Submission for a communication at the Annual Conference of the Population Association of America 2019, 10-14 April, Austin

The Emergence and Diffusion of Birth Limitation in Urban Areas of Developing Countries

Mathias Lerch

Max Planck Institute for Demographic Research

Konrad-Zuse-Str. 1, 18057 Rostock - Germany

email: lerch@demogr.mpg.de

Abstract

The rising heterogeneity of women in terms of family size over the course of the fertility transition challenges the classic hypothesis about the diffusion of birth limiting behaviors across parities, known as family limitation. We evaluate whether birth limiting behaviors diffused sequentially from upper to lower parities over time in urban populations of 19 developing countries. Relying on multiple fertility surveys and censuses, we decompose long-term declines in cohort fertility into the parity-specific contributions, and propose two new summary indicators for international comparison. The results challenge the hypothesis of family limitation. We find a significant international variation in the parities at which birth limitation initially emerges, in the direction of its subsequent diffusion to other parities, as well as in the extent to which the limiting behavior is generalized. The implications of our results for fertility inequality and its socioeconomic consequences are finally discussed.

Introduction

Fertility decline brought about major opportunities for developing countries. The shrinking number of children leads to a temporary concentration of the population in young working ages, while the share of non-active inhabitants to be supported decreases. Resources can instead be invested in economic production, savings and the improvement of the quality rather than the quantity of social services, including the health and education infrastructure (Bloom et al. 2003). Past research informed mainly about the trends in average fertility. One of the universal consequences of fertility decline, however, has been neglected: inequality in family size increases among women because some groups start to limit their fertility earlier and at a faster pace than others (Giroux et al. 2008; Lutz 1989; Shkolnikov et al. 2007). This has implications for the distribution of the socioeconomic gains from the fertility transition. Women with few births have increased freedom to work outside of the household and to invest in the quality of their children's education. Women with large families, by contrast, face difficulties in exploiting these opportunities brought about by the demographic dividend. Heterogeneity in women's family size tends to decelerate development (de la Croix and Doepke 2003) and to trigger (or reproduce) socioeconomic inequalities in the process (Bloom et al. 2012; Eloundou-Enyegue et al. 2017). In this paper, we study how fertility heterogeneity comes about by investigating the demographic diffusion of birth limiting behavior.

As the decision to have another birth is related to the number of children a women already has, a parity perspective is the most indicated to study the diffusion of birth limiting behavior (Henry 1952). According to the classic hypothesis, women stop childbearing once they attained the desired family size[1] (Coale 1973; Henry 1952, 1961; Knodel and van de Walle 1979). Family size norms shrink gradually with the structural and ideational transformations that accompany modern development, including "the growing importance of the individual rather than the family, and particularly the extended family group; the development of a rational and secular point of view; the growing awareness of the world and modern techniques through popular education; improved health; and the appearance of alternatives to early marriage and childbearing as a means of livelihood and prestige of women" (Notestein 1953: 18). The point here is that the new

[1] Compared to stopping behaviors, the practice of birth spacing, which leaves women with an insufficient number of reproductive years left to attain large family sizes, has a comparatively limited impact on completed fertility (Knodel and van de Walle 1979).

birth limiting behavior is expected to diffuse progressively from upper to lower parity groups over time (Henry 1961) – a process referred to hereafter as family limitation. In other words, the average level of fertility should drop because the share of (larger than) average-sized families declines in the population. This would lead to a limited heterogeneity in women's family size. Hence, the expectations based on the classic model of family limitation are in conflict with the empirical evidence on the rising fertility inequality over the course of the transition. In this study, we aim at shedding new light on this paradox.

National-level analyses of fertility trends by parity or age (as a proxy for parity) confirmed a role for family limitation across Latin America, Asia, as well as in contemporary high fertility contexts of Europe (Feeney 1991; Hobcraft 1985; Hosseini-Chavoshi et al. 2006; Juarez and Llera 1996; Knodel 1977; Lerch 2013; McDonald et al. 2015; Rodriguez 1996; Spoorenberg 2009, 2013; Spoorenberg and Dommaraju 2012). Yet there are notable exceptions. Instead of spreading gradually from upper to lower parities, birth limiting behaviors had been initiated among several different parities at the onset of the fertility transitions in Costa Rica and Colombia (Hobcraft 1985; Juarez and Llera 1996). Sub-Saharan Africa also follows an "exceptional" pathway of slow fertility decline (Bongaarts 2017), which is driven by a distinct pattern of birth spacing at all parities (Johnson-Hanks 2007; Moultrie et al. 2012; Timaeus and Moultrie 2008). Women only recently started to limit their family size in the countries that are most advanced in the fertility transition (Lerch and Spoorenberg 2017).

National-level trends in parity-specific fertility actually mask considerable variation between population subgroups, which reached different stages of the fertility transition. According to the demographic transition model, the above mentioned transformations in values and socioeconomic structures that motivate smaller family ideals emerge and diffuse at a particular fast pace in urban environments (Notestein 1953). International cross-sectional research confirm a lower fertility in urban than in rural areas at all parities in the developing world (Lutz 1984; Mboup and Saha 1998). The rural-to-urban fertility gap tends first to widen and then to shrink over the course of the national fertility transition, although a residual rural excess level remains even at very advanced stages (Lerch *accepted*). A longitudinal analysis of the diffusion of parity-specific fertility decline across the levels of China's urban hierarchy concluded that "it is [..] tempting to conceptualize the fertility transition as a sequence of overlapping [urban-to-rural] diffusion waves of innovative stopping behaviors (first with the sixth birth, then the fifth, then the fourth, etc.)“ Skinner et al. (2000: 645); (see also Feeney and Yu 1987). Therefore, fertility change at the national level may not provide useful information about the demographic diffusion of birth limiting behavior, as the observed pattern is confounded by a geographic diffusion.

In this study, we focus on the demographic diffusion of fertility decline within urban populations. Urban areas concentrate more than half of the population in the global South and the bulk of its demographic dividend (United Nations 2017). Patterns of fertility decline in cities are therefore particularly relevant for our understanding of the rising inequality among women in terms of family size. We evaluate whether the urban fertility transition followed the model of family limitation, with stopping behaviors of childbearing diffusing progressively from upper to lower parities over time. We contribute to the literature by describing long-term trends in the parity-specific diffusion of fertility decline and by covering all major regions of the developing world. Moreover, two new summary indicators are proposed to test the hypothesis of family limitation in a comparative perspective.

In the next section we present the data and methods used to decompose the fertility transition into its parity-specific contributions. We then define two descriptive measures that capture the direction and generalization of the diffusion of birth limiting behavior across parities over time, and apply these to the urban populations in 19 developing countries for which our data cover the early and advanced stages of the urban fertility transition. The role of rural-to-urban migration on the diffusion of fertility decline in urban areas is also assessed. The last section summarizes the observed international heterogeneity in the patterns of emergence and diffusion of birth limitation, and draws theoretical conclusions and societal implications.

Data and research strategy

To analyze the diffusion of birth limiting behavior within urban societies, we estimate the parity-specific contributions to long-term fertility decline in a cohort perspective. When compared to the period indicators of fertility, cohort measures smooth out short-term variations and are therefore better suited to gauge long-term trends. Moreover, the conventional measure of period fertility – the total fertility rate (TFR) – is problematic in the contexts of important migration flows (as between rural and urban areas), especially when the decisions to move and have children are endogenous. In order to facilitate geographic relocation, migrants tend to postpone (or bring forward) births, which are then recuperated (or followed by a pause) at the destination. As the TFR at destination only measures the behavior after migration, it tends to overestimate (or underestimate) the intensity of childbearing in times of comparatively larger migration flows (Toulemon 2004). Unfortunately, half of the surveys used for this study (see below) do not provide information on women's duration of residence in urban areas, which would have enabled us to control for the tempo effects of migration on period fertility measures. We therefore focus on completed fertility of cohorts, which is not affect by tempo biases.

Data

The analysis covers urban areas of 19 developing countries. It is based on data from 117 World Fertility Surveys (WFS) and Demographic and Health Surveys (DHS), as well as Multiple Indicators Cluster Surveys (MICS) and public use samples of population Censuses (IPUMS; these supplementary data were relied upon when the WFS and DHS do not cover the early or the late stages of the fertility transition). While the WFS and DHS collect information on the number of children ever born and women's birth histories, the MICS and IPUMS only provide summary information on fertility. We thus reconstructed the recent birth histories by applying the own-children method (Cho et al. 1986) to the data about children and women of reproductive age, as listed in the household questionnaire.

Given our interest in long-term fertility trends, we selected the countries' urban areas based on the availability of data covering the early up to the advanced stages of the transition (i.e. starting with an average cohort fertility of at least 5.5 and ending with less than 3.5 children per woman). Surveys which only interviewed ever-married women are also included in order to increase the geographical and temporal coverage of this study. At the ages at which we measure fertility (see below), the majority of women are ever married in our sample of countries. Table 1 in the Appendix lists the countries considered in this study.

Although many surveys do not provide definitions of the urban populations, the vast majority (most probably) followed national standards at the time of data collection. We can rule out potential biases in our fertility estimates due to the changing definition and delineation of urban zones over time (i.e. the reclassification of populations from rural to urban): survey-specific estimates for overlapping years in a given country are indeed congruent to each other (see

Appendix). However, inter-country differences in the urban definition constitute a major challenge for comparative research. Fertility levels are likely to be underestimated when slum dwellers are not included in the official definition of urban populations, while the measures may be overestimated when including populations with a predominantly rural livelihood on the cities' vicinities. As we are unable to control for this unobserved heterogeneity in the definitions of urban areas, we compare the general pattern of diffusion of birth limiting behavior (rather than the fertility levels per se) across urban areas of different countries.

Estimation method

The decomposition of fertility change into its parity-specific contributions is based on cohort parity-progression ratios (PPR). PPRs measure "the proportion of women who have already had a certain number of children and go on to have an additional one" (Hinde 1998:109). We estimate survey-specific series of PPR by five-year age cohorts to increase the robustness of the results. For those cohorts that reached the end of their childbearing career at the time of the interview (i.e., aged 40-44 and 45 and above), completed PPR are computed directly based on the distribution of women according to the stated parity. In order to fill inter-cohort gaps and extend the survey-specific series of estimates with more recent cohorts, we also projected completed PPRs based on the truncated estimates for the cohorts aged 30-34 and 35-39 at the survey dates.

We applied the Brass and Juarez paired cohort comparison method to project the PPRs (Brass and Juarez 1983). The younger cohorts' completed PPRs (i.e. at age 40-44) are obtained by projection of the older cohorts' completed PPR into the future, taking into account the fertility differences between each pair of adjacent cohorts in the period immediately preceding the collection of the data (see Appendix). These cohort differences are estimated at equivalent ages and parity in order to control for the truncation of the fertility career and the selection of more fertile women in higher parity groups among younger cohorts. The method assumes that fertility differences between two adjacent cohorts remain constant and are not distorted by differential tempo of childbearing after age 30. This assumption is reasonable in the set of countries under study. Moreover, we are confident about the quality of the older women's reporting of achieved parity, as well as about the accuracy of the projections of PPRs for younger women: survey-specific estimates and projections of PPRs for overlapping cohorts are indeed congruent to one and another in a given country (see Appendix). Therefore, we averaged the survey-specific PPRs for overlapping cohorts, annually and linearly interpolated the figures and applied the locally weighted least squares technique to smooth the trend (with a bandwidth of 0.75).

Total fertility (*TF*) is then calculated as a weighted average of the parities attained in the cohort, with the weights being constituted by the parity distribution of women as implied by the PPRs. We used the PPRs from nulliparous to the first births (PPR0->1) through the progression from the fifth to the sixth birth (PPR5->6), and estimate the average parity among women with at least six births based on the surveys (see Appendix). External validation against UN statistics confirmed a high quality of the fertility estimates – even in countries where only ever-married women have been interviewed (see Appendix). Urban fertility declined continuously at a fast pace in all countries (with an average decline of 0.08 birth per woman and cohort), even in sub-Saharan Africa (see A-Table 1).

Our cohort estimation approach eliminates the tempo effects of migration on the measurement of urban fertility trends. Nevertheless, the inclusion of in-migrants may bias the observed pattern of diffusion of birth limitation. Cohort fertility trends by current urban residence do not necessarily reflect the pattern of childbearing of women who lived in urban areas during their childbearing ages, as a large share of women moved to cities in their adult ages. As a robustness test of our result, we therefore replicated the analysis only on the non-migrant urban population, and compare the results with those referring to all women interviewed in urban areas.

Two summary indicators of the pattern of diffusion of birth limiting behaviors

Classic theory emphasizes a role for family limitation in the process of fertility decline (Coale 1973; Henry 1952, 1961). To evaluate the extent to which stopping behaviors diffused progressively from higher to lower parities over time, we decomposed cohort fertility decline into the contributions by parity using the general algorithm of stepwise replacement (see Appendix; Andreev et al. 2002; Zeman et al. 2018). We computed the contributions to the decline in total fertility which are attributable to behavioral changes among women with none, one, two, three and up to six or more previous children ever born. The method accounts not only for the direct impact of declining progression ratios, but also for the indirect impact that operates through the transformation of the distribution of women by parity (e.g. the changes in the population at risk of progressing to higher parities).

Figure 1 illustrates the results of the parity-specific decomposition of the fertility decline in urban Kenya, starting from an average of 6.4 children per woman born in 1928 to 3.1 among the 1981 cohort (see the thick dashed line, which refers to the y-axis on the right-hand side). The vertically stacked bars represent the relative contributions of each parity group to the decline in total fertility (y-axis on left-hand side) in successive cohorts (plotted on the x-axis). In the first cohorts, total fertility declined mainly due to lower levels of childbearing among women with at least six previous children born. Childlessness, however, decreased in this early stage of the transition (e.g. nulliparous women contributed to a fertility increase). This can be related to the decline in the extent of primary sterility in the early process of modernization (Dyson and Murphy 1985). In more advanced stages of the transition, fertility decline was dominated successively by birth limitation among women with four, then three and finally among those with only two previous births. Although birth rates at upper parities slightly rebounded in the last stage of the transition, this example generally conforms to the family limitation model.

Figure 1: about here

To compare the detailed patterns of parity-specific contributions to the fertility decline across the 19 urban populations, we define two summary indicators. The first indicator indicates the direction of diffusion of the new birth limiting behavior across parities. The classic hypothesis conjectures that the stopping behavior progressively spreads downward across parities over the course of the transition. We identified for each cohort the *parity with the modal contribution to the fertility decline* (e.g. the parity associated to the largest vertically stacked bar in a given cohort, as highlighted in yellow in Figure 1). The left-hand side panel of Figure 2 illustrates the trend in this indicator (on the y-axis) over the course of a stylized fertility transition, as indexed by the average level of fertility in successive cohorts (on the x-axis). The first and last cohorts observed are indexed by their birth year and average level of fertility. As can be seen, the direction of diffusion of birth limiting behavior is downward: the drop in fertility between two adjacent cohorts is mainly driven by a declining rate of parity progression among women who already have had a number of previous births which is immediately below or equal to the average fertility level in the previous cohort.

The second indicator measures the generalization of the birth limiting behavior across parities. The classic model of family limitation conjectures a sequential diffusion process as constituted by two distinct dynamics (Rodriguez 1996). At the onset of the fertility transition, social interaction of women within the uppermost parity group leads to the spread of the new limiting behavior from the innovators to the other members of the group. As soon as the number of adopters reaches a critical threshold, the innovative behavior trickles down to the immediately lower parity group, and so on. This sequential diffusion of birth limiting behavior implies a concentration of fertility decline among the parity with the modal contribution to the decline. Our second descriptive measure indicates the extent to which this is the case: we calculated for each cohort the coefficient of variation (CV) of all parity-specific contributions to the fertility decline (i.e. the standardized variance of the stacked vertical bars in Figure 2, as indicated by the yellow brace). In the case of a positive contribution by a particular parity group (i.e. an increase in its fertility), we set this contribution equal to zero. A high CV indicates a strong *concentration of fertility decline* among the parity group with the modal contribution. A low CV, by contrast, corresponds to a situation of *generalized fertility decline*: several parities contribute more or less equally to the progress in the fertility transition. In other words, a heterogeneous group of parities leads the fertility decline.

Figure 2: about here

The middle panel of Figure 2 illustrates the trend in the generalization of fertility decline by parity over the course of a stylized fertility transition. At the start of the transition, the new birth limiting behavior is highly concentrated (among the uppermost parity, as shown in the left-hand side panel). As the behavior diffuses to lower parities over time, the fertility decline becomes less concentrated. This is because upper parity groups continue to limit childbearing, even though their contribution to the decline in total fertility becomes secondary (because their intensity of childbearing is already low). In the middle of the transition, when the average fertility level is between three and four children per woman, fertility decline arises from rather homogeneous contributions of several different parities. In the advanced stages of the transition, by contrast, the variation in the parity-specific contributions increases again. This is because women in upper parity groups will not contribute anymore to further reduction in total fertility, once birth limitation is entirely diffused within these groups. Progress in the transition is driven more and more by behavioral changes which are concentrated among women at lower parities (i.e. with three or two previous births, and finally with only one previous child). This inverted U-shaped trend in the generalization of the adoption of birth limiting behaviors is typical for social diffusion processes (Rogers 1983).

Although the CV of the parity-specific contributions to fertility decline is a global measure of variation, its demographic interpretation is not straightforward. The indicator may be compared with a more intuitive measure: the number of parity groups which cumulatively contribute to at least 60% of the inter-cohort decline in total fertility. This partial measure of variation is strongly and linearly associated with the CV (with a statistically significant r2 of 0.77 across all countries and cohorts in our sample). A CV of 0.30 corresponds to a situation in which four different parities are responsible for at least 60% of the fertility decline, while coefficients of variation of 1.0 and 1.5 correspond to a situation in which respectively two and only one parities dominate the decline.

In sum, the hypothesis of family limitation conjectures a step-wise drop in the parity with the modal contribution to fertility decline and a U-shaped trend in the variation of all parity-specific contributions (e.g. concentration, generalization, and resumed concentration). The right-hand panel of Figure 3 illustrates how a given population evolves within the two-dimensional indicator space over the course of a stylized fertility transition. The cohort series is plotted on the x-axis according to the indicator of the direction of diffusion of birth limitation, and on the y-axis according to the indicator of the generalization of fertility decline. The cohorts (shown by empty dots) are distinguished according to their level of fertility using different colors. The trend follows a step-wise U-shaped evolution in the concentration-generalization-concentration of fertility decline during its diffusion from upper to lower parities over cohorts. Birth limiting behaviors are most generalized in the middle of the fertility transition, when average fertility reached about four children per woman. This pattern constitutes the reference for the international comparison in the next section.

Results

The emergence of birth limiting behavior

In Figure 3, the urban populations in the 19 developing countries are plotted according to the pattern of birth limitation at the onset of the fertility transition. The parity that dominates the fertility decline between the first two observed cohorts is shown on the x-axis, and the extent to which the behavioral change is concentrated in that parity is given on the y-axis. Each empty dot refers to a single urban population and is colored according to the major world region it belongs to.

Figure 3: about here

The results reveal a significant international heterogeneity in the parities at which the birth limiting behavior emerges. The majority of populations are situated on the left of the dashed vertical line in Figure 1, meaning that upper parities dominated the early fertility decline. All major world regions are represented. The four urban areas situated in the upper-left corner conform to the classic onset of family limitation: fertility decline was indeed concentrated in those upper parities. In the remaining populations (in the lower-left corner), however, birth limiting behavior has emerged concurrently among different parities. The early fertility decline was generalized, even though women with at least six previous births slightly dominated the trend.

The remaining eight urban populations situated on the right-hand side of the dashed vertical line are all but one located in sub-Saharan Africa. Their patterns of fertility decline clearly challenge the classic model. In four of these populations, the initial drop in urban fertility was strongly concentrated among middle or lower – rather than upper – parity groups (see upper-right corner). In the other four populations (lower-right corner), fertility started to decline due to similar contributions of several different parities. Middle or low parities only slightly dominated.

The diffusion of birth limiting behavior

All 19 populations experienced (at least to some extent) a trend of initial concentration towards a generalization and a later resumed concentration of fertility decline by parity: the coefficient of variation of the parity-specific contributions generally follows a U-shaped trend over the cohorts (see A-Figure 3 in the Appendix). However, we find significant variation not only in the pattern of emergence of birth limiting behavior (as discussed above), but also in its later diffusion across parities. We clustered the populations in different patterns using two main rules.

On the one hand, we distinguished the populations in which the initial birth limitation is concentrated in a few parities from those populations which are characterized by a generalized fertility decline at the transition onset. The first group of series starts with a CV of the parity-specific contributions above unity, and the second group with a CV below (or equal to) unity. On the other hand, we differentiate those populations in which the limiting behavior diffused downward across parities from those which experienced an upward diffusion over the course of the fertility transition. Combining these two criteria gives four patterns: “early concentration and downward diffusion” (CD), “early concentration and upward diffusion” (CU), “early generalization and downward diffusion” (GD), and “early generalization and upward diffusion” (GU). Furthermore, there is significant variation in the extent of generalization of birth limiting behavior over the course of the transition within each group of patterns. We also observe some atypical cases.

In Figure 4, we map the cohort series of eight illustrative urban populations in the two-dimensional indicator space: cohorts are given on the x-axis according to the parity with the modal contribution to the inter-cohort fertility decline (i.e. the indicator of the direction of diffusion of birth limitation), and on the y-axis according to the importance of this parity’s impact, relative to other parities (i.e. the CV as an indicator of the concentration/generalization of fertility decline). The panels of Figure 4 are labeled with the acronyms for the pattern of fertility decline they represent, the trough in the CV of the parity-specific contributions over the entire course of the transition, and the name of the illustrative country. In addition, Table 1 lists all the 19 urban populations according to the pattern of fertility decline. The entire set of cohort series is shown in the A-Figure 3 (in the Appendix), where populations are ranked according to the pattern of fertility decline and the trough in the CV of the parity-specific contributions.

Figure 4: about here

Table 1: about here

The cluster "early concentration and later downward spread of fertility decline" (CD) is consistent with the classic hypothesis of family limitation and exemplified by urban Kenya and Peru. Both cohort series reveal a sequential top-down diffusion of birth limitation across parities. Kenya’s trend follows a stepwise U-shaped evolution in the generalization-concentration of fertility decline. Note that birth limitation never totally generalized (among all parity groups within a given cohort): the trough in the CV of parity-specific contributions remains above 0.5.

The diffusion of the new behavior from upper to lower parities is indeed sequential. However, the trough in the CV is reached early on in the course of the fertility transition – as soon as average fertility crossed the 5-children bar. A similar pattern is found in Bangladesh. In Peru, by contrast, the new behavior generalized at a faster pace across parities over the course of the transition. While the uppermost parity clearly dominated the onset of fertility decline, almost all parities contributed to a similar extent before the cohort-specific average fertility crossed the 5-children-bar (as revealed by the trough in the CV of parity-specific contributions well below 0.5). This challenges the classic hypothesis of the sequential nature of behavioral diffusion across parities. Mexico followed a similar pattern, although the resumed concentration of fertility decline by parity in the final stages of the transition is very timid. Several parities continued to contribute to a similar extent.

Urban Ghana stands for a pattern of fertility decline which is characterized by an atypical onset and a fast but classic generalization/concentration across parities (a pattern labeled “CDm”). Congruent to the classic model, birth limitation was initially concentrated and later diffused to lower parities. However, the early fertility decline was concentrated among a middle, rather than upper, parity, and then diffused to several parities at a fast pace – with a trough in the CV of the parity-specific contributions of 0.27. In advanced stages of the transition, the fertility decline in urban Ghana concentrated among lower parities (i.e. the CV of parity-specific contributions increased again to levels above unity). Although the urban populations of Ethiopia experienced a pattern similar to the Ghanaian one, the CV of parity-specific contributions remained below unity until the last cohort observed. Fertility decline remained generalized across parities throughout the entire course of the transition.

Gabon represents the pattern of “early concentration and later upward diffusion of fertility across parities” (CU). Similarly to the case of Ghana, initial fertility decline was concentrated among a middle (rather than an upper) parity and generalized to other parities at a fast pace (with a trough in the CV of 0.48 before average fertility crossed the 5-children-bar). Although this was followed by a renewed concentration in later stages, which is consistent with the classic model, advanced fertility decline was more and more driven by upper (rather than lower) parities. Middle and lower parity groups resist to the diffusion of birth control in the advanced transitional stages.

Compared to this first group of patterns, in which the onset of fertility decline was concentrated among a given parity, the remaining types of fertility transitions are characterized by a generalized onset of birth limitation among several parities (with a CV of parity-specific contributions to the initial inter-cohort fertility decline equal to or below unity). Egypt and Morocco illustrate the most frequent pattern of "early generalization and later downward diffusion of fertility decline" (GD). In Egypt, fertility decline remained generalized among several parities over the entire course of the transition. However, the trough in the CV of parity-specific contribution to the decline remained above 0.5, which reveals a limited extent of generalization. In Morocco, by contrast, the already generalized fertility decline at the transition onset generalized even more to all parities at a fast pace. The trough in the CV of parity-specific contributions of 0.26 is reached before average fertility fell below five. Birth limitation among childless women then started to dominate more and more the subsequent fertility decline, leading to a resumed increase in its concentration by parity. Similar patterns are also found in Columbia, Ecuador, Togo, Madagascar and Tunisia. When compared to Morocco, however, either the generalization of the fertility decline to all parities, or the resumed concentration at later transitional stages, was less marked.

The urban population of Rwanda stands for the pattern which is characterized by an "early generalization and upward diffusion" of birth limiting behavior across parities. While the upward diffusion is similar to the one found in Gabon, the fertility decline was more generalized across parities starting from the very onset of the transition until advanced stages. In the "other" a-typical pattern, portrayed by Malawi, the stopping behavior also emerged among several parities at the transition onset, with only a slight dominance of middle parities. Later on, however, fertility decline was increasingly concentrated among the uppermost parities. This again points to significant resistances to fertility decline among women with lesser previous births. Similar resistances to the adoption of stopping behaviors of childbearing among women with lesser previous births are observed in urban Senegal and Côte d'Ivoire.

The Philippines constitute another special case (see A-Figure 3), in which birth limitation was widespread at the onset of fertility decline – even though women with three previous births slightly lead the process – and remained generalized across parities throughout the subsequent course of the transition.

It is interesting to note that each of the patterns discussed above can be found in any major region of the developing world. Nevertheless, the generalized fertility decline among several parities throughout the entire course of the transition tends to be more prevalent in the Middle East and Northern Africa. The initiation of birth limiting behaviors among middle parities and its later upward diffusion, however, are often observed in sub-Saharan Africa.

Discussion & conclusion

Fertility decline opens up major opportunities for socioeconomic development through a demographic dividend, which is exacerbated in urban areas by the in-migration of young adults. The pattern of diffusion of birth limiting behavior that underlies the decline in urban fertility matters for the heterogeneity of women in terms of family size and, thus, for the inequalities in their freedom to take advantage of the new socioeconomic opportunities. Empirical evidence about the parity-specific patterns of fertility decline is scarce. It mainly refers to national-level populations in which the demographic and geographic spreads of behavioral innovation are confounded by each other. Focusing on urban populations spanning all regions of the global South, we proposed two new descriptive indicators to evaluate in a comparative and long-term perspective whether the parity-specific pattern of fertility decline was congruent to the classic model of family limitation.

The results confirmed a general trend characterized by an initial concentration of fertility decline among a given parity, which was followed by a generalization and then by a resumed concentration among another parity group at later stages of the transition. This is consistent with the process of social diffusion of a behavioral innovation. However, there is significant international heterogeneity in the parity at which fertility decline emerged, in the direction of diffusion of the new behavior, and in the extent of its generalization across parities. The classic model of family limitation was only confirmed in four of the 19 urban populations studied. Even in this limited number of cases, the downward diffusion of birth limiting behaviors across parities was much faster than anticipated: fertility decline tended to generalize by parity as soon as average fertility was approaching the five-children-bar. In other urban populations, birth limiting behaviors emerged either among a heterogeneous group of parities or essentially among middle (rather than upper) parities. In some of these populations, the new behavior also diffused to (and concentrated predominantly among) upper parities in later stages of the transition because lower parities resisted to advanced fertility decline. Rural-to-urban migration did not significantly alter the observed patterns of diffusion of birth limiting behaviors (as revealed by the robustness tests in the Appendix).

This diversity in the patterns of fertility decline is not constrained to the urban populations in the developing world. Zeman et al. (2018) also found contrasting parity-specific pathways towards below-replacement fertility levels in OCDE countries. Although our results confirm the importance of stopping behaviors in the process of fertility decline across all urban populations, the diversity in the parity groups which are (simultaneously) involved contradicts the classic hypothesis of family limitation. More research is needed to better understand the factors of the observed heterogeneity in the parity-specific patterns of fertility decline.

As the different patterns are not regionally clustered, cultural differences do not seem to matter. In particular, our results revealed a major role of stopping behaviors at different parities in the urban fertility transitions of sub-Saharan Africa. This challenges the argument of an African "exceptionalism" of slow fertility decline driven by the spacing of births, as derived from national level observations (Bongaarts 2017; Moultrie et al. 2012). The socioeconomic differentiation of urban societies may be the key explanation. The early generalization of stopping behaviors to different parity groups may be related to different motives for fertility decline among different sub-populations. One may distinguish between an opportunity-seeking stopping of childbearing at low parities among higher educated and more affluent groups versus a poverty-driven termination of fertility at middle or upper parities among disadvantaged groups (Basu 1986; Cosio-Zavala 1995). Different types of fertility transition may unfold simultaneously not only within distinct social strata, but also within different neighborhoods which leads to a strong intra-urban spatial heterogeneity in fertility (Weeks et al. 2010). Furthermore, the emergence of birth limitation among middle (rather than upper) parities may be related to an initiation of the fertility transition by a specific subpopulation which may be engaged more intensively in social interactions with other countries that are more advanced in the transition. This onset pattern is indeed predominantly observed in the more recent fertility declines in sub-Saharan African cities.

The rejection of the classic hypothesis of family limitation has implications for our understanding of the rising heterogeneity of women in terms of their family size over the course of the fertility transition (Lutz 1989). Fertility transitions initiated by middle (rather than upper) parities, or by several parities simultaneously, should lead to a particularly strong heterogeneity in terms of family size within cohorts: while some women stop after two children, others terminate childbearing only after the fourth, fifth or sixth birth. In such contexts, only a minority of less fertile women are able to take advantage from the new socioeconomic opportunities brought about by the demographic dividend that accompanies the drop in average fertility. In other words, the generalized patterns of urban fertility decline and the resulting heterogeneity in women's family size may constitute the root causes of the persistence of socioeconomic inequalities in developing countries' cities (UN-Habitat 2008), which may in turn reproduce fertility inequality over generations. Future research may identify the contextual determinants of these generalized fertility declines in order to better inform policy makers in high fertility countries. A particular research focus should also be directed towards the sub-populations in cities that resist to the diffusion of birth limiting behaviors among lower parities at advanced stages of the transition. This will help to better focus family planning programs on those women who have been left behind, and to ensure equal chances of human development.

Appendix

Projection of cohort parity progression ratios and estimation of total fertility

To project the completed PPRs for the cohorts aged 30-34 and 35-39 at the survey dates, the Brass-Juarez paired-cohort comparison procedure was applied (Brass and Juarez 1983; Moultrie et al. 2012). The truncated PPRs for the younger cohorts are projected forward in time by multiplying the completed PPR of the cohort aged 40-44 at the survey date *t* (*PPR(40-44, t)* in Equation 1) by that cohort's fertility differential with the immediately younger cohort and by the latter cohort's fertility differential with the subsequent cohort (second right-hand term in the Equation below). In other words, the completed PPRs are multiplied with the downward-cumulated fertility change ratios between successive pairs of adjacent cohorts.

$$PPR(30-34, t+10) = PPR(40-44, t) * \prod_{c=35-39}^{40-44} \frac{PPR(c-5,t)}{PPR(c,t-5)} \quad (1)$$

The innovative idea of the Brass-Juarez method is to estimate the inter-cohort fertility change ratios at equivalent ages and parities in order to control for the truncation of the fertility career and the selection of more fertile women in higher parity groups among younger cohorts. For the older women in each pair of cohorts, the number of births that occurred in the five-year period immediately preceding the survey (as reported in the birth histories) is subtracted from the stated parity at the survey date *t*. Thus, the older cohort's PPR as of five years before the survey (*PPR(c, t-5)*) is truncated and affected by selection to the same extent as the younger cohort's PPR at the time of the survey (*PPR(c-5, t)*).

Total cohort fertility (*TF*) can be obtained as a weighted average of the parities attained in the cohort, with the weights constituted by the parity distribution of women (i.e. the proportion having given birth to one, two, etc. children; p*i*):

$$TF = 1 * p1 + 2 * p2 + 3 * p3 + 4 * p4 + 5 * p5 + avCEBP6 * p6 \qquad (2)$$

The average number of children ever born among women in the last open ended parity group (six children or more), *avCEBP6*, was estimated at the survey dates; inter-survey estimates have been linearly interpolated, pre-survey estimates extrapolated, and the trend smoothed.

The parity distribution of women (p*i*) is implied by the chaining of the progression ratio of nulliparous women to the first birth (*PPR0->1*) through the ratio of progression from the fifth to the sixth birth (*PPR5->6*):

$$pi = \left[\prod_{k=1}^{i} PPR_{(k-1)\rightarrow k}\right] * \left[1 - PPR_{i\rightarrow(i+1)}\right] \qquad (3)$$

Cross-validating and smoothing of the estimates

We performed two quality tests of our estimations series. The first is based only on the survey/census-samples. To assess the quality of the reporting of women's parity, on the one hand, and the accuracy of our projections for younger cohorts, on the other hand, we cross-validated the observed and projected values of completed PPRs for overlapping cohorts as obtained respectively from two successive surveys. This internal plausibility test of our data revealed a higher agreement between observed and projected PPRs at lower parities, which can be explained by larger samples of women. A-Figure 1 shows the most problematic crude series of observed and projected progression ratios as obtained from successive surveys: the transition from the fifth to the sixth birth (PPR6). Countries are purposively selected to illustrate the range of data quality. On each individual blue line, the last two points designate projected values, whereas prior points represent estimates. The averaged and smoothed trend (see below) is also plotted in red.

Overall, we can conclude that the quality of our series of completed PPRs is good. We smoothed the trend by, first, averaging survey-specific data points for overlapping cohorts, linearly interpolating the estimates, and then applying a running line function (see thick lines in A-Fig. 1).

As a second external plausibility test, we estimated national-level total cohort fertility (TF) based on the PPRs (which are primarily based on parity data) and compared the trends with two external estimates: the United Nations' period TFR series which have been back-translated by the average age at childbearing to get a cohort indicator, and Sneeringer's (2009) estimates of the total cohort fertility rates (CTFR; i.e. the sum of age-specific rates) based on the pooled birth histories from successive DHS in Africa. As shown in A-Figure 2, our estimates fit the two other series well – even in countries where only ever-married women have been interviewed (such as in Bangladesh, Egypt and Morocco).

A-Figure 3 shows the direction and generalization of the diffusion of birth limiting behavior for the urban areas in all 19 countries, ranked according to the pattern observed and the through in the coefficient of variation of the parity-specific contribution to the inter-cohort fertility decline

Decomposition of cohort fertility decline by parity

We decomposed cohort fertility decline into the contributions by parity using the general algorithm of stepwise replacement (Andreev et al. 2002; Zeman et al. 2018). The contributions are given by the differences between a set of simulations of total fertility as implied by the chained PPRs which are measured for two adjacent cohorts and step-wise replaced for each other. Using equation 2 and 3 (above), the first simulation starts with the chaining of all PPRs of the older cohort and provides the baseline level of fertility. The second simulation of total fertility is obtained by substituting only the PPR0->1 of the younger cohort for the value referring to the older cohort. Comparing the two simulations provides us with the contribution of the inter-cohort change in the PPR0->1 to the inter-cohort decline in total fertility. In subsequent simulations, we step-wise substitute an additional PPR of the younger cohort for the estimate of the older cohort (moving upward across parities), and compare the successively simulated values of total fertility.

The impact of urban in-migrants on the pattern of diffusion of birth limiting behaviors

The inclusion of in-migrants in the estimates of urban fertility may bias the observed pattern of diffusion of birth limitation. Urban in-migrants have been socialized to rural fertility standards and did not spend their whole reproductive period in the city. The process of adaptation to urban fertility standards is generally completed only among the migrants' descendants, who have been socialized in cities (Brockerhoff 1998; Goldstein and Goldstein 1981; White et al. 2005). Consequently, urban in-migrants may stop childbearing at higher parities when compared to non-migrant urban dwellers. Alternatively, migrants may be selected among women with low fertility preferences and may therefore stop childbearing at lower parities, when compared to non-migrants.

In order to evaluate the impact of migration on the results presented above, we compared these with another set of estimates based exclusively on the non-migrant populations in urban areas. Non-migrants are defined as those women who have been socialized (until age 15) *and* interviewed in an urban area. We identified these women based on the information about the childhood or previous type of residence location as reported in a sub-set of WFS and DHS surveys. The cohort series for the non-migrants are shorter than those for the total urban population (inter-cohort gaps have been linearly interpolated). This is because several (more recent) surveys do not provide any information on migration. The pattern of diffusion of birth limitation among non-migrants is shown by a gray line in the Appendix Figure 3 for comparison with the results for the total urban population.

When compared to the results for the entire urban population, the robustness tests among non-migrants reveal more erratic cohort trends in the two-dimensional indicator space due to the sampling biases which stem from the lower numbers of observations. In general, the direction of diffusion of fertility decline across parities and the trough in the variation of parity-specific contributions are generally not affected by the inclusion of migrants in the estimates. However, when compared to the total population, the emergence of birth limiting behaviors tended to be more concentrated in the upper-most and lowest parities at, respectively, the onset and advanced stages of the fertility transition of the non-migrants.

At the onset of the transition, migrants tend to be selected among less fertile women who stopped childbearing at lower parities when compared to non-migrants. This diversified the parities that contributed to the onset of fertility decline in the total urban population (such as in Bangladesh, Morocco, Madagascar, Tunisia and the Philippines). In late stages of the transition, the inverse is often observed: urban in-migration increased the share of higher fertile women in cities, which lead to a more pronounced generalization of birth limiting behaviors across parities in the total urban population, when compared to the non-migrant sub-group (such as in Mexico, Bangladesh, Morocco, Madagascar, Philippines). The arrival of less fertile in-migrants in early transitional stages and the arrival of more fertile in-migrants in the advanced stages are congruent with migration theory. While migrants are initially selected among the most progressive social group at origin, the opportunities to move diffuse within society as the risks and uncertainty of the mobility project diminish with the institutionalization of the migration flow through a growing network of migrants who assists new migration candidates.

At the transition onset in Gabon, Kenya, and Togo, however, the emergence of birth limiting behavior among the total urban population is concentrated among an upper parity, while it is rather generalized among non-migrants – with often a slight predominance of a lower parity group. In-migration increased the share of more fertile women to the extent that birth limitation at higher parities dominated the early urban fertility decline. For similar reasons, the advanced stages of the transition are dominated to a greater extent by birth limitation at higher parities in the total when compared to the non-migrant population (Ecuador, Kenya, Rwanda, and particularly Senegal and Malawi).

We can conclude that the general pattern of diffusion of birth limiting behavior across parities is not strongly affected by the inclusion of in-migrants in the estimates for the majority of urban populations. The countries in which migrants make a significant difference are either small and predominantly urban, or characterized by a low level of urbanization. As in these contexts in-migrants represent a large share of the urban population, and we lack information on the migrants' duration of residence, their exclusion from the analysis would be questionable.

References

Andreev, E.M., V.M. Shkolnikov, & A.Z. Begun. 2002. Algorithm for decomposition of differences between aggregate demographic measures and its application to life expectancies, healthy life expectancies, parity-progression ratios and total fertility rates. *Demographic Research* 7(14):499-522.

Basu, A.M. 1986. Birth Control by Assetless Workers in Kerala: The Possibility of a Poverty Induced Fertility Transition. *Development and Change* 17:265-282.

Bloom, D.E., D. Canning, G. Fink, & J.E. Finlay. 2012. Microeconomic Foundations of the Demographic Dividend. *Harvard School of Public Health Program on the Global Demography of Aging Working Paper* No. 93.

Bloom, D.E., D. Canning, & J. Sevilla. 2003. *The Demographic Dividend*. Santa Monica: Rand.

Bongaarts, J. 2017. Africa's Unique Fertility Transition. *Population and Development Review* 43(S1):39–58.

Brass, W., & F. Juarez. 1983. Censored Cohort Parity Progression Ratios from Birth Histories. *Asian and Pacific Census Forum* 10(1):5-13.

Brockerhoff, M. 1998. Migration and the Fertility Transition in African Cities. in R.E. Bilsborrow *Migration, urbanization, and development: new directions and issues* (pp. 357-390). Norwell, Massachusetts: Kluwer Academic Publishers.

Cho, L.-J., R.D. Retherford, & M.K. Choe. 1986. *The Own-Children Method of Fertility Estimation*. Honolulu: Est-West Centre.

Coale, A.J. 1973. The Demographic Transition. in International Union for the Scientific Study of Population (IUSSP) *International Population Conference 1973*. Liège: IUSSP.

Cosio-Zavala, M.E. 1995. Inégalités économiques et sociales et transitions de la fécondité en Amérique Latine. Presented at Chaire Quetelet 1992 - Transition démographiques et sociétés, Institut de Démographie, Université Catholique de Louvain, Louvain-la-Neuve.

de la Croix, D., & M. Doepke. 2003. Inequality and Growth: Why Differential Fertility Matters. *The American Economic Review* 93(4):1091-1113.

Dyson, T., & M. Murphy. 1985. The Onset of Fertility Transition. *Population and Development Review* 11(3):399-440.

Eloundou-Enyegue, P., S. Giroux, & M. Tenikue. 2017. African Transitions and Fertility Inequality: A Demographic Kuznets Hypothesis. *Population and Development Review* 43(S1):59-83.

Feeney, G. 1991. Fertility Decline in Taiwan: A Study Using Parity Progression Ratios. *Demography* 28(3):467-479.

Feeney, G., & J. Yu. 1987. Period Parity Progression Measures of Fertility in China. *Population Studies* 41(1):77-102.

Giroux, S.C., P.M. Eloundou-Enyegue, & D.T. Lichter. 2008. Reproductive Inequality in Sub-Saharan Africa: Differentials versus Concentration. *Studies in Family Planning* 39(3):187-198.

Goldstein, S., & A. Goldstein. 1981. The Impact of Migration on Fertility: an 'Own Children' Analysis for Thailand. *Population Studies* 35(2):265-284.

Henry, L. 1952. Fécondité des mariages - Nouvelle méthode de mesure. *Population* 7(4):697-700.

—. 1961. Some data on natural fertility. *Eugenics quaterly* 8:81-91.

Hinde, A. 1998. *Demographic Methods*. London: Arnold.

Hobcraft, J. 1985. Family-building patterns. in J. Cleland, & J. Hobcraft *Reproductive Change in Developing Countries* (pp. 64-86). New York: Oxford University Press.

Hosseini-Chavoshi, M., P. McDonald, & J. Mohammad. 2006. The Iranian Fertility Decline, 1981-1999: An Application of the Synthetic Parity Progression Ratio Method. *Population* 61(5-6).

Johnson-Hanks, J. 2007. Natural Intentions: Fertility Decline in the Africa Demographic and Health Surveys. *American Journal of Sociology* 112(4):1008-1043.

Juarez, F., & S. Llera. 1996. The Process of Family Formation during the Fertility Transition. in J.M. Guzman, S. Singh, G. Rodríguez, & E.A. Pantelides *The fertility transition in Latin America* (pp. 48-73). Oxford: Oxford University Press.

Knodel, J. 1977. Family Limitation and the Fertility Transition: Evidence from the Age Patterns of Fertility in Europe and Asia. *Population Studies* 31(2):219-249.

Knodel, J., & E. van de Walle. 1979. Lessons from the Past: Policy Implications of Historical Fertility Studies. *Population and Development Review* 5(2):217-245.

Lerch, M. 2013. Fertility Decline During Albania's Societal Crisis and its Subsequent Consolidation. *European Journal of Population* 29(2):195-220.

—. *accepted*. Fertility decline in urban and rural areas of the developing world. *Population and Development Review*.

Lerch, M., & T. Spoorenberg. 2017. Fertility transition in sub-Saharan Africa: A view using parity progression ratios. *International Population Conference 2017, Cape Town, South Africa*.

Lutz, W. 1984. *Parity-specific fertility analysis: a comparative study on 41 countries participating in the World Fertility Survey*. Vienna: Demographic Institute of the Austrian Academy of Sciences.

—. 1989. *The Distributional Aspects of Human Fertility: a Global Comparative Study*. London: Academic Press.

Mboup, G., & T. Saha. 1998. *Fertility Levels, Trends and Differentials*. Calverton, Maryland: Macro International Inc.

McDonald, P., M. Hosseini-Chavoshi, M.J. Abbasi-Shavazi, & A. Rashidian. 2015. An assessment of recent Iranian fertility trends using parity progression ratios. *Demographic Research* 32(58):1581−1602

Moultrie, T.A., T.S. Sayi, & I.M. Timaeus. 2012. Birth intervals, postponement, and fertility decline in Africa: A new type of transition. *Population Studies* 66(3):241-258.

Notestein, F.W. 1953. Economic problems of population change. Presented at Proceedings of the Eighth International Conference of Agricultural Economists, London.

Rodriguez, G. 1996. The Spacing and Liming Components of the Fertility Transition in Latin America. in J.M. Gnuzman, S. Sigh, G. Rodriguez, & E.A. Pantelids *The Fertility Transition in Latin America* (pp. 27-47). Oxford: Oxford University Press.

Rogers, E.M. 1983. *Diffusion of Innovation*. New York: The Free Press.

Shkolnikov, V.M., E.M. Andreev, R. Houle, & J.W. Vaupel. 2007. The Concentration of Reproduction in Cohorts of Women in Europe and the United States. *Population and Development Review* 33(1):67-99.

Skinner, W.G., M. Henderson, & Y. Jianhua. 2000. China's Fertility Transition through Regional Space. *Social Science History* 24(3):613-652.

Sneeringer, S.E. 2009. Fertility Transition in Sub-Saharan Africa: A Comparative Analysis of Cohort Trends in 30 Countries. Pp. 23 in *DHS Comparative Reports*. Calverton, Maryland, USA: ICF Macro.

Spoorenberg, T. 2009. The Impact of the Political and Economic Transition on Fertility and Family Formation in Mongolia. *Asian Population Studies* 5(2):127-151.

—. 2013. Fertility changes in Central Asia since 1980. *Asian Population Studies* 9(1):50-77.

Spoorenberg, T., & P. Dommaraju. 2012. Regional Fertility Transition in India: An Analysis Using Synthetic Parity Progression Ratios. *International Journal of Population Research* 2012(35859):20.

Timaeus, I.M., & T.A. Moultrie. 2008. On Postponement and Birth Intervals. *Population and Development Review* 34(3):483-510.

Toulemon, L. 2004. La fécondité des immigrées: nouvelles données, nouvelle approche. *Population & Sociétés* 400(Avril).

UN-Habitat. 2008. *State of the World's cities 2008/2009*. Nairobi: United Nations Human Settlements Programme.

United Nations. 2017. *World Population Prospects: The 2017 Revision, Key Findings and Advanced Tables*: New York, United Nations, Department of Economic and Social Affairs, Population Division.

Weeks, J.R., A. Getis, A.G. Hill, S. Agyei-Mensah, & D. Rain. 2010. Neighborhoods and Fertility in Accra, Ghana: An Amoeba-based Approach. *Annals of the Association of American Geographers* 100(3):558-578.

White, M.J., E. Tagoe, C. Stiff, K. Adazu, & D. Jordan Smith. 2005. Urbanization and the fertility transition in Ghana. *Population Research and Policy Review* 24:59-83.

Zeman, K., E. Beacujouan, Z. Brzozowska, & T. Sobotka. 2018. Cohort fertiltiy decline in low fertility countries: Decomposition using parity progression ratios. *Demographic Research* 28(25):651-690.

Tables & Figures

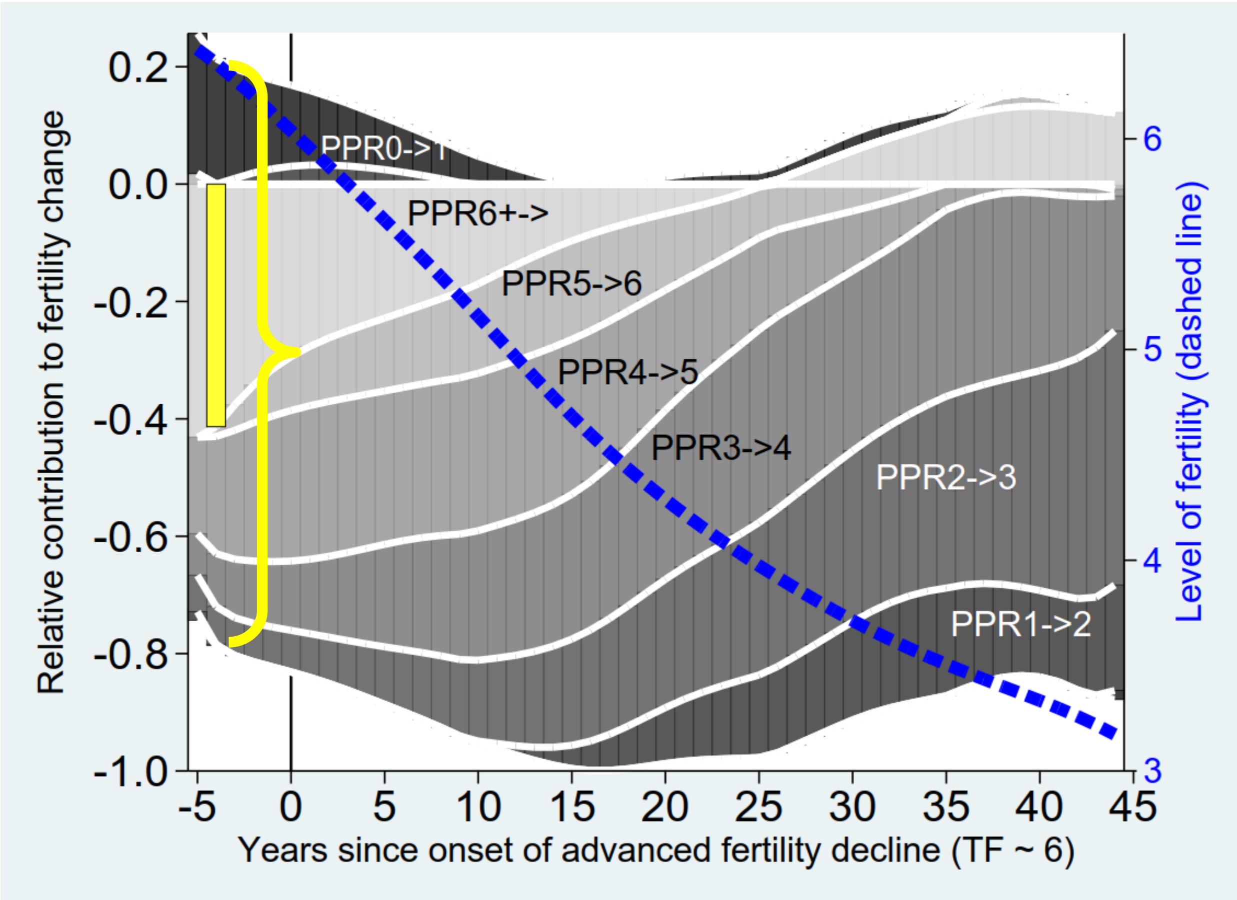
Table 1: Urban populations ranked according to the pattern of diffusion of birth limitation and the trough in the CV of the parity-specific contributions to the fertility decline over the course of the transition, 19 developing countries.

Pattern	Trough in CV	Country
CD	0.31	Peru
CD	0.50	Mexico
CD	0.54	Bangladesh
CD	0.69	Kenya
CDm	0.27	Ghana
CDm	0.46	Ethiopia
CU	0.43	Gabon
GD	0.34	Morocco
GD	0.47	Ecuador
GD	0.47	Togo
GD	0.55	Colombia
GD	0.58	Madagascar
GD	0.60	Tunisia
GD	0.68	Egypt
GU	0.31	Rwanda
other	0.23	Philippines
other	0.25	Côte d'Ivoire
other	0.30	Senegal
other	0.56	Malawi

Sources: WFS, DHS, MICS, IPUMS.

Notes: CV = coefficient of variation, CD = early concentration among an upper parity and subsequent downward diffusion of fertility decline, CDm = early concentration among a middle parity and subsequent downward diffusion of fertility decline by parity, CU = early concentration and upward diffusion, GD = early generalization and downward diffusion, GU = early generalization and upward diffusion.

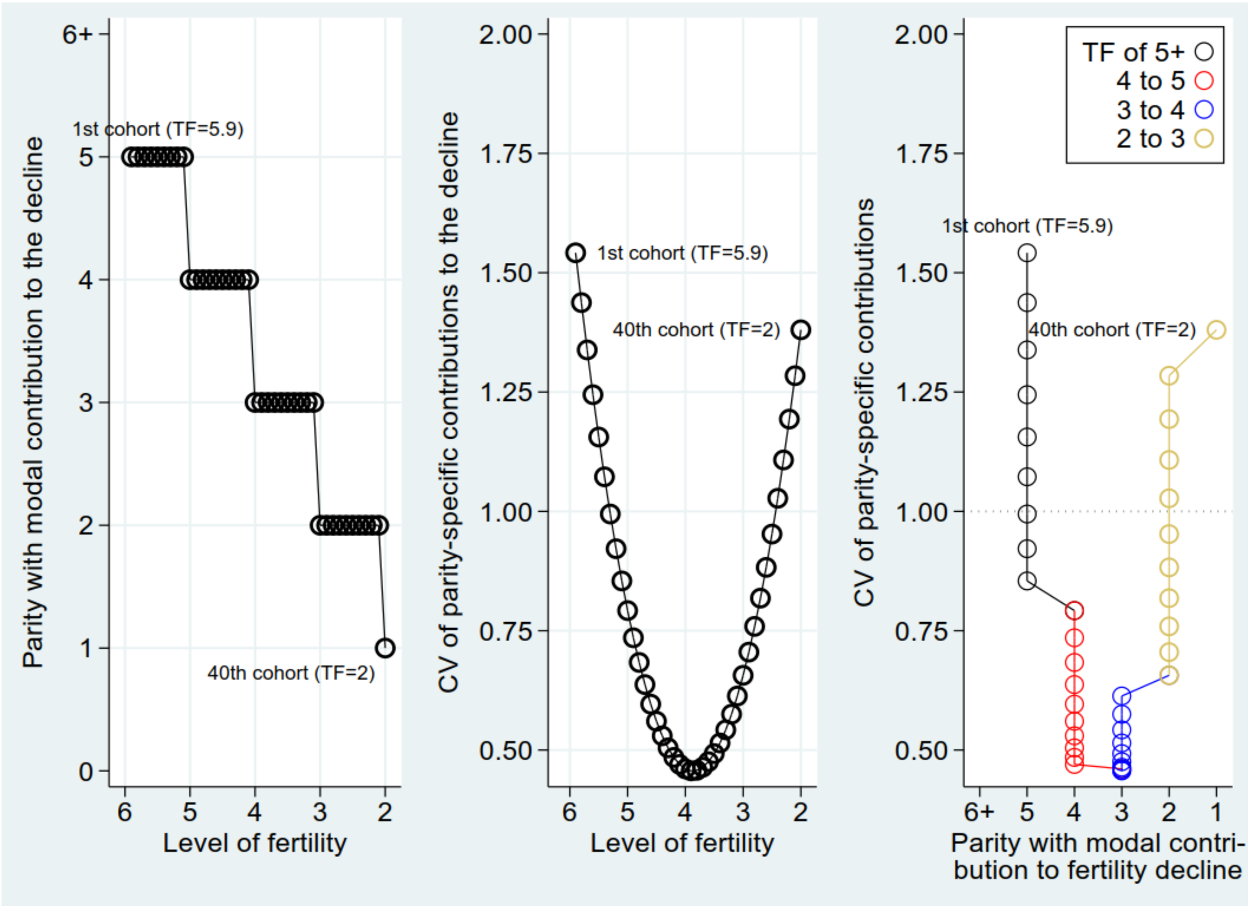
Figure 1: Figure 1: Relative parity-specific contributions to the change in total fertility over the course of the fertility transition, urban cohorts 1928-1981, Kenya.



Source: WFS & DHS.

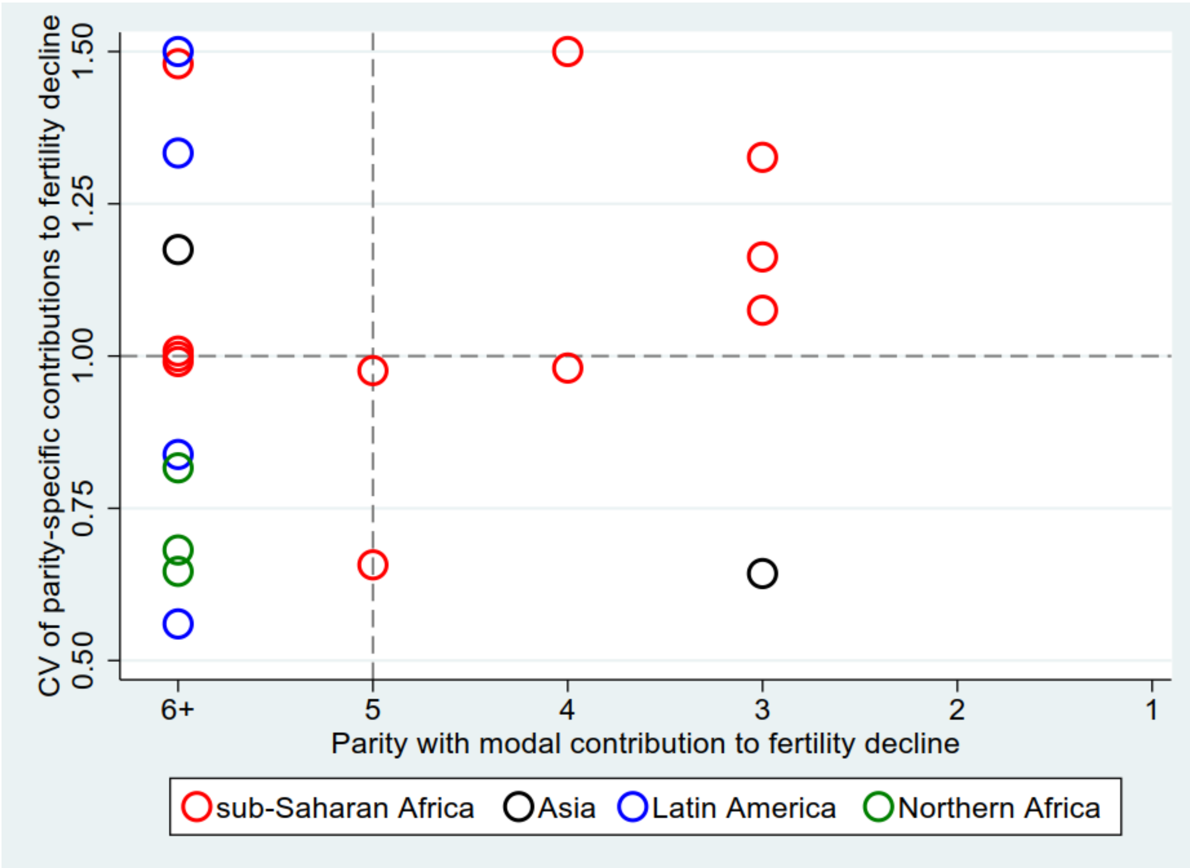
Note: each vertically stacked bar represents the impact of a change in a given PPR on the variation in total fertility between two adjacent cohorts; the yellow bar highlights the modal contribution to fertility change between the cohort born five years prior to the onset of advanced decline and the immediately following cohort; the yellow brace indicates the parity-specific contributions that are considered when calculating the coefficient of variation of the contributions to the decline (see text).

Figure 2: The evolution in two indicators that capture the direction (left-hand panel) and generalization (middle panel) of fertility decline across parities over the course of a stylized fertility transition (the right-hand panel combines the two indicators)



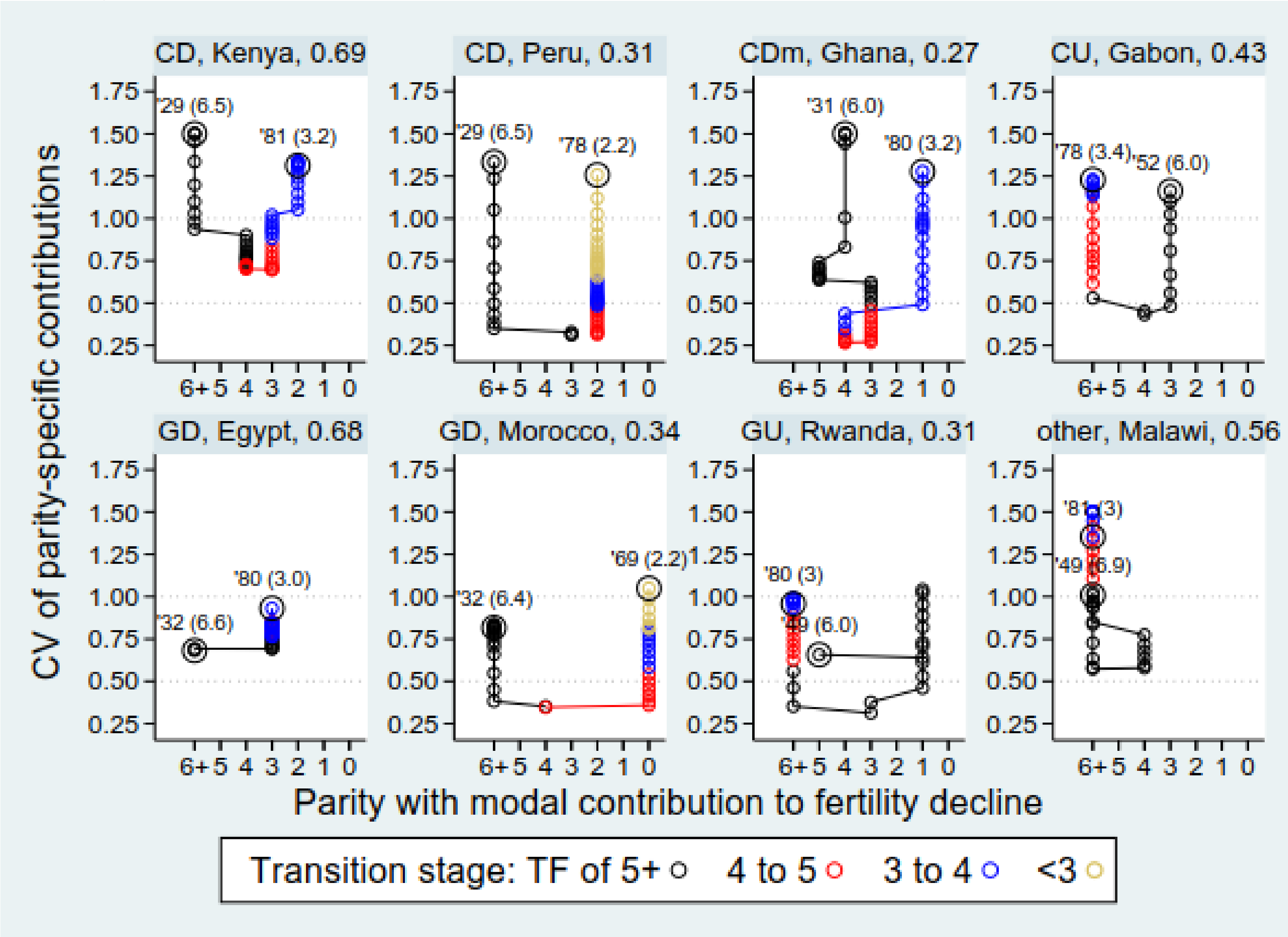
Source: Simulated data. Notes: CV = coefficient of variation, TF = total fertility.

Figure 3: Starting pattern of birth limitation between the two first observed urban cohorts in 19 developing countries, 1926-1982



Source: WFS & DHS, MICS, IPUMS. Notes: CV = coefficient of variation.

Figure 4: The direction (x-axis) and generalization (y-axis) of diffusion of birth limiting behaviors across parities over the course of the fertility transition, urban cohorts in eight illustrative developing countries.



Sources: WFS, DHS, MICS, IPUMS.

Notes: each empty dot represents a cohort; the first and last cohort is indicated by an empty, larger and black dot, and is indexed with its year of birth and average level of fertility; values next to the country name refer to the trough in the CV of parity-specific contributions to the fertility decline over the entire course of the transition; CV = coefficient of variation; TF = total fertility; CD = “early concentration among an upper parity and subsequent downward diffusion of fertility decline by parity”; CD = “early concentration among a middle parity and subsequent downward diffusion of fertility decline by parity”; CU = “early concentration and upward diffusion”; GD = “early generalization and downward diffusion”; GU = “early generalization and upward diffusion”.

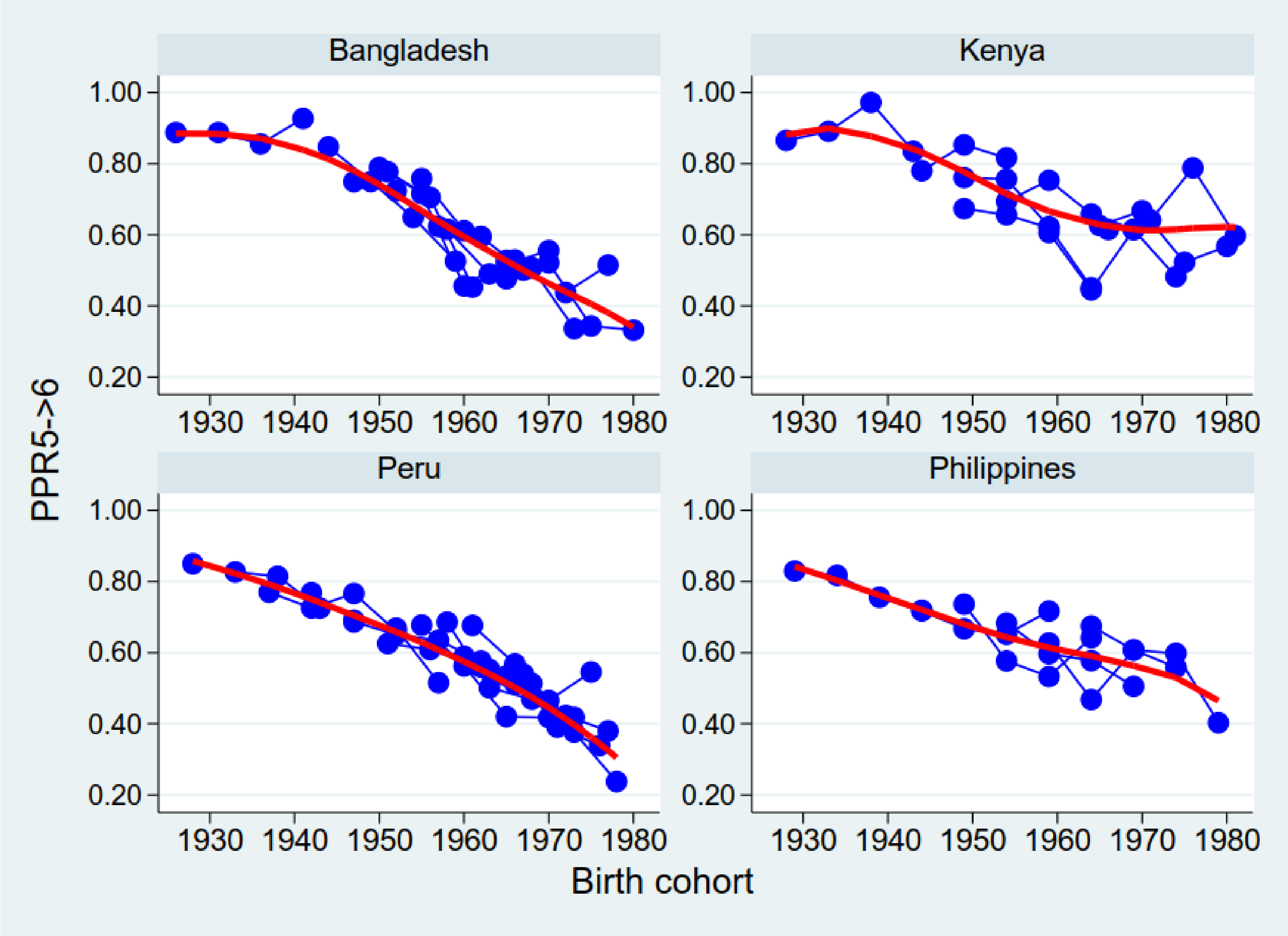
Appendix-Tables & Figures

A-Table 1: Country-specific levels of urbanization, number and dates of fertility surveys, observed urban cohorts and their level of fertility in 19 African, Asian and Latin American countries.

	Country (abbr. & name)		%urban (UN)		Survey (census) years												Obs. cohorts & urban levels of fertility			
			1950	2000	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	First	TF	Last	TF
ASIA	BD	Bangladesh	4	24	1975	1993	1996	1999	2000	2004	2007	2011	2014				1926	7.2	1980	2.6
	PH	Philippines	27	48	1978	1993	1998	2003	2008	2013							1929	6.4	1979	2.6
LA	CO	Colombia	33	72	1976	1986	1990	1995	2000	2004	2009						1927	6.4	1975	2.2
	EC	Ecuador	28	60	1979	1987	2001	2010									1930	5.9	1976	3.4
	MX	Mexico	43	75	1976	1987	2015										1927	7.0	1966	2.6
	PE	Peru	41	73	1977	1986	1991	1996	2000	2004	2007	2009-2012					1928	6.6	1978	2.2
MENA	EG	Egypt	32	43	1980	1988	1992	1995	2000	2003	2005	2008	2014				1931	6.7	1980	3.1
	MA	Morocco	26	53	1980	1987	1992	2003									1931	6.4	1969	2.2
	TN	Tunisia	32	63	1978	1988	2012										1929	7.0	1978	2.6
SSA	CI	Côte d'Ivoire	10	44	1980	1994	1998	2005	2011								1931	6.6	1977	3.5
	ET	Ethiopia	5	15	2000	2005	2011										1951	5.7	1977	3.0
	GA	Gabon	11	80	2000	2012											1951	6.1	1978	3.4
	GH	Ghana	15	44	1979	1988	1993	1998	2003	2008	2014						1930	6.0	1980	3.2
	KE	Kenya	6	20	1977	1988	1993	1998	2003	2008	2014	2015					1928	6.5	1981	3.1
	MD	Madagascar	8	27	1992	1997	2003	2008	2011	2013	2016						1943	5.9	1982	3.1
	MW	Malawi	4	15	1992	2000	2004	2010	2012	2014	2015						1948	6.9	1981	3.0
	RW	Rwanda	2	15	1992	2000	2005	2007	2010	2013	2014						1948	6.1	1980	2.9
	SN	Senegal	17	40	1978	1986	1992	1997	1999	2005	2006	2008	2010	2012	2014	2015	1929	6.8	1981	3.3
	TG	Togo	4	33	1988	1998	2013										1939	6.1	1979	3.4

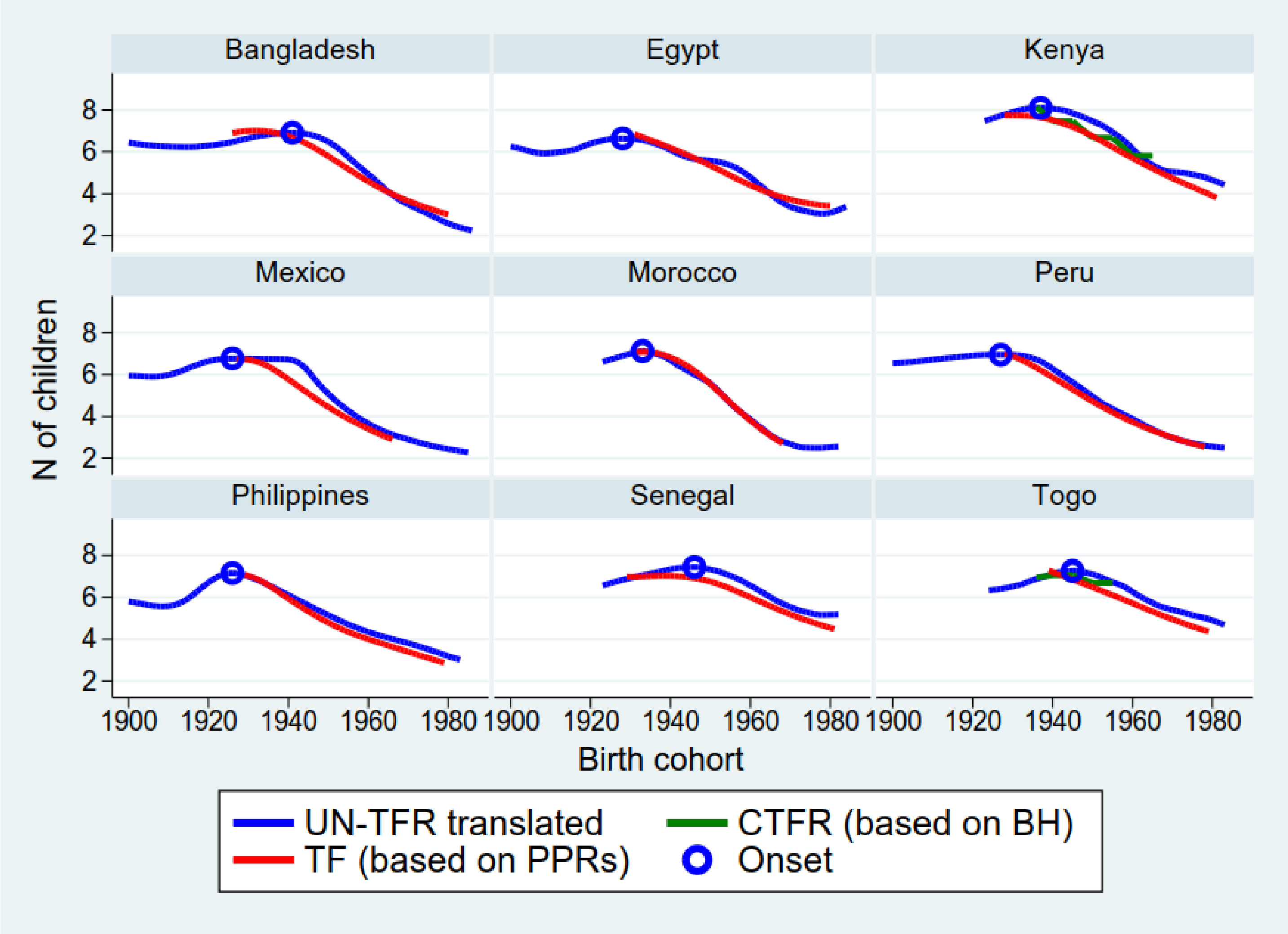
Sources: WHS & DHS, MICS, IPUMS, UN World Urbanization Prospects 2015.
Notes: LA = Latin America, MENA = Middle East and Northern Africa, SSA = sub-Sahara Africa, TF = total fertility

A-Figure 1: Survey-specific estimates and projections of transition ratios from the fifth to the sixth birth (in blue; PPR5->6) and the smoothed trend (in red) in urban populations, cohorts 1926-1982 in selected developing countries.



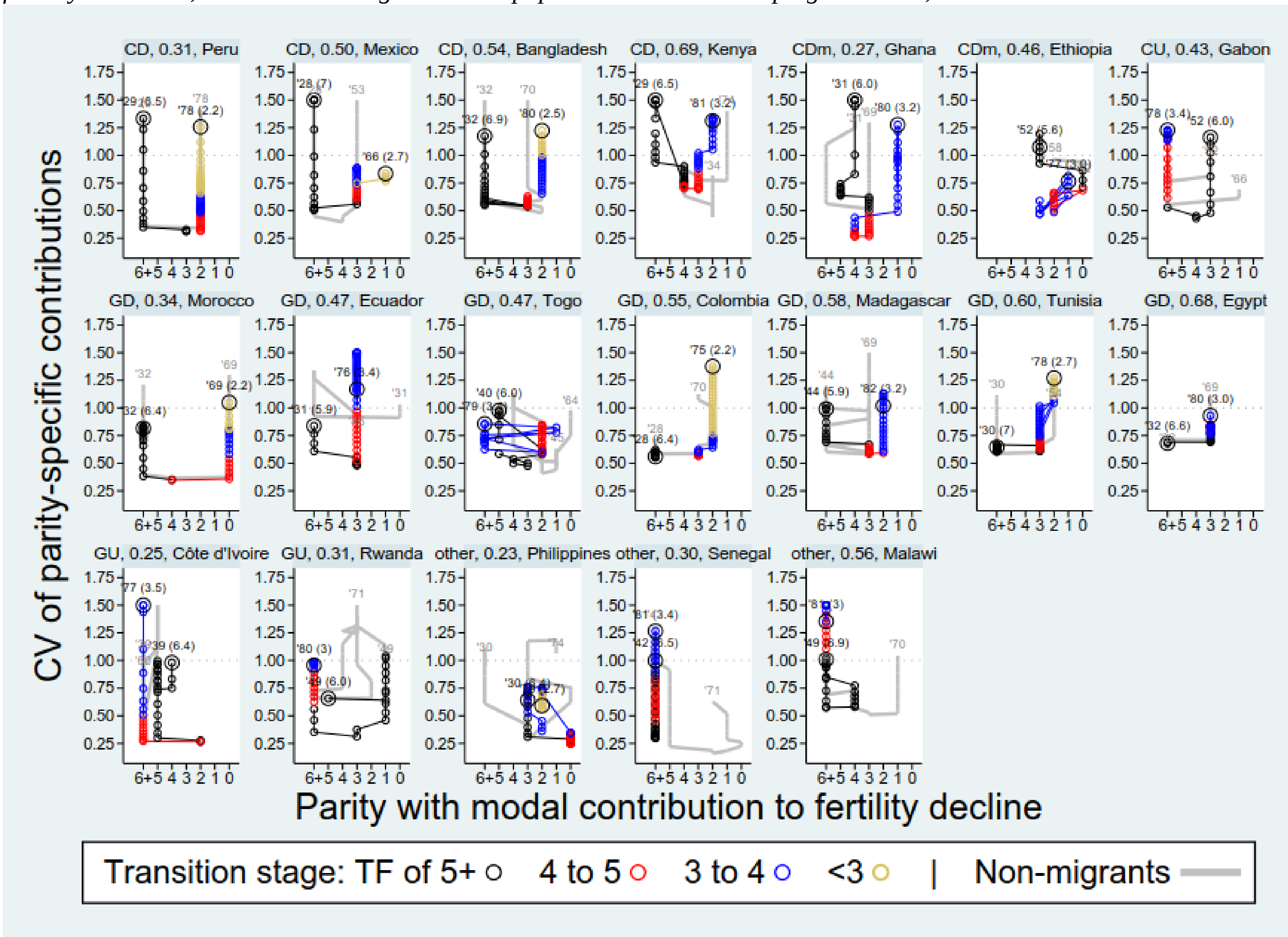
Sources: WHS & DHS, MICS, IPUMS.

A-Figure 2: Three estimates of the national-level total cohort fertility trends, as implied by the chaining of cohort PPRs, by cohort age-specific fertility rates, and by the back-translation of period TFRs (by the mean age at birth), cohorts 1900-1985 in selected developing countries



Sources: WHS & DHS, MICS, IPUMS, United Nations (2017)

A-Figure 3: Direction (x-axis) and generalization (y-axis) of birth limiting behavior across parities over the course of the cohort fertility transition, total and non-migrant urban populations in 19 developing countries, 1926-1982.



Sources: WHS & DHS, MICS, IPUMS.

Notes: the first and last cohort is indicated by a larger dot and indexed with its year of birth and average level of fertility; values next to the country name refer to the trough in the CV of parity-specific contributions to the fertility decline over the entire course of the transition, CV = coefficient of variation, TF = total fertility, CD = early concentration and subsequent downward diffusion of fertility decline by parity, CU = early concentration and upward diffusion, GD = early generalization and downward diffusion, GU = early generalization and upward diffusion