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The Impact of International Migration and the Third Childbirth Event in Egypt using the Simultaneous Hazard Model

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Abstract: This study examines the case of male migration in Egypt, a significant and relatively recent phenomenon. Fertility and migration models are estimated simultaneously to account for cross-correlation. The main aim of the national strategy for population and development 2015-2030 is to reduce the total fertility rate to an average of 2.4 by 2030, compared with 3.5 at present. This paper aims to study the mutual influence of international migration and fertility in Egypt using a simultaneous hazard regression model of two processes, the third childbirth event and the migration event. We use data from the Egypt-HIMS (Egypt Household International Migration Survey 2013). The main conclusion from the study is that there is endogeneity between the husband's migration and fertility behavior. Specifically, we control for unobserved heterogeneity. The transition to the third childbirth increases the hazard of migration, while a migration event produces a significant increase in the hazard of the third childbirth.

Keywords: Simultaneous Hazard Models, International Migration, Fertility, Survival Analysis.

1 Introduction

Migration is a selective process in which hosting countries usually host migrants in the working-age groups and those who have distinguished skills. A recent survey by CAPMAS (Central Agency for Public Mobilization and Statistics, 2013) data were collected from the families of some Egyptian migrants. More than half of the migrants (55%) are less than 35 years of age, 43% are in the age group (35-59). Moreover, 98% of the migrants are males with a median age (at their first migration) of 25.1 years.

Migration started playing an important role in the population-size changes for the last three decades. The total number of migrated Egyptians reached 65.8 % in the Arab countries at the end of 2016 of the whole migrated Egyptians, estimated to be about 9.5 million people. Egyptians in Saudi Arabia is about 2.9 million people that equals 46.9% of the Egyptians living in the rest of all the Arab countries; followed by Jordan with 18.4%, Kuwait with 14%, and the United Arab Emirates (UAE) with 12.3% (Census 2017).

The 2014 Egypt Population Health Survey indicated that the accelerated pace of the population growth and the total fertility rate increased from 3 children per woman in 2008 to 3.5 children per woman in 2014. Consequently, the total number of births in Egypt rose from less than 2 million births to 7.2 million births in 2015, probably due to changes in the fertility rates. This hypothesis is one of the motives for conduct this research.

In fact, the slow pace of the fertility transition in Egypt has attracted the attention of researchers and policymakers. The total fertility rate in Egypt declined from 4.7 children per woman in 1988 to 3.9 in 1992, but the rate of decline slowed afterward, reaching 3.1 in 2005 and 3 in 2008, and finally, it started to rise again, reaching 3.5 in 2014 (Ministry of Health and Population et al.) [1]. We consider husbands' migration the main pathway to accelerate the fertility transition, this is so since approximately 98% of the immigrants are males. Therefore, the husband's migration is usually included among the background variables used to study the differentials in fertility levels and patterns. However, husbands' migration, unlike

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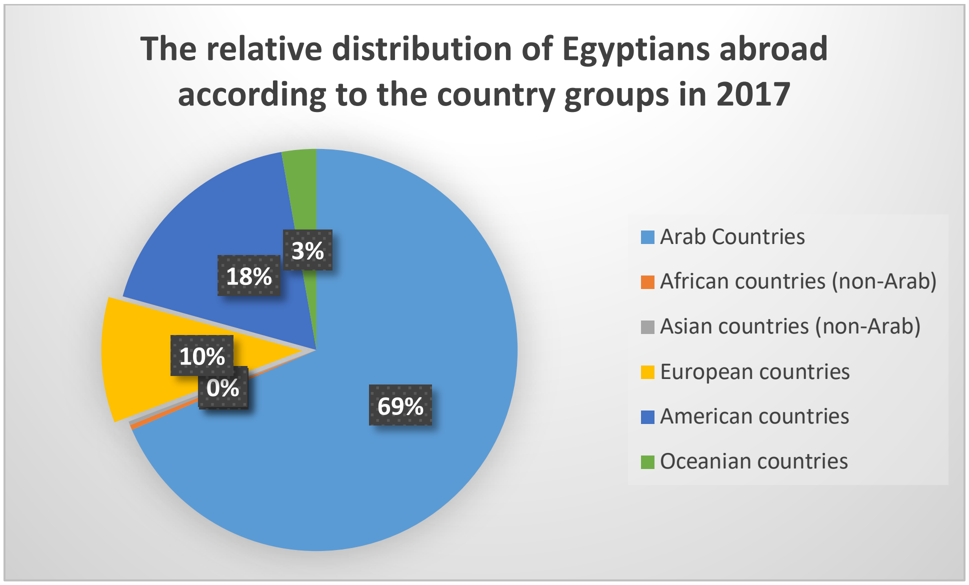
education, for example, is not an exogenous factor in the reproduction process, since fertility can also affect husbands' migration.



Source: Egyptian Ministry of Foreign Affairs. Annual Statistical Book 2018-Central Agency for Public Mobilization and Statistics

Figure 1: The relative distribution of Egyptians abroad according to the country groups in 2017

Most studies linking migration with fertility have treated each as significant in shaping the other. Following Kulu and Milewski's [2] advice, the approach is to examine the mutuality between the two. The joint modeling of fertility and migration equations provides not only an estimate of the influence of spousal separation on fertility but also some insights into the extent to which migrants self-select because of characteristics associated with fertility.

The study aims to examine the mutual relation between husbands' migration and wives' fertility using a simultaneous hazard regression model of two processes, the third childbirth event and the migration event. We used unobserved heterogeneity, which is correlated across the two processes. Migration and having a third child were defined in separate equations and tested using a joint maximum likelihood procedure, which allows explicit examination of the interaction of the transitions, controlling for the potential endogeneity of each transition related to the other. We tested the model using data from the Egypt Household International Migration survey 2013.

2 Literature Review

Researchers have proposed four main theoretical perspectives to show the differences in fertility behaviors between immigrants and non-immigrants. The four theoretical perspectives concern socialization, adaptation, selectivity and disruption [3], [4].

Each hypothesis has received support, but it has also been challenged by the literature. These hypotheses concern migrant selection before the move; life disruption around the time of fertility; adaptation to modern norms, beliefs, opportunities and constraints in the new environment in the years following migration (for first-generation migrants); and socialization involves temporal change, but these take place over a period of time across generations.

The four hypotheses have been mentioned in many studies [5, 6, 7,8] but have been tested only a few times (such as White [9], Kulu [10], Corgeau [11]).

These hypotheses differ from each other largely in terms of whether they view the differentials in fertility as having existed before the migration occurred (the selection model) or as manifested after migration in response to the fertility norms of the host population (the socialization and adaptation models). The disruption model argues that the migration process itself largely accounts for differentials between the fertility of migrants and natives at the destination [12].

Selection suggests that migrants are not a random sample of the population at their place of origin [33]. Instead, migrants are different from non-migrants in terms of socioeconomic and demographic characteristics (such as education, occupation, age and marital status), which leads their fertility behavior and preferences to also be different [13].

Disruption is an effect of migration, which causes a low level of fertility, especially in the first stage after migration, because of spousal separation or the physiological consequences of the stressful situation associated with living in a new place [14,15]. However, this decline in fertility due to disruption is temporary, and a more normal pace of fertility is expected to be resumed later.

Adaptation predicts that migrants tend to adopt – gradually or quickly – the norms of the destination area in many aspects, including number of children, and after a while their fertility resembles more the fertility of the destination area rather than that of the origin area. The adaptation effect could be sociological or economic. From the sociological view, adaptation poses that fertility is determined by the social and cultural norms present in the residential environment and emphasizes factors that are important in shaping and transmitting values and ideas. The economic view describes the adaptation process primarily in terms of household income and the relative cost of children. Rural-urban wage differentials for men, women and children and price and income constraints at the destination area, along with employment and educational opportunities, change the real and opportunity cost of childbearing, which alters fertility behavior [13].

Finally, socialization emphasizes the critical role of the social environment during childhood. Values and norms dominant during childhood shape an individual's 'habits', which, in turn, to a large extent guide her/his behavior in later life. Therefore, people who move from one social environment to another exhibit fertility levels similar to those who stay at the origin (residence during childhood), and convergence towards fertility levels at the destination occurs only in the next generation (given that differences between locations do exist) [16].

It is worth noting that acculturation plays a role in migration studies. Definitely, international migration implies the coexistence of different ethnic and cultural groups in the receiving country. The refugee crisis of 2015 has resulted in critical levels of opinion polarization on the question of whether to welcome migrants, who might cause clashes in receiving countries. This scenario emphasizes the need for better understanding of the dynamics of mutual adaptation between locals and migrants, and the conditions that favor successful integration.

A prominent model in the field of acculturation studies is the fourfold model proposed by [17, 18], which identifies acculturation as a mutually adaptive process between a local community and migrant minorities. It assumes that acculturation occurs at two levels: (1) a cultural-group level made up of norms and (2) a psychological-individual level concerning the individual experience of adaptation [17, 18]. The model is based on the orientations people adopt to face issues related to maintaining their own cultural identities and participating in the larger society. Four orientations emerge from the intersection of the two distinct dimensions: Integration, assimilation, separation, and marginalization, see, e.g., [18, 19], among others.

Speaking of which, we would like to mention that in the Egyptian culture, the majority of husbands do not agree to use condoms.

Many economists and demographers have attempted to study the importance of different theories in explaining fertility differences between immigrants and non-immigrants. The study by [20] concluded that experimental results on the fertility of immigrants and non-immigrants differ from one region to another and from one study to another. Much research conducted in several regions around the world has led to a variety of inconsistent conclusions and evidence. Various studies have concluded that immigrant fertility is lower, higher, or similar to non-immigrant fertility [12]. These apparent differences are attributed to different analytical methods, different sample designs, different definitions of variables and controls, different drivers of migration in different regions, and the ineffectiveness of the cross-sectional data to distinguish between several dynamic and competing hypotheses developed to describe the differences in the fertility of indigenous migrants [21,22,23,24,25,26,27,28].

Milewski [29] made a comparison between the fertility of immigrants in Germany and the native population. The study concluded that migrant fertility was higher immediately after migration, which supports the hypothesis of selection. When controlling for socioeconomic factors, there is a difference between the fertility of the second generation of migrants and the native population, which supports the hypothesis of adaptation and socialization. Sobota [30] found that immigrants commonly have higher rates of fertility than the native population during the period they lived in the destination countries.

Differences in fertility differ by country of origin, showing heterogeneity in migrant fertility. In the Italian context, Gabrielli et al. [31] examined the hypotheses of selection, adaptation, and socialization, controlling different structural factors. This study found evidence for the hypothesis of socialization and selection and no evidence for the hypothesis of adaptation. Evidence for the disruption hypothesis is limited in the European context.

3 Study Objective

This study aims to identify the mutual relationship between a man's migration and his wife's fertility behavior to reach the replacement level, which is fertility at the replacement level with two live births per woman. In this study, we build on the literature on the estimation of simultaneous processes by specifying a simultaneous hazard regression model of two processes, the birth event and the migration event, allowing for unobserved heterogeneity correlated across the two processes.

4 Data

The main source of the data is the Egypt-HIMS (Egypt Household International Migration survey 2013). The Egypt Household International Migration Survey (Egypt-HIMS) was conducted in 2013 by the Central Agency for Public Mobilization and Statistics (CAPMAS) of Egypt. The survey was conducted as a part of the MED-HIMS(Mediterranean Household International Migration Survey Program), which is a joint initiative of the European Commission/Eurostat, the World Bank, UNFPA (United Nations Fund for Population Activities), UNHCR (United Nations High Commissioner for Refugees), ILO (International Labour Organization), IOM (International Organization for Migration), and LAS (League of Arab States) in cooperation with the National Statistical Offices of the Arab countries in the southern and eastern Mediterranean region.

The survey is representative of the population in Egypt at the household and individual levels. The survey includes standardized information for both migration and fertility and includes demographic and socioeconomic variables.

The Egypt-HIMS 2013 is the only survey conducted in Egypt that has migration and birth histories and hence allows us to look at the two processes simultaneously.

5 Data Manipulation

Preparing the data and processing the variables is one of the most important phases of the study. It took much time to determine the right way to formulate some of the key variables in the analysis. The unit of time used here is the year. The study hypothesizes some important assumptions to create the background variables according to the proposed framework. It takes the starting point as the date of marriage because of our interest in the simultaneity of the two processes: migration and the transition to the third childbirth.

For women who give birth in the same year of marriage, there can be several children born in the same year, and the first birth is likely to take place 9 months (0.75 years) after marriage. For women who have two children in the same year (not twins), we assume that the first birth would have a time duration equal to 0.25 years in the year of giving the birth assuming she was pregnant in the previous year. This would be followed by the second birth after 0.75years (this is clear in the EDHS, 2014). For women who have multiple births (twins), the number of children ever born would change by the number of multiples, not by 1, thus increasing by 2 for twins, by three for triplets, and so on. For women who experience migration in the same year as marriage, we assume that they migrated 6 months (0.5 years) after the marriage date. For women who give birth in the same year of migration, we assume that they migrated 6 months (0.5 years) after giving birth. If migration occurs before marriage, we assume that it does not count in the calculation of time periods. If the date of migration is unknown, then we assume that migration took place after marriage. If the migration occurred in the same year as the survey, we assume that the migration occurred before the end date of the survey, and we assume that the migration occurred 6 months (0.5 years) before the end of the survey.

The background variables include region of residence, husband's educational level, wife's highest level of education, age at first marriage, husband's work, and wife's work. The information about birth events includes the sex of the second child, use of family planning, and woman's age as stochastic variables (time varying covariates). Migration events include status, parity of birth, and number of children ever born as time-dependent variables. The data we rely on in this analysis contain the dates of migration for every woman. For the time duration, first, for the calendar time of migration, the data include one date for every woman. Second, for the calendar time of birth, the data include the dates of the first three childbirths from the beginning of marriage, and the maximum number of children is three.

For all women, we divide the number of children they had into categories. The first category is set to 0 (no children); for each period after the second period, the number of children born is calculated according to the date of birth of the first and second children until the date of the birth of the third child. Concerning the variable "number of children" born to each woman, the starting point is the date of marriage, and each woman is tracked from the date of her marriage to the date of the survey to determine the number of children she has. The starting number for each woman is "0 children", and the number ultimately increases to the total number of children born.

Regarding background variables, or socioeconomic variables, for the wife's age, we have two events: migration and childbirth. The wife's age changes according to these two events. For example, a woman may marry at age 20, give birth to the first child at age 22 and the second child at age 24, migrate at age 25, and give birth to the third child at 25, so the age changes according to these successive events. The wife's age is a variable that changes over time. We divide the variables for the husbands and wives educational levels into No education, Primary complete, Preparatory complete, Vocational technical, Secondary complete, University and above. We divide the husband's and the wife's work variables into Not currently working, Self-Employed, Paid, and Unpaid.

Second, regarding demographic variables, the variable for ever having used family planning was divided into (never used and ever used). For the sex of the second child, from the date of marriage to the date of the survey, the number of children the woman gives birth to is tracked, and the children's gender is determined because gender can affect the birth of the third child, and this variable changes over time. Regarding the husband's age, this variable changes with time, so we track migration and childbirth events. The wife's and the husband's ages change in relation to these events. For the indicator of third childbirth, we consider all the women who give birth to second and third children. A binary variable to determine whether the woman gave birth to a third child is determined according to the time when the woman gave birth to the third child. Regarding parity of birth, the number of children a woman gives birth to changes from the date of marriage until the date of the survey, during which period we have two events, the migration event and the fertility event. Therefore, we change the number of children according to the two events; for example, a woman may marry at age 20, give birth to the first child at age 22 (the number of children = 1), migrate at age 23 (the number of children is still one) and then give birth to a second child at age 25 (the number of children = 2).Finally, she may give birth to a third child at age 30 (the number of children = 3). This variable changes over time.

Third, time variance and covariance, regarding migration status, is considered a binary variable, where the beginning of the baseline period is marriage, and the end of the period is the date of the survey.

6 Methodology

I expose the phenomenon of migration, giving particular attention to some methodological problems, including the following:

- Bias in estimating data:

1. The simultaneous equation bias problem may arise, where the independent variables are measured at the time of the survey, but the migration decision is made in a period before the survey, leading to changes in some measured independent variables at the time of the survey. These variables may change over time, and some of them may affect the phenomenon of migration and thereby become dependent variables of migration rather than independent variables. This problem results in a reciprocal relationship between decision-making and social and economic demographic factors; furthermore, the level of measurement for some of these factors is affected by the migration phenomenon.

2. Migration is selective rather than random.

Therefore, this current study uses simultaneous hazard models.

This study adopts the simultaneous hazard equation model, which is composed of several equations. The dependent variable in the first equation may exist within the range of independent variables in the second equation, which means that the dependent variable plays a double role because it affects the first equation and is influential in the second equation.

The existence of dependent variables on the right hand side of the equations with the independent variables in these models leads to the disruption of the constant independent variable hypothesis and leads to the existence of correlation between the independent variables and the random error.

The simultaneous hazards model is used when the variable of interest is the length of time T until an event occurs, and several processes correlated through the specification of a heterogeneity factor common to them. While the concept of simultaneous equations has been extended quite effectively to models with a few qualitative dependent variables, it was seldom applied to hazard or duration (failure time) models until the development of the simultaneous hazards model by Lillard [32].

The first person to discuss this method and how to implement it was Lillard; previous scholars used to consider each variable separately. Lillard and Waite [32], [9] analyze panel data in a study of income dynamics to test the hypothesis that the hazard of marriage dissolution faced by a married woman affects the probabilities that she will conceive and bear a child. The estimated model takes into account the simultaneous hazard between marriage dissolution and marital fertility by including the hazard of dissolution as a predictor of the timing and the likelihood of marital conception and by including the results of previous fertility choices as predictors of the disruption of marriage. The model is designed to capture the joint or simultaneous relationships between marriage dissolution and marital fertility and to allow testing of various hypotheses about these relationships. The model may be characterized by two sets of equations for each woman: one for the hazard of divorce and the other for the hazard of marriage dissolution.

Lillard [32] developed an approach to consider simultaneity through hazard equations, which are similar to simultaneous Tobit models. He introduced a class of continuous-time models that incorporates two forms of simultaneity across related processes when the risk rate of one process depends on the risk rate of other processes, the current event, or previous outcomes of a related multi-stage process. He also developed an approach to modeling the notion of "numerous outcomes" in which one process may rely on the duration of a related process, in addition to its own duration. The model is estimated using maximum likelihood estimation.

Aassve et al. [33] followed an economic approach to analyze poverty that focused on endogenous demographic and employment transitions as the driving forces behind changes in poverty. They specified a model of related dynamic discrete choices following Lillard [32], considering childbearing, union formation, union dissolution, employment, and non-employment. They estimated five simultaneous hazards with unobserved correlated heterogeneity. The model studies the dynamics of these processes jointly and allows any of the related processes to enter as a time-dependent variable, which means their values could change over time in the analysis of other processes. The processes are determined as a hazard function, which is a conditional function with both exogenous and endogenous factors, in addition to unobserved heterogeneity, which is correlated across the various processes.

El Misery [34] used data from the Egypt Labor Market Panel Survey of 2006 (ELMPS06) to study the interactive relation between female employment and fertility in Egypt. The model was fitted using simultaneous hazard regression. The study concluded that there is endogeneity between women's work entry and fertility behavior. Precisely, controlling for unobserved heterogeneity, the transition to the third childbirth reduces the hazard of joining the labor market, while a work entry event offers a significant decline in the transition's hazard to the third childbirth.

6.1 The proposed Model

Simultaneous hazard models are applied to examine the related dynamic discrete choices regarding the two endogenous variables, namely, the third live birth and migration status change events. Each of the processes is identified as a hazard function, which is conditional on both exogenous and endogenous covariates as well as potentially correlated unobserved heterogeneity components. The set of hazards takes the following form:

$$\ln h^B(t) = b_1 T^B(t) + b_2 M(t) + b_3 X^B(t) + \varepsilon^B \tag{1}$$

$$\ln h^M(t) = m_1 T^M(t) + m_2 B(t) + m_3 X^M(t) + m_4 P^B(t) + \varepsilon^M \tag{2}$$

Where $h^B(t)$ is the hazard of giving birth. Women are assumed to be at risk of the first birth beginning from the first marriage. After the first child is born, women become at risk of having the second child; after the second child, they become at risk of having the third child; and so on. In this study, we focus on the hazard of having a third child.

$h^M(t)$ is the hazard of migration. Men (spouses) are assumed to be at risk of migration starting from the age of entry into the labor force, which typically takes 15 years; because of our interest in the simultaneity of fertility and migration of spouses, the starting point taken as the date of marriage.

$T^B(t)$ and $T^M(t)$ are the baseline log hazards for birth and migration, respectively, which are assumed to be piecewise-linear (piecewise-Gompertz).

The Gompertz model is a proportional hazards model and is a (linear) log-hazard, which is specified by defining a spline without nodes, so that the slope follows the Gompertz slope.

$B(t)$ is an endogenous binary variable taking a value of 1 if the woman gives birth at time t and 0 otherwise. $M(t)$ is an endogenous binary indicator for migration taking a value of 1 if the spouse migrates at time t and 0 otherwise. $X^B(t)$ and $X^M(t)$ are vectors of exogenous covariates for birth and migration processes, some of which are time varying covariates.

$\boldsymbol{b_i} = (b_1\, b_2 \dots b_k)$ and $\boldsymbol{m_i} = (m_1\, m_2 \dots m_k)$ are the coefficient parameters corresponding to the birth and migration equations, respectively. In general, it is easier to interpret the exponential of the estimated parameters, for example, e^{b_i},which is the relative change in the hazard when *Xi* increases by one unit.

$P^B(t)$ is the stock of the event (parity) at time *t*; birth parity is the number of children a woman has at time t; the unit of measurement of intervals is in discrete years.

ε^B Band ε^M are the random heterogeneity components for each process, birth and migration, respectively, which capture unobserved factors influencing each of the processes that are not picked up by the observed covariates. However, given that the processes are related, it is likely that there will be a correlation between the unobserved heterogeneity terms across the two processes. The entry of endogenous covariates will lead to correlation since these variables are outcomes and therefore functions of the other processes. For instance, $B(t)$, in equation (2), is an outcome of the function ln $h^B\,(t)$, which in turn depends on the unobserved heterogeneity ε^B. component To allow for these numerous sources of correlation, the unobserved heterogeneity components are specified to have joint normal distribution.

We have two equations. In the first equation, the outcome is the birth of the third child. For the second equation, the outcome is migration. Each equation has some exogenous variables, namely, $X^B(t)$, and $X^M(t)$. The two equations are linked by ε^B and ε^M There are other factors that affect each process (random heterogeneity), and they affect the endogenous variables. Therefore, we expect a correlation between ε^B and ε^M, which is explained in equation (3):

$$\begin{pmatrix}\varepsilon^B \\ \varepsilon^M\end{pmatrix} \sim N\left(\begin{pmatrix}0 \\ 0\end{pmatrix}, \begin{pmatrix}\sigma_B^2 & \sigma_{BM} \\ \sigma_{BM} & \sigma_M^2\end{pmatrix}\right), \text{ where } \sigma_{BM} = \rho_{BM}\sigma_B\sigma_M. \tag{3}$$

By integrating the unobserved heterogeneity components, the observed completed durations and outcomes are independent and can, therefore, be fitted by maximum likelihood techniques. The model is estimated using full-information maximum likelihood, as implemented in the multilevel multi-process statistical software package aML (Lillard and Panis 2000). There is no specific form of the maximum likelihood function, so it is estimated by numerical integration to obtain the best estimate using the aML program, as clarified after equation (3).

7 Results

In this section, we examine the simultaneous relationship between male migration and fertility in Egypt. Migration and the fertility transition are defined with separate equations and estimated using a joint maximum likelihood procedure, which allows explicit analysis of the influence of the transition, controlling for the potential endogeneity of each transition concerning the other.

Table 1: Summary results for the piecewise-Gompertz hazard model for the simultaneous transition to the third childbirth and to migration.

Variables	**Model 1:with heterogeneity**	**Model 2:simultaneous**
	Hazard Ratio exp(β)	**Hazard Ratio exp(β)**
I. Hazard of having a third child		
Baseline hazard		
Intercept	0.03**	0.02**
Baseline spline 0-<2	3.56**	3.52**
Baseline spline 2-<4	1.27**	1.25**
Baseline spline 4-<6	1.19**	1.18**
Baseline spline 6+	0.91**	0.89**
Background variables		
Wife's age	0.85**	0.83**
Migration status		
Not migrated	(Reference)	(Reference)
Migrated	1.08**	1.05**
Socioeconomic variables		
Region of residence		
Urban Governorates	(Reference)	(Reference)
Lower Egypt	1.18**	1.15**
Upper Egypt	1.57**	1.52**
Frontier Governorates	1.35**	1.25**
Husband's educational level		
No education	(Reference)	(Reference)
Primary complete	0.98	0.82
Preparatory complete	0.88	0.75
Vocational technical	1.11	1.05
Secondary complete	0.98	1.04
University and above	1.22**	1.15**
Wife's highest level of education		
No education	(Reference)	(Reference)
Primary complete	0.97	1.69
Preparatory complete	0.91	1.02
Vocational technical	0.74**	0.55**

Table 1 (Cont'd): Summary results for the piecewise-Gompertz hazard model for the simultaneous transition to the third childbirth and to migration.

Secondary complete	0.85**	0.81**
University and above	0.71**	0.19**
Husband's work		
Not currently working	(Reference)	(Reference)
Self-Employed	1.51**	1.43**
Paid	1.35**	1.27**
Unpaid	1.51	1.41
Wife's work		
Not currently working	(Reference)	(Reference)
Self-Employed	1.08	1.05
Paid	0.13**	0.11**
Unpaid	1.18	1.16
Demographic variables		
Ever use of family planning		
No: Never used	(Reference)	(Reference)
Yes: Ever used	0.92**	0.91**
Sex of the second child		
Boy	(Reference)	(Reference
Girl	1.25**	1.08**
Age at first marriage	1.15**	1.11**
S.D. of unobserved heterogeneity terms (fertility)	0.78**	0.28**
II. Hazard of migration		
Baseline hazard		
Intercept	0.003**	0.002**
Baseline spline 0-<1	5.03**	1.13**
Baseline spline 1-<3	0.53**	0.51**
Baseline spline 3-<5	1.26**	1.24**
Baseline spline 5+	0.98**	0.85**
Background variables		
Husband's age	0.93**	0.88**
Indicator of third childbirth		

Table 1 (Cont'd): Summary results for the piecewise-Gompertz hazard model for the simultaneous transition to the third childbirth and to migration.

No	(Reference)	(Reference)
yes	1.69**	1.34**
Socioeconomic variables		
Region of residence		
Urban Governorates	(Reference)	(Reference)
Lower Egypt	1.18**	1.17**
Upper Egypt	1.62**	1.45**
Frontier Governorates	0.38	0.45
Husband's educational level		
No education	(Reference)	(Reference)
Primary complete	1.39**	1.36**
Preparatory complete	1.50**	1.47**
Vocational technical	0.90	0.98
Secondary complete	1.41**	1.38**
University and above	1.51**	1.11**
Wife's highest level of education		
No education	(Reference)	(Reference)
Primary complete	0.99	0.98
Preparatory complete	1.03	0.95
Vocational technical	1.07	0.94
Secondary complete	1.21**	1.12**
University and above	1.94**	1.65**
Wife's work		
Not currently working	(Reference)	(Reference)
Self-Employed	0.99	1.04
Paid	0.59**	0.54**
Unpaid	0.82	0.80
Intermediate variables		
Parity of birth	1.50**	1.19**
S.D. of unobserved heterogeneity terms (migration)	0.76**	0.27**
III. Correlations between unobserved heterogeneity terms		
Fertility& Migration		0.71**

Note:**p-value<0.05

Source: calculated by researchers using aML[1].

Table 1 includes three parts: (I) determinants of the transition to the third childbirth, (II) determinants of the transition to migration, and (III) the correlation between the unobserved heterogeneity terms in the two processes.

First: Determinants of the transition to the third birth

The first panel of table 1 demonstrates the baseline Gompertz hazard for the transition to the third birth. Our analysis declares that the hazard increases in the first two years after that it starts to decline. The baseline fertility has an inverse U-shape. The second panel, focusing on background and demographic variables, shows that the hazard of the transition to a third child is higher among women residing in Upper Egypt.

The results confirm the strength of son-preference in Egypt by indicating that a woman has significantly higher risk to have a third birth only when she had a second birth girl. The third panel, focusing on intermediate variables, shows that the more migrated women, as manifested in their decision-making power, the more likely to have a third birth.

The model includes the region of residence, husband's highest level of education, woman's highest level of education, husband's work and woman's work migration status as deterministic explanatory variables. Age at first marriage is treated as continuous explanatory variables. Women's age is treated as stochastic explanatory variables (time-varying covariates).

For the region of residence, in model 1, there is a significant difference between the woman who lives in Lower Egypt and Frontier Governorates compared to one living in Urban Governorates. However, the hazard of having the third birth increases by 57% if the woman residing in Upper Egypt compared to the one living in Urban Governorates. Furthermore, in model 2, there is a significant difference between the woman living in Lower Egypt and Frontier Governorates compared to one living in Urban Governorates. However, the hazard of having the third birth increases by 52% if the woman residing in Upper Egypt compared to the one living in Urban Governorates.

Regarding the highest education level of the husband, in model 1, there is no significant difference between women whose husbands completed their primary, preparatory, secondary or Vocational Technical Education, and those whose husbands received no education. On the other hand, the hazard of having the third birth increases by 22% for those whose husbands completed their university education or above compared to women whose husbands received no education. Furthermore, in model 2, there is no significant difference between women whose husbands completed their primary, preparatory, secondary or Vocational technical education, and women whose husbands received no education. On the other hand, the hazard of having the third birth increases by 15% for women whose husbands completed their university education or above compared to women whose husbands received no education, controlling for other common determinants including unobserved factors.

As for the highest education level of the woman, in model 1, the results clearly indicate that there is no significant difference between the woman who completed her primary or preparatory education and the one who did not have any schooling. The hazard of having the third birth decreases by 26% for the mother who completed vocational-technical education compared to the one who did not go to school. Moreover, the hazard of having the third birth decreased by 15% for the mother who received a secondary education compared to the one who did not go to school, and by 29% for the mother who received a university education or above compared to the one who did not go to school. Furthermore, in model 2, the results clearly indicate that there is no significant difference between the woman who completed her primary or preparatory education and the one who did not go to school. The hazard of having the third birth decreases by 45% for the mother who completed vocational-technical education compared to the one who did not go to school. Moreover, the hazard of having the third birth decreases by 19% for the mother who completed secondary education compared to the one who did not go to school, and by 81% for the mother who received university education or above compared to the one who did not go to school, controlling for other common determinants including unobserved factors.

As for the characteristics of the previous births, sex of the second birth is included. In model 1, the findings indicate that the hazard of having the third birth increases by 25% for the woman who has the second birth girl compared to the one who has the second birth boy. Furthermore, in model 2, the findings indicate that the hazard of having the third birth increases by 8% for the woman who has the second birth girl compared to the one who has the second birth boy, controlling for other common determinants including unobserved factors.

[1] aML (Multiprocess Multilevel Modeling) is a powerful statistical software for multilevel and multiprocess models. It supports multilevel hazard, (censored/truncated) linear, ordered and unordered categorical, and count outcomes

Concerning the working wives, in model 1, the hazard of having the third birth decreases by 87% for women got work wages or salaries compared to the wives who never worked. Furthermore, in model 2, the hazard of having the third birth decreases by 89% for women who got work payment compared to the women who never worked, controlling for other common determinants including unobserved factors.

Turning to the main interest of this study: the effect of men migration on fertility, noticed that migrating men's wives are at higher risk to bear a third birth. Treating migration as a time-varying covariate, the results indicate that it encourages women to have a third birth.

Second: Determinants of the transition to migration

The results indicate that baseline migration has increased. Soon after marriage, non-migrating women have a high probability of migration. The hazard initially increases but starts to decline quickly as married women don't migrate. The hazard of migration is higher among younger husbands, husbands residing in Upper Egypt and Lower Egypt, women with at least secondary education and those who are married to husbands who complete their primary, preparatory or secondary stages, and women who have paid jobs. In short, controlling for residuals, the background and intermediate characteristics that depress the risk of moving to the third birth are the same that increase the probability which increases the probability of migration, and vice versa.

In *model 1*, regarding husband's educational level, there is no significant difference between women whose husbands completed their vocational-technical education, and women whose husbands received no education. The risk of migration increases by 39% for those whose husbands completed their primary education, and by 50% for women whose husbands completed their preparatory education, and 41% for women whose husbands completed their secondary education compared to women whose husbands received no education, controlling for other common determinants including unobserved factors.

For the woman's highest level of education, in model 1, there is no significant difference between women who completed their primary, preparatory or vocational-technical education and the reference group of those who did not go to school. However, the risk of migration increases by 21% for women who completed their secondary education and by 94% for those who completed their university education or above, controlling for other common determinants including unobserved factors.

Treating fertility as a time-varying covariate variable, it is possible to see that the higher the number of children ever born (birth parity), the higher the hazard of migration controlling for all other variables in addition to the unobserved factors. In general, the birth of an extra child causes a 50% increase in the hazard of migration. The transition to the third birth, in particular, is associated with a 70% increase in the hazard of migration.

Third: The simultaneous relationship between transition to third birth and Migration.

The determinants of the transition to migration are examined. The model for the risk of migration is fitted using data on all ever-married women whose husbands have migrated and who have given birth. The hazard of migration is modeled as a function of the set of background and intermediate variables in addition to the unobserved heterogeneity component; in this case, fertility outcome is treated as an exogenous variable that can affect the hazard of migration but is not affected by it. The simultaneous relationship between the transition to the third childbirth and migration is examined. In the second model of the analysis comes the step of moving to the more realistic scenario in which both fertility and migration are simultaneously determined, and both are endogenous to the model.

The model proposed in Table 1 is fitted in two types of models using data from the Egypt-HIMS-2013. In the first model, equation (1) and equation (2) are fitted separately with heterogeneity. In the second model, we estimate the two equations simultaneously using aML.

The simultaneous relationship between the transition to the third childbirth and migration in the two models of the analysis comes to the step of moving to the more realistic scenario in which fertility and migration are simultaneously determined and are both endogenous to the model. Table 1 presents the results of simultaneously fitting the two equations of the proposed model using aML.

Table 1 includes three parts: (I) determinants of the transition to the third childbirth,(II) determinants of the transition to migration, and (III) the correlation between the unobserved heterogeneity terms in the two processes. The main difference between the two types of analysis appears when the focus is on the relationship of most interest to us (the relationship between fertility and migration). As would be expected, the reciprocal relationship between the two processes is usually greater when the endogeneity is ignored because when the two processes are fitted separately, the feedback mechanisms appear as part of the direct effect of one process on the other. When the effect does not increase between model 1 and model 2, the effect can be taken as an indication that the two processes are not endogenous because the effect, if it exists, mainly runs in one direction.

In the simultaneous processes model, a migration event results in a 5% increase in the risk of having a third child. The corresponding effect is estimated assuming that migration is exogenous at 7%. The effect of the transition to the third childbirth and birth parity on the hazard of migration is magnified in the simultaneous model compared to the model when fertility is treated as exogenous to migration. An additional birth is associated with a 19% increase in the migration hazard according to the more realistic model, compared to 50% in the model where fertility is treated as exogenous. The specific transition to a third child birth is associated with a 34% increase in the simultaneous model compared to 69% in the separate model.

Comparing the simultaneous processes model to the two separate processes models also indicates that the standard deviation of the unobserved heterogeneity components tends to be larger in the former than in the latter, which may suggest that part of the unobserved heterogeneity is captured by the reciprocal relationship between the two processes. When such a feedback mechanism is ignored, it could appear as unexplained heterogeneity among women. Some women seem much more prone to having a third child than other women who share background and demographic characteristics and even husbands' migration history. When endogeneity is taken into consideration, these women tend to have a third child quickly, which could be attributed to their not being inclined to migrate (or not being encouraged to migrate) and their decision to invest more in their reproductive role. Alternatively, women who choose to postpone having a third child (or who are forced to do so due to low fecundability) might choose to seek migration. This result, hence, demonstrates the endogeneity of the two processes.

The last row of Table 1 shows a strong positive relationship between the unobserved heterogeneity components within the two processes, which means that women who are more prone to postpone bearing a third child are more likely to seek husbands who do not migrate, and vice versa. This positive relationship between the risk of migration and the risk of having a third child comes on top of the three other explicit mechanisms that introduce a positive relationship: a positive effect of each process on the other, a direct effect of common observed determinants, and the endogeneity feedback mechanism discussed in the previous paragraph.

The husband's level of education increases the likelihood of giving birth to the third child. The wife's level of education reduces the likelihood of giving birth to the third child. For the husband's level of education, husbands all seek to migrate, while the only women who seek to migrate are those who have completed secondary and university education, and above. According to DHS (Demographic and Health Survey) data and statistics in Egypt, most families have three children, as this is the ideal number, but Egypt's strategic plan by 2030 aims to reduce this number, on average, for each family, and education is one of the most important variables that help achieve this goal. This is clear regarding the education of the wife, as it reduces the probability of having a third child. Regarding immigration and the impact of the wife's education, because of the poor economic conditions in Egypt during the recent period and the lack of suitable jobs or work for those with higher education, most individuals with higher degrees (husband or wife) prefer to migrate abroad with the purpose of finding job opportunities.

8 Conclusion

Achieving gender quality in economic participation is one of the sustainable development goals both globally and in Egypt. A family in which the wife works is associated with a decrease in the husband's emigration, so there must be equality between men and women at work. Likewise, reaching replacement fertility is a national goal, which is considered an important route for achieving sustainable development in Egypt. Economic theory informs us that the two goals are not only compatible but mutually necessary. However, few studies in Egypt have shown the validity of this theory. Past studies, handicapped by the lack of detailed migration data in the demographic surveys, such as Pande, S., Pandit, A. [28], find that socioeconomic changes that come along with economic development, such as women's empowerment, the opportunity cost of raising children and the transition from communal to societal demographics with more nuclear families, can only explain a decreasing trend with development.

Sustainable development is among the goals outlined in Egypt's 2030 Strategic Plan. Among the goals of sustainable development is reducing the number of migrants with distinctive qualifications and experience with higher or middle degrees. Since the state provides health and education support to these individuals, who then migrate abroad for work, the national income of the state is negatively affected. Therefore, one of the most important goals of sustainable development in the country's strategic plan for 2030 is to reduce the migration of these individuals abroad and take advantage of their competencies and experiences in improving the economic level of the country.

This study not only benefited from the availability of a unique data set but also adopted an advanced statistical methodology that facilitates the elucidation of the reciprocal and simultaneous relationship between fertility and migration. The study results demonstrated three important conclusions about the relationship between migration and fertility.

1. Given that the third childbirth is associated with a higher likelihood of the husband's migration, controlling for other common determinants, including unobserved factors, we recommend reducing fertility because it reduces immigration.
2. There is a strong feedback mechanism between the third childbirth and the migration of the husband, which suggests that the two decisions are endogenous and simultaneous.
3. There is a positive relationship between the unobserved components of the two processes, the transition to the third childbirth and migration. This means that controlling for common determinants and the reciprocal relationship, women whose husbands migrate are the same women who give birth to a third child, meaning that when fertility is lower, immigration is less likely, which thus helps stabilize the family.

Therefore, policies that encourage migration, especially that of high-level skilled laborers in high-quality and rewarding jobs, do not help achieve the targets of Egypt's population policy. In contrast, investment in family planning services targeting women with unmet needs and promoting small family norms could significantly contribute to the realization of gender parity without promoting husbands' migration. The best sets of policies are those that provide employability through training, including life skills and reproductive health promotion. Such programs could benefit from exploiting the reinforcement mechanisms implicit in the reciprocal relationship and endogeneity of the two processes, transition to the third childbirth and husbands' migration.

There should be effective family awareness programs for reducing childbearing that lead to reducing the migration rate, which help keep the family as a major component and lead to a lower divorce rate. In this study,reducing the reproductive rate leads to women's employment and economic participation in the family, which leads to reduced migration and increases the rate of economic growth. Additionally, there must be awareness programs to encourage women to reduce the number of children they have and to maintain their general health.

The government should provide good job opportunities according to the level of education and place of residence, which helps reduce the rate of migration, increase the economic growth rate, and prevent illegal immigration. This is one of the most important problems facing Egypt.

9 Limitations

Future efforts must be made, and in the next study, we will make a comparison between the results for migration and fertility during the period considered in this study to determine the most important causes of migration and childbirth. In addition, a new survey may focus on illegal immigration because it represents a problem faced by the government of Egypt.

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References

[1] El-Zanaty and Associates and The DHS Program ICF International. *EDHS (Egypt Demographic and Health Survey) Ministry of Health and Population*. Ministry of Health and Population and ICF International, Cairo, Egypt and Rockville, Maryland, USA, (2014).

[2] Kulu, H., and N. Milewski, N. Family change and migration in the life course: An introduction. *Demographic Research*: Volume **17**, Article 19 reflexion (2007).

[3] Caldwell, J. Theory of Fertility Decline. *London: Academic Press* (1982).

[4] Jensen, E.R. and Ahlburg, D.A. *Why does Migration decrease Fertility? A MULTICOUNTRY ANALYSIS*. https://paa2004.princeton.edu/papers/40172 . (2003).

[5] Brokerhoff, M. Fertility and Family Planning in African Cities: the impact of Female Migration. *Journal of Biosocial Science*., **27**, 364-392(1995)..

[6] Goldstein, S., and A. Goldstein. *Techniques for analyzing of the Interrelations between Migration and Fertility, in National Migration Surveys: X. Guidelines for Analyses.a Manual of Comparative Study on Migration and Fertility in the ESCAP region*. United Nations. New York., 132-155 (1982)..

[7] Hendershot, G.E. Social Class, Migration and Fertility in the Philippines. The Dynamics of Migration: *Internal Migration and Fertility*., **1**, 197-257 (1976).

[8] Lee, B.S. *Fertility Adaptation by Rural-Urban Migrants in Cameroon*. University of Nebraska at Omaha, unpublished (1985).
[9] White, M.J., Chattopadhyay, A. *Migration and Fertility in Ghana: Beyond Rural-Urban Differentials* http://www.pstc.brown.edu/ghana/Papers/Chattopadhyay&White_Migration_Fertility_Ghana_DHS.pdf,.(2005).
[10] Kulu, H. Migration and Fertility: competing hypothesis re-examined. *European Journal of Population*., **21**, 51-87 (2005).
[11] Courgeau, D. Family formation and urbanization. *Population*. An English Selection., **44(1)**, 123–146 (1989).
[12] Goldstein, S. Interrelations between Migration and Fertility in Thailand. *Demography*., **10**, 225-241 (1973).
[13] White, M.J., Smith, D., and Stiff, C. *Urbanization and the Fertility transition in Ghana* http://www.brown.edu/Departments/Sociology/faculty/mwhite/documents/urbanization_and_the_fertility_transition_in_ghana.pdf . (2002).
[14] Hiday, V. Migration, Urbanization and Fertility in the Philippines*. International Migration Review*., **12**, 370-383(1978).
[15] Zohry, A.G. *Rural-to-Urban Labor Migration*: *A Study of Upper Egyptian Laborers in Cairo*. Unpublished D.Phil.thesis, Centre for Comparative Study of Culture, Development and the Environment (CDE), University of SUSSEX, Brighton (2002).
[16] Stolnitz, G.J. *Urbanization and Rural-to-Urban Migration in Relation to LDC Fertility, in George J Stolnitz and collaborators, Development Impacts on Third World Fertility: A Review of Quantitative Assessments*. Washington DC: Future Group, Inc./AID Project Report (1983).
[17] Berry, J. W. Multicultural policy in Canada: A social psychological analysis. *Canadian Journal of Behavioral Science*, 16(4), 353–370 (1984).
[18] Berry, J. W. (2005). Acculturation: Living successfully in two cultures*. International Journal of Intercultural Relations*., **29**, 697–712(2005).
[19] Berry, J. W. Theories and models of acculturation. In S. J. Schwartz & J. Unger (Eds.). The Oxford handbook of acculturation and health (*Oxford, UK: Oxford University Press*, pp. 1-24) (2017).
[20] Pande, S., Pandit A. Hydro-social metabolism: scaling of birth rate with regional water use. *Palgrave Commun* **4**, 85. https://doi.org/10.1057/s41599-018-0140-6 (2018).
[21] Farber, S.C, and B. S, Lee. Fertility Adaptation of Rural-to-Urban Migrant Women: A Method of Estimation Applied to Korean Women. *Demography*., **21**, 339-345 (1985).
[22] Goldstein, S., and A. Goldstein. *The Impact of Migration on Length Birth Intervals: An Analysis Using Life History Data for Malaysia*. Annual Meeting of the Population Association of America*,* San Diego, California (1982).
[23] Goldstein, S., and A. Goldstein. *Migration and Fertility in Peninsular Malaysia: An Analysis using life history data*. Rand note N-1860-Aid 134 (1983).
[24] Hervitz, H.M. Selectivity, Adaptation or Disruptive? A comparison of Alternative Hypotheses of Migration on fertility: The case of Brazil. *International Migration Review*., **19**, 293-317 (1985).
[25] Lee, B.S, and S.C Farber. The Influence of Rapid Rural-Urban Migration on Korean National Fertility Levels. *Journal of Development Economics*., **17**,47-71 (1985).
[26] Lillard, L., and c. Pains. *aML multilevel multiprocessing statistical software*, Release 1.0, Econware, Los Angeles, California. http://www.applied-ml.com (2000).
[27] Muhidin, S., and J. Ledent. *Migration and Fertility in Burkina Faso: Evidence from the 2000 Survey on Migration/Urbanization and Environment. Migration and fertility changes in developing countries* at the XXV IUSSP International Population Conference, Tours, France, 18-23 July (2005).
[28] Ribe, H., and T.P Schultz. *Migrant and Native Fertility at Destination in Colombia: Are Migrants Selected According to Their Reproductive Preferences?*.Unpublished monograph (1980).
[29] Milewski, N. *Fertility of Immigrants: A Two Generational Approaches in Germany*. Springer Verlag London (2010).
[30] Sabotka, T. The Rising Importance of Migrants for Childbearing in Europe. *Demographic Research* **19**, 225-248 (2008).
[31] Gabrielli, G., A. Paterno, and M., White. The impact of origin region and internal migration on Italian fertility. *Demographic Research* **24**,705-740 (2007).
[32] Lillard, L. Simultaneous equations for hazards: marriage duration and fertility timing. *Journal of Econometrics* **56**,189-217 (1993).
[33] Aassve, A. Modeling poverty by not modelling poverty: an application of a simultaneous hazards approach to the UK. CASE Papers /106.*Center for analysis of social exclusion London school of econometrics*. (2006)
[34] El Misery, M. The Impact of Female Employment and The Third Birth Event in Egypt using Simultaneous Hazard Regression. *Advances and Applications in Statistics*.Pushpa Publishing House, Allahabad, India., **51**, 283-293 (2017).