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Investigating the Impact of Region and Living Standards on Fertility Trends: An Analysis of Potential and Counterfactual Outcomes

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Abstract

This study investigates the determinants of fertility in Algeria by analysing the dual influence of spatial location and household living standards. Using data from the Multiple Indicator Cluster Surveys (MICS-6), the research adopts a Potential and Counterfactual Outcomes framework to disentangle the causal effects of geography versus economy. The application of Average Treatment Effects (ATE) and Potential Outcome Means (POmeans) reveals a remarkable equivalence between the "power of place" and the "power of wealth". Spatially, results highlight a persistent North-South gradient, identifying the Southern region as a distinct demographic regime where environmental and cultural factors sustain high fertility rates independent of individual characteristics. Socio-economically, the analysis detects a "wealth threshold", showing that significant fertility declines are contingent upon reaching the middle class, while improvements at the lowest income levels yield negligible changes. These findings challenge the "one-size-fits-all" approach to population policy, emphasizing the need for targeted economic interventions combined with region-specific educational sensitization programs to address the structural inertia of high-fertility zones.

Keywords: Fertility Transition, Spatial Inequality, Treatment Effects, Living Standards, Potential Outcomes, Regional Disparities, Algeria

1. Introduction

The demographic transition in the Global South, particularly in the Middle East and North Africa (MENA), presents a complex mosaic of declining fertility rates accompanied by persistent intra-national disparities. While the region has witnessed a significant aggregate decline in fertility, recent trends suggest a stalling or even a reversal in certain contexts, often driven by economic instability and uneven development (Pourreza et al., 2021). In Algeria, the fertility trajectory has fluctuated significantly, raising questions about the underlying drivers of reproductive behaviour. The debate largely oscillates between economic theories, which posit that rising living standards increase the opportunity cost of childbearing, and socio-cultural perspectives that emphasize the role of norms, education, and spatial location (Ouadah-Bedidi et al., 2012; Sadia Afroze and Robbyn Theresa, 2010; Zarat and Rahal, 2025).

In analysing the determinants of fertility, two primary approaches govern the literature: the monetary approach and the multidimensional asset-based approach. While monetary metrics based on income or expenditure offer quantitative precision, they are often volatile. In contrast, non-monetary indicators, such as the wealth index, provide a more stable and holistic reflection of long-term economic status (Sathar and Kazi, 1987; Schoumaker, 2003; Skirbekk, 2008; Tabutin, 2007). Simultaneously, the mechanisms linking this economic status to fertility are often viewed through the lens of intermediate variables (Davis and Blake, 1956) or broader socio-cultural determinants such as education and urbanization (Schoumaker, 2003; Schoumaker and Tabutin, 2003; Tabutin, 2007; UNICEF, 2024).

However, existing studies often overlook a critical dimension: the “power of place”. Spatial inequality implies that where a woman lives may exert an independent pressure on her reproductive choices, distinct from her individual socio-economic characteristics (Sato, 2007). Despite the abundance of research on fertility in Africa, few studies have applied rigorous causal inference to disentangle the effects of geographic location from those of economic status in the North African context (Chang and Kidman, 2021; Lidstone and Williams, 2006; Morri, 2020).

2. The Aims of the Research

This study aims to address this gap by providing a dual analysis of fertility disparities in Algeria, distinguishing between the spatial effects of regional location and the socio-economic effects of living standards. Unlike traditional regression analyses, this research adopts a Potential and Counterfactual Outcomes framework. This methodological approach allows for the estimation of causal effects, specifically the Average Treatment Effect (ATE) and the Average Treatment Effect on the Treated (ATET), to answer counterfactual questions regarding how fertility changes with spatial or economic mobility (Cattaneo, 2010; Cattaneo et al., 2013; Frölich and Melly, 2010; StataCorp., 2015; Winship and Morgan, 1999).

To achieve this, the study utilizes the household living standard index as a proxy for economic status and the administrative regional decomposition as a proxy for spatial environment. The analysis relies on data from the Multiple Indicator Cluster Survey (MICS-6), focusing exclusively on women of reproductive age (15-49). The exclusion of men from this specific analysis is methodologically grounded in the structure of the MICS data, where detailed reproductive histories and birth chronologies are exclusively collected in the women’s questionnaire. By integrating these advanced econometric tools with a geographical perspective, this study seeks to provide robust evidence to inform population policies that are both socially equitable and regionally targeted.

3. Model and estimation

The model evaluates the impact of multivalued treatments regional decomposition and standard living on women’s fertility rates using a potential outcomes framework, consider $y_i(t)$ denote the potential fertility rate for woman i if she were exposed to treatment level t, in this study, t represents either the Standard of Living (where $t \in \{1,2,3,4,5\}$ from Poorest to Richest) or the Region (where $t \in \{1,2,3,4,5,6,7\}$ representing the distinct region). The observed fertility rate is therefore:

$$y_i = y_i(t_i)$$

where t_i is the actual treatment level (living standard or region) assigned to woman i.

In multivalued-treatment settings (Cattaneo, 2010; Cattaneo et al., 2013; Winship and Morgan, 1999), the individual treatment effect of moving from the reference level 0 (no treatment) to level t is defined as:

$$y_i(t) - y_i(0) \qquad \text{For } \ t \in \{1, \ldots, 5\}.$$

Similar to the binary-treatment case, three parameters are of primary interest: the Average Treatment Effect (ATE), the Potential Outcome Means (POM), and the Average Treatment Effect on the Treated (ATET).

"Average Treatment Effect (ATE)": measures the average impact of giving treatment t instead of no treatment:

$$ATE_t = \mathbb{E}(y_i(t) - y_i(0))$$

"Potential Outcome Mean (POM)": quantifies the average potential outcome for each treatment level:

$$POM_t = \mathbb{E}(y_i(t))$$

"Average Treatment Effect on the Treated (ATET)": represents the expected difference between the potential fertility outcome under treatment level t and the outcome under the baseline level 0, restricted to the subgroup of women observed in treatment level t'. It therefore measures how the treatment t would affect the fertility of those women currently receiving level t'.

$$ATET_{(t',t)} = \mathbb{E}(y_i(t) - y_i(0) \mid t_i = t')$$

The notation for ATET highlights the complexity involved with multivalued treatments. Here, t indicates the potential treatment level being compared to baseline 0, and t' indicates the treatment level actually received by the subgroup.

The estimation relies on Inverse Probability Weighting (IPW) and Efficient Influence Function (EIF) estimators to recover the average potential outcomes (Cattaneo, 2010; Cattaneo et al., 2013). The IPW estimator assigns each observation a weight equal to the inverse of the probability of receiving its observed treatment level, conditional on covariates:

$$\hat{\mu}_j = \frac{1}{n}\sum_{i=1}^{n} \frac{\mathbb{1}(t_i = t)y_i}{\hat{p}_t(X_i)}$$

where:

- $\mathbb{1}(t_i = t)$: is an indicator function,
- $\hat{p}_t(X_i) = P(t_i = t \mid X_i)$: is the estimated generalized propensity score.

The EIF estimator improves upon the IPW approach by adding a correction component that addresses estimation errors in both the propensity score and the conditional mean outcome. This adjustment reduces bias and enhances statistical efficiency. Combined, the IPW and EIF estimators yield robust estimates of the causal effects of both region and living standards on fertility, offering a comprehensive assessment of their socioeconomic and spatial determinants (Cattaneo et al., 2013).

The identification strategy relies on two key assumptions: conditional independence and the no-empty-cell (positivity) assumption.

The conditional independence assumption, also referred to as selection on observables, requires that for every treatment level $t \in \{1, \dots, 5\}$:

$$y_i(t) \perp t_i \mid Xi$$

This assumption states that, conditional on the covariates X_i, the assignment of a woman to a given treatment category is independent of her potential fertility outcomes. In this context, the covariates include socioeconomic, demographic, and health-related characteristics that jointly influence both fertility behaviour and the probability of belonging to a treatment group. This condition is standard in the treatment-effects literature and ensures that the observed differences in fertility across treatment levels can be interpreted as causal, rather than resulting from unobserved confounders (Cattaneo et al., 2013; Frölich and Melly, 2010).

The no-empty-cell assumption (or overlap / positivity condition) requires that for each treatment level:

$$0 < p_t(X_i) = P(t_i = t \mid X_i)$$

This ensures that for every combination of observable characteristics, there exist women in each treatment category. In the context of this study, this assumption is crucial because it allows the model to compare fertility outcomes across different economic or spatial levels for women with similar demographic and socioeconomic profiles.

By satisfying the no-empty-cell condition, the estimation procedures (IPW and EIF) can properly weight observations and recover the distribution of potential fertility outcomes $y_i(t)$ for all women. Without this condition, certain covariate profiles would only appear in specific treatment groups, preventing valid comparisons and leading to biased estimates of the effect of treatment on fertility.

This assumption is directly related to the research question: it guarantees that observed fertility differences across treatment levels reflect the causal influence of region and economic status rather than artifacts of sample composition or the absence of certain covariate-treatment combinations (Cattaneo, 2010; Cattaneo et al., 2013).

4. Datasets

The Multiple Indicator Cluster Surveys (MICS), supported by UNICEF, are critical for obtaining comprehensive and internationally comparable data on various aspects of child and maternal health. In Algeria, these surveys have been conducted at four intervals: MICS-2 in 2000, MICS-3 in 2006, MICS-4 in 2012, and MICS-6 in 2018. The 2018 survey provides extensive data through seven distinct files, covering household information, individual household members, women of reproductive age (15-49), birth histories of ever-married women, caregivers of children under five, caregivers of children aged 5-17, and general mortality rates.

This study specifically utilizes data from MICS-6, focusing on married or previously married women aged 15 to 49. The methodological decision to exclude men and single women is driven by the study's focus on maternal reproductive history, as detailed fertility data in MICS is exclusively collected through the individual questionnaire for eligible women. The data selection process is detailed in Figure 1.

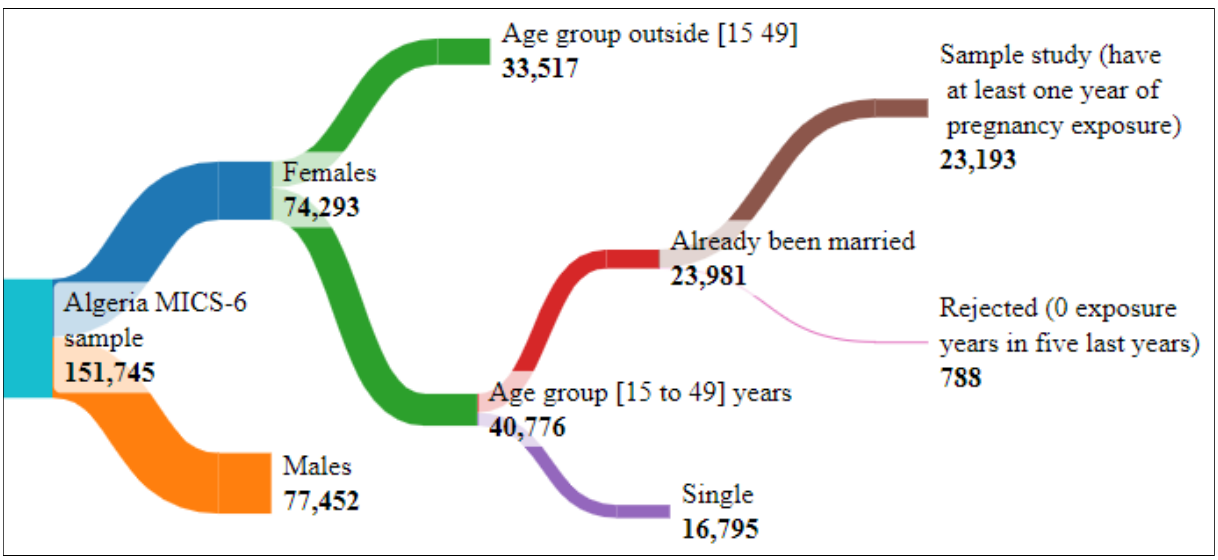

Figure 1. Data selection process. Source: Author's elaboration based on MICS-6 (2018) survey data.

Several qualitative variables in the study were derived from merged databases. Crucially, this includes the subnational decomposition into seven regions, which serves as a primary treatment variable: North-Centre, North-East, North-West, *Hauts-Plateaux-Centre*, *Hauts-Plateaux-East*, Hauts-Plateaux-West, and the South. Other covariates included the area of residence (urban or rural), the presence of at least one chronic disease, and education level categorized into five tiers: Preschool or None, Primary, Medium, Secondary, and Superior. Additionally, a dichotomous variable indicating women's occupation (occupied or not occupied) was included, alongside a quantitative variable representing the age at first marriage. This framework allows for the integration of both the analytical variables of interest and the geographical distribution of women, ensuring that spatial heterogeneity is consistently embedded in the empirical strategy.

Certain variables were transformed through mathematical calculations. This includes the dependent variable representing the Woman Fertility Rate over the last five years. It is calculated by dividing the number of births of each woman in the past five years by the number of years exposed to the risk of pregnancy, as shown in the following formula:

$$WFR = \frac{\textit{Total births in last five years}}{\text{Duration of exposure to conception}}$$

The duration of exposure to conception varies among women based on their marital status and marriage date. Women married for five years or longer are assigned a fixed exposure duration of 5 years. For those married for less than five years, the exposure duration is calculated by subtracting the marriage date from the interview date. Similarly, for women who are widowed, divorced, or separated, the duration is determined by subtracting the date of their change in marital status from the interview date, relative to their marriage date.

The second primary variable of interest is the standard of living, which is divided into five categories: Poorest, Second, Medium, Fourth, and Richest. In MICS surveys, the standard of living is assessed using a wealth index based on asset ownership and housing characteristics. This index is computed through Principal Component Analysis, which combines these factors into a single composite measure. Households are then classified into quintiles based on this index to reflect stratified levels of socio-economic status.

5. Result and considerations

5.1 Spatial Distribution of Living Standards and Fertility: A Descriptive Overview

Figure 2 illustrates the spatial distribution of the Total Fertility Rate (TFR) across Algeria, revealing a pronounced geographic gradient. The map highlights that reproductive intensity is highest in the Southern region, with a TFR reaching 3.42 children per woman. In contrast, the wealthier Northern coastal regions exhibit significantly lower rates, ranging between 2.5 and 2.8. This pattern generally aligns with the expected demographic transition, where the most urbanized and modernized areas demonstrate the lowest birth rates.

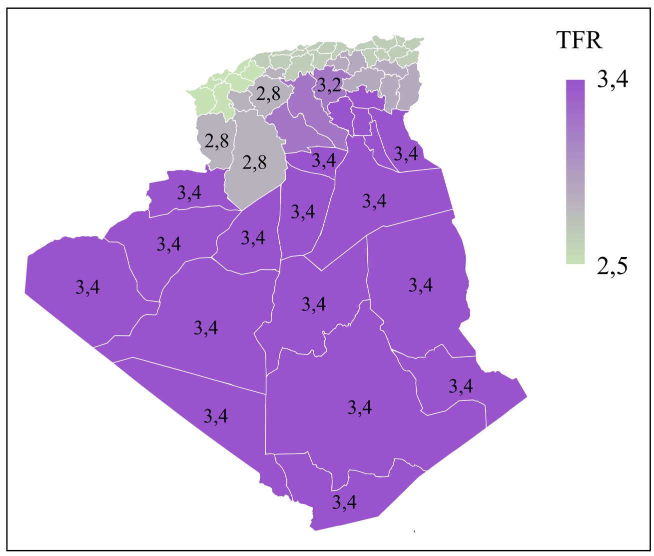

Figure 2. Total fertility rate across Algerian regions. Source: Author's elaboration based on MICS-6 (2018) survey data.

Figure 3 presents the Standard of Living Index, which displays a distinct centre-periphery economic structure. Wealth is heavily concentrated in the North-Centre and North-East (indicated in purple), reflecting higher accumulation of household assets. In sharp contrast, the interior regions, specifically the Western and Central *Hauts plateaux*, emerge as the most economically deprived territories (indicated in red), with indices dropping significantly below the national average. Notably, the Southern region occupies an intermediate economic position, displaying moderate living standards relative to the severe deprivation observed in the *Hauts plateaux*.

A critical anomaly emerges when comparing these two spatial distributions. While the wealthy North correlates with low fertility, the inverse does not hold true for the poorest regions: the *Hauts plateaux* are the most economically deprived, yet they do not exhibit the highest fertility rates. Instead, the highest reproductive intensity is concentrated in the South, despite its better economic standing relative to the *Hauts plateaux*. This discrepancy underscores that economic deprivation alone cannot explain regional fertility patterns. Consequently, the subsequent analysis employs a counterfactual outcome framework to rigorously disentangle the specific "place effect" from the "wealth effect".

5.2 Average treatment-effects ATE

To strictly isolate the impact of environmental and economic factors on fertility, this analysis employs a regression adjustment model that controls for critical sociodemographic determinants. By explicitly accounting for the area of residence (urban/rural), health status (chronic diseases), education level, women's occupation, and age at first marriage, the results filter out the influence of confounding variables. This rigorous approach allows for a dual examination of fertility drivers: first, the spatial influence of regional location, and second, the socio-economic impact of household living standards.

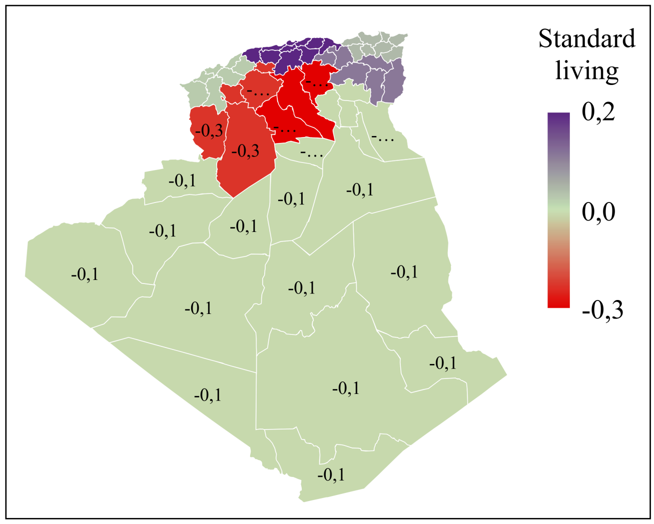

Figure 3. Standard of living index across Algerian regions. Source: Author's elaboration based on MICS-6 (2018) survey data.

The analysis of spatial determinants reveals a profound North-South gradient, confirming that geography acts as a potent independent predictor of reproductive behaviour in Algeria. The summary of results in Table 1 identifies the Southern region (S) as a distinct demographic regime characterized by the country's highest fertility potential.

The most striking finding emerges when contrasting the extremes of the territory. The results indicate that if a woman with identical education, marital status, and health profile were to move from the North-West to the South, her fertility rate would increase by approximately 0.063 points ($p < 0.001$). Ranking as the largest spatial coefficient in the model, this value quantifies a persistent "Southern effect". Even when compared to other northern regions like the North-East and North-Centre, the South maintains a significant fertility surplus of 0.049 and 0.047 points respectively. Analytically, this suggests that the South operates under a specific socio-cultural dynamism where traditional family structures resist the diffusion of low-fertility norms observed in the north. The regional norm itself exerts a pressure that overrides individual characteristics, likely due to a stronger cultural preference for larger families and lower density of modern family planning infrastructure.

From (Region) \ To (Region)	NW	NE	NC	HPW	HPE	HPC	S
NW	0.000	0.014	0.014	0.016	0.020	0.043	0.020
NE	-0.014	0.000	0.000	0.002	0.006	0.029	0.042
NC	-0.014	0.000	0.000	0.002	0.006	0.029	0.047
HPW	-0.016	-0.002	-0.002	0.000	0.004	0.027	0.049
HPE	-0.020	-0.006	-0.006	-0.004	0.000	0.023	0.049
HPC	-0.043	-0.029	-0.029	-0.027	-0.023	0.000	0.063
S	-0.063	-0.049	-0.049	-0.047	-0.043	-0.020	0.000

Table 1. Matrix of Average Treatment Effects (ATE) estimations by regional decomposition.
Source: MICS-6 data, 2018 (Author's processing).

In direct contrast, the North-West (NW) functions as the country's strongest depressive environment for fertility. It acts as a statistical floor, showing significantly lower rates than the interior. For instance, the transition from the *Hauts Plateaux-Centre* (HPC) to the North-West corresponds to a fertility reduction of 0.043 ($p < 0.001$). This identifies the coastal North-West as the most advanced zone in the demographic transition, likely driven by "diffusion effects", greater exposure to globalized norms regarding small family sizes and higher accessibility to health services.

Furthermore, the data reveals a "demographic fracture line" separating the coast from the hinterland. As shown in Table 1, the *Hauts Plateaux Centre* (HPC) behaves far more similarly to the South than to the coast, exhibiting a fertility rate 0.029 points higher than the North-Centre ($p < 0.001$). This indicates that the "coastal effect" of modernization does not penetrate deeply into the central *Hauts plateaux*. Instead, the central interior functions as a transitional reservoir of traditionalism, buffering the deep South from the modernized littoral.

The analysis of living standards (Table 2) reveals that economic mobility influences fertility through a distinct, non-linear threshold mechanism. The results indicate that if a woman with identical background characteristics were to move from the "Poorest" to the "Second" wealth quintile, her fertility rate would decrease by only 0.0096 points, a change that is statistically insignificant ($p = 0.232$). This critical finding implies that a marginal upward shift from absolute poverty produces no measurable change in reproductive behaviour. However, the dynamic shifts fundamentally once the middle-class threshold is crossed. The estimates show that if a woman were to move from the Poorest to the "Medium" class, her fertility rate would significantly drop by 0.0280 points ($p < 0.001$). The impact intensifies with further upward mobility: if a woman were to transition from the Poorest to the "Richest" quintile, her fertility rate would plummet by 0.0688 points ($p < 0.001$). Even within the upper strata, the effect persists; if a woman were to move from the medium class to the Richest, her fertility would further reduce by 0.0408 points ($p < 0.001$).

		To (Standard living)				
		The Poorest	The Second	The Medium	The Fourth	The Richest
From (Standard living)	The Poorest	0.0000	0.0096	0.0280	0.0494	0.0688
	The Second	-0.0096	0.0000	0.0184	0.0398	0.0591
	The Medium	-0.0280	-0.0184	0.0000	0.0214	0.0408
	The Fourth	-0.0494	-0.0398	-0.0214	0.0000	0.0193
	The Richest	-0.0688	-0.0591	-0.0408	-0.0193	0.0000

Table 2. Matrix of Average Treatment Effects (ATE) estimations across living standards.
Source: MICS-6 data, 2018 (Author's processing).

This counterfactual analysis uncovers a "fertility poverty trap" at the bottom of the economic ladder. The fact that moving to the second quintile yields no reduction in fertility suggests that escaping absolute deprivation is not sufficient to alter reproductive strategies. Women in this marginal group likely still face the economic insecurity that incentivizes "child quantity" as a form of social insurance and future labour. They behave identically to the poorest because they have not yet secured the financial stability required to prioritize "child quality", investment in the education and health of fewer children, over family size.

The significant drop observed when moving to the Medium and Richest groups signals that fertility reduction in Algeria is fundamentally driven by opportunity costs. Once a woman secures a middle-class or wealthy status, the cost of maintaining that lifestyle and investing in children's human capital rises, while the time-cost of raising a large family becomes prohibitive compared to professional or economic opportunities. The distinct, steep drop among the Richest confirms that financial autonomy is the strongest lever for fertility control, allowing women to align their family size with modern preferences for smaller households to maintain their socio-economic status.

5.3 Average Treatment Effect on the Treated ATET

To assess the stability of the spatial findings, the Average Treatment Effect on the Treated (ATET) evaluates the fertility differentials conditional on women's actual area of residence. This estimator serves as a validation mechanism, verifying that the identified "Regional Effect" is not an artifact of population averaging but a structural characteristic affecting the exposed populations.

The analysis reveals that the fertility gap is environmentally driven. Specifically, the estimation predicts that if the woman actually residing in the North-West were exposed to the socio-environmental conditions of the South, her fertility rate would surge by 0.0633 points $(p < 0.001)$. This structural pressure is geographically consistent; exposing women from the North-East or North-Centre to the Southern environment would similarly raise her fertility potential by 0.0516 and 0.0526 points respectively $(p < 0.001)$. Furthermore, Table 3 shows that the HPC confirms its status as a high-pressure zone; for women originating from the North-West, residing in this *Hauts plateaux centre* region implies a fertility increase of 0.0408 points $(p < 0.001)$.

From (Region) \ To (Region)	NW	NE	NC	HPW	HPE	HPC	S
NW	0.00000	0.01167	0.01066	0.01586	0.01498	0.04076	0.06331
NE	-0.01167	0.00000	-0.00101	0.00418	0.00330	0.02908	0.05164
NC	-0.01066	0.00101	0.00000	0.00520	0.00431	0.03009	0.05265
HPW	-0.01586	-0.00418	-0.00520	0.00000	-0.00088	0.02490	0.04745
HPE	-0.01498	-0.00330	-0.00431	0.00088	0.00000	0.02578	0.04834
HPC	-0.04346	-0.02905	-0.03040	-0.03004	-0.02413	0.00000	0.01618
S	-0.06331	-0.05164	-0.05265	-0.04745	-0.04834	-0.02255	0.00000

Table 3. Matrix of ATET estimations by regional decomposition. Source: MICS-6 data, 2018 (Author's processing).

These findings support the hypothesis of "Geographical Determinism" in Algerian fertility trends. By isolating the effect on treated populations, the results confirm that "place" acts as an active agent of demographic change. The Southern environment, characterized by specific cultural norms and limited family planning infrastructure, exerts a potent pressure that overrides individual background characteristics. Consequently, the low fertility observed in the North-West is not merely an inherent trait of its residents (selection) but a result of environmental protection; once this protection is counterfactually removed, fertility behaviours align with the traditional patterns of the interior and south.

The standard living ATET results confirm a distinct non-linear response to economic mobility. For the specific subpopulation of women in the "Poorest" quintile, a counterfactual transition to the "Second" quintile yields a statistically insignificant fertility reduction of 0.010 points $(p = 0.164)$. However, substantial upward mobility triggers a sharp decline: if these same women were to achieve "Medium" status, their fertility would significantly drop by 0.033 points $(p < 0.001)$. The effect maximizes with a transition to the "Richest" quintile, predicting a plummet of 0.065 points $(p < 0.001)$. Conversely, the shock of downward mobility is even more profound: Table 4 indicates that if women from the "Richest" group were exposed to the conditions of the "Poorest", their fertility is estimated to surge by 0.075 points $(p < 0.001)$.

These findings reveal a structural "fertility poverty trap". The lack of significant change between the first two quintiles implies that escaping absolute deprivation is insufficient to alter the economic incentives favouring larger families, such as reliance on children for social security. A behavioural shift is only unlocked once the middle-class threshold is crossed, where the opportunity costs of childbearing rise significantly. Furthermore, the massive fertility increase predicted for wealthy women if they were to lose their economic status $(+0.075)$ serves as definitive proof that low fertility is a rational, reversible adaptation to economic opportunity, rather than an immutable cultural or personal trait.

5.4 Potential Outcome Means

While ATE and ATET measured the difference between groups, the Potential Outcome Means (POmeans) estimator provides the absolute expected level of fertility for each category. This analysis answers a fundamental counterfactual question: "What would be the average fertility rate of the entire Algerian women if everyone was assigned to a specific region or standard of living?", The results presented in Table 5 allow us to rank the demographic regimes of the country from highest to lowest.

From (Standard living) \ To (Standard living)	The Poorest	The Second	The Medium	The Fourth	The Richest
The Poorest	0.00000	0.01712	0.04250	0.07151	0.07476
The Second	-0.01005	0.00000	0.02538	0.05439	0.05764
The Medium	-0.03320	-0.02538	0.00000	0.02901	0.03226
The Fourth	-0.05160	-0.05439	-0.02901	0.00000	0.00325
The Richest	-0.06530	-0.05764	-0.03226	-0.00323	0.00000

Table 4. Matrix of ATET estimations across living standards. Source: MICS-6 data, 2018 (Author's processing).

Fertility Rate POmeans	Coefficient	std.err.	z	P > z	[95% conf. interval]	
NW	0.1850	0.0043	42.9	0.000	0.1765	0.1934
NE	0.1813	0.0047	38.6	0.000	0.1721	0.1905
NC	0.1793	0.0048	37.3	0.000	0.1699	0.1887
HPW	0.1791	0.0046	39.3	0.000	0.1702	0.1880
HPE	0.1651	0.0042	38.9	0.000	0.1568	0.1735
HPC	0.2281	0.0048	47.7	0.000	0.2187	0.2375
S	0.2082	0.0049	42.7	0.000	0.1987	0.2178

Table 5. Estimation of POmeans for Fertility Rates by regional decomposition.
Source: MICS-6 data, 2018 (Author's processing).

Fertility Rate POmeans	Coefficient	std.err.	z	P > z	[95% conf. interval]	
The Poorest	0.2135	0.0065	32.97	0.000	0.2008	0.2262
The Second	0.2039	0.0048	42.29	0.000	0.1944	0.2133
The Medium	0.1855	0.0045	41.6	0.000	0.1768	0.1943
The Fourth	0.1641	0.0057	28.8	0.000	0.1529	0.1753
The Richest	0.1448	0.0084	17.29	0.000	0.1283	0.1612

Table 6. Estimation of POmeans for Fertility Rates across standard living.
Source: MICS-6 data, 2018 (Author's processing).

The analysis redraws the demographic map, identifying a distinct "high-fertility belt" in the interior. The HPC and the South exhibit the highest potential fertility rates (0.228 and 0.208 respectively, $p < 0.001$), characterizing them as reservoirs of traditional demographic behaviour. In stark contrast, the Northern coastal regions converge around a significantly lower average (~ 0.180), indicating a stabilized transition to modern family norms. This creates a clear dichotomy between a resistant interior/south and a transitional north.

Regarding living standards, Table 6 reveals a perfectly linear stratification. Potential fertility peaks among the “Poorest” (0.214) and declines systematically with every step up the economic ladder, reaching its nadir among the “Richest” $(0.145, p < 0.001)$. This massive 32% gap between the extremes serves as a definitive validation of the economic theory of fertility. It confirms that in Algeria, economic development acts as the most effective contraceptive; as material security increases, the reproductive model shifts decisively from “quantity” to “quality”.

The empirical evidence presented in this study delineates the demographic landscape of Algeria as being governed by two equipotent forces: regional structuralism and socio-economic transition. The spatial analysis confirms the persistence of a rigid North-South gradient, where the Southern region functions not merely as a geographic location but as a distinct socio-cultural regime that sustains high fertility rates (POmean: 0.208). The robustness of the ATET results demonstrates that this “Southern Effect” is environmental and exogenous; it exerts a structural pressure that overrides individual characteristics, whereas the coastal North-West has effectively consolidated its demographic transition. Parallel to this spatial determinism, the socio-economic analysis reveals a non-linear “wealth threshold”. The data identifies a fertility poverty trap where marginal improvements from absolute deprivation to the second quintile fail to alter reproductive behaviours. A significant fertility decline is contingent upon reaching the middle class, where the opportunity costs of childbearing spur a shift from “quantity” to “quality”, culminating in the lowest fertility rates among the richest stratum (POmean: 0.145). Ultimately, the most profound insight of this study is the remarkable equivalence in the magnitude of these two drivers: the fertility gap generated by geography (North-West vs. South) is statistically identical to the gap generated by class (Poorest vs. Richest). This implies that in contemporary Algeria, regional inequalities in development and cultural norms are as deeply entrenched as economic disparities, creating parallel and equally powerful determinants of reproductive behaviour.

6. Discussion

The spatial analysis uncovers a resilient “Southern Effect”, confirming that geography acts as an independent determinant of fertility in Algeria. The finding that moving a woman counterfactually from the North-West to the South increases her fertility by 0.063 points highlights a structural lag in the demographic transition of the interior. This supports the diffusion of innovation theory, suggesting that the coastal North-West acts as the epicentre for modern low-fertility norms, while the South and Central *Hauts plateaux* function as “reservoirs of resistance” due to conservative social structures and distance from health infrastructure. These results are broadly consistent with Sato’s (2007) economic geography framework, reinforcing our conclusion about the deep disparities between the different regions of northern, *Hauts plateaux* and southern Algeria.

Regarding living standards, the results challenge the assumption of a linear inverse relationship between living standard and fertility. The lack of statistical difference between the “Poorest” and “Second” quintiles $(p = 0.232)$ points to a reproductive “poverty trap”, where marginal economic improvements fail to alter the incentives for larger families. This echoes Schoumaker and Tabutin (2003), who noted that fertility declines in developing contexts are often contingent upon crossing a specific economic threshold. In Algeria, this threshold is the “Medium” class; once households reach this level, the opportunity costs of childbearing rise, triggering a shift from “quantity” to “quality” that culminates in the low fertility rates of the richest stratum, as observed by Skirbekk (2008) on 879 samples from 129 sources and Ouadah-Bedidi et al (2012) among the Maghrebian elite.

Ultimately, the most significant insight is the empirical equivalence between place and status. The magnitude of the fertility gap driven by regional inequality (0.063) is statistically comparable to that driven by extreme wealth inequality (0.068). This finding bridges the gap between economic demography and health geography (Dummer, 2008), suggesting that regional disparities in development have calcified to the point where they mimic class disparities. Consequently, the recent "stalling" of fertility declines in the MENA region (Goujon and Al Zalak, 2018; Kebede et al., 2019; Zarat and Rahal, 2025) may be largely attributed to these persistent sub-national inequalities that national averages fail to capture.

7. Conclusion

This study investigated the determinants of fertility in Algeria by applying a robust Potential Outcomes framework to disentangle the causal effects of spatial location and living standards. The results corroborate well-established demographic theories regarding the inverse relationship between economic status and fertility, while simultaneously revealing that geography acts as an equipotent driver of reproductive behaviour.

The ATE was pivotal in establishing the magnitude of these forces. It demonstrated a remarkable equivalence between the "power of place" and the "power of wealth", showing that the causal increase in fertility associated with moving from the North-West to the South (+0.063) is statistically identical to the increase associated with falling from the Richest to the Poorest wealth quintile (+0.068). This confirms that in the Algerian context, regional inequalities in development and culture are not merely background variables but determinants as powerful as socio-economic stratification.

The ATET provided critical validation of these findings, confirming their structural nature. The analysis indicates that the "Southern Effect" is exogenous; the socio-cultural environment of the South exerts an isomorphic pressure that raises fertility regardless of a woman's individual background. simultaneously, the socio-economic analysis highlighted a non-linear trajectory. As noted in previous research, the decline in fertility is most pronounced at higher income levels. The ATET results exposed a "fertility poverty trap", suggesting that initial improvements in living standards (from Poorest to Second) do not immediately translate into significant fertility reduction; substantial declines are contingent upon crossing the middle-class threshold.

Moreover, POmeans reconstructed the demographic hierarchy of the country. Spatially, it delineated a clear fracture line between the stabilized "coastal regime" of the North and the "high-fertility belt" of the South. Socio-economically, it confirmed the "quantity-quality" trade-off, where the richest women exhibit the lowest fertility potential. In sum, the integration of these three estimators confirms that the fertility transition in Algeria is neither spatially uniform nor socially linear. Consequently, effective population policies must move beyond a "one-size-fits-all" approach, requiring a dual strategy: targeted economic interventions to lift households above the middle-class threshold, combined with region-specific programs to address the unique infrastructural and cultural inertia of the Southern territories.

Finally, the detailed estimation matrices provided in the Appendix offer a comprehensive breakdown of the pairwise comparisons for all regional and socio-economic categories. These supplementary data serve to validate the robustness of the identified gradients and provide a granular statistical foundation for future spatial demographic research in the region.

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Appendix

I. Estimation of ATE relative to the Algeria regions

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux-Centre vs South	-0.0198995	0.0068016	-2.93	0.003	-0.03323	-0.00657
Hauts Plateaux-East vs South	-0.0431509	0.0064068	-6.74	0.000	-0.05571	-0.03059
Hauts Plateaux-West vs South	-0.046804	0.0066701	-7.02	0.000	-0.05988	-0.03373
North-Centre vs South	-0.0488002	0.0067353	-7.25	0.000	-0.062	-0.0356
North-East vs South	-0.0489971	0.006563	-7.47	0.000	-0.06186	-0.03613
North-West vs South	-0.0629746	0.0063668	-9.89	0.000	-0.07545	-0.0505

Table 7. Estimation of ATE relative to the Southern region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux-Centre vs North West	0.0430751	0.0064427	6.69	0.000	0.030448	0.055703
Hauts Plateaux-East vs North West	0.0198237	0.006027	3.29	0.001	0.008011	0.031636
Hauts Plateaux-West vs North West	0.0161706	0.0063048	2.56	0.010	0.003814	0.028528
North-Centre vs North West	0.0141744	0.0063755	2.22	0.026	0.001679	0.02667
North-East vs North West	0.0139775	0.0061949	2.26	0.024	0.001836	0.026119
South vs North West	0.0629746	0.0063668	9.89	0.000	0.050496	0.075453

Table 8. Estimation of ATE relative to the North West region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux-Centre vs North-East	.0290976	.0066408	4.38	0.000	.0160817	.0421134
Hauts Plateaux-East vs North-East	.0058462	.0062348	0.94	0.348	-.0063738	.0180662
Hauts Plateaux-West vs North-East	.0021931	.006507	0.34	0.736	-.0105604	.0149466
North-Centre vs North-East	.0001969	.0065723	0.03	0.976	-.0126845	.0130783
North-West vs North-East	-.0139775	.0061949	-2.26	0.024	-.0261193	-.0018358
South vs North-East	.0489971	.006563	7.47	0.000	.036134	.0618603

Table 9. Estimation of ATE relative to the North East region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux-Centre vs Nord-Centre	.0289007	.0068097	4.24	0.000	.015554	.0422474
Hauts Plateaux-Est vs Nord-Centre	.0056493	.0064155	0.88	0.379	-.0069248	.0182234
Hauts Plateaux-Ouest vs Nord-Centre	.0019962	.0066799	0.30	0.765	-.0110961	.0150886
Nord-Est vs Nord-Centre	-.0001969	.0065723	-0.03	0.976	-.0130783	.0126845
Nord-Ouest vs Nord-Centre	-.0141744	.0063755	-2.22	0.026	-.0266702	-.0016786
Sud vs Nord-Centre	.0488002	.0067353	7.25	0.000	.0355992	.0620012

Table 10. Estimation of ATE relative to the North Centre region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux-Centre vs *Hauts Plateaux*-Ouest	.0269045	.006744	3.99	0.000	.0136865	.0401224
Hauts Plateaux-Est vs *Hauts Plateaux*-Ouest	.0036531	.0063461	0.58	0.565	-.008785	.0160912
Nord-Centre vs *Hauts Plateaux*-Ouest	-.0019962	.0066799	-0.30	0.765	-.0150886	.0110961
Nord-Est vs *Hauts Plateaux*-Ouest	-.0021931	.006507	-0.34	0.736	-.0149466	.0105604
Nord-Ouest vs *Hauts Plateaux*-Ouest	-.0161706	.0063048	-2.56	0.010	-.0285278	-.0038135
Sud vs *Hauts Plateaux*-Ouest	.046804	.0066701	7.02	0.000	.0337308	.0598772

Table 11. Estimation of ATE relative to the Hauts Plateaux West region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux-Est vs *Hauts Plateaux*-Centre	-.0232514	.0064828	-3.59	0.000	-.0359574	-.0105453
Hauts Plateaux West vs *Hauts Plateaux*-Centre	-.0269045	.006744	-3.99	0.000	-.0401224	-.0136865
Nord-Centre vs *Hauts Plateaux*-Centre	-.0289007	.0068097	-4.24	0.000	-.0422474	-.015554
Nord-Est vs *Hauts Plateaux*-Centre	-.0290976	.0066408	-4.38	0.000	-.0421134	-.0160817
Nord-Ouest vs *Hauts Plateaux*-Centre	-.0430751	.0064427	-6.69	0.000	-.0557026	-.0304476
Sud vs *Hauts Plateaux*-Centre	.0198995	.0068016	2.93	0.003	.0065686	.0332305

Table 12. Estimation of ATE relative to the *Hauts Plateaux* Centre region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs *Hauts Plateaux*-Est	.0232514	.0064828	3.59	0.000	.0105453	.0359574
Hauts Plateaux West vs *Hauts Plateaux*-Est	-.0036531	.0063461	-0.58	0.565	-.0160912	.008785
Nord-Centre vs *Hauts Plateaux*-Est	-.0056493	.0064155	-0.88	0.379	-.0182234	.0069248
Nord-Est vs *Hauts Plateaux*-Est	-.0058462	.0062348	-0.94	0.348	-.0180662	.0063738
Nord-Ouest vs *Hauts Plateaux*-Est	-.0198237	.006027	-3.29	0.001	-.0316364	-.008011
Sud vs *Hauts Plateaux*-Est	.0431509	.0064068	6.74	0.000	.0305938	.055708

Table 13. Estimation of ATE relative to the *Hauts Plateaux* East region.

II. Estimation of ATET relative to the Algeria regions

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux East vs Hauts Plateaux Centre	-.024134	.0064818	-3.72	0.000	-.0368381	-.01143
Hauts Plateaux West vs Hauts Plateaux Centre	-.0300351	.007136	-4.21	0.000	-.0440215	-.0160487
North Centre vs Hauts Plateaux Centre	-.0304039	.0071981	-4.22	0.000	-.0445119	-.016296
North East vs Hauts Plateaux Centre	-.029049	.0068202	-4.26	0.000	-.0424164	-.0156815
North West vs Hauts Plateaux Centre	-.0434581	.0067624	-6.43	0.000	-.0567123	-.030204
South vs Hauts Plateaux Centre	.016179	.0071087	2.28	0.023	.0022461	.0301118

Table 14. Estimation of ATET relative to the *Hauts Plateaux* Centre region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs Hauts Plateaux East	.0257815	.006122	4.21	0.000	.0137826	.0377804
Hauts Plateaux West vs Hauts Plateaux East	.0008824	.0063619	0.14	0.890	-.0115867	.0133515
North Centre vs Hauts Plateaux East	-.0043132	.0069902	-0.62	0.537	-.0180136	.0093873
North East vs Hauts Plateaux East	-.0033006	.0068243	-0.48	0.629	-.016676	.0100748
North West vs Hauts Plateaux East	-.0149755	.00623	-2.40	0.016	-.0271861	-.0027648
South vs Hauts Plateaux East	.0483363	.0066131	7.31	0.000	.0353748	.0612977

Table 15. Estimation of ATET relative to the *Hauts Plateaux* East region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs Hauts Plateaux West	.0248991	.0059838	4.16	0.000	.013171	.0366272
Hauts Plateaux East vs Hauts Plateaux West	-.0008824	.0063619	-0.14	0.890	-.0133515	.0115867
North Centre vs Hauts Plateaux West	-.0051956	.0068745	-0.76	0.450	-.0186693	.0082781
North East vs Hauts Plateaux West	-.004183	.0067121	-0.62	0.533	-.0173384	.0089725
North West vs Hauts Plateaux West	-.0158579	.0060805	-2.61	0.009	-.0277755	-.0039402
South vs Hauts Plateaux West	.0474539	.0064803	7.32	0.000	.0347528	.060155

Table 16: Estimation of ATET relative to the *Hauts Plateaux* West region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs North Centre	.0300947	.0066596	4.52	0.000	.0170421	.0431472
Hauts Plateaux East vs North Centre	.0043132	.0069902	0.62	0.537	-.0093873	.0180136
Hauts Plateaux West vs North Centre	.0051956	.0068745	0.76	0.450	-.0082781	.0186693
North East vs North Centre	.0010126	.0073055	0.14	0.890	-.0133059	.0153311
North West vs North Centre	-.0106623	.0067462	-1.58	0.114	-.0238846	.00256
South vs North Centre	.0526494	.0070993	7.42	0.000	.038735	.0665638

Table 17. Estimation of ATET relative to the North Centre region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs North East	.0290821	.0064947	4.48	0.000	.0163526	.0418115
Hauts Plateaux East vs North East	.0033006	.0068243	0.48	0.629	-.0100748	.016676
Hauts Plateaux West vs North East	.004183	.0067121	0.62	0.533	-.0089725	.0173384
North Centre vs North East	-.0010126	.0073055	-0.14	0.890	-.0153311	.0133059
North West vs North East	-.0116749	.0065836	-1.77	0.076	-.0245786	.0012288
South vs North East	.0516368	.006943	7.44	0.000	.0380289	.0652448

Table 18. Estimation of ATET relative to the North East region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs North West	.040757	.0058307	6.99	0.000	.0293291	.0521849
Hauts Plateaux East vs North West	.0149755	.00623	2.40	0.016	.0027648	.0271861
Hauts Plateaux West vs North West	.0158579	.0060805	2.61	0.009	.0039402	.0277755
North Centre vs North West	.0106623	.0067462	1.58	0.114	-.00256	.0238846
North East vs North West	.0116749	.0065836	1.77	0.076	-.0012288	.0245786
South vs North West	.0633117	.0063452	9.98	0.000	.0508753	.0757481

Table 19. Estimation of ATET relative to the North West region.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
Hauts Plateaux Centre vs South	-.0225548	.0062576	-3.60	0.000	-.0348195	-.0102901
Hauts Plateaux East vs South	-.0483363	.0066131	-7.31	0.000	-.0612977	-.0353748
Hauts Plateaux West vs South	-.0474539	.0064803	-7.32	0.000	-.060155	-.0347528
North Centre vs South	-.0526494	.0070993	-7.42	0.000	-.0665638	-.038735
North East vs South	-.0516368	.006943	-7.44	0.000	-.0652448	-.0380289
North West vs South	-.0633117	.0063452	-9.98	0.000	-.0757481	-.0508753

Table 20. Estimation of ATET relative to the South region.

III. Estimation of ATE relative to the living standard

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Medium	.0279922	.0078245	3.58	0.000	.0126564	.0433281
The Second vs The Medium	.0183736	.0065264	2.82	0.005	.0055821	.0311652
The Fourth vs The Medium	-.0214253	.0071974	-2.98	0.003	-.0355319	-.0073187
The Richest vs The Medium	-.0407701	.0094432	-4.32	0.000	-.0592785	-.0222617

Table 21. Estimation of ATE relative to the Medium level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Fourth	.0494175	.0085993	5.75	0.000	.0325632	.0662719
The Second vs The Fourth	.0397989	.0074359	5.35	0.000	.0252248	.0543731
The Medium vs The Fourth	.0214253	.0071974	2.98	0.003	.0073187	.0355319
The Richest vs The Fourth	-.0193448	.0100916	-1.92	0.055	-.039124	.0004344

Table 22. Estimation of ATE relative to the Fourth level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Richest	.0687623	.0105518	6.52	0.000	.0480812	.0894434
The Second vs The Richest	.0591437	.0096305	6.14	0.000	.0402683	.0780191
The Medium vs The Richest	.0407701	.0094432	4.32	0.000	.0222617	.0592785
The Fourth vs The Richest	.0193448	.0100916	1.92	0.055	-.0004344	.039124

Table 23. Estimation of ATE relative to the Richest level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Second	.0096186	.0080485	1.20	0.232	-.0061562	.0253934
The Medium vs The Second	-.0183736	.0065264	-2.82	0.005	-.0311652	-.0055821
The Fourth vs The Second	-.0397989	.0074359	-5.35	0.000	-.0543731	-.0252248
The Richest vs The Second	-.0591437	.0096305	-6.14	0.000	-.0780191	-.0402683

Table 24. Estimation of ATE relative to the Second level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Second vs The Poorest	-.0096186	.0080485	-1.20	0.232	-.0253934	.0061562
The Medium vs The Poorest	-.0279922	.0078245	-3.58	0.000	-.0433281	-.0126564
The Fourth vs The Poorest	-.0494175	.0085993	-5.75	0.000	-.0662719	-.0325632
The Richest vs The Poorest	-.0687623	.0105518	-6.52	0.000	-.0894434	-.0480812

Table 25. Estimation of ATE relative to the Poorest level.

IV. Estimation of ATET relative to the living standard

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Medium	.0424957	.0083536	5.09	0.000	.026123	.0588685
The Second vs The Medium	.0253774	.0094234	2.69	0.007	.0069078	.043847
The Fourth vs The Medium	-.0290121	.0136567	-2.12	0.034	-.0557788	-.0022455
The Richest vs The Medium	-.0322638	.0184423	-1.75	0.080	-.0684101	.0038824

Table 26. Estimation of ATET relative to the Medium level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Fourth	.0715078	.0122364	5.84	0.000	.0475249	.0954908
The Second vs The Fourth	.0543895	.0129703	4.19	0.000	.0289681	.0798109
The Medium vs The Fourth	.0290121	.0136567	2.12	0.034	.0022455	.0557788
The Richest vs The Fourth	-.0032517	.0204664	-0.16	0.874	-.0433652	.036

Table 27. Estimation of ATET relative to the Fourth level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Richest	.0747595	.0174133	4.29	0.000	.0406301	.108889
The Second vs The Richest	.0576412	.0179372	3.21	0.001	.022485	.0927975
The Medium vs The Richest	.0322638	.0184423	1.75	0.080	-.0038824	.0684101
The Fourth vs The Richest	.0032517	.0204664	0.16	0.874	-.0368618	

Table 28. Estimation of ATET relative to the Richest level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Poorest vs The Second	.0171183	.0072008	2.38	0.017	.0030051	.0312315
The Medium vs The Second	-.0253774	.0094234	-2.69	0.007	-.043847	-.0069078
The Fourth vs The Second	-.0543895	.0129703	-4.19	0.000	-.0798109	-.0289681
The Richest vs The Second	-.0576412	.0179372	-3.21	0.001	-.0927975	-.02248

Table 29. Estimation of ATET relative to the Second level.

Fertility Rate	Coefficient	std. err.	z	P>|z|	[95% conf. interval]	
The Second vs The Poorest	-.0100461	.0072122	-1.39	0.164	-.0241818	.0040897
The Medium vs The Poorest	-.0332025	.0072267	-4.59	0.000	-.0473665	-.0190385
The Fourth vs The Poorest	-.0516013	.0088226	-5.85	0.000	-.0688934	-.0343093
The Richest vs The Poorest	-.065299	.0117336	-5.57	0.000	-.0882964	-.0423016

Table 30. Estimation of ATET relative to the Poorest level.