Fertility Behavior in Azerbaijan: On the Demographic-Economic Paradox

by

Maximilian Salvador Stiefel

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Committee in charge:
Dr. Stuart Sweeney, Chair
Dr. Susan Cassels
Dr. Frank Davenport

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The dissertation of Maximilian Salvador Stiefel is approved:

Chair Date

Date

Date

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Abstract

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Life history theory proposes that individuals increase fertility when able to generate more resources per unit of energy. However, modern, industrialized societies typically exhibit a negative wealth-fertility relationship as hypothesized by demographic transition theory. This mismatch between evolutionary and demographic theories, termed the demographic-economic paradox, is known as the 'central theoretical problem in sociobiology.' This study contributes to the demographic-economic paradox literature by analyzing Demographic and Health Survey data from 2005 in Azerbaijan. I seek to answer two primary questions: (1) How does wealth affect lifetime reproductive success among post-reproductive women? and (2) Do individuals in market integrated societies exhibit increased preferences towards socioeconomic success over fertility? I use multilevel modeling to capture the variability among both individuals and sampling clusters. To model the relationship in (1) I took Lifetime Reproductive Success (LRS) as count data with a Poisson error structure.

For (2) I looked at how educational attainment affects the risk of birth at a given age conditional on no births before that age using a discrete time hazard model. I find that LRS is negatively correlated with wealth and significantly lower in more urban areas. Higher educated women delay fertility longer, and urban women tend to delay fertility longer holding educational attainment constant. This analysis shows that the wealthier tend to have lower lifetime reproductive success, and that the more market integrated preference socioeconomic status seeking over fitness maximization, at least in early life stages.

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Glossary

Acronym	Term
LRS	Lifetime Reproductive Success
AFB	Age at First Birth
TFR	Total Fertility Rate
DHS	Demographic and Health Survey
DT	Demographic Transition
Q-Q Tradeoff	Quantity-Quality Tradeoff
DEP	Demographic-Economic Paradox

Chapter 1

Background

1.1 Introduction

Human behavior and physiology have evolved over time to maximize fitness, usually understood as reproductive success. Until recently, fitness maximization depended upon a delicate allocation of energy over the life course to increase offspring quantity and survival chances. This energy either translated into embodied (contained within the individual, e.g., strength, knowledge, etc...) or extra-somatic resources (those beyond the person, e.g., wealth, status, etc) (Low, Simon, and Anderson, 2002; Kaplan et al., 2002; Low, 2013). When able to generate more resources per unit of energy, evolutionary sciences assumed that individuals would increase their fertility. This is the central focus of *life history theory*, and the preeminent way in which scientists have thought about the human adaptive suite in pre-modern societies (Low, Simon, and Anderson, 2002; Hopcroft, 2006; Skirbekk, 2008).

In the modern era, however, we observe a contradictory pattern regarding wealth accumulation and fertility. The "demographic-economic paradox," sometimes termed the central theoretical problem in sociobiology, has left evolutionists unclear as to the validity of the classic wealth-fertility relationship. Modern societies instead exhibit a *negative* wealth-fertility relationship (Low, Simon, and Anderson, 2002; Perusse, 1993; Hill and Kaplan, 1999. Although this appears at odds with the relationship evolutionists have hypothesized with life history theory, it has been accepted as normal in demographic transition theory for over a century (Bongaarts, 1993; Leslie and Winterhalder, 2002; Shenk, 2009). Demographers posit fertility to decline as economic development generates greater wealth.

Many studies have attempted to better explain the empirics in light of these differing theories (Kaplan, 1996; Mace, 2008; Lawson and Mace, 2010). However, there appears to be meager consensus surrounding the paradox, specifically under what circumstances either demographic transition or life history theory most effectively and efficiently explain fertility levels. Perhaps the paradox is exactly that – a phenomenon not easily explained using a coherent theory.

The last statement is likely not the case, but instead reflects limitations to data availability and existing theoretical integration. There is a paucity of data across a typology of societies (from hunter-gatherer to post-industrial), economic systems (command, market, etc...), and dimensions of age and generation. Theoretical integration has yet to bring together previously surreptitious amalgams such as life history and demographic transition theory, although attempts have been made. Evolutionists ought to continue contributing to a more integrated framework that combines approaches from economics and sociology, among other disciplines. This will lead to a more holistic and functional bedrock in our contemporary attempts at understanding human behavior, particularly around fertility.

1.2 Motivation and Purpose

The present study seeks to serve as a link between the social and evolutionary sciences. In it I explore the classic wealth-fertility relationship using survey data from Azerbaijan. The two analyses conducted, one on lifetime reproductive success and another on age at first birth, attempt to decipher the relationship by looking across an urban-rural gradient. I aim to explore one question with each analysis:

1. How does wealth affect lifetime reproductive success among post-reproductive women?
2. Do individuals in market integrated societies exhibit increased preferences towards socioeconomic success over fertility?

In a country like Azerbaijan, which exhibits a massive discrepancy in levels of development and modernization across rural to urban populations (Habibov and Fan, 2007; Habibov, 2010; Pomfret, 2011), there is a great deal of room to explore how fertility varies between socioeconomic positions. I hypothesize that for *Question 1:* The wealthier tend to have lower lifetime reproductive success (LRS), and for *Question 2:* More market integrated, i.e., urban, areas tend to exhibit later age at first birth (AFB), suggesting preferences towards socioeconomic success over fertility. Since Azerbaijan recently experienced a transition from a command to market-based economy (Rasizade, 2003), this discrepancy can be seen as a degree of transition with which we can answer these questions. This insight will help us empirically understand the wealth-fertility relationship, and in which ways human behavior adapts to changing environments.

The approach is based off an article by Alexandra Alvergne and Virpi Lummaa, at

Oxford University and the University of Sheffield respectively, titled, "Ecological variation in wealth–fertility relationships in Mongolia: the 'central theoretical problem of sociobiology' not a problem after all?". Alvergne and Lummaa (2014) explore whether there is a demographic-economic paradox, using Mongolia as the case study, and how market integration plays a role in fertility decisions. The authors find that the paradox is not as clear cut as we might have thought. Within regions, they find that there is a positive wealth-fertility relationship. Between regions, however, the relationship is negative. This means that, say within a city, the wealthier tend to have higher fertility, whereas when comparing between a city and a nearby rural village, the wealthier tend to have fewer children.

Alvergne and Lummaa's study is not abstracted from the dynamic socio-economic dimensions that exist in modern societies. It is likely that rural households tend to favor child quantity as mortality rates are higher and children are a greater within-household asset (Becker and Tomes, 1976; Shenk, 2009). Therefore the rural context for these findings does not seem surprising. It is the finding that even in urban areas, where we usually assume fertility preferences drive towards child *quality*, there is the same positive wealth-fertility relationship. Clearly, additional studies in a similar vein are necessary.

The present study explores the same relationships using data from the 2006 Demographic and Health Survey (DHS). Azerbaijan shares several similar characteristics with Mongolia. Both are Central Asian nation-states previously under Soviet control, albeit in different forms. Mongolia remained a Soviet satellite state while Azerbaijan was fully incorporated into the USSR as a Soviet Socialist Republic. Azerbaijan sits in the caucuses on the Caspian Sea just north of Iran, east of Turkey, and south of Russia. Religious differences do exist between the two countries–Azerbaijan is overwhelmingly Muslim whereas Mongolia has a slight Buddhist majority. The Azeri population is far more sedentary than the Mongolian, as many Mongols remain nomadic herders. The study populations are taken from around the same years, Azerbaijan 2006 and Mongolia 2003, using DHS and Reproductive Health Survey, respectively.

1.3 Study Context

The Republic of Azerbaijan, a Eurasian country saddled in the southern Caucuses, has experienced many transformative events in recent history. These include transitioning from a centrally planned to market economy, a bloody ethnic conflict in the Nagorno-Karabakh region, and declining economic cooperation with other republics of the former Soviet Union (Habibov, 2010). More influential and remarkable for the country's development is the most recent oil boom. Following a series of agreements to develop oil fields in the Caspian Sea and construct transnational pipelines, Azerbaijan became fully able to export its oil resources to the global market. With this the Azerbaijani economy has grown exponentially in the past decade, ranking it as the highest annual growth rate in recorded human history.

Azerbaijan was a major oil-producing region for the Soviet Union throughout the 1900s (Pomfret, 2011). The initial socioeconomic transition out of the USSR began in 1985 for Azerbaijan. This period was followed by a prolonged economic crisis until the late 90s (Habibov, 2010). The crisis was a result of transition and also conflict in the Nagorno-Karabakh region. A six-year war over the region engulfed Azerbaijan from 1988 to 1994, after which a truce was established. Tensions between Azerbaijan and the semi-autonomous ethnic Armenian governed region remain high. The conflict is embroiled in power politics of the region. Azerbaijan's tenuous relationship with the West, Armenia's steady alliance with Russia, and a deluge of energy resources continues to complicate the already heated situation. Unlike many other post-Soviet states, which recently assessed the breakup as harmful to their wellbeing, Azerbaijanis found the breakup to be beneficial (Pizzi, 2013). Likely due to oil wealth, Azerbaijan is navigating the 21st century with more clout and autonomy than the previous Soviet era.

Although scarce natural resource endowments may provide fast, short-term growth, they do not guarantee prolonged growth compelled by competitive export industries. Many adjustments are necessary before and after the oil-rich period, which could have serious implications for socio-economic conditions in Azerbaijan (Winbergen and Budina, 2011). The current situation in Azerbaijan can be called a "stable trap," wherein the economy lacks diversification, has a rural labor surplus, increased public sector employment, and a predatory political state. The domestic situation is also influenced by the amount of oil revenues, which are highly dependent upon international oil prices.

Economic inequality is quite high in Azerbaijan. A large share of this wealth came from oil-export and land privatization (Rasizade, 2003). As of 2007 the Gini coefficient has increased since the disintegration of the Soviet Union (Lear, 2007). Wealthier, more urban, and more educated individuals experience greater health across the country (Harhay, Harhay, and Nair, 2013). Wage effects on household income are highest in urban areas, particularly in Baku (Afandi and Pellenyi, 2007). Even so, from 1995-2002 income distribution was not a hindrance to successful and sustained economic growth (Habibov, 2010).

However, a weak, economically significant relationship exists between growth and poverty reduction in Azerbaijan (Afandi and Pellenyi, 2007).

Salaries of many middle class residents have not increased concurrently with GDP. Baku is transforming through a series of world-class construction projects spearheaded by international architects and designers. Many who do not have the privilege of sharing in the wealth are facing tough decisions about steps moving forward (Erickson, 2011), while taxes are increasing on incomes and many commodities (Economist(a), 2015).

Social assistance in Azerbaijan does not optimally target low-income individuals. There are three primary reasons: many of the poor are not covered by social assistance programs; an inequitable distribution of social assistance benefitting wealthier quintiles; and even for transfers that the poor do receive, most often these transfers are not sufficient to lift them out of poverty (Habibov and Fan, 2007). Social welfare spending has not increased concurrent to GDP growth or increased income from oil revenues (Lear, 2007). For example, GDP expenditure on healthcare is at .9% from the period 1998-2007, which is the lowest among the Commonwealth of Independent States members and Eastern Europe (Habibov and Fan, 2011).

World Bank estimated that poverty rates declined from 72 percent to 49 percent from 1995 to 2001 (Habibov, 2010). Most of the poverty rate decline from 2004 to 2009 is due to oil boom effects on the labor market and not from effective government spending on social programs (Pomfret, 2011). During 2001-2006 public spending volatility was only 50 percent the volatility of oil revenues (Winbergen and Budina, 2011). Social spending commitments have been guaranteed to stay consistent despite a recent manat devaluation, yet there are no assurances of transfers to account for relative decreases in household incomes. There is still uncertainty around increases in social transfers and pensions as a way to mitigate the negative domestic effects of currency deflation (Economist(b), 2015). Despite the numerous benefits from growth, oil wealth has subjected Azerbaijan to high inflation, geopolitical vulnerability, and a lack of economic diversity. Furthermore, progress in coping with these disadvantages is inhibited by high rates of government corruption and economic inequality, financial underdevelopment, and lacking social assistance.

1.4 A Note on Market Integration

Amid rapid economic growth from oil resources, the fertility level of Azerbaijan increased from 1.8 to a high of 2.4 over a nine-year period from 2002 to 2011 after decades of decline, shown in Figure A.1. This raises the question over whether the increased fertility level is the preferred level in Azerbaijan, and whether it only decreased because of the collapse of the Soviet Union. It would seem, based on increasing fertility along with economic growth, that evolutionary theory explains this trend. However, it is not so simple. The research by Alvergne and Lummaa (2014) in Mongolia, illustrated in Figure A.2, found that increasing wealth within regions leads to higher fertility. Between regions, say urban and rural areas, higher wealth correlates to lower fertility outcomes. During the period mentioned, Azerbaijan saw a 20 percent urban population increase, mostly fueled by low-skilled, low-wage earning laborers seeking employment in petro-chemical industries. We would expect to see decreasing fertility as the poor-to-rich ratio of the population increases, shown in Figure A.3. Even from this brief discussion, it's clear that there is no straightforward theory or distal determinant that easily explains shifting fertility levels.

The demographic transition may not necessarily require that countries experience high levels of economic growth (Bjorvatn and Farzanegan, 2013). Especially in the modern, globalized era, there are instances in which countries go through a demographic transition simply based on social learning from external sources. Especially in the Soviet case, there was a centrally planned and controlled system that extended its social preferences upon far-reaching peoples lacking the same level of economic development as the most important centers of the Soviet empire.

One important effect from market integration is that wealth and status become decoupled. In centralized, distributive economies, these two characteristics are more synonymous because of prescribed norms about economic inequality. However, in a transition or post-transition economy, wealth and status should have differential impacts on fertility. If we assume educational capital drives reproductive strategy, Colleran et al. (2015) propose that, "educational capital should moderate how wealth influences fertility." This would of course depend on how market oriented the community is.

Colleran et al. (2015) find that educational capital and market integration negatively correlate with fertility while farming and non-farming wealth positively associate, and educational capital is the most significant. The top quintile doesn't show a significantly different age at first birth. In a market economy, there appears to be a reemphasis on embodied capital (resources contained within an individual), primarily because of the educational and social capital necessary to be successful in modern society. Higher educated individuals tend to have fewer children In a mid-transition context among the wealthy, implying different fitness strategies even in the same social strata. The following quote directly addresses this:

> "First, if wealth and status become decoupled during market integration, then (i) they should have different effects on fertility. If reproductive stratification is driven by differences in educational capital, then (ii) educational capital should moderate how wealth influences fertility. This moderating effect should itself depend on how market-oriented the community is, and since convergence on low fertility is already underway in more highly educated communities, we expect (iii) reproductive strategies to vary more where farming remains a viable alternative to the labour market. Then, if converging reproductive strategies drive reductions in wealth inequality, (iv) fertility should vary less and (v) average fertility should be lower in more equal communities. Finally, if community-level inequalities reliably reproduce macro-level patterns, then (vi) wealthier, more educated and market-integrated communities should be less unequal and (vii) communities with more equal distributions of market integration and wealth should have higher educational capital." Colleran et al., 2015, Page 2

Chapter 2

Literature Review

2.1 Evolutionary Theory

Evolutionary theory, at its root, seeks to explain the *ultimate* function of a trait as it has evolved over to time, thus allowing any species to succeed. Therefore the most salient question here would be: How does a given trait allow a species to maximize fitness? Evolutionists also look for explanations surrounding the mechanisms through which a trait achieves success. Yet, not all traits are absolutely successful. Therefore, evolutionists look for the degree to which behavior adaptively adjusts to ecological conditions (Smith, Mulder, and Hill, 2001).

Evolutionary advance is typically understood as an improvement in general organization (Huxley, 1955). This could be within an organismal system, i.e., nervous or humoral, or it could be among a species system, i.e., institutions, ideas, and technology. Humans have been effective in not only advancing the latter through pure invention and innovation, but also at disseminating these organizational tools. The other main type of evolution is diversification, the increase in variety of successful trait configurations.

Human behavior is inevitably a product of evolution (Sear, 2015). When thinking about behavior in this way, there are three important points to keep in mind: traits are heritable, there is variation in traits, and variation leads to differential reproductive success within a population. Evolutionists tend to call reproductive success "inclusive fitness." This implies that there are other types of fitness that reproductive success takes into account. To be reproductively successful, an individual must also match with a good mate, sustain good health, and achieve an acceptable social status.

Two dominant perspectives exist in the evolutionary sciences, one in which humans are "adaptation executers" and another in which humans choose optimal outcomes based on a variety of choices. Humans as adaptation executers is a difficult proposition, primarily because of critiques pointing out that we confuse proximate motivation with evolutionary mechanism. For the former, the existence of distinct modules is at odds with co-opting existing evolved traits to solve novel adaptive problems (Smith, Mulder, and Hill, 2001). Essentially, what these perspectives ask is whether humans achieve their agenda by adapting traits to their environment or utilize any number of available options.

To the extent that evolved traits affect human behavior, there are both genetic and environmental determinants (Courgeau et al., 2014). Single nucleotide polymorphisms (SNPs), the genetic variation of an individual, lead to the phenotypic variety observed in human populations. SNPs have a number of alleles, or available variation at a specific point on the genome, that allow for a set of genetically determined outcomes. However, genetics are not ultimately decisive for many traits. For example, it has been found that parent's income is a better predictor of child's IQ than are genetics (Black et al., 2015). Even so, it is important for us to understand there to be a genetic component in behavioral traits and how this component contributes to behavioral variance within the population. Environmental determinants include the physical situation and the socio-cultural setting, among others. Though we may be able to infer genetic influence from the environment through new methods developed in epigenetics, culture is not as easily probed.

Since the onset of sedentary societies, much evolution has been cultural. We can look at culture as both self-operating and self-reproducing, and ask questions of it based on its function and structure. Cultural evolution occurs in nearly all species. "Niche construction," a term used by cultural evolutionists, is the idea that humans, instead of inhabiting, construct their own ecological niche. This is usually achieved by changing the surrounding environment. Niche construction then leads to new adaptations. Yet, we must bring the conversation back to the role of evolution in our attempt to scientifically study culture. This demands that we attempt to describe and explain cultural systems as a, "product of the past and agent for the future" (Huxley, 1955).

There is no consensus scientific convention for studying the effect of culture on our psychology or physiology, nor vice versa. Instead we must think of culture as a complex force with many interacting levels, from educational capital to knowledge systems. It would be to our disadvantage to simply understand demographic patterns and processes as solely guided by a single theory. Rather, it is in the idiosyncrasies of human nature that we begin to explain social complexity.

Processes other than natural selection lead to evolution. Our environment sets parameters for human evolution guided by genetic advance and diversification. Environmental constraints prevent the ideal adaptation from arising, adaptations become maladaptive because of an environmental shift, and gene frequencies change in populations simply by chance, which is called "genetic drift." Although evolution may not be the most practical way for individuals to adapt behavior for their or society's benefit–social learning can be used to enhance or speed up this process–it is nonetheless integral (Sear, 2015). Smith, Mulder, and Hill (2001) provide some broad conclusions about adaptive strategies:

> "1) All adaptations are solutions to recurrent adaptive problems in the remote past, 2) a well formed description of an adaptation must consist solely of words for things, events relations, and so forth. 3) There is a gap between EEA and the present, which creates mismatches and compromises the effectiveness of human adaptations. 4) Given 1 and 3, there may no longer be an association between reproductive success differentials and the proper functioning of psychological adaptations, which means that 5) measures of current fitness are irrelevant to determining the adaptive significance of human behavior."

2.2 Life History Theory

Life history theory, the main theoretical framework of human evolutionary ecology, concerns the allocation of energy over a life course. Specifically, it concerns how humans allocate energy between our most important functions: survival, reproduction, and growth. Life history theory is based on the principle of allocation, which asserts that an individual may only use a unit of energy for one purpose. This forces tradeoffs among the aforementioned functions.

There is a growing importance in social, especially intergenerational, transfers within the literature on evolution of life history patterns. Individuals receive energy from others, leading to a "pooled energy budget" (Sear, 2015). Turke (1989) also referred to this as an extended kinship network dispersing the cost of childrearing. This allows individuals to have a higher total energy allotment than would have otherwise been possible. We can think of unions and other social institutions as additional ways in which we increase our energy availability. This has oft been discussed by economists relating to union formation as a way to achieve more of what we want through a join utility function (Becker, 1981).

However, during modernization, extended kinship networks tend to disintegrate due to high levels of mobility, socio-cultural deemphasis on family, etc... Although social institutions, such as state-sponsored childcare, make up for part of this disintegration, there is likely a diminishing effect on child quantity. The costs of bearing children concentrates on parents instead of dispersing throughout the community (Turke, 1989).

2.3 Fertility Theories

Many disciplines have dedicated much literature to the study of fertility, most notably economics, demography, and evolutionary science. There are two main theoretical frameworks: *the quantity-quality tradeoff* and *fitness maximization*. Both have been briefly discussed previously. This section expands upon and clarifies these two approaches.

As noted earlier, the human adaptive suite of traits seeks to maximize *inclusive* fitness, or reproductive success. Generally, we consider reproductive success as the number of offspring raised to reproductive age, and potentially include additional generations depending on the depth and purpose of applying the concept. From life history theory we know that humans only have a certain amount of energy, which can be enlarged in a pooled energy budget context. Furthermore, humans have adapted to maximize fitness based on their environment (Bavel, 2006). Therefore, fitness maximization occurs when energy is optimally allocated to ensure survival, growth, and reproduction.

Economists and demographers approach fertility slightly differently. Changes in human fertility are mediated through the supply of and demand for children along with the costs of fertility regulation. Dumont, a famous french demographer, was one of the first to think about fertility decisions in this way, and specifically the maximization of reproductive fitness. Individuals may, instead of seeking to have as many surviving offspring as possible, limit their fertility in order to invest more resources in both themselves and their children. This has become known as the quantity-quality tradeoff.

The Q-Q tradeoff, as its known, posits that households either choose to invest in child quality, i.e., education, or in child quantity, i.e., the amount of children. Many articles published in influential economics and demography journals attempt to model this decision under various constraints (see Becker and Tomes (1976) for an early attempt). To date, attempts at standardizing fertility behavior are numerous. Taking a simple dichotomy, the literature addresses explicit and implicit strategies. Explicit strategies are those employed by individuals to directly advantage themselves. These include children as an asset from which parents benefit earlier in the life course, such as on a farm, and children as an investment that requires early life course inputs and delivers returns later in life when parents are less able to care for themselves.

Children as an investment has been thoroughly researched. It's also important to provide the socio-cultural background as to why this has become more prevalent in modern society. We've seen with the creation of childhood as a concept (Fass, 2015) alongside the development of the welfare state and leisure as a commodity. Following that, society became much more child-oriented wherein a parent's main investment over life is typically their child (Aries, 1965). Furthermore, we've seen a change in how people access incentives and in the shear number of socioeconomic opportunities for individuals within a society. This change has led people to prefer later ages at first birth and fewer children.

Implicit strategies have to do with households mediating their fertility to achieve *preferred* LRS. For example, Shenk (2009) studied the role of risk in child quantity decisions. The greater the risk (understood as the external mortality rate), the more families would positively compensate, i.e., have more children than they would have preferred as a hedge against the potential loss of life risk. Negative compensation would occur if households were less uncertain (lower risk) about the fate of their children. However, if preferred LRS was a function of economic wellbeing, increased *economic* uncertainty might lead to negative compensation.

Beyond the basics of fitness maximization and the Q-Q tradeoff, one evolutionary reason why individuals limit their fertility despite perceived consequences for maximizing reproductive success stems from two assumptions outlined by Bavel (2006): 1) humans have an evolved motive disposition to seek higher social status, and 2) society has evolved to advantage those with fewer children based on the high contemporary input costs to childrearing. The first assumption should be clarified, in that an "evolved motive disposition" is an adaptation common to most people. This specific adaptation seeks to increase personal and intergenerational social mobility through higher social status attainment. People tend to gauge their success relative to those around them, thus incentivizing them to increase their own status if they see it as a viable option (MacDonald, 1999).

Bridging off of this idea leads us to the rationale for the demographic transition. Taking insight from both evolutionary and economic theories, we see that lifetime fertility depends on optimal per child investment, optimal inter-birth intervals, and adult mortality schedules (Low, Simon, and Anderson, 2002). Instead of seeking a purely biological reason why those in wealthier societies reduced their fertility, it may in fact be a product of socially learned behavior from higher status individuals. As mentioned, humans seek to achieve higher status and compare ourselves to those of higher status. Limiting fertility as an adaptation can be socially beneficial. Yet, many assert this strategy as genetically maladaptive since it reduces our chance at disseminating genetic material (Shenk, 2009). Since reproductive strategies are socially learned, it would then be the case that certain groups do not adopt the behavior of higher status individuals. The below quote explains two basic concepts intrinsic to social learning:

> "When humans construct their environment and adapt through social learning, there are two forms of bias regarding the learning process. Content biases indicate that what we learn is not random, and transmission biases indicate how we learn is not random. Common transmission biases are considered to be (1) prestige bias, which makes us more likely to learn from prestigious or high-status individuals, and (2) conformity biases, which makes us likely to copy the most common behavior." Sear, 2015, Page S48

Disparate reproductive strategies as a product of social learning bias would be a beneficial process, as households select the most salient and advantageous reproductive strategy. There is, however, one issue with differing reproductive strategies in modern societies. Lower status individuals who *do* adjust their fertility because of social learning and not for their benefit may be disenfranchised. This could be one cause of economic inequality later on in the demographic transition (Colleran et al., 2015). There is also a fertility trap, in that women who lack agency or resources to properly manage fertility outcomes are further disenfranchised in the labor market.

Our evolved motive disposition to seek a higher status may be at odds with a drive to maximize reproductive success, in that larger family sizes in most modern societies are not just unnecessary but a detriment to increasing both wealth and status. Women who have later AFB and fewer children may employ a reproductive strategy with higher assurance of genetic propagation into more generations and higher status for their lineage (Low, Simon, and Anderson, 2002). In a wage-labor economy, we see that returns to child investment do not diminish until very high levels. This means that child quality would increase. Based on life history theory we would then see a decrease in child quantity (Shenk, 2009). Perceived wealth trajectory, social wellbeing, and comparative wealth may play an important role in fertility/mortality outcomes.

Although adaptive strategies to maximizing fitness may be localized, in that different groups or geographies prefer certain strategies, there ought to be a general theory and model that determines which strategy a household chooses (Smith, Mulder, and Hill, 2001). Previous explanations about our desire to conceive children assumed that it was a strong incentive in human life history. Due to the limited advantage bestowed upon parents by bearing high quantities of children in modern societies, it may in fact be that households are equally compelled by socioeconomic success and genetic propagation (Turke, 1989).

Education plays a key role in determining fertility levels. Shenk (2009) find that this role is mediated through AFB, so there must be embodied investment considerations undertaken by more educated parents. Embodied investment here would include both the individual and offspring. Even so, it is not just educational level influencing increases in AFB–lower mortality risk and social learning also play a role.

There has been a great deal of interest in modeling relationships among socioecological variables and life history traits. Beyond social learning, our physical environment also conditions us to prefer quality or quantity, primarily based off the mortality level. Our traits are in fact not fixed–physiological and behavioral traits adapt to our environment. Evolutionists call this "phenotypic plasticity" (Sear, 2015). In instances where parental investment makes little difference in influencing the likelihood of offspring success, we would expect to see a decrease in parental investment. This situation positions households towards emphasizing child quantity. Such cases could be very high mortality rates from endemic diseases, e.g., malaria. However, if extrinsic risk decreases, i.e., malaria incidence begins to decrease, then parents would increase child quality (Shenk, 2009).

In modernized societies, we spend a shorter amount of time rearing children over the life course while committing the same effort within that time period. This is a result of us being unable to adapt to kinship network disintegration. The end result is therefore that we have fewer children. Kinship network existence or the degree to which they function are not the only considerations for resulting family size. The structure of kinship networks also influences quantity-quality decisions (Turke, 1989). Since low-fertility behavior is a social adaptation, we would expect to see exposure to low-fertility norms before a fertility decline. Formal educational opportunities precede fertility decline, with or without a wage-labor market. Following fertility decline we would expect to see higher availability of contraceptives (Shenk, 2009). Couples also alter contraceptive methods based on fertility supply experiences (Rosenzweig and Schultz, 1985).

2.4 Investments in Child Quality

To our advantage, humans lay on the slow extreme of the fast-slow reproduction continuum. This allows us to either slow down or speed up achievement of family size goals. Because of this, we have recently begun to choose alternatives to inclusive fitness maximization. As outlined in the Q-Q tradeoff, investment in child quality serves as one of these alternatives. Beyond this evolved motive disposition, investing in children also helps ensure child survival and further genetic propagation.

The more embodied resources dedicated to a child, e.g., breastmilk, the greater chance they have to survive until they are of reproductive age. More socially successful and somatically nurtured offspring have the highest chance of success in selecting a premium mate. Socioeconomic success is endogenous to copulation, as greater status increases chances of high quality children and mating. Aside from mating and survival as evolutionary drives to acquiring more resources, Turke (1989) proposed that resource insolvency was another factor. Having children is essentially a sunk cost, so humans would seek to recuperate or advance their status post-birth. Additional questions come up about the sociological rationale underlying our desire to have children. According to many studies, children don't actually help us achieve those things we deem most important in life (Alesina, Tella, and MacCulloch, 2004 for example). Therefore, there must be an evolutionary (biological) reason why we have children.

There are differential effects from family composition characteristics. The most notable are birth order and parity, both of which affect social status seeking. It is likely that effects are more nuanced than expected. Parity, or achieved family size, has a somewhat clear effect–the more children for which parents provide somatic resources the more those resources spread thin. However, there may be some benefit to siblings because they can serve as a caretaker for younger children along with enhancing and quickening social learning. Birth order is more complicated. When we compare average social status enhancement for, say, third children versus second children, we might see differences based on parity. This could be endogenous to family size, and the relationship among these variables has not been clearly delineated. Bavel (2006) found that parity may be a better predictor of parents' social status and birth order for the intergenerational success of children.

2.5 Applying Theory to the Demographic Transition

This section addresses the demographic transition by building out aforementioned theoretical approaches to fertility behavior. Understanding the demographic-economic paradox rests on analyzing the proximate determinants of fertility, or *intermediate factors*. Bongaarts (1993) divides these determinants into behavioral (duration of postpartum infecundability, coital frequency, age at marriage) and biological (age at onset of sterility, intrauterine mortality, conception failure). The majority of social science research has focused on behavioral determinants, as these are thought to be the primary way through which individuals have moderated fertility outcomes.

Before continuing, it is important to distinguish between wealth and status in the literature. Wealth is typically understood as resource holdings, while status determines the degree to which an individual can access resources. The DEP is at times understood as resulting from the predicaments and privileges of modern society. Social status, perhaps the primary vessel through which we understand the DEP, now relies upon increased consumption and embodied investment. The first, increased consumption, is important for those seeking to advance their relative and absolute social status. Having certain goods and services propels an individual into appearing successful in society, while other goods absolutely enable an individual to rise in status more quickly, such as a computer. For the latter, however, there is likely a threshold at which the marginal benefit is minimal. It is at this point that relative social status seeking through consumption occurs. We seek to emulate the same consumptive behavior as those around us to ensure that we do not fall behind. If those whose consumptive behavior we seek to mimic also exhibit lower fertility levels, it's likely that lower status individuals will also decrease their fertility. This idea proposed by Boyd and Richerson (1985), known as "prestige bias," is thought to be a major factor in the spread of low fertility.

Since theory indicates that humans seek social status and resources are limited, society tends to advantage children with fewer siblings. As economic development increases, opportunities for social status seeking behavior become greater. More opportunities for embodied investment lead parents to more frequently limit their fertility so that their children are more successful. Embodied investment is clearly an important driver of wealth and status seeking in our current society. The highest paying, most prestigious positions are almost always those that require high skill-levels and social manicure. Coming off our previous assumption that there is an evolved motive disposition towards social status seeking, it would in fact be surprising if there were no DEP. Indeed, we see lower fertility levels in wealthier subgroups for transitioning and post-demographic transition populations. Economic inequality is also temporarily lower for these populations, which is later adjusted back to higher levels of inequality.

Even when a country is going through the demographic transition, it's generally not the case that everywhere will portray the same trends. Oftentimes local resources may influence reproductive decision-making more than macro-trends (Colleran et al., 2015). More interestingly, it might be the case that different households employ distinct reproductive strategies even within the same community. Especially in transitioning and developing economies, two or more reproductive strategies may be prevalent. Therefore the relevant question might not be, "what reproductive strategy led to the observed fertility level," but rather, "which mixture (or not) of reproductive strategies does this community (state, culture, society, etc...) employ."

Chapter 3

Methods

3.1 Data

The data for this study comes from the Demographic and Health Survey, which was carried out from July to November 2006. This DHS was implemented by the State Statistical committee of the Republic of Azerbaijan with support from the United States Agency for International Development and UNICEF. The DHS is a nationally representative sample containing 7,619 households, in which there are 8,444 women age 14-49 and 2,558 men age 15-59 (less than 1% of the over 9 million population). DHS data cover a wide range of topics from household wealth, fertility history, and socio-demographic characteristics. Interviewees were selected in two stages using a randomized probability sampling method. During the first stage 313 clusters in total among Baku and 8 economic regions were selected at random from the 1999 Population Census master sample frame. The second stage then systematically selected households from a complete listing in each cluster.

All women ages 14-49 were eligible to be surveyed if they were permanent residents of the household or visitors staying from the night before. Men age 15-59 were selected using the same criteria from one-third of the households. Eleven teams collected the survey data. Each team contained four female interviewers, one male interviewer, a field editor, and a team supervisor.

A demographic transition had occurred before the survey took place as evidenced by low fertility and infant/child mortality. The total fertility rate (TFR) was 2.0, with lower rates in urban areas (1.8) than in rural areas (2.3). The infant mortality rate was 4.3% and the under-five morality was 5%, which are relatively high for a country with such low TFR. A majority (51%) of women use any type of family planning, but modern methods are not prevalent. Only 14% of women use a modern method whereas 37% use a traditional method. Over a third of all women have had an abortion (38%). To bring this number into perspective, for a developed country such as the United States the fertility level was 2.01 in 2009 (Kent, 2011) while 21% of all pregnancies end in abortion as of 2011 (Jones and Jerman, 2014). Most developed countries outside of Eastern Europe exhibit similar, if not lower, values for both measure. This highlights the abnormal abortion prevalence in a country with a low fertility level. Table A.1 contains descriptive statistics focusing on differences along the urban-rural gradient among the rich and poor. Definitions of these measure are as follows:

- *Under Five Mortality:* The number of children who die under the age of five per 1,000 children born. DHS provides age at death for any child who has passed away prior to the survey.
- *Birthweight:* Weight in grams at birth with the standard error.

- *AFB:* The reported age at first birth for all women in the sample with the standard error.
- *LRS:* Lifetime reproductive success is the total number of children born to each woman who survive to the age of five.

We see that the rich have the lowest rates of under five mortality, oddly the rural poor have the highest birthweight, the urban poor have the highest age at first birth, and the rural poor have the highest lifetime reproductive success. Interpreting the first statistic, it would make sense that with access to more resources, the rich are more able to limit mortality risk at early ages. The birthweight result is odd, although I don't put much faith in it as the discrepancy is small and this may just be a measurement or recording error. AFB being highest for the urban poor might make sense from the social status as embodied resource perspective. In more modernized areas, i.e., urban, we would expect to see greater importance placed upon status. Therein it might be more difficult for lower status individuals to find mates and reproduce. Social status may be deemphasized in less modern, i.e., rural, areas, however we still see a lower AFB for higher status individuals. The LRS results follow demographic transition theory to a tee; more urban, wealthier individuals tend to have lower fertility.

3.2 Approach

I use multilevel modeling to capture the variability among both individuals and sampling clusters. Multilevel models are regressions wth either fixed or variable coefficients on terms included in the model. The only varying effect included in the model is used to capture dependence among households within a sampling cluster. All other variables measure marginal effects. Table A.2 provides a look at the potential set of variables used in each analysis. Both methods take advantage of the DHS's cross-section data format. See Gelman (2006). Model 1 explores the relationship between wealth and lifetime reproductive success. Model 2 is a discrete time hazard of first birth in which covariates proportionally shift the baseline hazard. Time to first birth is measured in years since the woman's 15th birthday.

Overall the approaches successfully inform the research posed at the beginning of this thesis. However, causality is impossible to infer and the interpretation does depend on a couple of key assumptions commonplace in the corresponding body of literature. The first assumption is that offspring survival past age five is a good indicator of LRS. The second is that AFB is a good indicator of individual preferences towards investing in fitness maximization or socioeconomic success. Even so, these assumptions are theoretical in nature and do not affect the integrity of the statistical models–rather, they influence the way in which I interpret the results. All analysis was carried out in R using packages lme4, survival, and survey (Bates et al., 2015; Therneau, 2000; Lumley, 2004).

3.3 Model 1: Lifetime Reproductive Success

The first model examines whether we see differences in LRS along an urban-rural gradient between socioeconomic status. Here I modeled LRS as count data with a Poisson error structure. In a Poisson distribution, the usual assumption of homoskedasticity is not appropriate because the mean is equal to the variance: $E(Y) = var(Y) = \mu$. Informally we can think of Poisson distributions in this way:

- The probability of at least one occurrence of the event in a given time interval is proportional to the length of the interval.
- The probability of two or more occurrences of the event in a very small time interval is negligible.
- The numbers of occurrences of the event in disjoint time intervals are mutually independent.

This means that the probability distribution of n event occurrences in a fixed time interval is Poisson with mean $\mu = \lambda t$, where λ is the rate of occurrence of the event per unit of time and t is the length of the time interval. Poisson models capture the fact that as $\mu \to \infty$ the σ^2 tends to increase. I subset and analyzed only those women who are older than 45 years and who had given their last birth before 2001 (n=757). DHS contains a variable with the total number of births in the past five years. Then I gathered the lifetime reproductive success for each woman. This was done by subtracting the number of children who died under five years of age from the total number of children born to each woman. For the sake of this research, LRS can be considered in this way. However, many studies have elaborated upon the operationalization of reproductive success, specifically at which age a child is deemed to be successful. The mean LRS for the sample of post-reproductive women who have not given birth in the last five years is 2.73. Figure A.4 displays the mean and standard error for LRS along an urban-rural gradient among the rich and poor. For every region the poor have higher LRS except for "small city." Table A.3 shows the regression results. The equation takes the form:

$$totbir_{ij} = \beta_0 + \beta x_{ij} + u_{0j} + \epsilon_{ij} \tag{3.1}$$

Where *totbir* is the LRS for post-reproductive women, β_0 is a constant term, X is a vector of explanatory variables defined in Table A.2, u_{0j} are the cluster mixed effects, and ϵ_{ij} is a stochastic error term for individual i in cluster j. The explanatory variables included were chosen based on their inclusion in Alvergne and Lummaa (2014), as this thesis tries to arrive at results through the same methods. Even so, theoretically these variables make sense to include as they would all influence LRS. I also ran the model including survey weights (Table A.4), yet the results are almost identical save for "town," which is less statistically significant with survey weights included.

3.4 Model 2: Age at First Birth

For this analysis I looked at how educational attainment relates to fertility, specifically AFB. Therefore I explored the risk of birth at a given age conditional on no births before that age. To do this I used a discrete time hazard model, also known as event history analysis. Event history analysis seeks to explain why certain individuals are at a higher risk of an event, in this case AFB. A hazard model is a regression model in which the "risk" of experiencing an event at a certain time point is predicted with a set of covariates.Two special features distinguish hazard models from other types of regression models. The first is that they make it possible to deal with censored observations, which are observations containing only partial information on the timing of the event of interest. Another special feature is that they can deal with covariates that change their values during the observation period, enabling dynamic analysis (See Beck, 1996). Five concepts are fundamental to event history analysis: state, event, duration, risk period, and censoring:

- *States:* Categories of the dependent variable (given birth or not), known as the state space.
- *Event:* Transition from one state to the next (giving first birth).
- *Risk period:* Period in which an individual is at risk of an event happening (before giving first birth, after fifteen years of age).
- *Duration:* Time span of the risk period.
- *Censoring:* We don't know if the event has happened, we only know the event has happened during an unspecified amount of time but the exact timing is unknown (for those who haven't experienced age at first birth, we know how long it has been to the interview date, but are unsure as to how much longer she will go without giving birth, called *right censoring*).

Event history analysis therefore explores time to event from the beginning of the risk period. Discrete time hazard models involve regressing the probability of observing an event in the i^{th} time interval given that the event did not occur before this period. The hazard is denoted by $\lambda(t)$ and in hazard regression the log of the rate is conditional on a set of covariates. Data preparation for a discrete time model includes separating each observation into time discrete time intervals equal to the amount of time the observation is within the risk period, i.e., before an event occurs. For these data I chose one year as the time interval, 15 years of age as the beginning of the risk period (because sex may have occurred before marriage), and

AFB as the end of the risk period. At the time of the survey, there are n=3,192 individuals who had not reproduced, with a total of n=5,252 women who had reproduced.

You can see how the data are arranged in Table A.5: "case.id" is the respondents identification number, "birth.age" represents the number of time periods until AFB or age at the time of the survey, "birth.event" is a dummy indicator for whether a birth event occurred–for those who have not given birth there is no indicator and the risk period stops, "start" is a counting assist, and "year" for this data frame functions the same as birth.age–if the time interval were anything other than one year these two variables would be different.

For each time period the model estimates the probability of an event occurring by using logistic regression to regress the event indicator (first birth) on the time indicator (number of years since 15 years old). I also included a group level effect for the cluster by using the survey package, which included weights and a survey design stratifying the sample at the cluster level. As there are many time intercepts with the general model (more than 20) and the hazard is likely near zero in some of the time periods, I explored other time specifications tos see if we could obtain a comparable, more parsimonious fit. Figure A.5 shows the different specifications, ranging from the general model, the curvilinear, quadratic, cubic, to the quartic. I found that the quartic model had the best fit compared to the general model, based on the AIC difference outlined in Table A.6. The model takes the following form:

$$logit[AFB_{ij}(t)] = \alpha(t) + \beta x_{ij}(t) + u_{0j} + \epsilon_{ij} \tag{3.2}$$

where changes in the hazard function *h(t)* over time are captured by $\alpha(t)$, which takes the following quartic time specification:

$$\alpha(t) = \alpha(t) + \alpha_1(t) + \alpha_2(t)^2 + \alpha_3(t)^3 + \alpha_4(t)^4 \tag{3.3}$$

The dependent variable is the log hazard of age at first birth for an individual j during episode i at time interval t. $x_{ij}(t)$ is a vector containing individual-level explanatory variables defined in Table A.2, u_{0j} is a random effect representing unobserved characteristics of individual j, known as shared frailty, and ϵ_{ij} is a stochastic error term. Just as with the equation in 3.2, the explanatory variables were chosen based on their inclusion in Alvergne and Lummaa (2014).

3.5 Results

How does wealth affect lifetime reproductive success among post-reproductive women?

For post-reproductive women who began giving birth while Azerbaijan was still part of the USSR, LRS was 2.73 (±s.d.=1.52). LRS is negatively correlated with wealth, although the relationship is not strong. Likewise, LRS is significantly lower (22% more likely to have one fewer children) in more urban areas. Therefore the trends observed in regard to LRS and wealth accommodate demographic transition theory, in that wealthier households are more likely to limit their fertility. In this analysis we don't observe the dynamics of wealth and fertility as the data is cross-sectional. We are simply comparing the wealthy to the non-wealthy, and therefore cannot speak to the effect of becoming wealthy on fertility outcomes.

Does market integration increase individual preferences towards socioeconomic success over fertility?

From Figure A.6 we can see that higher educated women delay fertility longer, and that urban women tend to delay their fertility longer holding educational attainment constant. Regression output is shown in Table A.7. The only anomaly from Table A.8 is that primary educated women tend to be 11% more likely to start reproducing than their non-educated counterparts. Most likely this is because the primary educated are more able to find mates with whom they can reproduce. It appears that the lower educated tend to limit their fertility earlier in their reproductive career, but the difference is not drastic. AFB does increase with educational level in every area. However, after age 25–the age by which most women in the sample have finished their education–the negative relationship among high educational attainment plus urban domicile and AFB becomes relatively weak. This suggests that women do preference socioeconomic success through educational attainment up until an age at which they are able to pursue both their professional and LRS goals. In Table A.8 we can see that higher educated women are significantly less likely to start reproducing than the non-educated, that those living in the capital (largest, most market integrated) city tend to be about 10% less likely to start reproducing, and that the rich are actually about 10% more likely to start reproducing.

Chapter 4

Discussion and Conclusion

Both evolutionary and demographic theories provide important insight into fertility behavior in modern populations. The former helps us understand how individuals allocate energy over the life course while the latter contributes a framework through which we can analyze individual preferences under changing ecological conditions. As noted at the beginning of this thesis, it is not simply that we may find a unifying theory to explain fertility behavior, insofar continuing to distinguish these theories as we have. Instead, we might think of evolutionary and demographic theories on fertility behavior as I have just portrayed–theories distinctly explaining life history and the role of ecological shifts respectively. From this analysis we saw that the wealthier tend to have lower lifetime reproductive success, and that the more market integrated preference socioeconomic status seeking over fitness maximization, at least in early life stages.

As this thesis was in part a replication of Alvergne and Lummaa (2014), it is important to note one key difference in our results. For these data in Azerbaijan, we found a negative wealth-fertility relationship *within* each region, except for small cities. However, in Alvergne and Lummaa (2014) the authors found that there is a positive wealth-fertility relationship within each region. There are certainly some ecological differences between the two countries, not withstanding the glaring absence of significant proportions of nomadic peoples in Azerbaijan. Furthermore, there is a large difference in contraceptive use between the two countries (contraceptive use is much higher in Mongolia) along with abortion rates–nearly a third of women have received an abortion in Azerbaijan, far higher than in Mongolia. Even so, it would require additional analysis to determine whether these differences are significant. For the sake of work contained herein, the main conclusion that I may come to is that we must consider and include ecological conditions more nuanced than generic, broad characteristics such as market integration, urban domicile, and high abortion rates. This brings us to the following question: When and under which circumstances can we expect to see differing wealth-fertility relationships?

There remain many additional questions to explore with regard to the intersection of market transition, fertility, and evolution. Emphasizing how market transitions influence preferences towards socioeconomic status seeking over fitness maximization requires that we think of the pre-market transition economy as rather egalitarian. However, this is not realistic. Especially near the end of most command-style economic regimes, there is often a marked increase in economic inequality as global economic integration advances for the privileged. How then does a decrease in inequality prior to the DT affect later fertility rates?

Furthermore, much of this literature examines social learning. Social learning effects are likely neighborhood specific, depending on both context and composition. Do less educated households, through social learning from more educated households, limit their fertility? Do these effects translate in both directions? If status seeking is an evolved motive disposition, then it is unlikely that this is the case, but nonetheless worthy of inquiry.

Human biology increasingly incorporates into social research to understand life course outcomes, including fertility and health. The causes of these outcomes can be divided into genetics, physical environment, resource access, behavior, and psychosocial condition. First, it is important to place "social learning" as a concept within these causes, and second determine to what degree social learning plays a role. More so, as we are interested in ecological shifts, how does ecological change affect evolved traits, and which types of change lead to disadvantaging evolved traits? Additionally, how does social learning influence our ability to limit adaptive behavioral traits?

A more metaphysical question stemming from all of this is: How do we understand a trait that is socially beneficial but genetically maladaptive, and vice versa? The evolutionary social sciences get at the most basic questions regarding humanity, both about our species' and society's histories. This thesis has covered but one of the directions, and further research by myself and others will bring us even closer to a scientific approach incorporating the complexity of the human experience.

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Appendix A

Tables and Figures

Figure A.1: Fertility and Economic Growth in Azerbaijan

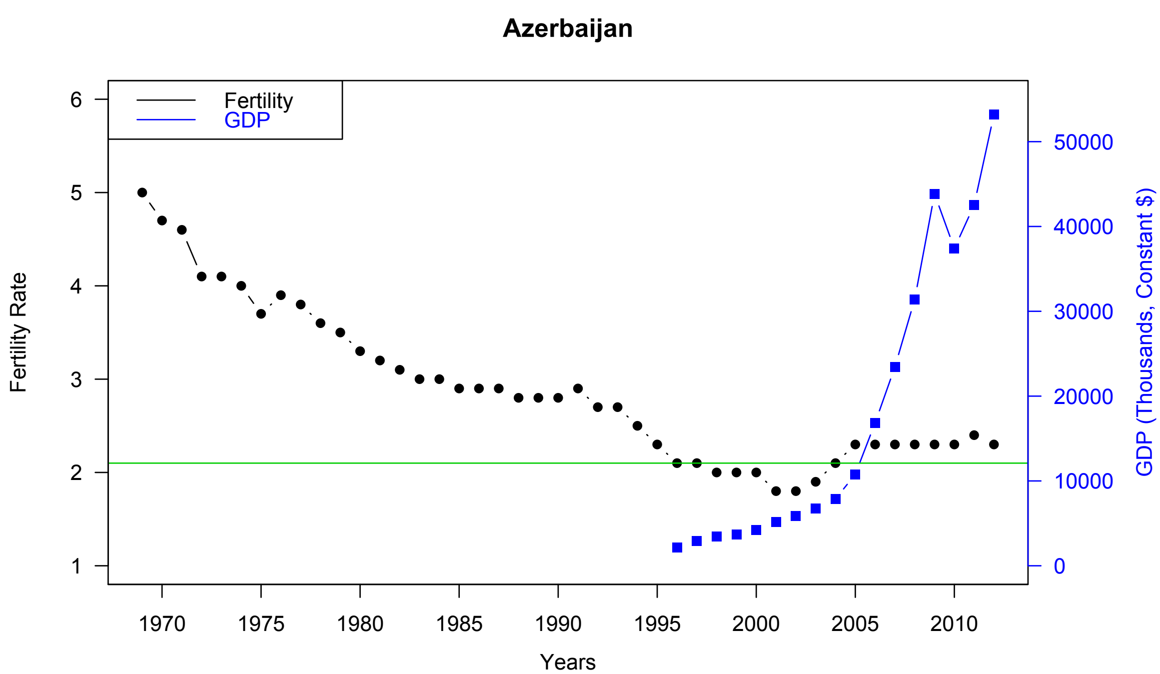

Figure A.2: Fertility Across a Wealth and Regional Gradient

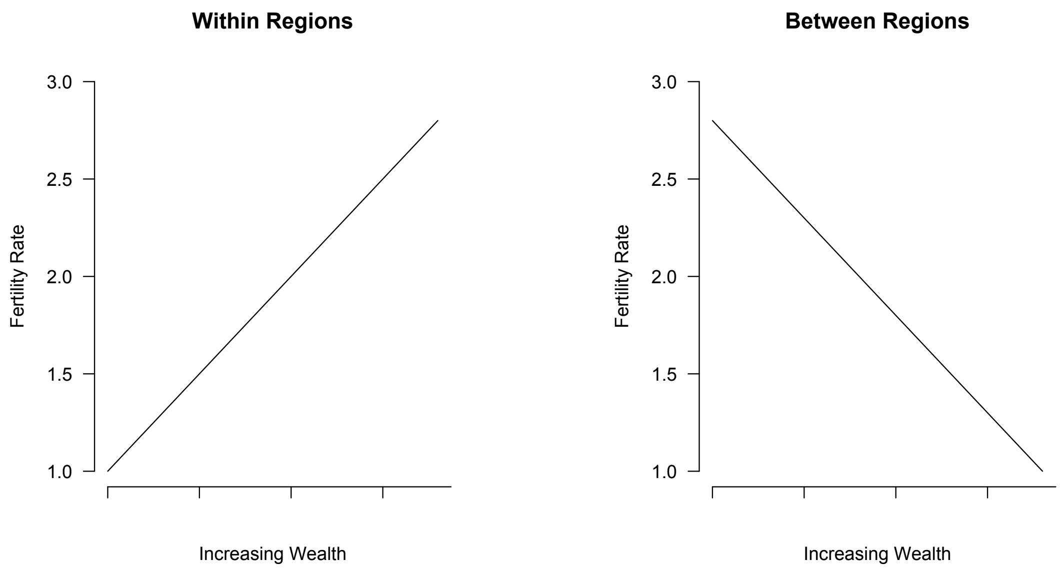

Figure A.3: Fertility and Urbanization

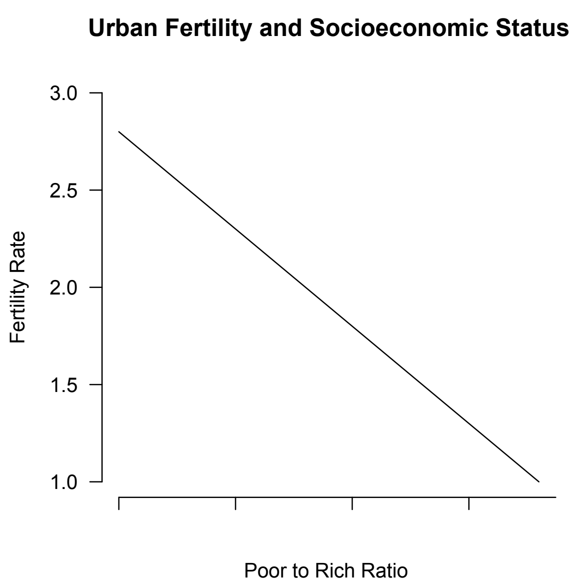

Table A.1: Descriptive Statistics

	Urban	**Rural**
< 5 **Mortality**		
Rich	11/1000	11/1000
Poor	23/1000	18/1000
Birthweight		
Rich	3366 ± 38	3329 ± 111
Poor	3317 ± 87	3405 ± 59
Age at First Birth		
Rich	$22.79 \pm .09$	$21.47 \pm .21$
Poor	$23.01 \pm .20$	$22.06 \pm .09$
LRS		
Rich	$2.56 \pm .07$	$3.21 \pm .31$
Poor	$2.93 \pm .19$	$3.37 \pm .12$

Figure A.4: Mean and SE for Rich and Poor Along an Urban-Rural Gradient

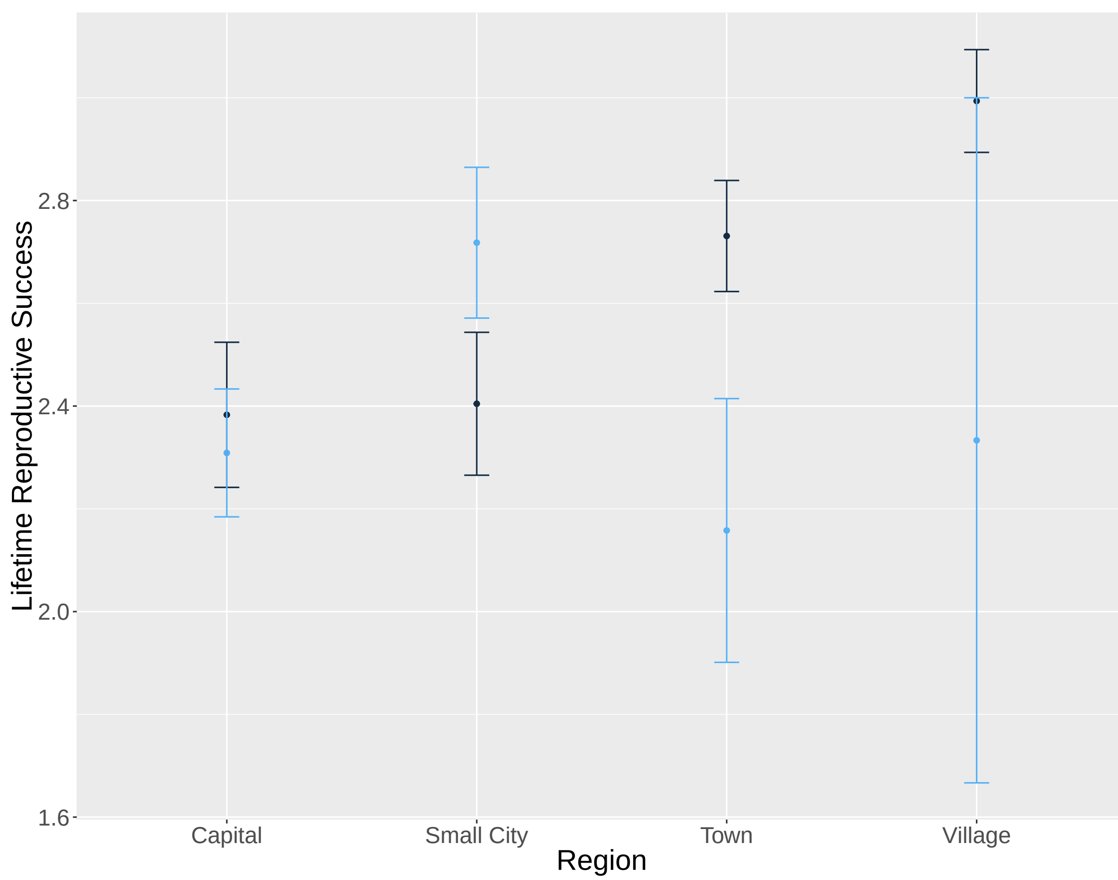

Table A.2: Variable Descriptions

Category	Description
Fertility	
totbir	Lifetime reproductive success
AFB	Age at first birth, starting at age 15
Age	
age	Age of respondent
cohort	Cohort dummy (born before 1973)
Wealth	
rich	Rich, top two wealth quintiles
reference category	Poor, bottom three wealth quintiles
Region	
capital	Capital city, Baku
smcity	Small city
town	Town
reference category	Countryside
Marital Status	
nevermarried	Never married
livingtogether	Living together
divorced	Divorced
notlivtogether	Not living together
widowed	Widowed
reference category	Married
Educational Achievement	
primary	Primary, elementary school
secondary	Secondary, high school
higher	Higher, university
reference category	No education

Table A.3: Predicting Lifetime Reproductive Success among Post-Reproductive Women

	Dependent variable:
	LRS
age	0.037*
	(0.020)
rich	−0.034
	(0.072)
capital	−0.248***
	(0.080)
small city	−0.213***
	(0.068)
town	−0.123**
	(0.055)
never married	−3.178***
	(0.409)
living together	0.408
	(0.504)
divorced	−0.550***
	(0.122)
not living together	0.130
	(0.225)
widowed	−0.118
	(0.075)
Constant	1.118***
	(0.057)
Observations	757
Log Likelihood	−1,257.820
Akaike Inf. Crit.	2,539.639
Bayesian Inf. Crit.	2,595.191
Note:	*p<0.1; **p<0.05; ***p<0.01
Reference categories:	"poor", "village", "married"

Table A.4: Predicting LRS among Post-Reproductive Women w/ Survey Weights

	Dependent variable:
	LRS
age	0.042**
	(0.021)
rich	−0.033
	(0.064)
capital	−0.247***
	(0.065)
small city	−0.203***
	(0.074)
town	−0.130*
	(0.069)
never married	−3.119***
	(0.410)
living together	0.413
	(0.697)
divorced	−0.510***
	(0.114)
not living together	0.025
	(0.369)
widowed	−0.104
	(0.079)
Constant	1.092***
	(0.059)
Observations	757
Log Likelihood	−1,186.785
Akaike Inf. Crit.	2,397.569
Bayesian Inf. Crit.	2,453.122
Note:	*p<0.1; **p<0.05; ***p<0.01
Reference categories:	"poor", "village", "married"

Table A.5: Person-Period Data Frame for Discrete Hazard Modeling

	caseid	birth.age	birth.event	start	year
8445	1 3 2	1	0	0	1
16889	1 3 2	2	0	1	2
25333	1 3 2	3	1	2	3
8446	1 3 5	1	0	0	1
16890	1 3 5	2	0	1	2
25334	1 3 5	3	0	2	3
33778	1 3 5	4	0	3	4
42222	1 3 5	5	0	4	5
50666	1 3 5	6	0	5	6
59110	1 3 5	7	0	6	7
67554	1 3 5	8	0	7	8
8447	1 5 2	1	0	0	1
16891	1 5 2	2	0	1	2
25335	1 5 2	3	0	2	3
33779	1 5 2	4	1	3	4
8449	1 6 2	1	0	0	1
16893	1 6 2	2	0	1	2
25337	1 6 2	3	0	2	3
33781	1 6 2	4	0	3	4
42225	1 6 2	5	0	4	5

Table A.6: AIC Differences from the General Model

	model	aic	aic_dif
1	general	29,601.380	0
2	linear	31,764.750	2,163.370
3	square	29,869.840	268.460
4	cubic	29,717.900	116.520
5	quartic	29,604.520	3.140

Figure A.5: Hazard Function from Different Time Parameterizations

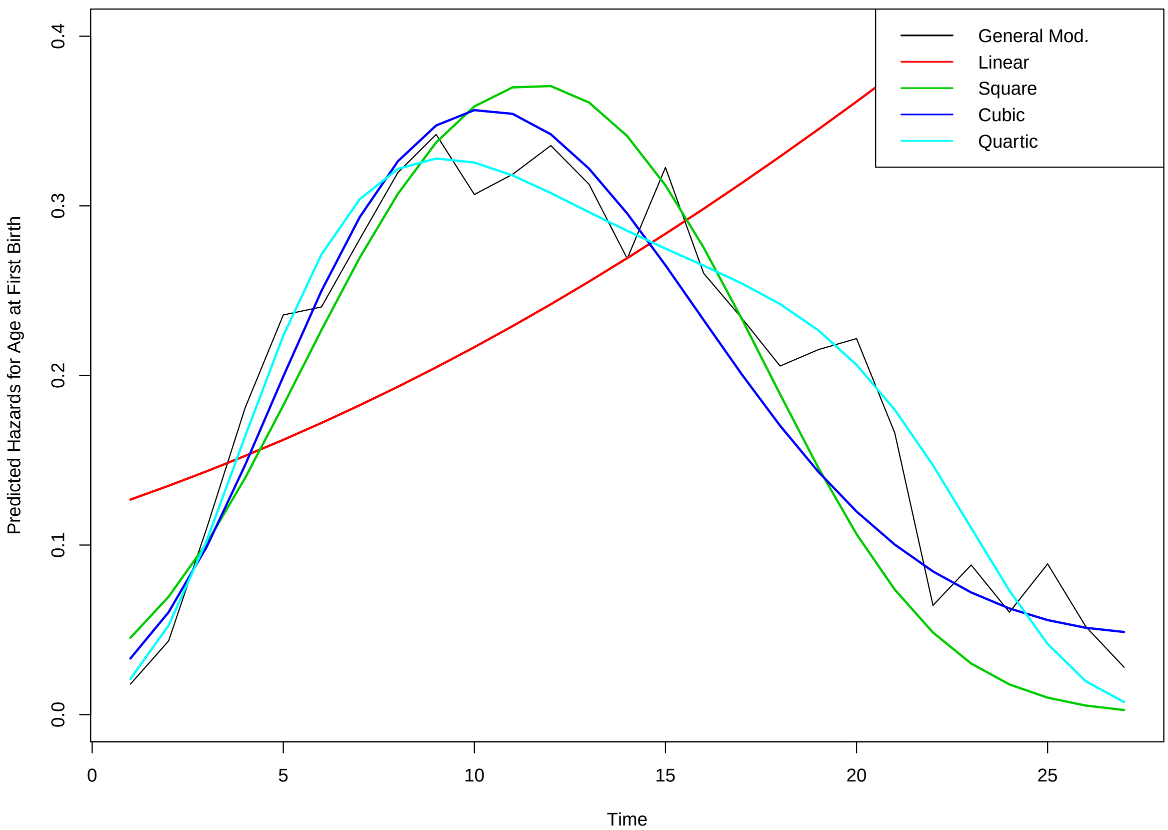

Table A.7: Predicting Age at First Birth with Quartic Time Using Discrete Time Modeling

	Dependent variable:
	AFB
Time	1.351***
	(0.064)
Time^2	−0.151***
	(0.011)
Time^3	0.007***
	(0.001)
Time^4	−0.0001***
	(0.00001)
rich	0.094*
	(0.052)
capital	−0.103*
	(0.054)
small city	−0.160***
	(0.048)
town	−0.132***
	(0.038)
never married	−6.264***
	(0.409)
living together	−0.743***
	(0.264)
divorced	−0.646***
	(0.077)
not living together	−0.490***
	(0.174)
widowed	−0.165**
	(0.076)
primary	0.107
	(0.198)
secondary	−0.096
	(0.141)
higher	−0.535***
	(0.149)
cohort	−0.484***
	(0.033)
Constant	−5.045***
	(0.188)
Observations	64,761
Note:	*p<0.1; **p<0.05; ***p<0.01
Reference categories:	“poor”, “village”, “married”, “no education”

Table A.8: Predicting AFB with Quartic Time using Discrete Time Modeling (Odds Ratios)

	OR	2.5 %	97.5 %
(Intercept)	0.006	0.004	0.009
year	3.862	3.411	4.391
I(yearˆ2)	0.860	0.842	0.878
I(yearˆ3)	1.007	1.006	1.009
I(yearˆ4)	1.000	1.000	1.000
rich	1.099	0.992	1.216
capital	0.902	0.811	1.003
smcity	0.852	0.775	0.937
town	0.876	0.812	0.945
nevermarried	0.002	0.001	0.004
livingtogether	0.476	0.273	0.772
divorced	0.524	0.449	0.608
notlivtogether	0.613	0.429	0.850
widowed	0.848	0.728	0.982
primary	1.113	0.754	1.641
secondary	0.909	0.695	1.208
higher	0.586	0.440	0.790
cohort	0.616	0.578	0.657

Figure A.6: Quartic Time Hazard Function across Regional-Educational Gradients