Structural Change, Gender Gaps and Educational Choice[†]

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Abstract

In low-income countries, men invest considerably more years in school than women, and also spend more time in formal work. As countries become richer, women's years of schooling and hours in formal work increase relatively faster than men's. To realign both facts, I develop a general equilibrium, structural change model in which men and women make endogenous labor supply and schooling choices. Women have a comparative advantage in services, and their hours in formal work catch-up to men's as structural change gives rise to a formal service sector. Quantitatively, the model can reconcile the common decline of both gender gaps.

JEL-Classification: I24, I25, J16, J24, O41
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† A model-appendix to this paper is available here.

1 Introduction

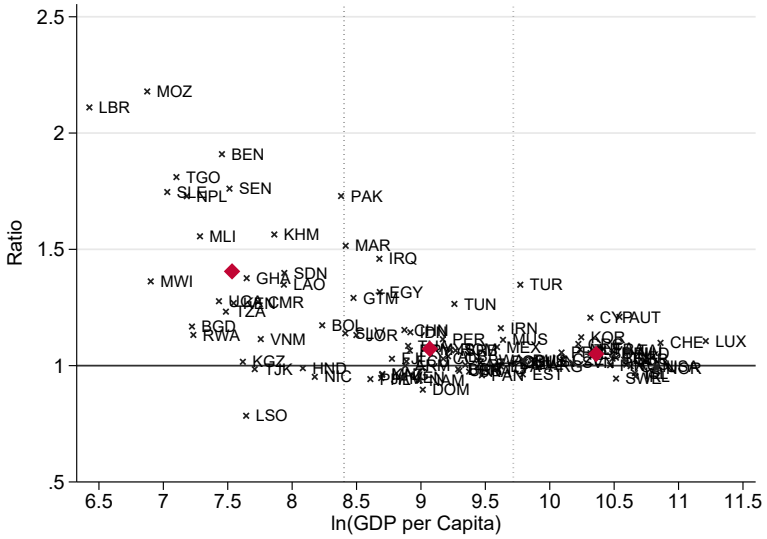
Cross-country data from Barro and Lee (2013) suggests that men in low-income countries (the bottom third of the world income distribution) spend on average 40% more years in school than women. Figure 1 shows that in a number of cases, actually, men spend nearly or even more than twice as many years in school as women. But why do women's years of schooling increase relatively faster than men's, so that schooling levels converge as countries become richer? Since Boserup's (1970) work on gender inequalities and economic development, this remains an important question in the development literature.

So far, it has not been theoretically investigated in how far the decline of the gender gap in years of schooling may be related to the parallel decline of a gender gap in hours of "formal" work, which occurs as economies undergo structural change. This is what I address in the present paper.

I use the term "formal" to describe hours worked by paid employees and by employers in larger-scale, modern production schedules (along the lines of Gollin, 2008). Based on the large cross-sectional dataset of Bick et al. (2018), I find that men in low-income countries spend on average more than twice as many hours in formal work than women. But from low- to high-income countries, women's hours of formal work increase relatively faster than men's, so that the gender gap in formal hours also declines. And, this decline goes along with considerable shifts in the industry structure, away from agriculture and to services, the industry that women specialize in. This points towards gender-biased technological change as an important determinant for the decline of both gaps (Ngai and Petrongolo, 2017).

I presume that gender differences in hours of formal work and years of schooling are closely linked. I deduce this from the model by Restuccia and Vandenbroucke (2014), where hours in formal work are paid a wage that depends on human capital. The model does not distinguish by gender, but it forwards the idea that the level of hours in formal work governs the extent to which agents can realize the returns to schooling. As countries become richer, the service share in the economy increases and this enables women, in particular, to increase their hours in formal work (Ngai and Petrongolo, 2017). When women's hours in formal work increase faster than men's, so do their opportunities to realize the returns to schooling (and therefore

Figure 1: Male/female ratio in years of schooling



Sources: Data by Barro and Lee (2013), year 2005. Includes all countries for which I have GDP per capita in 2005 real, ppp-adjusted US$. The vertical lines separate the 41 low, 48 middle, and 49 high-income countries. Red diamonds mark the country-income group averages.

their economic incentives to invest in schooling). Consequently, female years of schooling should rise faster than men's, too.

The contribution of this paper is to formalize, test, and validate this link. I develop a general-equilibrium, structural change model in which both genders' labor supply and schooling choices are endogenous. This allows me to analyse systematically how incentives to invest in human capital are connected to hours in formal work, why both gender gaps arise simultaneously, and why they co-move.

In the model, I distinguish between a traditional and a formal production sector, each of which comprises three industries (agriculture, manufacturing, and services). Traditional (small-scale) production occurs on the household level, using basic technologies. This reflects the dominant forms of production in low-income countries: own-account, unpaid, family, or household work (Gollin, 2008). Formal production occurs on a larger-scale, by firms which use paid labourers and modern technologies. This is the prevalent form of production in high-income countries. I recur to uneven technological progress as an exogenous force that causes sectoral shifts in hours worked (across industries and from traditional to formal production as countries become richer). So, in a broad sense my work connects to the literature

surrounding the theory of structural change, as reviewed in Herrendorf et al. (2014).

More narrowly, my work connects to prior works on gender-biased technological change, such as Goldin (1995), Rendall (2013), Akbulut (2011) Olivetti and Petrongolo (2016), and in particular Ngai and Petrongolo (2017). These works suggest that the faster rise of women's formal hours may be closely related to changes in the industry structure. The line of argumentation is as follows: Women's sectoral comparative advantage lies in services, because their production is relatively less intensive in the use of "brawn" skills (compared to manufacturing and agriculture). Structural change gives rise to a formal service sector and thus enables women, in particular, to enter formal work. To generate this pattern, I assume that in each sector labor productivities differ by gender (Ngai and Petrongolo, 2017). This gives rise to sectoral comparative advantages and is the first key element of the model.

The other key element of the model is that human capital enhances labor productivity (and is remunerated) only in formal production, but not in traditional production. This is to capture, in a reduced form, the idea that work in modern production schedules requires higher human capital than work in basic production schedules. This puts this work in line with other studies that impose similarly strict assumptions on the ambivalent role of human capital (Restuccia and Vandenbroucke, 2014; Hiller, 2014; Porzio and Santangelo, 2019). Less stylized assumptions are made in Herrendorf and Schoellman (2018), who assume that human capital intensity is lower in agricultural than in non-agricultural production.

The model implies that schooling choices are made along two margins. First, along an *individual decision margin* each agent faces the classic trade-off from investing in human capital: higher schooling increases the productive wage earned in formal work, but reduces the remaining life span during which one can engage in formal work. Additionally, the schooling choice is subject to the level of hours in formal work. This is because more hours in formal work creates more opportunities to realize the returns to schooling. Second, men's and women's schooling choices are also made along a *household decision margin*. There, men and women compare the marginal utility they each derive from a marginal increase in years of schooling to the marginal effect of this increase on each of their lifetime incomes.

I use micro-data of 15 low-, 27 middle- and 23 high-income countries to assess

the extent to which the gender gap in years of schooling should close, given the observed decline of the gender gap in formal hours. For this quantitative exercise, I calibrate the model to replicate the male/female formal hours ratio in each country income group. But I let the model speak freely to the schooling choices of men and women. It predicts that the male/female ratio in years of schooling should decline by -24% from low- to high-income countries (as compared to -12.7% in the data of those countries). This implies that in high-income countries, women should spend more years in school than men, which contradicts the data. I test which forces and model assumptions shape this controversial finding. It results from my assumption about schooling preferences: I adopt the concave utility specification from Bils and Klenow (2000). Given that there, agents derive a positive utility from schooling, their assumption is reasonable. In my calibration, however, schooling turns out to be a nuisance. So, I argue for the use of a simple and convex specification for schooling preferences. The model predictions for the decline of the male/female ratio in years of schooling then amount to -12.6%, which closely matches the data.

I conclude that gender gaps in education are closely linked to gender gaps in hours of formal work, and that it is helpful to think about the decline of both gaps in the context of structural change. This seemingly contrasts prior studies that emphasize how discriminating norms and institutions may prevent women from investing as much in education as would be economically optimal for them (Dollar and Gatti, 1999; Cooray and Potrafke, 2011; Hiller, 2014). My findings, however, do integrate with those. This is because norms and institutions most probably affect female labor supply choices as well (Goldin 1995, 2006). What distinguishes this work is that it puts more emphasis on how the economic rationales surrounding gender gaps in schooling change as gender gaps in formal hours decline with structural change.

Next, I present stylized facts about men's and women's years of schooling and formal hours. Section 3 develops and solves the model, which is followed by a quantitative analysis in Section 4. Finally, I conclude.

2 Stylized Facts

I now turn to the empirical facts that motivate this paper. For years of schooling, I mainly rely on the dataset that Barro and Lee (2013) assemble from census

data and report for year 2005. In three cases, I retrieve years of schooling from the database of the United Nations' Human Development Report. This is to be able to present mean schooling years for 65 countries that form my sample for the computation of hours in formal and traditional work. This sample is, in turn, based on the micro-data surveys harmonized in Bick et al. (2018) and that surround year 2005. They use these to compute hours worked in a large sample of countries, in particular more low-income countries than in previous studies (as reviewed in Folbre, 2014). I postpone details on traditional hours to Section 4 and on the surveys used to Appendix A. For 60 of the 65 countries, I can identify hours in formal work using the status in the main occupation: I classify hours worked in paid employment or as an employer as formal hours. This is to capture hours worked in a larger-scale, modern production schedule, which I presume uses advanced technologies and imposes certain requirements on human capital. The reason is that work there is non-routinized, and requires analytical and coordinative skills (Spitz-Oener, 2006).

I divide countries into low-, middle-, and high-income countries, according to their position in the global income distribution. To do so, I retrieve the threshold levels of ppp-adjusted GDP per capita that separate low- from middle-income countries and middle- from high-income countries in 2005. Based on each country's level of GDP per capita, I classify countries accordingly.

2.1 Years of schooling

Panel A of Table 1 shows that in low-income countries, there exist considerable differences in men's and women's years of schooling. Actually, women in low-income countries have an average of 5 years of schooling. Men, on the other hand, have an average of 6 years of schooling, or about 20% more. I find this gap as striking as the fact that these schooling values are just as high as those that prevailed in today's OECD countries about 100 years ago (Behrman and Grant, 2010).

Schooling levels increase as countries become richer, which is in line with Evans et al. (2020). From low- to middle-income countries, male and female years of schooling increase to 8.6 and 8.0. In high-income countries, schooling is 10.8 years for men, and 10.4 years for women. Overall, years of schooling increase by 80% for men. For women, they increase relatively faster, by 106% for women.

Table 1: Stylized facts

	Country Income Group			Δ Low-high
	Low	Middle	High	
Panel A: Years of schooling				
Men	6.0	8.6	10.8	80 %
Women	5.0	8.0	10.4	106 %
Ratio	1.20	1.07	1.05	−13 %
Panel B: Weekly hours in formal work				
Men	16.9	22.3	22.6	34 %
Women	7.9	11.5	14.1	79 %
Ratio	2.14	1.94	1.60	−25 %

Sources: Mean years of schooling, ages 15+, based on data of Barro and Lee (2013) and of the UN (Timor-Leste, Bosnia, China, Angola). Mean weekly hours in formal work based on data of Bick et al. (2018) (13 low + 24 middle + 23 high-income countries). Note that there is a lot of variation in the formal hours data (see Appendix Figure B.1). In anticipation of the model that I bring to the data in Section 4, this is formal hours of all men/women who have completed education.

2.2 Hours in formal work

Now consider Panel B of Table 1. Men's average hours in formal work amount to 16.9 in low-income countries. This is more than twice the amount of hours that women spend per week in formal work (7.9). So, in low-income countries there exists a considerable gender gap in the amount of hours in formal work.

Men's hours in formal work increase mostly from low- to middle-income countries (to 22.3), and stay more or less constant thereafter. Women's hours in formal work increase more evenly, to 11.5 in middle- and 14.1 in high-income countries. Overall, men's formal hours increase by 34% from low- to high-income countries, while women's formal hours increase relatively faster, by nearly 80%.

2.3 Common trends in both gender gaps

Across the 60 countries for which I know both, formal hours and schooling, the male/female ratios in years of schooling and formal hours are positively correlated (the correlation coefficient amounts to 0.62). I also run a simple log-log regression which suggests that a 1% lower male/female ratio in formal hours (independent variable) is associated to a 0.17% lower male/female ratio in years of schooling.

For the common trends of both gaps with GDP per capita, consider the *Ratios* in Panels A and B. Men in low-income countries spend 20% more years in school than

women. They also spend more than twice as many hours as women in formal work. From low- to high-income countries, women's years of schooling increase relatively faster than men's. Because of this, the schooling *ratio* declines by -13%. This is considerable, given that it implies that the *gap* in relative schooling years falls by $(0.05-0.2)/0.2=-75\%$. Similarly, women's hours in formal work increase relatively faster than men's, so that the *ratio* in hours of formal work declines by -25%. And again this is considerable, because it implies that the *gap* in hours of formal work declines by $(0.6-1.14)/1.14=-47\%$. I use the (market hours) data by Bridgman et al. (2018) to check if these findings are an artefact of my data.[1] In their sample of countries, the *gaps* in years of schooling and in market hours decline similarly: by -86% and -49%, respectively (see Appendix Table B.1).

2.4 Linking both gender gaps

The model by Restuccia and Vandenbroucke (2014) forwards the idea that higher hours in formal work should go along with higher years of schooling. The reason is that hours in formal work are paid a wage that depends on human capital, so that higher formal hours create more opportunities to realize the returns from schooling. This increases the incentive to stay in school. In my data, this is supported by the fact that hours in formal work increase with education (Appendix Table B.2). So eventhough Restuccia and Vandenbroucke (2014) do not distinguish by gender, their model forms a promising starting point to formalize how gender gaps in years of schooling may be related to gender gaps in hours of formal work.

But what can explain why both gaps decline from low- to high-income countries? One answer is related to structural change, and in particular to gender-biased technological progress. As countries become richer, there occur sectoral shifts in hours, away from agriculture towards services and manufacturing. These structural change patterns are clearly visible in my data (Table 2). Goldin (1995), Akbulut (2011), Rendall (2013), Olivetti and Petrongolo (2016), and Ngai and Petrongolo (2017) suggest that the rise of a formal service sector may be a key factor in explaining why women's hours of formal work rise relatively faster than men's. The

[1] The terms formal and market are closely related, but should not be used interchangeably. Bridgman et al. (2018, p.105) define market hours "as hours worked for a salary, wage, or as a proprietor". This can include very basic forms of production. I rely on formal versus traditional work because I focus on the role of human capital, which depends on the scale and technology of production.

Table 2: Industry shares and female intensity

	Sector share			% of women's formal hours		
	Low	High	ΔLow-high	Low	High	ΔLow-high
Agriculture	29.4	3.1	−26.3	30.5	1.9	−28.7
Manufacturing	17.6	30.8	13.2	17.9	17.7	−0.2
Services	53.1	66.1	13.0	51.5	80.4	28.9

Sources: Columns 1 and 2 report industry shares, as % of hours worked by men + women in formal work, and column 3 the %-point change from low- to high-income countries. Columns 4-6 report industry shares in women's hours of formal work, and their %-point change.

line of argumentation is as follows. Compared to agriculture and manufacturing, the production of services is relatively less intensive in the use of "brawn" skills, with which women are less endowed than men. Therefore, women's sectoral comparative advantage lies in services, and the rise of a formal service sector attracts women, in particular, into formal work. In my data, services constitute the majority of women's hours in formal work (52% in low- and 80% in high-income countries), which reflects their comparative advantage in that industry. Together with the 13%-point rise of services, I expect that a theory around gender-biased structural change may explain why women's formal hours and schooling levels rise faster than men's.

This is not to say that other forces are not important. Amongst other things, stigmatization and norms (Goldin, 1995; Hiller, 2014), tax considerations (Bick and Fuchs-Schündeln, 2017, 2018), fertility (Attanasio et al., 2008; Kleven and Landais, 2017), and in particular declining gender wage gaps may matter. As for the latter, Eckstein and Lifshitz (2011) and Wong and Fernandez (2012) find that the historical decline of the gender wage-gap in the US contributed to the rise in female labor force participation and was accompanied by improvements in female education. That would make rising relative wages a promising candidate force to explain why both gaps decline as countries become richer. However, a conventional Blinder-Oaxaca (1973) decomposition on micro-level wage-data from a subset of my countries actually suggests that women's relative wages remain more or less constant across countries (between 0.8 and 0.85, see Appendix Figure B.2).

So next, I formalize how gender gaps in years of schooling and in hours of formal work may be related, and why both gaps decline together. To do so, I develop a multi-sector general equilibrium model in which both genders make endogenous

labor supply and schooling choices in an environment of structural change.

3 Model

Time is continuous. At any given time, a household is born, which consists of one male and one female agent. Both live to the age of T. Their lives can be divided into two stages. First, an agent is young and consumes, spends time in leisure, in traditional forms of production, and goes to school to accumulate human capital. After schooling is completed, human capital remains fixed. Agents then consume, spend time in leisure and in traditional work, but also in formal work.[2]

Production occurs in three formal and three traditional production sectors. In each formal sector, there is a representative firm that produces and sells either agricultural goods, manufacturing goods, or services.[3] These firms combine a modern technology and labor inputs of men and women to produce output for sale. All three kinds of commodities are also produced in traditional production, which occurs on the household level and uses basic technologies. One key feature is that human capital enhances the individual labor productivity of men and women in formal work, but not in traditional work. The other key feature of the model is that labor productivities differ by gender, which gives rise to sectoral comparative advantages.

3.1 The supply side of the economy

I start with the supply side of the economy to highlight the role of gender specific labor productivities and the different ways in which human capital affects production. First, consider the traditional production of commodities c_i, $i = \{A_h, M_h, S_h\}$. I follow the conventional notation and use subscript h since tradi-

[2] I impose that only formal work-work starts after schooling is finished. This is to highlight the link between formal hours and years of schooling more easily. I present data supporting this assumption in Appendix Table (B.3). And, I show in Section 4.4 that my main results also hold if years of schooling reduce the remaining working-life in both, formal and traditional work.

[3] I distinguish between agricultural and manufacturing commodities, although earlier studies tend to combine those commodities. For example, Ngai and Petrongolo (2017) consider goods in general and only distinguish household from market services. For their purpose (explaining the rise of women's market hours in the US), this is the simplest, yet conducive, setup. Here, I aim to capture how differently men and women reallocate their time also at earlier stages of development: from low- to high-income countries, both genders reduce time in agriculture. But while men increase time in manufacturing, women increase time in services (Reimers, Unpublished). So, I differentiate further.

tional production occurs by the household, which forms its own production unit. To produce, the couple uses technology Z_i and combines labor:

$$c_i = Z_i L_i, \tag{1a}$$

$$L_i = \left[\xi_i \left(l_i^f\right)^{\frac{\eta-1}{\eta}} + (1-\xi_i)\left(l_i^m\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{1b}$$

The terms l_i^m and l_i^f denote male and female sectoral labor inputs. For the traditional sector, these will result from household optimization. The parameter η governs the substitutability of male and female inputs in the composite L_i. I restrict $\xi_i \in (0,1)$. Suppose $\xi_i > \xi_k$, for $i,k \in \{A_h, M_h, S_h\}$ but $i \neq k$. In that case, I claim that women have a sectoral comparative advantage in producing c_i rather than c_k. Labor productivities are thus gender-specific. This is a key feature of the model as it governs how agents allocate their productive time relatively across sectors. And, it allows me to use structural change as an exogenous force to replicate the faster rise of women's hours in formal work (Ngai and Petrongolo, 2017; Reimers, Unpublished).

Each kind of commodity is also produced by a firm. This is a formal production entity that pools labor inputs of all men and women who finished school, and uses technology Z_j to produce output y_j, $j = \{A_m, M_m, S_m\}$. I follow the conventional use of subscript m, and think of it as a placeholder for "modern":

$$y_j = Z_j L_j, \tag{2a}$$

$$L_j = \left[\xi_j \left((T-s_f)H(s_f)l_j^f\right)^{\frac{\eta-1}{\eta}} + (1-\xi_j)\left((T-s_m)H(s_m)l_j^m\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}. \tag{2b}$$

Again, $\xi_j \in (0,1)$ governs where each gender has a sectoral comparative advantage. The terms $(T-s_g)$, $g = f,m$ aggregates individual labor choices l_j^g across all working generations. I follow Bils and Klenow (2000) and specify:

$$H(s_g) = \exp\left(\frac{\zeta}{1-\nu} s_g^{1-\nu}\right), \qquad g = m, f. \tag{2c}$$

Most importantly, human capital enhances the labor productivity of workers in formal work, but not in traditional work. This is the second key feature of the model.

3.2 The demand side of the economy

To simplify, I abstract from life-cycle considerations in consumption, leisure and work choices.[4] Husband and wife of a representative household derive joint utility from consumption c, leisure L_l and years of schooling s_m, s_f:

$$U(c, L_l, s_f, s_m) = \int_{t=0}^{T} e^{-\rho t} \quad \Big[ln(c) + \varphi ln(L_l)\Big] dt + W(s_m) + W(s_f). \tag{3a}$$

$W(s_g)$ is the utility derived from spending s_g years in school. This is to capture possible non-monetary costs (for example psychic costs) or benefits of schooling (Heckman et al., 2006; Oreopoulos and Salvanes, 2011). I specify

$$W(s_g) = \beta_g \int_{t=0}^{s_g} e^{-\rho t} dt, \qquad g = m, f, \tag{3b}$$

as in Bils and Klenow (2000). Here, β_g captures the flow utility of going to school.

Consumption c is a nested-CES composite of three commodity kind bundles c_j: agricultural goods c_A, manufacturing goods c_M, and services c_S. Each bundle is, in turn, formed from a firm and a household commodity version (c_{j_m} and c_{j_h}):

$$c = \left[\sum_{j=A,M,S} \omega_j c_j^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{3c}$$

$$c_j = \left[\psi_j (c_{j_m})^{\frac{\sigma-1}{\sigma}} + (1-\psi_j)(c_{j_h})^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}. \tag{3d}$$

I limit my attention to the case in which $\varepsilon < 1$ and $\sigma > 1$. This is common and key to generate sectoral shifts in labor as productivities grow unevenly across sectors (Herrendorf et al., 2014; Ngai and Petrongolo, 2017; Moro et al., 2017).

The leisure composite L_l is formed by female and male leisure time, l_l^f and l_l^m:

$$L_l = \left[\xi_l (l_l^f)^{\frac{\eta-1}{\eta}} + (1-\xi_l)(l_l^m)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \qquad \xi_l \in (0,1). \tag{3e}$$

[4] I assume that the time-discount rate equals the interest rate in the lifetime budget constraint.

I subject household choices to a lifetime budget constraint. This is to abstract from an explicit asset accumulation choice (Restuccia and Vandenbroucke, 2014):

$$\int_{t=0}^{T} e^{-\rho t}\Big(\sum_{j=A,M,S} p_j c_{j_m}\Big)dt = \sum_{g=m,f}\int_{t=s_g}^{T} e^{-\rho t}\Big[M^g w_g H(s_g)\Big]dt. \tag{3f}$$

Both sides of (3f) are expressed in terms of present values (where I assume that the rate of interest is equal to the time discount rate ρ). The left-hand side is the present value of the household's lifetime expenditures on commodities produced by firms (from birth onwards). The right-hand side is the present value of earnings that both household members accumulate from formal work. These earnings depend on human capital $H(s_g)$ and the remaining duration of life after completion of school, $T - s_g$. Higher years of schooling reduce the life-span during which agents can engage in formal work. But they also increase human capital $H(s_g)$, and thus the productive wage on every unit of time that agents spend in formal work M^g:

$$M^g = L^g - l_l^g - l_{A_h}^g - l_{M_h}^g - l_{S_h}^g, \qquad g = f,m. \tag{3g}$$

3.3 General Equilibrium

The household chooses (i) consumption of commodities c_{A_m}, c_{M_m} and c_{S_m}; (ii) how much time $\{l_{j_h}^f, l_{j_h}^m\}_{j=A,M,S}$ each member shall spend in traditional production of each commodity, and in leisure (l_l^f, l_l^m); and (iii) how many years each member should stay in school $\{s_f, s_m\}$. Firms choose female and male labor units $\{l_{j_m}^f, l_{j_m}^m\}_{j=A,M,S}$.

A competitive equilibrium is defined by a set of market prices $\{p_{A_m}, p_{M_m}, p_{S_m}\}$ and wages $\{w_f, w_m\}$, time and consumption allocations $\{l_{j_m}^f, l_{j_m}^m, l_{j_h}^f, l_{j_h}^m, c_{j_m}\}_{j=A,M,S}$, leisure $\{l_l^f, l_l^m\}$ and years of schooling $\{s_f, s_m\}$ such that

1. Households maximize utility (3a) subject to their preferences (3c) - (3e), budget and time constraints (3f) - (3g), human capital (2c), and technology (1b);
2. Firms $j = \{A_m, M_m, S_m\}$ maximize profits subject to technology (2a) - (2b);
3. Commodity markets clear: $c_{j_m} = \frac{1}{T} Z_{j_m} L_{j_m}$ and $c_{j_h} = Z_{j_h} L_{j_h}$ for $j = A, M, S$,

The implicit intergenerational contract in this economy is that the young generations' consumption of firm commodities is provided by the working generations. Intuitively, working generations are like parents who are willing to finance their children's consumption of firm commodities, while these are still in school.

3.4 Optimization

I now derive optimal time allocations and schooling choices of both household members as functions of two sets of exogenous variables. These are, first, sectoral technology differentials: how advanced is technology in one sector as compared to another? The second are the female-specific productivity weights $\{\xi_{j_h}, \xi_{j_m}\}_{j=A,M,S}$. They govern where each gender has a sectoral comparative advantage. All upcoming equations are derived in detail in a model appendix (available here).

On the firm side, the first-order conditions take the form:

$$l_j^f : w_f = p_j Z_j \xi_j \big((T-s_f)H(s_f)\big)^{-\frac{1}{\eta}} \big(l_j^f\big)^{-\frac{1}{\eta}} L_j^{\frac{1}{\eta}} \qquad j = A_m, M_m, S_m \tag{4a}$$

$$l_j^m : w_m = p_j Z_j (1-\xi_j) \big((T-s_m)H(s_m)\big)^{-\frac{1}{\eta}} \big(l_j^m\big)^{-\frac{1}{\eta}} L_j^{\frac{1}{\eta}} \qquad j = A_m, M_m, S_m. \tag{4b}$$

The first-order conditions of the household problem are:

$$c_{j_m} : \frac{\partial U}{\partial c_{j_m}} = \lambda a_T p_{j_m}, \qquad j = A, M, S; \qquad g = f, m \tag{5a}$$

$$l_{j_h}^g : \frac{\partial U}{\partial c_{j_h}} \frac{\partial c_{j_h}}{\partial l_{j_h}^g} = \lambda w_g d(s_g) H(s_g), \qquad j = A, M, S; \qquad g = f, m \tag{5b}$$

$$l_l^g : \frac{\partial U}{\partial l_l^g} = \lambda w_g d(s_g) H(s_g), \qquad g = f, m \tag{5c}$$

$$s_g : W'(s_g) = -\lambda w_g M^g \Big[d(s_g) H'(s_g) + d'(s_g) H(s_g) \Big], \qquad g = f, m \tag{5d}$$

Definitions are as follows: $a_T := \int_{t=0}^{T} e^{-\rho t} dt$ is the lifetime discounting term. Similarly, $d(s_g) := \int_{t=s_g}^{T} e^{-\rho t} dt$ for genders $g = f, m$ is the working-life discounter. The parameter λ is the Lagrange multiplier on the lifetime budget constraint.

I clarify two terms. First, $d(s_g)H(s_g)$ measures the extent to which schooling contributes to lifetime income, conditional on hours in formal work M^g and wages

w_g. I see this as the value-added of schooling for lifetime income. Second,

$$d(s_g)H'(s_g) + d'(s_g)H(s_g), \tag{6}$$

is the first-order derivative of $d(s_g)H(s_g)$. So, it is the conditional marginal effect of schooling on lifetime income (holding hours in formal work M^g and the wage w_g constant). This term captures the trade-off from schooling highlighted in Becker (1962) and Mincer (1958): A marginal increase in years of schooling raises human capital, but shortens the remaining life span during which agents can engage in formal work. When both effects perfectly trade off, the term $d(s_g)H(s_g)$ is maximized.

I point this out because schooling and labor supply choices will be linked through $d(s_g)H(s_g)$. For this reason, it is important to have an understanding of how marginal changes in s_g affect this term. In the model appendix, I show that if schooling is a nuisance ($\beta_g < 0$ in 3b), then the conditional marginal effect of schooling on lifetime income in (5d) must be positive. This means that $d(s_g)H(s_g)$ is increasing in s_g. On the contrary, if $\beta_g > 0$ it must be that $d(s_g)H(s_g)$ is decreasing in s_g. I preview that in the calibration, $\beta_m, \beta_f < 0$, so I limit my attention to that case.

3.4.1 Men's and women's labor supply choices

Profit and utility maximization yield relations for male and female sectoral hours. For hours in traditional work, combine (5b) for men and women. For hours in formal work, combine (4a) and (4b). For $j = A, M, S$, this yields

$$\frac{l^m_{j_h}}{l^f_{j_h}} = \alpha^{-\eta}_{j_h} x^{\eta} \left(\frac{d(s_f)H(s_f)}{d(s_m)H(s_m)} \right)^{\eta} \quad \text{and} \quad \frac{l^m_{j_m}}{l^f_{j_m}} = \alpha^{-\eta}_{j_m} x^{\eta} \frac{H(s_f)}{H(s_m)} \frac{(T - s_f)}{(T - s_m)}, \tag{7}$$

where x is the wage ratio w_f/w_m and $\alpha_j := \frac{\xi_j}{1-\xi_j}$. The higher the gender-specific productivity of women compared to men, the higher are relative hours of women. Household members compare their opportunity costs of spending time in traditional work (foregone discounted lifetime earnings from the alternative of spending that time in formal work). Firms compare the productive wages that they have to pay to the working generations of women and men.

Pricing. I follow Ngai and Petrongolo (2017) and use (7) to rewrite the production functions (1b, 2b) in terms of female hours. Let wages equalize across sectors

(perfect labor mobility). Relative prices of two firm commodities c_{j_m} and c_{i_m} are:

$$\frac{p_{j_m}}{p_{i_m}} = \frac{Z_{i_m}}{Z_{j_m}} \left(\frac{\xi_{i_m}}{\xi_{j_m}} \right)^{\frac{\eta}{\eta-1}} \left(\frac{I_{j_m}}{I_{i_m}} \right)^{\frac{1}{\eta-1}}, \tag{8a}$$

where I_{i_m}, I_{j_m} denote female sectoral wage-bill shares.[5] The more advanced technology Z_{j_m} is compared to Z_{i_m}, the lower is the relative price of c_{j_m}. As common, I refer to "structural transformation" as a process during which technologies in (8a) improve unevenly for different commodity kinds.

For the three commodities produced by the household, assume that there exists an implicit market price p_{j_h} which is defined such that $\frac{\partial U}{\partial c_{j_h}} = \lambda a_T p_{j_h}$. This is the price the household would pay if it were to buy the traditional commodity on the market. Then, relative prices of household and firm commodities are given by

$$\frac{p_{j_h}}{p_{j_m}} = \frac{Z_{j_m}}{Z_{j_h}} \left(\frac{\xi_{j_m}}{\xi_{j_h}} \right)^{\frac{\eta}{\eta-1}} \left(\frac{I_{j_h}}{I_{j_m}} \right)^{\frac{1}{\eta-1}} \frac{d(s_f)H(s_f)}{a_T}. \tag{8b}$$

The more advanced is firm technology compared to household technology, the lower is the relative price of the firm commodity. "Modernization" is a process during which technology in a formal sector improves relatively faster than in the respective traditional sector.[6] So far, this is as in Ngai and Petrongolo (2017). Note though that the higher s_f, the lower is the relative price of the commodity produced by the firm.[7] So, higher schooling accelerates the process of modernization.

Expenditures. I now address how the household adjusts expenditures when relative prices change. It might either decrease or increase *relative* expenditures for the commodity that becomes relatively more expensive. This depends on the underlying force that drives the change in relative prices.

To see this, first consider modernization or, equivalently, an increase in female years of schooling. From the marginal rate of substitution, relative expenditures on

[5] I define $I_{j_h} := \frac{w_f l_j^f d(s_f) H(s_f)}{w_f l_j^f d(s_f) H(s_f) + w_m l_j^m d(s_m) H(s_m)}$ and $I_{j_m} := \frac{w_f (T-s_f) H(s_f) l_{jm}^f}{w_f (T-s_f) H(s_f) l_{jm}^f + w_m (T-s_m) H(s_m) l_{jm}^m}$

[6] Ngai and Petrongolo (2017) and Bridgman et al. (2018) use the term "marketization", as they focus on the move of production away from commodities for own use, to those for sale. "Modernization" is more sensible to describe shifts away from traditional (basic) to formal (modern) production.

[7] Keep in mind that if $\beta_f < 0$, then $d(s_f)H(s_f)$ is increasing in s_f.

firm versus household versions of the same commodity kind are given by

$$E_{j_{mh}} := \frac{p_{j_m} c_{j_m}}{p_{j_h} c_{j_h}} = \left(\hat{Z}_{j_{mh}} \left(\frac{\xi_{j_m}}{\xi_{j_h}} \right)^{\frac{\eta}{\eta-1}} \left(\frac{I_{j_h}}{I_{j_m}} \right)^{\frac{1}{\eta-1}} \frac{d(s_f) H(s_f)}{a_T} \right)^{\sigma-1}, \tag{9a}$$

$$\text{with } \hat{Z}_{j_{mh}} := \frac{Z_{j_m}}{Z_{j_h}} \left(\frac{\psi_j}{1-\psi_j} \right)^{\frac{\sigma}{\sigma-1}}.$$

When Z_{j_m}/Z_{j_h} or s_f increase, firm commodities become relatively cheaper than their household counterparts. For $\sigma > 1$, preferences are such that firm and household versions of a commodity kind are good substitutes. So the intuitive reaction of the household is to shift resources towards firm commodities: $E_{j_{mh}}$ increases.

Under structural transformation, the household does not shift resources to the commodity that becomes relatively cheaper. To see why, note that relative expenditures for two different kinds of commodities c_{j_m}, c_{k_m}, $j,k = A,M,S$ are given by:

$$E_{j_m k_m} = \left[\hat{Z}_{k_m j_m} \left(\frac{\xi_{k_m}}{\xi_{j_m}} \right)^{\frac{\eta}{\eta-1}} \left(\frac{I_{j_m}}{I_{k_m}} \right)^{\frac{1}{\eta-1}} \right]^{1-\varepsilon} \left[\frac{1+E_{k_{mh}}}{E_{k_{mh}}} \frac{E_{j_{mh}}}{1+E_{j_{mh}}} \right]^{\frac{\sigma-\varepsilon}{\sigma-1}}, \tag{9b}$$

$$\text{with } \hat{Z}_{k_m j_m} := \frac{Z_{k_m}}{Z_{j_m}} \left(\frac{\omega_k}{\omega_j} \right)^{\frac{\varepsilon}{1-\varepsilon}} \left(\frac{\psi_k}{\psi_j} \right)^{\frac{\sigma}{\sigma-1}}.$$

Consider a case in which Z_{k_m}/Z_{j_m} increases such that c_{k_m} becomes relatively cheaper than c_{j_m}. When preferences are such that different commodity kinds are hard to substitute ($\varepsilon < 1$), changing the commodity mix is costly in terms of utility. Therefore, the household shifts relatively more resources towards the kind of commodity that becomes relatively more expensive: $E_{j_m k_m}$ increases.

Labor. Demand and supply of each commodity must balance out under market clearing. Because of this, when demand is adjusted then agents have to readjust the time they allocate to the production of each commodity, too. For a firm commodity c_{j_m} and its traditional counterpart c_{j_h}, they do so according to:

$$\frac{l^f_{j_m}}{l^f_{j_h}} = E_{j_{mh}} \frac{I_{j_m}}{I_{j_h}} \frac{d(s_f)}{a_T} \frac{T}{T-s_f}. \tag{10a}$$

When technologies advance faster in formal than in traditional production, the

higher relative demand for firm commodities is met as agents allocate relatively more time to formal work. Mechanically, this occurs through a rise of $E_{j_{mh}}$.

The allocation of time towards different kinds of firm commodities is given by

$$\frac{l^f_{j_m}}{l^f_{k_m}} = E_{j_m k_m} \frac{I_{j_m}}{I_{k_m}}. \tag{10b}$$

When technological progress occurs faster in commodity kind k than in j, agents reallocate their time towards j. They do so in order to compensate for the lower relative productivity there. Mechanically, this occurs through a rise in $E_{j_m k_m}$.

3.4.2 Men's and women's schooling choices

I now formulate two conditions for years of schooling. The first describes an ***individual decision margin*** of schooling choices. Combining (5b) and (5d) yields

$$-\beta_f e^{-\rho s_f} = \frac{M_f}{L^f_{S_h}} \hat{H}(s_f) \left[E_{S_{mh}} \sum_{j=A,M,S} E_{j_m S_h} \frac{1+E_{j_{mh}}}{E_{j_{mh}}} \right]^{-1} I_{S_h} a_T. \tag{11a}$$

Keep in mind that I presume $\beta_f, \beta_m < 0$. The left-hand side is women's marginal utility of schooling. It must equal the marginal cost of schooling. Higher formal hours M^f are associated to higher marginal costs of schooling. This is because higher schooling comes at the opportunity cost of reducing the remaining life span in which agents can engage in formal work. The higher are formal hours, the higher is that opportunity cost of schooling. On the contrary, the higher are hours in traditional services (where human capital is irrelevant), the lower that opportunity cost.

Furthermore, it should be noted that the term

$$\hat{H}(s_g) := \frac{H'(s_g)}{H(s_g)} + \frac{d'(s_g)}{d(s_g)}, \qquad g = f, m,$$

is a rewritten version of the conditional marginal effect of schooling on lifetime income in (6). It is falling in s_g. This is because when $\beta_f < 0$, the conditional marginal effect of schooling on lifetime income is positive, but decreasing to zero (where the marginal benefit of s_f on $H(s_f)$ and the marginal cost of s_f on $d(s_f)$ trade each-other off). On the margin, schooling years therefore reduce the marginal

costs by increasing conditional lifetime earnings from formal work.

This effect is reinforced by the marginal effect of schooling on I_{S_h}. Think of this as the female share in the household's foregone earnings (from spending time in production of household services rather than in formal work). A marginal rise in female schooling is, of course, associated to higher foregone earnings from formal work. However, I_{S_h} incorporates that in response to the marginal rise in s_f, women reduce their time in household production (relative to men, 7). Because this effect prevails, the female share in the household's foregone earnings is decreasing in s_f.

Finally, the marginal cost of schooling depends on how the household allocates its expenditures to firm and household versions of the same commodity kind, and across different kinds of commodities. The effect of those terms is ambiguous.

The household decision margin. I now turn to an equation that links both genders' choices of hours in formal work and years of schooling. The derivative for years of schooling (5d) holds for both, men and women. Combining yields

$$\frac{\beta_m}{\beta_f}\frac{e^{-\rho s_m}}{e^{-\rho s_f}} = \frac{M^m}{M^f}\frac{w_m}{w_f}\frac{H(s_m)}{H(s_f)}\frac{d(s_m)}{d(s_f)}\frac{\hat{H}(s_m)}{\hat{H}(s_f)}. \tag{11b}$$

This condition relates both genders' marginal utilities from years of schooling to both genders' lifetime earnings. The terms $M^g w_g H(s_g) d(s_g)$ for $g = f, m$ measure discounted lifetime earnings from formal work. This is scaled by the conditional marginal effects of years of schooling on the lifetime income of each gender (holding hours in formal work and wages constant): $\hat{H}(s_m)/\hat{H}(s_f)$.

So, along a household margin men and women optimize on years of schooling and time in formal work such that relative marginal disutilities of schooling equal relative discounted lifetime earnings. Doing so, they also take into account the conditional marginal benefit that schooling has on each of their lifetime incomes.

3.4.3 Solving the model

I solve for an equilibrium computationally. To do so, I numerically approximate the wage ratio x and the schooling choices s_f, s_m that satisfy three equilibrium conditions. The first is (11a) on female years of schooling. The second is (11b) which relates male and female years of schooling. For the third condition, I follow Ngai and Petrongolo (2017). From the budget constraint, I derive an expression for

female time in traditional services $l^f_{S_h}$, as a share of time endowment L^f:

$$\frac{l^f_{S_h}}{L^f} = \left(I_L \sum_{\substack{j=A_m,M_m,S_m \\ A_h,M_h,S_h,l}} \frac{E_{jS_h}}{I_{S_h}} \right)^{-1}. \tag{12a}$$

I_L is defined as the hypothetical female wage-bill share, if men and women were to spend all of their time endowment in formal work. Also, I use (10a) and (10b) on women's relative time allocations to rewrite the female time constraint as

$$\frac{l^f_{S_h}}{L^f} = \left(\sum_{j=A,M,S} E_{j_m S_h} \frac{I_{j_m}}{I_{S_h}} \frac{d(s_f)}{a_T} + \sum_{\substack{j=A_h, \\ M_h,S_h,l}} E_{jS_h} \frac{I_j}{I_{S_h}} \right)^{-1} \tag{12b}$$

Combined, equations (12a) and (12b) form the third condition.

4 Quantitative Analysis

Next, I quantitatively assess in how far a decline of the male/female ratio in formal hours is associated to a decline of the male/female ratio in years of schooling.

4.1 Calibration

My strategy is to first calibrate the model to match time allocations and years of schooling in low-income countries. This includes calibrating the preference parameters for schooling and leisure, but also the exogenous inputs that govern men's and women's relative time allocations: the sectoral technology differentials and the gender-specific productivity weights. Then I recalibrate the model once for middle- and once for high-income countries. Doing so, I hold preferences fixed. I only recalibrate the exogenous inputs by targeting men's and women's relative time allocations, but let the model speak freely to schooling choices. This allows me to assess the extent to which the model predicts that the gender gap in years of schooling should close, given the actual decline of the male/female formal hours ratio.

4.1.1 Data

I calibrate the model based on micro-data of 15 low-, 27 middle- and 23 high-income countries from Bick et al. (2018). I list all countries in Appendix Tables

(A.1)-(A.3). When data allows I include individuals aged less than 15 years (the typical cut-off age for studies on hours worked by adults). This is to be consistent with timing in the model (where life starts with the beginning of school), and important because in low-income countries, many finish schooling before they are 15 years old.[8] For hours in formal work, I focus on individuals who report not being enrolled in education (to proxy for having completed schooling). I classify all non-enrolled who report to be in paid employment or an employer (in their primary occupation) as formal workers, and all unpaid/family/household workers or self-employed without employees as traditional workers, irrespective of enrollment. This stylized distinction is to capture whether someone engages in a larger-scale, modern production schedule (that requires human capital), or in a smaller-scale, basic production schedule. It is, of course, a crude approximation of reality. And, it abstracts from the possibility that part of traditional output is sold on a commodity market (in the model, all output from traditional production is destined for own consumption). More consistent approaches are, unfortunately, limited by data.

To hours in traditional services, I add time-use data on hours spent producing household services such as cooking or cleaning at home, childcare, shopping or collecting water and firewood (particularly relevant in low-income countries). When available, these are also compiled by Bick et al. (2018) from the surveys containing information on labor hours, or from Multinational Time Use Studies (where otherwise possible). The value added from hours in these activities is not accounted for in NIPA, the National Income and Product Accounts (Folbre, 2014), and thus typically excluded in "hours worked" measures. However, they form a substantial part of total productive time (Freeman and Schettkat, 2005; Aguiar and Hurst, 2007; Bridgman et al., 2018). Moreover, much of the increase in women's hours of formal work is attributed to women reducing hours in unpaid/household services while increasing hours in formal (or market) services (Bar and Leukhina, 2011; Ngai and Petrongolo, 2017). It is therefore important to account for those facts.

Since labor force surveys do not usually include time-use modules, I observe

[8] In most low-income countries, the labor module is asked to individuals aged 5 or older (7 or 10 years in middle- and high-income countries). For some countries, the labor module is only asked to individuals aged 15 or above. However, except for three cases mean years of schooling are such that if kids start school at age 6, then they finish school after the age of 15.

how many hours are spent cooking, cleaning, in childcare, shopping or collecting water and firewood only for 7 low-, 7 middle- and 8 high-income countries.[9] And in some countries I do not observe hours in all five time-use activities. So, I calculate mean hours in the production of all those household services together, by country income group. I follow Bick et al. (2018) and proceed in three steps: First, calculate mean hours worked per adult for each activity available in a country. Second, average hours worked per adult in each activity across low-, across middle- and across high-income countries. Third, sum these averages to form mean total hours in household services by country income groups.

4.1.2 Baseline Parameters

Table (3) presents the parameters that I take from prior works. I follow Ngai and Petrongolo (2017) with ε to 0.002, and $\sigma = 2.0$. Different kinds of commodities that form the composite c are thus hard to substitute, while firm and traditional versions of the same commodity kind are easy to substitute. I also use the aforementioned authors' value for η, which is 2.27. Consequently, male and female hours in all production sectors and in leisure are good substitutes. Finally, the fourth parameter I take as given from Ngai and Petrongolo (2017) is the female weight in traditional services, ξ_{S_h}, which is 0.49. I set the discount factor ρ to 0.04 as in Restuccia and Vandenbroucke (2014). Both genders are endowed with one unit of time.

For the parametrization of human capital $H(s)$, I rely on Bils and Klenow (2000). They estimate $\nu = 0.58$ from a cross-country regression of Mincerian returns in Psacharopoulos (1994) on years of schooling, and set ζ at 0.32 to match the average Mincerian return across countries. Under this parametrization, the marginal return of schooling on human capital is positive, but decreasing.

Life expectancy T is the same for both genders, but differs across country income groups. I compute it based on the data on life expectancy at birth from the World Development Indicators. Data starts in 1960, but in most datasets there exist individuals who where born before that year. So for each country, I impute life expectancy using a simple regression: I regress life expectancy (in logs) on year of birth, using post 1960 data, and predict life expectancy at birth for all individuals in

[9] Note that for two low- and three middle-income countries, I observe hours in household services, but I cannot disaggregate NIPA-hours into formal versus traditional hours.

Table 3: Baseline parameters

Parameter		Description	Source
ε	0.002	Substitutability of diff. commodity kinds	Ngai & Petrongolo, 2017
σ	2	Subst. of mkt. vs. non-mkt commodities	
η	2.27	Subst. of male vs. female time inputs	
ξ_{S_h}	0.49	Wgt. on female time in non-mkt services	
ρ	0.04	Discount (and interest) rate	Restuccia & Vandenbroucke, 2014
ν	0.58	$H(s)$ curvature, falling Mincerian returns	Bils & Klenow, 2000
ζ	0.32	Governs avg Mincerian return to schooling	
T	50	Life expectancy, low income countries	World Development Indicators
	60	Middle income countries	
	69	High income countries	

each country survey. Average life expectancy amounts to 50 years in low-, 60 years in middle- and 69 years in high-income countries.

4.1.3 Calibrated parameters

I calibrate the remaining parameters numerically, in two steps. First, I focus on low-income countries. I calibrate (i) five sectoral technology differentials in (9a) and (9b); (ii) the gender-specific weights $\xi_{A_m}, \xi_{M_m}, \xi_{S_m}$ and ξ_{A_h}, ξ_{M_h} in (7); and (iii) the preference parameters ξ_l and φ (for leisure) and β_f, β_m (for schooling).

Let μ_{low} contain the parameters to be calibrated for low-income countries:

$$\mu_{low} = \left(\hat{Z}_{A_{mh}}, \hat{Z}_{M_{mh}}, \hat{Z}_{S_{mh}}, \hat{Z}_{A_m M_m}, \hat{Z}_{A_m S_m}, \xi_{A_m}, \xi_{M_m}, \xi_{S_m}, \xi_{A_h}, \xi_{M_h}, \xi_l, \varphi, \beta_f, \beta_m\right).$$

I target how women allocate their productive time relatively across sectors, how men allocate their time relative to women, and years of schooling of both genders in low-income countries. I vectorize these data targets in $\hat{\Phi}_{low}$:

$$\hat{\Phi}_{low} := \left(\frac{l^f_{A_m}}{l^f_{A_h}}, \frac{l^f_{M_m}}{l^f_{M_h}}, \frac{l^f_{S_m}}{l^f_{S_h}}, \frac{l^f_{A_m}}{l^f_{S_m}}, \frac{l^f_{M_m}}{l^f_{S_m}}, \frac{l^m_{A_m}}{l^f_{A_m}} \frac{l^m_{S_m}}{l^m_{M_m}}, \frac{l^m_{S_m}}{l^f_{S_m}}, \frac{l^m_{A_h}}{l^f_{A_h}}, \frac{l^m_{M_h}}{l^f_{M_h}}, l^f_l, l^m_l, s_f, s_m\right).$$

For the exact time allocations of both genders, see Table (B.4) in the Appendix. I vectorize the model predictions for the same variables in $\Phi(\mu_{low})$. Formally, μ^*_{low}

minimizes the distance between model predictions and data targets,

$$\mu^*_{low} := \min_{\mu_{low}} || \, \Phi(\mu_{low}) - \hat{\Phi}_{low} \, || \, . \tag{13a}$$

The second part of the calibration focuses on middle- and high-income countries. I leave preferences for schooling and leisure as well as the female weights in traditional work unchanged (as calibrated in the first step). What I recalibrate are the sectoral technology differentials and the female weights in formal work

$$\mu_c := (\hat{Z}_{A_{mh}}, \hat{Z}_{M_{mh}}, \hat{Z}_{S_{mh}}, \hat{Z}_{A_mM_m}, \hat{Z}_{A_mS_m}, \xi_{A_m}, \xi_{M_m}, \xi_{S_m}),$$

so as to best replicate how women allocate their productive time relatively across sectors and how men allocate their time relative to women:

$$\hat{\Phi}_c = \left(\frac{l^f_{A_m}}{l^f_{A_h}}, \frac{l^f_{M_m}}{l^f_{M_h}}, \frac{l^f_{S_m}}{l^f_{S_h}}, \frac{l^f_{A_m}}{l^f_{S_m}}, \frac{l^f_{M_m}}{l^f_{S_m}}, \frac{l^m_{A_m}}{l^f_{A_m}}, \frac{l^m_{S_m}}{l^m_{M_m}}, \frac{l^m_{S_m}}{l^f_{S_m}} \right),$$

with $c = middle, high$. To replicate the male/female ratio in hours of formal work, I have to recalibrate both, the sectoral technology differentials as well as the gender-specific productivities. If I only recalibrate the sectoral technology differentials, the model can not fit the observed male/female ratio in formal hours well enough. For details, I refer to a related work of mine (Reimers, Unpublished).

4.1.4 Parameter values

Table (4) presents the resulting parameter values. First, note how the sectoral technology differentials become more pronounced across country income groups. For all commodity kinds, the formal-traditional technology differential increases (for example, $\hat{Z}_{M_{mh}}$ rises from 0.9 in low- to 13 in high-income countries). This is "modernization". In formal sectors, the agriculture-manufacturing and the agriculture-service differentials increase ($\hat{Z}_{A_mM_m}$ rises from 0.1 to 4.1, and $\hat{Z}_{A_mS_m}$ rises from 2.5 to 31.4). This is "structural transformation". Qualitatively, these values make sense. Quantitatively, however, technology differentials seem to change rather fast.[10] A

[10]The 10-sector database of Timmer and de Vries (2015) provides information on hourly labor productivity for 4 of my low-, 10 middle- and 9 high-income countries. Using this data, I can

Table 4: Calibrated parameters

	$\hat{Z}_{A_{mh}}$	$\hat{Z}_{M_{mh}}$	$\hat{Z}_{S_{mh}}$	$\hat{Z}_{A_mM_m}$	$\hat{Z}_{A_mS_m}$	ξ_{A_m}	ξ_{M_m}	ξ_{S_m}	ξ_{A_h}	ξ_{M_h}	ξ_l	φ	β_f	β_m
Low	0.12	0.9	0.10	0.10	2.5	0.33	0.33	0.32	0.39	0.38	0.38	1.4	−0.14	−0.39
Middle	0.16	2.4	0.15	0.44	6.1	0.23	0.30	0.35	-	-	-	-	-	-
High	0.32	13.0	0.20	4.1	31.4	0.28	0.27	0.38	-	-	-	-	-	-

Notes: Calibrated values for technology differentials and female-specific productivity weights in all three country income groups, as well as the preference parameters resulting from the estimation based on low-income countries. Once calibrated for low-income countries, I hold ξ_{A_h} to β_m fixed.

probable reason is that in my model structural change is generated by supply-side factors only, as opposed to demand-side factors, too (see f.e. how Stone-Geary type preferences give rise to structural change in Kongsamut et al., 2001). My calibration strategy is likely to bundle demand- as well as supply-side forces.

I group modernization and structural transformation as two between-sector forces (similar to Ngai and Petrongolo, 2017, who think about "marketization" rather than modernization). This is to distinguish these forces from within-sector, gender-specific forces. Here, such forces may capture cross-country differences in norms or institutions that affect the relative demand of female labor. They are reflected by changes of ξ_{A_m}, ξ_{M_m}, and ξ_{S_m} across country income groups. For example, ξ_{S_m} increases from 0.32 to 0.38, which points to a rise of relative demand for female hours in formal services as countries become richer. These values resemble those in Ngai and Petrongolo (2017) (0.34 for market services in the US in the 1970's, to 0.43 in the early 2000's). The values for ξ_{A_m} are u-shaped, and decreasing for ξ_{M_m}. Both values resemble those in Ngai and Petrongolo (2017) for a sector that combines agriculture and manufacturing.

The preference for leisure is governed by $\varphi = 1.4$. As I previewed, $\beta_f = -0.14$ and $\beta_m = -0.39$ are both negative, so that schooling is a nuisance. This is in line with Heckman et al. (2006), who emphasize the importance of accounting for psychic costs to schooling, and Wong and Fernandez (2012) who model schooling as a nuisance. Given the values for T, ν, ζ, and ρ, the model can only rationalize the low levels of schooling in the data if schooling is a nuisance. Psychic costs are

compare how the differential in agriculture versus manufacturing and agriculture versus services (formal only) change across country income groups. The former increases by a factor of about 4, the latter by a factor of 3. This compares to $41 = 4.1/0.1$ and $12.5 = 31.4/2.5$ in my calibration.

Table 5: Non-targeted model predictions

	Men			Women			Ratios	
	T^m	N^m	M^m	T^f	N^f	M^f	$\frac{L_l^m}{L_l^f}$	$\frac{w_f}{w_m}$
Δ Low-high: Data	−16.6	−50.3	33.6	−18.1	−36.0	79.2	−4.3	−0.7
Δ Low-high: Model	−8.4	−47.0	48.8	−8.7	−28.7	99.7	−2.0	−14.4

Notes: %-change, computed as difference in high- minus low-income countries relative to values in low-income countries. Changes in women's relative wages are computed for a subsample of countries and using a Blinder-Oaxaca decomposition (see Section 2.4 and Appendix Figure B.2).

higher for men, which is also in line with Wong and Fernandez (2012). Through the lens of this model, men in low-income countries must have a larger aversion against schooling than women. This is because men spend more than twice as many hours in formal work, but not proportionally as many years in schooling.

4.2 Fit

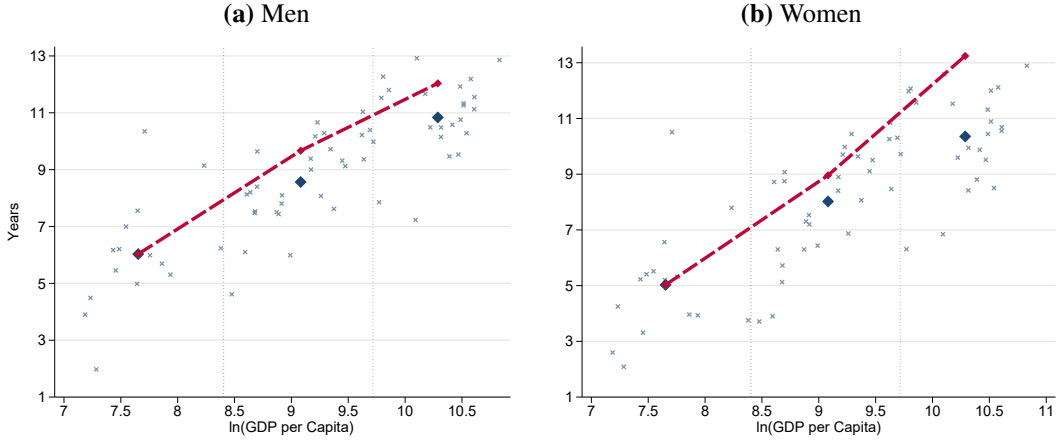
The calibration targets relative time allocations of men and women. In low-income countries, it also targets leisure levels. Because of this, in low-income countries I match both genders' productive time allocations in terms of levels, too. One may then ask to what extent the model correctly predicts the observed level changes in the time allocations of both genders (from low- to high-income countries).

Table (5) shows that in the data, total productive time of men (T^m) falls by nearly 17% across country income groups, and by 18% for women (T^f). This reflects the findings on development and leisure time by Aguiar and Hurst (2007). In the model, total productive time decreases by 8.4% for men, and slightly more for women (8.7%), so that the predicted falls amount to about half of those in the data. The reason the model generates such a sizeable fall in total productive time is due to the nested-CES structure in preferences for c (Ngai and Petrongolo, 2017): agents prefer to take advantage of technological progress and reduce hours, rather than keep hours constant and consume relatively more of just one commodity kind.[11]

The model under-predicts the falls of both genders' traditional hours, especially for women. This is because their sectoral comparative advantage lies in the traditional production of services, which prevents women from reducing traditional

[11] If technologies in formal sectors improve evenly, this alone incentivizes agents to reduce time in traditional work. When technologies grow unevenly across commodity kinds, then both agents reduce their time in the production of those commodities that exhibit faster technology growth.

Figure 2: Data vs. model: Years of schooling



Notes: Blue diamonds mark average years of schooling of men and women in the country income groups. These values are computed from data by Barro and Lee (2013) and from the United Nation's Development Report. Red lines connect predicted years of schooling in low-, middle-, and high-income countries, which are plotted against the respective mean GDP per capita in the data.

hours. The model predicts that women's relative wages w_f/w_m fall by 14% across country income groups. This is not consistent with wage data from a small sample of countries that suggests that women's relative wages stay relatively constant across country income groups (-0.7%). These relative wage predictions might be counter-intuitive because hours shift towards services, where women have their sectoral comparative advantage. However, hours also shift away from traditional to formal services, where the female weight is lower (in high-income countries, $\xi_{S_m} = 0.38$ versus $\xi_{S_h} = 0.49$). This puts pressure on women's relative wages.

Finally, observe that the model's predictions for the rise in men's and women's hours of formal work are higher than in the data. Most importantly, however, the calibration replicates the fact that women's hours in formal work increase relatively faster than men's. This leads me, next, to the main results.

4.3 Results

I emphasize that the calibration only targets mean years of schooling in low-income countries, but not in middle- and high-income countries. Figure 2 plots model predictions for years of schooling in low-, middle-, and high-income countries against their respective GDP per capita in the data (the model does not yield predictions for GDP per capita). Male schooling is predicted to rise from 6 to

Table 6: Benchmark predictions

		Country Income Group		
		Low	Middle	High
***Ratio* in formal hours**	Data & Model	2.14	1.94	1.60
***Ratio* in schooling years**	Data	1.20	1.07	1.05
	Model		1.08	0.91

Notes: The first row indicates the male/female ratio in hours of formal work, as targeted and replicated in the calibration. The rows below yield the ratio in schooling years (data and model).

nearly 12 years, as compared to nearly 11 years in the data (blue diamonds). Female schooling is predicted to rise from 5 to 13 years, as compared to 10.4 years in the data. So the model over-predicts the rise of both genders' years of schooling. However, it does replicate the fact that across country income groups, female years of schooling increase relatively faster than men's.

This leads me to my key result: The model predicts that as women's hours in formal work increase relatively faster than men's, so do women's years of schooling. I find that the considerable decline in the male/female ratio in hours of formal work is associated to a considerable decline in the male/female ratio in years of schooling, which validates my theory.

To see this, consider Table (6). Row (1) repeats the male/female ratio in formal hours. I target and match those values in the calibration. The second row shows the male/female ratio in years of schooling that prevails in the data, and the third row the schooling ratio implied by the model. According to the model, the decline of the ratio in formal hours from 2.14 in low- to 1.94 in middle-income countries should be accompanied by a decline the schooling year ratio from 1.2 in low- to 1.08 in high-income countries. So far, this matches the data well. Overall, though, the model predicts that as the ratio in hours of formal work declines further to 1.6, the schooling year ratio should decline substantially again: to 0.91 as opposed to 1.05 in the data. This actually implies that from low- to high-income countries, women not only catch-up to men in terms of schooling, but even overtake men.

I hesitate to deduce from this that women in high-income countries are prevented from investing as many years in school as would be optimal (at least through the lens of this model). I am aware of previous studies which find that gender

norms, culture and institutions dampen schooling opportunities for women (Dollar and Gatti, 1999; Cooray and Potrafke, 2011; Hiller, 2014). However, common to these studies is that they find such factors to affect women's schooling choices in less developed countries, not in industrialized ones. So next, I assess which forces and assumptions of the model shape the overall decline of the schooling ratio.

4.4 Extensions

One interesting extension would be to decompose in how far structural change versus cross-country differences in norms or institutions shape the results above. However, it is not clear in how far what the calibration captures as technological progress and cultural or institutional differences can actually be traced back to those exact factors, and not other ones (f.e. fertility, family structure). As long as availability of actual productivity data is limited, the informative value of such a decomposition would barely be suggestive, let alone testable empirically. So I rather focus on why the male/female schooling ratio is predicted to fall by -24.2% across country income groups, which is more than in the data (-12.7%, Table 7, rows 1-2).

First, I assess the extent to which this result can be maintained if I reverse the calibration strategy from Section 4.1.3. I calibrate preference parameters to match leisure and years of schooling of men and women in *high-income* countries, and hold these parameters fixed for middle- and low-income countries. Row 3 of Table 7 suggests that then, the predicted decline of the schooling ratio is even larger. This is because now the model predicts that schooling years in low-income countries are lower than in the data, and this is particularly pronounced for women.

Second, I assess the extent to which my results are shaped by improvements in life expectancy. I perform a counterfactual exercise in which I resolve the model, holding constant technology differentials and gender-specific productivities (as calibrated for low-income countries). I do, however, allow for improvements in life expectancy (from 50 to 60 to 69 years).[12] Think of the predicted years of schooling as those that would be optimal if life expectancy in low-income countries were to be as in middle- or in high income countries. I present the results in row 4 of

[12]Note that in the model, life expectancy does not differ by gender. I impose this because the WDI data suggests that both genders' life expectancies increase very similarly across country income groups: by 39% for women and 38% for men. Given this, there is not much room for gender differences in life expectancy improvements to explain why the gender gap in schooling falls.

Table 7: Extensions

	Δ Low-high		
	s_m/s_f	s_m	s_f
Data	−12.7	79.7	106
Benchmark model	−24.2	99.6	163
Reverse calibration (High-low)	−34.0	122	237
Life expectancy improves only	2.1	26.6	24.0
Traditional work after schooling, too	−20.2	134	193
Quadratic utility	−12.6	34.4	53.9

Notes: %-changes in the schooling ratio and schooling levels. Row 3 yields predicted changes if the order of calibration is reversed; Row 4 yields results in a counterfactual exercise if life expectancy in low-income countries were to improve; Row 5 yields results for an extended model where both forms of work can only take place after schooling is completed.

Table (7). They suggest that improvements in life expectancy have contradictory implications for the male/female ratio in years of schooling (+2.1%). In response to improvements in life expectancy, men increase their years of schooling by 26.6%, while women increase theirs slightly less (24%). The reason is that as T increases, the positive conditional marginal effect of schooling on lifetime income in (11b) becomes more and more pronounced. Given that men's schooling years are higher than women's to begin with, this incentivizes men to invest proportionally more in school as life-expectancy rises. Thus, the schooling gap increases.

Third, I assess whether the excessive overall decline of the schooling ratio pertains if I assume that agents can engage in both, formal as well as traditional work only after they complete schooling. For a brief description of the environment in this version of the model, its calibration, and a full derivation, see the model appendix. To summarize, a marginal increase in years of schooling now comes at the additional opportunity cost of reducing working life traditional work, too. This cost becomes, however, less relevant as hours in traditional work decline across country income groups. The calibration follows Section 4.1.3 closely, but I also aim to capture this decline in traditional hours. To do so, for middle- and high-income countries I also recalibrate the female weights ξ_{A_h}, ξ_{M_h} and ξ_{S_h}. Row 5 of Table (7) shows that in this setting, the male/female schooling ratio is predicted to decline by -20% across country income groups. This matches the data better than the bench-

mark, but is still too pronounced. Note that years of schooling increase more than in the benchmark because agents are less and less reluctant to increase schooling as traditional hours decline. The benchmark model does not capture this effect.

Finally, I assess the role of schooling preferences for the extent to which the schooling ratio declines. In the benchmark model, utility from schooling $W(s_g)$ follows Bils and Klenow (2000). In the calibration, $\beta_f, \beta_m < 0$ so that schooling is a nuisance. In this case, $W'(s_g) < 0 < W''(s_g)$ so that utility is falling in schooling, but as schooling levels rise agents are less and less reluctant to increase schooling further. There do exist intuitive reasons why concave disutility might be a valid assumption. Typically however, it is assumed that agents are increasingly averse to increasing the consumption of a "bad". Take, for example, the standard labor/leisure choice: the implication of assuming a concave utility from leisure is that the disutility from labor is convex. In this light, it would be consistent to specify $W(s_g)$ such that both, $W''(s_g) < 0$ and $W'(s_g) < 0$. The problem is that depending on whether agents have a decreasing or an increasing aversion against higher schooling, they respond to a fall in the marginal cost of schooling in opposite ways (see 11a). Under decreasing (increasing) aversion, agents are more and more (less and less) willing to increase schooling further as schooling levels rise. To assess how convexity affects my main result, I decide to recalibrate the model exactly as in Section 4.1.3, but assume

$$W(s_g) = \beta_g \frac{1}{2} s_g^2, \qquad g = f, m. \tag{14}$$

This functional form ensures that if $\beta_f, \beta_m < 0$, then $W''(s_g), W'(s_g) < 0$. Yet, being quadratic it is simple enough to have been used similarly in other contexts (see f.e. Hara, 2005 and Ohanian, 2009). The last row of Table (7) shows that in such a setting, the male/female ratio in years of schooling falls by -12.6% across country income groups. This is less than in the benchmark (-24.2%), but considerably closer to the data (-12.7%). However, note that for both genders, the rise in years of schooling is less pronounced than in the data and benchmark. For example, male years of schooling rise by 34%, compared to 80% (data) and 100% (benchmark).

To summarize, the model predicts a strong relationship between differences in

both genders' formal hours and their years of schooling. But the last exercise, in particular, points out that the extent to which women increase years of schooling relatively more than men highly depends on the specification for schooling preferences. And while one specification captures better the decline in the ratio, the other captures better the rise in years of schooling.

5 Conclusion

I develop a model of structural change that allows me to think formally about how gender differences in years of schooling could be related to gender differences in hours of formal work, and why both gaps decline as countries become richer.

I then test and validate the model. Quantitatively, it suggests that both gender gaps may indeed be closely linked: Given the observed relative faster increase of women's hours in formal work, it predicts that the male/female schooling ratio should decline by 24%. This is, however, more than in the data, where the ratio declines by 12.7%. The decline of 24% is attained in a setup where schooling preferences are as typically imposed when it is assumed that agents derive a positive utility from schooling. Given that schooling is a nuisance, I argue for the use of a convex specification for utility from schooling. The model predictions for the decline of the male/female ratio in years of schooling then match the data (-12.6%).

Overall, this work emphasises the economic rationales that surround gender gaps in years of schooling and arise from gender gaps in hours worked. Also, it shows that it is helpful to place an analysis of both gaps in the context of structural change. Along the development process, both gaps may result - to a certain extent of course - from optimizing behavior. However, I consider the results of this work very suggestive. In particular, I stress that I cannot deduce the exact role of technological progress for the decline of both gender gaps. This is due to a current lack of data on how sectoral technologies actually differ across countries. What my calibration captures as technological progress might also be driven by other forces of structural change that originate on the demand-side, or factors like cross-country differences in norms, institutions, fertility and family structure. All these are factors that may shape both gaps individually or, possibly, simultaneously. But I anticipate that future research will help identify and disentangle the relevant factors.

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Appendix (For Online Publication Only)

A Data sources

Bick et al. (2018) collect and harmonize micro-data on hours worked for a large sample of countries. Their main sources are Labor Force, Living Standards Measurement and other household surveys. In their analysis, they mainly rely on surveys where data was collected year-round and that provide information on actual hours worked last week. This is the benchmark for international comparability. Here, I also include surveys that do not satisfy these criteria. Either fieldwork lasted less than the whole year, or the survey asks for usual instead of actual hours worked per week. These surveys might not adequately capture vacation and sickness days or seasonal fluctuations in hours worked. I acknowledge that these surveys are less reliable for international comparisons, but do so to increase the sample. In total, I rely on data for 65 countries. For 60 of those countries, I can classify hours into formal versus traditional work. For the five remaining countries, I cannot do so. The reason I include them is because they have a time-use module that provides information on hours worked in household services, which I lack in many countries.

Table A.1: Low-income countries

Country	Year	Survey	Time-Use
Benin	2010	Enquete Modulaire Integree sur les Conditions de Vie des Menages (EMICOV)	Yes
Bolivia	2005	Encuesta de Hogares (RIGA)	-
Cambodia	2011	Cambodia Socio-Economic Survey (CSES)	-
Ghana	1998	Living Standards Measurement Survey (LSMS)	Yes
Kenya	2005	Kenya Integrated Household Budget Survey	-
Lao PDR	2007	Expenditure and Consumption Survey	-
Lesotho	2008	Integrated Labor Force Survey	Yes
Mali	2010	Permanent Household Survey (EPAM)	Yes
Pakistan	2011	Labor Force Survey	Yes
Rwanda	2011	Enquete Integrale sur les conditions de vie des menages	Yes
Tajikistan	2007	Living Standards Survey (LSMS)	-
Tanzania	2009	National Panel Survey (LSMS)	-
Timor Leste	2007	Living Standards Survey (LSMS)	Yes
Uganda	2010	National Panel Survey (LSMS)	-
Vietnam	2002	Household Living Standards Survey (LSMS)	-

Table A.2: Middle-income countries

Country	Year	Survey	Time-Use
Albania	2012	Labor Force Survey	-
Angola	2008	Inquerito Integrado sobre o Bem-Estar da Populacao (IBEP)	-
Bosnia	2001	Living Standards Measurement Survey (LSMS)	-
Botswana	2005	Labor Force Survey	-
Brazil	2009	National Household Sample Survey (PNAD)	-
Bulgaria	2005	European Union Labor Force Survey	-
China	2006	The China Health and Nutrition Survey	Yes
Columbia	2008	Integrated Household Survey (GEIH)	-
Ecuador	2005	Encuesta de Condiciones de Vida (LSMS)	-
Egypt	2006	Labor Market Panel Survey	Yes
Guatemala	2000	Encuesta Nacional Sobre Condiciones de Vida (ENCOVI)	Yes
Indonesia	2010	Sakernas (National Labor Force Survey)	-
Iraq	2007	Household Socio-Economic Survey (LSMS)	Yes
Kazakhstan	1996	Living Standards Measurement Survey (LSMS)	Yes
Latvia	2005	European Union Labor Force Survey	-
Lithuania	2005	European Union Labor Force Survey	-
Mauritius	2010	Continuous Multi Purpose Household Survey (CMPHS)	-
Mongolia	2006	Labor Force Survey	Yes
Namibia	2009	Household Income and Expenditure Survey	-
Panama	2008	Encuesta de Niveles de Vida (ENV) (LSMS)	-
Paraguay	2011	Encuesta de Hogares (Household Survey)	-
Peru	2010	Encuesta Nacional de Hogares (ENAHO)	-
Philippines	2010	Labor Force Survey (Jan, Apr, Jul, Oct)	-
Poland	2005	European Union Labor Force Survey	-
Romania	2005	European Union Labor Force Survey	-
South Africa	2008	Combined Quarterly Labor Force Surveys	MTUS
Tunisia	2010	Enquete Nationale sur la Population et l'Emploi	-

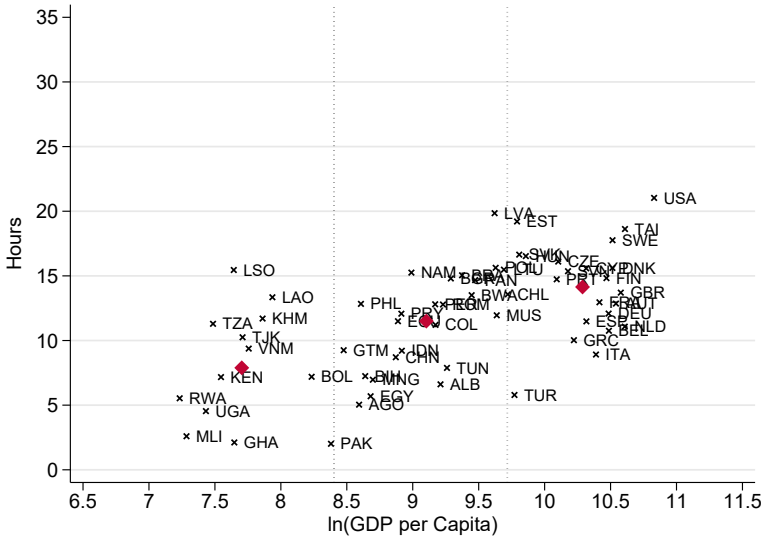
Table A.3: High-income countries

Country	Year Survey	Time-Use
Austria	2005 European Union Labor Force Survey	MTUS
Belgium	2005 European Union Labor Force Survey	-
Chile	2009 National Socioeconomic Survey (CASEN)	-
Cyprus	2005 European Union Labor Force Survey	-
Czech Republic	2005 European Union Labor Force Survey	-
Denmark	2005 European Union Labor Force Survey	-
Estonia	2005 European Union Labor Force Survey	-
Finland	2005 European Union Labor Force Survey	-
France	2005 European Union Labor Force Survey	MTUS
Germany	2005 European Union Labor Force Survey	MTUS
Greece	2005 European Union Labor Force Survey	-
Hungary	2005 European Union Labor Force Survey	-
Italy	2005 European Union Labor Force Survey	MTUS
Netherlands	2005 European Union Labor Force Survey	MTUS
Portugal	2005 European Union Labor Force Survey	-
Slovak Republic	2005 European Union Labor Force Survey	-
Slovenia	2005 European Union Labor Force Survey	-
Spain	2005 European Union Labor Force Survey	MTUS
Sweden	2005 European Union Labor Force Survey	-
Taiwan	2011 Labor Force Survey	-
Turkey	2011 Household Labor Force Survey	-
United Kingdom	2008 European Union Labor Force Survey	MTUS
United States	2005 Current Population Survey	MTUS

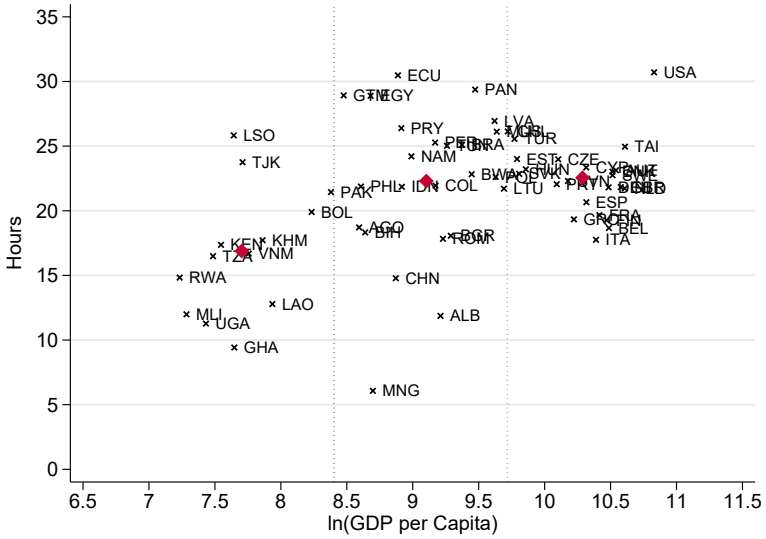
B Additional facts

Figure B.1: Hours in formal work

(a) Women



(b) Men



Notes: Red diamonds mark country income group averages (for the 13 low-, 24 middle-, and 23 high-income countries for which I can infer formal hours).

Table B.1: Market hours and years of schooling, ***Bridgman et al. (2018)***

	Country Income Group		
	Low	Middle	High
Years of schooling			
Men	6.4	8.7	10.6
Women	5.0	8.2	10.2
Ratio	1.28	1.06	1.04
Market hours			
Men	34.2	37.9	35.4
Women	14.3	18.5	20.7
Ratio	2.40	2.05	1.71
# of countries	7	30	85

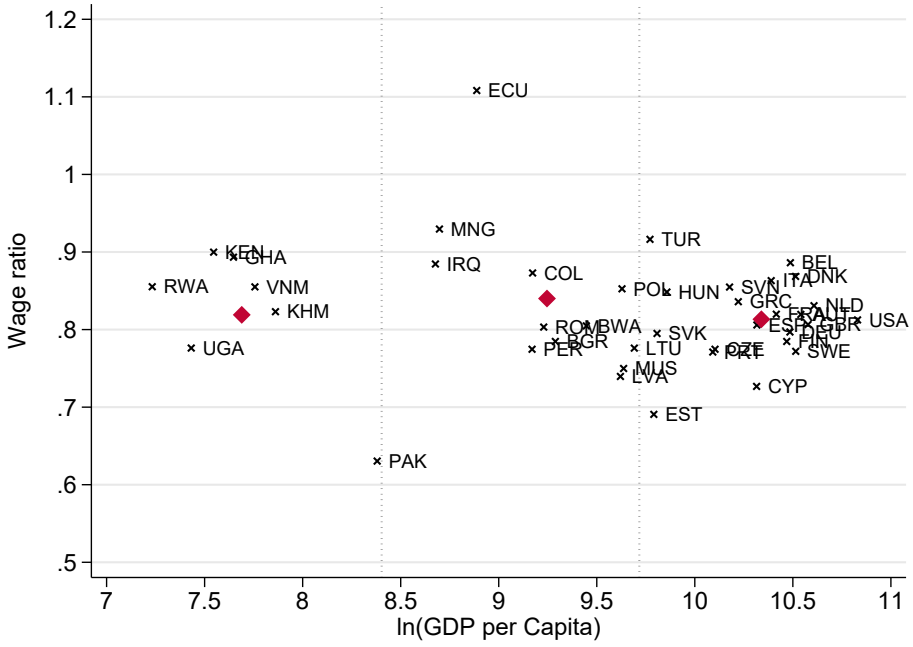
Notes: Years of schooling again based on Barro and Lee (2013), but for the sample of countries in Bridgman et al. (2018). (Weekly) market hours are based on the publicly available data of Bridgman et al. (2018). The decline in the schooling gap amounts to $(0.04-0.28)/0.28=-86\%$, and for the gap in market hours to $(0.71-1.4)/1.4=49\%$.

Table B.2: Hours in formal work, by education

	Country Income Group		
	Low	Middle	High
Men			
Less than Secondary	14.1	17.0	15.6
Secondary Completed	23.7	27.1	25.3
More than Secondary	32.6	31.3	27.6
Women			
Less than Secondary	6.2	5.7	7.0
Secondary Completed	14.8	15.1	17.3
More than Secondary	29.7	24.7	22.3

Notes: Average weekly hours in formal work, all men and women who completed education (are not enrolled in educational programs).

Figure B.2: Wage ratio (female/male)



Notes: Based on the micro-level wage-data in Bick et al. (2018). Relative wages of women after accounting for differences in observables (the "unexplainable" difference between men's and women's wages as computed from a conventional Oaxaca-Blinder decomposition as proposed in Weichselbaumer and Winter-Ebmer, 2005). Diamonds mark country income group averages.

Table B.3: Formal and traditional hours, by status of enrollment in education

(a) Formal hours

	Country Income Group		
	Low	Middle	High
Men, Ages 5-24			
Completed education	14.3	19.9	23.9
Enrolled in education	1.2	2.5	4.4
Ratio	12.3	8.1	5.4
Women, Ages 5-24			
Completed education	8.9	11.8	19.0
Enrolled in education	1.0	1.9	3.8
Ratio	9.1	6.3	5.0

(b) Traditional hours

	Country Income Group		
	Low	Middle	High
Men, Ages 5-24			
Completed education	25.3	16.5	6.5
Enrolled in education	15.5	7.7	3.9
Ratio	1.6	2.1	1.7
Women, Ages 5-24			
Completed education	41.7	37.0	16.1
Enrolled in education	21.3	14.3	8.2
Ratio	2.0	2.6	2.0

Notes: Weekly hours, men and women aged 5-24. *Ratio* describes hours worked in formal/traditional work by those who completed education relative to those who are still enrolled in education. The high ratios in Panel a imply that hours in formal work are considerably for those who completed education than for those who are still enrolled in education. This provides suggestive evidence that work in formal production indeed starts after education is completed (as assumed in the model). For traditional hours the evidence is less straightforward, as they are more homogenous across both groups.

Table B.4: Full time allocations in the data

(a) Men

	Agric.		***Manufact.***		***Services***		***Leisure***
Country Income Group	$L^m_{A_h}$	$L^m_{A_m}$	$L^m_{M_h}$	$L^m_{M_m}$	$L^m_{S_h}$	$L^m_{S_m}$	L^m_l
Low	10.1	4.9	0.8	2.9	14.2	9.1	42.0
Middle	5.0	3.2	0.7	5.5	11.3	13.5	39.2
High	0.9	0.9	0.7	8.8	10.9	12.9	35.0

(b) Women

	Agric.		***Manufact.***		***Services***		***Leisure***
Country Income Group	$L^f_{A_h}$	$L^f_{A_m}$	$L^f_{M_h}$	$L^f_{M_m}$	$L^f_{S_h}$	$L^f_{S_m}$	L^f_l
Low	9.1	2.4	0.7	1.4	32.9	4.1	50.6
Middle	3.1	0.5	0.4	2.1	33.3	8.8	48.4
High	0.5	0.3	0.1	2.5	26.8	11.4	41.5

Notes: Here, I provide the full time allocations of men and women, across all sectors of the economy. For $g = m, f$, these are traditional and formal hours in agriculture $(L^g_{A_h}, L^g_{A_m})$, manufacturing $(L^g_{M_h}, L^g_{M_m})$, and services $(L^g_{S_h}, L^g_{S_m})$. Below I provide these time allocations in hours per week. In the model, I compute hours worked by men and women in each production sector as a share of total time endowment (112 hours, i.e. individuals sleep 8 hours per day). Leisure is computed as the residual from total time (112 hours per week) minus total productive time.