ_{pi}. Indeed, the size of country *i*'s diaspora might increase with the level of income instability in the home economy. Likewise, economic fluctuations in home country *i* may well be transmitted to the migrants' destination countries through trade or financial exchanges. We therefore take advantage of properties of the system-GMM estimator to correct this reverse causality bias, notably by instrumenting the relative size of the diaspora and the contagion risk by the lagged values of their first differences (Blundell & Bond, 1998). Following Roodman (2009), we limit the number of instruments and apply the Windmeijer's (2005) correction for standard errors in order to avoid overestimating the significance of the coefficients.

Following the literature on economic growth volatility (Beck, Lundberg, & Majnoni, 2006; Easterly, Islam, & Stiglitz, 2000; Easterly, Kremer, Pritchett, & Summers, 1993), we assume that higher instability of terms of trade and domestic prices leads to higher output fluctuations and that swings in credit supply and in government expenditure are both likely to amplify business cycles. The control variables included in the *X* vector, their measurement and the sources are listed in Appendix 1. The list of countries included in our sample is presented in Appendix 2.

The results are presented in Table 2. We provide separate estimations for the overall contagion risk (columns (1)–(2)) and for its different components, the average individual volatility in host countries (columns (3)–(4)) and the co-movement between them (columns (5)–(6)). First, whereas the coefficient of contagion risk is not significant alone (column (1)), its interaction with the size of the diaspora turns positive and significant (column (2)). This suggests that volatility in migrants' host countries is transmitted to the origin country only when the diaspora is sizeable. Predicted margins reported in Figure 5 confirm that the impact of the contagion risk on aggregate volatility becomes positive and significant for countries with a large diaspora (beyond a 20% share of the population corresponding to the top 15% of the variable distribution). This result makes sense to the extent that the bigger the diaspora, the larger the amount of remittance flowing to the home country.

In order to identify which dimension of the contagion risk matters the most to explain the volatility in home economies, the two components of the σ_p variable (i.e., the average host countries' idiosyncratic volatility and average co-movement) are separately tested in Equation (17). Results reported in columns (3)–(6) show that the contagion risk is mostly driven by the average host countries' idiosyncratic volatility component, the average business co-movement between host

TABLE 2 System-GMM estimation of economic growth volatility in migrants' origin countries, 5-year periods (1995–2015)

Exogenous variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: volatility of growth in origin countries						
Lag dependent variable	0.097	0.090	0.119	0.099	0.073	0.103	0.109
	(0.158)	(0.115)	(0.161)	(0.115)	(0.149)	(0.163)	(0.137)
Contagion risk	0.002	−0.086**					
	(0.020)	(0.040)					
Diaspora (*DIASP*)	0.083	0.052	0.077	0.048	0.080	0.061	0.039
	(0.090)	(0.059)	(0.088)	(0.057)	(0.077)	(0.077)	(0.064)
Contagion risk × DIASP		0.009**					
		(0.004)					
Volatility host countries			0.003	−0.088**			−0.088**
			(0.020)	(0.039)			(0.041)
Volatility host countries × DIASP				0.009**			0.010**
				(0.004)			(0.004)
Co-movement host countries					1.189	1.519	
					(1.615)	(1.738)	
Co-movement host countries × DIASP						−0.064	
						(0.089)	
σ FDI							0.024
							(0.101)
σ Exports							0.041
							(0.062)
σ Terms of trade	12.559**	14.068***	12.019**	13.711***	14.533**	11.953**	12.903***
	(4.948)	(3.841)	(5.121)	(4.033)	(6.120)	(5.273)	(4.771)
σ Inflation	−0.005	−0.003	0.001	0.001	−0.005	−0.005	0.002
	(0.006)	(0.005)	(0.009)	(0.007)	(0.006)	(0.007)	(0.007)
Credit	0.017	0.021	0.017	0.021	0.024	0.016	0.019
	(0.017)	(0.014)	(0.018)	(0.014)	(0.023)	(0.019)	(0.017)
σ Government expenditure	1.130***	0.917**	1.072**	0.875*	1.046***	1.211**	0.783*
	(0.425)	(0.429)	(0.448)	(0.449)	(0.403)	(0.513)	(0.460)
GDP/Capita	0.000	−0.000	0.000	−0.000	−0.000	0.000	−0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Constant	−1.811	−0.852	−1.749	−0.797	−1.112	−1.775	−0.770
	(1.427)	(1.591)	(1.432)	(1.576)	(1.799)	(1.648)	(1.593)
Observations	341	341	345	345	341	341	345
Countries	93	93	93	93	93	93	93

(Continues)

TABLE 2 (Continued)

Exogenous variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: volatility of growth in origin countries						
Arellano-Bond AR(2) (p value)	0.164	0.252	0.242	0.351	0.192	0.113	0.396
Hansen (p value)	0.465	0.579	0.358	0.470	0.494	0.332	0.481
Number of instruments	18	19	18	19	18	19	21

Notes: Two-step system-GMM estimates. Standard errors with Windmeijer's (2005) correction in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

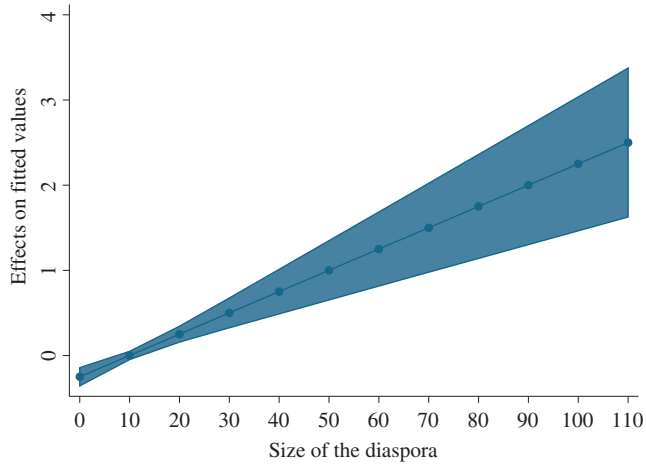

FIGURE 5 Average marginal effects of the contagion risk.
Note: 95% confidence interval [Colour figure can be viewed at wileyonlinelibrary.com]

countries being not statistically significant even when interacted with the size of diaspora (column (6)). In other words, while output volatility in host countries triggers instability in migrants' origin countries, business cycle co-movement between the different locations of the diaspora does not channel volatility contagion in our sample.

Insofar as levels of remittances, trade and financial flows sourced in migrants' host countries fluctuate along with the latter countries' business cycle, they all might transmit economic volatility to the origin countries during bad times as argued in Section 2. Equally, growing amounts of remittances and other flows during good times fuel economic growth in migrants' origin countries, leading to larger fluctuations in business cycles. To make sure that the contagion effect is not related to other external flows such as exports or FDI, we have also included the volatility of these two variables into the model (column (7)). The two coefficients are insignificant, while our coefficient of interest remains unchanged.[18] Lastly, it should be emphasised that estimated coefficients are very stable across specifications and the Arellano–Bond and Hansen statistics reported at the bottom of Table 2 confirm that our model is correctly specified.

[18]The results in Table 2 also suggest that higher volatility in terms of trade and government expenditure amplifies GDP growth fluctuations in home countries.

4.2 | Remittances are one channel of volatility transmission

The previous section provided empirical evidence of the transmission of macroeconomic volatility from the host to the home economy, notably for countries having a large proportion of their population working abroad. However, reduced-form estimations could not identify whether output volatility is effectively transmitted through the channel of remittances. Moreover, in addition to being affected by the economic conditions of host countries, the stability of remittances might also depend on whether the distribution of the diaspora is geographically concentrated or not. As argued in Section 3, the more concentrated the diaspora across the host countries, the more unstable the flows of remittances to the origin country. In the extreme case where the whole diaspora is located in a single destination country, remittances received by the origin country might be strongly conditional to the economic cycle prevailing in this specific destination. In contrast, a more scattered diaspora might increase the number of countries from which remittances are sourced, leading to averaging out effects and to a lower concentration risk.

In accordance with the results in Section 3.2, we compute the concentration risk as an Herfindahl index, using the United Nations International migrants stock database.[19] By definition, an individual is considered to be a migrant when she or he resides in a country other than her or his native country.[20] In Equation (18), ϕ_{ij} is the share of the stock of origin country i's diaspora, which is located in the destination country j:

$$CONC_i = \sum_{j=1}^{n} \phi_{ij}^2. \tag{18}$$

We then estimate Equation (19) below:

$$\sigma_{it}^{REM} = \alpha_1 + \alpha_2 \sigma_{it-1}^{REM} + \alpha_3 CONC_{it} + \alpha_4 \sigma_{pit} + \alpha_5 \zeta_{it} + \eta_i + \mu_t + \varepsilon_{it}, \tag{19}$$

σ^{REM} represents the instability of remittances,[21] $CONC$ stands for the concentration risk and σ_{pi} is the contagion risk already discussed in the previous section. As before, the dependent variable σ^{REM} is measured by the standard deviation of the data in five-year intervals, without overlap (1995–2000, 2000–05, 2005–10, 2010–15). A coefficient α_3 taking a positive value would provide support for the concentration effect as it would imply that a stronger concentration of migrants in destination countries increases the volatility of remittances received by the origin country. Similarly, a positive coefficient α_4 would provide evidence of the contagion effect for it implies that remittance instability increases with host countries' volatility or co-movement. As in the previous section, we estimate Equation (19) using the two component variables of the contagion risk separately, in order to determine their respective impact on remittances flows.

[19]UN estimates cover the years 1990, 1995, 2000, 2005, 2010, 2015 and are carried out in the middle of the year. Other sources of migrant stocks exist (Docquier, Lowell, & Marfouk, 2009) but they have limited time variability as they only cover two non-consecutive years (1990 and 2000).

[20]One drawback of this definition is that it considers persons born of foreign parents to migrants in countries using the basis of *jus sanguinis*. In these countries, persons born to foreign parents do not acquire the nationality of the country of residence, which then counts them as migrants. However, the UN database is the most complete source about global migration and provides updated estimates every five years.

[21]To the extent that our study focuses on macroeconomic effects, we use the "broad" definition of remittances, which also includes compensation of employees. The "narrow" definition of remittances excludes compensation of employees, which are also sourced from abroad. The "broad" definition is more appropriate for our study because we examine risks related to external capital flowing to origin countries.

The literature conveys only a small number of papers on the stability of remittances at the macroeconomic level. Still, we use them to select the control variables covering all the usual determinants of remittance levels and fluctuations. For example, Lartey (2016) includes controls for the exchange rate, GDP per capita in the country of origin, GDP per capita in host countries[22] and institutional quality. In our setting, it seems appropriate to use exchange rate volatility because the local currency value will determine the monetary value of the transfer from the host country of the migrant. A highly volatile currency will generate uncertainty that might increase the variability of remittances. Similarly, institutional uncertainty might create disincentives for migrants to remit, especially if they wish their transfers to be invested in the country of origin. Volatile government spending in the origin country—particularly transfers to households—is another explanatory factor of the volatility of remittances. In addition, a more volatile credit supply limits the ability of households to stabilise their consumption and might therefore create more uncertain needs for remittances. The volatility of inflation in the migrant's country of origin may also put strong pressure on the capacity of the migrant's family to satisfy its needs, which may result in large fluctuations of private transfers. A large dependent population (aged or young) is also a negative determinant of the volatility of remittances because migrants send money more regularly to inactive households (Jackman, 2013). The last control concerns the occurrence of natural disasters, since damages are often followed by the sending of foreign funds (Bettin & Zazzaro, 2018).[23]

Here again, estimations use a dynamic model and it should be noted that Equation (19) might be immune from endogeneity issues. Obviously, there is no reason why more volatile remittances received in the origin country should increase output volatility in the host country. Moreover, more unstable remittances have no reason to induce a more concentrated diaspora because it may impact the size of migration flows and not the structure.[24]

The results are reported in Table 3. As expected, the positive and significant coefficient of diaspora concentration (columns 1, 5, 6, 7) suggests that a more concentrated diaspora increases the volatility of remittances in our sample. This result confirms recent reduced-form estimations by Balli and Rana (2015), finding that remittances fail to smooth consumption volatility in the country of origin when migrants are concentrated in a small number of countries. Likewise, columns 2 and 5 suggest that a larger size of the overall migration portfolio risk increases the instability of remittances, providing empirical support for the contagion risk.

Results reported in columns (3)–(4) and (6)–(7) confirm that the effect of the total portfolio risk is mostly driven by the host countries' idiosyncratic volatility component, while the average comovement between host countries is not significant. When the contagion and concentration risks are simultaneously included (columns (5)–(7)), the estimated coefficients of the former remain unchanged while those of the latter are slightly reduced. This suggests that although the concentration risk is partially included in the overall portfolio risk, which is fully consistent with the

[22]For sake of consistency, we weighted GDP/capita in host countries in relation to the relative weight of the country *i*'s diaspora working in the four destination countries.

[23]The impact of natural disaster on remittance volatility is ambiguous because natural disasters, which are essentially random, might create sudden variations in the amounts of remittances, while a regular occurrence may also stabilise flows in order to prevent damages (Mohapatra et al., 2012).

[24]A possible bias could come from exchange rate volatility (used as a control variable) because empirical literature has shown that if exchange rate affects the flows of remittances, the opposite relationship is also observed (Higgins, Hysenbegasi, & Pozo, 2004; Rahman, Foshee, & Mustafa, 2013). For this reason, exchange rate volatility is treated as endogenous in the dynamic model.

TABLE 3 System-GMM estimation of remittances volatility, 5-year periods (1995–2015)

Exogenous variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: volatility of remittances						
Lag dependent variable	0.116	0.277	0.219	0.262	0.200	0.128	0.189
	(0.209)	(0.190)	(0.217)	(0.187)	(0.198)	(0.213)	(0.187)
Concentration of diaspora	0.339**				0.248*	0.285**	0.315**
	(0.147)				(0.128)	(0.145)	(0.137)
Contagion risk		0.026**			0.024**		
		(0.012)			(0.011)		
Volatility host countries			0.026**			0.023**	
			(0.011)			(0.010)	
Co-movement host countries				−0.177			0.004
				(0.553)			(0.570)
Investment freedom	−0.010**	−0.010**	−0.010**	−0.009**	−0.011**	−0.011**	−0.010**
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)
Dependency	−0.007	−0.007	−0.006	−0.008	−0.008	−0.006	−0.009
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
σ Credit	0.048***	0.039*	0.041**	0.051**	0.039**	0.041**	0.048**
	(0.018)	(0.022)	(0.019)	(0.022)	(0.019)	(0.017)	(0.020)
Natural disaster	−0.042***	−0.039***	−0.045***	−0.046***	−0.036***	−0.040**	−0.038***
	(0.016)	(0.013)	(0.017)	(0.014)	(0.013)	(0.015)	(0.013)
σ Exchange rate	−0.000	0.000	−0.000	0.000	0.000	−0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
σ Inflation	0.003**	−0.003	0.003**	−0.004	−0.002	0.003**	−0.003
	(0.002)	(0.007)	(0.001)	(0.008)	(0.007)	(0.002)	(0.008)
GDP/capita home country	−0.687***	−0.564***	−0.630***	−0.614***	−0.606***	−0.667***	−0.630***
	(0.215)	(0.181)	(0.215)	(0.180)	(0.193)	(0.215)	(0.192)
GDP/capita host countries	0.406***	0.392***	0.452***	0.359***	0.391***	0.451***	0.341***
	(0.138)	(0.113)	(0.144)	(0.109)	(0.114)	(0.136)	(0.106)
σ Government expenditure	0.178**	0.171**	0.172**	0.174**	0.182**	0.183**	0.180**
	(0.074)	(0.077)	(0.078)	(0.079)	(0.075)	(0.074)	(0.077)
Constant	0.132	1.747	1.756	2.549*	0.317	−0.044	0.485
	(1.313)	(1.277)	(1.339)	(1.377)	(1.222)	(1.305)	(1.231)
Observations	294	291	294	291	291	294	291
Countries	93	93	93	93	93	93	93

(Continues)

TABLE 3 (Continued)

Exogenous variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: volatility of remittances						
Arellano-Bond, AR(2) (p value)	0.892	0.669	0.787	0.601	0.713	0.887	0.691
Hansen (p value)	0.212	0.164	0.190	0.226	0.164	0.203	0.202
Number of instruments	23	23	23	23	24	24	24

Notes: Two-step system-GMM estimations. Standard errors with Windmeijer's (2005) correction in parentheses.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

arithmetic of the portfolio risk (Equation (12)), the contagion and concentration risks capture two different mechanisms of host country's volatility transmission through diasporas.

Now, this section's results should be related to those of the previous one. Section 4.1 provided reduced-form evidence of the diaspora's volatility effect, without explicitly identifying the remittance channel through which volatility might be transmitted. Section 4.2 confirms that the volatility of remittances increases with the size of both the contagion and concentration risks, that is, with the two types of risks involved by the pattern of geographical distribution of the diaspora. Therefore, our estimations are strongly suggestive that remittance volatility represents one channel transmitting the volatility from the host countries to the home country of migrants. In following next Section, this hypothesis is fully investigated by estimating a structural model recomposing the volatility effect of diaspora through remittances and controlling for other sources of volatility transmission that may be related to diaspora's locations and to host countries' business cycle.

4.3 | The volatility impact of diaspora's location: Structural model estimations

This section explicitly tests the assumption of a volatility effect of diasporas. This assumption can be formulated as follows: the more volatile the migrants' host countries and the more geographically concentrated the diaspora, the more likely volatility will be channelled to the home country via remittance instability. Indeed, higher volatility of remittances might affect exchange rate, income and consumption stability in the home country, potentially leading to macroeconomic policy issues in fixed exchange rate regimes.[25] Government financial stability might also be impacted as remittances are a source of tax revenues through consumption (Asatryan et al., 2017). Lastly, because of unstable private and public revenues, investment might be destabilised, with adverse effects on economic growth.

In order to test whether remittances do effectively transmit volatility from the host to the home economy, we estimate the structural system of simultaneous Equations (20a, 20b):

$$\begin{cases} \sigma_{it}^{REM} = \beta_1 + \beta_2\ CONC_{it} + \beta_3\ Volatility_{jt} + \beta_4 \xi_{it} + \eta_i + \mu_t + \phi_{it} & \text{(20a)} \\ \sigma_{it}^{\Delta GDP^c} = \theta_1 + \theta_2 \sigma_{it}^{REM} + \theta_3 \sigma_{it}^{TOT} + \theta_4\ GDP/capita_{it} + \eta_i + \mu_t + \omega_{it} & \text{(20b)} \end{cases},$$

where ξ is a vector of controls including the GDP per capita in host and home countries.

[25]Singer (2010) shows that countries receiving more remittances are more likely to adopt a fixed exchange rate regime.

When estimating a structural model, endogeneity is a central issue because of the presence of an endogenous variable among the regressors of the main equation. The dependent variable of Equation (20a), namely remittance volatility, is naturally included as one explaining factor of home country's volatility since we seek to identify how remittances channel volatility from host to home country. We thus have to estimate a two-equation model where instability in host countries determines the volatility of remittances, while the latter simultaneously explains output volatility in the origin country. The system of Equations (20a, 20b) is identified by using three-stage least squares (3SLS) that simultaneously allows for error correlation across equations and for the use of external instrument to predict the endogenous regressor. As shown by Zellner and Theil (1962) and Wooldridge (2010), 3SLS are a generalisation of the 2SLS providing consistent estimates of simultaneous equation models with endogenous regressors. Equation (20a) can be understood as a pseudo-first stage whereby the endogenous regressor (remittance volatility) is regressed on a set of exogenous determinants, including the diaspora concentration and the average idiosyncratic risk of the four main locations of the diaspora. In order to estimate the validity of the results, we also report the Hansen/Sargan statistic in all specifications. Rank and order identification conditions have also been systematically and successfully tested.

Results of the 3SLS estimation of model (20a, 20b) are presented in Table 4. Columns (1)–(7) in Table 4's upper panel confirm that both greater instability and a more concentrated diaspora in host countries increase the volatility of remittances. Moreover, columns (1)–(7) in Table 4's lower panel show that the coefficient of remittance volatility is positive and significant in the equation for home country's GDP growth volatility. When combined together, these results confirm that remittance volatility effectively channels external volatility to the migrants' origin countries: 3SLS estimated coefficients confirm that the intensity of remittance volatility is determined by the volatility of host countries and by the concentration risk characterising each home country *i*'s migration portfolio, while it simultaneously determines the level of GDP growth volatility in the home country *i*. In order to make sure that the effect found on GDP volatility is related to remittances and not to other external factors, we have run the model by including the volatility of host countries in Equation (20b) (columns (2)–(7)). The coefficient of the volatility of remittances remains positive and becomes even more significant, thereby confirming the active role of remittances in the transmission of external shocks. Likewise, including the two alternative channels of volatility transmission also linked to the pattern of geographical distribution of the diaspora and to the business cycle of host countries, that is, the volatility of FDI and of exports revenue flowing from abroad, does not affect the results (column 3). Although export volatility significantly increases output volatility in the home country, it does not modify the magnitude and significance of the volatility impact of diaspora. We also checked the robustness of our findings to various specification changes and found that the coefficients do not vary a lot when we use different sets of host countries (columns (4) and (5)) and when we omit the concentration of the diaspora in the first equation (columns (6) and (7)). Moreover, columns (4)–(7) show that the volatility of remittances is driven by the first two main destination countries. This is consistent with our main finding since the first two main host countries determine an important part of aggregate remittances sent to the origin country. GDP growth instability in these countries has strong effects on remittance volatility, which, in turn, impacts aggregate output stability in the home country of the migrant.

5 | POLICY IMPLICATIONS

Looking more closely at the magnitude of the estimated impacts enables drawing some policy implications from the paper's estimation results. Table 5 shows that the volatility of remittances

TABLE 4 Remittances as a transmission channel of external volatility: 3SLS estimates of the structural model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Equation (20a)	**Dependent variable: volatility of remittances**						
Concentration of diaspora	0.607**	0.616**	0.509*	0.394*	0.442*		
	(0.281)	(0.276)	(0.291)	(0.239)	(0.241)		
Volatility host countries	0.021***	0.022***	0.023***				
	(0.007)	(0.007)	(0.007)				
Volatility host country 1				0.065**	0.064**	0.063**	0.063**
				(0.032)	(0.032)	(0.032)	(0.032)
Volatility host country 2				0.040**	0.038**	0.044**	0.042**
				(0.017)	(0.017)	(0.017)	(0.017)
Volatility host country 3				−0.012		−0.007	
				(0.031)		(0.031)	
Volatility host country 4				−0.016		−0.014	
				(0.019)		(0.019)	
GDP/capita home country	−0.895**	−0.889**	−0.898**	−0.814**	−0.624*	−0.825**	−0.632*
	(0.360)	(0.360)	(0.361)	(0.354)	(0.346)	(0.355)	(0.347)
GDP/capita host countries	1.150***	1.121***	1.138***				
	(0.270)	(0.272)	(0.273)				
GDP/capita host country 1				0.410***	0.243***	0.396***	0.222***
				(0.097)	(0.082)	(0.097)	(0.081)
GDP/capita host country 2				0.316***	0.190***	0.317***	0.187***
				(0.066)	(0.054)	(0.067)	(0.054)
GDP/capita host country 3				0.188***		0.203***	
				(0.058)		(0.058)	
GDP/capita host country 4				0.110***		0.111***	
				(0.041)		(0.041)	
Constant	−9.159**	−9.027**	−8.233**	−6.999**	−3.264	−3.730	0.647
	(4.054)	(4.050)	(4.108)	(3.430)	(3.228)	(2.713)	(2.348)
Observations	375	375	375	375	385	375	385
Country fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Times dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Equation (20b)	**Dependent variable: volatility of GDP/capita**						
Volatility of remittances	1.124*	1.357**	1.859**	2.027***	2.004**	2.007***	1.890**
	(0.588)	(0.685)	(0.890)	(0.641)	(0.803)	(0.663)	(0.844)
σ Terms of trade	12.585***	12.698***	10.294***	11.721***	11.822***	11.804***	11.885***
	(2.210)	(2.218)	(2.846)	(2.229)	(2.184)	(2.230)	(2.187)

(Continues)

TABLE 4 (Continued)

Equation (20b)	Dependent variable: volatility of GDP/capita						
Volatility host countries		−0.015	−0.042				
		(0.021)	(0.036)				
Volatility host country 1				0.071	0.073	0.072	0.081
				(0.112)	(0.113)	(0.113)	(0.113)
Volatility host country 2				0.048	0.059	0.048	0.062
				(0.054)	(0.054)	(0.054)	(0.053)
Volatility host country 3				0.073		0.072	
				(0.097)		(0.097)	
Volatility host country 4				0.019		0.019	
				(0.061)		(0.061)	
σ Exports			0.157**				
			(0.078)				
σ FDI			−0.803				
			(0.722)				
GDP/capita home country	−1.590	−1.437	−1.492	−1.193	−1.175	−1.208	−1.234
	(1.041)	(1.088)	(1.302)	(1.173)	(1.159)	(1.173)	(1.146)
Constant	15.099**	14.140**	14.642*	11.941	11.989	12.039	12.353*
	(6.807)	(7.100)	(8.617)	(7.631)	(7.534)	(7.628)	(7.446)
Observations	375	375	375	375	385	375	385
Country fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Times dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Countries	105	105	105	105	109	105	109
Hansen/ Sargan (p value)	0.574	0.500	0.737	0.886	0.912	0.792	0.833

Notes: 3SLS estimates. Standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$

has a strong direct impact on home country's own GDP volatility as a 1% increase of the former leads to a 0.48% increase of the latter. The impact of the pattern of location in host countries on volatility in the home country can be reconstituted by multiplying the remittance volatility elasticities to the concentration (0.33) and the contagion risk (0.10) with the elasticity of home country volatility to remittance volatility (0.48) derived from the estimation of the structural model. A doubling of the concentration of diaspora would lead to a 16% increase in growth volatility on host country, while a doubling of the growth volatility would bring a 5% increase in GDP volatility in home country. Still, if we consider the sample variability of the concentration and growth volatility in host countries, that is if we look at the impact of one standard deviation of these two variables on the volatility in home country, the hierarchy of magnitude changes. A one standard deviation increase in the concentration of diaspora would lead to a 0.03 standard deviation increase in the

TABLE 5 Magnitudes of impacts in standard deviation change

'*x*' increase of … …1% increase of	Volatility in remittances		Growth volatility in home country
	GMM[a]	3SLS[b]	3SLS[c]
Concentration of diaspora	0.26	0.33	0.16
Growth volatility in host countries	0.10	0.10	0.05
Volatility of remittances	–	–	0.48

Notes: [a]Elasticities are computed based on estimated coefficients of Table 3's column 5.
[b]Elasticities are computed based on estimated coefficients of Table 4's column 3.
[c]Elasticities are computed based on estimated coefficients of Table 4's column 3. One % increase of the variables in line drives a '*x*'% increase of the variables in columns.

volatility in home country, whereas a similar one standard deviation increase in the income volatility in host countries would lead to a 0.08 increase in the standard deviation of volatility in the home country. These figures mean that the magnitudes of impact are not large. Still, not only are they not insignificant but also they may cumulate their impacts with other sources of imported volatility during episodes of crisis in host countries.

The signs and magnitudes of the coefficients estimated in this paper suggest that employing a macroeconomic approach of the risk sharing impact of migrant transfers leads to adoption of a nuanced assessment of the volatility impact of remittances. Since the seminal article of Stark and Bloom (1985), many studies have found that remittances allow households stayed in home countries to diversify their source of income. Our findings suggest two reasons why this conclusion does not necessarily hold as soon as a macroeconomic perspective is adopted for. First, aggregate flows of transfers from migrants are exposed to business cycles in host countries, with potentially negative consequences for the home country's own macroeconomic stability. Second, host countries' fluctuations are even more damaging when migrants are more concentrated in a limited number of destinations, mainly because remittance fluctuations will not be averaged out over a large set of host countries. Although the stabilisation potential of migrants' transfers was evidenced by the microeconomic literature, aggregate flows of remittances may induce macroeconomic volatility home for some patterns of the diaspora's geographical distribution, with this induced volatility undermining or possibly annihilating the positive microeconomic impacts on migrants' family if it leads to more unstable public spending or private investment.

These results have important implications for economic policy, notably in countries featuring large diasporas and receiving large flows of remittances. Our estimations in this paper show that external conditions (i.e., business cycles in host countries) are crucial conditioning factors of the stability of remittances. Countries receiving large amounts of remittances prove more vulnerable to external shocks since economic instability in host countries can be literally "imported" in the home country through the channel of aggregate remittances, at least for some patterns of diaspora distribution and location. Given the importance of migrants' transfers in sustaining economic growth in developing countries (Catrinescu, Leon-Ledesma, Piracha, & Quillin, 2009; Giuliano & Ruiz-Arranz, 2009), remittance instability is prone to undermine medium run growth potential in countries strongly dependent on remittances. More generally, policymakers should care about the reliance of the economy to remittances and increase diversification in order to avoid sudden drop of GDP during bad times in migrants' destination countries. Let's take the example of Moldova again, which features a sizeable and concentrated diaspora in Russia and Europe. The recent episodes of economic instability in Russia (2015 currency crisis) and in Europe (2011 foreign debts

crisis) made remittances to Moldova more volatile, with significant effects on the GDP growth rate. After the global crisis of 2008, remittances have become much more volatile, inducing large fluctuations of GDP growth durably impacting both households' income and government revenues. This sequence is fairly close to the "when it rains, it pours" effect (Kaminsky et al., 2005) since capital flows follow the same trend that business cycles, inducing more dramatic GDP growth instability.

Because economic uncertainty in host countries can induce sudden fluctuations, remittances should be considered by developing countries' policymakers as a temporary additional income rather than as a providential resource. This is all the more the case as remittances are not only subjected to business cycles in host countries but also to political shocks. In particular, immigration policies may change quickly and create important drop in remittances. For instance, Ratha (2005) pointed out that MENA oil producers' countries have strongly tightened their immigration policies during the 1980s, inducing a significant decrease in remittances sent to developing countries. Policies in host economies therefore represent an additional source (and cumulative one) of remittance volatility, particularly if migrants are concentrated in one or two specific countries adopting similar policies like in Europe. One implication of these cumulative risks linked to the concentration of diasporas is that countries sending migrants should settle down various policy or regulatory mechanisms in order to reduce their vulnerability to the risk of importing volatility through transfers. Equally, governments should not rely too extensively on remittances to promote economic growth and should provide countercyclical policies to smooth cycles when migrants' transfers drop. They could, for example, tax FDI sourced in host countries concentrating large diaspora's share, or else export flows to these countries, in order to endow a stabilisation fund that could be used when remittances become excessively volatile. Cooperation with countries hosting large shares of the diaspora would ease these policies notably if they are integrated to comprehensive international trade and investment agreements.

6 | CONCLUSION

This paper theoretically and empirically documents the mechanisms through which the pattern of geographical distribution of a country's diaspora generates GDP growth volatility in the home country. Two types of risks, the contagion risk and the concentration risk, are derived from a portfolio theory of migration and remittances before they are empirically identified for a large panel of developing countries over 1995–2015. On the one hand, we find that income volatility in host countries has a positive indirect impact on volatility in home country, which is driven by countries with large diasporas. The contagion risk is exclusively driven by the individual income volatility in the two main host countries. By contrast, business cycle co-movement across the different host countries has no impact on the volatility of remittances in our sample.

We find that remittances are a channel of volatility transmission from host to home country as they are exposed to a contagion and a concentration risk. The remittance's impact on home country's volatility we measure is net from other possible channels of volatility transmission also related to diaspora's location. On the other hand, we find evidence of the concentration risk as diaspora's concentration has an impact on output volatility in home country through increased volatility of remittances. Our results are robust to the inclusion of additional controls and to outliers' exclusion.

Our findings raise important policy issues as we show that, although migrants can have altruistic motivations, remittances are not systematically countercyclical with respect to home country's

income level and may even turn pro-cyclical if business cycles in host and home countries are sufficiently synchronised. These effects are amplified when host countries are more volatile and when the diaspora is more concentrated. Moreover, pro-cyclical effects shall also be amplified in the future if bilateral trade and capital exchanges intensify between home and host countries. Indeed, the most recent literature has established that migration tends to strengthen trade and financial ties (Kugler et al., 2018). As countries get increasingly connected through FDI and value chains, these sources of cumulative effects should be investigated in the future.

ACKNOWLEDGEMENTS

We want to thank Jean-Louis Combes, Mathilde Maurel, El Mouhoub Mouhoud and the anonymous referee for their useful suggestions. We also thank participants of the 2018 CESifo Junior Economist Workshop on Migration Research (Munich) and participants of the 2018 IDE-GDRI Conference on International Development Economics (CERDI, Clermont-Ferrand). All remaining errors are ours.

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How to cite this article: Rougier É, Yol N. The volatility effect of diaspora's location. *World Econ*. 2019;42:1796–1827. https://doi.org/10.1111/twec.12773

APPENDIX

APPENDIX 1: Additional Controls

Variable	Measurement	Source
Exchange rate volatility	5-year standard deviation	World Bank and IMF
Inflation volatility	5-year standard deviation	World Bank and IMF
Credit volatility	5-year standard deviation	World Bank and IMF
Natural disaster	5-year average	CRED (Catholic University of Louvain)
GDP/capita (home country)	5-year average	World Bank and IMF
GDP/capita (host countries)	5-year average	World Bank and IMF
Public expenditure volatility	5-year standard deviation	World Bank and IMF
Dependency	5-year average	World Bank and United Nations
Investment freedom	5-year average	Heritage Foundation
Export volatility	5-year standard deviation	World Bank
FDI volatility	5-year standard deviation	World Bank
Diaspora size	Quinquennial data	United Nations

APPENDIX 2: Sample of Countries

Afghanistan	Lesotho
Albania	Liberia
Algeria	Libya
Angola	Macedonia, FYR
Argentina	Malawi
Armenia	Malaysia
Azerbaijan	Maldives
Bangladesh	Mali
Belarus	Mauritania
Belize	Mauritius
Benin	Mexico
Bhutan	Moldova
Bolivia	Mongolia
Bosniaand Herzegovina	Morocco
Botswana	Mozambique
Brazil	Namibia
Bulgaria	Nepal
Burkina Faso	Nicaragua
Burundi	Niger
Cambodia	Nigeria

(Continues)

TABLE A2 (Continued)

Cameroon	Pakistan
Cape Verde	Panama
China	Papua New Guinea
Colombia	Paraguay
Congo (Dem. Rep.)	Peru
Congo (Rep.)	Philippines
Costa Rica	Romania
Djibouti	Russian Federation
Dominican Republic	Rwanda
East Timor	Senegal
Egypt. Arab Rep.	Sierra Leone
El Salvador	Solomon Islands
Eritrea	South Africa
Ethiopia	Sri Lanka
Fiji	Sudan
Gabon	Swaziland
Gambia, The	Tajikistan
Georgia	Tanzania
Ghana	Thailand
Guatemala	Togo
Guinea	Tonga
Guinea-Bissau	Tunisia
Guyana	Turkey
Haiti	Uganda
Honduras	Ukraine
India	Venezuela, RB
Indonesia	Vietnam
Iran. Islamic Rep.	Yemen, Rep.
Ivory Coast	Zambia
Jordan	
Kazakhstan	
Kenya	
Kyrgyz Republic	
Lao PDR	
Lebanon	