Migration, Family, and Risk Diversification

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This paper proposes a formal model of migration in which workers are heterogeneous and markets are stochastically correlated. We derive and characterize the optimal migration pattern of a family. It is shown to depend on differences in expected earnings, costs of migration, income risks, and more importantly market correlations. We show that migration can take place even when migrants earn less abroad and, more surprisingly, when earnings in the foreign country are riskier for every member of the family. Moreover, it may well be an optimal arrangement to have only dependents migrate, thus rationalizing the recent dependent-oriented migration flows from places like Hong Kong and Taiwan. We also provide some evidence in support of our theory.

Keywords: Migration, Emigration, Family, Risk Diversification, Dependents

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1. Introduction

For the past three decades, the theory of migration has been a growing field in economics. While migration may arise from social or political considerations, economists have been able to demonstrate the importance of labor market factors in the migration process. Studies, notably by Sjaastad (1962), Borjas (1989), and many others, view migration as an investment in which the income gain along with other benefits resulting from migration must at least exceed the costs associated with it to justify the move, provided that there are no institutional or political barriers inhibiting migration. Harris and Todaro (1970) consider migration as a response to the urban-rural (which can also be interpreted as foreign-home) wage differential in their two-sector model in which the urban employment rate acts as an equilibrating force on migration.

Recent studies by Stark (1991) and others, known as the new economics of labor migration, add a new dimension to the theory of migration. Since then, focus has been shifted from individual-based to mutually interdependent family-based studies. Remittances from migrants to their families at home and inter-personal income transfers among family members are thus the results of collective migration decisions. Put differently, the view of the family as the decision-making unit has been strongly emphasized in this part of the literature. This new approach provides a more complex, but more realistic framework in which intra-family tradeoffs and hence their effects on migration behavior can be fully analyzed.[1] In the presence of uncertainty, Stark (1991) argues convincingly for the importance of risks in family migration decisions. The decision to migrate in his model is

[1] For surveys of the "new economics" of migration, see Ghatak et. al. (1996), Massey et. al. (1993), and especially Stark (1991).

derived from risk diversification, a result that is consistent with the theory of investment in financial economics.

For all of its accomplishments, we feel that the introduction of risks and the role derived from it have not yet been fully explored in the literature. Nor has the pattern of migration of a typical family in response to income risks across countries been thoroughly investigated, at least in a coherent theoretical model. By assuming a stochastic foreign market and a deterministic domestic market, the existing theory is incapable of addressing the effects of market interactions on family migration decisions. Furthermore, by assuming that family members are homogeneous (although market uncertainty may affect them differently), the relationship between family characteristics and migration patterns has consequently been ignored. Given these shortcomings, the existing theory of migration is not equipped to offer an explanation for the observation that in some families the breadwinners migrate to support the dependents at home, while in others only their dependents migrate, leaving the breadwinners at home.

The purpose of this paper is to formulate a general model of migration under uncertainty. Our main task is to investigate how the income risk in each country along with their correlation interacts with the expected income of each family member to influence the migration decision of the family. In our model, we allow family members to differ in productivities. Their expected incomes in both countries are subject to some random but correlated disturbances.[2] As a result, we are able not only to explore the impact of country risks on migration, but also to characterize the migration pattern of a family. In

[2] Note that the assumption of heterogeneous labor is also employed in Borjas (1987) in his "individual" migration model. However, as far as the "family" migration models are concerned, homogeneity of labor is assumed. This restrictive assumption is relaxed in the present paper.

particular, we can explain why in some Asian countries (e.g., Hong Kong and Taiwan), dependents (who have no income at home as well as abroad) migrate while their (more productive) parents stay home. Furthermore, we can also show that some members in a family may migrate even if *every* migrant makes less in the foreign country. This holds true even when the income risk in the foreign country is *higher* than that in the home country. To this end, we emphasize the role of the income correlation between countries on the family migration decision. A negative market correlation helps reduce the overall risk and enhances the incentive to migrate. Consequently, migration may take place even when migrants' incomes actually fall after migration and/or the income risk in the foreign country is higher than that in the home country.

The idea that income risk, or even correlation of incomes between regions, can influence the migration decision is not new (see, e.g., Stark and Levhari 1982). Using data on marital arrangements among rural Indian households, Rosenzweig and Stark (1989) test the hypothesis that marital migration serves to mitigate income risk in an environment where insurance markets are underdeveloped and there are spatially covariant risks. Although they do not set up a formal theoretical model for it, the basic insight that income risks, together with the covariance of the risks, strongly influence the mobility of people across regions and countries is clearly embedded in their paper. The paper that is closest to ours is Daveri and Faini (1999). They consider a three-country model and study the influence on the migration flow of (i) an increase in the correlation between home and foreign incomes, and (ii) an increase in the home income risk. They also use Southern Italian migration data to test and confirm their theoretical results. Similar to our paper, they find that the correlation of incomes between countries (regions) influences the migration decision. Unlike our paper, they do not attempt to characterize the optimal migration pattern of a family. In view of these existing studies, the main contribution of this paper is essentially to provide a formal model of migration behavior under uncertainty and to characterize the optimal family migration pattern as a function of expected incomes, country risks, and market correlations. A unique feature of our model is that it can offer a coherent explanation for two antithetical patterns of family migration: breadwinner-oriented migration and dependent-oriented migration.[3]

The paper is organized as follows. Section 2 presents the general model and characterizes the optimal migration pattern. Section 3 investigates the properties of the model, conducts a sensitivity analysis, and examines the role of some key assumptions in the model. Section 4 presents some empirical evidence that are supportive of our theory. Section 5 concludes the paper. Detailed mathematical proofs are provided in the Appendix.

2. The Model

Consider a family consisting of n members. There are two countries, home and foreign, for the family to allocate its members. For each member, the cost of migration is $c > 0$, which includes the cost of moving to and working in the foreign country. Let $N = \{1, 2, ..., n\}$ denote the set of family members, H and F denote the set of family members in the home country and the foreign country, respectively, then $H \subseteq N$, $F \subseteq N$, $H \cup F = N$, and $H \cap F = \phi$. Let n_H and n_F be the number of elements in H and F, respectively. The

[3] As noted above, recent migration flows from Taiwan and Hong Kong have been mostly dependents. Neither the human capital model of Sjaastad (1962) and Borjas (1989) nor the "new" economic theory of migration of Stark (1991) attempts to explain this phenomenon. The motivation behind this migration pattern may have nothing to do with income gains as the dependents earn practically nothing abroad.

income (or wage) of member i is h_i if he stays in the home country and f_i if he moves to the foreign country. Let $r_i = f_i - h_i$ denote the gain (or loss) in income if member i migrates to the foreign country, $i \in N$. Without loss of generality, we order i such that $r_1 \geq r_2 \geq ... \geq r_n$. A small or negative value of r_i does not imply that i has a small or negative income in the foreign country. It only means that the gain from migration is low or negative for i, and in fact the income of i may be high in both countries.[4]

In addition to the deterministic components h_i and f_i, each individual's welfare is subject to a country-specific random shock denoted by ε_H in the home country and ε_F in the foreign country. The random variables ε_F and ε_H are assumed to be correlated. Let y_i denote member i's income, then $y_i = h_i + \varepsilon_H$ in the home country and $y_i = f_i + \varepsilon_F$ in the foreign country. This formulation assumes that the random shock is additive and that income can be added up with other measures (political or social) of welfare. Notice that the random shock in each country affects everyone in that country in the same way, i.e., neither ε_H nor ε_F depends on i. Each random shock is supposed to capture the variations in each country's economic, political, and social situations that affect the welfare (including income) of its residents. Therefore, ε_F and ε_H are interpreted as country risks rather than individual specific shocks. This assumption differentiates our model from the new economics of migration (Katz and Stark 1986, Stark 1991), which is

[4]By defining f_i and h_i as income only, we have implicitly excluded all other possible variables that may affect individual welfare, e.g., amenities. Nevertheless, our model can readily be extended to incorporate these variables. For instance, we can define $f_i = y_{iF} + \beta z_{iF}$ and $h_i = y_{iH} + \beta z_{iH}$; where y_{ij} is member i's income in country j ($j = H, F$) and z_{ij} denotes the amenities member i enjoys in country j. $\beta > 0$ is the rate of transformation between amenities and income as they (in unit terms) may not generate the same utility. In this modified case, the purpose of migration is not only to pursue higher income and diversify risk but also to seek a higher level of amenities. Since in this paper we are mainly concerned with the former, the amenity aspect of family welfare will for the most part be ignored. This means that we implicitly assume that the level of amenities a member (and in particular a dependent) enjoys is the same in both countries. Our results essentially demonstrate that there is still motivation to migrate (namely, risk diversification) even if the level of amenities is not a concern.

mainly concerned with the migration decision under individual risks.

Given these assumptions, the total family income I is given by

$$\begin{aligned} I &\equiv \sum_{i=1}^{n} y_i = \sum_{i\in H}(h_i + \varepsilon_H) + \sum_{i\in F}(f_i - c + \varepsilon_F) \\ &= \sum_{i\in H}(h_i + \varepsilon_H) + \sum_{i\in F}(f_i + \varepsilon_F) - n_F c \\ &= \sum_{i\in F}(r_i + \varepsilon_F) + \sum_{i\in H}\varepsilon_H + \sum_{i\in N} h_i - n_F c. \end{aligned}$$

Assume that the family has a mean-variance utility function $U(F)$ given by

$$U(F) = E(I) - kV(I), \tag{1}$$

where $E(I)$ is the expected family income, $V(I)$ is the variance, and $k > 0$ measures the degree of risk aversion of the family. The greater the value of k, the more risk averse is the family.[5] The objective of the family is to allocate its members between the two countries (home and foreign) so as to maximize family utility, i.e., it chooses F (and H) to maximize $U(F)$.

The assumption that the family acts as a coherent unit which sets out to maximize a family utility function can be justified in two different ways. First, the main family migration patterns that we seek to explain in this paper are particularly pervasive in societies where the families are led by a dominant head (usually the father as in the case of patriarchy). In these societies, it is not unreasonable to assume that there exists

[5] Although U depends on many variables other than F, we only highlight F here because it is sufficient to convey the ideas. We employ a mean-variance utility because it offers a precise measure of riskiness and it enables us to derive tractable analytical results. This specification has been used in other studies as well (e.g., Grossman and Stiglitz, 1980). It can be justified if the underlying utility function is quadratic or if the income is normally distributed (see Huang and Litzenberger, 1988). For a general utility function, we cannot separate the expected utility into mean and variance, so the expected utility may not depend on mean and variance only. However, as long as the family prefers income and abhors risk, its desire to balance the mean and variance of income still exists. Qualitatively, our results and conclusions should not be affected by using a more general utility function, as long as we can define a precise measure of riskiness.

an authoritative head or benevolent dictator in the family who controls the migration decision of its members based on some aggregate measure of utility.

Second, the family utility function $U(F)$ can be derived from aggregating individual utility functions under certain conditions. Suppose every family member has the same mean-variance utility function $u(y_i) = E(y_i) - aV(y_i)$, $i \in N$, where a measures the degree of risk aversion. Assuming that the family allocates income to achieve optimal risk sharing among its members, then each member will receive the average income $\overline{y} = \sum_{i=1}^{n} y_i/n$. It follows that $u(\overline{y}) = E(\sum_{i=1}^{n} y_i/n) - aV(\sum_{i=1}^{n} y_i/n) = \left[E(\sum_{i=1}^{n} y_i) - \left(\frac{a}{n}\right) V(\sum_{i=1}^{n} y_i)\right]/n = \left[E(I) - \left(\frac{a}{n}\right) V(I)\right]/n = \left[E(I) - kV(I)\right]/n = U(F)/n$, where $k \equiv a/n$. Consequently, maximizing the individual utility function $u(y_i)$ with respect to y_i for member i is equivalent to maximizing the family utility function $U(F)$ with respect to I. In other words, each member's objective essentially coincides with the family's objective.[6] In this case, the degree of risk aversion for the entire family decreases with the family size ($k = a/n$), which is very much expected because of the risk pooling effect.

Although the above two justifications (dominant head versus family risk-sharing) have different meanings, all the main results of this paper hold regardless of whether k is a constant or equals a/n. Thus we will simply use the general symbol k when there is no need to distinguish between the two cases. When the two cases do differ or when the case $k = a/n$ enhances interpretation, we will state it explicitly in the paper.

Assume $E(\varepsilon_F) = E(\varepsilon_H) = 0$, $V(\varepsilon_F) = \sigma_F^2$, $V(\varepsilon_H) = \sigma_H^2$, and $cov(\varepsilon_F, \varepsilon_H) = \sigma_{HF}$. Substituting these into (1), the objective of the family becomes

$$\max_F U(F) = \sum_{i \in F} r_i + h - n_F c - k\left(n_F^2 \sigma_F^2 + n_H^2 \sigma_H^2 + 2 n_F n_H \sigma_{HF}\right), \tag{2}$$

[6] We are grateful to Yoram Weiss for pointing out this risk-sharing argument.

where $h \equiv \sum_{i \in N} h_i$. Let F^* and H^* denote the optimal solution to (2), and n_F^* denote the optimal number of migrants. The existence of a solution to (2) is obvious as there are only a finite number of ways (i.e., 2^n) to assign n people between two countries. We assume that a member will stay home if the family utility remains the same regardless of whether that member stays home or migrates. Throughout this paper, we assume that $V(\varepsilon_F - \varepsilon_H) > 0$.[7]

Let ΔU_l denote the marginal benefit of migrating the $(l+1)$-st member to the foreign country, given that the first l members have already migrated, then $\Delta U_l \equiv U(\{1, ..., l+1\}) - U(\{1, ..., l\})$, $l = 0, 1, 2, ..., n-1$. Throughout this paper, we define $\{1, 2, ..., l\} = \phi$ if $l = 0$. Substituting (2) into the right-hand side of ΔU_l and simplifying,

$$\Delta U_l = r_{l+1} - c - k\left\{(2l+1)\sigma_F^2 - [2(n-l)-1]\sigma_H^2 + 2(n-2l-1)\sigma_{HF}\right\}. \tag{3}$$

Differencing the marginal utility of migration ΔU_l,

$$\begin{aligned} \Delta U_l - \Delta U_{l-1} &= (r_{l+1} - r_l) - 2k\left(\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF}\right) \\ &= (r_{l+1} - r_l) - 2kV(\varepsilon_F - \varepsilon_H) < 0, \end{aligned} \tag{4}$$

as $r_{l+1} \leq r_l$ and $V(\varepsilon_F - \varepsilon_H) > 0$ by assumption. Thus, the marginal utility of migration strictly diminishes with the number of migrants.

The following proposition characterizes the optimal equilibrium migration pattern for an interior solution.

Proposition 1 *Let l be such that $\Delta U_{l-1} > 0$ and $\Delta U_l \leq 0$, then $F^* = \{1, 2, ..., l\}$ and $H^* = \{l+1, ..., n\}$.*

[7] This assumption will hold if either $\sigma_F \neq \sigma_H$ or $\sigma_{HF} \neq \sigma_H\sigma_F$ (i.e., ε_F and ε_H are not perfectly positively correlated). This follows from the fact that $V(\varepsilon_F - \varepsilon_H) = \sigma_F^2 + \sigma_H^2 - 2\sigma_{HF} = (\sigma_F - \sigma_H)^2 + 2(\sigma_H\sigma_F - \sigma_{HF})$. As $\sigma_H\sigma_F \geq |\sigma_{HF}|$, therefore $V(\varepsilon_F - \varepsilon_H) > 0$ if either $\sigma_F \neq \sigma_H$ or $\sigma_{HF} \neq \sigma_H\sigma_F$.

Proof: See Appendix.

Proposition 1 shows that there is a unique way of allocating the family members between home and abroad to maximize the family utility. If migration is to occur, the member with the highest foreign-home income differential (r_1) will be the first one to migrate. The second one to migrate is the one with the second highest foreign-home income differential (r_2). In other words, the order of migration follows exactly the order of i. Migration takes place among those members with higher foreign-home income differentials. The process will continue until the marginal benefit of migration turns negative. In the presence of country-specific risks and heterogeneous family members, the proposition reveals that the foreign-home income differential remains an important determinant of migration. This result is broadly consistent with the "classical theory" of migration (e.g., Harris and Todaro, 1970) in that the income gap between two regions is shown to be the main impetus for migration. Nevertheless, we will demonstrate below that our analysis goes beyond the classical one and our findings are also substantially different.

3. Optimal Migration Pattern and Related Issues

In this section, we will investigate the properties of the model, conduct a sensitivity analysis, and re-examine the results when some assumptions are relaxed.

3.1 First and Last Movers

Proposition 1 characterizes the optimal migration pattern for an interior solution. In this section, we will examine the conditions for an interior solution ($0 < n_F^* < n$) as well as the conditions for a corner solution ($n_F^* = 0$ or $n_F^* = n$). These conditions will reveal some important and unique features of our model.

From (3), the marginal benefit of migrating the first, and thus the relatively most productive, member to the foreign country is given by

$$\begin{aligned}\Delta U_0 &= U(\{1\}) - U(\phi) \\ &= r_1 - c - k\left[\sigma_F^2 + 2(n-1)\sigma_{HF} - (2n-1)\sigma_H^2\right]. \quad (5)\end{aligned}$$

Thus, if

$$r_1 - c > k\left[\sigma_F^2 + 2(n-1)\sigma_{HF} - (2n-1)\sigma_H^2\right], \quad (6)$$

then $n_F^* > 0$; otherwise $n_F^* = 0$. Hence, there will not be any migration unless (6) holds.

As a benchmark, consider the special case where $\sigma_H^2 = \sigma_{HF} = 0$, i.e., the home income is deterministic (as in the case of the new economics of migration). Then (6) reduces to $r_1 - c > k\sigma_F^2$, implying that the foreign-home income differential net of migration costs must exceed $k\sigma_F^2$ for migration to take place. This, however, is no longer true in our general setting. Even if $r_1 - c < 0$ (and thus $r_i - c < 0$ for all $i = 2, 3, ..., n$), (6) can still hold when (a) σ_H^2 is sufficiently larger than $\left[\sigma_F^2 + 2(n-1)\sigma_{HF}\right]/(2n-1)$, or (b) $\sigma_H^2 > \left[\sigma_F^2 + 2(n-1)\sigma_{HF}\right]/(2n-1)$ and k is sufficiently large.[8] The intuition behind this result is as follows. If the home country is so unstable that condition (a) holds, then it makes sense to migrate even if the foreign income is lower than the home income. The loss resulting from a lower income abroad is more than compensated by a reduction in the variation of income. If condition (b) holds (that is, when the family is very sensitive to income variation), a small reduction in total income variation (from migration) can more than compensate for the fall in income. Notice that, even if $r_1 - c < 0$ and $\sigma_H^2 < \sigma_F^2$ (the foreign country is riskier than the home country), (6) can still hold.

[8] For the case where $k = a/n$, this requires that a be sufficiently large, holding n constant.

From (3), the marginal benefit of migrating the last, and thus the relatively least productive, member to the foreign country is

$$\Delta U_{n-1} = U(N) - U(\{1, ..., n-1\}) = r_n - c - k\left[(2n-1)\sigma_F^2 - 2(n-1)\sigma_{HF} - \sigma_H^2)\right]. \quad (7)$$

Hence, if

$$r_n - c > k\left[(2n-1)\sigma_F^2 - 2(n-1)\sigma_{HF} - \sigma_H^2)\right], \quad (8)$$

then $n_F^* = n$; otherwise $n_F^* < n$. Complete family migration occurs if (8) holds. Even if $r_n - c < 0$, (8) can still hold if $\sigma_F^2 < \sigma_{HF}$ and k is sufficiently large.[9] The result has an intuitive interpretation. Given $\sigma_F^2 < \sigma_{HF} < \sigma_H^2$, it is safer (in terms of risk) for the members to move to the foreign country. If the family is sufficiently risk averse, then all members will migrate even though the foreign income is lower than the home income for every member. In this case, diversification will not mitigate, but instead exacerbate, the risk in total family income.

If (6) holds but (8) does not hold, then we have an interior solution, i.e., $0 < n_F^* < n$. There is an important difference between (6) and (8). While (6) can still hold even when $r_1 - c < 0$ and $\sigma_H^2 < \sigma_F^2$, (8) cannot hold if $r_n - c < 0$ and $\sigma_H^2 < \sigma_F^2$.[10] This is intuitively reasonable because the family gains nothing from moving all its members abroad when the foreign income is lower than the home income for every member and the foreign country is also riskier than the home country.

[9] The proof is as follows. Since $\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF} = V(\varepsilon_F - \varepsilon_H) > 0$, $\sigma_F^2 < \sigma_{HF}$ implies that $\sigma_{HF} < \sigma_H^2$. It follows that $(2n-1)\sigma_F^2 - 2(n-1)\sigma_{HF} - \sigma_H^2 = (2n-1)(\sigma_F^2 - \sigma_{HF}) + (\sigma_{HF} - \sigma_H^2) < 0$.

[10] The proof is as follows. If $\sigma_F^2 > \sigma_H^2$, then $\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF} = V(\varepsilon_F - \varepsilon_H) > 0$ implies that $\sigma_F^2 + \sigma_F^2 - 2\sigma_{HF} > 0$, hence $\sigma_F^2 - \sigma_{HF} > 0$. Consequently, $(2n-1)\sigma_F^2 - 2(n-1)\sigma_{HF} - \sigma_H^2 > (2n-1)\sigma_F^2 - 2(n-1)\sigma_{HF} - \sigma_F^2 = 2(n-1)(\sigma_F^2 - \sigma_{HF}) > 0$. Hence, the right-hand side of (8) is positive but the left-hand side is negative, so (8) cannot hold.

The above results can be seen crystal-clear if we consider the special case where $k = a/n$ and n is large. Substituting $k = a/n$ and letting $n \to \infty$, (5) and (7) can be simplified to

$$\Delta U_0 = U(\{1\}) - U(\phi) = r_1 - c - 2a(\sigma_{HF} - \sigma_H^2), \tag{9}$$

and

$$\Delta U_{n-1} = U(N) - U(\{1, ..., n-1\}) = r_n - c + 2a(\sigma_{HF} - \sigma_F^2), \tag{10}$$

respectively. It is clear from (9) that the relatively most productive member can still migrate even if $r_1 - c < 0$ and $\sigma_H^2 < \sigma_F^2$. For any given values of r_1 and c, migration will occur if σ_{HF} is sufficiently negative.[11] That is, as long as there is enough negative covariance between the country risks, there will be migration. Similarly, (10) shows that the relatively least productive member can still migrate even if $r_n - c < 0$, provided that $\sigma_H^2 > \sigma_F^2$.[12] Clearly, (9) and (10) indicate that a sufficiently negative σ_{HF} will spur migration but forestall complete migration, giving rise to an interior solution. Alternatively, if the risk aversion a is sufficiently high and the covariance σ_{HF} is moderately positive (such that both $\sigma_{HF} < \sigma_H^2$ and $\sigma_{HF} < \sigma_F^2$ hold), then the family will also migrate some but not all of its members.

The main results can now be summarized in the following proposition.

Proposition 2 *(i) If (6) holds, then* $n_F^* > 0$ *(i.e., there is migration)*; *otherwise* $n_F^* = 0$. *Migration can still occur even if the foreign income is lower than the home income and the foreign country risk is higher than the home country risk.*

[11] Empirically, a negative correlation in income between countries is not impossible. For example, the Vietnam War had brought an economic boom to many Asian countries, although it was an economic disaster for Vietnam.

[12] From footnote 10, $\sigma_H^2 < \sigma_F^2$ implies $\sigma_F^2 - \sigma_{HF} > 0$. Thus, $r_n - c + 2a(\sigma_{HF} - \sigma_F^2) < 0$ if $r_n - c < 0$ and $\sigma_H^2 < \sigma_F^2$.

(ii) If (8) holds, then $n_F^* = n$ (i.e., complete migration); otherwise $n_F^* < n$. Even if the foreign income is lower than the home income for every family member, it is possible for the entire family to move abroad, provided that the foreign country risk is lower than the home country risk.

The proposition illustrates how the inclusion of country risks can generate new results that are considerably different from the prevailing ones in the literature. Our analysis is closely related to the new economics of migration (Stark 1991) in that uncertainty serves as a key factor motivating family migration. However, our analysis is different in two aspects. First, Stark and others assume that markets are stochastically independent, thus ruling out the possible effect of market relationships on individuals' migration decisions. On the contrary, we allow markets to be stochastically correlated and the market uncertainty affects individuals within the same country in the same way. The risks in our model are country risks, as opposed to individual risks in Stark's setup. The correlation between home and foreign markets plays an important role in family migration decisions. In Stark's model, for someone to migrate the foreign income must be higher than the home income in order to offset the risk involved. We, however, show that one may migrate even if the foreign income is lower and the foreign country risk is also higher. The foreign country risk is not necessarily "bad" because the overall risk can be mitigated if the home and foreign incomes are negatively correlated.[13] Second, Stark assumes that family members are homogeneous. In our model family members are heterogeneous with respect to their earning abilities. The question of *who* to migrate becomes an important

[13] It should, however, be emphasized that although Stark (1991) does not investigate the role of covariance in a theoretical model, its role is clear in some empirical works. See, for example, Rosenzweig and Stark (1989).

issue. Individual heterogeneity is a unique feature of our model and it is a key element in explaining some recent and distinct family migration pattern.

3.2 Incentive to Migrate

In this section, we will present some sensitivity results on the incentive (propensity) to migrate, as measured by the marginal utility of migration ΔU_l. It is straightforward to derive the following proposition.

Proposition 3 *(i)* $\partial \Delta U_l / \partial (r_i - c) > 0$, $\partial \Delta U_l / \partial \sigma_F^2 < 0$, *and* $\partial \Delta U_l / \partial \sigma_H^2 > 0$.

(ii) If $\sigma_H^2 > \sigma_{HF} > \sigma_F^2$, *then* $\partial \Delta U_l / \partial k > 0$. *If* $\sigma_H^2 < \sigma_{HF} < \sigma_F^2$, *then* $\partial \Delta U_l / \partial k < 0$. *Replacing* $\partial \Delta U_l / \partial k$ with $\partial \Delta U_l / \partial a$, *these results also hold for the case where* $k = a/n$.

(iii) Let ΔU_l^n *denote the marginal utility of migration* ΔU_l *when there are* n *members in the family. For the case where* k *does not depend on* n, $\Delta U_l^{n+1} - \Delta U_l^n = 2k(\sigma_H^2 - \sigma_{HF}) \gtreqless 0$ *if and only if* $\sigma_H^2 \gtreqless \sigma_{HF}$. *For the case where* $k = a/n$, $\Delta U_l^{n+1} > \Delta U_l^n$ *holds unconditionally.*

(iv) $\partial \Delta U_l / \partial \sigma_{HF} = 2k(-n + 2l + 1) \gtreqless 0$ *if and only if* $l \gtreqless (n-1)/2$.

Proof: See Appendix.

Proposition 3(i) shows that the home variance σ_H^2 encourages migration while the foreign variance σ_F^2 discourages it. The incentive to migrate increases with the foreign income f_i and decreases with the home income h_i as well as the migration cost c. Proposition 3(ii) indicates that a more risk averse family does not necessarily have a higher incentive to migrate its members. The propensity to migrate will increase (decrease) with the degree of risk aversion if the home country is riskier (less risky) than the foreign country.

Proposition 3(iii) reveals that the impact of family size on the incentive to migrate depends on whether the risk aversion parameter is a function of family size. If k does not depend on n, as in the dominant head model, then the propensity to migrate increases with the family size if and only if the home variance σ_H^2 is larger than the covariance σ_{HF}.[14] However, if $k = a/n$, as in the family risk-sharing model, then the incentive to migrate increases with the family size unambiguously and unconditionally. Even though the effects of k and n on the incentive to migrate may move in opposite directions, the net effect turns out to be unambiguously positive.

In the case where $k = a/n$, the family's risk aversion k will become very small as n gets large. Does this imply that the risk diversification role of migration will vanish as n tends to infinity? To answer this question, it is necessary to recognize that $\lim_{n\to\infty}(a/n)V(I) = \infty$ despite $\lim_{n\to\infty}(a/n) = 0$.[15] In other words, the variance of income $V(I)$ approaches infinity faster than the rate at which the risk aversion a/n goes to zero. Consequently, $(a/n)V(I)$ will not disappear from the family utility function, hence the role of risk diversification will not vanish as n gets large. To the contrary, risk diversification becomes *even more* important to the family as n grows because the income variance, which grows at the rate of n^2, rises much more rapidly than n. This is consistent with the second part of Proposition 3(iii) in which the incentive to migrate is found to be strictly increasing in n unconditionally. Put differently, if the risk diversification role of migration vanishes as n

[14] If $\sigma_{HF} < 0$ or $\sigma_H^2 > \sigma_F^2$, then $\sigma_H^2 - \sigma_{HF} > 0$ (the proof for $\sigma_H^2 > \sigma_F^2 \Rightarrow \sigma_H^2 - \sigma_{HF} > 0$ is identical to the one for $\sigma_F^2 > \sigma_H^2 \Rightarrow \sigma_F^2 - \sigma_{HF} > 0$ in footnote 10). This result is intuitively reasonable. If the country risks are negatively correlated or if the home country risk is higher than the foreign country risk, then a bigger family will have more incentive to migrate because the risk of staying home is higher and migration helps reduce the overall risk. On the other hand, $\sigma_H^2 - \sigma_{HF} < 0$ if and only if $\sigma_H^2 < \sigma_{HF} < \sigma_F^2$. In this case, the incentive to migrate decreases with the family size because the foreign country is riskier than the home country.

[15] This result holds regardless of the choice of n_F, provided that the country risks are not perfectly negatively correlated. A proof is provided in the Appendix.

tends to infinity, then the propensity to migrate will not increase with n unconditionally.

The result for Proposition 3(iv) may not appear to be obvious at first. It will become transparent if we first examine the effect of σ_{HF} on $U(\{1, 2, .., l\})$. From (2), we know that $\partial U(\{1, 2, ..., l\})/\partial \sigma_{HF} = -2k(n - l)l < 0$. An increase in the covariance σ_{HF} will reduce the family utility $U(\{1, 2, ..., l\})$ through increasing the income variance $V(I)$. Thus a higher covariance is bad for the family. Now we examine the effect of the covariance on the marginal family utility ΔU_l. Clearly, $\partial \Delta U_l/\partial \sigma_{HF} = 2k(-n + 2l + 1)$. Therefore, the effect of σ_{HF} on ΔU_l depends on the magnitude of l. This dependence originates solely from the total covariance $2l(n - l)\sigma_{HF}$ in $U(\{1, 2, ..., l\})$ as it is the only term in U that contains both l and σ_{HF}. Again, a higher total covariance is bad for the family. For any given n, the total covariance $l(n - l)\sigma_{HF}$ increases with l when l is smaller than $n/2$, reaches a maximum at $l = n/2$, and decreases with l when l is larger than $n/2$. Using these results, we can now provide an intuitive interpretation for Proposition 3(iv). If the majority of the family stays home ($l < (n - 1)/2$), then an increase in the covariance σ_{HF} will reduce the incentive to migrate ΔU_l because sending more members abroad (increasing l) will further increase the total covariance $2l(n-l)\sigma_{HF}$, thereby lowering the family utility U. On the other hand, if the majority of the family has already moved abroad ($l > (n - 1)/2$), then a higher covariance will encourage more migration because sending more members abroad will reduce the total covariance, thereby increasing the family utility. In both cases, the family benefits from reducing the total covariance $2l(n - l)\sigma_{HF}$.

As shown in (6), the presence of a correlation between the country risks is neither necessary nor sufficient for migration to take place. However, Proposition 3(iv) shows that

$\partial \Delta U_0 / \partial \sigma_{HF} = -2k(n-1)$ for the relatively most productive member ($l = 0$ for $i = 1$) and $\partial \Delta U_{n-1} / \partial \sigma_{HF} = 2k(n-1)$ for the relatively least productive member ($l = n-1$ for $i = n$). Therefore, the smaller (more negative) is σ_{HF}, the more likely that the first member ($i = 1$) will migrate and the less likely that the last member ($i = n$) will move abroad. Hence, a sufficiently negative σ_{HF} will initiate migration but inhibit complete migration. This result echoes the one obtained from (9) and (10) for the special case where $k = a/n$ and $n \to \infty$ as discussed in Section 3.1.

3.3 Dependent Migration

In the past two decades or so, there has been a surge in dependent-oriented migration from some Asian countries. The unique feature of this type of migration pattern is that, after a family landed in a foreign country, the father returned to his home country, leaving his wife and children behind. The breadwinner returned home while the dependents remained abroad. This new phenomenon is quite widespread among Taiwan and Hong Kong immigrants in a number of countries, e.g., Canada, the United States, New Zealand, and Australia (see Section 4 for detailed evidence). To many observers, this is unthinkable, particularly because the immigrants are from the regions that put a strong emphasis on family values.

Neither the classical nor the new theory of migration provides a satisfactory explanation for dependent migration. Dependents usually do not earn any income in either the home country or the foreign country, therefore dependent migration cannot be explained in terms of the difference in expected income between the two countries as suggested by the classical theory of migration. Nor can it be explained in terms of the diversification of individual risk as suggested by the new theory of migration because dependents have no earnings to offset the risk incurred in migration. In their current formulations, both the classical theory and the new theory are only concerned with the migration of *workers*, therefore they are incapable of explaining dependent migration. We will examine in this section whether our model can account for the migration of dependents.

Let $M^0 = \{i \in N \mid f_i = h_i = 0\}$ and $M = N \setminus M^0$.[16] We will call the members in M^0 dependents because they have no income in either country. We will also call the members in M productive members. Let $M^+ = \{i \mid r_i > 0\}$, $M^- = \{i \mid r_i < 0\}$, and $m_0 =$ the number of elements in M^0 (i.e., the total number of dependents in the family). The optimal migration policy described in Proposition 1 calls for the family to migrate its members in descending order of their foreign-home income differentials. The process starts with members in M^+ (i.e., those with positive r_i). If it remains profitable after all the members in M^+ have moved, then the members in M^0 (i.e., dependents) will follow. Again, if the marginal benefit continues to be positive after migrating all the dependents, then those in M^- will be next. That is, a dependent can migrate even before a productive member (who earns more at home than abroad). It is clear that dependent migration is not to increase family income (as $r_i = 0\ \forall i \in M^0$), but to diversify risk. The following proposition gives the conditions under which only dependents in the family migrate.

Proposition 4 *Only dependents will migrate, i.e., $F^* \subseteq M^0$, if and only if the following three conditions hold:*

(C4a) $M^+ = \phi$ *(i.e., $r_i < 0$ for all $i \in M$),*

(C4b) $\Delta U_0 = -c - k\,[\sigma_F^2 + 2(n-1)\sigma_{HF} - (2n-1)\sigma_H^2] > 0,$ *and*

(C4c) $\Delta U_{m_0} = r_{m_0+1} - c - k\,\{(2m_0+1)\sigma_F^2 - [2(n-m_0)-1]\sigma_H^2 + 2(n-2m_0-1)\sigma_{HF}\} \leq$

[16] Since it is only the change in income (r_i) that affects the migration decision, one can relax the assumption by defining M^0 to be the members with $f_i = h_i$.

0.

Therefore, if all productive members earn more at home than abroad, at least half of the family members are dependents, and the covariance between the home and foreign country risks is sufficiently negative, then only dependents will migrate.

Proof: See Appendix.

Conditions (C4a) and (C4b) guarantee that some dependents will move abroad, while condition (C4c) ensures that all the productive members will stay home. If (C4a), (C4b), and (C4c) hold, then only dependents will migrate.[17] Not all dependents must migrate, but those who migrate must be dependents. The proposition also offers a scenario in which dependent migration will occur. If at least half of the family members are dependents (i.e., $m_0 \geq n/2$, hence $n - 2m_0 - 1 < 0$) and the covariance between the country risks σ_{HF} is sufficiently negative, then conditions (C4b) and (C4c) will be satisfied. These conditions are not stringent as they are not difficult to meet in reality. For example, the families migrated from Hong Kong and Taiwan tend to have more dependents than non-dependents. Because of political uncertainties in Taiwan and Hong Kong, their country risks will likely vary inversely with those of the receiving countries such as Canada and the United States.

The above result can most easily be grasped if we consider the case where $k = a/n$

[17] A referee has suggested that (C4c) is too strong and the correct condition should be $\Delta U_{l^*} \leq 0$ where l^* is the optimal number of dependents emigrated (i.e., (C4c) should be evaluated at the optimal l^* instead of m_0). We disagree with the suggestions for two reasons. First, if our condition $\Delta U_{m_0} \leq 0$ is too strong, it suggests that it is possible to have dependent migration with $\Delta U_{l^*} \leq 0$ *and* $\Delta U_{m_0} > 0$ for $l^* < m_0$. Clearly, this is impossible because $\Delta U_{l^*} \leq 0$ implies $\Delta U_{m_0} < 0$ as $\Delta U_{m_0} < \Delta U_{l^*}$ for $l^* < m_0$ (by (4)). Thus, as a sufficient condition, $\Delta U_{m_0} \leq 0$ is not stronger than $\Delta U_{l^*} \leq 0$. Second, as a *practical* sufficient condition, $\Delta U_{l^*} \leq 0$ is not as neat as $\Delta U_{m_0} \leq 0$ because the former depends on an unknown quantity l^*. It is necessary to find the optimal l^* in order to demonstrate or verify that $\Delta U_{l^*} \leq 0$ is satisfied. In contrast, it is much simpler and easier to check whether $\Delta U_{m_0} \leq 0$ holds because m_0 is a known number. Thus, our condition $\Delta U_{m_0} \leq 0$ is no less general but even simpler and more readily verifiable than the condition $\Delta U_{l^*} \leq 0$.

and n is large. Let $k = a/n$ and $n \to \infty$, then (C4b) and (C4c) can be simplified to $\Delta U_0 = -c - 2a\,(\sigma_{HF} - \sigma_H^2) > 0$, and $\Delta U_{m_0} = r_{m_0+1} - c - 2a\,[(m_0/n)\sigma_F^2 - (1 - m_0/n)\sigma_H^2 + (1 - 2m_0/n)\sigma_{HF}] \leq 0$, respectively. Both inequalities will hold if σ_{HF} is sufficiently negative and m_0/n is greater than 1/2. The result is intuitively reasonable. A sufficiently negative σ_{HF} will trigger migration. From Proposition 1, we know that it will start from the members with higher r_i (i.e., dependents in this case). When there are more dependents than productive members in the family, a sufficiently negative σ_{HF} will eliminate the propensity for productive members to migrate.

3.4 Individual Shock

Thus far we have been concerned only with the effects of country risks on migration. While there are shocks which affect everyone's income in the country in the same way, there are also shocks which affect people individually. In this section we will discuss how the interplay of these two kinds of risk affects family migration decisions.

To introduce individual risk ξ_i into the model, let the income of member i be given by $h_i + \varepsilon_H + \xi_i$ if he stays home and $f_i + \varepsilon_F + \xi_i$ if he migrates. We assume that ξ_i and ξ_j $(i \neq j)$ are independent and $E(\xi_i) = 0$, for all $i, j \in N$. Following the literature on the new economics of migration, we assume that $\xi_i = 0$ if $i \in H$. That is, there is no individual income risk if one stays in the home country.[18] Hence, the family income is given by $I = \sum_{i \in F}(r_i + \varepsilon_F + \xi_i) + \sum_{i \in H} \varepsilon_H + \sum_{i \in N} h_i - n_F c$. Let $\sigma_i = V(\xi_i)$ and $\sigma_{iF} = cov(\xi_i, \varepsilon_F)$,

[18] This assumption is not unrealistic because at an individual level, an individual's income is more uncertain in the foreign country than in the home country. Thus, $V(\xi_i)$ is generally larger for $i \in F$ than for $i \in H$. Here we simply rescale the variance and assume that $V(\xi_i) = 0$ if $i \in H$. Incidentally, this model virtually reduces to that in Katz and Stark (1986) when $\sigma_F^2 = \sigma_H^2 = 0$ and $r_i = r$ for all i.

$i \in F$, then the optimization problem (2) becomes

$$\max_F U(F) \equiv \sum_{i \in F} r_i + h - n_F c - k \left(n_F^2 \sigma_F^2 + n_H^2 \sigma_H^2 + 2 n_F n_H \sigma_{HF} + \sum_{i \in F} \sigma_i^2 + 2 \sum_{i \in F} \sigma_{iF} \right). \tag{11}$$

Now migration may be more costly because the family has to overcome the individual income risks, in addition to the migration costs, the loss of income (if any), and the country risks. Let us define $s_i = r_i - k(\sigma_i^2 + 2\sigma_{iF})$, $i \in F$, and call s_i the risk-adjusted foreign-home income differential, then (11) can be expressed as

$$\max_F U(F) \equiv \sum_{i \in F} s_i + h - n_F c - k \left(n_F^2 \sigma_F^2 + n_H^2 \sigma_H^2 + 2 n_F n_H \sigma_{HF} \right). \tag{12}$$

Clearly, (12) is identical to (2) except that s_i replaces r_i. Assume that $s_i \geq s_{i+1}$ $\forall i = 1, 2, ..., n-1$, then the characterization of the optimization problem in (12) is the same as that given in Proposition 1. That is, the optimal allocation calls for migrating the members with higher risk-adjusted foreign-home income differentials, and stops at the one whose marginal benefit of migration is non-positive. There are, however, at least two differences between the two cases. First, the decision of which family member to migrate depends not only on his/her foreign-home income differential (as in the case of no individual risk), but also on the variance of the individual risk as well as its covariance with the country risk. Second, while Propositions 3(i) and 3(iv) continue to hold here, Propositions 3(ii) and 3(iii) will have to be modified because the dependence of s_i on k complicates the sensitivity analysis. Consider Proposition 3(iii) for example. If $k = a/n$, then $\Delta U_l^{n+1} - \Delta U_l^n = a \left[\sigma_{l+1}^2 + 2\sigma_{l+1,F} + (2l+1) V(\varepsilon_F - \varepsilon_H) \right] / [n(n+1)]$, which is no longer unambiguously positive. If $\sigma_{l+1,F}$ is sufficiently negative, then $\Delta U_l^{n+1} - \Delta U_l^n$ will become negative.

3.5 Multiplicative Risk

The country risk considered in the previous sections is additive in nature in the sense that it exerts a uniform effect on all individuals even though they have different earning capacities. In reality, individuals with higher earning capacities may have a higher stake in political and social instabilities. As a result, uncertainty has a greater impact on them than it does on those with lower earning capabilities. To study this possibility, we consider in this section country risks that affect income multiplicatively. Let the income of member i in the foreign and home countries be $f_i\varepsilon_F$ and $h_i\varepsilon_H$, respectively; where $E(\varepsilon_F) = E(\varepsilon_H) = 1$, $V(\varepsilon_F) = \sigma_F^2$, $V(\varepsilon_H) = \sigma_H^2$, and $cov(\varepsilon_F, \varepsilon_H) = \sigma_{HF}$. Similar to the additive risk case considered in the previous sections, this multiplicative risk does not alter the mean income as $E(f_i\varepsilon_F) = f_i$ and $E(h_i\varepsilon_H) = h_i$. However, $V(f_i\varepsilon_F) = f_i^2\sigma_F^2$ and $V(h_i\varepsilon_H) = h_i^2\sigma_H^2$, thus the income variance increases with the mean income of each individual. In other words, a high-income individual will face a higher country risk than a low-income individual. The family's objective (2) becomes

$$\begin{aligned}\max_F U(F) \equiv & \sum_{i\in F} r_i + h - n_F c \\ & -k\left[\left(\sum_{i\in F} f_i\right)^2 \sigma_F^2 + \left(\sum_{i\in H} h_i\right)^2 \sigma_H^2 + 2\left(\sum_{i\in F} f_i\right)\left(\sum_{i\in H} h_i\right)\sigma_{HF}\right] \quad (13)\end{aligned}$$

A comparison between (2) and (13) is now in order. When uncertainty is additive, the risk terms in (2) depend only on the number of migrants n_F. Consequently, the migration pattern is driven only by individual differences in the foreign-home income differential r_i. When uncertainty is multiplicative, however; the risk terms in (13) depend not only on the number of migrants n_F, but also on their composition (i.e., who migrate). Apart from the difference r_i, the migration pattern is also affected by f_i and h_i themselves.

This considerably complicates our analysis. In particular, since high income also brings in high risk, the family may be reluctant to migrate its high-income (in its relative sense) members if the foreign risk is high enough to offset any income gain from migration.

Since there are only a finite number of ways (2^n) to allocate family members between the home and foreign countries, (13) must have a solution. That is, an optimal migration pattern must exist. Unfortunately, there is no easy way to characterize the optimum. Proposition 5 below provides a set of sufficient conditions that will generate the same migration pattern as given in Proposition 1.

Proposition 5 *Under multiplicative uncertainty, if*

(C5a) the dispersion in home income is sufficiently small, and

(C5b) the foreign country risk is sufficiently small,

then the optimal solution to (13) will be given by $F^* = \{1, 2, ..., n_F^*\}$ *and* $H^* = \{n_F^* + 1, ..., n\}$. *In this case, migration takes place only among the productive members.*

Proof: see Appendix.

Intuitively, condition (C5a) ensures that the difference in home income between members is small (i.e., $h_j - h_t$ small for any $j \neq t$, $j, t \in N$), thus marginalizing any possible unfavorable effect of uncertainty on higher-income individuals in the home country. As a result, the difference in foreign income becomes the main consideration in determining who should migrate. Condition (C5b) ensures a small income risk in the foreign country (i.e., σ_F small), thus minimizing the hesitation to move abroad. As a result, the family's migration decision will be determined according to the relative income of the members and therefore those with high values of r_i will migrate first. Put differently, if

σ_F^2 is too high, the family may prefer to keep home those members with relatively high foreign income since the gain from higher income abroad may be more than offset by the loss resulting from a higher foreign income risk. Thus, conditions (C5a) and (C5b) serve to minimize the impact of the home income and the foreign country risk on the migration decision problem so that the magnitude of the foreign income becomes the only determinant.

In the additive-risk case, the total covariance is $2n_F n_H \sigma_{HF}$ (see (2)), which will be minimized by setting (i) $n_F = n_H = n/2$ if $\sigma_{HF} < 0$, and (ii) $n_F n_H = 0$ (either $n_F = 0$ or $n_H = 0$) if $\sigma_{HF} > 0$. In other words, the family can minimize the total covariance by equalizing (polarizing) the number of family members between the two countries if $\sigma_{HF} <$ ($>$) 0. The result is similar for the multiplicative-risk case. Here the total covariance is given by $2(\sum_{i \in F} f_i)(\sum_{i \in H} h_i)\sigma_{HF}$, which will be minimized by equalizing (polarizing) the total home income $\sum_{i \in H} h_i$ and the total foreign income $\sum_{i \in F} f_i$ if $\sigma_{HF} <$ ($>$) 0.

Finally, we wish to note that there is an important difference between the additive-risk case and the multiplicative-risk case in terms of dependent migration. For the additive-risk case, we have shown in Section 3.3 that it is possible to migrate only dependents. For the multiplicative-risk case, however, the dependents will *never* migrate. The reason is that if risk is multiplicative and dependents earn zero income regardless of where they are, then their expected income as well as their income risk is zero everywhere. That is, their contribution to the family utility is zero, therefore they become "irrelevant." Given that migration costs are strictly positive, dependents will never migrate, contrary to our previous claim. Thus, the multiplicative-risk model is not capable of explaining dependent migration. To overcome this shortcoming, a reasonable amendment would be to bring in amenities (e.g. education, social security, living environment, etc.) to the family utility function.[19] In this case, we can write the utility of member i as $f_i\varepsilon_F + \theta_F$ if he migrates and $h_i\varepsilon_H + \theta_H$ if he stays home; where θ_F and θ_H are the nonstochastic amenities provided by the foreign and home countries to their residents, respectively. By replacing f_i, h_i and r_i in (13) with $f_i + \theta_F$, $h_i + \theta_H$, and $f_i + \theta_F - (h_i + \theta_H)$, respectively, one obtains the family's utility function. Since $f_i + \theta_F - (h_i + \theta_H) = \theta_F - \theta_H$ for a dependent (as $f_i = h_i = 0$), it is evident that dependents will migrate if and only if $\theta_F - \theta_H > c$. Here, however, the rationale for dependents to migrate is to pursue better amenities in the foreign country. This is distinctly different from the additive-risk case where dependent migration is purely driven by the desire to diversify income risk.[20]

4. Empirical Evidence

One unique feature of our model is that it can offer a coherent explanation for two antithetical patterns of family migration: breadwinner migration and dependent migration. While both the classical theory and the new theory of migration can easily explain breadwinner migration, they cannot yet account for dependent migration. In our model, whether only breadwinners or dependents migrate depends crucially on their relative positions in the ranking of the foreign-home income differentials r_i. If breadwinners have higher r_i than dependents, then the former will migrate before the latter. This scenario is more likely to occur if breadwinners have portable skills and there are little barriers

[19] Empirical evidence suggests that the level of amenities in the destinations has a strong influence on migration behavior. For example, Borjas (1999) documents that the location choices of immigrants to the United States are affected by interstate dispersions in welfare benefits.

[20] Of course, dependent migration can also be driven by differences in amenities in the additive-risk case. What we have shown in the additive-risk case is that dependents can migrate even if the level of amenities is not a concern.

to entry for their professions in the foreign country. On the other hand, if breadwinners have only home-country-specific human capital (e.g., certain government officials) or face licensing problems in the foreign country (e.g., lawyers, medical doctors, dentists), then they may experience a sharp fall in income in the foreign country, hence their r_i will be very low or even negative. In this scenario, dependents will likely migrate ahead of breadwinners.

Both patterns of family migration can be found in Asia. For example, breadwinner migration is the most prominent pattern observed in the Philippines. In 1996, the total number of overseas Filipino workers (OFWs) was estimated to be about 900,000, of which 56 percent were males and 44 percent were females (National Statistics Office 1997). Over 78 percent of OFWs worked in Asia and the Middle East. About 83 percent of female OFWs worked as service workers (domestic helpers, nurses) while 92 percent of male OFWs worked as manual workers (production workers, transport equipment operators, and laborers). OFWs earn substantially more abroad, mainly because of the lack of employment opportunities in the Philippines. Through cash remittances, this labor-exporting industry generates a sizeable and steady source of national income for the Philippines. Female OFWs are probably the largest group of female migrant workers in the world. Many female Filipinos possess professional and portable skills that are highly valued in the world labor market. For instance, their proficiency in English is a portable skill that is particularly apt for service work abroad. The high unemployment rate at home, the high demand for service workers abroad, and the possession of portable skills are the most important factors for the massive migration of female workers from the

Philippines.[21]

In contrast to the persistent and massive breadwinner migration from the Philippines, Hong Kong and Taiwan have experienced significant dependent migration in recent decades. Feeling apprehensive about future economic and political developments, many well-to-do and middle-class families in Hong Kong and Taiwan have moved their dependents to more stable foreign countries, while the fathers stay in their home countries to make a living. This pattern is just opposite to breadwinner migration. As this is a relatively new and recent phenomenon, the evidence is less well-known and not well documented. In this section, we will present some empirical evidence in more details.

Table 1 reports the number of Hong Kong-born Chinese immigrants in Australia in 1991 by age group and sex. Table 2 displays the population of Hong Kong by age group and sex. The tables offer two important findings. First, 22.9% of the Hong Kong immigrants in Australia were teenagers, whereas only 14.6% of the Hong Kong population were teenagers. The difference between the two percentages suggests that a disproportional number of teenagers moved, or were moved, to Australia. Second, the sex ratios of the 30-39 and 40-49 age groups in Australia were 84 and 91, respectively, which were considerably lower than those in Hong Kong (104 and 117). In other words, there were substantially more Hong Kong females than males in the 30-49 age group in Australia, which was exactly the opposite of the situation in Hong Kong. The males in the 30-49 age group were most likely the breadwinners of their families. The disproportional number of Hong Kong female immigrants in the 30-49 age group in Australia suggests that many of their husbands returned to and worked in Hong Kong. These families sent their wives

[21] There are studies on the impact of the massive out-migration on the well-being of the dependents left behind, see for example, Cruz (1987).

and children to Australia, while the husbands stayed in Hong Kong to keep working or running their businesses.

The phenomenon of female bias is not confined to the Hong Kong immigrants in Australia. Table 3 presents the sex ratios of two groups of foreign-born population, namely Hong Kong-born Chinese and Non-Chinese born elsewhere, in Vancouver and Toronto in 1991. These two cities host the majority of the Hong Kong immigrants in Canada (Benjamin, Gunderson, and Riddell 1998). For the purpose of comparison, the corresponding age-specific sex ratios of the general population in Hong Kong are displayed in the last column of the table. The figures show that there were noticeably more females than males in the 25-44 and 45-64 age groups among the Hong Kong born-Chinese in both Vancouver and Toronto. Neither the Non-Chinese foreign-born population in these two cities nor the general population in Hong Kong exhibited such a strong female bias. Similar to Tables 1 and 2, the female bias is consistent with our theory of dependent migration: the breadwinners (husbands) chose to stay in Hong Kong for work or business purposes, leaving their wives and children in Canada.

Table 3 also reveals an interesting difference: the female bias in the 25-44 age group was much more pronounced in Vancouver than Toronto. This difference is also consistent with our theory. The geographical distance between Vancouver and Hong Kong is significantly shorter than that between Toronto and Hong Kong. There are regular daily direct non-stop flights between Vancouver and Hong Kong, but not between Toronto and Hong Kong. Therefore, the lower time and monetary costs of traveling between Vancouver and Hong Kong enabled the husbands in Hong Kong to visit their families in Vancouver more often, thereby facilitating this particular pattern of dependent migration. In other words, households opting for dependent migration would choose Vancouver over Toronto as their destination, other things being equal.

Dependent-oriented migration occurs not only among Hong Kong immigrants but also among Taiwan immigrants in Australia. For example, Ho and Coughlan (1997) report that the substantially high median age of the Taiwan-born males in Australia is not consistent with recent migration data on the age of new settlers upon arrival in Australia. It is not difficult to rationalize why this particular form of dependent migration is popular among Hong Kong and Taiwan immigrants. Both Hong Kong and Taiwan faced political and economic uncertainties caused by the impending return of Hong Kong to China in 1997 and the long-standing tensions between Taiwan and China. Diversifying the political and economic risks is the main impetus for Hong Kong and Taiwan families to migrate their dependents.

Although our theory of dependent migration can explain the age group and sex ratio differentials in Tables 1 and 3, we cannot rule out other alternative explanations on the basis of these aggregate data. For the age group differentials, it is possible that a disproportional number of Hong Kong teenagers went to Australia for better education opportunities. For the sex ratio differentials, the female bias can be caused by selective immigration policies. To alleviate their labor shortage problems, some countries grant priorities to the importation of certain professionals, such as nurses, secretaries, and teachers, etc. As these professions tend to be held by females, the selective immigration policies may unintentionally attract more females than males.[22] More disaggregate and

[22] In the case of Canada, this alternative explanation is rejected by the data in Table 3. If selective immigration policies produce a female bias, then it should be observed among *all* the foreign-born residents in Vancouver and Toronto because Canadian immigration policies are generally worldwide and not country-specific. The finding that only the Hong Kong-born Chinese, but not the Non-Chinese born elsewhere, exhibit a female bias for the 25-44 and 45-64 age groups in both Vancouver and Toronto

refined data are needed to test our theory vis-à-vis the alternative hypotheses. Although such kind of data is not yet available at this moment, various small-scale but in-depth household interviews of Hong Kong immigrants in Australia, Canada, Singapore, and other places (see, e.g., Skeldon (1994), Pe-Pua et al. (1996), and Waters (2001)) do find significant evidence of dependent migration. These studies lend credence to our theory of family risk diversification.

5. Conclusion

In this paper, we characterize the optimal family migration pattern in a utility-maximizing framework with heterogeneous members and stochastically interdependent markets. We carry out a comprehensive analysis and obtain the following results: (1) Migration occurs among members with relatively higher earning potentials abroad; (2) Migration can take place even if migrants earn less abroad *and* the income risk in the foreign country is also higher; (3) The incentive to migrate is shown to depend on the wage differential between the home and foreign countries, the risk in each country, the costs of migration, and more importantly the market correlation between the two countries; (4) For families with dependents, migrating only dependents can be an optimal strategy; and (5) Our model provides a coherent explanation for both breadwinner-oriented migration and dependent-oriented migration.

An important aspect of migration that is not dealt with in this paper is return migration. The motivation behind many migration movements, for example the migration of Europeans to the United States before World War II and the Hong Kong migration before 1997, were driven by the desire is to shun political risks. After the risks were resolved,

suggests that the bias is not generated from the immigration policies.

some of the migrants returned to their home countries. Incorporating the possibility of return migration into our model will complicate but also enrich the analysis.

In addition to return migration, combining both country risks and individual shocks to account for dependent migration, extending the analysis to more than two countries, and incorporating information asymmetry on worker's productivity (as observed by foreign and domestic employers) are issues worthy of further investigation.

Appendix

Proof of Proposition 1

Suppose the family wants to allocate n_F members to the foreign country, then $U(F)$ will be maximized if $\sum_{i\in F} r_i$ is maximized because all the other terms on the right-hand side of (2) are fixed, given n_F and $n_H = n - n_F$. Clearly, the maximum of $\sum_{i\in F} r_i$ will be achieved if F contains the first n_F members of N because they have the highest values of r_i. Thus, $F = \{1, 2, ..., n_F\}$ and $H = \{n_F + 1, ..., n\}$. In other words, conditional on n_F, then $F = \{1, 2, ..., n_F\}$ and $H = \{n_F + 1, ..., n\}$ are optimal. Now suppose there exists an integer l such that $\Delta U_{l-1} > 0$ and $\Delta U_l \leq 0$, $1 \leq l < n$. As ΔU_l is strictly decreasing in l (see (4)), $U(\{1, 2, ..., l\})$ achieves a maximum at l. It follows that $n_F^* = l$, $F^* = \{1, 2, ..., l\}$, and $H^* = \{l + 1, ..., n\}$. The solution is unique because ΔU_l is strictly decreasing in l.

Proof of Proposition 3

(i) It is straightforward to verify from (3) that $\partial \Delta U_l / \partial(r_i - c) = 1$, $\partial \Delta U_l / \partial \sigma_F^2 = -k(2l + 1) < 0$, and $\partial \Delta U_l / \partial \sigma_H^2 = k[2(n - l) - 1] > 0$ (because $l < n - 1/2$).

(ii) Differentiating (3) with respect to k, $\partial \Delta U_l / \partial k = -(2l + 1)\sigma_F^2 + [2(n - l) - 1]\sigma_H^2 - 2(n - 2l - 1)\sigma_{HF} = (2l + 1)(\sigma_{HF} - \sigma_F^2) + [2(n - l) - 1](\sigma_H^2 - \sigma_{HF})$. If $\sigma_H^2 > \sigma_{HF} > \sigma_F^2$, then $\partial \Delta U_l / \partial k > 0$. If $\sigma_H^2 < \sigma_{HF} < \sigma_F^2$, then $\partial \Delta U_l / \partial k < 0$.

(iii) If k does not depend on n, then it is straightforward to verify from (3) that $\Delta U_l^{n+1} - \Delta U_l^n = 2k(\sigma_H^2 - \sigma_{HF})$. If $k = a/n$, then it follows from (3) that $\Delta U_l^{n+1} - \Delta U_l^n = \{a/[n(n + 1)]\}\{(2l + 1)\sigma_F^2 - [2(n - l) - 1]\sigma_H^2 + 2(n - 2l - 1)\sigma_{HF} + 2n(\sigma_H^2 - \sigma_{HF})\} = a(2l + 1)(\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF})/[n(n + 1)] = a(2l + 1)V(\varepsilon_F - \varepsilon_H)/[n(n + 1)] > 0$.

(iv) It is obvious from (3) that $\partial \Delta U_l / \partial \sigma_{HF} = -2k(n - 2l - 1) \gtreqless 0$ if and only if $l \gtreqless (n - 1)/2$.

Proof of $\lim_{n\to\infty} (a/n)V(I) = \infty$

There are two cases to consider in the proof: $\sigma_{HF} \neq \sigma_H \sigma_F$ and $\sigma_{HF} = \sigma_H \sigma_F$.

(i) Suppose $\sigma_{HF} \neq \sigma_H \sigma_F$ (the country risks are not perfectly correlated). By assumption, $V(\varepsilon_F - \varepsilon_H) = \sigma_F^2 + \sigma_H^2 - 2\sigma_{HF} > 0$, thus

$$\begin{aligned} V(I) &= n_F^2 \sigma_F^2 + (n - n_F)^2 \sigma_H^2 + 2 n_F (n - n_F) \sigma_{HF} \\ &= \left(\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF}\right) \left[n_F + \frac{n\left(\sigma_{HF} - \sigma_H^2\right)}{\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF}} \right]^2 + \frac{n^2\left(\sigma_H^2 \sigma_F^2 - \sigma_{HF}^2\right)}{\sigma_F^2 + \sigma_H^2 - 2\sigma_{HF}} \\ &\geq \frac{n^2\left(\sigma_H^2 \sigma_F^2 - \sigma_{HF}^2\right)}{V(\varepsilon_F - \varepsilon_H)}. \end{aligned}$$

It follows that $\lim_{n\to\infty} (a/n)V(I) \geq \lim_{n\to\infty} \left[na\left(\sigma_H^2 \sigma_F^2 - \sigma_{HF}^2\right) / V(\varepsilon_F - \varepsilon_H) \right] = \infty$. Therefore, $\lim_{n\to\infty} (a/n)V(I) = \infty$.

(ii) Suppose $\sigma_{HF} = \sigma_H \sigma_F$ (the country risks are perfectly positively correlated). In this case, $V(I) = \left[n_F \sigma_F + (n - n_F)\sigma_H\right]^2 \geq n^2 \min\{\sigma_H, \sigma_F\}$, hence $\lim_{n\to\infty} (a/n)V(I) = \infty$.

It follows from cases (i) and (ii) that, regardless of the choice of n_F, $\lim_{n\to\infty} (a/n)V(I) = \infty$ if the country risks are not perfectly negatively correlated.

Note: If $\sigma_{HF} = -\sigma_H \sigma_F$ (the country risks are perfectly negatively correlated), then $V(I) = \left[n_F \sigma_F - (n - n_F)\sigma_H\right]^2$, which does not have a positive lower bound. For instance, if $n_F = n\sigma_H/(\sigma_H + \sigma_F)$, then $V(I) = 0$. Therefore, whether $\lim_{n\to\infty} (a/n)V(I) = \infty$ depends on the choice of n_F. If $n_F = 0$ or n, then $\lim_{n\to\infty} (a/n)V(I) = \infty$. If $n_F = n\sigma_H/(\sigma_H + \sigma_F) + \pi$ for some constant π that does not depend on n, then $V(I) = \left[\pi(\sigma_F - \sigma_H)\right]^2$, thus $\lim_{n\to\infty} (a/n)V(I) = 0$.

Proof of Proposition 4

Sufficiency: Condition (C4b) implies that there must be at least one migrant. Conditions (C4a) and (C4c) imply that no productive members will migrate because (4) implies that $\Delta U_{m_0+1} < \Delta U_{m_0} \leq 0$, hence the $(m_0 + 1)$-st member (i.e., the first productive member) must stay home. Hence, $F^* \subseteq M^0$.

Necessity: Suppose $F^* \subseteq M^0$, i.e., there are m^* migrants and they are all dependents, $0 < m^* \leq m_0$. By Proposition 1, this implies (C4a), (C4b), $\Delta U_{m^*-1} > 0$, and $\Delta U_{m^*} \leq 0$. Clearly, $\Delta U_{m_0} = \Delta U_{m^*}$ if $m^* = m_0$, and $\Delta U_{m_0} < \Delta U_{m^*} \leq 0$ if $m^* < m_0$ (by (4)), thus (C4c) follows.

Proof of Proposition 5

Assume (C5a) $h_j - h_t$ is sufficiently small for any $j \neq t$, $j, t \in N$, and (C5b) σ_F is sufficiently small. Using (13), the utility of migrating the members in F as well as member j ($j \notin F$), can be expressed as

$$\begin{aligned} & U(F \cup \{j\}) \\ = & \sum_{i \in F \cup \{j\}} f_i + \sum_{i \in H \backslash \{j\}} h_i - c(n_F + 1) \\ & -k \left\{ \left(\sum_{i \in F \cup \{j\}} f_i \sigma_F + \sum_{i \in H \backslash \{j\}} h_i \sigma_H \right)^2 + 2 \left(\sum_{i \in F \cup \{j\}} f_i \right) \left(\sum_{i \in H \backslash \{j\}} h_i \right) (\sigma_{HF} - \sigma_H \sigma_F) \right\}. \end{aligned}$$

For j, $t \in H$, $t > j$, the family will migrate j instead of t ($t \notin F$) if

$$\begin{aligned} & U(F \cup \{j\}) - U(F \cup \{t\}) \\ = & r_j - r_t \\ & -k \left\{ \left[\left(f_j + f_t + 2 \sum_{i \in F} f_i \right) \sigma_F - \left(h_j + h_t - 2 \sum_{i \in H} h_i \right) \sigma_H \right] [(f_j - f_t)\sigma_F + (h_t - h_j)\sigma_H] \right. \\ & \left. +2 \left[(f_j - f_t) \sum_{i \in H} h_i - (f_j h_j - f_t h_t) - (h_j - h_t) \sum_{i \in F} f_i \right] (\sigma_{HF} - \sigma_H \sigma_F) \right\} \\ > & 0 \end{aligned}$$

Since $h_i - h_{i+1}$ is sufficiently small, thus $r_i \geq r_{i+1}$ implies that $f_i \geq f_{i+1}$, $i = 1, 2, ..., n-1$. The first term in the brace is negligible if σ_F^2 is small enough. The second term in the brace is negative because $\sigma_{HF} - \sigma_H \sigma_F < 0$ and $f_j > f_t$. As a result, the risk term in the brace is negative. Moreover, since $r_j \geq r_t$ for $j < t$, we have $U(F \cup \{j\}) - U(F \cup \{t\}) > 0$. This implies that if t is to migrate, j must have already migrated. The optimal allocation of the family members is therefore $F^* = \{1, 2, ..., n_F^*\}$ and $H^* = \{n_F^* + 1, n_F^* + 2, ..., n\}$.

Next, we show that ΔU_l is decreasing in l if (C5a) and (C5b) hold. Let $F = \{1, 2, ..., l\}$, then using (13),

$$\begin{aligned} \Delta U_l = & r_{l+1} - c \\ & -k \left\{ \left[\left(\sum_{i \in F \cup \{l+1\}} f_i \right)^2 - \left(\sum_{i \in F} f_i \right)^2 \right] \sigma_F^2 + \left[\left(\sum_{i \in H \backslash \{l+1\}} h_i \right)^2 - \left(\sum_{i \in H} h_i \right)^2 \right] \sigma_H^2 \right. \end{aligned}$$

$$+2\left[\left(\sum_{i\in F\cup\{l+1\}} f_i\right)\left(\sum_{i\in H\setminus\{l+1\}} h_i\right)-\left(\sum_{i\in F} f_i\right)\left(\sum_{i\in H} h_i\right)\right]\sigma_{HF}\Bigg\}.$$

The $(n+1)$-st member will migrate if $\Delta U_l > 0$. It is straightforward but tedious to show that

$$\begin{aligned}\Delta U_l - \Delta U_{l-1} &= r_{l+1} - r_l - k\Bigg\{ \\ &\quad V(f_{l+1}\varepsilon_F - h_{l+1}\varepsilon_H) + V(f_l\varepsilon_F - h_l\varepsilon_H) \\ &\quad +2\left[\left(\sum_{i\in F} f_i\right)\sigma_F + \left(\sum_{i\in H} h_i\right)\sigma_H\right][(f_{l+1}-f_l)\sigma_F - (h_{l+1}-h_l)\sigma_H] \\ &\quad +2\left[(f_{l+1}-f_l)\left(\sum_{i\in H} h_i\right) - (h_{l+1}-h_l)\left(\sum_{i\in F} f_i\right)\right](\sigma_{HF} - \sigma_H\sigma_F)\Bigg\},\end{aligned}$$

which is negative if both σ_F and $h_{l+1} - h_l$ are sufficiently small. Hence, ΔU_l is strictly decreasing in l. Consequently, $F^* = \{1, 2, ..., n_F^*\}$ and $H^* = \{n_F^* + 1, ..., n\}$.

If j is a dependent, then $f_j = h_j = 0$ and $\Delta U_{j-1} = -c < 0$. Thus, dependents will never migrate and migration takes place only among the productive members.

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Table 1
Hong Kong-born Chinese Immigrants in Australia by Age Group and Sex, 1991

Age group (years)	Males		Females		Both Sexes		Sex ratio
0-9	2509	(8.9)	2489	(8.5)	4998	(8.7)	101
10-19	6924	(24.5)	6230	(21.3)	13154	(22.9)	111
20-29	6492	(23.0)	6842	(23.3)	13334	(23.2)	95
30-39	6478	(22.9)	7686	(26.2)	14164	(24.6)	84
40-49	3358	(11.9)	3707	(12.6)	7065	(12.3)	91
50-59	1546	(5.5)	1276	(4.4)	2822	(4.9)	121
60 and over	930	(3.3)	1083	(3.7)	2013	(3.5)	86
Total	28237	(100)	29313	(100)	57550	(100)	96

Notes: Numbers in parentheses are percentages. Sex ratio = Number of males per 100 females.
Source: Kee and Skeldon (1994, Table 10.2).

Table 2
Hong Kong Population by Age Group and Sex, 1991

Age group (years)	Males		Females		Both Sexes		Sex ratio
0-9	404700	(13.8)	374400	(13.3)	779100	(13.5)	108
10-19	436000	(14.8)	401200	(14.3)	837200	(14.6)	109
20-29	521700	(17.8)	531000	(18.9)	1052700	(18.3)	98
30-39	583500	(19.9)	559000	(19.9)	1142500	(19.9)	104
40-49	364800	(12.4)	311300	(11.1)	676100	(11.8)	117
50-59	280600	(9.6)	238300	(8.5)	518900	(9.0)	118
60 and over	346900	(11.8)	398600	(14.2)	745500	(13.0)	87
Total	2938200	(100)	2813800	(100)	5752000	(100)	104

Notes: Numbers in parentheses are percentages. Sex ratio = Number of males per 100 females.
Source: Hong Kong Census and Statistics Department (1998, Table 1.2).

Table 3
Sex Ratios of Hong Kong-born Chinese and Non-Chinese
born elsewhere in Vancouver and Toronto, 1991

Age group (years)	Vancouver		Toronto		Hong Kong
	Hong Kong-born Chinese	Non-Chinese born elsewhere	Hong Kong-born Chinese	Non-Chinese born elsewhere	
0-14	114	104	111	105	108
15-24	99	102	112	102	104
25-44	85	99	92	96	104
45-64	92	102	93	98	116
65 and over	86	73	72	73	79
Total	92	98	97	96	104

Note: Sex ratio = Number of males per 100 females.
Sources: Skeldon (1997, Table 11.2), Hong Kong Census and Statistics Department (1998, Table 1.2).