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Indicators of Fertility Change in a Developing Nation: Examining the Impact of Motorcycles as a *Distance Demolishing Technology* on Fertility Change in Rural Indonesia

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ABSTRACT

Indicators of Fertility Change in a Developing Nation: Examining the Impact of Motorcycles as a *Distance Demolishing Technology* on Fertility Change in Rural Indonesia.

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Given the consistent findings in the development literature that fertility is associated with economic growth for individuals, families, and even influences a country's Gross Domestic Product, I explore to what degree motorcycles impact changes in fertility in rural Indonesia. I argue that motorcycles function as a "Distance Demolishing Technology" (Scott 2009:11) and therein empower individuals, particularly young rural women from lower socioeconomic groups who are socially and economically isolated, through increasing their access to labor markets, educational opportunities, non-familial social organizations, and more diverse social networks—key indicators in affecting fertility decisions identified in the existing literature. I examine this relationship in Indonesia where from 1990 to 2009, motorcycle ownership in Indonesia increased approximately 893% while the Indonesian population increased approximately 15% (Badan Pusat Statistik 2009). Using Demographic and Health Survey data across 1994, 1997, 2002, 2003 and 2007, I examine this relationship through a combination of multilevel regression models. My findings show a strong association between motorcycle ownership and a decrease in four different measures of fertility. Considering the importance of fertility in indicating individual and aggregate economic development—particularly in terms of increasing GDP and GNI per Capita—my findings indicate that sometimes even the simplest of technologies can be the "engines" of social and economic change.

Keywords: fertility, social change, social mobility, distance demolishing technology

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INTRODUCTION

Given the consistent findings that fertility is correlated with economic development (Docquier 2004; Korinek et al. 2006; Kravdal 1994; Lee and Mason 2009; Li and Zhang 2007; Palivos 1994); development scholars have focused on creating models which predict changes in fertility as well as identifying specific indicators that influence female fertility decisions in developing countries (Korinek et al. 2006). The options and consequences of fertility have become central topics in both the economic development literature and feminist critique as both address unique aspects of female autonomy (Docquier 2004; Ekert-Jaffe and Stier 2009). As Axinn and Yabiku (2001) argue, "the process of transition from high fertility and no use of birth control to low fertility and the widespread use of birth control" is perhaps "the most theoretically and empirically studied subject in social demography" (1220). Furthermore, "the transformation of reproductive behavior involved in the transition from high to low levels of fertility represents one of the most fundamental changes in human history" (Knodel, Havanon, and Pramualratana 1984:297). Not only is control over one's fertility a primary indicator of personal autonomy; it also affects one's social mobility and social and economic status (Dharmalingam and Morgan 1996; Docquier 2004; Ekert-Jaffe and Stier 2009; Korinek et al. 2006; Kravdal 1994; Morgan and Hegewen 2005). Furthermore, individual female fertility choices have significant effects for broader society, because delayed child bearing and lower fertility are two of the most important indicators of a country's economic progress (Korinek et al. 2006), affecting Gross Domestic Product (GDP) and Gross National Income per Capita (GNICP) (Docquier 2004; Kravdal 1994; Lee and Mason 2009; Li and Zhang 2007; Palivos 1994).

As stated by Barber and Axinn (2004), the pursuit of theoretical models and indicators of female fertility decisions in developing countries is complicated as "[a] controversy between

structural and ideational explanations of behavior characterizes much of social science research; including numerous studies of families and social change…there are strong theoretical reasons for expecting both structural and ideational forces to shape behavior" (1180) (see also Bongaarts and Watkins 1996; Knodel et al. 1984; Morgan and Hegewen 2005). Accordingly, in an attempt to better explain changes in fertility—economists, psychologist, sociologists, and demographers have created a wide range of theoretical models and frameworks (Axinn and Yabiku 2001; Barro and Becker 1989; Becker 1960; Blake 1973, 1989; Caldwell 1982; Dharmalingham and Morgan 1996; Knodel et al. 1984; Mason 1987 and 1997; Notestein 1953; Poston 2011; Potter, Schmertmann, and Cavernaghi 2002). While Hirschman (1994) and Morgan and Hegewen (2005) offer extensive reviews of these frameworks, two key concepts, *proximity* (Axinn and Yabiku 2001; Barber 2004; Korinek 2006; Zakharenko 2009) and *access* (Bacshieri and Falkingham 2009; Leinbach 2000), are frequently highlighted throughout the fertility transitions literature (Bacshieri and Falkingham 2009; Barber 2004; Behrman, Kohler, and Watkins 2002; Feyisetan and Casterline 2000). We define *proximity* as the relative closeness of one place to another especially as it concerns places with social or economic opportunities; and *access* as the ability to obtain a scarce resource (Leinbach 2000).

This "process of transition from high fertility and no use of birth control to low fertility and the widespread use of birth control" (Axinn and Yabiku 2001: 1220) is mitigated by differential access to scarce resources, i.e. family planning, labor markets, educational opportunities, mass media, and non-familial social organizations; but access to these resources is further mitigated by one's relative proximity to them (Barber 2004; Leinbach 2000; Massey and Denton 1993; Pebley and Sastry 2004; Sampson and Morenoff 2006; Wilson 1987, 1999; Zakharenko 2009). Geographic location vis-à-vis a developed labor market or school affects an

individual's access to employment and education (Bacshieri and Falkingham 2009; Korinek et al. 2006; Leinbach 2000; Wilson 1987, 1996, 1999; Massey and Denton 1993; Pebley and Sastry 2004; Sampson and Morenoff 2006). Similarly, access to sources of mass media (Barber and Axinn 2004), non-familial social networks and organizations, and outside cultural influences are mitigated by proximity to locations with these resources (Barber 2004). Consequently, it is assumed that women located in relatively isolated areas[1], as compared to women located in more urbanized or suburbanized locations, will generally have less access to these scarce resources. They will also be more likely to lack the personal and social resources needed to bridge the various disadvantages associated with physical isolation than would their less isolated or segregated counterparts (Massey and Denton 1993; Leinbach 1983; Pebley and Sastry 2004; Sampson and Morenoff 2006). Thus, a necessary next step in explaining changes in fertility[2] is to examine what types of interventions, technologies, and other mechanisms may help more physically and socially isolated rural women overcome their disadvantaged position vis-à-vis

[1] While this paper focuses on social and economic isolation in rural areas (Leinbach 1983 and 2000), we recognize that social and economic isolation may also occur in more urbanized locations (Wilson 1987, 1996, and 1999) as well. Therefore, our evaluations account for both rural and urban isolation.

[2] Barber and Axinn (2004), Knodel et al. (1984), and Hirschman (1994) argue that answering the question "Why fertility changes?" (Hirschman 1994) requires a nuanced discussion of multiple theories, frameworks, and indicators. Hirschman (1994) demonstrates that no one theory, framework, or indicator fully explains changes in fertility. Accordingly, our intention is not to provide an all encompassing framework explaining fertility change, but to present motorcycles as an example of a "distance demolishing technology" (Scott, 2009), which, situated within the context of theories and frameworks supported in the literature, potentially functions as an indicator in fertility change.

labor markets, educational opportunities, mass media sources, and non-familial social organizations and networks--resources that are generally located in more urbanized or suburbanized regions of developing countries (Korinek et al. 2006; Leinbach 2000; Rigg 2002).

One increasingly prevalent technology in the developing world that has yet to be examined for its potential to help isolated rural women is inexpensive motorcycles. In this research, I examine to what extent motorcycles function as a "distance demolishing technology" (Scott 2009:11), which may mitigate the disadvantages of lack of proximity by creating greater access to more urban locations, and thus affect fertility options and transitions of rural women in a developing country. Specifically, I examine these issues in Indonesia and hypothesize that motorcycles will negatively affect fertility through enabling rural Indonesian women to transcend the constraints of place (Scott 2009). Motorcycle use should dramatically change the opportunity costs of rural households associated with travel and increase rural women's access to labor markets, educational opportunities, mass media, and non-familial social organizations and networks—all of which are identified as key indicators affecting fertility decisions and outcomes. I further hypothesize that these effects are observed more strongly for rural women than for their urban counterparts.

LITERATURE REVIEW

Fertility and Economic Development

"The literature on population and economic growth is about as old as economic science itself" (Ehlrich and Lui 1997:205). Yet, contrary to Malthus' (1798) original hypothesis predicting a positive relationship between population and economic growth because increased economic welfare would sustain larger families; current research supports a negative relationship, but outliers do exist and are the substance of considerable debate (Bryant 2007). I

am interested in this negative relationship (depicted in Figure 1, reproduced from the CIA World Fact Book 2004) between fertility and economic growth experienced in both developed and developing nations (Docquier 2002; Lee and Mason 2009; Li and Zhang 2007; Palivos 1994).

(Figure 1 about here)

In as much as "macro economic change arises in part through changes in the activities performed by units that constitute the economy" (Korinek et al. 2006:192), researchers have developed a variety of frameworks and theories in an attempt to explain the negative relationship between individual and household fertility decisions and economic growth. For example, Becker (1960), Becker and Lewis (1973), and Barro and Becker (1989) argue that the relationship results from a tradeoff between 'quantity' and 'quality' in raising children. In essence, economic well-being shifts from parents seeking an increase in the number of children for some immediate economic benefit, to seeking to raise fewer but higher quality children for future economic benefit. This, in turn, creates a greater investment in human capital benefiting society in general. Furthermore, decreased fertility in the aggregate is related to increased socioeconomic prosperity by reducing the overall population and increasing the portion of the population of working age (Lee and Mason 2009). Consequently, scarce economic resources are distributed among a smaller population enabling a more concentrated investment in human resources while also increasing the socioeconomic well-being of the general population (Becker, Murphy, and Tamura 1990; Lee and Mason 2009; Li and Zhang 2007). Fewer citizens with whom a nation's GDP must be divided means not only an overall increase in economic growth, but an increase in Gross National Income per capita as well (Lee and Mason 2009; Li and Zhang 2007; Palivos 1994). Although the negative relationship between fertility and economic growth is well supported in the literature, the directionality of the influence is less certain and difficult to

determine. Empirical evidence suggests that the relationship is multidirectional because of feedback between the two variables, e.g. a decrease in fertility enables economic growth while economic growth increases the demand for a reduction in fertility (Lee and Mason 2009; Potter et al. 2002; Thorton et al. 2010). Furthermore, Thornton et al. (2010) argue that the multidirectional relationship between economic growth and fertility is generally accepted today. My research examines motorcycles net the effects of other known indicators that affect fertility recognizing overall reductions in fertility are associated with increased economic development (Lee and Mason 2009). One of the most important of these "known" indicators predicting fertility is family planning.

Family Planning

While demographic transition theory posits that fertility decline is directly associated with a decreased demand for live births, Feyisetan and Casterline (2000) found evidence that during the 1960s, women in developing countries lacked control over their fertility despite their expressed desires to limit it. Accordingly, most contemporary models of change in fertility recognize the importance of both knowledge of, *and* access to, family planning services, including methods of contraception, as key indicators in predicting fertility change (Morgan and Hegewen, 2005). They represent the "supply" of means to control fertility (Feyisetan and Casterline 2000). After accounting for knowledge of, and access to, family planning, models of fertility change also attempt to account for structural and ideational indicators of change—some (Poston 2011) even argue that without the influence of social and economic changes to structural and ideational indicators which result in changes in reward structures "family planning programs would have little or no effect on fertility" (Poston 2011:4).

Structural Indicators of Fertility Change

Structural indicators of fertility transitions generally focus on two issues: 1) economic forces and their effects on fertility (see Becker 1960; Barro and Becker 1987; Blake 1973; Caldwell 1976, 1982; Dharmalingham and Morgan 1996; Knodel at al. 1984, Poston 2011; Mason 1987) and 2) the accessibility of family planning options (see Feyisetan and Casterline 2000).

Economic explanations of fertility change generally identify education (Knodel et al. 1984), labor market participation (Knodel et al. 1984), and wealth flows (Caldwell 1976, 1982; Dow et al. 1997) as key indicators in predicting fertility change[3]. Specifically, education and labor market participation potentially change the opportunity costs of fertility thus also potentially affecting a couple's "demand" (Feyisetan and Casterline 2000) for children (Brewster and Rinfduss 2000; Budig 2003; Derose and Kravdal 2007; Ekert-Jaffe 1986; Ekert-Jaffe and Stier 2009; Feyisetan and Casterline 2000; Hakim 2003; Knodel et al. 1984; Lobao and Meyer 1995; Moursund and Kravdal 2003; Spain and Bianchi 1996).

"The consensus of the large existing literature is that the cross-sectional relationship between fertility and education is nearly always sharply inverse: women with more education have lower fertility" (Derose and Kravadal 2007:59). Moursund and Kravdal (2003) further argue that "there is overwhelming empirical evidence for a fertility-depressing effect of education" (286). Education is both a structural and ideational indicator in that it acts as a gateway to higher earning potential as well as a potential means for disseminating new ideas and

[3]While I recognize the importance of wealth flows as an established indicator within the fertility literature, I focus on the effects of education and labor market participation as these indicators are directly available within my dataset.

attitudes towards fertility goals and contraception, e.g. health and sexual education courses (Barber and Axinn 2004; Kravdal 1994; Kremer and Chen 1999; Ekert-Jaffe and Stier 2009). Increased access to education not only empowers women to balance motherhood and other pursuits, but increases the overall opportunity cost of fertility (Ekert-Jaffe and Stier 2009; Gailor and Weil 1996; Kremer and Chen 1999). Ekert-Jaffe and Stier (2009) note:

> Education is an important resource for women in the labor market, and as such is expected to affect their fertility too. Women's work decisions depend on their educational level because women take into account their opportunity costs, that is, their forgone earnings while staying at home. Accordingly, higher education, which is translated into higher reservation wages, is expected to have a strong positive effect on women's labor force participation (645).

Even if women choose motherhood, but do so later in their life course after securing more education and income; they tend to have smaller families, and are thus more likely to concentrate on rearing their children with quality, providing them greater experiences and opportunities in their lives versus emphasizing quantity, having many children (Becker 1960, 1971; Knodel et al. 1984; Lee and Mason 2009; Lord and Rangazas 2006). Consequently, the subsequent generation benefit from an increased quality of life ratcheting up opportunities to pursue educational and occupational goals in adult life (Knodel et al. 1984; Lee and Mason 2009). Postponement of child birth thus gives women and their children, and importantly, their grandchildren, greater opportunity to pursue academic and/or occupational goals (Knodel et al. 1984).

Reasonable and reliable access to labor markets is another structural indicator in fertility transitions. Wage-earning women, particularly those in primary rather than secondary labor markets, are more likely to postpone their first pregnancy, and, have fewer children across the

life course (Brewster and Rindfuss 2000; Budig 2003; Ekert-Jaffe 1986; Ekert-Jaffe and Stier 2009; Hakim 2003; Knodel et al. 1984; Kremer and Chen 1999; Lord and Rangazas 2006; Spain and Bianchi 1996). Additionally, women who are active earners in the labor market potentially derive personal satisfaction and status in their household and community (Dharmalingam and Morgan 1996), thus motivating them to safeguard the positive rewards derived from these activities by avoiding conditions that would threaten them, such as pregnancy (Ekert-Jaffe and Stier 2009). Consequently, economic models used to explain the negative relationship between fertility and labor market participation focus on the opportunity costs of fertility for women who experience an increase in income potential (Ekert-Jaffe and Stier 2009; Galor and Weil 1996; Knodel et al. 1984). Ekert-Jaffe and Stier (2009) explain the opportunity costs of fertility as follows:

> In explaining fertility decisions, this approach focuses on "income vs. substitution" considerations, arguing that higher wages ease budget constraints [especially child-care payments, (Ekert-Jaffe 1986)] and allow a rise in the number and quality of children: this is the "income effect" on fertility decisions. Women's work, however, affects the number of children negatively, because child care is time costly, and while rearing children women cannot earn money (substitution effect). While women who participate in paid employment contribute to a rise in the family income (hence can afford to have more children), at the same time they must limit their fertility because of forgone earnings while the children demand more of their time, and because career interruptions, associated with having children, adversely affect their long term achievements in the market.

Accordingly, women who experience an increase in employment opportunities concomitantly face increased opportunity costs in motherhood.

These opportunity costs of motherhood/fertility extend beyond the individual by also influencing household economic strategies and decisions (Korinek et al. 2006). "Neoclassical economic theory, as articulated in the new home economics, assumes that households are decision making units. Household welfare is dependent upon rational allocation of labor and consumption resources and on adaptation to economic environment" (Lobao and Meyer 1995:579). Households may accrue economic advantages by moving women from money-saving activities (e.g., tending a garden, domestic labor, etc.) into money-earning ones (Lobao and Meyer 1995; McMichael 2004). "In order to maximize welfare, households should allocate members' home and market work time by criteria such as human capital skills, external labor market characteristics, and substitutability of purchased home inputs for member-provided ones" (Lobao and Meyer 1995:579). Because the household generally functions as the economic unit in the developing world, particularly in rural areas (Korinek et al. 2006; Lobao and Meyer 1995; Moen and Wethington 1992; Tilly and Scott 1978), increasing the actual amount, reliability, and predictability of money coming into the household through money-earning activities by its members, changes the household's and its members' economic and social options (Ekert-Jaffe and Stier 2009; Korinek et al. 2006; Lobao and Meyer 1995). Thus, a pregnancy affects a household's options in addition to the individual woman herself as opportunity costs accrue at both levels (Ekert-Jaffe and Stier 2009; Korinek et al. 2006; Lobao and Meyer 1995).

Particularly in developing countries, increasing women's potential to earn income alters the household's economic strategies as members shift from viewing female labor as a money-saving activity to a money-earning one (Ekert-Jaffe and Stier 2009; Korninek et al 2006;

McMichael 2004). Thus fertility, inasmuch as it limits female earning potential, constitutes an opportunity cost not only for the individual, but for the household as a whole affecting the socioeconomic wellbeing of the entire household (Ekert-Jaffe and Stier 2009; Korninek et al. 2006). "In less developed countries, where families face innumerable challenges in attaining secure economic conditions, the birth of a child is a transformative event that may seriously alter the constellation of family needs, may bring economic hardship, and thus may encourage newly configured economic activities" (Korinek et al. 2006:193). Having the option to postpone fertility is thus a necessary condition for women interested in increasing their own socioeconomic status and that of their household's. In short, access to educational opportunities and labor markets may create an opportunity cost to fertility and therein influence both a woman's as well as a household's demand for children. In addition to these and other structural indicators potentially affecting fertility, *ideational* indicators must also be considered.

Ideational Indicators of Fertility Change

By incorporating the concepts of *social learning* and *social influence*, ideational frameworks examine how mass media, social organizations and networks external to the family, and cultural influences change perceptions and expectations of fertility (Barber and Axinn 2004; Basten 2009; Behrman et al. 2002; Feyisetan and Casterline 2000; Meyers 2001; Potter et al. 2002). They focus on how outside influences can affect a couple's "demand" for children through increasing awareness and acceptability of contraception options as well as decreasing cultural costs of fertility limitation (Barber and Axinn 2004; Feyisetan and Casterline 2000). There is however, no consensus concerning the direction in which ideational indicators influence fertility or how fertility norms and ideas are reinforced (Meyers 2001).

Meyers (2001) argues that traditional social norms and ideals regarding fertility culminate in "Matrigyno-Idolatry" – epitomizing motherhood as "true womanhood" and "the only creditable form of fulfillment for women" (759). Meyers further asserts that the juggernaut of messages from popular media reinforces matrigyno-idolatry in contemporary society and cites Gerson (1985:164) who states, "I think the only reason I'm considering having children right now is because it's *heresy* not to consider having children". Opposing the perspective of Meyers, Barber, and Axinn (2004) and Feyisetan and Casterline (2000) acknowledge the traditional nature of social norms and ideals concerning fertility, but argue that there is an emerging trend in modern society opposing them facilitated by mass media.

Family Organization Framework

Axinn and Yabiku (2001) proposed a hybrid framework called the Family Organization Framework, as a synthesis of structural, ideational, and family planning indicators affecting fertility, supporting the framework as "an important advance in the causal connections between macro level social changes and individual behavior" (1221) inasmuch as it allows for "a variety of social processes [to] influence fertility behavior, including changes in the mode of economic production, institutional organization of social life, and patterns of diffusion of ideas" (1221). I too use this framework as it attempts to account for many of the important indicators affecting fertility transition but I also examine how they are mitigated by place.

Place, Proximity, and Access

The relative power of the structural and ideational indicators affecting fertility is further mitigated by place (Bacshieri and Falkingham 2009; Barber 2004; Korinek et al. 2006; Leinbach 2000; Massey and Denton 1993; Pebley and Sastry 2004; Rigg 2002; Sampson and Morenoff 2006; Wilson 1987, 1996, 1999). Place can either work to empower individuals—for example

when jobs and educational institutions to train for them are located nearby (Wilson 1987, 1996, 1999), or it can entrap residents when it keeps them isolated from greater economic resources (Brown et al. 2000; Leinbach 2000, Rigg 2002; Wilson 1987, 1996, 1999). Places with comparatively low economic resources can even entrap entire nations (Sampson and Morenoff 2006). Subsequently, "place context" is an emerging key indicator within new orientations of development theory (Leinbach 2000:1).

More specifically, in developing countries in Asia and Southeast Asia, "the line delineating residents of city and countryside is one of the most salient in differentiating socioeconomic circumstances, occupational structures, and economic trends" (Korinek et al. 2006:197). Thus, within developing countries in Asia and Southeast Asia, place is a strong indicator of social and economic opportunities, including access to scarce resources (Attane 2002; Do et al. 2001; Korinek, Entwisle, and Jampaklay 2005; Korinek et al. 2006; Leinbach 2000; Rigg 2002). For instance, Korinek et al. (2006) assert that in China and Vietnam "poverty remains a disproportionately rural phenomenon" (197). Rigg (2002) further states, "for governments in Southeast Asia, the integration of marginal areas and populations is seen as a central, and in some cases even guiding, development objective…this is founded on the belief that poverty has a strong spatial component" (619).

The importance of place is further substantiated in the community research (Bell 1997; Brown et al. 2000; Marans and Rogers 1975; Wilkinson 1991). Wilkinson (1991) asserts that community is the *place* where individuals and society connect. Marans and Rogers (1975) argue that community satisfaction is "the subjective evaluation of objective conditions (services, ecology, and other things) in the *local* community and how they contribute to a person's overall quality of life" (Brown et al. 2000:429, emphasis added). Brown et al. (2000) expound upon

Marans and Rogers' argument through defining "community attachment" as "measuring one's sense of rootedness to a *place*" (430, emphasis added) and "community satisfaction" as "measuring how well one's community meets mass societal expectations" (430). The implication of these definitions is that an individual can indeed be stuck in a particular place without their societal needs being satisfied (Brown et al. 2000). Rootedness to place is potentially disadvantageous in a modern society to the extent that Rushdie (1991) claims modern life requires a "new [type] of human being" (124-125), people that root themselves in ideas versus places. Modern life requires physical mobility.

Physical Mobility

Physical mobility may mitigate the constraints of place and physical isolation and thus correspond to positive economic mobility through empowering individuals and groups to transcend the disadvantages of place in accessing scarce resources (Leinbeck 2000; Rigg 2002; Wilson 1966). Specifically, in urban and rural locations of developing nations, but especially in rural areas, physical mobility has the potential to increase access to scarce resources such as education and occupational opportunities (Leinbeck 2000; Rigg 2002) as well as facilitate the "flow of new ideas and belief systems" (Rigg 2002:620). At a minimum, physical mobility for the purpose of increasing individual and household accessibility to scarce resources requires two components: 1) a public infrastructure in the form of useable roads (De Konick 2000; Kundstader 2000; Rigg 2002) and 2) vehicles (public and/or private) for individual use (Leinbach 2002; Repogle 1991). Roads increase mobility potential within all demographic regions, i.e. urban, sub-urban, and rural sectors; but their influence in increasing accessibility is most significant for suburban and rural populations whose mobility potential pertains to an increase in opportunity to enter urban locations (Leinbach 1983). Road access is especially

important in suburban areas as they compound the effects of mobility with proximity to urban locales (Leinbach 1983).

Conversely, insufficient access to urban marketplaces, institutions of education, and labor markets due to poor road infrastructure and lack of a vehicle represents a major obstacle preventing "the transformation and integration of the rural sector" (Leinbach 1983:350; see also De Konick 2000; Kundstader 2000; Olsson 2009; Rigg 2002). While many developing nations have invested in creating public roads in anticipation of acquisition of vehicles by individual citizens, unfortunately, in many such locations, inexpensive vehicles remain a problem (Leinbach 1983). The transportation literature shows that in the early- to mid-1980s there remained for families and individuals with limited financial resources a deficiency of economical, personally owned and operated vehicles in developing nations (Leinbach 1983, 2000; Repogle 1991). Lacking access to inexpensive, personally owned vehicle options cripples the potential physical mobility of individuals and families of lower socioeconomic status. Lack of transportation thus limits their access to labor markets and education opportunities. This is especially the case for individuals and families residing in rural locations (Leinbach 1983).

Physical mobility, particularly in situations in which transportation is a 'binding constraint', acts (as it can empower individuals by granting greater access to opportunities), as an agent of development (De Konick 2000; Kundstader 2000; Leinbeck 2000; Rigg 2002; Wilson 1966). "It is, of course, generally recognized among social scientists and development planners that transport has and will continue to play a critical role in development (e.g., Cooley 1894; Moavenzadeh and Geltner 1984; Owen 1987)" (LeinBach 2000:2). This critical role is augmented by access to owner operated transportation and affordable, reliable transport services (Leinbach 2000). The impact of owner operated transportation is demonstrated by the

stratification of benefits resulting from road creation in which poor village members experience a disproportionately lower degree of benefit from road construction as compared to members of the village elite (Howe 1994; Leinbach 2000). Thus, individuals with access to roads and vehicles to transport them are able to access options that otherwise would not be possible (Leinbeck 2000). Accordingly, what technologies exist which could offer economical, personally owned and operated vehicles to individuals and families of relatively limited economic resources?

Motorcycles—A Distance Demolishing Technology

Sometimes even the simplest of technological shifts can become the "engines" of social and economic change (Coolie 1894; Lenski 1984). Beginning in the mid-1990s, many Southeast Asian countries experienced dramatic increases in the number and availability of inexpensive motorcycles, in effect, moving their respective populations from pedestrian economies with a limited range of physical mobility to economies balanced on two motorized wheels and based on increased mobility and access to labor markets and educational opportunities. In Indonesia, between 1987 and 2009, the number of motorcycles in the country increased from 5.5 million to approximately 52.4 million with the most dramatic period of growth occurring from 1990 to 2009 at which time the number of documented motorcycles increased by approximately 893% (Badan Pusat Statistik 2009). During the same approximate period, the total amount of asphalted roads in Indonesia increased by approximately 52,000 kilometers (Badan Pusat Statistik 2009). These changes took place while the Indonesian population increased by only 15%. Similar trends occurred in Thailand and Vietnam. In Thailand, from 1999 to 2003 the total number of registered motorcycles increased from 13 million to 18 million and the motorcycle to car ratio increased from four motorcycles for every car to five (Center for Information and

Communication Technology 2004). And, in Vietnam, since 1990 motorcycles have increased by 1000% while population increased by only 24% (Hsu et al. 2003:15). In 2003, 95% of all registered vehicles in Vietnam were motorcycles (Hsu et al. 2003). Today, with few exceptions (Malaysia, Brunei, Singapore), motorcycles represent the primary means of personal transportation for both rural and urban populations throughout Southeast Asia.

Much of this dramatic growth, especially over the past 10 to 15 years, can be attributed to the increased availability of less expensive Chinese models. With access to one or more motorcycles in a household; members in that household become more geographically mobile and thus, may gain easier access to jobs, mass media, and educational opportunities. Most importantly, increased physical mobility should create dramatic shifts in social mobility, especially for young women, by shifting their opportunity costs at the household level (Leinbach 2000). "The focus on adequate transport within the changing dynamics of urban/rural relations is important as the household is restructured and becomes more diversified. Genders and generations renegotiate their respective roles" (Leinbach 2000:5).

Traditionally young women from rural regions in developing countries are engaged in "secondary" economic activities – those activities like planting and caring for a garden, watching livestock, etc., that save the household money versus making money (Cloud and Garret 1996). Yet given the opportunity, rural households, or pre-industrialized households, will almost always opt to have their members make money (McMichael 2004; Morgan and Hagewen 2005) in "primary" economic activities versus money-saving activities as an economic strategy if the opportunity costs are in their favor. McMichael (2004:92) states, "Rural families propel…their teenage girls into labor contracts, viewing their employment as a daughterly duty or a much-needed source of income." Despite this preference, transportation costs and/or the lack of a

transportation infrastructure have been, for many rural households in the developing world, a prohibiting factor (Leinbach 1983; Olson 2009; Repogle 1991; Rigg 2002). Consequently, young women tend to stay at home while their male siblings leave to pursue incomes (Cloud and Garrett 1996). When secondary economic strategies prevail in rural households, early first pregnancies in young women are at worst inconsequential for the households' economic strategies and may in fact be beneficial by providing more domestic labor for localized money-saving activities (Knodel et al. 1984; Morgan and Hagewen 2005). More specifically, Morgan and Hagewen (2005) follow Caldwell (1982) in suggesting that in pre-industrialized settings children were viewed as additional potential labors capable of increasing the flow of economic resources to the head of household. Under such conditions higher fertility rates are likely. Consequently, access to relatively inexpensive motorcycles should alter the economic strategies of rural households by decreasing overall transportation costs and increasing the opportunity costs of fertility (Leinbach 2000). Under such a scenario, women may be viewed in the household's economic strategy as important money-generators in the short-term if they can drive themselves to reasonably close labor markets or even in the long-term if they can access additional educational opportunities as a gateway to long-term career opportunities. Early and frequent pregnancies in these conditions would constitute a major disruption to the individual woman's and household's economic strategies.

Summary

The options and consequences of fertility have become central topics in both the economic development literature and feminist critique (Docquier 2004; Ekert-Jaffe and Stier 2009). Not only is control over one's fertility a primary indicator of personal autonomy; it also affects one's social mobility and social and economic status (Dharmalingam and Morgan 1996;

Docquier 2004; Ekert-Jaffe and Stier 2009; Korinek et al. 2006; Kravdal 1994; Morgan and Hegewen 2005). Furthermore, individual female fertility choices have significant effects for broader society. Delayed child bearing and lower fertility are two of the most important indicators of a country's economic progress (Docquier 2004; Korinek et al. 2006; Kravdal 1994; Lee and Mason 2009; Li and Zhang 2007; Palivos 1994). However, pursuit of theoretical models and indicators of female fertility transitions in developing countries is complicated as there is heavy debate between structural and ideational explanations of behavior within much of social science research; (Barber and Axinn 2004; Bongaarts and Watkins 1996; Knodel et al. 1984; Morgan and Hegewen 2005).

Amid the complication, two key concepts, *proximity* (Axinn and Yabiku 2001; Barber 2004; Korinek 2006; Zakharenko 2009) and *access* (Bacshieri and Falkingham 2009; Leinbach 2000), are frequently highlighted throughout the fertility transition literature (Bacshieri and Falkingham 2009; Barber 2004; Behrman et al. 2002; Feyisetan and Casterline 2000) in their association with access to scarce resources. The process of fertility transition (Axinn and Yabiku 2001) is mitigated by differential access to scarce resources, i.e. family planning, labor markets, educational opportunities, mass media, and non-familial social organizations; but access to these resources is further mitigated by one's relative proximity to them (Barber 2004; Leinbach 2000; Massey and Denton 1993; Pebley and Sastry 2004; Sampson and Morenoff 2006; Wilson 1987, 1999; Zakharenko 2009). Thus, a necessary next step in explaining changes in fertility[4] in rural

[4] Barber and Axinn (2004), Knodel et al. (1984), and Hirschman (1994) argue that answering the question "Why fertility changes?" (Hirschman 1994) requires a nuanced discussion of multiple theories, frameworks, and indicators. Hirschman (1994) demonstrates that no one theory, framework, or indicator fully explains changes in

[continued on following page]

regions of developing countries is to examine what types of interventions, technologies, and other mechanisms may help more physically and socially isolated rural women overcome their disadvantaged position (Korinek et al. 2006; Leinbach 2000; Rigg 2002).

One increasingly prevalent technology in the developing world that has yet to be examined for its potential to help isolated rural women is inexpensive motorcycles which may mitigate the disadvantages of lack of proximity by creating greater access to more urban locations, and thus affect fertility options and transitions of rural women in a developing country. I examine this in Indonesia and hypothesize that motorcycles will negatively affect fertility through enabling Indonesian women to transcend the constraints of place (Scott 2009). Motorcycle use should dramatically change the opportunity costs of households associated with travel and increase women's access to labor markets, educational opportunities, mass media, and non-familial social organizations and networks—all of which are identified as key indicators affecting fertility decisions and outcomes. I further hypothesize that these effects are observed more strongly for rural women than for their urban counterparts.

METHOD

I use datasets of cross-sectional survey interviews of the Indonesian Demographic and Health Surveys (DHS). The surveys were conducted in 1994, 1997, 2002, 2003 and 2007. These DHS samples are of ever-married women from Indonesia. The data were obtained through face-

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fertility. Accordingly, our intention is not to provide an all encompassing framework explaining fertility change, but to present motorcycles as an example of a "distance demolishing technology" (Scott, 2009), which, situated within the context of theories and frameworks supported in the literature, potentially functions as an indicator in fertility change.

to-face survey interviews conducted with women between the ages of 15 and 47 in 34 provinces of Indonesia using a formal survey instrument by trained interviewers and clustered random sampling. My analysis evaluates the relationship between motorcycle access and four separate dependent variables measuring female fertility: *Fertility Preference, Birth in the Past Year, Total Births in the Past 5 Years*, and *Total Births*. Using the variable *Fertility Preference* gives insight into how the various indicators in the analysis are associated with changes in respondent's attitudinal preference towards fertility while the three different variables of actual birth outcomes measured at different ranges of time give insight into short and long term relationships between fertility and the various indicators. The analysis is divided into two sections. Section 1 tests the hypothesis that there is a negative association between motorcycle access and fertility. This section is composed of multilevel mixed effects models with a total of four models[5] for each dependent variable. Section 2 tests the hypothesis that the relationship between motorcycle access and fertility varies according to a respondent's location of residence (Korinek et al. 2006) through examining interaction effects between cluster level motorcycle access and rural vs. urban residence.

Measures

Dependent Variables

The models in the analysis consist of a range of dependent variables[6]. *Fertility Preference* was record in the survey with the categories "have another," "undecided," "no more," "sterilize,"

[5] The four analyses differ according to the dependent variables tested. Accordingly, a different interpretation of my analysis is that I am testing one model with four different dependent variables.

[6] Descriptive statistics for both dependent and independent variables are located in Table 1.

and "infecund." For my analysis, I collapsed these categories into two groups comparing 1= "No More", 0 = everything else. *Birth in the Past Year* measures whether the respondent had a birth in the previous year and is coded 0=No, 1=Yes. *Total Births in the Past Five Years* is the respondent's total number of children born in the previous five years and is coded as a count variable. *Total Births* is the respondent's total number of children born at the time of the survey and is coded as a continuous variable.

(Table 1 about here)

Independent Variables

The impact of place is accounted for in my analysis with the variable *Rural vs. Urban Residence* which is a dichotomous variable coded as Rural = 0, Urban =1. The impact of physical mobility is accounted for in my analysis with variables concerning access to motorcycles. *Individual Level Motorcycle Access* is a dichotomous variable of ownership of, or access to, one or more motorcycles or motor scooters coded as 0 = No, 1 = Yes. *Cluster Level Motorcycle Access* is computed as the mean level of ownership of, or access to, one or more motorcycles or motor scooters within the respondent's survey cluster and represents a range of ratios from 0 to 1 with 0 = *Absence of Motorcycles* and 1= *Saturation of Motorcycles* (100% of respondents in the cluster have access to a motorcycle).[7] These variables constitute the potential "distance demolishing technologies" (Scott 2009) indicators in the analyses.

Multiple control variables are incorporated in the models. *Age* is the respondent's stated age and is a continuous variable. *Knowledge of Modern Contraception* is whether the

[7] Cluster Motorcycle Access were created using the Stata commands bysort and egen, e.g. bysort v001: egen Cluster Motorcycle Access = mean (Motorcycle Access).

respondent is aware of modern contraception methods and is a dichotomous variable with 0 = No, 1 = Yes. *Educational Attainment* is the ranked category a respondent completed in schooling and is coded as an ordinal variable, i.e. 0 = No School, 1 = Incomplete Primary, 2 = Complete Primary, 3 = Incomplete Secondary, 4 = Complete Secondary, 5 = Higher. *Labor Market Participation*[8] is broken down into dummy variables for multiple possible careers including: Professional, Clerical, Sales, Self Employed Agriculture, Services, Skilled Manual Labor and Unskilled Manual Labor. All are dichotomous and coded as 0=No, 1=Yes. Interaction terms for *Cluster Level Motorcycle Access* and *Rural vs. Urban Residence* are computed[9] and included within the second section of the analysis.

Models

The models consist of a range of dependent variables including continuous, binary, and count variables. Under the proper circumstances, it is appropriate for continuous dependent variables to be analyzed with Linear Regression. However, binary dependent variables, which "[do] not—and will not—follow a normal" (Hoffmann 2004:45) distribution, are most commonly analyzed using a Logistic Regression Model. Similarly, count variables, which generally follow a Poisson distribution, require either a Poisson or Negative Binomial Regression Model (Hoffmann 2004). Accordingly, I use the *xtmixed, xtmelogit, and xtmepoisson* commands in Stata (Statacorp 2009) to run the different models. These commands result in mixed effects Linear Regression, mixed effects Logistic Regression, and mixed effects Poisson Regression models and are applied in the analyses according to their appropriate use with the

[8] The final category for Labor Market Participation was dropped from the model.

[9] Interaction terms were created using the Stata command: c.ruralurban#c.cma.

dependent variable of interest in a given model. Using these commands results in multilevel mixed effects models which allows me to analyze both the within and between cluster effects of a variable (Mackinnon 2008)—this enables multilevel analyses to compare the effects between individual and cluster level variables in my models and alleviates some of the statistical problems associated with single level analyses which use cluster level data (Mackinnon 2008).

Each of the models in Section 1 follows the same structure. First, I explore the relationship between individuals' access to a motorcycle and fertility with hierarchal models which progressively control for more indicators of fertility transition. The final models constitute multi-level analyses in that they add an additional independent variable of interest: *Cluster Level Motorcycle Access*. The addition of this variable enables me to evaluate the effect of living in geographic clusters in which there are relative increases or decreases in access to motorcycles among the respondents in the cluster. This allows me to examine to what extent women living within geographic communities and/or social networks with greater access (on average) to distance demolishing technologies, such as motorcycles, influence fertility.

The first model examines the relationship between *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Fertility Preference* while controlling for the indicators established in the literature as ideational and structural indicators of fertility change. The model uses mixed effect logistic regression to evaluate the dependent variable *Fertility Preference*. The results for the analysis are presented in Table 2.

Model 2 examines the relationship between *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Birth in the Past Year* while controlling for the indicators established in the literature as ideational and structural indicators of fertility change. The model

uses a mixed effects logistic regression model to evaluate the dependent variable. The results for this analysis are presented in Table 3.

Model 3 examines the relationship between *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Total Births in the Past 5 Years* while controlling for the indicators established in the literature as ideational and structural indicators of fertility change. The model uses a mixed effects Poisson logistic regression model to evaluate the dependent variable. The results for this analysis are presented in Table 4.

The final model in Section 1 of the analysis examines the relationship between *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Total Births*. The model uses a mixed effects linear regression model to evaluate the dependent variable. The results for this analysis are presented in Table 5.

Section 2 of the analysis consists of a composite of all previously tested models with the addition of interaction terms for *Cluster Level Motorcycle Access* and *Rural vs. Urban Residence.* Each model in this section uses the appropriate mixed effects regression analysis for the dependent variable of interest in the model. The results for section 2 are presented in Table 6.

RESULTS

Fertility Preference

In the first model, I analyze the relationship between both *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Fertility Preference*. The analysis results are displayed as odds ratios and presented in Table 2.

The results presented in Model 4 of Table 2 suggest that after controlling for all other variables, there is a significant positive association between individual access to a motorcycle and the odds that a respondent reported she wants no more children. After controlling for all

other variables, the odds of wanting to have no more children as compared to all other categories are 7.3 percent[10] higher for respondents with access to a motorcycle as compared to those without access to a motorcycle. Furthermore, there is a significant positive association between a respondent's cluster's level of access to a motorcycle and the odds that a respondent would respond that they would like to have no more children, and the effect of clustered motorcycle access is stronger than that of individual motorcycle access. After controlling for all other variables, the odds that a respondent would respond that she would like to have no more children as compared to all other categories are 24.7 percent higher for respondents living in a cluster group with complete saturation of motorcycle access as compared to complete absence of motorcycle access. There is also a significant rural-urban effect on the odds of wanting to have no more children. The odds that a respondent would like to have no children are 5.3 percent higher among women living urban areas as compared to those living in a rural area after controlling for all other variables. The strongest indicator concerning whether a respondent reported a desire to have no more children was *Knowledge of Modern Contraception*. After controlling for all other variables, the odds that a respondent would respond that she would like to have no more children as compared to all other categories are 181 percent higher for respondents with knowledge of modern contraception. While the relationship between some of the control variables and fertility preference are positive as expected, although they are not always significant, e.g. *Unskilled Manual Labor*, many of the control variables do not behave as expected. However, the relationship between *Educational Attainment* and the labor participation

[10] Calculated using equation (100*[.891-1]) = 10.9

variables with *Fertility Preference* is negative and significant. This conflicts[11] with the theoretical argument that education acts a gateway to employment opportunities and that both have negative relationships with fertility. However, this conflict is mitigated in the *Total Births* analysis.

(Table 2 about here)

Birth in the Past Year

The model for *Birth in the Past Year* is presented in Table 3. This model analyzes the relationship between both *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Birth in the Past Year*. The results of this analysis presented in Model 4 of Table 3 suggest that after controlling for all other variables, there is a significant negative association between individual access to a motorcycle and the odds that the respondent had a birth in the past year. After controlling for all other variables, having access to a motorcycle was associated with a 5.1 percent decrease in the odds of having a birth in the last year. Furthermore, there is a significant negative association between the cluster level of access to a motorcycle and the odds that the respondent had a birth in the past year and this relationship is stronger than the relationship between individual access to a motorcycle and the odds that the respondent had a birth in the past year. After controlling for all other variables, living in a cluster group with complete saturation of motorcycle access as compared to complete absence of motorcycle access is associated with a 16.7 percent decrease in the odds that a respondent would have had a birth in

[11] *Educational Attainment* maintains a relationship to fertility that is in conflict with our theoretical understanding of the relationship between education and fertility for all models but *Total Births*. We address this issue in our discussion of the models.

the past year. Whether a respondent lives in an urban as compared to a rural location also has a significant negative association with the odds that the respondent had a birth in the past year. After controlling for all other variables, living in an urban area as compared to living in a rural area is associated with a 6.6 percent decrease in the odds that a respondent had a birth in the past year. The relationship between the control variables and the dependent variable *Birth in the Past Year* are generally negative as expected.

(Table 3 about here)

Total Births in the Past 5 Years

The next model analyzes the relationship between both *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Total Births in the Past 5 Years*. This analysis uses a mixed effects Poisson regression model. Final results for this analysis are presented in Model 4 of Table 4. After controlling for all other variables, having access to a motorcycle as compared to lack of access to a motorcycle is associated with 6.2 percent decrease in the total number of births in the past 5 years. The relationship between a respondent's cluster's level of access to a motorcycle and the total number of births in the past 5 years is also negative and this relationship is stronger. After controlling for all other variables, living in a cluster group with complete saturation of motorcycle access as compared to complete absence of motorcycle access is associated with a 18.3 percent decrease in the total number of births in the past 5 years. Whether a respondent lives in an urban as compared to a rural location has a negative association with the total number of births of a respondent in the past 5 years. After controlling for all other variables, living in an urban area as compared to living in a rural area is associated with a 1.6 percent decrease in the total number of births of a respondent in the past 5 years. The relationship between the control variables and the total number of births of a respondent in the

past 5 years is generally negative as expected although they are not always significant. The ideational indicators *Radio Use* and *Television Use* as well as the *Labor Market Participation* variables all have negative associations with fertility as anticipated and are significant except Professional and *Unskilled Manual Labor*. However, the control variables *Modern Contraception* and *Education Attainment* have positive associations which conflict with our theoretical understanding of the relationship between these indicators and fertility.

(Table 4 about here)

Total Births

The last model in our analysis examines the relationship between *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access* and *Total Births*. This analysis uses a mixed effects linear regression model. Final results for this analysis are presented in Model 4 of Table 5. An individual respondent having access to a motorcycle as compared to lack of access to a motorcycle is not a significant indicator in this model while a respondent's cluster's level of access to a motorcycle has a strong negative association with *Total Births*. Accordingly, after controlling for all other variables, living in a cluster group with complete saturation of motorcycle access as compared to complete absence of motorcycle access, is associated with a .580 unit decrease in a respondent's *Total Births*. Whether a respondent lives in an urban as compared to a rural location has a negative association with respondents' *Total Births*. After controlling for all other variables, living in an urban location, as compared to a rural location, is associated with a .12 unit decrease in a respondent's *Total Births*. The relationship between the control variables and the dependent variable *Total Births* is generally negative as expected although they are not always significant, e.g. *Unskilled Manual Labor*. The *Total Births* model is helpful in that it rectifies one of the concerns with our previous models—a respondent's level

of educational attainment now has a negative association with the respondent's fertility. In addition, the ideational indicators *Newspaper Use, Radio Use,* and *Television Use* as well as the *Labor Market Participation* variables all have negative associations of varying strength with fertility as anticipated. However, the control variable *Knowledge of Modern Contraception*[12] remains problematic.

Checks for model appropriateness were completed for all models. VIF scores checking for multi-collinearity, when necessary, were within acceptable ranges. AIC and BIC numbers decrease in almost all models[13] as the models have additional variables added to them suggesting that each new additional set of variables does contribute to a more appropriate model.

(Table 5 about here)

Interaction Effects

Interaction effects were created to measure the potential for varying levels of association between *Cluster Level Motorcycle Access* and the fertility variables as a consequence of a respondent's residence in either a rural or urban location. The previously discussed models demonstrate that both *Individual Level Motorcycle Access* and *Cluster Level Motorcycle Access*

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[12] *Knowledge of Modern Contraception* is negatively associated with fertility preference and whether a respondent has a birth in the past year or not, but is positively associated with the number of births respondent had in the last 5 years and the respondent's total births. Such results indicate that respondents' knowledge of modern contraception negatively affects their preferences for fertility and short term fertility outcomes, but, when significant, is positively associated with long term fertility outcomes. Thus, knowledge of modern contraception and the related decrease in preference for fertility does not translate to decreased fertility overall suggesting that knowledge of modern contraception does not necessarily correlate to use of contraception in limiting fertility.

[13] The BIC score for Birth in the Past Year increases slightly in Model 4 while the AIC score decreases as expected.

are predominately associated with a reduction in fertility and that living within an urban location is negatively associated with fertility which suggests that living in a rural area is positively associated with fertility. Rerunning our models with interaction effects allows us to test whether there is a significant difference between the association between motorcycle access and fertility for respondents residing in urban areas as compared to rural areas. Results for the models run with interaction effects are presented in Table 6.

(Table 6 about here)

The results for the models including interaction effects demonstrate that, under certain conditions, there is significant difference between the association of motorcycle access and fertility for respondents residing in urban areas as compared to rural areas. The associations between cluster level motorcycle access and fertility in the models for *Total Births in the Past 5 Years* and *Birth in the Past Year* are significant at the .001 level. However, the interactions in the models for a respondent's total births and whether or not they desire to have another child are not significant.

My prediction was that motorcycle access will have a stronger negative relationship to fertility in rural areas, but that this relationship would be relative. Converting the results from the model *Birth in the Past Year* into percentages results in a 27.7 percent decrease in the odds of a respondent having given birth in the past year after controlling for all other variables and when the respondent lives in a rural area where there is a saturation of cluster level motorcycle access. This compares to a 3.5% increase for respondents in an urban area where there is a saturation of cluster level motorcycle access. For urban residents, there is a small positive relationship between a respondent's cluster's level of access to a motorcycle and the odds of having given

birth in the past year. This contrasts with the results for rural residents, which is negative; furthermore, the odds of having given birth in the past year are 31.2 percent less for respondents in a rural versus an urban locations. The trend is continued in the *Birth in the Past Year* model.

The interaction effects demonstrated in the model for *Total Births in the Past 5 Years* are significant and further support my hypothesis. After controlling for all other variables, in rural locations a saturation of motorcycle access is associated with a 26.5 percent decrease in the number of births a respondent had in the past 5 years. This compares with the results for urban residents where, after controlling for all other variables, a saturation of motorcycle access is associated with a 3.4 percent decrease in the number of births a respondent had in the past 5 years. Such findings support my hypothesis that motorcycle access has a negative association to fertility in both urban and rural locations, but that this association is stronger in rural areas where there is greater potential for social isolation. Comparing the results, there is a 23.1 percent decrease in the number of births for rural resident as compared to urban residents in circumstances of complete cluster saturation of motorcycles.

DISCUSSION

The results documented in the fertility models generally support the hypothesis that "distance demolishing technologies" (Scott 2009:11) such as motorcycles are negatively associated with fertility—both fertility preference and fertility outcomes. The results also suggest that the relationship between motorcycle access and fertility is more pronounced in rural locations.

I hypothesized that motorcycles will demonstrate a negative association with fertility as it potentially creates opportunity costs to fertility, especially in rural locations, through increasing an individual's ability to access scarce resources, such as education and labor market

opportunities[14]—particularly in circumstances in which such opportunities are located beyond an individual's local community. The results in this thesis support the hypothesis that motorcycle access is predominately associated with a decrease in respondents' preference for continued fertility and a decrease in respondents' live birth outcomes. Results presented in Section 1 provide indirect support of this assertion. Individual level and cluster level motorcycle access is associated with reduced fertility while rural residence is associated with increased fertility. Section 2 adds additional direct support through exploring interaction effects between the variables *Rural vs. Urban Residence* and *Cluster Level Motorcycle Access*. For the variables *Birth in the Past Year* and Births *in the Past 5 Years* there are significant, negative interactions which suggest an association between decreases in fertility for respondents living in a rural location and a saturation of motorcycles in the respondent's cluster.

In line with the theoretical framework outlined in this thesis, I further hypothesized that motorcycle access will have greater influence on fertility when individuals live within communities or social networks with relatively higher access to motorcycles. The results for *Cluster Level Motorcycle Access* consistently support this prediction. Motorcycle access has stronger negative coefficients at the cluster level suggesting that living within communities or social networks with relatively greater aggregate access to these technologies will affect

[14] While not tested directly in the models incorporated in this thesis, results from two research articles in progress directly address the issue of whether or not motorcycles increase rural respondents' access to education and labor market opportunities. The results in both articles demonstrate a positive association between motorcycle access and access to these resources.

individual fertility preferences and outcomes above and beyond the degree to which individual level access affects fertility.

Comparing the strength of the coefficients for both the individual and cluster level variable for motorcycle access to those of the other control variables further substantiates my argument. The control variables in my models constitute many of the primary indicators of fertility change in the literature. The ideational variables *Newspaper Use*, *Radio Use*, and *TV Use* generally have significant relationships with fertility. However, the direction of the relationship between these variables and fertility fluctuates—they are positively associated with fertility preferences, but negatively associated with fertility outcomes. *Educational Attainment* is associated with a decrease in fertility in the *Total Births* model, but increases fertility in analyses of limited time duration[15]. The various dummy variables for *Labor Market Participation* predominately have negative relationships with fertility and are consistently significant. The coefficients of these control variables give evidence that the models in this thesis are predominately in agreement with the established literature. Establishing that the models are in agreement with similar models established in the literature is important; however, considering that the coefficients for motorcycle access, both individual and cluster level, are of comparable

[15] It is possible that the relationship between education attainment and fertility is dependent upon the time span of the fertility variable. The relationship is negative in the *Total Births* models, but positive in the *Birth in the Past Year* and *Births in the Past 5 Years* models. It could be that there is a lack of variance between the education and fertility in the time sensitive models, e.g. the total possible births in the *Birth in the Past Year* model is l and the total possible births in the *Births in the Past 5 Years* model is 5 with a mean average of .603 and standard deviation of .719. Compare these potential out comes to those in *Total Births* in which the total possible births in the sample is 16 and the mean average is 2.867 and standard deviation is 2.122.

strength and are at times of even greater strength to the variables which represent established indicators of fertility change in the current fertility literature suggests the significance of technologies such as motorcycles as potential new indicators in fertility change.

CONCLUSION

The intention of this research is not to provide an all-encompassing framework explaining fertility change (see Footnote 2). Rather, to present evidence to support the assertion that motorcycles constitute a "distance demolishing technology" (Scott 2009) which, situated within the context of theories and frameworks supported in the literature, potentially function as an indicator in fertility change. My findings support this premise—motorcycles are significantly associated with a decrease in desire for more children as well as a decrease with live births. In contrast, rural residence, as compared to urban residence, is associated with an increase in desire to have more children and an increase in live births. Consequently, through the implementation of interaction effects, the results of this thesis demonstrate that the impact of motorcycles in reducing fertility is greater in rural regions as compared to urban areas. This suggests that the impact of the motorcycles on fertility is connected to their functioning as "Distance Demolishing Technologies" (Scott 2009) through which they empower individuals to overcome the social isolation associated with rural residence. In as much as this thesis demonstrates that motorcycles do have a significant impact in affecting both fertility preferences and live birth outcomes, the implications of the findings in this thesis are substantial.

As stated previously, fertility is a central topic in both the economic development literature and feminist critique (Docquier 2004; Ekert-Jaffe and Stier 2009). Fertility is a primary indicator of personal autonomy and it also affects one's social mobility and social and economic status (Dharmalingam and Morgan 1996; Docquier 2004; Ekert-Jaffe and Stier 2009; Korinek et

al. 2006; Kravdal 1994; Morgan and Hegewen 2005). Furthermore beyond its impact on the lives of individual women, female fertility choices have significant effects for society. Delayed child bearing and lower fertility are two of the most important indicators of a country's economic progress as they are highly correlated with Gross Domestic Product and Gross National Income per Capita (Docquier 2004; Korinek et al. 2006; Kravdal 1994; Lee and Mason 2009; Li and Zhang 2007; Palivos 1994). Considering the importance of fertility as an indicator of social and economic progress for individuals and society, e.g. social mobility and status for the individual and social and economic development for a society; the findings of this thesis are significant in indicating the potential for distance demolishing technologies to function as engines of social change; specifically, social and economic development.

Additional "Distance Demolishing Technologies" (Scott 2009) such as cell phones and the internet deserve attention in accounting for the ability of individuals and their communities to overcome social and economic isolation and therein affect fertility change as these technologies, like motorcycles, may also change the opportunity costs of fertility, especially more isolated rural populations in the developing world. Furthermore, there is the potential that these technologies may assist individuals overcome social isolation associated with circumstances beyond just a rural urban divide. In as much as these technologies empower individuals to overcome social isolation, there is the potential that they function as indicators of social mobility, individual autonomy, and may even influence individuals' experience of community.

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Table 1. Descriptive Statistics

	N	Mean	St. Dev	Min	Max
Fertility Preference: No More	119356	0.40	0.49	0	1
Birth Past Year	119356	0.13	0.34	0	1
Births Past 5 Years	119356	0.59	0.71	0	5
Total Births	119356	2.86	2.11	0	16
Individual Level Motorcycle Access	118078	0.32	0.47	0	1
Rural/Urban	119356	0.35	0.48	0	1
Year	119356	6.39	5.05	0	13
Age	119356	33.38	8.40	15	49
Knowledge of Modern Contraception	119356	0.96	0.20	0	1
Newspaper Use	119259	0.22	0.48	0	1
Radio Use	119286	0.43	0.55	0	1
Television Use	119246	0.73	0.50	0	1
Education Attainment	119353	2.20	1.38	0	5
Professional	119266	0.04	0.20	0	1
Clerical	119266	0.02	0.14	0	1
Sales	119266	0.13	0.34	0	1
Self Employed Agriculture	119266	0.28	0.45	0	1
Services	119266	0.04	0.20	0	1
Skilled Manual Labor	119266	0.06	0.23	0	1
Unskilled Manual Labor	119266	0.00	0.03	0	1
Cluster Level Motorcycle Access	119356	0.33	0.25	0	1

Table 2. Estimates from Mixed Effects Logistic Regression Predicting Fertility Preference

	Model 1	Model 2	Model 3	Model 4
Constant	.019***	.008***	.008***	.008***
Individual Level Motorcycle Access	1.069***	1.096***	1.099***	1.073***
Rural vs. Urban Residence	1.0514*	1.072***	1.091***	1.053*
Survey Year	.994**	.994**	.995*	.991***
Age	1.118***	1.117***	1.119***	1.119***
Knowledge of Modern Contraception		2.808***	2.823***	2.810***
Newspaper Use		.964*	0.975	0.977
Radio Use		0.983	0.983	0.984
Television Use		1.059***	1.058***	1.054***
Education Attainment		.932***	.935***	.934***
Professional			.822***	.824***
Clerical			.675***	.673***
Sales			.838***	.837***
Self Employed Agriculture			.877***	.880***
Services			.614***	.610***
Skilled Manual Labor			.757***	.754***
Unskilled Manual Labor			1.021	1.018
Cluster Level Motorcycle Access				1.247***
n	118078.0	117855.0	117766.0	117766.0
df	6.0	11.0	18.0	19.0
AIC	141047.2	139938.9	139530.4	139511.6
BIC	141105.3	140045.3	139704.5	139695.4

Notes: *p < .05; **p < .01; ***p < .001

Table 3. Estimates from Mixed Effects Logistic Regression Predicting Whether or Not a Respondent Had a Birth in the Past Year

	Model 1	Model 2	Model 3	Model 4
Constant	3.943***	4.096***	5.486***	5.504***
Individual Level Motorcycle Access	0.965	.938**	.923***	.949*
Rural vs. Urban Residence	1.023	0.999	.910***	.934*
Year	0.998	.991***	.995*	0.998
Age	.898***	.901***	.907***	.907***
Knowledge of Modern Contraception		.868**	.871**	.876**
Newspaper Use		.942*	.916***	.915***
Radio Use		.924***	.915***	.925***
Television Use		.712***	.679***	.683***
Education Attainment		1.165***	1.115***	1.117***
Professional			.855**	.854**
Clerical			0.904	0.906
Sales			.498***	.499***
Self Employed Agriculture			.400***	.399***
Services			.402***	.404***
Skilled Manual Labor			.469***	.471***
Unskilled Manual Labor			.264*	.265**
Cluster Level Motorcycle Access				.833**
n	118078.0	117855.0	117766.0	117766.0
df	6.0	11.0	18.0	19.0
AIC	81694.1	81059.4	79336.7	79329.2
BIC	817.52.21	81165.9	79336.7	79513.0

Notes: *p < .05; **p < .01; ***p < .001

Table 4. Estimates from Mixed Effects Poisson Regression Predicting a Respondent's Total Number of Births in the Past 5 Years

	Model 1	Model 2	Model 3	Model 4
Constant	4.187***	3.477***	3.742***	3.775***
Individual Level Motorcycle Access	.937***	.919***	.915***	.938***
Rural vs. Urban Residence	0.987	.963***	.954***	0.984
Year	.996***	.992***	.993***	.997**
Age	.940***	.942***	.944***	.944***
Knowledge of Modern Contraception		1.161***	1.163***	1.168***
Newspaper Use		0.988	0.982	0.981
Radio Use		.929***	.930***	.929***
Television Use		.890***	.884***	.889***
Education Attainment		1.066***	1.052***	1.054***
Professional			0.974	0.972
Clerical			.912**	.915**
Sales			.804***	.805***
Self Employed Agriculture			.800***	.798***
Services			.659***	.663***
Skilled Manual Labor			.740***	.743***
Unskilled Manual Labor			0.801	0.805
Cluster Level Motorcycle Access				.817***
n	118078.0	117855.0	117766.0	117766.0
df	6.0	11.0	18.0	19.0
AIC	214866.8	213858.0	212779.8	212724.8
BIC	214924.9	213964.4	212954.0	212908.7

Notes: *p < .05; **p < .01; ***p < .001

Table 5. Estimates from Mixed Effects Linear Regression Predicting a Respondent's Total Number of Births

	Model 1	Model 2	Model 3	Model 4
Constant	-1.649***	-1.440***	-1.515***	-1.453***
Individual Level Motorcycle Access	-.193***	-.034**	-.034**	-.001
Rural vs. Urban Residence	-.448***	-.235***	-.227***	-.120***
Year	-.052***	-.048***	-.046***	-.036***
Age	.151***	.142***	.144***	.144***
Knowledge of Modern Contraception		.585***	.572***	.577***
Newspaper Use		-.145***	-.052***	-.054***
Radio Use		-.061***	-.037***	-.038***
Television Use		-.108***	-.063***	-.059***
Education Attainment		-.211***	-.201***	-.199***
Professional			-.404***	-.406***
Clerical			-.514***	-.511***
Sales			-.122***	-.120***
Self Employed Agriculture			-.049***	-0.051***
Services			-.346***	-.339***
Skilled Manual Labor			-.286***	-.282***
Unskilled Manual Labor			-0.218	-0.210
Cluster Level Motorcycle Access				-.580***
n	118078.0	117682.0	117766.0	117766.0
df	7.0	12.0	19.0	20.0
AIC	449933.8	444941.6	444779.6	444620.7
BIC	450001.5	445057.7	444963.5	444814.3

Notes: *p < .05; **p < .01; ***p < .001

Table 6. Multiple Mixed Effects Models Predicting a Respondent's Fertility with Interaction Effects

	Fertility Preference:	Birth in Past Year	Births in Past 5 Years	Total Births
Constant		5.646***	3.857***	-1.446***
Individual Level Motorcycle Access	1.073***	.947*	.938***	-.001
Rural vs. Urban Residence	1.076	.813***	.884***	-0.004**
Year	.991***	0.998	.997**	-.036***
Age	1.120***	.907***	.944***	.144***
Knowledge of Modern Contraception	2.087***	.883*	1.173***	.577***
Newspaper Use	0.977	.915***	0.981	-.054***
Radio Use	0.984	.925***	.929***	-.038***
Television Use	1.053***	.688***	.893***	-.059***
Education Attainment	.934***	1.117***	1.053***	-.199***
Professional	.824***	.853**	0.971	-.406***
Clerical	.673***	0.903	.912**	-.511***
Sales	.837***	.499***	.804***	-.120***
Self Employed Agriculture	.880***	.397***	.796***	-0.051***
Services	.610***	.404***	.662***	-.339***
Skilled Manual Labor	.754***	.471***	.742***	-.282***
Unskilled Manual Labor	1.018	.265*	0.804	-0.21
Cluster Level Motorcycle Access	1.273***	.723***	.735***	-.570***
Interaction CMA*R/U	0.948	1.431***	1.314***	-1.456
n	117766.0	117766.0	117766.0	117766.0
df	20.0	20.0	20.0	21.0
AIC	139513.2	79138.2	212691.6	444622.6
BIC	139706.7	79511.7	212885.1	444825.9

Notes: *p < .05; **p < .01; ***p < .001

Figure 1. The Inverse Relationship Between Gross Domestic Product (GDP) and Total Fertility