

On Gender and Growth

The Role of Intergenerational Health Externalities and Women's Occupational Constraints

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Abstract

This paper studies the growth effects of externalities associated with intergenerational health transmission, health persistence, and women's occupational constraints—with particular emphasis on the role of access to infrastructure. The first part provides a review of the evidence on these issues. The second and third parts present an overlapping generations model of endogenous

growth that captures these interactions, and characterize its properties. The model is then used to perform several gender-based or gender-related experiments—a reduction in the cost of child rearing, improved wage equality in the market place, and better access to infrastructure. The last part draws together the implications of the analysis for promoting the role of women in growth strategies.

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On Gender and Growth: The Role of Intergenerational Health Externalities and Women's Occupational Constraints

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Contents

- I. Introduction
- II. Overview of the Evidence
 - 1. Intergenerational Health Externalities and Health Persistence
 - 1.1 Intergenerational Health Externalities
 - 1.2 Health Persistence from Childhood to Adulthood
 - 2. Women's Labor Supply and Occupational Constraints
 - 2.1 Labor Market Participation Rates
 - 2.2 Infrastructure and Occupational Constraints
 - 3. Analytical Implications
- III. An Analytical Framework
 - 1. Home Production
 - 2. Time Allocation and Utility
 - 3. Market Activity
 - 4. Health and Productivity
 - 5. Government
 - 6. Market-Clearing Conditions
- IV. Women's Time Allocation and Growth
 - 1. Women's Time Allocation
 - 2. Balanced Growth Path
- V. Gender-Related Policy Experiments
 - 1. Reducing the Cost of Child Rearing
 - 2. Reducing Wage Gaps in the Market Place
 - 3. Improving Access to Infrastructure
 - 3.1 The Basic Transmission Mechanism
 - 3.2 Escaping a Mothers' Health-Based Trap
- VI. Implications for Growth Strategies

Appendix A: Other Channels through which Mothers Affect Child Health

Appendix B: Model Solution

References

Box 1: Preventing Mother-to-Child Transmission of HIV: Lesotho's Experience

Box 2: Channels through which Infrastructure Affects Growth: Education and Health

Box 3: Gender and Growth Effects of Natural Disasters

Box 4: Gender-Based OLG Growth Models

Figures 1 to 8

I. INTRODUCTION

The role of women in promoting growth and development continues to occupy center stage in policy debates. As documented in a number of studies, gender inequality (in terms of access to education, health, formal sector employment, and income) remains a significant constraint to growth in many countries.¹ On the one hand, the gender gap in educational attainment has gradually narrowed or moved in favor of women in some regions; and in many individual countries the gender gap in primary school enrollment has almost disappeared. According to the United Nations (2010) for instance, in 2007 over 95 girls for every 100 boys of primary school age were in school in developing countries, compared with 91 in 1999. In a study of four decades of birth cohorts covering the period 1940-80 for Latin America and Caribbean, Duryea et al. (2007) found that the gender gap in educational attainment has moved in favor of females at an average pace of 0.27 years of schooling per decade. On the other hand, however, 54 percent of girls in Sub-Saharan Africa still do not complete even a primary school education (Herz and Sperling (2004), UNICEF (2005)). In addition, progress towards gender equality in secondary schooling has been slower, and in some regions, gaps are widening. In Sub-Saharan Africa, the percentage of enrollment of girls compared with boys in secondary education fell from 82 percent in 1999 to 79 percent in 2007 (United Nations (2010)). Only 53 of the 171 countries with available data had achieved gender parity in both primary and secondary education during that period. At this rate, achieving the Millennium Development Goal of complete parity by 2015 appears to be out of reach for many countries (see World Bank (2010)).

Related in part to gender bias in education, in today's low- and middle-income countries the labor force participation rate for women is only 57 percent, compared to 85 percent for men (International Labour Office (2010)). In most regions female employment is concentrated in either services or agriculture, with fewer women than men employed in industry. Gender inequality in health remains large as well; maternal mortality rates in many developing countries have only declined marginally (United Nations (2010)). Combined with gender bias in the work place, the consequence is large pay differentials. According to data compiled by UNIFEM (2008), the gender pay gap ranges from 3 percent to 51 percent, with a global average of 17 percent. Seven out of ten of the world's poor are women or girls, so a focus on poverty reduction involves necessarily addressing their plight.

This paper focuses on two aspects of the debate on the role of women in growth and development: the role of inter- and intra-generational health externalities (namely, how mothers affect their children's health, and how health in childhood affects health in adulthood) and constraints on women's time allocation—particularly lack of access to infrastructure—and how, in turn, policy-induced changes in such allocation affect growth.² In line with the above evidence, much research on gender and growth in developing countries

¹See Blackden and Bhanu (1999), Blackden et al. (2006), Morrison, Raju, and Sinha (2007), Nallari and Griffith (2009), and Momsen (2009). Some of the recent evidence is further discussed in subsequent sections.

²Lazear (1983) provides one of the first systematic discussions of the concept of intergenerational externalities. A key point of his contribution was to draw attention to the negative externalities that may result when parents underinvest in themselves (both in terms of education and health) because they fail to consider spillover benefits to their children.

has focused on women's differential access to education, formal sector employment, assets, production technology, health care, and social institutions, as well as on how the relationship between gender and growth is mediated by women's labor force participation, productivity, and earnings. However, the transmission of health from mothers to children, coupled with the general issue of health persistence from childhood to adulthood (which is not gender specific), and the role of women's access (or lack thereof) to basic infrastructure services, has not been the subject of formal analysis. We integrate all of these issues in a three-period, gender-based overlapping generations (OLG) model of endogenous growth, and use the resulting framework to address the role of public policy.

The remainder of the paper proceeds as follows. Section II begins with a review of the evidence on the intergenerational transmission of health, and the persistence of health between childhood and adulthood. It continues with a review of the evidence on women's time use, with particular emphasis on how inadequate access to infrastructure constrains time allocation and market work. Section III presents our analytical framework. The solution of the model, in terms of women's occupational choices and long-run growth, is discussed in Section IV. A number of gender-related policy experiments (an increase in subsidies to child care, a reduction in the wage gap in the market place, and improved access to, and efficiency in the use of, public infrastructure), are discussed in Section V. The implications of our analysis for the role of women in the design of growth strategies in developing countries are discussed in Section VI.

II. OVERVIEW OF THE EVIDENCE

This section begins with a review of the evidence on the intergenerational (or vertical) transmission of health, and the persistence of health (or horizontal transmission) between childhood and adulthood. We pay particular attention to the transmission of HIV-AIDS from mothers to newborns, a widespread problem in Sub-Saharan Africa. It continues with a review of the evidence on women's time use, with particular emphasis on how access to core infrastructure services (or lack thereof) constrains time allocated to market and nonmarket activities.

1. Intergenerational Health Externalities and Health Persistence

1.1 Intergenerational Health Externalities

There is much evidence that a mother's health—which may itself depend on her level of education—affects directly the health of her children. In addition, to the extent that health in childhood affects health in adulthood, a mother's health today may determine the health of future mothers and their earning ability.

1.1.1 Mothers' Health Status and Child Development

It is now well documented that the children of inadequately nourished mothers are likely to suffer systematic negative effects—including low birth weight, stunted growth,

susceptibility to disease, and intellectual impairment. This may be due either to nutritional reasons (insufficient nutrition to the fetus) or physiological factors (the growth potential of a fetus may be constrained in a stunted woman). In turn, the potential damage to low-birth weight babies from being born undernourished is compounded when they remain undernourished during infancy and early childhood. A malnourished or anemic mother may be unable to produce the quality or the quantity of breast milk needed to help her low-birth weight baby; and without breast milk, an infant's immune system does not develop properly. It becomes prone to diseases such as malaria, respiratory tract infections, and pneumonia. Early weaning also puts a child at severe risk of infections and disease. In addition, to the extent that a malnourished mother has a low life expectancy, it may induce her to take her daughters out of school, because a shorter time horizon lowers the value of educational investments. This may lead to persistence in poor health for women, through the “education channel” discussed later.

Evidence that a mother’s poor health actually affects the health of their children *in utero*, that is, even before they are born, includes Lim et al. (2002) and Field, Robles, and Torero (2007). Lim et al. (2002) found that the nutritional status of Korean women in pre-pregnancy (with respect notably to folate, a B vitamin essential for cell growth and reproduction, as well as iron, and calcium intakes) affects pregnancy outcomes. In a study of Tanzania, Field, Robles, and Torero (2007) found that children who benefited from iodine supplements *in utero* exhibited higher rates of grade progression at ages 10 to 14. Furthermore, the effects appear to be substantially larger for girls, consistent with the evidence indicating greater cognitive sensitivity of the female fetus to *in utero* iodine deprivation. Thus, a mother’s lack of iodine intake during pregnancy may also help to explain gender differences in schooling, as discussed later.

A contrario evidence that low life expectancy for mothers may adversely affect their daughters’ health and education prospects is provided by Jayachandran and Lleras-Muney (2009), in a study of Sri Lanka between 1946 and 1953. They found that the increase in life expectancy of girls associated with a large drop in maternal mortality was accompanied (for every extra year of life expectancy) by an increase in female literacy of 0.7 percentage points and years of education by 0.11 years. Finally, there is also evidence that maternal *mental* health may have a sizable effect on child development, with maternal depression significantly increasing the odds that a child will experience growth faltering (that is, low height for age) and poorer education outcomes (see Das et al. (2009)).³

Another aspect of the mother-to-child transmission of health that has received much attention in recent years is related to the AIDS/HIV epidemic. As documented by the United Nations (2010), the number of women receiving treatment for prevention of mother-to-child transmission of HIV has increased threefold in recent years, from 15 percent in 2005 to 45 percent in 2008. There have been some notable successes in prevention, most notably in Lesotho (see Box 1). However, in 2008 only 21 percent of pregnant women worldwide were receiving HIV testing and counseling, while only one third of those identified as HIV-positive during antenatal care were subsequently assessed for eligibility to receive antiretroviral

³However, these associations could also reflect genetic links between parents and children.

therapy for their own health. These problems are most pressing in Sub-Saharan Africa, where the prevalence of HIV is, by far, the highest.

Box 1: Preventing Mother-to-Child Transmission of HIV: Lesotho's Experience

With nearly a quarter of its adult population living with HIV, Lesotho has one of the highest HIV prevalence rates in the world. Average life expectancy is just over 40 years. In recent years the country has launched a major effort to reverse the spread of HIV and to make AIDS prevention, treatment and care accessible to all.

Through its country-wide *Know your Status* campaign and a renewed national policy and strategic plan on HIV and AIDS, Lesotho has made significant progress in getting more people tested for HIV. At the same time, more of those in need are getting access to anti-retroviral (ARV) treatment. The most notable success, however, has been the country's rapid expansion of prevention of mother-to-child transmission (PMTCT) of HIV services.

In 2007, a massive effort was initiated to improve the country's PMTCT services. Every clinic in the country became able to provide HIV testing and treatment. Nurses were allowed to administer ARV treatments, thereby greatly expanding access to these interventions in the remote areas of the country, where fewer doctors are available. In 2006, only 5 percent of HIV positive pregnant women received PMTCT services; today, the coverage stands at 42 percent. Out of 207 health facilities around the country, 180 of them now provide PMTCT services.

However, initial efforts were met with a significant challenge—the fact that many women are likely to make only one visit to a health facility. Although ARV drugs can increase the chances that a baby is born free of the virus, providing HIV-positive mothers with the treatment is not easy, especially in remote areas. This is a typical problem for many health systems in Sub-Saharan Africa, and is caused by a variety of factors—cultural attitudes, distance, lack of transport (or poor infrastructure, as discussed elsewhere in the text) and poverty prevent many women from making regular antenatal care visits. Such factors also lead many women to drop out of the PMTCT programs, and to deliver their babies at home without the presence of trained medical professionals.

In response to these difficulties, new prevention methods were developed. The Government designed a minimum package for expectant mothers that includes the most effective ARV drugs and antibiotics needed to keep them, and their children, healthy. When they leave the clinic, these women are also provided with clear instructions on what medicines they need to take, and when, and what medicines they need to give to their babies after their birth. More recently, a new color-coded take-home box was introduced; instead of the nurses having to pack the medicines all in small pill bags, this “mother to baby pack” clearly separates the ARV drugs and the antibiotics according to when they need to be taken. This new approach may further reduce the number of babies born with HIV.

1.1.2 Mothers' Educational Status and Child Development

A mother's level of education also affects her children's health. A number of studies have found that mothers with higher levels of education have healthier children, even after controlling for variation in household resources, and that the education of mothers has a much

stronger effect on children's health than does the education of fathers.⁴ Better-educated mothers know more about the benefits of proper diet and hygiene; they are also more likely to seek medical care, ensure that their children are immunized, be better informed about their children's nutritional requirements, and adopt improved sanitation practices. In addition, these women may have better access to information about health care, and to be better able to process and act on the information that they acquire. As a result, infants and children of women with some formal education have higher survival rates and tend to be healthier and better nourished. A mother with a few years of formal education is also more likely to send her children to school—which in turn may improve their health, by allowing them to learn better hygiene practices.

The evidence for Sub-Saharan Africa for instance shows that children of mothers who receive five years of primary education are 40 percent more likely to live beyond age five, and educated mothers are about 50 percent more likely to immunize their children than uneducated mothers (see Morrison, Raju, and Sinha (2007)). McGuire (2006) found that the average number of schooling years for women has a statistically significant impact on the mortality rate of children under five. Kiros and Hogan (2001) for Ethiopia, Castro et al. (2006) for Guatemala, and Oloo (2005) for a larger group of developing countries, also found that female literacy tends to lower child mortality. Similarly, in a study of 47 Sub-Saharan African countries over the period 1999-2004, Anyanwu and Erhijakpor (2009) found that female literacy is significantly and negatively related to both infant and under-five mortality rates. A study that followed women for over 35 years in Guatemala showed that the benefits of mothers' schooling for their children's health are even greater than previously estimated from studies conducted at one point in time (Maluccio et al. (2009)). More generally, the educational attainment and cognitive development of children are positively affected by the educational attainment of parents, partly through improved health.⁵

There are a number of other ways through which maternal education benefits children, boys and girls alike. Better educated mothers may spend more *time* and *resources* on children's health and education ((Brown (2006)). Behrman et al. (1999), in a study of rural India, found that literate and better-educated mothers spend more time on children's school work. Educated women tend to have fewer children, which reduces dependency ratios and thus increases (all else equal) per capita consumption within households. In their study of Brazil, Lam and Duryea (1999) found a strong negative effect of women's schooling on fertility. Brazilian women with zero years of schooling give birth to 6.5 live children; this number declines to 3 for women with 8 years of schooling. Further, they argue that the effect of schooling on fertility works primarily through increased investment (including time) in child quality. As discussed in more detail in Appendix A, educated mothers may also have greater bargaining power within the household over intra-family allocation of monetary resources, be better able to act on their preference for investing in children, and have a greater impact on family decisions regarding the allocation of children's time to household chores

⁴See Hill and King (1995) and Glewwe (1999) for early surveys. See also Morrison, Raju, and Sinha (2007).

⁵For evidence on the positive effect of parental schooling on children's schooling, see for instance Lam and Duryea (1999).

(meal preparation and cleanup, doing laundry, ironing, dusting, and indoor home cleaning and maintenance, etc.).

However, some caution is needed in interpreting the link between mothers' education and children's health. First, it is not simply the completion of a certain number of years of schooling by mothers that may yield the benefits outlined earlier; rather, it is *literacy* that appears to drive the relationship between education and health outcomes. This means that school *quality* is what really determines the extent to which children may experience health benefits from their parents' education (see Lloyd (2009)). Moreover, if access to infrastructure is poor, even well-educated mothers may be unable to act upon their health knowledge and take their children to health facilities—an all too common problem in Sub-Saharan Africa (see Box 1). Second, there is evidence that better-educated women marry better-educated men; it is thus possible that the observed effect of women's education may also, to some extent, reflect unobserved preferences of their husbands for healthier or better-educated children (see Schultz (2002) and Duflo (2005)). A study of rural India, for instance, found that in a setting where educated women do not participate in the labor market, better-educated men are more likely to marry better-educated women (Behrman et al. (1999)).

1.2 Persistence from Childhood to Adulthood

There has been much research in recent years on the effects of early childhood influences on later life outcomes; studies include Case, Fertig, and Paxson (2005), Schady and Paxson (2007), and Smith (2008).⁶ In particular, it has been shown that events before five years old may have a very large long-term impact on adult outcomes: child and family characteristics measured at school entry do as much to explain future outcomes as factors that economists have more traditionally focused on, such as years of education. In a study based on data for Ecuador, Paxson and Schady (2007) for instance found that health measures such as height for age and weight for age are positively related to language development, a measure of cognitive ability. Perhaps more dramatically, Helmers and Patnam (2010) found, in a study of Andhra Pradesh, India, that child health at age one influences significantly cognitive abilities at age five.⁷

The persistent effect of health in childhood on health in adulthood appears to operate to a significant extent through its impact on educational attainment in childhood. Indeed, the available evidence suggests that protein-energy malnutrition during the early stages of a child's life can lead to permanent impairment of central nervous system functions. Folate and iodine deficiency *in utero*, as documented earlier, and iron deficiency during infancy, may also cause permanent neurological damage. An adult's physical work capacity is thus determined by his entire nutritional history. Consequently, health represents a key inter- and intra-generational mechanism through which poverty is transmitted: people born into poorer families experience poorer childhood health, lower benefits from investments in human capital, and poorer health in early adulthood, all of which are associated with lower

⁶See Currie (2009) and Almond and Currie (2010) for an overview of the literature on the role of health in the intergenerational transmission of socioeconomic status—with a focus, however, on industrial countries.

⁷They also find that child health at age one is influenced by parental care during pregnancy, consistent with our previous discussion.

productivity and earnings in middle age—when children themselves become parents. To the extent that health in childhood depend on the time that mothers allocate to their brood, health dependence gives a crucial role to mothers' time allocation in shaping the future of their children.

2. Women's Labor Supply and Occupational Constraints

2.1 Evidence on Women's Participation Rates

While participation of women in the labor force has increased in recent decades in almost all regions of the world, there are still significant gender gaps in participation rates, occupational levels and wages. As noted in the introduction, in today's low- and middle-income countries the labor force participation rate for women (the percentage of the women population aged between 15 and 65 years who are in the labor force) is only 57 percent, compared to 85 percent for men. The share of women above the working age who are employed (the employment-to-population ratio) was about 50 percent in 2009 compared to a male employment-to-population ratio of about 74 percent (International Labour Office (2010)). In the Middle East and North Africa adult labor force participation rates are below 30 percent, and in South Asia below 35 percent (see Table 1).⁸

Moreover, paid employment for women has expanded slowly and women continue to assume the largest share of unpaid work. Close to two-thirds of all employed women in developing countries work as contributing family workers or as workers on their own account, typically in forms of employment that are highly vulnerable and lack job security and benefits. In that sense, the relatively high labor force participation rates for women in East Asia and Sub-Saharan Africa documented in Table 1 do not tell the full story. Indeed, women's share of waged non-agricultural employment has increased in the last decade but only marginally; the share of women in the agricultural labor force exceeds 45 percent in Sub-Saharan Africa and South East Asia and the Pacific (Figure 1). In most regions female employment remains concentrated in either services or agriculture, with fewer women than men employed in industry (ranging from 7 to 23 percent, compared to 12 to 34 percent for men). The only region where men and women have similar patterns of employment by sector, both in relative composition and in trend, is East Asia and Pacific. There is also considerable variation in the gap between the proportions of males and females participating in the labor market in some regions, especially Asia and Sub-Saharan Africa (Figure 2).

⁸Studies based on data pertaining to both developed and developing countries suggest the existence of a U-shape relationship between labor force participation and the level of income per capita, with participation being the highest in the poorest and richest countries (see Mammen and Paxson (2000)). Box 4 discusses a possible rationale for this pattern, based on Galor and Weil (1996).

Table 1
Labor Force Participation Rates for Adults, World and Regions, 1999-2009

Males	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*
World	79.2	79.0	78.8	78.6	78.4	78.2	78.1	78.0	77.8	77.7	77.7
Developed Economies and European Union	70.4	70.3	69.9	69.5	69.2	69.0	69.1	69.1	69.1	69.2	68.6
Central and South-Eastern Europe (non-EU) & CIS	69.1	68.7	68.5	68.1	67.9	68.2	68.6	68.6	69.2	69.3	69.0
East Asia	83.5	83.1	82.7	82.2	81.6	81.0	80.5	80.1	79.6	79.3	79.4
South-East Asia and the Pacific	83.1	82.9	83.1	82.9	82.9	82.9	82.5	82.2	81.9	81.7	82.0
South Asia	82.9	82.7	82.6	82.5	82.4	82.2	82.1	82.0	81.7	81.5	81.6
Latin America and the Caribbean	80.7	80.4	80.1	80.0	79.8	80.0	80.1	80.3	80.1	80.1	79.7
Middle East	75.8	75.7	75.6	75.5	75.5	75.6	75.7	75.4	75.1	74.4	75.3
North Africa	76.4	76.2	76.0	75.9	75.8	75.8	75.7	75.7	75.5	75.5	76.4
Sub-Saharan Africa	81.4	81.4	81.3	81.3	81.2	81.2	81.2	81.1	81.1	81.2	81.2
Females	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*
World	51.8	51.6	51.6	51.5	51.4	51.4	51.5	51.6	51.6	51.7	51.6
Developed Economies and European Union	51.8	51.9	51.9	51.9	52.0	52.0	52.4	52.7	52.8	53.2	52.9
Central and South-Eastern Europe (non-EU) & CIS	49.8	49.4	49.7	50.1	49.9	49.7	49.9	50.2	50.5	50.7	50.6
East Asia	69.9	69.6	69.2	68.8	68.3	67.9	67.5	67.1	66.8	66.6	66.5
South-East Asia and the Pacific	58.0	57.5	57.7	57.4	57.3	57.1	57.2	57.0	57.2	57.4	57.4
South Asia	34.3	34.1	34.0	33.9	33.9	33.8	34.2	34.6	34.8	35.1	34.9
Latin America and the Caribbean	46.6	46.8	47.0	47.9	48.3	49.3	50.0	50.8	51.0	51.6	51.7
Middle East	22.6	22.8	23.1	23.4	23.7	24.1	24.4	24.6	24.8	24.9	25.4
North Africa	26.6	26.6	26.2	26.3	26.7	26.9	26.9	27.1	27.3	27.5	27.4
Sub-Saharan Africa	60.4	60.8	61.1	61.3	61.5	61.6	61.8	61.8	61.9	62.1	62.6

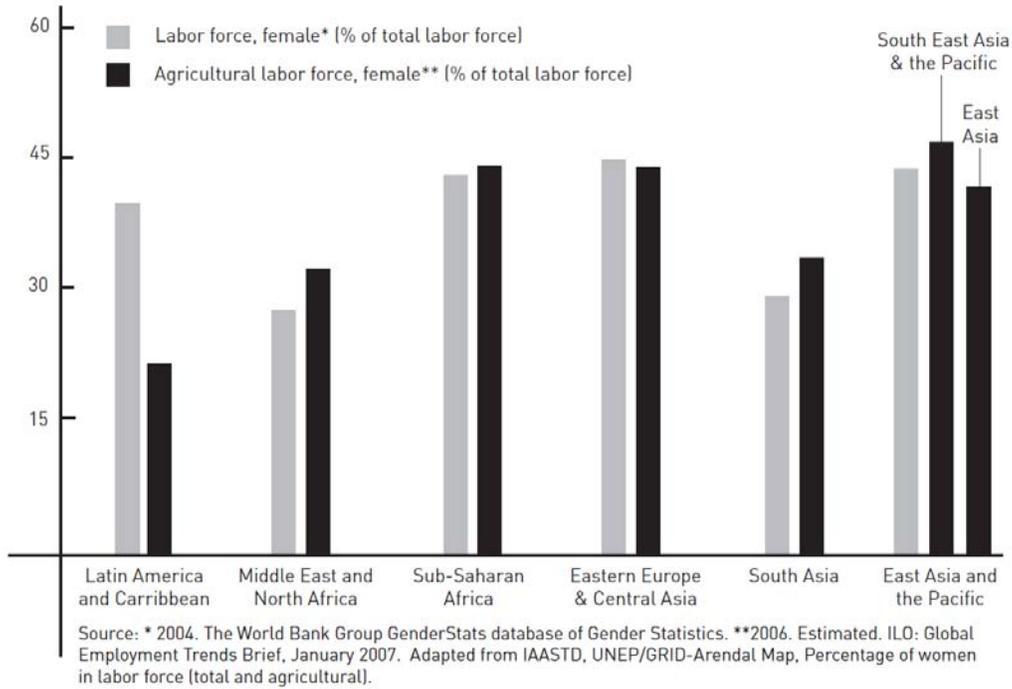
*Preliminary.

Source: ILO, *Global Employment Trends*, January 2010 (p. 50).

There are a number of reasons that explain why women in developing countries, in general, have significantly lower labor force participation rates than men. They include social norms and religious beliefs, which often translate into women devoting more time to household production activities than men.⁹ In what follows we focus on the constraints in access to infrastructure.

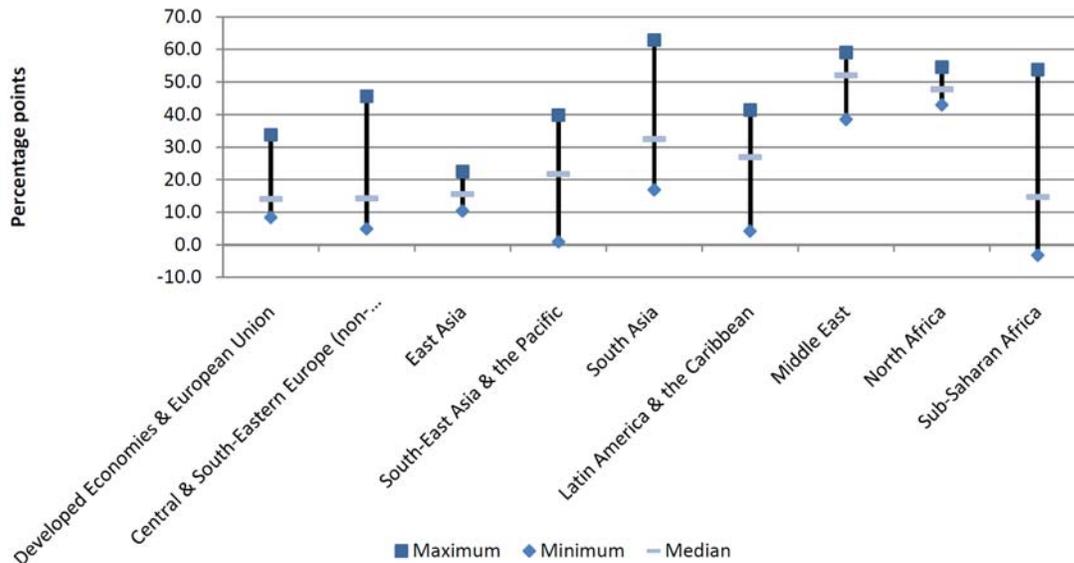
⁹See for instance Kevane and Wydick (2001) for the case of Burkina Faso and Ilahi and Grimard (2000) for an overview. There is also evidence that, despite reductions in gender gaps in the workplace and large increases in female labor participation rates, women in some industrial countries continue to spend nearly twice as much time on housework than their male counterparts. See for instance Schaffnit-Chatterjee (2009) for Germany. At the same time, as documented by Del Boca and Locatelli (2006), although mothers may continue to devote more time to childcare than fathers, the gender gap has fallen in several industrial countries and husbands' contribution to home production has become more relevant.

Figure 1
Percentage of Women in Total and Agricultural Labor Force



Source: Mehra and Rojas (2008).

Figure 2
Male-Female Gaps in Labor Force Participation Rates
Regional Minimum, Maximum, and Median, 2008
(Percentage Points)



Source: ILO, *Global Employment Trends*, January 2010 (p. 13).

2.2 Women’s Occupational Constraints

Women in developing countries face a number of constraints on the allocation of their time between market and nonmarket activities. There are various factors, including cultural and social norms that may account for them; in many countries, cultural norms are that women are expected to continue to do most of the housework and childrearing—even if they engage in market work full time.¹⁰ This tendency is often exacerbated by a lack of government programs to alleviate constraints associated with child care.

In what follows we will focus on access (or lack thereof) to infrastructure. The role of infrastructure in promoting growth in developing countries has been the subject of renewed scrutiny in recent years (see Box 2).¹¹ While many of the “new” channels through which infrastructure may affect growth are not gender specific, some of them do affect disproportionately women and their ability to allocate their time. In what follows we provide a brief review of some of the empirical evidence on how constraints on access to transport infrastructure, water and sanitation, and electricity, affect women's time allocation.

Box 2: New Channels through which Infrastructure Affects Growth

In addition to the conventional positive effects on factor productivity and private investment, and possible adverse effects through crowding out, recent research and evidence on the role of infrastructure in the growth process has highlighted a significant impact on health and education outcomes.

Indeed, a number of studies have found a direct positive impact of various types of infrastructure services (namely, roads, electricity, water and sanitation, and telecommunications) on learning indicators, for boys and girls alike. A better transportation system (particularly in rural areas) helps to raise school attendance. Similarly, greater access to safe water and sanitation in schools tends to raise attendance rates (especially for girls) and the ability of children to learn, by improving their health. Access to electricity helps also to improve the learning process, by allowing children to spend more time studying and by providing the opportunity to use electronic learning devices.

Infrastructure may have a sizable impact on health outcomes as well. Access to safe water and sanitation helps to reduce infection risks, particularly among children. Better transportation networks contribute to easier access to health care, especially in rural areas. Access to electricity, by reducing the cost of boiling water, helps to improve hygiene and health as well. Availability of electricity is essential for the functioning of health care facilities and the delivery of health services. Getting access to clean energy for cooking in people's homes (as opposed to smoky traditional fuels, such as wood, crop residues, dung, and charcoal) improves health outcomes by reducing indoor air pollution and the incidence of respiratory illnesses (such as asthma and tuberculosis), and low birth weight and infant mortality (see World Bank (2008)). According to some estimates, indoor air pollution from

¹⁰See for instance Thambiah (2009) for a discussion of the case of Malaysia.

¹¹Agénor (2010a, 2010b, 2010c, 2011) provides a more extensive review of these channels, which include, in addition to health and education (as discussed in Box 2), an effect on the durability of private capital, network externalities, and an impact on innovation. For a more “conventional” review of the role of infrastructure, and a general perspective on policy options for Sub-Saharan Africa, see Foster and Briceño-Garmendia (2010).

the burning of solid fuels kills over 1.6 million people (predominantly women and children) a year.¹² More efficient electric (or solar-powered) stoves would reduce this death toll, which is almost as great as that caused by unsafe water and sanitation, and greater than that the one million people killed every year by malaria.

2.2.1 Transportation

Lack of roads and other transport infrastructure constrains the ability of women to travel to perform activities related to household production and income-generating activities. They often end up traveling on foot, while at times carrying heavy loads. As documented by Riverson et al. (2006) for instance, in Ethiopia, 73 percent of women's trips and 61 percent of their travel time is dedicated to meeting their household's energy, water, and food needs. On average, women in rural Sub-Saharan Africa spend between .9 and 2.2 hours per day on transporting water and firewood (see Weiss (1999) and Blackden and Wodon (2006)); they travel on average between 1 and 5km per day on foot for 2.5 hours, while carrying a load of about 20kg (Riverson et al. (2006)).

Women also depend on transportation for health care, for themselves and their children. In many countries in Sub-Saharan Africa, a majority of women in rural areas rank distance and inadequate transportation as major obstacles in accessing health services (African Union (2005)). Women may have to travel long distances sometimes to reach obstetric care, and may die or lose their babies as a result (see Mills et al. (2007)). As discussed in Box 1, lack of transportation is one of the reasons why women with HIV/AIDS in Lesotho fail to visit health facilities often enough to seek treatment. Thus, lack of access to transport infrastructure not only constrains time available for market-related activities but may also have direct adverse implications for women's health—and thus their productivity and earning potential.

2.2.2 Water and Sanitation

Women in low-income countries allocate a considerable amount of time to collecting water for household production (see Isha (2007) for an overview). In Pakistan, women allocate an average of 27 hours per month—or approximately 15 percent of their monthly work time—to this activity (Ilahi and Grimard (2000)). In Madagascar and Benin, women spend 164 hours per year and 273 hours per year, respectively, collecting water; this corresponds to 14 and 23 hours a month, or 8.8 percent and 14.4 percent, respectively, of monthly working time (Blackden and Wodon (2006)). In Kenya, as documented by d'Adda et al. (2009), women devote 3.8 hours a week collecting water (compared to 1.3 for men), or equivalently 15.2 hours a month (compared to 5.2 hours a month for men). In Guinea, lack of access to water also imposes a very high time cost on women (Bardasi and Wodon (2009)). More

¹²For instance, in a study of rural Orissa, India, Duflo et al. (2009) found that over 72 percent of all households in India and 90 percent of households in the country's poorer, rural areas use traditional solid fuels, such as crop residue, cow-dung, and firewood to meet their cooking needs; they also found a high correlation between using a traditional stove and having symptoms of respiratory illness, although the direction of causality is not easy to establish.

generally, the WHO estimates that 40 billion “woman-hours” are spent carrying water in Africa annually (see Temin and Levine (2009)).

Lack of access to water and sanitation (combined with poor access to transportation services) may also have an adverse, indirect effect on education outcomes for girls—especially in rural areas. Studies have indeed found that when sanitation facilities are lacking, dropout rates for girls tend to be higher.

2.2.3 Electricity

A number of studies have shown that lack of access to electricity acts as a significant constraint on women’s time, by forcing them to rely on fossil fuels and to devote less time to income-generating activities, rearing children and furthering their education, and accessing health care for themselves and their children. For instance, Ilahi (2001) found that women living in rural Peru who rely on firewood or coal as a source of energy tend to allocate a smaller proportion of their time to self-employment activities and a greater proportion of time to housework, compared to women who use gas or electricity. In Kenya, as documented by d’Adda et al. (2009), women devote 2.7 hours a week collecting firewood (compared to 0.3 for men), in addition to the almost 4 hours a week that they spend collecting water.

Lack of access to electricity may also hamper the ability of women to take care of their own health and the health of their children, both directly and indirectly.¹³ Infants’ and children’s health may be adversely affected because of greater exposure to indoor air pollution produced by the burning of fossil fuels (as discussed in Box 2), or greater exposure to bacteria and parasites due to lack of refrigeration of food and boiling of water. Lack of access to electricity may also affect child health outcomes by increasing the amount of time that women allocate to home production activities and reducing the amount of time that they can devote to raising their children and engaging in market work—which reduces (as noted earlier) the ability of mothers to generate income.

To the extent that it leads to more intensive use of wood charcoal, and thus to environmental degradation, lack of access to electricity may contribute to a larger work burden for children. In turn, children who spend more hours on resource collection work are less likely to go to school; this is particularly so for girls. This means that environmental degradation affects children’s school performance, but the impact on girls may be much more damaging. It has been argued that this may be one explanation for the increased gender gap in education in Malawi (Nankhuni and Findeis (2003)).

3. Analytical Implications

The evidence reviewed in the previous subsections has important analytical implications for understanding and modeling the links between gender and growth. First, to

¹³Wang (2003) found that access to electricity had the greatest impact on decreasing infant mortality in poor countries compared to other significant variables, namely income, access to water and sanitation, vaccination in the first year of life, and the share of health expenditures to GDP. Similarly, access to electricity explained 64 percent of the variation in mortality among children under five.

the extent that children's health depends on their mother's health and the time that they allocate to child rearing, and that health in childhood is an important determinant of health in adulthood, women's time allocation plays a crucial role in determining health outcomes, productivity and wages in adulthood, and the overall growth process. Second, when women lack access to core infrastructure services, they must allocate a greater proportion of their time to household chores. This is vividly illustrated in the aftermath of major shocks, such as earthquakes (see Box 3).¹⁴ The opportunity costs of poor infrastructure for women include wage labor, acquiring an education, and investing in their own health and the health of their children. Thus, to a significant extent, the gender gap in employment and wages in adulthood may result from women's lack of access to infrastructure.

Box 3: Gender and Growth Effects of Natural Disasters

The loss of life and the material destruction caused by natural disasters is often staggering. The January 2010 earthquake in Haiti is a case in point. Understandably, the initial efforts focused on helping survivors cope with their immediate needs. But strikingly absent from some of the initial, longer-term reconstruction plans aimed at putting the country on the path to recovery was any discussion of what should specifically be done to support Haitian women in the months and years ahead.

When it comes to taking lives, earthquakes are gender-blind; but in poor countries their consequences, often, are not. In Haiti, there is little doubt that the earthquake has put women in a more precarious position compared to men. Research on women's time allocation, infrastructure, and economic growth (as discussed in the text) suggests that there are two main reasons why this largely hidden cost may have potentially serious implications for the country's longer-term economic recovery.

The first is that women in Haiti, as in many other developing countries, bear the brunt of household chores, such as collecting water and fuel; the destruction of most of the country's (already weak) road infrastructure forced them to allocate even more of their time to these activities. In the immediate aftermath of the quake, some women in Port-au-Prince were spending up to 4 hours a day collecting water; although the situation will improve over time, progress will only occur gradually. Damages to roads have also forced women living in rural areas to devote more time to taking their goods to urban markets. As a result, they have been forced to spend less time taking care of themselves and their children—with potentially serious long-term effects on their children's cognitive skills and brain development. In turn, lower educational achievements and lower productivity in adulthood, will act as a severe constraint on economic growth.

The second reason is that although the reconstruction effort will create many badly needed jobs in construction and related activities, many of them, by their very nature, will go to men. Even though women (and their children) will benefit indirectly from male employment, the lack of job opportunities for them will weaken their earnings capacity; in turn, this may diminish their bargaining position in household decisions, with some possibly serious adverse effects (see Appendix A). In particular, empirical studies suggest that weaker female bargaining power renders women more vulnerable to intimate partner violence and often translates into less family resources being allocated to children's health and education. Poor health and educational outcomes in childhood will also have longer-run implications for the quality of the labor force and the country's growth prospects.

¹⁴Box 3 is based on an unpublished note by P.-R. Agénor and M. Agénor.

Helping women is thus not simply a matter of social justice (a desirable goal in and of itself); it is essential to promoting sustained growth in Haiti. From this perspective, and as discussed in this paper, specific measures designed to help women (in areas such as employment, health care, and education) must be implemented early on, at the inception of the recovery program—rather than assuming or hoping that the benefits of the reconstruction effort will somehow “trickle down” to them.

By implication, improved access to core infrastructure services may enable women to devote more time to market activity for instance, possibly reducing the gender gap and promoting growth. At the same time, it may lead to improved learning monitoring (in the case of electricity, for instance) as well as improved child care practices (including breast feeding), which may strengthen the health status of children and their ability to learn.¹⁵ Greater access to safe water and sanitation in schools may also raise attendance rates for girls. However, it is possible that the increase in time that women devote to market work come at the expense of time allocated to child care; if so, and given health persistence, the longer-run effects on growth could be mitigated, or possibly reversed—despite the fact that higher earnings may allow mothers to spend more on goods and medical supplies for their children. The key issue to address therefore is how an improvement in the quality and quantity of infrastructure affects, both directly and indirectly, the time women allocate to these various activities and how, in turn, changes in women's time allocation affect economic growth.

III. AN ANALYTICAL FRAMEWORK

While many studies have examined the relationship between gender, growth, and development, there have been few attempts to rigorously model the role of inter- and intra-generational (or vertical and horizontal) health externalities, and the impact of access to infrastructure on women's time allocation in this context. In this section we present a three-period, gender-based overlapping generations (OLG) model of economic growth with public capital that captures both of these aspects.¹⁶

¹⁵In developed countries, a number of studies have focused on how greater access to consumer durables (made possible by improved technologies and access to electricity) helped to “liberate” women from domestic production activities and led to dramatic increases in married female labor-force participation. Studies for the United States include Greenwood and Seshadri (2005), Greenwood et al. (2005), and Coen-Pirani et al. (2010); Cavalcanti and Tavares (2008) provide a cross-country analysis. Coen-Pirani et al., in particular, estimated the effect of household appliance ownership on the labor force participation rate of married women using micro-level data from the 1960 and 1970 US Censuses. The results show that the diffusion of household appliances contributed significantly to the increase in married women's labor force participation rates during the 1960s. It may also be an explanatory factor for the subsequent increase—today, 80 percent of college-educated women are in the labor force, compared to 62 percent in 1963; as of July 2010, women accounted for almost 47 percent of the work force and 51 percent of professional workers. However, the spread of contraception methods may have played an equally (if not more) important role in the latter expansion, by allowing women to postpone marriage and child bearing, and increasing their incentives to invest time in the acquisition of advanced skills.

¹⁶The model both simplifies—by excluding human capital aspects—and integrates the models in Agénor (2009) and Agénor and Agénor (2009), while focusing on different issues. A brief summary of the literature on gender-based OLG models is provided in Box 4. None of the existing contributions, however,

In the model, women's time is endogenously allocated not only to market work, but also to home production and child rearing. In most of the literature, time allocated to home production is usually ignored, whereas rearing time is typically considered exogenous. However, in the present context endogenizing mothers' rearing time is important because such time is *productive*—it helps to enhance children's health outcomes, as documented earlier. In addition, the model accounts not only for the productivity effects of public infrastructure (as in many other contributions) but also for its effects on the efficiency of mothers' time allocated to child rearing and home production. Through these channels, infrastructure may exert sizable indirect effects on long-run growth.

Box 4: Gender-Based OLG Growth Models

Gender-based OLG models of economic growth are relatively few; among the notable exceptions are Galor and Weil (1996, 2000), Momota (2000), Zhang et al. (1999), Lagerlöf (2003), Andreassen (2004), Greenwood et al. (2005), de la Croix and Vander Donckt (2010), and Cavalcanti and Tavares (2010).

In an important contribution, Galor and Weil (1996) assume that in adulthood men can perform two types of labor, “physical” and “mental,” whereas women can offer only “mental” labor. These postulated differences in abilities translate into differences in wages earned. The decision-making unit in the model is the couple, which decides on fertility and savings (and thus capital in the next period). In turn, family decisions depend on the level of capital, because the level of capital per worker changes women's relative wages. The reason is the assumption that capital complements mental labor more than it complements physical labor. Increasing women's wages decreases fertility by raising the (opportunity) cost of having children, and lower fertility raises the level of capital per worker.

For low levels of capital, female relative wages are low. Thus, women devote all their time to child rearing and bearing, and fertility remains constant. Once capital per worker is sufficiently high to induce women to join the labor force, there is a rapid decline in fertility. An extension of the model that introduces technology for having children produces an inverted U-shaped pattern of fertility, consistent with the evidence. Technology for having children improves with the level of income or capital per capita. Thus, at very low levels of income, couples have fewer children than they would like. As income increases, so does the number of children per couple. However, once capital per capita reaches a certain level, women join the labor force and fertility declines. Women's labor force participation rate presents a U-shaped pattern corresponding to this pattern of fertility (see Mammen and Paxson (2000)). At low levels of income, they work more than they would like. As income increases, female labor force participation decreases. Eventually, capital per capita is high enough to induce women to join the labor force again. An *exogenous* technical change explains why society may go from an equilibrium with low wages for women, high fertility, and low female participation in the labor market, to another equilibrium with higher wages for women, lower fertility, and greater female labor force participation.

Galor and Weil (1996) abstract from issues of child quality versus quantity and do not consider the relation between fertility, growth, and the gender gap in education; growth is exogenous and the basic unit of analysis is the couple; thus gender is treated only implicitly. By contrast, Zhang et al. (1999) provide a more explicit treatment in the context of an

accounts explicitly for the impact of public capital on growth, either directly, through production, or indirectly, through women's time allocation.

endogenous growth model. They extend the OLG model of Ehrlich and Lui (1991) to the choice of sons and daughters. In their model gender bias takes the form of parents directly choosing more boys than girls. A child's human capital accumulation is based on the total human capital of both parents, and parents act as teachers to their children. Thus, in accumulating human capital in any generation, the cross-gender effects of mothers on sons, and fathers on daughters, tend to dissipate any initial gender gaps in human capital in a long-run growth equilibrium; however, this may not occur in an economy with little human capital investments—implying that the gender gaps are “locked in” in a poverty trap for both men and women. However, they do not provide a full discuss of mothers' allocation of time.

De la Croix and Vander Donckt (2010) introduce several dimensions of gender inequality (including gender heterogeneity in parental time requirements) into a gender-based OLG model that encompasses a non-unitary representation of household decision-making. They characterize a Malthusian corner regime (with high fertility and large gender disparities in education) in addition to the interior growth regime. The low growth Malthusian equilibrium is characterized by strong gender inequality in education and high fertility. They show that reducing the social and institutional gender gap in economies trapped in the Malthusian regime does not help to escape from it. Reducing the wage gender gap does not help either. The key policy measures which most likely will ease these countries out are to promote mother's health and longevity and to curb infant mortality. However, their model remains incomplete, because it does not explain wage formation endogenously.

A contribution focusing more directly on the role of public expenditure is Cavalcanti and Tavares (2010). In their model, government spending affects households' choices with respect to fertility and female labor participation in the workforce because it helps to reduce the cost of child rearing and child care. If public spending reduces sufficiently the per child cost of raising children, it may induce mothers to engage further in the market work. However, they do not distinguish between the time allocated (per child) and the cost per child.

Formally, we consider an OLG economy where two goods are produced, a marketed commodity and a home good, and individuals live for (at most) three periods (denoted $t-1$, t , $t+1$): childhood, adulthood (or middle age) and retirement. The marketed commodity can be either consumed in the period it is produced or stored to yield capital at the beginning of the following period. Each individual is either male or female, and is endowed with zero units of time in childhood and old age, and one unit of time in adulthood. Children are born with the same innate abilities and depend on their parents for consumption and any spending associated with health care. All individuals, males and females, work in middle age; the only source of income is therefore wages in the second period of life, which serve to finance family consumption in adulthood and old age.

In adulthood, individuals match randomly into couples with someone of the opposite sex to form a family. All income is pooled, and couples therefore become joint decision makers.¹⁷ For simplicity, once married, individuals do not divorce; couples retire together (if they survive to old age) and die together. Rearing children involves both parental time and spending on marketed commodities to feed them and keep them healthy (medicines, hospital visits, etc.). Male spouses allocate inelastically all their time to market work. Due to exogenous factors (e.g. social or cultural norms), mothers incur the whole time cost involved

¹⁷Gender implications of nonunitary models of family resource allocation are discussed in Appendix A.

in rearing children; however, the *efficiency* of that time depends on access to infrastructure. In addition, they also consider two other alternatives in allocating their time: market work and home production.

The health status of children depends on their mothers' health and the time that mothers allocate to rearing them. In addition, health outcomes exhibit serial dependence, in the sense that health status (and productivity) in adulthood depends on health outcomes in childhood. This dependence, which is consistent with a number of studies (as discussed in the previous section), gives a crucial role to mothers' time allocation in determining the earning ability of their children in adulthood. We also introduce gender bias in the workplace, by assuming that due to "glass ceiling" effects women workers earn less than men.

At the beginning of the first period of life and the end of the second, there is a non-zero probability of dying. For simplicity, survival probabilities for men and women, in both childhood and adulthood, are taken to be the same.¹⁸ In addition to individuals, the economy is populated by firms and an infinitely-lived government. Firms produce marketed commodities using public capital in infrastructure as an input, in addition to male and female labor and private capital. Home production (which affects positively utility) requires both women's time and infrastructure services.

1. Home Production

Home production, which includes core household chores, involves combining women's time, in proportion $\varepsilon^{f,P}$, and infrastructure services. For simplicity, we assume that these factors are perfect substitutes and that production, Q , takes place under decreasing returns to scale:¹⁹

$$Q = [\varepsilon^{f,P} + \zeta^P (K^I/K^{P,T})]^\wedge (\pi^Q), \quad (1)$$

where K^I is the stock of public capital in infrastructure, $K^{P,T}$ the aggregate stock of private capital, $\pi^Q \in (0,1)$, and $\zeta^P \geq 0$ is a fixed efficiency parameter. Thus, greater access to roads or electricity allows mothers to devote less time to home production. Access to infrastructure is subject to congestion, measured by the stock of private capital, as discussed next.

2. Market Activity

Firms are identical and their number is normalized to unity. They produce a single nonstorable commodity, using male labor, $N^{m,i}$, and female effective labor, defined as $A^f \varepsilon^{f,W} N^{f,i}$, where A^f is average (economy-wide) female labor productivity, private capital, $K^{P,i}$, and public infrastructure. Although public capital is *nonexcludable*, it is *partially rival* because of congestion effects; congestion is taken to be proportional to the aggregate private

¹⁸Our analysis therefore does not account for observed differences in life expectancy between men and women, which tend to be positive at low levels of income (due to high maternal mortality), and negative at higher levels. This issue is left for future research.

¹⁹To economize on notations, the time subscript t is omitted when all variables in an equation are dated in period t only.

capital stock, $K^{P,T}$. To capture the gender gap in the firm, we assume that in each firm men have privileged access to technology-intensive positions.²⁰ A productivity gap therefore emerges between men and women, leading employers to pay men relatively more.²¹

The production function of individual firm i takes the form

$$Y^i = (K^I/K^{P,T})^\alpha (N^{m,i})^\beta (bA^f \varepsilon^{f,W} N^{f,i})^\beta (K^{P,i})^{1-2\beta}, \quad (2)$$

where $\alpha, \beta \in (0,1)$ and $b < 1$. The labor shares of men and women are assumed to be the same.²²

Profit maximization with respect to private inputs yields

$$w^m = \beta Y^i / N^{m,i}, \quad w^f = b\beta Y^i / A^f \varepsilon^{f,W} N^{f,i}, \quad (3)$$

$$r = (1 - 2\beta) Y^i / K^{P,i}, \quad (4)$$

where w^m is the male wage, w^f the effective female wage, and r the rental rate of private capital.

Given that all firms are identical, and that their number is normalized to 1, aggregate output Y is

$$Y = (K^I/K^P)^\alpha (N^m/K^P)^\beta (bA^f \varepsilon^{f,W} N^f/K^P)^\beta K^P. \quad (5)$$

Thus, if the ratios in parentheses are constant (as happens to be the case in the steady state) the private capital-output ratio will also be constant; they would grow therefore at the same (long-run) rate.

Assuming full depreciation, private capital accumulation is driven by

²⁰Large gaps in wages or hourly earnings between men and women, even after controlling for education and other forms of human capital are well documented, as mentioned in the introduction. One explanation frequently given for these wage gaps is the occupational segregation of women into low-paying and precarious employment. Indeed, in a cross-country analysis of the factors contributing to the gender pay gap, Corley et al. (2005) found that women are more highly segregated in low-skilled occupations than are their male counterparts. Our assumption about technology captures this segregation in an implicit manner.

²¹In Chichilnisky (2008), the gender gap is the result of a Nash equilibrium in a game with incomplete information about women's work at home and in the marketplace. In her model, expectations about women's lower wages lead to the overutilization of women in the household; this, in turn, leads to lower productivity and lower wages for women in the market place. Thus, inequity at home breeds inequity in the market place and, reciprocally, inequity in the market place leads to inequity at home. She also shows that although rational, this equilibrium is inefficient.

²²Based on the male and female labor participation rates shown in Table 1, one would expect these shares to be significantly different; Momota (2000), for instance, uses values of 0.5 and 0.2, respectively, in a calibrated model without public capital. The assumption that the shares are the same helps to simplify the derivations.

$$K^P(t+1) = I(t). \quad (6)$$

3. Time Allocation and Utility

At the beginning of adulthood in t , all men and women are randomly matched into married couples. Each couple has n children. A family raising a child faces two types of costs. First, mothers must spend $\varepsilon^{f,R} \in (0,1)$ units of time on each of them, because they take care of the child's health (going to the hospital for checkups and vaccination, etc.). Second, raising children involves costs in terms of marketed commodities. Specifically, it entails a fixed cost per child (regardless of gender) equal to a fraction $\theta^R \in (0,1)$ of the family's net income. This cost is related to taking care of their health needs, namely, buying medicines.²³ Thus, there is both a direct (private) cost to access to health services, and an indirect cost, in terms of foregone wage income and foregone consumption.

As noted earlier, $\varepsilon^{f,P}$ denotes the time women allocate to home production (which includes time spent collecting water and firewood, as discussed in the previous section). The time that mothers can devote to market activity is thus

$$\varepsilon^{f,W} = 1 - \varepsilon^{f,P} - p^C n \varepsilon^{f,R}, \quad (7)$$

where $p^C \in (0,1)$ is the probability of survival from childhood to adulthood.²⁴

Families consume both the marketed commodity and the good produced at home. Assuming that consumption of children is subsumed in their parents' consumption, the family's lifetime utility U is²⁵

$$U = \ln[c^{t-1}(t)] + \eta_Q \ln[Q(t)] + \eta_N \ln[p^C n(t) h^C(t)] + p^A (1+\rho)^{-1} \ln[c^{t-1}(t+1)], \quad (8)$$

where $c^{t-1}(t)$ and $c^{t-1}(t+1)$ are the family's consumption in adulthood and old age, respectively, h^C health status of a child, $\rho > 0$ is the discount rate, and $\eta_Q, \eta_N > 0$ are preference parameters. Actual family size (or net fertility rate) is $p^C n(t)$, which differs from the gross fertility rate, $n(t)$, because the child survival rate is less than unity. The term $p^C n(t) h^C(t)$ is thus the actual number of healthy children. For simplicity, in each family half of the children are daughters and half of them sons. This is a sensible assumption in a model where only monogamous relationships can occur.

Children die, if at all, at the beginning of the period; parents therefore incur rearing costs only on their children who survive into adulthood. The family's budget constraints for periods t and $t+1$ are given by²⁶

²³As in Olivetti (2006), we could introduce a CES "child care production function," which combines mothers' time and market goods; this would allow us to analyze the implications of the degree of substitutability between these two inputs. It could be assumed also that the unit cost θ^R is itself a function of a child's health.

²⁴To avoid convergence of population size toward zero, it is assumed that $p^C n \geq 1$.

²⁵For simplicity, only the marketed commodity is consumed in old age.

²⁶In standard fashion, we assume that there is an actuarially fair annuity market that channels savings to investment in physical capital, for production in the next period. With the annuity market, old-age survivors

$$c^{t-1}(t) + s(t) = [1 - \theta^R p^C n(t)](1 - \tau)w^T(t), \quad (9a)$$

$$c^{t-1}(t+1) = [1 + r(t+1)]s(t)/p^A, \quad (9b)$$

where $p^A \in (0,1)$ is the adult survival probability, $\tau \in (0,1)$ a constant tax rate, $s(t)$ savings, and $w^T(t)$ gross wage income of the family, defined as

$$w^T = w^m + \varepsilon^{f,W} a^f w^f, \quad (10)$$

where a^f is female labor productivity.

From equations (9a) and (9b), the family's consolidated budget constraint is

$$c^{t-1}(t) + p^A c^{t-1}(t+1)/[1 + r(t+1)] = [1 - \theta^R p^C n(t)](1 - \tau)w^T(t), \quad (11)$$

4. Health and Productivity

Health status in childhood, h^C , depends on the fraction of the family's net income spent on each child, the effective amount of time allocated to child rearing by the child's mother, on the mother's health, and the provision of health services by the government, H^G , which is congested by the aggregate stock of capital:

$$h^C = \theta^R \cdot (h^f)^\kappa \cdot [(\zeta^R \varepsilon^{f,R})^{\wedge v_C}] \cdot [(H^G/K^{P,T})^{\wedge (1-v_C)}], \quad (12)$$

where $\kappa \in (0,1)$ measures the impact of a mother's health on a child's health, $v_C \in (0,1)$, and ζ^R is an efficiency parameter, which depends on access to (congested) infrastructure:

$$\zeta^R = (K^I/K^{P,T})^{\wedge \pi^R}, \quad (13)$$

with $\pi^R \in (0,1)$. Thus, greater access to infrastructure allows mothers to devote less “raw” time to child care, while providing the same effective time.²⁷

We do not model explicitly the health status of males and their productivity, and assume instead that both are constant and normalized to unity.²⁸ By contrast, we assume that the health status of females in adulthood, h^f depends on their health status in childhood:

$$h^f(t) = h^C(t-1). \quad (14)$$

share the savings plus interest left by savers who die at the end of their adult life. The gross rate of return to saving is thus $[1+r(t+1)]/p^A$, instead of $1+r(t+1)$, as shown in (9b).

²⁷The congestion factor in both (12) and (13) can be justified by assuming that taking advantage of government-provided health services, and accessing roads and other infrastructure services, are hampered by a more intensive use of these services by private sector firms, as measured by the aggregate private capital stock (see Agénor (2009)). The results would not be affected qualitatively if instead congestion was measured in terms of aggregate output.

²⁸Thus, h^C in equation (12) should be viewed as referring to the health of daughters.

This specification is consistent with the evidence reviewed earlier, which suggests that early childhood health affects cognitive and physical development, which in turn affects health outcomes later in life.

Female productivity, a^f , is a linear function of health status:²⁹

$$a^f = h^f. \quad (15)$$

Thus, a mother's health affects a child's health, which in turn affects the health and productivity—and thus earning capacity—of the child in adulthood. A child's health also affects eventually the health of their future children, and so on. As a result, there is serial dependence in health: the (average) health of a mother today depends on the (average) health of a mother yesterday. Crucial for the analysis is the magnitude of κ in (12); in what follows we will consider separately the cases where $\kappa = 1$ and $\kappa < 1$.

5. Government

As noted earlier, the government taxes only the wage income of adults. It spends a total of G^I on infrastructure investment, G^H on health, and G^U on other (not directly productive) items. All its services are provided free of charge. It cannot issue bonds and must therefore run a balanced budget:

$$G = G^I + G^H + G^U = \tau(w^m N^m + w^f A^f \varepsilon^f W^f N^f). \quad (16)$$

Shares of spending are all assumed to be constant fractions of government revenues:

$$G^h = \nu_h \tau(w^m N^m + w^f A^f \varepsilon^f W^f N^f), \quad h = I, H, U \quad (17)$$

where $\nu_h \in (0,1)$ for all h . Combining these equations therefore yields

$$\sum \nu_h = 1. \quad (18)$$

Assuming again full depreciation for simplicity, public capital in infrastructure evolves according to

$$K^I(t+1) = G^I(t). \quad (19)$$

The production of health services by the government is taken to be linear in public spending on health services:³⁰

²⁹For recent evidence on the positive link between health and productivity (as proxied by wages), see for instance Kedir (2009) for Ethiopia. He also finds evidence of nonlinearity, with the effect of health becoming stronger above a certain level. The analysis could be easily extended to account for decreasing marginal benefits of health.

³⁰As in Agénor (2008a, 2008b, 2009), and consistent with the evidence in Box 2, it could be assumed that the production of health services depends also on access to public capital in infrastructure.

$$H^G = G^H. \quad (20)$$

6. Market-Clearing Condition and Population Growth

The asset-market clearing condition requires equality between savings and investment, or equivalently, that tomorrow's private capital stock be equal to today's savings by adult workers. Given that s is savings per family, and that the number of families is $(N^m + N^f)/2$, we have

$$K^P(t+1) = 0.5(N^m + N^f)s(t) = N^f s(t). \quad (21)$$

The number of adults alive in period t is itself given by

$$N(t) = p^C n(t-1)N(t-1), \quad (22)$$

that is, the number of children born in period $t-1$, $n(t-1)N(t-1)$, who survived to period t .

Thus, there are two concepts of gender inequality in the model: a *time allocation gap* to market work between adult men and women, measured by the ratio $1/\varepsilon^{f,W}$; and a *core wage gap* in the market place, as measured by the parameter b . The first gap is endogenous and corresponds to the (*market*) *participation gap* in de la Croix and Vander Donckt (2010), for instance. However, because $\varepsilon^{f,W}$ is determined residually in our setting, it also reflects gender bias in the allocation of time to *home activities*—household chores and child rearing. Both measures can be viewed as pertaining to the concept of “economic participation and opportunity” for women incorporated in the Global Gender Gap Indicator proposed by the World Economic Forum (2010).³¹ Most importantly, in our analysis, the time allocation gap is influenced by access to infrastructure, which affects the efficiency of time allocated to home production and child rearing.

IV. WOMEN'S TIME ALLOCATION AND GROWTH: EQUILIBRIUM

An equilibrium of the economy requires the existence of a time sequence of prices, consumption in adulthood and in old age, physical capital stocks and female health status such that, given initial capital stocks $K^P(0)$ and $K^I(0)$ and initial health statuses $h^C(0)$ and $h^f(0)$, individuals maximize utility, firms maximize profits, markets clear, and the government budget is balanced. Individual and aggregate quantities must also coincide, so that $K^P = K^{P,T}$ and $a^f = A^f$. In addition, in a balanced growth equilibrium, consumption and capital (both public and private), and output grow at the constant, endogenous rate γ , the rate of return on private capital is constant, and health statuses of children and adult females are either constant

³¹In the Global Gender Gap report (2010), the size of the gender gap is measured based on four dimensions of inequality between men and women: economic participation and opportunity (including salaries, participation levels, and access to high-skilled employment); education attainment (including access to basic and higher-level education); political empowerment (including representation in decision-making structures); and health and survival (including life expectancy and sex ratio).

or grow at a constant rate. We now characterize the solution of the model, beginning with implications for women's time allocation.

1. Women's Wages and Occupational Choices

Consider first the implications of the analysis for the observed gender wage gap. In equilibrium, men and women are in equal numbers in the adult population ($N^m = N^f$); thus, from equations (3),

$$w^m/w^f = b^{-1}A^f\varepsilon^{f,W}. \quad (23)$$

This condition implies that if men and women have equal productivity ($A^f = 1$) and devote all their time to work ($\varepsilon^{f,W} = 1$), then $w^f = bw^m$; the observed wage differential between men and women is therefore constant and due entirely to the fact that men hold positions that entail access to a more productive technology than women—a direct reflection of discrimination in the workplace. In general, however, relatively lower wages for women may also result from differences in relative productivity, $1/A^f$, and the relative allocation of time, $1/\varepsilon^{f,W}$. Put differently, women may have lower wages than men also because they are not as healthy as men—which, as shown earlier, has an adverse effect on their productivity—or because they cannot devote as much time as they would like to market activity, as a result of social norms or inadequate access to infrastructure—the latter, as shown next, forcing them to allocate relatively more of their available time to child rearing and home production.

As shown in Appendix B, solving the family's optimization problem leads to the following solutions for women's time allocation and the fertility rate:

$$\varepsilon^{f,P} = \max\{\varepsilon^{f,P}_m, (1 + \Lambda)^{-1}(\Lambda - \zeta^P k^I)\}, \quad (24a)$$

$$\varepsilon^{f,W} = (1 - \varepsilon^{f,P})/\Lambda_2, \quad (24b)$$

$$\varepsilon^{f,R} = [\Lambda_3\theta^R\eta_{NV_C}(1 - \sigma)(1 - v_C)^{-1}]\varepsilon^{f,W}, \quad (24c)$$

$$n = (1 - v_C)/\Lambda_3\theta^R p^C, \quad (24d)$$

where $\varepsilon^{f,P}_m$ is the minimum amount of time that women must allocate to household chores, $\sigma = p^A/(1 + p^A + \rho)$ is the family's propensity to save, and

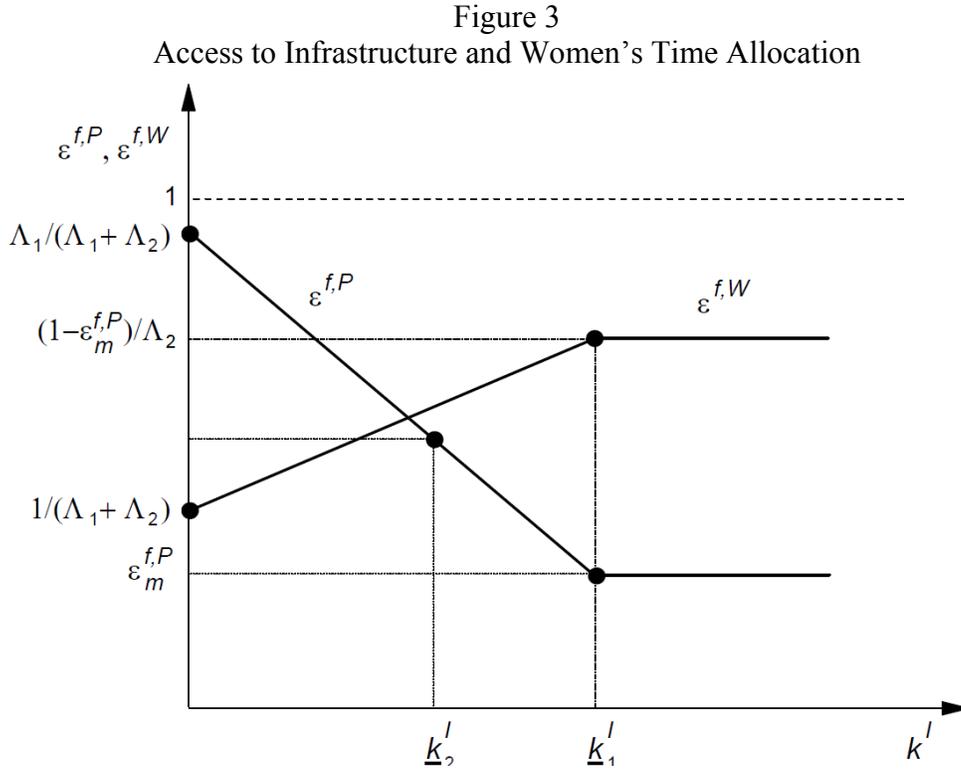
$$\Lambda = \Lambda_1/\Lambda_2,$$

$$\Lambda_1 = \eta_Q\pi^Q(1 - \sigma) > 0, \quad \Lambda_2 = 1 + \eta_{NV_C}(1 - \sigma) > 1,$$

$$\Lambda_3 = 1 - v_C + [\eta_N(1 - \sigma)]^{-1} > 0.$$

Equations (24a) to (24c) imply that improved access to infrastructure services, up to a critical threshold \underline{k}^I , reduces women's time allocated to home production and raises time

devoted to market work and child rearing. The decreasing relationship between k^I and $\varepsilon^{f,P}$ implied by (24a), as long as $\varepsilon^{f,P} \geq \varepsilon_m^{f,P}$, captures the main channel through which access to public infrastructure affects women's occupational choices.³² Figure 3 illustrates the behavior over time of $\varepsilon^{f,P}$ and $\varepsilon^{f,W}$ as a function of k^I .³³ From (24a) and (24b), there is a critical value of the public-private capital ratio, $\underline{k}_1^I = \Lambda/\zeta^P$, above which $\varepsilon^{f,P}$ is equal to its minimal value and $\varepsilon^{f,W}$ reaches its maximum value, $1/\Lambda_2$. Thus, the more efficient infrastructure is (the higher ζ^P is), the lower the threshold level will be.³⁴



Source: Adapted from Agénor and Agénor (2009).

³²The term $\varepsilon_m^{f,P}$ could be explicitly introduced in the model by rewriting the production function for home goods (1) in the form $Q = [(\varepsilon_m^{f,P} + \varepsilon^{f,P}) + \zeta^P(K^I/K^{P,T})]^{\pi^Q}$. Note also that, had we chosen to model the impact of mothers' rearing time and infrastructure services on health status in childhood as in equation (1), that is, by assuming perfect substitutability of these two inputs instead of the multiplicative form specified in (12), the solution of the model for $\varepsilon^{f,R}$ would have entailed a relationship similar to (24a).

³³The figure assumes that $\Lambda_1 > 1$, to ensure that the initial value $\varepsilon^{f,P}(0)$, for $k^I = 0$, is higher than $\varepsilon^{f,W}(0)$. In turn, $\Lambda_1 > 1$ requires $\eta_Q > 1/\pi^Q(1 - \sigma)$, or that the home good be sufficiently valued by the family.

³⁴Another possible direct channel relates to the impact of infrastructure on unit costs of child rearing, θ^R . As discussed in Agénor and Agénor (2009), if this cost tends to fall with greater access to infrastructure—because better access to roads reduces the cost that mothers may incur to take their children to medical facilities, for instance—an improvement in such access will increase the fertility rate, n , and reduce women's time allocated to rearing each child, $\varepsilon^{f,R}$. However, this channel exerts no independent effect on time allocated to home production or market work, because $d(p^C n \varepsilon^{f,R})/d\theta^R = 0$.

The figure also shows the possibility of a *home-bias equilibrium*, where women allocate relatively more of their time to domestic activities (home production and child rearing) compared to market work, in the absence of any benefit from infrastructure, that is, $\varepsilon^{f,P} + p^C n \varepsilon^{f,R} > \varepsilon^{f,W}$, for $\zeta^P = 0$. This condition can be written as

$$\varepsilon^{f,P} > \underline{\varepsilon}^{f,P}_M = [1 - \eta_N v_C (1 - \sigma)] / (\Lambda_1 + \Lambda_2), \quad (25)$$

which can be combined with (24a) to define a second threshold value, denoted \underline{k}^I_2 in the figure. Beyond that point, greater access to infrastructure services reverses the bias in women's time allocation toward domestic tasks.³⁵

From these solutions, it is also straightforward to show that an increase in the survival probability from adulthood to old age, p^A , increases the savings rate σ and reduces the fertility rate n , as is standard in the literature.³⁶ In addition, for a given public-private capital ratio, it increases as well time allocated to market work, $\varepsilon^{f,W}$, and reduces the amount of time allocated to home production, $\varepsilon^{f,P}$. However, it has an ambiguous effect both on *total* time allocated to child rearing, $p^C n \varepsilon^{f,R}$, and time allocated to *each* (surviving) child, $\varepsilon^{f,R}$. Intuitively, the reason for this is that such time does not have a direct effect on the family's resources, neither today (there is no child labor) nor in the future (there are no intergenerational bequests). The net effect depends, in general, on the structure of preferences—namely, η_N and the parameter that measures the response of health status in childhood to mothers' time, v_C . In particular, as can be established from the results in Appendix B, the less mothers value their surviving children (that is, the lower η_N is), the more likely it is that time allocated to each surviving child will fall. Because $\varepsilon^{f,R}$ affects the health status of women both in childhood and adulthood (as implied by (12) and (14)), this result is important to understand the general equilibrium effects of a change in the adult survival rate, as discussed in the next section.

Finally, as can be inferred from (24d), an increase in the survival probability from childhood to adulthood, p^C , reduces *pari passu* the fertility rate and has no effect on women's time allocation. Thus, parents fully internalize an improvement in the survival rate of their offspring by reducing the number of children; total time allocated to child care, $p^C n \varepsilon^{f,R}$, therefore does not change.³⁷ Note also that the equilibrium number of children does not depend directly on women's time allocation; in particular, there is no direct, inverse relationship between fertility and time devoted by mothers to market work.

2. The Balanced Growth Path

The balanced growth rate of the economy is derived in Appendix B. The public-private capital ratio is shown to be given by

³⁵Note that the condition for a home-bias equilibrium (25) does not depend on the discrimination parameter, b , that is, on the extent of gender bias in the workplace. This result is related to our assumption that husbands and wives pool their resources when taking family decisions.

³⁶See Agénor (2009) and the literature therein.

³⁷This, of course, is a strong property of the model. With a more general utility function, as for instance in Boucekine et al. (2009), it would not hold.

$$k^J = \nu\tau/\sigma(1 - \tau)(1 - \theta^R p^C n) = J, \quad (26)$$

which is constant, given that (24d) implies that $\theta^R p^C n = (1 - \nu_C)/\Lambda_3$. This expression also shows that an increase in the adult survival probability, p^A , lowers the public-private capital ratio, both by reducing the fertility rate, n , and by increasing the savings rate, σ .

As shown in Appendix B, if $\kappa < 1$, the model is characterized by a zero steady-state growth rate in income per worker.³⁸ By contrast, when $\kappa = 1$ (so that a parent's health status has a permanent effect on a child's health), the system boils down to an autonomous first-order linear difference equation in $q = \ln q$, where $q = h^f/(x^f)^2$ is the ratio of women's health status to the (squared) value of the private capital-female labor ratio, x^f :

$$q(t+1) = \ln q(t+1) = \Lambda_8 + [1 - \beta(1 + \nu_C)] \ln[q(t)], \quad (27)$$

where $\Lambda_8 > 0$ is a constant term defined in Appendix B. Because $1 - \beta(1 + \nu_C) < 1$, there is a unique, nontrivial and globally stable steady state, q^{SS} . As also shown in Appendix B, the balanced growth rate (in per capita terms) is given by

$$1 + \gamma = J^\alpha (p^C n)^{-1} (b \varepsilon^{f,W})^\beta b \beta \sigma (1 - \theta^R p^C n) [(1 - \tau)(1 + b)]^{-1} (q^{SS})^\beta. \quad (28)$$

Because q is constant in the steady state, female health status h^f grows at twice the rate of growth of the private capital-female labor ratio, x^f , which is also γ . This is also the rate of growth of public and private capital stocks.³⁹

The equilibrium is illustrated in Figure 4. Curve QQ on the right-hand side panel represents the dynamics of q_t , whereas curve GG on the left-hand side panel represents the dynamics of output growth per worker. The initial equilibrium obtains at Point A.

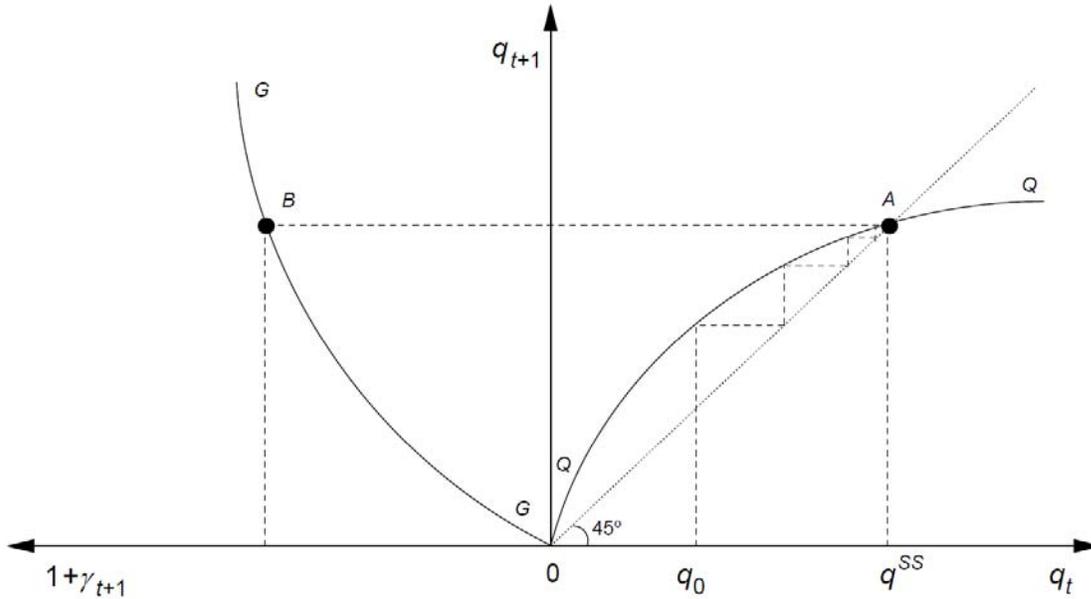
V. GENDER-RELATED POLICY EXPERIMENTS

To illustrate the role of public policy in the model, we consider three experiments: a reduction in the cost of child rearing, a reduction in wage gaps in the market place, and an improvement in access to infrastructure. The analysis is conducted under the assumption that $\varepsilon^{f,P} > \varepsilon^{f,m}$, which implies from (24a) that women's time allocated to home production is sensitive to changes in access to infrastructure.

³⁸Intuitively, if h^f is constant, so must be x^f , the private capital-female labor ratio, given the interdependence between these two variables. This implies that the stock of private capital (and thus the level of output, given (5)) must grow at the same rate as the rate of growth of the adult population—and so does the stock of public capital, given that J is constant. If J , h^f , and x^f are all constant so must be output per worker.

³⁹The fact that female health status increases indefinitely may be difficult to understand intuitively if health is understood only as a *physical* concept; if so, one would expect health status to eventually converge to a fixed value (a perfectly healthy body). However, as noted in Agénor (2009), the possibility that adult health can grow without bound is easier to comprehend if “health” is more broadly understood as consisting of both physical and *mental* health, with the latter being subject to continuous improvements over time.

Figure 4
Balanced Growth Path



1. Reducing the Cost of Child Rearing

Suppose that the government implements measures (free medical supplies, etc.) that lead to a drop in the unit cost of child rearing for the family, θ^R .⁴⁰ We assume that these measures result from a reallocation among unproductive components of spending, G_U , so that shares of all spending components remain constant. Thus, the shift in θ^R is budget neutral and can be considered in isolation from other changes.⁴¹ The results of this experiment are summarized in Figure 5.

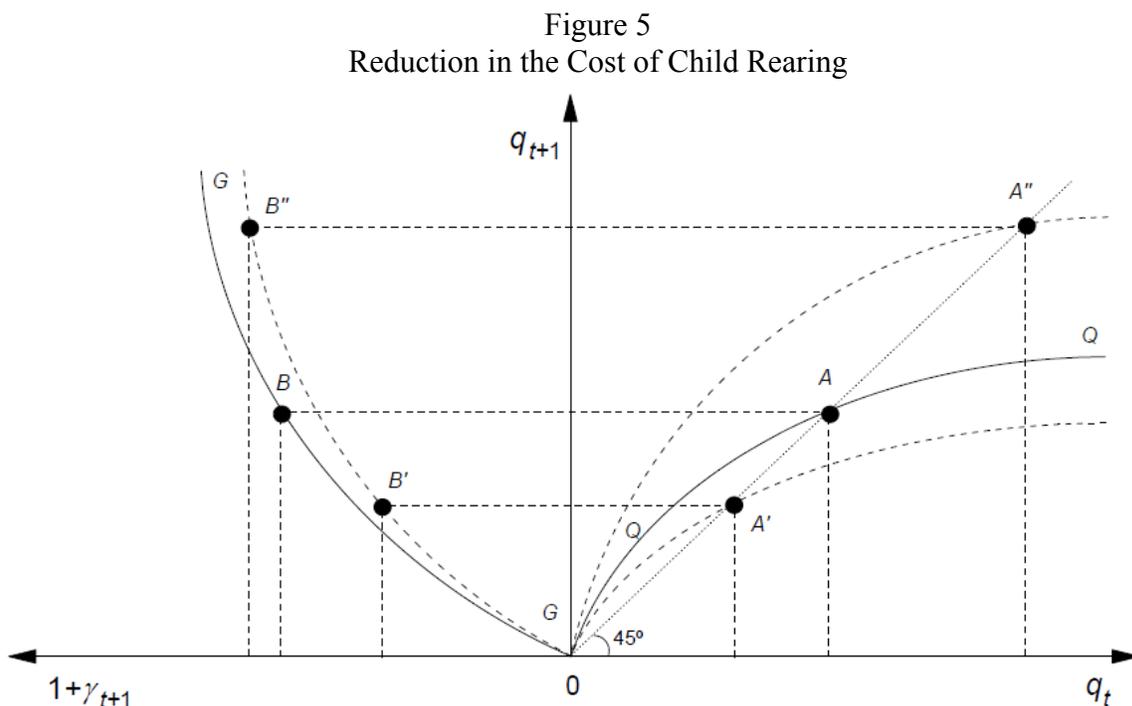
As can be inferred from (24d), a drop in θ^R raises the gross fertility rate; however, the total cost of rearing surviving children, $\theta^R p^C n$, does not change. By implication, from (26), the public-private capital ratio J does not change either. In addition, as implied by (24a) and (24b), the amount of time spent by women in home production and in market work does not change. To ensure that the time constraint (7) holds, time allocated to rearing each (surviving) child, $\varepsilon^{f,R}$, must fall, to ensure that total rearing time, $p^C n \varepsilon^{f,R}$, remains constant; this is indeed what (24c) implies. There is therefore a substitution of “quantity” for “quality.” Although the reduction in θ^R tends to promote growth (by raising savings) the fall in $\varepsilon^{f,R}$ tends to hamper it, because it has an adverse effect on children’s health, which eventually affects their productivity in adulthood. Whether the latter effect dominates the former depends in

⁴⁰d’Addio and d’Ercole (2005) discuss the role of a range of policies (including tax credits, cash benefits, leave provisions, and support for childcare costs) on the cost of child rearing and fertility in industrial countries. See also Apps and Rees (2005) and Del Boca and Locatelli (2006).

⁴¹A more general analysis would involve accounting explicitly for public subsidies to child rearing by introducing them in the family and government budget constraints (see for instance Momota (2000)). Doing so would allow also an analysis of possible trade-offs between subsidies and productive components of public spending, which consist here of health or infrastructure.

particular on the magnitude of the parameter v_C , which measures the impact of rearing time on children's health in (12).

Graphically, curve QQ in the right-hand side panel of Figure 5 may shift either upward or downward, whereas curve GG in the left-hand side panel shifts inward (because of the fall in $\varepsilon^{f,R}$). The new equilibrium may be either at points (A', B') or (A'', B'') , with lower growth in the first case and higher growth in the second.



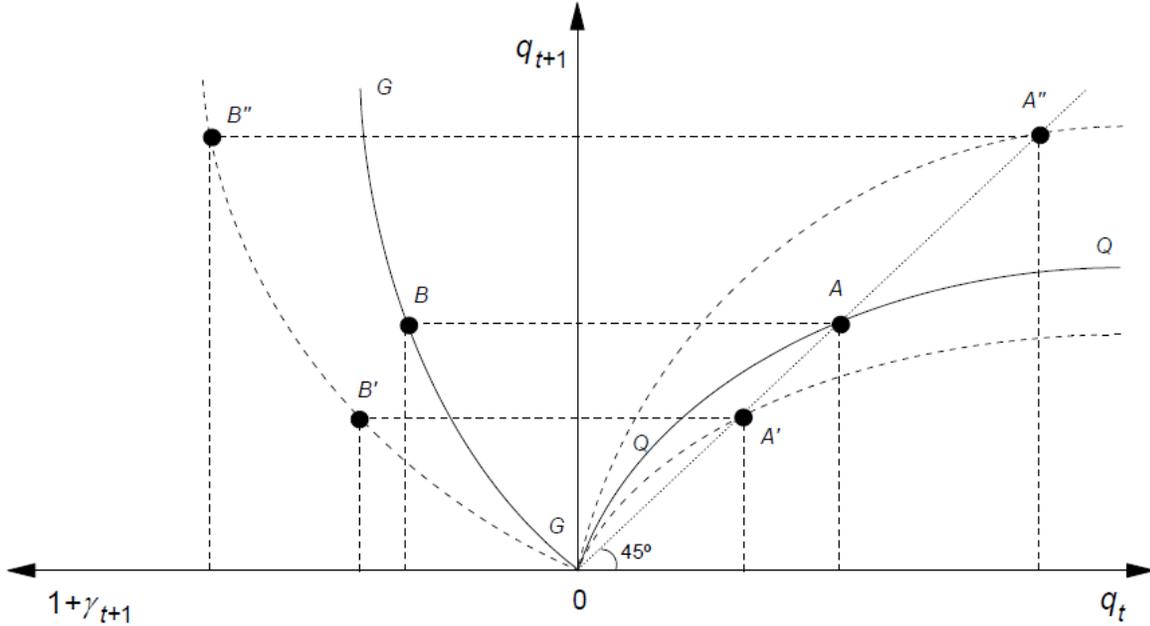
2. Reducing the Wage Gap in the Market Place

Suppose now that the government implements anti-discrimination laws that lead to a permanent reduction in wage bias against women in the work place; analytically, this can be captured by considering an increase in b .

By (23), the direct effect of this policy (at the initial level of wages) is to raise family income. In turn, higher income leads to a higher level of private savings and private capital stock, as well as higher tax revenues. From (24a) to (24d), women's time allocation and the fertility rate are not affected. And because changes in b affect tax revenues and private savings in exactly the same way, by (26) the public-private capital ratio is not affected either. But higher tax revenues also lead to higher public spending on health, which has a positive effect on health in childhood and female health in adulthood, h^f . Because private savings and capital increase, the capital-female labor ratio x^f increases as well; thus q may either increase

or fall. Nevertheless, the direct output effect always dominates, so the reduction in gender bias leads to an increase in the steady-state growth rate.⁴²

Figure 6
Reduction in the Wage Gap in the Market Place



Graphically, curve QQ in the right-hand side panel of Figure 6 may shift either upward or downward, depending on whether the “health effect” (through higher government spending) dominates the “savings effect” (through higher family income and savings). Curve GG in the left-hand side panel shifts upward. The new equilibrium is either at (A', B') or (A'', B'') , both characterized by higher growth.

3. Improved Access to Infrastructure

Finally, consider the case of a public policy aimed at promoting access to infrastructure by women, by investing in rural roads, power grids, etc. This can be captured by considering an increase in ν_I .⁴³ We focus on the case where the increase in investment in infrastructure is financed by a cut in unproductive spending ($d\nu_I + d\nu_U = 0$); thus, we do not

⁴²Note that our analysis does not capture the possibility that gender gaps in access to managerial positions and employment may distort the allocation of talent and the production and productivity of human capital, as for instance in Esteve-Volart (2004). In the present setting, this could be captured by extending the model to introduce (in line with the evidence provided by Corley et al. (2005)) a negative link between the female labor force participation rate and the gender gap, that is, between $\varepsilon^{f,W}$ and b^{-1} . Had we accounted for these effects, the benefits of an increase in b on economic growth would be magnified.

⁴³In our simplified setting, we do not distinguish explicitly between infrastructure-related spending that is “time-saving” specifically for women, and other types of infrastructure. Some of the latter type of spending may not lead to an increase in the “public” capital stock *per se*, but rather to a buildup of private assets (for instance, solar-powered cookers). Accounting for these assets and their implications for time allocation and growth could be a useful extension of our framework.

address the potential trade-off that arises if financing occurs through a cut in the other component of (productive) spending, namely, health outlays ($dv_I + dv_H = 0$). We consider two scenarios: the case where all other variables remain constant (the “basic” transmission mechanism), and the case where improvements in women’s health are large enough to translate into a discrete change in survival rates.

3.1 The Basic Transmission Mechanism

From (26), the direct effect of the shock is of course an increase in the public-private capital ratio J , which promotes growth directly. In addition, from (24a) and (26), and given that $\varepsilon^{f,P} > \varepsilon^{f,P}_m$, we have

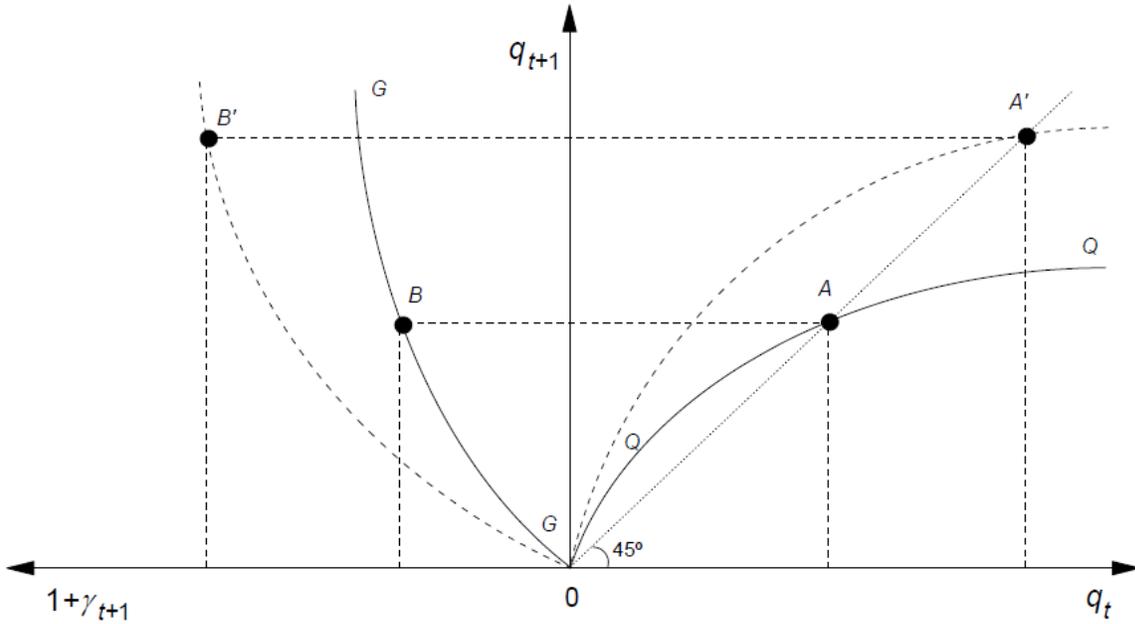
$$\varepsilon^{f,P} = (1 + \Lambda)^{-1}(\Lambda - \zeta^P J). \quad (29)$$

Thus, an increase in the share of government spending on infrastructure also lowers time allocated to home production, as discussed earlier. From (24b) and (24c), the drop in $\varepsilon^{f,P}$ raises time allocated to market work, whereas time spent on child rearing may either increase or fall; in the former case, this leads to better children’s health and, later in life, improved health in adulthood.⁴⁴ Because survival rates are constant for the moment, the change in time allocation has no direct effect on the fertility rate, as implied by (24d). In addition, the increase in the public-private capital ratio raises the efficiency of time that mothers allocate to child rearing, ζ^R . Thus, if rearing time per child does increase, all of these effects also help to promote growth per worker and health outcomes.

The results of this experiment are illustrated in Figure 7. Because the increase in the level of income also raises private savings and private capital, and because the fertility rate is not affected, the private capital-female labor ratio unambiguously increases. At the same time, female health in adulthood also improves—partly as a result of more rearing time (assuming indeed that it does increase) but also because of higher government spending on health (due to higher revenues induced by the increase in time allocated to market work). Because both x^f and h^f increase, the ratio q may either increase or fall. The outcome depends now on whether the combined “health and efficiency effect” (through higher government spending and improved efficiency of rearing time) dominates the “savings effect” (through higher family income). Curve GG in the left-hand side panel always shifts upward, whereas curve QQ is shown as shifting upward, reflecting indeed the case where the combined health-efficiency effect dominates. The new equilibrium is at points (A', B') , characterized by a higher capital-female labor ratio and higher steady-state growth per worker.

⁴⁴An increase in child rearing time is consistent with the results of Koolwal and Van de Walle (2010) on the impact of greater access to water infrastructure on women’s time allocation.

Figure 7
Budget-Neutral Increase in Spending on Infrastructure
with Constant Adult Survival Rate



3.2 Escaping a Mothers' Health-Based Trap

As indicated in the foregoing discussion, female health in adulthood h^f unambiguously improves following a shift in spending on infrastructure, as long as rearing time per child increases. Suppose first that, once women's health crosses a certain threshold, \underline{h} , the infant mortality rate p^C falls in a discrete fashion. In a way, this captures an intergenerational transmission of health, but in a different manner: a healthier mother, for instance, may breastfeed her child for a longer period of time, thereby reducing the risk of dying early in life. Formally, this can be captured by assuming that

$$p^C = \begin{cases} p_m^C & \text{if } h^f \leq \underline{h}; \\ p_M^C & \text{if } h^f > \underline{h}; \end{cases} \quad (30)$$

where $p_M^C > p_m^C$. The foregoing analysis corresponds therefore to the case where, although female health improves, it does not cross the threshold \underline{h} .

Suppose now that the increase in v_l leads, at some point during the transition to the steady state, to an improvement in female health that is such that $h^f > \underline{h}$ and thus child survival rate rises from p_m^C to p_M^C . In addition to the effects highlighted in the previous discussion, there are two additional effects to consider. First, as implied by (24d), the (gross) fertility rate falls *pari passu* with the reduction in child mortality. Second, from (24c), there is no change in rearing time per child, and thus no change in time allocated to home production or market work. Thus (as can be seen directly in (28)), the increase in the child survival rate has no

effect on steady-state growth per worker, fundamentally because in the present framework it leaves $p^C n$ unchanged. However, the welfare effects could be substantial, given that children's health matters for the family. In addition, with intergenerational bequests (from children to parents, for instance), the growth effects could be significant.

Suppose now that the threshold effect of female health operates with respect to the adult survival rate, p^A ; thus, instead of (30), we have

$$p^A = \begin{cases} p^A_m & \text{if } h^f \leq \underline{h}^f; \\ p^A_M & \text{if } h^f > \underline{h}^f; \end{cases} \quad (31)$$

where $p^A_M > p^A_m$.

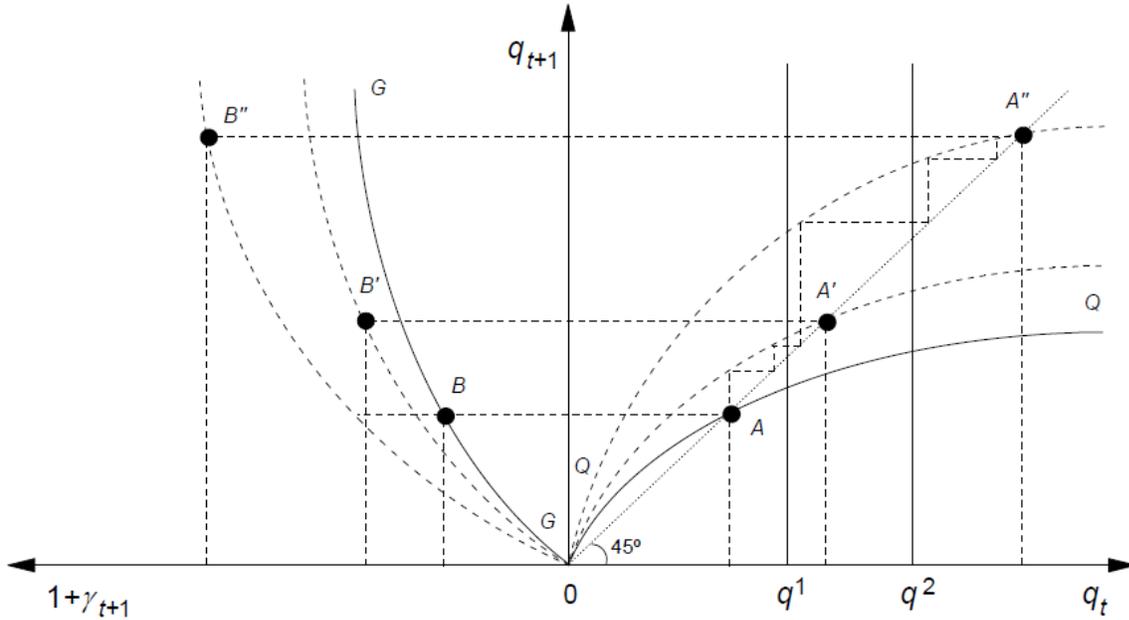
Again, there are now several additional effects to consider. As noted in the previous section, an increase in the survival rate leads to a higher savings rate, σ , and a fall in the (gross) fertility rate; both effects contribute to raising the steady-state growth rate per worker. At the same time, however, a higher savings rate raises the stock of private capital, which tends (through congestion effects) to *lower* the public-private capital ratio J , as implied by (26).⁴⁵ There is therefore an offsetting effect on J now, in contrast to the case where p^A remains constant. Nevertheless, we will assume in what follows that the *net* effect of an increase in p^A through these two channels is still to raise the growth rate.

More importantly, the model may now display multiple development regimes, as illustrated in Figure 8. Suppose that the economy is initially ($t = 0$) at point A . This corresponds to a value of $h^f(0)$ and $q(0) = h^f(0)/x^f(0)$. The figure also shows two threshold values of q , q^1 and q^2 , corresponding to two values of the threshold \underline{h} : $\underline{h}^{f,1}$ and $\underline{h}^{f,2}$. Suppose first that the threshold in health is first located at $\underline{h}^{f,2}$, with a corresponding value of q^2 , that is, to the *right* of point A' . As shown earlier, Point A' corresponds to the steady state of the system when the adult survival rate remains constant throughout. Following the increase in ν_t , the adjustment process is thus similar to the one depicted in Figure 7; the ratio q converges to A' , and the growth rate increases from B to B' .

Suppose instead that the threshold in health is located at $\underline{h}^{f,1} < \underline{h}^{f,2}$ with a corresponding value of q^1 , that is, to the *left* of point A' . When the rise in p^A occurs, and the female health threshold is crossed, both QQ and GG shift upward a second time, and the new adjustment path takes the economy now from A to A'' and from B to B'' . The jump in q results solely from the jump in female health when the threshold $\underline{h}^{f,1}$ is reached, because x^f does not jump. Thus, the effect of the shift in spending on infrastructure is *magnified* by the positive impact of the improvement in mothers' health on life expectancy.

⁴⁵This effect would occur even if infrastructure exerted no externality effects on the efficiency of time allocated to child rearing ($\pi^R = 0$), as long as $\alpha > 0$.

Figure 8
 Budget-Neutral Increase in Spending on Infrastructure
 with Threshold Effect on Adult Survival Rate



VI. IMPLICATIONS FOR GROWTH STRATEGIES

Our review of the empirical evidence on inter- and intra-generational health externalities and infrastructure-related constraints on women's time, together with our formal analysis and policy experiments, suggest several lessons for promoting the role of women in the growth process. These implications can be summarized as follows.

1. Intergenerational transmission of health between mothers and children, and the persistence of health in the course of an individual's lifetime (or, equivalently, vertical and horizontal health transmission), are essential concepts to understand the link between gender and growth. They may also be important to understand other issues as well, such as child labor and unemployment in early adult life—as well as persistence in income inequality. For instance, if parents internalize the fact that a child's poor health may limit his or her ability to acquire an education and support them financially in their old age (an important consideration in countries where pension regimes do not exist), they may choose to take them out of school at an early age—forcing them, in effect, to enter the labor market with limited or inadequate skills. Alternatively, if health can be improved through additional care, parents may be willing to invest more time in rearing their children, because this increases their potential earnings in adulthood and the amount of resources that they can allocate to support their parents.

2. The empirical evidence on women's time allocation shows clearly that women bear the brunt of domestic tasks—processing food crops, providing water and firewood, and caring

for children, the elderly, and the sick. While social, religious and institutional factors are important, economic and structural constraints—especially lack of access to core infrastructure services in rural areas—play a significant role as well in explaining these patterns. Growth-promoting supply-side policies may not yield desirable effects, independently of other constraints (such as gender bias in credit markets), if women are unable to reallocate their time to new activities because of poor access to infrastructure.

3. To reduce the share of time that women devote to domestic tasks, and to promote their participation in the labor force, it is important to alleviate infrastructure-related constraints and provide time-burden-reducing public goods. From that perspective, providing better access to roads may be as important as improving access to local community facilities (e.g. wells, nurseries, sanitation provision, etc.).

4. Giving greater priority in development programs to access to water supply and sanitation (e.g., standpipes in poor countries), energy for household needs, access to appropriate means of transport, can all contribute to improving women’s health as well; and to the extent that improved health lead to higher life expectancy and a reduction in the rate of time preference, it may promote investment in education, which in turn may increase wages and savings and induce a reallocation of family resources toward children—all of which contributing to higher growth.

5. Although policies aimed at promoting an increase in access to infrastructure have important benefits for women (in addition to other positive effects on growth), our formal analysis suggested that the reallocation of mothers’ time toward market work may be detrimental to the health of their children if it leads to a drop in time devoted to child care—with persistent effects in their adult life.⁴⁶ Thus, macroeconomic policies may need to be complemented by *microeconomic* measures aimed, in particular, at making it easier for mothers to provide adequate care to their children.⁴⁷ A possible route to explore is to consider using instruments that create pecuniary incentives for mothers to increase the quantity and quality of time devoted to child rearing. For instance, refining further conditional cash transfer programs (CCTs) such as *Oportunidades* or *Bolsa Familia* in Latin America could provide incentives, conditional on health outcomes, without necessarily inducing mothers to divert time too hastily toward market activity. An additional well-designed and targeted payment for such services, while controlling for the quality of health outcomes for children among beneficiaries, could be worth exploring.

6. A more systematic effort to build gender-based macroeconomic and growth models is an essential step to better link macro level changes and micro level responses. Such models (possibly along the lines of the OLG framework outlined in this paper, extended to account

⁴⁶Floro (1995) was one of the first to draw attention to the possibility that women’s time reallocated to market work may be detrimental to children, and possibly to economic growth.

⁴⁷Moreover, the fact that time allocated by mothers to child rearing is productive as a result of health persistence means that one should be cautious in using concepts such as “time poverty” (see Blackden and Wodon (2006)). For instance, if we were to introduce intergenerational transfers in our formal analysis, it could well be that allocating more time to child rearing today is an optimal strategy for a family because it raises the earning ability of children when they become adults—and thereby future transfers to parents in old age.

for human capital, labor market distortions, intergenerational bequests, etc.) would complement existing micro tools (such as gender-disaggregated expenditure incidence analysis) and help to quantify the gender and growth effects of public policies in general, and gender-based interventions in particular. As an input in these models, there is also a need to quantify the possibly *nonlinear* effects of access to infrastructure on female labor supply to the market.⁴⁸

⁴⁸For instance, using U.S. data, Kimmel and Connelly (2006) estimate a structural time use model (a simultaneous four-equation system) in which the dependent variables are the number of minutes in a mother's diary day that she devotes to home production, leisure, market work, and care giving. They are therefore able to estimate explicit wage and child care price elasticities for these variables. With the exception of Koolwal and Van de Walle (2010), cited earlier, studies of this type are clearly lacking for developing countries.

Appendix A

Other Channels through which Mothers Affect Child Health

There are several indirect channels, other than those discussed in the text (namely, intergenerational health externalities, which are related to mothers' health and education), through which mothers can affect the health of their children, especially daughters. In this Appendix we elaborate on two of them: the impact of mothers on *a*) the intra-family allocation of monetary resources toward children and their needs; and *b*) family decisions regarding the allocation of children's time to household chores.

Regarding the first issue, there is evidence suggesting that when women have greater control over a household's resources, they are more likely to spend more (compared to men in a similar position) on necessities and on the development of her children.⁴⁹ Thus, although working mothers may breastfeed less and have less time for child care, it is possible that this harm can be offset by the health benefits (in terms of greater access to medicines) that her earnings bring. Indeed, to the extent that policies aimed at encouraging female employment also reduce inequality in household income distribution and increase the share of household resources controlled by women, they will also be beneficial for the health of children. Put differently, the distribution of income within a household also affects children's health; additional household income in the hands of women is more likely to benefit children (boys and girls alike) directly, possibly leading to improvements in their health status. As a result, increases in women's influence over decision-making in the household may lead to an intergenerational transmission of earnings capability.

For instance, in a study on Bangladesh, Indonesia, Ethiopia, and South Africa, Quisumbing and Maluccio (1999) found that assets controlled by women have a positive and significant effect on expenditure allocations toward the next generation, such as education and children's clothing.⁵⁰ In the same vein, Joshi (2003) found that in rural Bangladesh certain types of female-headed households (those headed by married women in which husbands were not physically present) devote more resources to children, after controlling for a number of household and individual characteristics. Other studies reviewed in Morrison et al. (2007) also concludes that increases in maternal control over household resource allocation (which is typically associated with increased education levels of households) lead to improvements in child educational attainment and health. This, in turn, leads to increases in children's cognitive ability and productivity as adults (see specifically Hoddinott et al. (2005) and Behrman and Alderman (2006)). These studies therefore corroborate the view that there are causal links between women's control over resources and subsequent household decisions about resource allocation. This, in turn, may affect aggregate savings and growth. The fact that women may have greater concerns with improving the health of their children (or, more generally, human

⁴⁹See de la Croix and Vander Donckt (2008) for an endogenous treatment of bargaining power in a gender-based model of endogenous growth. In their model, bargaining power depends essentially on relative human capital between spouses.

⁵⁰The evidence comes from studies seeking to test the so-called unitary model of household decision making, which assumes that all members in the household have the same preferences for allocating resources. These papers test the underlying assumption of "income pooling," that is, the fact that husbands and wives pool their resources and that the marginal impact of additional resources coming into the household is independent of the identity of the person who owns it; see Park (2007) for a review of the recent evidence.

development outcomes in the household) may thus induce them to have a higher marginal propensity to consume out of their income than men.⁵¹

However, improvements in education and income do not necessarily lead to an improved allocation of family resources toward girls, specifically. In countries like China, India, and Korea, for instance, the preference for boys is equally strong in low- and high-income families.⁵² Because women in richer families tend also to have lower fertility rates, the pressure to produce a son and heir is very strong if the first child is an (unlooked-for) daughter.⁵³ In addition, the preference for sons may actually *reduce* spending and lead instead to higher savings. According to Wei and Zhang (2009) for instance, a comparison of savings rates for households with sons versus those with daughters reveals that in China the former type saves more than the second. The reason, in their view, is the fact that families with a single son must increase the chances of him attracting a wife. They argue that this “competitive saving” motive (due to intensified competition in the marriage market) may account for about half of the actual increase in the household savings rate during 1990-2007 (see also Du and Wei (2010)). The implication of course is lower spending on children—including girls.

Consider now the second channel, that is, the possibility that mothers may affect their children’s health through the intra-family allocation of children’s time. There is evidence suggesting that intra-family allocations regarding children’s school and work time tend to be adjusted in the face of disease among family members. Indeed, household coping behavior in the presence of illness and death may involve not only changes in the family’s asset holdings, and cash or in-kind transfers to and from relatives (the coping mechanisms that have received the most attention in empirical research), but also investments in children’s schooling and labor substitution. The latter has proved to be an important strategy to compensate for the lower productivity of HIV-infected household members, for instance. As discussed by Corrigan, Glomm, and Mendez (2005), when parents become ill, children may be pulled out of school to care for them, take on other responsibilities in the household, or work to support their siblings. Moreover, the intra-household reallocation of time often depends on the gender of household members: girls (who bear the brunt of domestic work to begin with) are more likely to be pulled out of school in response to adverse shocks.⁵⁴

Indirect evidence suggesting that the reallocation of family time may indeed be important in response to adverse health and income shocks is provided by Hamoudi and Birdsall (2004), Arndt (2006), and Kalemlı-Ozcan (2006), who all found that AIDS lowered

⁵¹At the same time, if women have a stronger preference than men for mitigating the effects of negative income shocks on the family, their marginal propensity to save may be higher. See Floro and Seguino (2002) and Stotsky (2006) for a further discussion.

⁵²Quisumbing and Maluccio (1999) provide formal evidence that parents do not have identical preferences towards sons and daughters, within *or* across countries. See Purewal (2010) for a broader discussion, with particular reference to India.

⁵³See Das Gupta et al. (2002) and the special report in *The Economist*, March 6th, 2010, on gendercide. Part of the problem is the fact that it has become easier to select the sex of children.

⁵⁴Evidence of discrimination in the household between boys and girls is provided for instance by Amin and Chandrasekhar (2009), in a study of Bangladesh. They found that time spent studying outside school is strongly influenced by household decisions that favor boys, who appear to have about 30 minutes more discretionary study time than girls. Thus, schooling does not necessarily promote gender equality; gender differences in study time may persist even as school enrollment gaps diminish.

school enrollment rates in Sub-Saharan Africa.⁵⁵ More specific evidence on how households adjust the intra-family allocations regarding school and work time of children in the face of disease within the family includes Corrigan, Glomm, and Mendez (2005), and D'Adda et al. (2009) for Kenya. The latter study for instance found that changes in intra-household allocations of time devoted to non-market labor activities (primarily household tasks such as cooking and washing, and water and firewood collection, which are often carried out by mothers and their daughters) is an important coping strategy when the individual afflicted by illness is a working-age adult.

⁵⁵These results are also consistent with the view that the mere *risk* that children may be infected by AIDS may deter parents from investing in their education, as argued by Bell, Devarajan, and Gerbasch (2006). Put differently, an environment where there is great *uncertainty* about child survival may exacerbate a precautionary demand motive for children, with less education being provided to each of them—a standard substitution of quantity for quality.

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