ACCESS TO INFRASTRUCTURE, WOMEN'S TIME ALLOCATION, AND ECONOMIC GROWTH

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THE CARE WORK AND THE ECONOMY (CWE-GAM) PROJECT

The Care Work and the Economy (CWE-GAM) Project strives to reduce gender gaps in economic outcomes and enhance gender equality by illuminating and properly valuing the broader economic and social contributions of caregivers and integrating care in macroeconomic policymaking toolkits. We work to provide policymakers, scholars, researchers and advocacy groups with gender-aware data, empirical evidence, and analytical tools needed to promote creative, gender-sensitive macroeconomic and social policy solutions. In this era of demographic shifts and economic change, innovative policy solutions to chronic public underinvestment in care provisioning and infrastructures and the constraints that care work places on women's life and employment choices are needed more than ever. Sustainable development requires gender-sensitive policy tools that integrate emerging understandings of care work and its connection with labor supply, and economic and welfare outcomes.

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TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

Despite notable progress in recent decades (including in primary school enrolment and access to the political system), gender gaps remain pervasive in rich and poor countries alike. In many developing economies, gaps in secondary and tertiary education, access to finance and health care, labor force participation, formal sector employment, entrepreneurship and earnings, remain large. In today's low- and middle-income countries for instance, the labor force participation rate for women is only 57 percent, compared to 85 percent for men. Women's share in formal sector employment remains low and in recent years has even fallen in some cases (International Labour Organization (2017)). On average, women workers earn about three-quarters of what men earn. In Sub-Saharan Africa more specifically, women still have fewer years of education and fewer skills than men; and learning gaps remain large (World Bank (2018)). Wage and employment gaps in certain occupations (particularly in managerial positions) and activities, and gaps in access to justice and political representation, also remain sizable. According to the World Economic Forum (2017), in 2016 the average gap between men and women in health, education, politics and economics widened for the first time since records began in 2006. As pointed out by a number of observers since the seminal contribution of Boserup (1970), closing the gender gap is important not only because it is a moral imperative but also because it may have important implications for economic and social outcomes.

In recent years formal academic research has shed new light on the causes of gender gaps and their consequences for economic growth. The mainstream analytical literature has identified at least five main channels through which gender inequality may affect growth: the *fertility channel* (Galor and Weil (1996) and Soares and Falcao (2008)), the *human capital channel* (Lagerlöf (2003) and Bloom et al. (2015)), the *women's enfranchisement and property rights channel* (Doepke and Tertilt (2009), Bertocchi (2011), and Fernández, (2013, 2014)), the *infrastructure-time allocation channel* (Agénor (2012, 2017), Agénor and Agénor (2014), Agénor et al. (2014), and Agénor and Canuto (2015)), and the *women empowerment channel* (Iyigun and Walsh (2007), Doepke and Tertilt (2014), Agénor (2018), and Prettner and Strulik (2017)). The infrastructure-time allocation channel, in particular, emphasizes the fact that, in addition to the conventional positive effects on factor productivity and private investment, improved access to infrastructure reduces the time that women allocate to household chores, and this may in turn allow them to devote more time to remunerated labor market activities. In addition, infrastructure may also have a significant impact on health and education outcomes, for both men and women, which may in turn affect their productivity, relative earnings, and indirectly the allocation of time within the family.[1]

[1] These effects may be magnified through interactions between health and education themselves: better health may have a large impact on the ability to learn and study, whereas more educated parents may take better care of themselves and their children. See Agénor (2012, Chapter 3) and Agénor (2019) for a more detailed discussion of these interactions.

This paper discusses further how improved access to infrastructure affects women's time allocation decisions and how, in turn, changes in these decisions affect the process of economic growth in low-income developing countries. To do so it develops a simple two-period, gender-based overlapping generations (OLG) model with public capital to explore the implications of public infrastructure on women's time allocation and growth.[2] Our focus is on the specific impact of access to public infrastructure services (whose supply can be directly influenced by policy decisions) on female time allocation decisions between market work and home production, and its interactions with economic growth. As in some existing contributions, the basic model accounts not only for the standard productivity effect of public infrastructure but also for its effect on home production and occupational choices. In addition, we also consider the case where gender bias and bargaining power, as well as fertility choices and rearing time, are endogenous, and the case where there are two types of infrastructure: physical infrastructure (which includes transport, water supply and sanitation, telecommunications, and energy) and social infrastructure (which includes the provision of maternal care).

Our main results can be summarized as follows. By inducing women to reallocate time away from home production activities and toward market work, improved government provision of infrastructure services—assuming a sufficient degree of efficiency—may help to trigger a process through which a poor country may escape from a low-growth trap. This result is in line with those established in a number of recent contributions based on OLG models. We also show that with endogenous gender bias and bargaining power, there are two additional channels through which improved access to infrastructure can affect growth: positive effects on the level and rate of savings, which tends to promote growth. However, the increase in both the public and capital stocks implies that the net effect on the public-private capital ratio, and thus women's time allocation, is ambiguous in general. This is due to the fact that a higher private capital stock increases congestion costs, which tend to lower the public-private capital ratio. By implication, the net effect on gender equality in the market place, and economic growth, is now also ambiguous. Improved access to infrastructure may not always be beneficial. With endogenous fertility and child rearing, we find that improved access to infrastructure may raise the fertility rate and total rearing time, thereby mitigating the positive effect on women's time allocated to market work. However, this effect is not robust. In addition, we show that if there is a positive externality associated with improved access to infrastructure. This may lead not only to a reduction in time allocated to household chores, but also to a reduction in total time allocated to child rearing; in turn, this may lead to women allocating more time to market work, thereby promoting growth. Finally, we also highlight the fact that although physical and social infrastructure are complementary at the microeconomic level, a trade-

[2] Related contributions include Greenwood et al. (2005) and Greenwood and Seshadri (2005), who focus on technological progress in the market, and technological progress in the home, as determinants of fertility and female labor force participation. Specifically, they focus on how greater access to consumer durables (made possible by improved technologies and access to electricity) helped to "liberate" women in the United States from domestic production activities and led to dramatic increases in participation rates of married females in the labor force. See Albanesi and Olivetti (2009), Cardia (2010), Jacobsen (2013), and Greenwood et al. (2017) for a further discussion.

off exists at the macroeconomic level as a result of the government's budget constraint. The optimal policy that internalizes this trade-off must account for the relative efficiency of investment in these two types of assets.

The remainder of the paper is organized as follows. Section 2 provides a brief overview of the evidence on the impact of infrastructure on women's time allocation in developing countries. Section 3 presents the basic model, which assumes a single type of public infrastructure. It also derives the steady-state growth rate and examines its properties. In particular, we examine how access to infrastructure affects women's time devoted to home production and market activity. Section 4 considers three main extensions of the analysis: endogenous gender bias and bargaining power, fertility choices and rearing time, and heterogeneous infrastructure assets. Section 5 identifies some perspectives for future research.

2. INFRASTRUCTURE AND WOMEN'S TIME ALLOCATION

The economic effects of access to infrastructure on productivity, investment, human capital and growth have been well documented (see Agénor (2012)). In what follows we focus specifically on its impact on women's time allocation and provide a review of the relevant literature. We first discuss differences in time use between women and men and then consider the effect of both physical and social infrastructure on women's time allocation.

2.1. GENDER AND TIME USE

An extensive body of research has shown that the allocation of time between paid and unpaid work varies significantly across genders, with women spending considerably more time in unpaid work (including cooking, cleaning, and caretaking) than men. For instance, in an analysis of 2006 Tanzania Time Use Survey data, Fontana and Natali (2008) found that women devote considerably more time to unpaid work, including household maintenance, management, and shopping (11.8 percent vs. 3.6 percent) and care for household members (2.5 percent vs. 0.8 percent), than their male counterparts. In the same vein, Budlender (2008) found that in Tanzania women devote more than five times more than men to domestic work.

In a more comprehensive analysis, Rubiano and Viollaz (2018) analyzed gender differences in time use patterns in 19 countries, at various levels of income. They found that on average women allocate 5.1 hours to unpaid domestic work (including childcare and household chores), 4.7 hours to leisure, and 2.3 hours to market work per day. For men, the corresponding numbers are 2, 5 and 5 hours, respectively. Personal care activities represent 11 hours for both. In an even larger study, based on 102 time use surveys carried out in 65 countries, Charmes (2015) found that the unpaid-paid gap between women and men is particularly pronounced in the Middle-East and North Africa; women there devote longer hours to unpaid work and much less time to paid work than men compared to most other parts of the world. Similar results are documented by Ferrant et

al. (2014). In sub-Saharan Africa the disparity between women and men regarding unpaid work remains also high, ranging from 3.3 hours per day in urban Benin to 5.1 hours per day in rural Ethiopia. Using the same data the International Labour Organization (2018, Chapter 2) highlighted that among the three main categories of unpaid care work—domestic services for own final use within the household, caregiving services to household members, and community services and help to other households—domestic services for own use occupy by far the largest component of women's time compared to men's.[3] Similar patterns are observed for richer countries as well.[4]

Empirical evidence has shown that the determinants of women's time allocation include a range of factors, including social norms, households' socio-demographic characteristics, the magnitude of the gender wage gap, the stage of economic development, and public policies, including access to core infrastructure services, child support, and anti-discrimination laws (see Stratton (2015) and Cortes and Pan (2018)). In what follows we focus on access to physical and social infrastructure.

2.2. PHYSICAL INFRASTRUCTURE AND TIME ALLOCATION

From a functional perspective, physical infrastructure assets are usually classified in terms of four categories: transportation, water supply and sanitation, energy, and telecommunications. Because the first three categories of assets affect disproportionately women's time allocation, we consider them in turn.

2.2.1. TRANSPORTATION

Empirical studies have shown that women in developing countries spend a significant amount of time traveling, whether it is for household production activities, health care (for themselves or their children), education, or income-generating activities. For example, Riverson et al. (2006) found that, in Ethiopia, 73 percent of women's trips and 61 percent of their travel time were dedicated to meeting their household energy, water, and food needs. In similar fashion Malmberg-Calvo (1994) found that, in Zambia, women spend over 800 hours per year gathering and transporting firewood, while their male counterparts spend no more than 50 hours per year. More generally, available data suggest that, on average, women in rural Sub-Saharan Africa spend between 0.9 and 2.2 hours per day on transporting water and firewood (see Weiss (1999)).

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[3] See also Menon and Rodgers (2017) for a related discussion. Comprehensive data on time use are available online from the United Nations at https://unstats.un.org/unsd/gender/timeuse/ and from the World Bank at http://datatopics.worldbank.org/gender/.} Similar patterns are observed for richer countries as well.

[4] Miranda (2011) for instance found that, across 29 OECD countries, women spend an average of more than 2 hours and 28 minutes per day engaging in unpaid work, including shopping for the household and caring for household members, relative to their male counterparts. Of note, working (40 minutes per day) and non-working (51 minutes per day) fathers spent less time on child care than working (74 minutes per day) and non-working (144 minutes per day) mothers in these countries. For a further discussion of women's time use in advanced economies, see Aguiar and Hurst (2016), Blau and Winkler (2018), Cortes and Pan (2018).

Moreover, because of scarce or inexistent modes of public transportation and a lack of access to private transportation (such as bicycles, two or four-wheel motor vehicles, and carts), poor women in developing countries tend to travel on foot. For instance, Malmberg-Calvo (1996) found that, in rural areas of Sub-Saharan Africa, 87 percent of women's travel occurs on foot and that women are more likely to walk to their destination than their male counterparts. On average, women in rural Sub-Saharan African travel over 1 to 5km per day on foot for 2.5 hours while carrying a load of about 20kg (Riverson et al. (2006)). The lack of access to roads and other transport infrastructure therefore acts as a constraint on the time that women have available for other activities, including market work.

2.2.2. WATER AND SANITATION

Women in low-income countries allocate also a significant amount of time to collecting water for household production, including cooking, cleaning, and child rearing (see Isha (2007) for an overview). In South Africa, 90 percent of the households in a survey reported that women were the primary collectors of water (Aggarwal et al. (2001)). Available data show that women in Benin, Madagascar, and South Africa spend 273 hours per year, 164 hours per year, and 48 hours per year, respectively, collecting water (Blackden and Wodon (2006)). Additionally, in Tanzania, 76 percent of all adult women collect water relative to 33 percent of adult men. Among adults who collect water, women spend about 30 minutes per day engaging in that activity compared to 20 minutes for men (Fontana and Natali (2008)).

The implication is that if clean water were more accessible, women would save a notable amount of time, which could in turn be allocated to other activities. For instance, Blackwell (1996) found that if a source of clean water were located within 400 meters of all households in rural areas of Burkina Faso, Uganda, and Zambia, every household would save between 125 and 664 hours per year. While these data are not specific to women, it is reasonable to assume that women were the primary water collectors in the households sampled in these studies as well. In similar fashion, Ilahi and Grimard (2000) found that in rural Pakistan, as access to public water infrastructure improves, the amount of time women allocate to water collection decreases, whereas Fontana and Natali (2008) found that improvements in infrastructure would save Tanzanian women a total of 1,128 hours in water collection—thereby freeing up time to engage in other activities.

2.2.3. ELECTRICITY

A number of studies have shown that access to electricity can decrease the amount of time that women spend on household production activities such as cooking and collecting firewood. 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 their time to housework than their counterparts who use gas or electricity. Conversely, a World Bank study found that women in the Philippines spent one less hour per day on domestic tasks as a result of

electrification (World Bank (2008)). Women who have better access to electricity can devote more time to income-generating activities, furthering their education, accessing health care, compared to those who continue to rely on fossil fuels.

2.3. SOCIAL INFRANSTRUCTURE AND TIME ALLOCATION

Women's time allocation is also affected by access to social infrastructure, which typically includes assets that provide social services. Traditionally, examples of social infrastructure assets have included schools, hospitals, and child care facilities. Access to these assets has been shown to have an important impact on labor supply by women in both advanced economies (Stratton (2015), Aguiar and Hurst (2016), Blau and Winkler (2018), and Cortes and Pan (2018)) and developing economies (United Nations (2016)).[5]

An important characteristic of these assets is that they may be highly complementary to women's time spent in home production—although no more so than access to clean water or electricity, for instance. From that perspective, public investments aimed at improving access to water and sanitation, as well as electricity, can also be viewed as investments in "social" infrastructure, which may indeed be more complementary with women's time than access to roads, for instance. From an economic perspective, therefore, the definition of "social infrastructure" should be broader than the one provided earlier, so as to include some categories of physical infrastructure assets. In either case, investments in social infrastructure can also reduce women's care burden (related to children and the elderly, in particular), allowing them to devote more time to paid employment—which may not only improve their bargaining power within the household but also their own well-being, as well as that of their children. This, in turn, may have long-term benefits in terms of productivity and economic growth.

In sum, when women lack access to physical infrastructure, such as roads and transportation, clean water and sanitation, and electricity, or social infrastructure, such as health care and child care facilities, they often end up allocating a greater proportion of their time to household chores. The opportunity costs of poor infrastructure for women include wage income, acquiring an education, and investing in their own health. In particular, access to electricity may improve women's human capital by decreasing the amount of time that they allocate to home production activities and increasing the amount of time that they can devote to their education and health. The key issue to address therefore is how an improvement in access to physical and social infrastructure affects, both directly and indirectly, the time women allocate to various activities and how, in turn, changes in women's time allocation affect gender equality and economic growth. We do so next by considering a deliberately simplified gender-based model with proper micro-foundations.

[5]An alternative definition of social infrastructure would be limited only to public services whose goal is to improve human capabilities. These services include expenditure on education, health care, childcare, and eldercare services, but not school buildings, health clinics, etc. which instead would be classified as physical infrastructure. However, this definition does not make a proper distinction between *stocks* of infrastructure assets and the *flow* of services that they produce, as is typical of the endogenous growth literature.

3. A BASIC MODEL

We consider an OLG economy where two goods are produced, a marketed good and a home good. The marketed good can be either consumed in the period it is produced or stored to yield capital at the beginning of the following period. Population is constant at N and consists of men and women in equal size.[6] Individuals live for two periods, adulthood and old age. Each individual is endowed with one unit of time in both periods of life; but in old age, time is entirely devoted to leisure. All individuals, males and females, work in adulthood; the only source of income is therefore wages in the first period of life, which serve to finance family consumption in both periods. Gender bias in social norms are such that mothers incur the whole time cost involved in home production, which therefore acts as a constraint on their ability to engage in market-based activities. By contrast, male spouses are not involved in household chores and allocate inelastically all their time to market work.[7]

In addition to individuals, the economy is populated by firms and an infinitely-lived government. Firms produce marketed goods using public capital in infrastructure as an input, in addition to male and female labor and private capital. Home production combines women's time and infrastructure services. The government taxes wages and spends on infrastructure and other items, which are not directly productive. It cannot borrow and therefore must run a balanced budget in each period. Finally, all markets clear and there are no debts or bequests between generations.

3.1. FAMILIES

At the beginning of adulthood in period t, all men and women are randomly matched into married couples. For simplicity, once married, individuals do not divorce; couples retire together and die together. The only source of income for all individuals, male or female (identified with superscripts m and f, respectively), is wages earned from market work in adulthood. Agents have no other endowments, except for a stock of physical capital at $t = 0$, which is the endowment of an initial old generation. Each adult $j = f,m$ earns a market wage, w_t^j, per unit of time worked. Let $\varepsilon_t^{m,W}$ denote the time that men devote to market work; as noted earlier, $\varepsilon_t^{m,W} = 1$. Women allocate time to market activity, in proportion $\varepsilon_t^{f,W}$, and to home production (which includes time spent collecting water and firewood, as discussed earlier), in proportion $\varepsilon_t^{f,P}$. The time constraint that they face is thus

$$\varepsilon_t^{f,P} + \varepsilon_t^{f,W} = 1. \qquad (1)$$

[6] The assumption that men and women are in equal size in the population allows us to maintain a constant number of families.

[7] The assumption that males do not engage at all in household chores is for simplicity only. It could be assumed that they allocate a fixed fraction of time to these activities but that such fraction (in line with the evidence) is lower than that allocated by women. This would have little effect on the analysis. Agénor (2018) provides a full treatment of the case where both parents engaged in home production, albeit in a model without infrastructure.

Only the marketed good is consumed in old age. Thus, each spouse's utility function is given by

$$U_t^j = \eta_Q \ln Q_t + \eta_C^j \ln c_t^{j,t} + \frac{1-\eta_C^j}{1+\rho} \ln c_{t+1}^{j,t} \quad (2)$$

where $c_t^{j,t}$ ($c_{t+1}^{j,t}$), is adult j's consumption in adulthood (old age), Q_t production of home goods, and $\rho > 0$ the discount rate. Spouses value in the same way consumption of the home good; the preference parameter η_Q therefore does not carry an index j. However, they differ with respect to the weight that they attach to today's consumption of marketed goods, as measured by $\eta_C^j \in (0, 1)$. Consistent with the evidence (see World Bank (2011) for an overview), we assume that $\eta_C^f < \eta_C^m$. Thus, women are less (more) concerned than men about current (future) consumption, which creates an incentive for the family to save more today.

Spouses pool their resources. The family's budget constraints for periods t and $t + 1$ are thus given by

$$c_t^{f,t} + c_t^{m,t} + m_t + s_t = (1-\tau) w_t \quad (3)$$

where $\tau \in (0, 1)$ is the tax rate on wages, m_t spending on marketed goods used to produce the home good, s_t family saving, r_{t+1} the net rental rate of capital, and w_t the gross wage income of the family, defined as

$$w_t = \varepsilon_t^{f,W} w_t^f + w_t^m \quad (5)$$

Combining (3) and (4), the family's consolidated budget constraint is thus

$$c_t^{f,t} + c_t^{m,t} + m_t + \frac{c_{t+1}^{f,t} + c_{t+1}^{m,t}}{1+r_{t+1}} = (1-\tau) w_t \quad (6)$$

The family's utility takes the form

$$U_t = \varkappa U_t^f + (1-\varkappa) U_t^m, \quad (7)$$

where $\varkappa \in (0, 1)$ measures the wife's bargaining power in the household decision process, assumed constant for the moment. Families maximize (7), subject to each spouse's utility function (2), the budget constraint (6), and home production (8) below, with respect to $c_t^{f,t}$, $c_t^{m,t}$, $c_{t+1}^{f,t}$, $c_{t+1}^{m,t}$, m_t, and $\varepsilon_t^{f,P}$.

3.2. HOME PRODUCTION

Home production (which includes cooking, doing laundry, house cleaning, and so on) involves combining women's time allocated to that activity with infrastructure services and, as in Silver and Verbrugge (2010) for instance, marketed goods. For simplicity, we assume that the first two factors are perfect substitutes and that production entails decreasing returns to scale with respect to the composite input:

$$Q_t = \left[\varepsilon_t^{f,P} + \zeta_Q \left(\frac{K_t^I}{K_t^P}\right)\right]^{\pi_Q} m_t, \tag{8}$$

where K_t^I is the stock of public capital in infrastructure, K_t^P the aggregate stock of private capital, $\pi_Q \in (0, 1)$, and $\zeta_Q > 0$ a coefficient that parameterizes the degree of efficiency of infrastructure services relative to women's time. To ensure sensible long-run properties of the production function, access to infrastructure is subject to congestion, as discussed next.[8]

3.3. MARKET PRODUCTION

Firms use the same technology and their number is normalized to unity. They produce a single nonstorable good, using male labor, $N_t^{m,i}$, and female labor, defined as $\varepsilon_t^{f,W} N_t^{f,i}$, private capital, $K_t^{P,i}$, and public infrastructure. Although public capital is nonexcludable, it is partially rival (use of it by one firm partly precludes its use by another firm) because of congestion effects. In turn, congestion is taken to depend on both the aggregate private capital stock, $K_t^P = \int_0^1 K_t^{P,i} di$, and the size of the (adult) population, N.

The production function of individual firm i takes the form

$$Y_t^i = \left[\frac{K_t^I}{(K_t^P)^{\phi_K} \overline{N}^{\phi_N}}\right]^{\alpha} (\varepsilon_t^{f,W} N_t^{f,i})^{\beta} (N_t^{m,i})^{\beta} (K_t^{P,i})^{1-2\beta}, \tag{9}$$

where $\alpha > 0$, $\beta \in (0, 1)$, and $\phi_K, \phi_N > 0$ are congestion parameters. To facilitate the exposition, the elasticity of output with respect to male and female labor is assumed to be the same.
Profits are given by

$$\Pi_t^i = Y_t^i - w_t^f \varepsilon_t^{f,W} N_t^{f,i} - w_t^m N_t^{m,i} - (r_t + \delta^P) K_t^{P,i}$$

where $\delta_P \in (0, 1)$ is the depreciation rate of private capital.

[8] Because women's time allocation and the public-private capital ratio are constant in equilibrium, the assumption that the home good technology is linear in m_t ensures that production of these goods grows at a constant rate along the balanced growth path.

Profit maximization with respect to private inputs yields

$$w_t^f = b\frac{\beta Y_t^i}{\varepsilon_t^{f,W} N_t^{f,i}}, w_t^m = \frac{\beta Y_t^i}{N_t^{m,i}}, r_t = (1-2\beta)\frac{Y_t^i}{K_t^{P,i}} - \delta_P \qquad (10)$$

where the parameter $b \in (0, 1)$ captures the degree of gender bias in the marketplace. Specifically, we assume that, due to discrimination women are paid less than their marginal product, so that $b < 1$.[9] In addition, we assume that this inefficiency is a pure deadweight loss for society.[10]

In equilibrium, given that men and women are in equal numbers in the adult population ($N_t^m = N_t^f$), the first two equations yield:

$$w_t^m = b^{-1}\varepsilon_t^{f,W} w_t^f, \qquad (11)$$

which shows that the gender wage gap, $w_t^m/\varepsilon_t^{f,W} w_t^f$, is equal to b^{-1} and is a direct reflection of discrimination in the workplace.

In a symmetric equilibrium, aggregate output is

$$Y_t = \int_0^1 Y_t^i di = \left[\frac{K_t^I}{(K_t^P)^{\phi_K}\overline{N}^{\phi_N}}\right]^{\alpha} (\varepsilon_t^{f,W} N^f)^{\beta}(N^m)^{\beta}(K_t^P)^{1-2\beta},$$

or equivalently, given that $N^f = N^m = 0.5N$,

$$Y_t = 0.5^{2\beta}\left(\frac{K_t^I}{K_t^P}\right)^{\alpha} \overline{N}^{-\alpha\phi_N+2\beta}(\varepsilon_t^{f,W})^{\beta}(K_t^P)^{1-2\beta+\alpha(1-\phi_K)}.$$

As shown subsequently, $K_t^I/K_t^P = k_t^I$ and $\varepsilon_t^{f,W}$ are constant in the steady state. Thus, to ensure steady-state growth (that is, linearity of output in the private capital stock) and eliminate the scale effect associated with population requires setting $-\alpha\phi_N + 2\beta = 0$ and $1 - 2\beta + \alpha(1 - \phi_K) = 1$, or equivalently[11]

$$\phi_N = \frac{2\beta}{\alpha}, 2\beta - \alpha(1-\phi_K) = 0.$$

[9] In the present setting, discrimination could also take the form of men having access to a more productive technology, or more physical capital, than women.

[10] As in Agénor (2018), it could be assumed instead that men benefit directly from discrimination against women. This would affect the relative wage effect on women's bargaining power, when it is treater later on as endogenous. However, given the issue at stake, we abstract from that effect.

[11] Combining these conditions yields $\phi_N + \phi_K = 1$,as first shown inGlomm and Ravikumar (1994).

Assuming that these conditions hold, under a symmetric equilibrium where $K_t^P = K_t^{Pi}\ \forall i$, aggregate output is given by:

$$Y_t = 0.5^{2\beta}(k_t^I)^{\alpha}\left(\varepsilon_t^{f,W}\right)^{\beta}K_t^P \tag{12}$$

3.4. GOVERNMENT

As noted earlier, the government taxes only wages. It spends G_t^I on infrastructure and G_t^U on other items. All its services are provided free of charge. It also runs a balanced budget:[12]

$$G_t^I + G_t^U = \tau(w_t^f \varepsilon_t^{f,W} N_t^f + w_t^m N_t^m). \tag{13}$$

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

$$G_t^h = \upsilon_h \tau\left(w_t^f \varepsilon_t^{f,W} N_t^f + w_t^m N_t^m\right), h = I, U \tag{14}$$

where $\upsilon_h \in (0, 1)$. Combining (13) and (14) therefore yields

$$\upsilon_I + \upsilon_U = 1. \tag{15}$$

Assuming full depreciation, public capital in infrastructure evolves according to[13]

$$K_{t+1}^I = G_t^I. \tag{16}$$

The assumption in (16) is that investment is fully efficient; each unit of currency invested by the government translates into an equivalent change in the stock of infrastructure assets. In practice, this is hardly the case in developing countries, due to waste, inadequate management, and corruption. As proposed by Agénor (2010), this can be captured by replacing (16) by $K_{t+1}^I = \varphi G_t^I$, where $\varphi \in (0, 1)$ can be viewed as a parameter that measures the efficiency of public investment. In a study of 71 developing countries, Dabla-Norris et al. (2012) found a median value of φ (renormalized in a 0-1 range) of about 0.4 only, which implies that up to 60 percent of investment flows may not serve their purpose. In what follows, given the focus of the paper on the gender effects of infrastructure from a theoretical (rather than quantitative) perspective, the simpler specification (16) will be used. However, it is worth keeping in mind, in subsequent

[12] An extension of the model to account for public debt accumulation and sustainability can follow along the lines of Agénor and Yilmaz (2017), who consider in particular the case where debt is used solely for the purpose of financing infrastructure (the so-called golden rule). However, given the focus of this paper on the expenditure side and gender issues, it is sensible to focus on the case where the budget is continuously balanced through tax revenues.

[13] The assumption of full depreciation eliminates the distinction between stocks and flows, but it helps to abstract from an inessential source of dynamics at this stage and to focus on steady-state effects.

discussions, that in practice poor efficiency may significantly affect the impact of increased public investment on the stock of infrastructure assets—thereby mitigating their benefits for women and the economy.

3.5. MARKET-CLEARING CONDITION

The asset-market clearing condition requires tomorrow's private capital stock (today's investment) to be equal to savings in period t. Given that s_t is savings per family, and that the number of families is $N/2$, we have, under the assumption of full depreciation ($\delta_p = 1$),

$$K_{t+1}^{P} = 0.5\overline{N}s_t. \tag{17}$$

3.6. EQUILIBRIUM AND GROWTH

Let $c_{t+n}^{t} = c_{t+n}^{t,f} + c_{t+n}^{t,m}$ denote family consumption at period $n = 0, 1$. A *competitive equilibrium* for this economy is a sequence of prices $\{w_t^f, w_t^m, r_t\}_{t=0}^{\infty}$, allocations $\{c_t^t, c_{t+1}^t, s_t\}_{t=0}^{\infty}$, physical capital stocks $\{K_t^I, K_t^P\}_{t=0}^{\infty}$, a constant tax rate, and a constant spending share υ_I such that, given initial stocks $K_0^I, K_0^P > 0$, families maximize utility, firms maximize profits, markets clear, and the government budget is balanced. A *balanced growth equilibrium* is a competitive equilibrium in which c_t^t, c_{t+1}^t, m_t, Q_t, w_t^f, w_t^m, K_{t+1}^I, K_{t+1}^P, and Y_{t+1} grow at the constant, endogenous rate $1 + \gamma$, the rate of return on private capital r_t is constant, and women's time allocation between home production and market work, $\varepsilon_t^{f,P}$ and $\varepsilon_t^{f,W}$, is constant.

Let $\varepsilon_m^{f,P} \geq 0$ denote the minimum amount of time that women devote to household chores. As shown in the Appendix, solving the family's optimization problem leads to the following solutions for women's time allocation:

$$\varepsilon^{f,P} = max\left(\varepsilon_m^{f,P}, \Lambda - \zeta k^I\right), \tag{18}$$

$$\varepsilon^{f,W} = 1 - \varepsilon^{f,P} = min\left(1 - \varepsilon_m^{f,P}, 1 - \Lambda + \zeta k_t^I\right) \tag{19}$$

where

$$\Lambda = \frac{\pi_Q(1-\sigma)\Gamma}{1 + (\eta_C/\eta_Q) + \pi_Q(1-\sigma)\Gamma} < 1, \tag{20}$$

$$\zeta = \zeta_Q \frac{1 + (\eta_C/\eta_Q)}{1 + (\eta_C/\eta_Q) + \pi_Q(1-\sigma)\Gamma}, \tag{21}$$

with $\Gamma = 1 + b^{-1}$ and $\zeta < 1$ if $\zeta_Q \leq 1$. Coefficient η_C is the composite preference parameter for current consumption, and $\sigma \in (0, 1)$ the family's propensity to save, which are defined as

$$\eta_C = \varkappa \eta_C^f + (1 - \varkappa)\eta_C^m, \tag{22}$$

$$\sigma = 1 - \frac{1 + \eta_Q/\eta_C}{1 + \eta_Q/\eta_C + (1 - \eta_C)/(1 + \rho)\eta_C}. \tag{23}$$

The equilibrium public-private capital ratio is constant over time and given by

$$k^I = \frac{\upsilon_I \tau}{\sigma(1 - \tau)}. \tag{24}$$

The properties of these solutions can be summarized in the following proposition:

Proposition 1. *With constant gender bias in the marketplace and women's bargaining power, b and ϰ, improved access to infrastructure services, up to a critical threshold* $\hat{k}_C^I$*,reduces women's time allocated to home production and raises time allocated to market work.*

In this basic model, the decreasing relationship between k^I and $\varepsilon^{f,P}$ implied by (18), as long as $\varepsilon^{f,P} \geq \varepsilon_m^{f,P}$, is the main channel through which access to public infrastructure affects women's time allocated to market work. If $k^I = 0$, time allocated to market work is constant and equal to $\Lambda < 1$. As k^I increases, it can be inferred from (18) that there is a critical value of the public-private capital ratio, given by $\hat{k}_C^I = (\Lambda - \varepsilon_m^{f,P})/\zeta$, above which $\varepsilon^{f,P}$ is equal to $\varepsilon_m^{f,P}$ and $\varepsilon^{f,W}$ reaches its maximum value of $1 - \varepsilon_m^{f,P}$:

$$\varepsilon^{f,P} = \begin{cases} \Lambda - \zeta k^I & \text{If } k^I < \hat{k}_C^I \\ \varepsilon_m^{f,P} & \text{If } k^I \geq \hat{k}_C^I \end{cases}, \qquad \varepsilon^{f,W} = \begin{cases} 1 - \Lambda + \zeta k^I & \text{If } k^I < \hat{k}_C^I \\ 1 - \varepsilon_m^{f,P} & \text{If } k^I \geq \hat{k}_C^I \end{cases}. \tag{25}$$

Figure 1 illustrates the behavior of $\varepsilon^{f,P}$ and $\varepsilon^{f,W}$ as a function of k^I. We assume that Λ, the initial value of $\varepsilon^{f,P}$ for $k^I = 0$ is high enough to ensure that $\varepsilon^{f,P} > \varepsilon^{f,W}$ (that is, $0.5 < \Lambda < 1$) corresponding to a *home-bias equilibrium*. This is consistent with the facts documented previously. In turn, this condition requires that the family's preference for the home good (as measured by π_Q) be sufficiently high or, conversely, that the preference parameter for the marketed good, η_C, be sufficiently low.

As also shown in the Appendix, the steady-state growth rate is given by, using (24),

$$1+\gamma = 0.5^{2\beta}\left[\frac{\upsilon_I \tau}{\sigma(1-\tau)}\right]^{\alpha}(\varepsilon^{f,W})^{\beta}\sigma\beta(1-\tau)(1+b) \qquad (26)$$

The impact of changes in the share of public infrastructure investment on women's time allocation and growth can be summarized in the following proposition:

Proposition 2. *An increase in the share of public investment in infrastructure, υ_I, financed by a cut in unproductive spending, raises the steady-state growth rate both directly, through a productivity effect, and indirectly, by inducing women to allocate more time to market work.*

The proof of this proposition is straightforward from (18), (19), (24), and (26).[14]

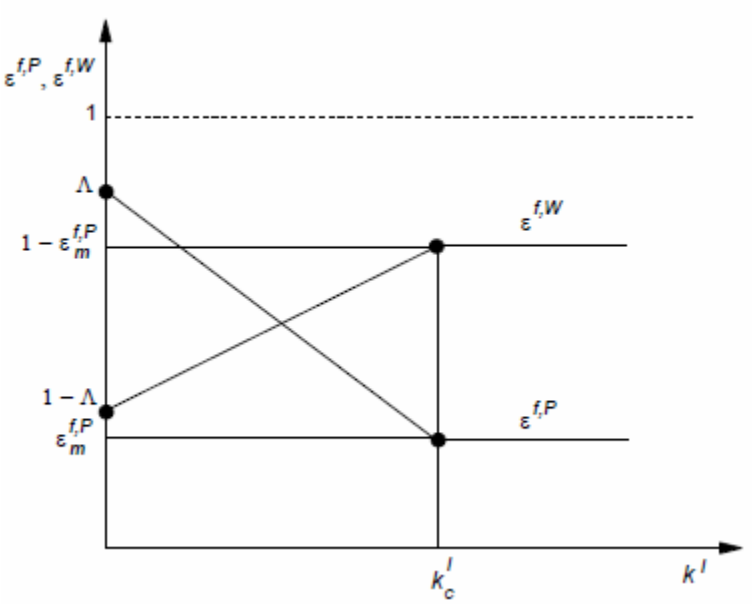

Figure 1: Access to infrastructure and women's time allocation

This simple model can be readily extended to explain the persistence of a low-growth equilibrium and provide a motivation for a Big Push in public investment. Suppose that the efficiency parameter in the home production function, ζ_Q, is subject to discontinuity, depending on the degree of access to infrastructure. Specifically, let

$$\zeta_Q = \begin{cases} 0 & \text{If } k^I < k_m^I \\ \zeta_Q^m > 0 & \text{If } k^I \geq k_m^I \end{cases}, \qquad (27)$$

[14] Combining these equations yields indeed $\frac{d\ln(1+\gamma)}{d\upsilon_I} = \frac{\alpha d\ln \upsilon_I}{d\upsilon_I} + \frac{\beta d\ln \epsilon^{f,W}}{d\upsilon_I}$, or again $\frac{d\ln(1+\gamma)}{d\upsilon_I} = \frac{\alpha}{\upsilon_i} + \frac{\beta\zeta_Q k^I}{\upsilon_I \epsilon^{f,W}}$

with $k_{m'} < \hat{k}^{I}_{C'}$. Thus, as long as the supply of infrastructure services remains limited, it has no impact on women's time spent on home production; it is only when it crosses a certain threshold that it begins to affect their time allocation decisions. Put differently, (27) captures the idea (at the household level) of a *critical mass* associated with infrastructure.[15] A portion of a road, for instance, does not make much difference to women who have to walk long hours to collect wood and water far from where they live. An increase in υ_I that helps to raise k' above $k_{m'}$ would therefore trigger a process whereby women can begin to reduce the time that they allocate to home production (until it eventually reaches the lower bound $\varepsilon_{m'}^{f,P}$), and increase the time that they devote to market work. In turn, this would shift the economy to an equilibrium with higher growth—with possibly strong nonlinear effects during an initial stage.

Finally, from the above equations, the following results can be established with respect to greater gender inequality in the market place:[16]

Proposition 3. *An autonomous increase in gender equality in the marketplace (a higher b) lowers women's time allocated to household chores and has a positive effect on growth, through both an increase in time allocated to market work and its level effect on family savings*.

From (18), and the definitions of Γ, and Λ and ζ in (20) and (21), it can be established that a higher Γ raises Λ and lowers ζ. Now, because $\Gamma = 1 + b^{-1}$, an increase in gender equality (a higher b) lowers Γ, and therefore lowers Λ and raises ζ. Thus, for k' given, greater equality (or less discrimination in the marketplace) lowers women's time allocated to household chores, so that $d\varepsilon^{f,P}/db < 0$. The reason is that it raises the female income brought to the family, and therefore the opportunity cost of home production. The lower η_Q is, the larger this effect. From (19), time allocated to market work rises, so that $d\varepsilon^{f,W}/db = -d\varepsilon^{f,P}/db > 0$. Thus, from (26), both the direct effect of a higher b (on family income and saving) and the indirect effect (through an increase in women's time devoted to work) combine to raise the growth rate. As discussed next, if women's bargaining power is endogenously related to wages, or when fertility is accounted for, the effect of a change in b on women's time allocation may operate through other channels as well.

Similarly, the following results can be established with respect to an autonomous increase in women's bargaining power:

Proposition 4. *An autonomous improvement in women's bargaining power (a higher* ν*) raises the family's savings rate,* σ*, but has an ambiguous effect on women's time allocated to market work,* $\varepsilon^{f,W}$.

[15] See Agénor (2010; 2012, Chapter 6).

[16] These properties are worth highlighting to illustrate the properties of the model, even though they are not directly related to access to infrastructure

The effect of an increase in women's bargaining power on the savings rate results from the fact that, given the assumption (discussed earlier) that $\eta_{c^f} < \eta_{c^m}$, a higher $\varkappa$ raises the composite preference parameter for current consumption, η_c (as implied by (22)), which in turn raises σ (as implied by (23)). However, as can be inferred from (18) and (19), although a higher savings rate tends to reduce (increase) women's time allocated to household chores (market work), the reduction in the preference for the market good—which corresponds to a relative increase in the preference for the home good—induces women to allocate more (less) time to domestic (market) production.

4. EXTENSIONS

The simple model presented in the previous section can be extended in a number of directions. In what follows we briefly consider three of them: endogenous gender bias and bargaining power, fertility choices and rearing time, and heterogeneous infrastructure assets.[17]

4.1. GENDER BIAS AND BARGAINING POWER

In the foregoing analysis it was assumed that both the degree of gender bias in marketplace, b, and women's bargaining power, $\varkappa$, are constant. Suppose now that, as in Agénor (2018), gender bias in marketplace responds to the relative presence of women in the labor market:

$$b_t = b\left(\frac{\varepsilon_t^{f,W} N_t^f}{N_t^m}\right) = b\left(\varepsilon_t^{f,W}\right), \tag{28}$$

where $b > 0$. Thus, women's decisions regarding the time that they allocate to paid activity have a direct impact on gender inequality in the marketplace. The underlying view is that working women can be *agents of change* with respect to their perceived role in society in general, and the workplace in particular (see for instance International Labour Organization (2015)).

Suppose also that women's bargaining power in the family evolves as a function of the average (economy-wide) ratio of earned incomes in the family:[18]

$$\varkappa_t = \varkappa_m \left(\frac{\varepsilon_t^{f,W} w_t^f}{w_t^m}\right)^{\mu B}, \tag{29}$$

[17] Another useful extension relates to the impact of acccess to infrastructure on child labor, especially girls in home production. See Agénor and Alpaslan (2013) for a thorough discussion.

[18] For a discussion of the evidence, see for instance Frankenberg and Thomas (2003), Quisumbing (2010), Doss (2013), and Majlesi (2016). Theoretical contributions that follow a similar approach include Iyigun and Walsh (2007), Prettner and Strulik (2017), Agénor (2018), and Agénor et al. (2018).

where $\varkappa_m > 0$ and $\mu_B > 0$ measures the sensitivity of bargaining power to relative wages. Thus, the more women earn, the stronger their ability to influence family decisions with respect to current consumption and saving, given (20) and (21), and thus the rate of economic growth.

Substituting (11) in (29) yields

$$\varkappa_t = \varkappa_m b_t^{\mu_B}, \tag{30}$$

which therefore relates positively women's bargaining power in the family to the degree of (in)equality in the market place—and, consequently, women's time allocation, as implied by (18) and (19), given the effect of $\varkappa$ on η_c, the family-wide preference parameter for current consumption, and the effect of η_c on the savings rate, σ.[19] Indeed, given this time allocation effect, gender inequality at home and in the work place are not independent phenomena but instead jointly determined.

With endogenous gender bias and bargaining power, as in (28) and (30), there are now two new channels through which improved access to infrastructure (in the form of an increase in the share of public investment, υ_i, as before) can affect growth. First, the resulting increase in women's time allocated to market work mitigates gender bias (an increase in b_t) and raises family income; this generates a *level* effect on saving, which tends to promote growth. At the same time, greater equality in the market place leads to greater bargaining power for women in the family; as a result, the family-wide preference parameter for current consumption, η_c, as defined in (20), tends to fall, given that $\eta_{c^f} < \eta_{c^m}$. Consequently, there is also a *relative* effect on saving, to the extent that a lower preference for current consumption raises the family's propensity to save σ_t, as implied by (21). In turn, this tends to increase private investment and the private capital stock.

However, the increase in *both* the public and capital stocks implies that the net effect on the public-private capital ratio, and thus women's time allocation, is now *ambiguous* in general. This is due to the fact that a higher private capital stock increases congestion costs, which tend to lower the public-private capital ratio. This can be seen in (24), where now both υ_i and σ increase. Because the net effect on the public-private capital ratio is ambiguous, so is the net effect on women's time allocated to market work. By implication, the net effect on gender equality in the marketplace, and economic growth, is now also ambiguous.

This analysis provides a note of caution to the results derived in the previous section; improved access to infrastructure is not always beneficial—neither at the microeconomic level nor at the macroeconomic level. The reason is that the very fact that such access can lead to a higher savings rate (through greater bargaining power for women in the family) can mitigate the direct benefits of an increase in the stock of infrastructure assets associated with higher government investment, as a result of greater congestion through the private capital stock.[20] Nevertheless, If the preference parameter for the home good, π_Q, is not too large, the positive effect of greater access to infrastructure services on

[19] As in Agénor (2018), transitional dynamics could be introduced by assuming some degree of persistence in $\boldsymbol{b_t}$ or $\boldsymbol{\kappa_t}$.

[20] Note that in this setting time allocated by spouses to household chores does not directly depend on women's bargaining power. To the extent that it does, as shown by Agénor (2018), it may indirectly affect growth.

women's time allocated to market activity will be relatively large, and the net effect on savings is likely to be fairly muted. As a result, infrastructure investment is likely to translate into a reduction in the gender wage gap, an increase in women's bargaining power, and a higher rate of economic growth.

Another cautionary note relates to the effect of an autonomous change in the degree of gender inequality in the market place on women's time allocation. With endogenous bargaining power as in (29)-(30), an autonomous increase in b would increase ν and lower η_C. As noted in Proposition 4, the increase in ν unambiguously raises the savings rate, which promotes growth, but because the savings rate and the family's preference parameter for current consumption operate in opposite directions in terms of their impact on women's time allocated to household chores, the net effect on growth would again be ambiguous.

4.2. FERTILITY AND REARING TIME

The basic model presented earlier can also be extended to account for endogenous fertility and child rearing. Thus, women's time is now allocated not only to market work and home production, but also to child rearing. For the moment, suppose that, as in most of the literature, rearing time is exogenous.[21]

Let n denote the number of children and $\varepsilon^{f,R}$ the fixed amount of time that mothers allocate to each of them. Assuming that only women are engaged in child rearing (again, as a result of gender bias in social norms), equation (1) is now replaced by

$$\varepsilon_t^{f,P} + n_t \varepsilon^{f,R} + \varepsilon_t^{f,W} = 1, \tag{31}$$

whereas before $\varepsilon^{m,W} = 1$. The utility function (2) takes now the form

$$U_t^j = \eta_Q \ln Q_t + \eta_N^j \ln n_t + \eta_C^j \ln c_t^{j,t} + \frac{1-\eta_C^j}{1+\rho} \ln c_{t+1}^{j,t}, \tag{32}$$

where we assume that spouses differ also with respect to the weights that they attach to the number of children, as measured by η_N. Specifically, the restriction $\eta_N^f < \eta_N^m$ is imposed. Thus, women prefer to have fewer children than men. This is consistent with the evidence which suggests that gender-specific differences in preferences regarding the number of children play a substantial role in high-fertility environments (see Doepke and Tertilt (2014) and Prettner and Strulik (2017))). For simplicity, we assume that there are no direct pecuniary costs associated with raising children, so that the budget constraint (6)

[21] The case of endogenous rearing time is discussed by Agénor and Agénor (2014) in a related setting.

continues to hold.[22] We also assume that parents have ready access to gender selection techniques, so that half of their children are daughters and half of them sons.[23]
The equilibrium values (18) and (20) to (26) remain the same, but the solution of the model now also involves solving for the number of children. As shown in the Appendix, the equilibrium fertility rate is given by

$$n_t = \left(1 + \frac{\eta_Q}{\eta_C}\right)^{-1} \frac{\eta_N(1-\sigma)(1+b^{-1})\varepsilon_t^{f,W}}{\eta_C \varepsilon^{f,R}} = \left(\frac{\Phi - 1}{\Phi}\right)\left(\frac{1-\varepsilon_t^{f,P}}{\varepsilon^{f,R}}\right), \tag{33}$$

and women's time allocated to market work by

$$\varepsilon^{f,W} = 1 - \varepsilon^{f,P} - n\varepsilon^{f,R} = \frac{1-\varepsilon_t^{f,P}}{\Phi}, \tag{34}$$

where the composite preference parameters η_N and Φ are defined as

$$\eta_N = \varkappa\eta_N^f + (1-\varkappa)\eta_N^m,$$

$$\Phi = 1 + \left(1 + \frac{\eta_Q}{\eta_C}\right)^{-1} \frac{\eta_N(1-\sigma)(1+b^{-1})}{\eta_C} > 1.$$

From (33) and (34), the following proposition can also be established:

Proposition 5. *With constant gender bias in the market place and women's bargaining power, b and ϰ, and constant rearing time, $\varepsilon^{f,R}$, improved access to infrastructure services, up to threshold $\hat{k}_C^I$, raises the fertility rate and total rearing time, thereby mitigating the positive effect on women's time allocated to market work.*

The increase in the fertility rate is, of course, the result of at least one parent valuing children ($\eta_N > 0$). In more general models where the choice of $\varepsilon^{f,R}$ is endogenous (because, for instance, mothers' time benefits children's health or education), and preferences take a similar log-linear form as used here, the net effect on the fertility rate is zero and the effect on time allocated to child rearing is positive.[24]

[22] If a cost of $\theta^R \in (0,1)$ is associated with each child, the net wage on the right-hand side of (6) would be replaced by $(1-\theta^R n_t)(1-\tau)w_t$. This would complicate the analysis without adding much insight if θ^R is fixed. However, if the pecuniary cost of child rearing depends, as discussed by Agénor et al. (2014), on access to infrastructure, this would create another channel through which access to infrastructure can affect gender equality and growth

[23] This assumption ensures that the gender composition of the populationremains balanced over time.

[24] See Agénor and Agénor (2014) and Agénor (2017). A simple way to visualize this result is to note that, in these models, the solution for $\epsilon^{f,R}$ is proportional to $1-\epsilon^{f,P}$, which implies from (33) that this term cancels out. Thus, n does not depend directly on access to infrastructure.

From (33) and (34), the following proposition can also be established:

Proposition 6. *An autonomous increase in women's time allocated to each child, $\varepsilon^{f,R}$, has no effect on the time that they allocate to market work, $\varepsilon^{f,W}$.*

Indeed, given that from (33) n and $\varepsilon^{f,R}$ are inversely proportional, an autonomous increase in women's time allocated to each child is exactly offset by a reduction in the fertility rate—in effect, a substitution of quality for quantity—which implies, from (34), that $n\varepsilon^{f,R}$ is constant and that time spent in market activity does not change either.

However, suppose now that the number of children (as a result of social norms or government policy) is no longer a choice variable for parents but fixed instead at $n = 2$, to ensure that the population is constant. Thus, (33) no longer applies. Suppose also that $\varepsilon^{f,R}$, although not a choice variable at the level of the household, benefits from a *positive externality* associated with improved access to infrastructure. For instance, with better roads, it is easier for all mothers (independently of their family's income) to take their children to health facilities. Thus, $\varepsilon^{f,R} = g(k)$, with $g' < 0$. In this setting, improved access to public infrastructure services leads not only to a reduction in time allocated to household chores (as before), but also to a reduction in total time allocated to child rearing, $n\varepsilon^{f,R}$; in turn, as implied by (34), this leads to women allocating more time to market work—thereby promoting growth, as discussed earlier.

More generally, suppose that child rearing also involves time allocated to taking care of the health of children (taking them to health facilities for vaccines or regular visits to doctors) or helping them with school work.[25] Broadly speaking, therefore, mothers' rearing time contributes to the human capital of children, and is therefore directly *productive*—by helping children to build human capital in childhood, they become more productive in adulthood, which helps to promote growth. It is possible that improved access to infrastructure leads simultaneously to a reduction in the *gross amount* of time allocated to child rearing (as before) but that at the same time it improves its *efficiency*—implying that the net effect on *effective* rearing time is nil, or even positive. In the latter case this would tend to promote growth as well, even when the fertility rate is endogenous.

The broader implication of this analysis is that when assessing the effect of improved access to infrastructure on female time allocation decisions, it is important to account also for interactions between health, education outcomes, and economic growth. In particular, if women substitute time away from child rearing, persistence in health or education outcomes may lead to lower productivity in adulthood if at the same time efficiency in time use does not improve. In the absence of complementary (possibly microeconomic) measures, a Big Push policy involving a reallocation of public spending toward infrastructure investment may not succeed in triggering a shift to a high-growth path and sustained improvements in health, education outcomes, and productivity.

[25] For evidence that parental tutoring is important for children in developing countries, see Glewwe and Kremer (2006) for instance.

At the same time, it should be noted also that improved access to infrastructure could generate positive externalities for health and education, as discussed by Agénor (2012, Chapters 2 and 3). For instance, better access to infrastructure could also lead to improved learning monitoring (in the case of electricity, for instance) or improved child care practices (including breast feeding), which may strengthen the health status of children and their ability to learn—leading to greater productivity in adulthood. These effects could very well offset any adverse effect on growth operating through a reduction in women's time allocated to child rearing, should they occur.
Finally, from (33) and (34), the following proposition can be established:

Proposition 7. *Greater gender equality in the market place (a higher b) lowers the fertility rate and raises women's time allocated to market work, in addition to its effect on time allocated to household chores*.

Indeed, in this setting time allocated to household chores, $\varepsilon^{f,P}$, remains as in (18). Thus, as established in Proposition 3, a higher b tends again to reduce $\varepsilon^{f,P}$ and to raise $\varepsilon^{f,W}$. In addition, a higher b now lowers the composite parameter Φ ($\partial\Phi/\partial b < 0$), while $d[(\Phi - 1)/\Phi]/d\Phi > 0$; by implication, from (33) and (34), a higher b lowers the fertility rate ($\partial\varepsilon^{f,W}/\partial b < 0$) and raises women's time allocated to market work ($\partial\varepsilon^{f,W}/\partial b > 0$) for $\varepsilon^{f,R}$ constant. Thus, from (26), greater gender equality is beneficial to growth not only by reducing time allocated to household chores and through its effect on savings, but also by reducing total time allocated to child rearing. This channel is different from the one examined previously, which was based on endogenous changes in women's bargaining power. In a more general model where (as in Agénor (2018)) b evolves endogenously, because women are *agents of change* in the labor market, and women's bargaining power depends on relative wages, an initial policy aimed at reducing gender inequality in the workplace can be a key source of dynamics.

4.3. SOCIAL AND PHYSICAL INFRASTRUCTURE

In the foregoing analysis we considered infrastructure as a single homogeneous asset, which affects both market activity and home production. However, as noted earlier, in practice the *type* of infrastructure also matters. Indeed, social infrastructure (as defined earlier) may be more complementary to women's time than physical infrastructure, whose impact may be more significant on market activity.

To account for two types of infrastructure involves a number of changes to the model. The key modification is with respect to the home production technology (8), which in the most general case can be written as a two-level CES function:

$$V_t = \left\{ \Lambda_S \left(\frac{K_t^{I,S}}{K_t^P} \right)^{\frac{\varsigma_S - 1}{\varsigma_S}} + (1 - \Lambda_S)\left(\varepsilon_t^{f,P}\right)^{\frac{\varsigma_S - 1}{\varsigma_S}} \right\}^{\varsigma_S/(\varsigma_S - 1)}, \qquad (35)$$

$$Q_t = \left\{ \Lambda_R \left(\frac{K_t^{I,R}}{K_t^P} \right)^{\frac{\varsigma_R - 1}{\varsigma_R}} + (1 - \Lambda_R) V_t^{\frac{\varsigma_R - 1}{\varsigma_R}} \right\}^{\frac{\pi_Q \varsigma_R}{\varsigma_R - 1}} m_t, \tag{36}$$

where $K_t^{I,R}$ ($K_t^{I,S}$) is the stock of physical (social) infrastructure, Λ_S, $\Lambda_R \in (0, 1)$ distribution parameters, $\varsigma_S > 0$ the elasticity of substitution between women's time and social infrastructure in the composite input V_t, and $\varsigma_R > 0$ the elasticity of substitution between V_t and physical infrastructure. Once again, both types of infrastructure are subject to (proportional) congestion to ensure sensible long-run properties. The assumption that women's time is more complementary with social infrastructure than with physical infrastructure can be captured by assuming that $\varsigma_S < \varsigma_R$, that is, by imposing that the elasticity of substitution between $\varepsilon_t^{f,P}$ and $k_t^{I,S} = K_t^{I,S}/K_t^P$ be *lower* than the elasticity of substitution between V_t and $k_t^{I,S} = K_t^{I,R}/K_t^P$.[26]

The model must be further modified to account for heterogeneity in public infrastructure assets. In equations (9) and (12) the terms K_t^I and k_t^I on the right-hand side must be replaced by $K_t^{I,R}$ and $k_t^{I,R}$, respectively, because private activity depends only on physical infrastructure. Assuming that both types of infrastructure services are provided free of charge, equations (14), (15) and (16) must also be modified accordingly, so that, in particular,

$$\upsilon_{I,R} + \upsilon_{I,S} + \upsilon_U = 1. \tag{37}$$

The model again has no transitional dynamics and the growth rate is given by an expression similar to (26), with υ_I replaced by $\upsilon_{I,R}$ and using (19):

$$1 + \gamma = 0.5^{2\beta} (k^{I,S})^{\alpha} \{ b[1 - \varepsilon^{f,P}(k^{I,R}, k^{I,S})] \}^{\beta} \sigma \beta (1 - \tau)(1 + b), \tag{38}$$

where, similar to (24),

$$k^{I,h} = \frac{\upsilon_I \tau}{\sigma(1 - \tau)}. h = R, S$$

Women's time allocated to home production (and thus, market activity) depends now on both the physical infrastructure-private capital ratio and the social infrastructure-private capital ratio. Specifically, as shown in the Appendix, with the two-level home production

[26] A simpler specification would involve a CES function at the first level and a Cobb-Douglas function at the second level, of the form $Q_t = V_t^{\pi^Q} \left(\frac{K_t^{I,R}}{K_t^P} \right)^{1 - \pi^Q} m_t$, where V_t is as defined in the text. To ensure women's time is more complementary with social infrastructure requires now $\varsigma_S < 1$, given the properties of the Cobb-Douglas specification.

structure described by (35) and (36), in the particular case where $\pi_Q = 1$, the family's first-order condition with respect to $\varepsilon^{f,P}$ is given by

$$\eta_Q \frac{1}{Q_t} \frac{dQ_t}{d\varepsilon_t^{f,P}} = \frac{\eta_C(1 + \frac{\eta_Q}{\eta_C})}{1 - \sigma}, \tag{39}$$

where $dQ_t/d\varepsilon_t^{f,P} = (\partial Q_t/\partial V_t)(\partial V_t/\partial \varepsilon_t^{f,P})$. This expression implies that time allocated to home production is in general a function of both capital ratios, but no explicit solution can be derived as equation (39) is highly nonlinear.

Although an explicit analytical characterization is not feasible, the implications of adding heterogeneous public infrastructure assets are intuitively clear: although there is complementarity at the *micro*economic level (in the sense that both types of infrastructure assets help to reduce women's time devote to household chores) it may create a trade-off at the *macro*economic level. The reason of course is the existence of the government budget constraint (37), which implies that, if spending on "other" items cannot be implemented (because they represent mostly spending on public sector wages and salaries, for instance), any change in spending on one type of infrastructure must be offset by spending on the other ($d\upsilon_R + d\upsilon_S = 0$). To internalize this trade-off the government must balance two main considerations: on the one hand, social infrastructure has a larger impact on women's labor supply than physical infrastructure (as implied by the assumption that $\varsigma_S < \varsigma_R$), which affects growth, but on the other physical infrastructure has a direct impact on the productivity of private inputs, which also affects growth. The optimal allocation of investment—which, again, cannot be explicitly solved for here given the nonlinearities associated with the two-level specification—balances these two effects.[27]

5. SOME RESEARCH PERSPECTIVES

This paper provided an overview of the recent literature on the links between access to infrastructure, women's time allocation, and economic growth in developing countries. The first part reviewed the empirical evidence on these links, with an emphasis on the differential effects of two types of infrastructure: physical infrastructure (such as roads, water, and electricity) and social infrastructure (including, schools, hospitals, and access to child care facilities), which are more direct complements to care provisioning. The second part provided a
basic analytical framework that captures some of the key channels through which improved access to infrastructure affects changes in women's time allocation, and how these changes in turn affect economic growth. The third part extended the analysis to consider endogenous gender bias and bargaining power, endogenous fertility and rearing time, and heterogeneous infrastructure assets.

[27] Another consideration in choosing this allocation is the relative degree of efficiency associated with the two types of investment; see Agénor (2012, Chapter 1) for a discussion.

The main results of our analysis were summarized in the introduction; to conclude, it is worth identifying some fruitful areas for further research. First, in the paper, social norms regarding the role of women in the economy (including the time that they must allocate to household chores and child rearing) were taken as given. Endogenizing these norms (as in Agénor (2018) for instance) helps to study how they interact with access to infrastructure in determining women's occupational choices, and how norms change over time. Second, the focus in this paper was on mothers' time allocation; however, access (or lack thereof) to infrastructure affects the time that their daughters allocate to household chores as well. Webbink et al. (2012), for instance, in an extensive study of 16 African and Asian countries, found that girls are generally more involved in housework than boys. In a study for Bolivia, Zapata et al. (2011) found that girls are 51 percent more likely than boys to be out of school and working, mostly in domestic activities. This has important implications for growth and gender inequality. In Agénor and Alpaslan (2013) for instance, only girls' time is allocated to household chores and endogenously related to access to infrastructure. Parents make decisions about girls' time allocation but mothers are more intergenerationally altruistic towards girls—in the sense that they care more than fathers about the human capital of their daughters. Schooling also affects productivity in market activity in adulthood. In that setting, if women's bargaining power is weak to begin with, the equilibrium may be characterized by low growth and high gender inequality, which could perpetuate a poverty trap. The practical policy implication is that in poor countries where access to infrastructure is, to begin with, limited, promoting girls' education and reducing gender inequality may well require *at the margin* to allocate more public resources to infrastructure investment than education. However, this analysis should be extended to consider jointly endogenous time allocation by mothers and daughters, to account for possible substitution effects, and decisions by parents not only with respect to the time spent in household chores by their daughters but also by their sons in market work. In particular, intergenerational altruism may operate not only from mothers to daughters but also in the opposite direction: if mothers expect their daughters to provide substantial support to their parents in their old age for instance, they may be more willing to engage in home production today and allow them to accumulate human capital (especially if this enhances their prospects of marrying highly-skilled men, with better income potential), in return for future transfers. By contrast, if they expect their sons to provide these transfers, they may discriminate more against their daughters—which may contribute once again to perpetuate a high inequality, low-growth trap. This mechanism, together with lack of access to infrastructure services (as documented by Cubas (2016) for instance) may also help to account for cross-country differences in women's labor force participation rates.

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