# Industry Structure and the Composition of Men's and Women's Productive Time[‡]

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**Abstract**

In this paper, I examine why women's hours in formal work increase faster than men's as countries become richer. Based on harmonized micro-data of 76 countries, I present evidence that there exist considerable gender gaps in hours of formal (paid) work, and that men and women allocate their productive time very differently across industries. In particular, these findings also hold in economies that are very poor. This suggests that comparative advantages play an important role for how men and women reallocate their productive time as countries become richer. I develop a general equilibrium, structural change model with comparative advantages and apply it to my data. Quantitatively, it suggests that structural change could explain a third of the reduction of the gender gap.

*JEL-Classification:* J21, J22, O14, O41
*Keywords:* Growth, Structural Change, Labor,

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‡ A model-appendix to this paper is available here.

# 1 Introduction

As countries become richer, gender inequalities in hours of paid work tend to decrease. Historically, women's participation in paid work has been low in the US, but increased considerably in the 20$^{th}$ century (Goldin, 1995, 2006; Costa, 2000). In particular, women's market hours have increased relatively faster than men's since the 1970's, leading to a decline of the gender gap in paid work (Ngai and Petrongolo, 2017). In low-income countries, gender differences in paid and home (or household) work are large (Badgett and Folbre, 1999; Kan et al., 2011; Folbre, 2014). But the cross-sectional data from Bridgman et al. (2018) suggests that from low- to high-income countries women's hours in paid work also increase relative to men's.

Why does the gender gap in hours of paid work decrease with development? Understanding this is important, because it could help us to understand other facts in the development literature relating to wage differentials, fertility choices, marriage, or gender differences in education.

Previous studies attribute the historical or cross-country declines in gender gaps in paid and unpaid work to changing (or cross-country differences in) norms, institutions, and cultural factors (Badgett and Folbre, 1999; Budlender, 2008; Kan et al., 2011). But the industrial structure and the modernization of an economy also play an important role. In particular, Ngai and Petrongolo (2017) formalize and show how gender-biased technological change is important to understand the relatively faster rise of women's market hours in the US: If the sectoral comparative advantage of women lies in the service sector, then their opportunities to enter market work improve, in particular, once structural change gives rise to a market-based service sector.

Can cross-country differences in industry structure, combined with the existence of sectoral comparative advantages, explain why women's hours in paid work increase faster than men's also from low- to high-income countries? This is the question I address in this paper. To clarify this, it is necessary to (i) assess whether gender-specific sectoral comparative advantages prevail in countries at all stages of economic development, especially in low-income countries, and to (ii) test Ngai and Petrongolo (2017)'s model of gender-biased technological change using data from low-, middle-, and high-income countries. This is the purpose of this work.

Until now, such exercises were limited by the availability of the necessary data. Historical data does not go back far enough to assess how differently men and women allocated their productive time when today's industrialized economies were still underdeveloped. For example, reliable U.S. estimates of men's and women's working hours go back as far as the end of the 19$^{th}$ century (Goldin, 1995; Folbre and Wagman, 1996). However, Bick et al. (2018) highlight that even by today's standards the US would already have been classified as a middle-income country at that time. And when it comes to documenting the gender differences in hours worked in low- or from low- to high-income countries, the facts are typically based on a single or small number of countries (Budlender, 2008; Burda, 2013; and Folbre, 2014 for a review). Here, I decide to make use of the large cross-sectional dataset assembled by Bick et al. (2018). Overall, I have harmonized data for 76 countries, which I group into 17 low-income, 35 middle-income, and 24 high-income countries.

Against this background, one contribution of this paper is to assess the potential role of structural change and gender-biased technological progress, in particular, for the cross-country decline of the gender gap in hours of paid work. Importantly, I do so in a setting that includes a large number of low-income countries.

In the empirical part of this paper, I first decompose total productive time of men and women into hours worked in "traditional" versus "formal" forms of production. Note that this contrasts with the more common use of "household" and "market" work. Due to data limitations, I cannot classify individuals as market versus household workers as defined by Reid (1934) and Ramey and Francis (2009). This would require knowing whether individuals produce goods *for sale* and/or *paid* services, or whether they produce goods *for their own consumption* and/or *household* services. I do not have that information. I therefore go along the lines of Gollin (2008), who focuses on the disappearance of small family businesses, household production, and self-employment as countries become richer. With "traditional" work, I refer to hours in unpaid work, in the family, household, or on one's own-account. This is to capture work in these smaller, basic forms of production. In contrast, "formal" hours describe hours worked in paid employment or as an employer, to capture work in larger, modern forms of production.[1]

[1]Nevertheless, I consider "formal" work to be closely related to "market" work, with the ex-

I document that in low-income countries, men work twice as many hours in formal work as women. But this gender difference decreases across country income groups (although in high-income countries men still spend 50% more hours in formal work than women). Then, I document that both genders specialize in different industries (agriculture, manufacturing, and services). Women spend the majority of their time in the service sector, while men divide their productive time more uniformly across industries. This applies to all country income groups, especially also low-income countries.

Following Rendall (2013, 2017) and Ngai and Petrongolo (2017), I argue that these gender differences in the division of labor by industry reflect the existence of sectoral comparative advantages. Compared to agriculture and manufacturing, the production of services is relatively less *brawn*-intensive and relatively more *brain*-intensive. Naturally, women are relatively less endowed with physical skills than men. So, the requirements imposed on workers in services suit women relatively better than those imposed on workers in agriculture or manufacturing.

Given this, I wonder what role structural change plays in shaping the decline of the gender gap in formal hours. Results from previous works suggest that the rise of a formal service sector could explain why women's hours in formal work increase relatively faster than men's as countries become richer (Galor and Weil, 1996; Goldin, 1995, 2006; Rendall, 2017; Ngai and Petrongolo, 2017). Put simply, the rise of a formal service sector means that more jobs where women have a sectoral comparative advantage are created. But this finding holds for countries at higher levels of development. Less clear is the extent to which differences in industrial structure may shape gender differences in hours of formal work in the cross-section of countries.

In the second part of this paper, I clarify this. I develop a general equilibrium multi-sector model that draws on key elements from the model of Ngai and Petrongolo (2017). There is a representative household consisting of a male and a female member. Both dedicate their productive time to various sectors of the economy. First, they supply labor inputs to firms that produce either agricultural, manufactur-

ception that my measure for formal hours excludes self-employed without employees who produce output for sale. In high-income countries, this is certainly the prevalent form of self-employment. In low-income countries however, it is not clear whether the output is really destined for own-consumption, or for the market.

ing, or service commodities in a formal sector. These firms produce using modern technologies. Second, both agents also engage in traditional forms of work to produce those kinds of commodities. In traditional sectors, production occurs on the household level and technology is basic. In all sectors, labor productivity differs by gender. This gives rise to sectoral comparative advantages.

I show analytically that structural change is associated to a decline in the gender gap in formal hours if the sectors that arise are those in which women have their sectoral comparative advantage. And the more pronounced these comparative advantages are, the greater the decline. Then, I conduct a calibration exercise that aims to replicate the male/female formal hours ratio that I observe in low-, middle-, and high-income countries. For each country income group, it calibrates two sets of parameters. First, sectoral technology differentials: Changes in these differentials suggest that as countries become richer, between-sector forces are at work. This is essentially structural change. Second, the parameters that determine where women have their sectoral comparative advantages and how pronounced these are. Changes in these parameters suggest that within-sector forces are at work. These increase the relative demand for female labor and may be due to in cross-country differences in culture, norms, institutions, or technological improvements that reduce the need for brawn-skills.

I then conduct counterfactual exercises to gauge the extent to which structural change may explain the 27% decline in the formal hours ratio. Alone, structural change would be associated to a -9% decline of the formal hours ratio. To derive this, I keep constant how pronounced sectoral comparative advantages are (as in low-income countries). On the other hand, within-sector forces alone are associated with a -14% decline of the formal hours ratio. These findings emphasize that both forces must occur together to explain why the formal hours ratio declines as much as observed: Along with the rise of a formal service sector, in that sector there must also occur shifts in the relative demand that favor women.

The paper is structured as follows. Section 2 describes the data and how I classify hours into formal and traditional work. In Section **??** I provide empirical evidence on how differently men and women allocate their productive time. This is followed by the model in Section **??**. In Section **??**, I conduct a calibration exercise that allows me to quantify the potential roles of between- and within-sector forces.

Finally, I conclude.

# 2 Data

## 2.1 Data Sources

I build on the cross-sectional micro-data presented in Bick et al. (2018). The authors collect and harmonize micro-data on hours worked from labor force, living standards measurements, and other household surveys for a large sample of countries. If available, they use surveys from the year 2005. Otherwise they use surveys closest to 2005. In total, I rely on data for 76 countries. I classify them into 17 low-income, 35 middle-income and 24 high-income countries, depending on their position in the world distribution of GDP per capita (in 2005 real, PPP-adjusted US$). Appendix Tables (A.1)-(A.3) list the surveys that I use.

In the case of 46 countries, data were throughout the year. These surveys provide information on actual hours worked per week (rather than usual hours). This is the benchmark for international comparability. In 30 countries, fieldwork for the survey took less than the whole year, or the survey asks for usual instead of actual hours worked per week. As a result, these surveys may not adequately capture vacation days, sick leave or seasonal fluctuations in working hours. I admit that this makes these surveys less reliable for international comparisons. However, I include them in order to increase the sample of countries I use.

## 2.2 Concepts

Conceptually, I follow Kuznets (1973) and Gollin (2008) to distinguish between "traditional" forms of work and "formal" forms of work. One of the six characteristics of modern economic growth identified in Kuznets (1973, p. 248) is that as economies undergo structural change, there "*occur shifts in the scale of productive units, and a shift from personal enterprise to impersonal organization of economic firms, with a corresponding change in the occupational status*".

In view of this, I rely on the self-reported occupational status of an individual to classify hours. I group together individuals who report being unpaid, working in the family, household, or on their own-account as traditional workers. This intends to record working hours in small, unincorporated or informal production schedules. To summarize Gollin (2008), these small production schedules constitute the dominant forms of production in low-income countries, and are relatively unproductive.

On the other hand, I group individuals who report being paid employees or employers as formal workers. This intends to capture work in larger-scale, modern production schedules (e.g. in firms that use more advanced technologies). This is the predominant form of production in high-income countries.

This classification scheme is admittedly very stylized and could classify individuals inconsistently.[2] I find it reassuring that the average amount of hours per person in formal work is close to the average amount of hours per person worked in a formal workplace like a firm, office or a store. Mirroring this, average hours per person in traditional work are very similar to aggregate hours worked per person at home, on the household plot, or in a mobile location on the road. I deduce this from a subset of my countries for which I know both the status of occupation and the place of work (see Appendix B.1).

### 2.3 Hours in Household Services

The hours measure constructed in Bick et al. (2018) includes all hours worked in the production of output that is counted in the National Income and Products Accounts (NIPA). Hours spent in the provision of household services, such as cooking or cleaning at home, childcare, household purchases, or collecting water and firewood are excluded. However, the hours spent on these types of services account for a substantial part of total productive time (Freeman and Schettkat, 2005; Aguiar and Hurst, 2007; Bridgman et al., 2018), and I consider these hours as part of traditional work that should be accounted for. Unfortunately, the value of output produced by these activities is not taken into account in NIPA. As a result, hours in those activities are also not included in the labor modules of most surveys (Folbre, 2014; Bick et al., 2018). Although data is scarce, I can compute hours in those activities for 22 countries: 7 low, 7 middle and 8 high-income countries.[3]

The surveys do not necessarily provide information on hours spent in all of the five activities. So, to calculate mean hours in household services by country

[2]For example, an individual working in the IT sector for a company will be classified as a formal worker, while a self-employed individual without employees who provides the same IT-services is classified as a traditional worker.

[3]From the surveys that Bick et al. (2018) use to compute hours worked, only 9 also provide hours in those activities. To increase the sample of countries, I rely on additional time-use surveys that Bick et al. (2018) harmonize, and even include 2 surveys of countries for which I can not decompose hours worked into formal versus traditional hours due to lack of occupational status.

**Table 1:** Total productive time, by gender

| | Country Income Group | | |
|---|---|---|---|
| | Low | Middle | High |
| ***Total productive time*** | | | |
| Men | 45.2 | 40.5 | 37.1 |
| Women | 58.4 | 54.0 | 45.3 |
| *Ratio* | 0.77 | 0.75 | 0.82 |

*Notes:* Total hours worked per week, men and women aged 15-64 years. The ratio is computed as male over female total hours.

income group, I follow Bick et al. (2018), who proceed in three steps: First, for each country and for each available activity in that country compute mean hours (per person). Second, average values for each of these activities across all low-, all middle-, and all high-income countries. In Appendix Table (B.1), I present mean hours by activity and country income group. Third, for each country income group aggregate mean hours in each activitiy to form total hours in household services (last row of the latter table).

## 3 Men's and Women's Allocation of Productive Time

In this section, I document how differently men and women work across country income groups. I begin with both genders' total productive time.

### 3.1 Trends in Total Productive Time

According to Table (1), men's total hours decline evenly across country income groups, from 45 in low- to 41 in middle- and 37 hours in high-income countries. For women, the decline in total productive time occurs less evenly. In low-income countries, their total hours amount to 58, but they fall mostly between middle and high-income countries: from 54 to 45 hours.

In general, women work more than men. The third Row of Table (1) shows the male/female ratio in total hours. In low-income countries, the ratio is 0.77. That is, men work 23% fewer hours than women. This estimate is higher than prior ones based on smaller samples of poor economies (ranging from 6% in Burda, 2013, between 3%-20% in Budlender, 2008, and 12% in the (market hours) data by Bridgman et al., 2018). Across country income groups, women reduce total hours relatively more than men (by $(45.3-58.4)/58.4=-22\%$, compared to $(37.1-45.2)/45.2=-18\%$). Women's hours thus decrease relatively more than men's,

**Table 2:** Hours in traditional and formal work, by gender

| | Country Income Group | | |
|---|---|---|---|
| | Low | Middle | High |
| ***Hours in traditional work*** | | | |
| Men | 28.9 | 18.0 | 12.8 |
| Women | 50.3 | 42.2 | 28.8 |
| *Ratio* | 0.58 | 0.43 | 0.45 |
| ***Hours in formal work*** | | | |
| Men | 16.2 | 22.5 | 24.3 |
| Women | 8.1 | 11.8 | 16.5 |
| *Ratio* | 2.00 | 1.91 | 1.47 |

*Notes:* Weekly hours, men and women aged 15-64 years. Both ratios are computed as male over female hours in traditional and formal work, respectively.

which is in line with Bridgman et al. (2018). However, in high-income countries the ratio amounts to 0.82, implying that men still work 18% fewer hours than women.

Next, I assess the extent to which these gender differences in total hours go along with gender differences in hours of formal and traditional work.

### 3.2 Trends in Hours of Formal and Traditional Work

Indeed, men and women allocate their time to formal and traditional work very differently. On the one hand, women in low-income countries work considerably more hours than men in traditional work: 50 versus 29 hours, respectively (see table 2). That is, men's hours in traditional work amount to 58% of women's. Across country income groups, both genders reduce their hours in traditional work, to 29 hours (women) and 13 hours (men). This implies that in high-income countries, men work less than half as many hours in traditional work as women. So, across country income groups women take responsibility for an increasingly larger share of traditional production.

On the other hand, men spend considerably more hours than women in formal work. Male hours in formal work amount to 16.2, which is twice as much as the 8.1 hours that women spend in formal work. Interestingly, both genders' hours in formal work rise by around 8 hours across country income groups, but they do so unevenly. For men hours rise mostly between low- and middle-income countries (by almost 6 hours to 22.5), and slightly from middle- to high-income countries (by less than 2 hours to 24.3). For women, the number of hours of formal work

**Table 3:** Hypothetical male/female ratios of hours in formal work

| | Country Income Group | | | |
|---|---|---|---|---|
| | Low | Middle | High | **Δ Low-high** |
| *Actual (ages 15-64)* | 2.00 | 1.91 | 1.47 | −0.27 |
| *Hypothetical* | | | | |
| US age composition | 2.15 | 1.95 | 1.46 | −0.32 |
| US age-parenthood composition | 2.03 | 1.87 | 1.52 | −0.25 |
| US age-marital status composition | 1.92 | 1.81 | 1.44 | −0.25 |

*Notes:* Actual and hypothetical ratios of male/female hours in formal work. Row 2 imposes that the population-age composition (in 5 year age-bins) is constant across countries and as in the US; Row 3 imposes that the age-parenthood composition (individual lives with a child aged less than 6 years in the household) in all countries is as in the US; Row 4 imposes that the age-marital compositions are the same as in the US. For hypothetical hours of men and women in levels, respectively, see Tables (B.2)-(B.4) in the Appendix.

increases by almost 4 hours to 11.8 in middle- and by 4.7 hours to 16.5 hours in high-income countries.

In absolute terms, formal hours rise similarly. However, as women's formal hours are lower to begin with, they rise relatively faster than men's across country income groups. Actually, women's hours in formal work more than double as countries become richer, while those of men increase by less than 50%. As a result, the male/female ratio in hours of formal work falls from 2.0 to 1.47. In other words, as countries become richer hours in formal work of both genders converge somewhat, but in high-income countries men still spend 47% more hours in formal work than women. Overall, the male/female ratio declines by $(1.47 - 2.0)/2.0 = -26.5\%$. This is similar to the decline in the male/female market hours ratio implied by the data of Bridgman et al. (2018): -29%. What factors could be the reason this considerable decline?

Previous studies suggest that several could be related to this decline. Consider, for example, that Killingsworth and Heckman (1986) document an inverted U-shape in age and labor market participation. It could thus be that the decline of the male/female ratio in formal hours is due to cross-country differences in population age-structures. Row (2) of Table (3) shows that if all countries in my sample had the same population-age structure as the U.S., then formal hours would be slightly higher in low-income countries. The ratio would decline by 32% across country income groups, so more than actually observed. Fertility and parental obligations

may also shape the decline of the formal hours ratio (Galor and Weil, 1996; Attanasio et al., 2008; Kleven and Landais, 2017). In Row (3), I condition on parenthood status. I do so by computing hypothetical hours in formal work if, for 5 year age-bins, the share of parents and non-parents in all countries were as in the U.S. Surprisingly, the male/female ratio in formal hours would only be minimally higher in low- and high-income countries, leaving the overall decline nearly unchanged. Finally, the studies of Killingsworth and Heckman (1986), Goldin (1995) and Costa (2000) emphasize the importance of distinguishing by marital status. This raises the question of extent to which differences in marital compositions shape the decline of the ratio. If I assume that, again in 5 year age-bins, the shares of married/unmarried men and women in all countries were the same as in the US, then the male/female ratio in formal hours would be somewhat lower in all country income groups (Row 4). Again, this leaves the overall decline of the ratio more or less unchanged.

But why, then, do women's hours of formal work increase relatively faster than men's as countries become richer?

### 3.3 Structural Change and Comparative Advantages

Galor and Weil (1996), Goldin (1995, 2006), Olivetti and Petrongolo (2016), Rendall (2017) and Ngai and Petrongolo (2017) suggest that the relatively faster increase in women's hours of formal work may be related to structural change. The latter authors develop a model of gender-biased technological progress in which the rise of a market-based service sector creates jobs for which women, in particular, have a sectoral comparative advantage. This model can explain why, in the U.S. since the early 1970's, women's market hours rose relatively faster than those men. However, it is not clear to what extent their model and findings also apply to economies at early stages of the development process.

Before I can apply the model of Ngai and Petrongolo (2017) to my data, I test whether my data is consistent with two key assumptions of that model. One concerns the existence of secular shifts in hours worked. The other concerns the existence of sectoral comparative advantages.

#### 3.3.1 Secular shifts in hours worked

Key to Ngai and Petrongolo (2017)'s model is, on the one hand, that several forces are at work as economies undergo structural change. One drives hours out

**Table 4:** Share of formal work in total productive time

| | Country Income Group | | |
|---|---|---|---|
| | Low | Middle | High |
| Men | 35.9 | 55.5 | 65.4 |
| Women | 13.9 | 21.9 | 36.5 |

*Notes:* Share (in %), men and women aged 15-64.

of traditional forms of production, into formal forms of production (Kuznets, 1973; Gollin, 2008). I regard this as "modernization".[4] In my data, modernization is reflected in the share of productive time that men (women) spend in formal work (Table 4). In low-income countries, this share is 36% (14%). Across country income groups, it increases to 65% (37%). So in my data productive time clearly shifts away from traditional work and toward formal work.

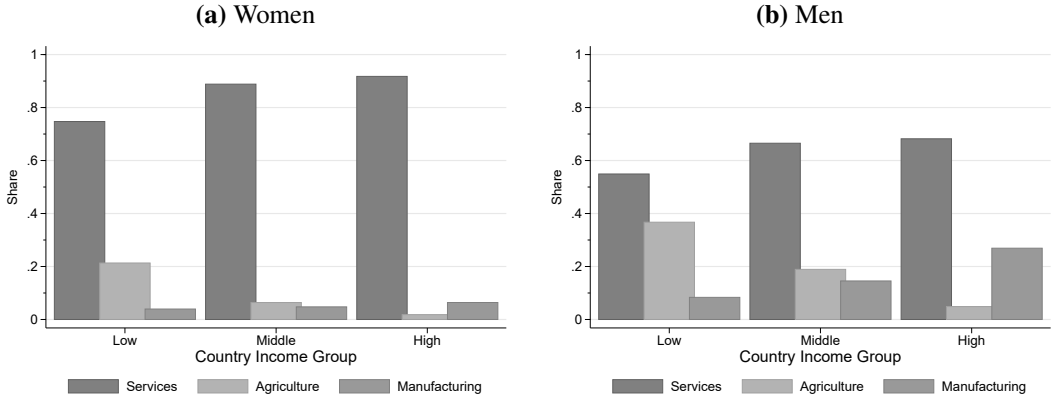
The other force of structural change is "structural transformation". It causes sectoral shifts in hours worked across industries (Fisher, 1939; Kuznets, 1973; Syrquin, 1988): Less time is spent on the production of agricultural goods and instead spent on the production of manufacturing goods and services. Figure 1 illustrates the shares of total productive time that men and women spend in the production of agricultural goods, manufacturing goods, and services. For both genders, the share of time spent in agriculture declines across country income groups. At the same time, the share in services and manufacturing increase, which points to the occurrence of structural transformation in hours worked.

### 3.3.2 Sectoral comparative advantages

Note that in Figures 1a and 1b, men's and women's manufacturing and service shares differ considerably in low-income countries. Moreover, they increase very differently from low- to high-income countries. I emphasize this because if men and women allocate their time differently across industries, then this confirms the second key assumption in Ngai and Petrongolo (2017): Men's and women's sectoral comparative advantages lie in different industries. I will now look into these

[4] Actually, earlier works such as Ngai and Pissarides (2008), Ngai and Petrongolo (2017), Moro et al. (2017), or Bridgman et al. (2018) think about the reallocation of hours slightly differently (from non-market or household work to market work) and thus use the term "marketization". I prefer "modernization" because it emphasizes the reallocation of hours away from basic towards advanced forms of production.

**Figure 1:** Industry shares in total productive time




*Notes:* Share of hours worked in formal and traditional production, by industry, and as of total hours worked.

differences in more detail.

In low-income countries, women spend most of their productive time in services (these account for nearly 75% of their productive time). For the most part, these are hours spent cooking and cleaning at home as well as hours in childcare. This is in line with Folbre (2014), who focuses on the proportion of hours in unpaid care work. Hours in agriculture form most of the remainder in women's productive time (around 21%). For men in low-income countries, the service share is around 55%, which is considerably lower than for women. Consequently, men spend a higher proportion of their time agriculture (37%) and manufacturing (8%).

From this I conclude that gender differences in the division of labor between industries also prevail in low-income countries, although less pronounced than in middle- and high-income countries. As countries become richer, women reallocate their time mainly to services (92% in high-income countries, while their share in manufacturing increases only slightly from 4% in low-income countries to 6% in high-income countries). Men, on the other hand, reallocate their productive time more evenly across services and manufacturing: the share of services rises by 13 percentage-points to 68%, and the share in manufacturing rises by 19 percentage-points to 27%.

So, in all country income groups there exist clear gender differences in the division of labor by industry. Ngai and Petrongolo (2017) argue that these differences could be due to differences in the endowment of men and women with "physical"

skills. Because of this, both genders' sectoral comparative advantages lie in different sectors. For women, in particular, the sectoral comparative advantage lies in the services, as their production is relatively less "brawn-intensive" than the production of manufacturing goods.

Overall, I conclude that the key assumptions in the model of Ngai and Petrongolo (2017) are validated in my data: There occur comparable shifts in working hours, and sectoral comparative advantages seem to exist. In the next section, I develop a model that allows me to reflect on how structural change could be related to the decline of gender differences in hours of formal work. In particular, I reflect on the possible roles of structural transformation and modernization when these two forces occur hand-in-hand and in an environment where genders have sectoral comparative advantages.

# 4 Model

The evidence provided has made it clear that (i) women spend less time in formal work; but that (ii) across country income groups, women's hours in formal work increase relative to men's; and that (iii) even in low-income countries, women's sectoral comparative advantage lies in services.

I now develop a general equilibrium, static multi-sector model of male and female labor supply. It draws on key elements of the model of Ngai and Petrongolo (2017). On the supply side, the economy consists of three formal sectors, each producing either an agricultural commodity, a manufacturing commodity, or a service commodity. Each formal sector is populated by a representative firm. These firms combine technology and male as well as female labor inputs to produce output that is sold to a representative household. The members of this household can also produce agricultural, manufacturing, and service commodities themselves and for their own use, in traditional production. Men and women each have sectoral comparative advantages in the producing of certain commodity kinds. There is free labor mobility so that wages equalize across sectors.

## 4.1 The Household Side

I follow closely the notation in Ngai and Petrongolo (2017). The household consists of a man and a woman who derive joint utility from consumption $c$ and leisure $L_l$. Both members choose how much time to spend in household production

of each commodity kind, how much time to spend in leisure, and how much of each firm commodity to consume.

Utility is given by

$$U(c, L_l) = ln(c) + \varphi ln(L_l), \tag{1a}$$

with

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

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

Consumption $c$ is a composite of three different commodity kind bundles $c_j$: Agricultural goods $c_A$, manufacturing goods $c_M$ and services $c_S$. Each commodity kind bundle is, in turn, a composite of two versions of that commodity: a household version produced using traditional technologies, and a firm version produced with advanced technologies. I denote household and firm commodity versions $c_{j_h}$ and $c_{j_m}$, respectively.[5] The parameters $\varepsilon$ governs the substitutability of different commodity kinds. $\sigma$ governs the substitutability of firm and household versions of the same commodity kind.

Traditional production of $\{c_{j_h}\}_{j=A,M,S}$ occurs by the household using male and female time inputs, $l^m_{j_h}, l^f_{j_h}$:

$$c_{j_h} = Z_{j_h} L_{j_h} \tag{1d}$$

$$L_{j_h} = \left[ \xi_{j_h} (l^f_{j_h})^{\frac{\eta-1}{\eta}} + (1-\xi_{j_h})(l^m_{j_h})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}. \tag{1e}$$

$Z_{j_h}$ is labor productivity. For $\eta > 1$, male and female labor inputs are good substitutes. The weights on female time inputs, $\xi_{j_h} \in (0,1)$, describe gender-specific productivities. Sectoral comparative advantages arise when these weights vary from sector to sector. For example, if $\xi_{S_h} > \xi_{A_h}$, then compared to traditional agriculture women have a sectoral comparative advantage in producing traditional services.

[5] Note that this follows convention, although the subscript $m$ is typically used to denote a "market" version of a commodity kind. In the context of this work, think of $m$ as a placeholder for a "modern" version of a commodity kind, produced in formal work and using advanced technologies.

Leisure $L_l$ is a composite of female and male leisure, $l_l^f$ and $l_l^m$:

$$L_l = \left[\xi_l (l_l^f)^{\frac{\eta-1}{\eta}} + (1-\xi_l)(l_l^m)^{\frac{\eta-1}{\eta_l}}\right]^{\frac{\eta}{\eta-1}}. \tag{1f}$$

Finally, the household's decision on how much to consume from each firm commodity $\{c_{j_m}\}_{j=A,M,S}$ is restricted by the budget constraint:

$$\sum_{j=A,M,S} p_{j_m} c_{j_m} = w_m M^m + w_f M^f \tag{1g}$$

It requires that expenditures on firm commodities be financed by the couple's pooled income from hours in formal work $(M^m, M^f)$, where men and women earn wages $w_m, w_f$, respectively. These hours are, in turn, limited by the time endowments $L_f$ and $L_m$ and by the time agents spend in the traditional sectors:

$$M^g = L^g - l_{A_h}^g - l_{M_h}^g - l_{S_h}^g - l_l^g, \qquad \text{g = f,m.} \tag{1h}$$

### 4.2 The Firm Side

There exist three representative firms, each of which produce a single kind of commodity $\{y_{j_m}\}_{j=A,M,S}$ in a perfectly competitive environment:

$$y_{j_m} = Z_{j_m} L_{j_m} \tag{2}$$

$$L_{j_m} = \left[\xi_j (l_{j_m}^f)^{\frac{\eta-1}{\eta}} + (1-\xi_j)(l_{j_m}^m)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{3}$$

Notationwise, $l_{j_m}^f$ and $l_{j_m}^m$ denote female and male time in the respective formal sectors. Here too, $\eta > 1$ regulates how well male and female time inputs can be substituted with each other in response to relative wage changes. $Z_{j_m}$ is labor productivity. Firms sell commodity $c_{j_m}$ at price $p_{j_m}$ and face labor costs $w_f l_{j_m}^f$ plus $w_m l_{j_m}^m$.

### 4.3 Equilibrium

The household chooses how much of each firm commodity $\{c_{j_m}\}_{j=A,M,S}$ shall be consumed, how much time each member should spend in traditional production of each commodity kind $\{l_{j_h}^f, l_{j_h}^f\}_{j=A,M,S}$, and how much time each member should spend in leisure $l_l^f, l_l^f$. Firms choose female and male time inputs $\{l_{j_m}^f, l_{j_m}^f\}_{j=A,M,S}$.

*A competitive equilibrium* is a set of prices $\{p_{j_m}\}_{j=A,M,S}$ and wages $\{w_f, w_m\}$, time and consumption allocations $\{l^f_{j_h}, l^m_{j_h}, l^f_{j_m}, l^m_{j_m}, c_{j_m}\}_{j=A,M,S}$ as well as leisure choices $l^f_l, l^m_l$ such that

1. Households maximize utility (1a) subject to preferences (1b) - (1c), production technology (1d), leisure preferences in (1f), and such that the budget constraint (1g) is satisfied.

2. Firms $j = \{A_m, M_m, S_m\}$ maximize profits subject to technology (2);

3. Commodity and labor markets clear

   - $c_{j_m} = y_{j_m} = Z_{j_m} L_{j_m}$ and $c_{j_h} = Z_{j_h} L_{j_h}$ for $j = A, M, S$;
   - $L^g = l^g_l + \sum_{j=A,M,S} \left[ l^g_{j_h} + l^g_{j_m} \right]$ for $g = m, f$.

Next, I solve the model. In doing so, I follow the derivations in Ngai and Petrongolo (2017) closely. I obtain optimal time allocations by the household and time inputs by firms as functions of the wage ratio $x := w_f / w_m$ and use these to formulate a condition for the equilibrium wage ratio.

### 4.4 Optimization

The derivatives of the household problem are

$$c_j : \frac{\partial U}{\partial c_j} = \lambda p_j, \qquad j = A_m, M_m, S_m \tag{4a}$$

$$l^g_i : \frac{\partial U}{\partial c_i} \frac{\partial c_i}{\partial l^g_i} = \lambda w_g, \qquad i = A_h, M_h, S_h \tag{4b}$$

$$l^g_l : \frac{\partial U}{\partial l^g_l} = \lambda w_g, \qquad g = f, m. \tag{4c}$$

The parameter $\lambda$ is the Lagrange multiplier for the budget constraint (Equation 1g). On the firm side, derivatives take the form:

$$l^f_j : w_f = p_j Z_j \xi_j \left(l^f_j\right)^{-\frac{1}{\eta}} L_j^{\frac{1}{\eta}} \qquad j = A_m, M_m, S_m \tag{5a}$$

$$l^m_j : w_m = p_j Z_j (1 - \xi_j) \left(l^m_j\right)^{-\frac{1}{\eta}} L_j^{\frac{1}{\eta}} \qquad j = A_m, M_m, S_m. \tag{5b}$$

### 4.4.1 Relative prices

Combining 5a and 5b yields the following relationship between male and female hours in formal sectors:

$$\frac{l_j^m}{l_j^f} = \alpha_j^{-\eta} x^{\eta}, \qquad j = A_m, M_m, S_m, \tag{6}$$

where $\alpha_j := \frac{\xi_j}{1-\xi_j}$ and $x = w_f/w_m$. Male hours co-move with female hours. Firms respond to a rise of women's relative wages by reducing their relative demand for female hours. In order to derive an expression for $L_j$, Ngai and Petrongolo (2017) define and rewrite the female wage bill share $I_j$ using Equation (6). This yields

$$I_j := \frac{w_f l_j^f}{w_f l_j^f + w_m l_j^m} = \frac{1}{1+\alpha_j^{-\eta} x^{\eta-1}}, \qquad j = A_m, M_m, S_m. \tag{7}$$

Given $x$, the female wage-bill share is increasing in the female-weight $\xi_j$. Aggregate time inputs equal

$$L_j = \left(\frac{\xi_j}{I_j(x)}\right)^{\frac{\eta}{\eta-1}} l_j^f, \qquad j = A_m, M_m, S_m. \tag{8}$$

These derivations are analogue for aggregate hours in traditional production. That is, Equations (6) - (8) hold for $j = \{A_h, M_h, S_h\}$ as well.

Derivative (5a) relates the wages women earn in formal work to the price of firm commodities. To derive a similar expression on the household side, assume that the *implicit* prices of household commodities are such that $p_{j_h} \frac{\delta c_{j_h}}{\delta l_{j_h}^f} = w_f$. Using (8),

$$p_{j_k} = \frac{w_f}{Z_{j_k}} \xi_{j_k}^{\frac{\eta}{1-\eta}} I_{j_k}(x)^{\frac{1}{\eta-1}}, \qquad j = A, M, S; \quad k = m, h \tag{9}$$

then relates the price of any commodity to female wages. This price is inversely related to the sectoral productivity level $Z_{j_k}$.

Under free labor mobility, Equation (9) applies to all sectors. Relative prices

between any two commodities $c_i, c_j$ with $i, j = \{A_k, M_k, S_k\}_{k=m,h}$ then equal

$$\frac{p_j}{p_i} = \frac{Z_i}{Z_j}\left(\frac{\xi_i}{\xi_j}\right)^{\frac{\eta}{\eta-1}}\left(\frac{I_j}{I_i}\right)^{\frac{1}{\eta-1}}. \tag{10}$$

Given the wage ratio $x$, an increase in the sectoral productivity differential $Z_i/Z_j$ raises the opportunity cost of consuming commodity $c_j$ instead of $c_i$.

### 4.4.2 Relative expenditures

The next step is to derive how the household allocates its budget relatively across commodities, given relative prices. This depends on whether the household is considering how to allocate household income to i) a firm versus a household version of the same commodity kind; or on ii) two different commodity kinds.

From the marginal rate of substitution, relative expenditures for firm versus household commodities of the same kind are given by

$$E_{j_{mh}} := \frac{p_{j_m} c_{j_m}}{p_{j_h} c_{j_h}} = \left(\frac{p_{j_h}}{p_{j_m}}\right)^{\sigma-1}\left(\frac{\psi_j}{1-\psi_j}\right)^{\sigma}. \tag{11a}$$

Using Equation (10) for relative prices,

$$E_{j_{mh}} = \hat{Z}_{j_{mh}}^{\sigma-1}\left[\left(\frac{\xi_{j_m}}{\xi_{j_h}}\right)^{\frac{\eta}{\eta-1}}\left(\frac{I_{j_h}(x)}{I_{j_m}(x)}\right)^{\frac{1}{\eta-1}}\right]^{\sigma-1}, \tag{11b}$$

$$\text{where } \hat{Z}_{j_{mh}} := \frac{Z_{j_m}}{Z_{j_h}}\left(\frac{\psi_j}{1-\psi_j}\right)^{\frac{\sigma}{\sigma-1}}. \tag{11c}$$

$E_{j_{mh}}$ is a function of $\sigma$, the degree of substitutability between firm and household versions of the same commodity kind.

In the model appendix, I show how to derive a similar expression for expenditures on two different kinds of firm commodities $c_{j_m}$ and $c_{k_m}$. I denote it by $E_{j_m k_m}$:

$$E_{j_m k_m} = \hat{Z}_{j_m k_m}^{\varepsilon-1}\left[\left(\frac{\xi_{j_m}}{\xi_{k_m}}\right)^{\frac{\eta}{\eta-1}}\left(\frac{I_{j_m}(x)}{I_{k_m}(x)}\right)^{\frac{1}{1-\eta}}\right]^{\varepsilon-1}\left(\frac{1+E_{k_{mh}}}{E_{k_{mh}}}\frac{E_{j_{mh}}}{1+E_{j_{mh}}}\right)^{\frac{\sigma-\varepsilon}{\sigma-1}} \tag{12a}$$

$$\text{where } \hat{Z}_{j_m k_m} := \frac{Z_{j_m}}{Z_{k_m}}\left(\frac{\omega_j}{\omega_k}\right)^{\frac{\varepsilon}{\varepsilon-1}}\left(\frac{\psi_k}{\psi_j}\right)^{\frac{\sigma}{1-\sigma}}. \tag{12b}$$

Here, relative expenditures on two different kinds of firm commodities $E_{j_m k_m}$ are a function of $\varepsilon$, the parameter that governs the substitutability of different commodity kinds in preferences (1b).

I join Ngai and Petrongolo (2017) and restrict the discussion to the case where $\varepsilon < 1$ and $\sigma > 1$ (a common assumption to generate secular shifts in hours and expenditures, see Herrendorf et al., 2014). Then, uneven labor productivity growth (i.e. changes in $\hat{Z}_{j_{mh}}$ and $\hat{Z}_{j_m k_m}$) have very different implications for relative expenditures in (11b) and (12a). I go into the details in the next subsection.

### 4.4.3 Between-Sector Forces and Time Allocations

Similar to previous works, I think about two types of between-sector forces that occur in this model as productivities grow unevenly across sectors (Ngai and Pissarides, 2008; Herrendorf et al., 2014; Ngai and Petrongolo, 2017). Under "modernization", productivities grow faster in the formal sector than in the traditional sector.[6] Under "structural transformation", productivities grow faster for one commodity kind than for another. Typically, earlier works analyze how labor productivities change in one country historically (Ngai and Pissarides, 2008; Ngai and Petrongolo, 2017). Here, I think of sectoral productivity differentials as being differently pronounced across country income groups.

Ultimately, I am interested in the sectoral allocation of men's and women's labor hours. Equations (11b) and (12a) provide an intermediate way of looking at how differently modernization and structural transformation shape labor allocations through shifts in relative expenditures. First, consider what happens when the firm/household labor productivity differential becomes more pronounced across country income groups ($\hat{Z}_{j_{mh}}$ rises). Then the household commodity becomes relatively more expensive than the version produced by the firm: $\frac{p_{j_h}}{p_{j_m}}$ increases. Since $\sigma > 1$, the two commodities in the commodity kind bundle are easy to substitute. The intuitive reaction of the couple is thus to reduce relative expenditures on the household commodity $c_{j_h}$: $E_{j_{mh}}$ increases. Market clearing requires that demand and supply of the two commodities be aligned. To assure this, women readjust the

[6] These studies use the term "marketization", because they focus on the shift away from production of commodities for own consumption, to commodities for sale. I use "modernization" because it better describes the shift away from traditional and basic to formal and modern forms of production.

hours they devote to formal and traditional work according to

$$\frac{l^f_{j_m}}{l^f_{j_h}} = E_{j_{mh}} \frac{I_{j_m}}{I_{j_h}}. \tag{13}$$

In summary, if firm productivity advances faster than household productivity, relative expenditures shift towards firm commodities and productive time is reallocated: away from traditional forms of production, towards formal forms of production.

Under structural transformation, this is different: productive time is not reallocated to the sector with relatively faster productivity growth. To see this, consider a case in which the differential $\hat{Z}_{j_m k_m}$ becomes more pronounced across country income groups (productivity $Z_{j_m}$ improves faster than $Z_{k_m}$). Then, commodity $c_{j_m}$ becomes relatively cheaper than $c_{k_m}$. However, if $\varepsilon < 1$, then for the household it is costly in utility terms to readjust demand in favor of $c_{j_m}$. In other words, the harder different commodity kinds are to substitute, the relatively more inelastic is demand to relative price changes. This is why in Equation (12a), $E_{j_m k_m}$ is inversely related to $\hat{Z}_{j_m k_m}$. This in turn has implications for the allocation of productive time,

$$\frac{l^f_{j_m}}{l^f_{k_m}} = E_{j_m k_m} \frac{I_{j_m}}{I_{k_m}}. \tag{14}$$

An increase in the productivity differential $\hat{Z}_{j_m k_m}$ leads to a rise of the opportunity cost of time spent producing $c_{k_m}$ rather than $c_{j_m}$. This effect exerts pressure on $l^f_{k_m}$. However, market clearing conditions require that the demand for both commodity kinds be met on the supply side. The relative increase of labor productivity in $c_{j_m}$ makes it possible to redistribute productive time away from production of $c_{j_m}$ to $c_{k_m}$. This re-balances supply and demand. Ultimately, the extent to which hours are reallocated depends on how hard it is to substitute different kinds of commodities.

### 4.4.4 Between- Versus Within-Sector Forces and Gender Gaps

Using the equation relating male and female working hours (6), I define sectoral gender gaps as

$$\frac{l_j^m - l_j^f}{l_j^f} = \alpha_j^{-\eta} x^{\eta} - 1, \qquad j = A_m, M_m, S_m. \tag{15}$$

Sectoral gender gaps are increasing in women's relative wages. The logic here is that firms can easily substitute female by male hours as women's labor hours become relatively more expensive. Otherwise, the gaps are negatively related to $\xi_j$, the parameter governing women's productivity (keep in mind that $\alpha_j := \frac{\xi_j}{1-\xi_j}$).

In Ngai and Petrongolo (2017), the weights placed on female time inputs in the formal sectors sectors are allowed to change overtime: They are calibrated once to the U.S. economy in the early 1970's, and re-calibrated to the U.S. economy in 2004-08. The authors attribute changes in this parameter to the existence of *within-sector* forces that alter the relative demand for female labor in a given sector. These may result, for example, from changes in cultural norms, less discrimination against women in formal work, or technological improvements that reduce the need for physical skills in brawn-intensive sectors. I emphasize this because these types of within-sector forces may also be at work across country income groups. If so, how do within- as opposed to between-sector forces shape the gender gap in hours of formal work?

To speak to this, I derive an expression for the male/female ratio in hours of formal work:

$$\frac{M^m}{M^f} = x^{\eta} \left[ 1 + \frac{l_{M_m}^f}{M^f} \left( \frac{\alpha_{A_m}^{\eta} - \alpha_{M_m}^{\eta}}{\alpha_{M_m}^{\eta}} \right) + \frac{l_{S_m}^f}{M^f} \left( \frac{\alpha_{A_m}^{\eta} - \alpha_{S_m}^{\eta}}{\alpha_{S_m}^{\eta}} \right) \right] \alpha_{A_m}^{-\eta} \tag{16}$$

First, relative hours in formal work and relative wages are negatively related. This is because in response to a rise of women's relative wages, firms replace female by male hours.

Second, the terms in brackets indicate how the male/female ratio in formal hours is shaped by between- and within-sector forces. On the one hand, it consists of the shares of the manufacturing and service sectors in women's hours of formal work

$\left(\frac{l^f_{M_m}}{M^f}, \frac{l^f_{S_m}}{M^f}\right)$. As modernization and structural transformation occur across country income groups, these shares change. In particular, the service share in women's hours of formal work increases across country income groups. For such an increase to be associated with a decline of the male/female ratio of formal hours, the following must hold: Compared to the formal agricultural sector, women must have a sectoral comparative advantage in the formal service sector ($\xi_{A_m} < \xi_{S_m}$). Similarly, for a rise in $\frac{l^f_{M_m}}{M^f}$ to be associated with a decline of $\frac{M^m}{M^f}$, compared to the formal agricultural sector women must have a sectoral comparative advantage in the formal manufacturing sector ($\xi_{A_m} < \xi_{M_m}$).

To see this better, consider this: If $\xi_{A_m} = \xi_{M_m} = \xi_{S_m}$, the term in brackets collapses. Then only relative wages determine the male/female ratio in formal hours. However, if, for example, $\xi_{A_m} < \xi_{S_m}$, then an increase of the service share in female hours of formal work is associated with a decline of the male/female formal hours ratio. The intuition is that structural transformation causes sectoral shifts towards a sector in which women, in particular, have a sectoral comparative advantage. In terms of productivity, women's competitive position therefore improves compared to men.

In summary, if $\xi_{A_m} < \xi_{S_m}$ and $\xi_{A_m} < \xi_{M_m}$, then the between-sector forces of structural change are associated with a decline of the male/female ratio in hours of formal work. The role of within-sector forces is to reinforce or weaken this mechanism: If women's sectoral comparative advantage in the formal services sector becomes more pronounced across country income groups, then this gives structural change more potential to reduce gender differences in hours of formal work.

### 4.4.5 Leisure Choices and Closing the Model

I now derive an expression that can be used to determine leisure hours. Then, I can close the model. Starting from the marginal rate of substitution between leisure and any firm commodity $c_{j_m}$, relative expenditures $E_{lj_m}$ are given by

$$E_{lj_m} = \varphi\left(\sum_{i=A,M,S} E_{i_m j_m} \frac{1+E_{i_{mh}}}{E_{i_{mh}}}\right). \tag{17}$$

The term in summation captures the extent to which modernization and structural transformation have already led to secular shifts in expenditures. Relative leisure

hours are given by

$$\frac{l_l^f}{l_{j_m}^f} = E_{l j_m} \frac{I_l}{I_{j_m}}. \tag{18}$$

The time constraint requires that all available time $L_f$ should be spent in the production of commodities or in leisure time. Time allocations also form part of the budget constraint. I follow Ngai and Petrongolo (2017) and derive the time women spend in traditional production of services as a share of their time endowment:

$$I_L \sum_{\substack{j=A_m,A_h,M_m,\\ M_h,S_m,S_h,l}} \frac{E_{jS_h}}{I_{S_h}} = \frac{L^f}{l_{S_h}^f} = \sum_{\substack{j=A_m,A_h,M_m,\\ M_h,S_m,S_h,l}} E_{j_k S_h} \frac{I_{j_k}}{I_{S_h}} \tag{19}$$

The left-hand side of Condition (19) is a rewritten version of the budget constraint, while the right-hand side is a rewritten version of the time constraint. $I_L$ is the female wage-bill share in the economy. I leave the details to the model appendix. The equilibrium wage ratio $x$ is such that (19) is satisfied. In the quantitative analysis, I solve for $x$ computationally and then retrieve the time allocations implied by the model.

## 5 Quantitative Analysis

Can the model explain how differently men and women reallocate their productive time across country income groups? If so, what is the potential role of between-sector forces as opposed to within-sector forces? To assess this, I calibrate the model and conduct a counterfactual exercise. For each country income group I numerically calibrate the sectoral technology differentials in Equations (11b) and (12a), as well as the female weights in the formal sectors ($\xi_{A_m}, \xi_{M_m}, \xi_{S_m}$). I do this by targeting women's and men's relative time allocations.

### 5.1 Calibration

I take four baseline parameters from Ngai and Petrongolo (2017). For one, $\varepsilon$ is set to 0.002, which is also in line with Herrendorf et al. (2013), or Moro et al. (2017) who find very low values of $\varepsilon$. Second, I set $\sigma$ to 2.0. Third, I set $\eta$ = 2.27. Ngai and Petrongolo (2017) calibrate this value based on U.S. data from the

**Table 5:** Parameters set from Ngai and Petrongolo (2017)

| Parameter | Value | Description |
|---|---|---|
| $\varepsilon$ | 0.002 | Substitutability of different commodity kinds |
| $\sigma$ | 2 | Substitutability of firm vs. traditional commodities |
| $\eta$ | 2.27 | Substitutability of male vs. female time inputs |
| $\xi_{S_h}$ | 0.49 | Weight on female time in traditional services |

1970s to 2004-08, to match how male and female hours in traditional services are substituted in response to changes in relative wages. Finally, I take their value for the productivity weight of women in traditional services, $\xi_{S_h} = 0.49$.

I calibrate the remaining parameters numerically by targeting moments that I compute from the data presented in Section 2. This includes, first, the calibration of the female weights in traditional sectors ($\xi_{A_h}, \xi_{M_h}$), in leisure $\xi_l$, and preferences for leisure $\varphi$. These parameters are calibrated once based on data for low-income countries, and then left unchanged for middle- and high-income countries.

Second, this includes the calibration of the female weights in formal sectors: $\xi_{A_m}, \xi_{M_m}, \xi_{S_m}$. Here, I allow these weights to change across country income groups. This is to capture within-sector forces that may be at work across countries (sourced in cross-country differences in culture, norms, or in institutions, all of which affect the relative demand for female labor). Similarly, Ngai and Petrongolo (2017) allow for changes in their gender-specific productivity weights to capture how within-sector forces affected the relative demand for female labor overtime in the United States.

Third, this includes the calibration of the sectoral productivity differentials in Equations (11b) and (12a). I do not have actual data on how pronounced productivity differentials are across countries or country income groups. I therefore re-calibrate them for each country income group to match how women allocate their productive time relatively across sectors. I recognize that this has important implications for the remainder of this work. In particular, this exercise is of an explorative character, as it enables me to estimate the extent to which different forces in my model *may* explain the decline of the gender gap in hours of formal work. I cannot infer in how far structural change and within-sector forces *actually* shape this decline.

Formally, I calibrate the model as follows. First, let

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

contain the parameters I calibrate based on *low-income countrie*s. I target the following data-moments:

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

The first five moments relate to the allocation of women's productive time between the different sectors. The next five moments are the male/female ratios in the three formal sectors, in traditional agriculture, and in traditional manufacturing. Finally, $l^f_l$ and $l^m_l$ denote leisure.

For $c$ = *middle-* and *high-income* countries, I hold preferences for leisure and the gender-specific weights in traditional sectors fixed. I re-calibrate

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

to match

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

I present the parameter values resulting from the numerical calibration in Table (6).[7] For the model to be able to replicate the allocations of productive time, across country income groups labor productivity must improve faster in the formal than in the traditional sectors. For example, the formal/traditional productivity differential in agriculture increases from 0.3 in low-income to 1.1 in high-income countries. Moreover, productivity must improve faster in formal agriculture than in formal services (the ratio rises from 2.6 in low- to 29.3 in high-income countries), and faster in formal agriculture than in formal manufacturing.

Finally, consider the calibrated values for the female weights in formal sectors.

[7] For brevity, I leave the exact values of the targeted data moments to Appendix Table (B.5).

**Table 6:** Parameters calibrated numerically

| | $\hat{Z}_{A_{mn}}$ | $\hat{Z}_{M_{mn}}$ | $\hat{Z}_{S_{mn}}$ | $\hat{Z}_{A_mM_m}$ | $\hat{Z}_{A_mS_m}$ | $\xi_{A_m}$ | $\xi_{M_m}$ | $\xi_{S_m}$ | $\xi_{A_n}$ | $\xi_{M_n}$ | $\xi_l$ | $\varphi$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 0.3 | 1.8 | 0.3 | 0.1 | 2.6 | 0.32 | 0.32 | 0.32 | 0.38 | 0.37 | 0.37 | 1.22 |
| Middle | 0.6 | 8.1 | 0.5 | 0.4 | 7.8 | 0.24 | 0.30 | 0.34 | - | - | - | - |
| High | 1.1 | 41.0 | 0.8 | 3.0 | 29.3 | 0.28 | 0.27 | 0.38 | - | - | - | - |

*Notes:* The parameters $\hat{Z}_{A_{mh}}$-$\hat{Z}_{M_mS_m}$ refer to the sectoral productivity differentials in Equations (11b) and (12a). $\xi_{A_m} - \xi_{M_h}$ denote the weight placed on female labor inputs. $\xi_l$ and $\varphi$ relate to preferences for leisure in Equations (Equation (1a))- (Equation (1f)).

In general, they are within the ranges calibrated in Ngai and Petrongolo (2017) for goods (agriculture and manufacturing combined) and services produced by firms. In the latter work these weights increase overtime, suggesting that within-sector forces have been at work and have raised the relative demand for female labor in the U.S. Interestingly, my calibration also suggests that there might be substantial within-sector forces at work across country income groups. On the one hand, the female weight in formal services increases across country income groups (from 0.32 to 0.38). On the other hand, the female-specific productivity weight in formal manufacturing decreases. In formal agriculture it is U-shaped. I attribute the initial decline to cross-country differences in social norms. This refers to Goldin (1995), who discusses how stigmatization hinders female participation in more brawn-intensive industries such as agriculture or manufacturing. On the other hand, I attribute the subsequent increase of $\xi_{A_m}$ to technological improvements that reduce the physical requirements imposed on workers (the brawn-intensity).

### 5.2 Model fit

I now assess to what extent the model's predictions for changes in the number of hours worked and in relative expenditures match the changes in the data.

In the data, men's total productive time falls by 18% (Table 7). The model predicts that men's total time in production increases by 1.5%. For women, the model predicts that total productive time falls by -2%, compared to -22% in the data. So, the model does not reproduce the considerable reductions in men's and women's total working hours. However, it scores reasonably well in terms of generating the observed reductions in hours worked by men and women in traditional work. Men's traditional hours fall by 56% in the data as compared to 48% in the model. For women, the model is slightly more off (-28% as compared to -43% in the data).

**Table 7:** Non-targeted model predictions

| | Men | | | Women | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $T^m$ | $N^m$ | $M^m$ | $T^f$ | $N^f$ | $M^f$ | $\frac{N^m}{N^f}$ | $\frac{E_A}{E_M}$ | $\frac{E_A}{E_S}$ | $\frac{E_M}{E_S}$ |
| $\Delta$ Low-high: Data | $-18$ | $-56$ | 50 | $-22$ | $-43$ | 104 | $-22$ | $-92$ | $-93$ | $-13$ |
| $\Delta$ Low-high: Model | 1.5 | $-48$ | 90 | $-2$ | $-28$ | 159 | $-28$ | $-86$ | $-96$ | 7.9 |

*Notes:* Actual and predicted changes (in %) across country income groups. Values are computed from the difference between high- minus low-income countries, in relation to low-income countries. $T^m, T^f$ are total productive time of men and women, respectively, $N^m, N^f$ are traditional hours and $M^m, M^f$ are market hours. The last three columns show relative expenditures (agriculture/manufacturing, agriculture/services, manufacturing/services), as computed using the World Development Indicators (WDI) and as predicted by the model.

The model predicts that for both genders, hours in formal work rise more than in the data (by 90% for men and 159% for women as opposed to 50% and 104% in the data). So for both genders formal hours rise too much, but they do rise relatively faster for women than for men. This is because I force the model to match the male/female ratio in formal hours.

Otherwise, the model broadly reproduces the observed secular shifts in expenditures. For example, expenditures shift from agriculture to manufacturing (-92% according to WDI data, -86% in the model) and to services (-93% in the data, -96% in the model). It does, however, predict that manufacturing expenditures increase relative to service expenditures, which is not observed in the data.

### 5.3 Between Versus Within-Sector Forces: A Preliminary Assessment

Through the lens of this model, there must be substantial between- as well as within-sector forces at work to explain how men and women reallocate their productive time across country income groups. Labor productivity must grow faster in formal sectors than in traditional sectors (modernization), and unevenly across different kinds of commodities (structural transformation).

Keep in mind that structural transformation is associated to a decline in the male/female formal hours ratio under the following condition: Compared to agriculture women must have a sectoral comparative advantage in producing manufacturing goods and/or services (Equation (16) in Section 4.4.4). In low-income countries, the calibration yields $\xi_{A_m} = 0.323 > 0.322 = \xi_{S_m}$ and $\xi_{A_m} = 0.323 < 0.325 = \xi_{M_m}$. So, in low-income countries the ordering condition is not fulfilled. From low- to middle-income countries, however, the ordering of the female weights

**Table 8:** Decomposing the male/female ratio in formal hours

| | Country Income Group | | | |
|---|---|---|---|---|
| | Low | Middle | High | ΔLow-high |
| Data & benchmark model | 2.00 | 1.91 | 1.47 | −26.6 |
| Between-sector forces *($\hat{Z}$ change)* | 2.00 | 1.97 | 1.82 | −9.1 |
| Marketization only | | 1.89 | 1.78 | −11.2 |
| Struc. Transformation only | | 2.10 | 2.04 | 2.0 |
| Within-sector forces *($\xi_{A_m}, \xi_{M_m}, \xi_{S_m}$ change)* | | 2.23 | 1.72 | −14.1 |

*Notes:* Predicted male/female ratio in hours of formal work, and its change across country income groups under counterfactual scenarios. Values in the first row and first column are targeted in the calibration. I compute the %-change as the difference in the ratio (high-low) over the value of the ratio in low-income countries.

is reversed. Women then have a sectoral comparative advantage in services as opposed to agriculture. And, this becomes even more pronounced from middle- to high-income countries. This happens as within-sector forces increase the relative demand for female labor in the formal service sector and reduce the relative demand for female labor in the formal agricultural sector (and in manufacturing, though to a lesser degree).

To see how between- versus within-sector forces shape the male/female ratio in hours of formal work, consider Table (8). In the first row, I present the male/female ratio in hours of formal work as observed in the data and targeted in the calibration. It falls from 2 in low-income to 1.91 in middle-income and 1.47 in high-income countries. Overall, this corresponds to a decline of -27%. The lower rows show the male/female ratios in four counterfactual exercises.

In the second row, I present the male/female ratios as predicted by the model if, across country income groups, only between-sector forces are at work. That is, the formal/traditional productivity ratios $\hat{Z}_{j_{mh}}$ change as in Table (6), and so do $\hat{Z}_{A_m M_m}$ as well as $\hat{Z}_{A_m S_m}$. But I hold fixed across country income groups the productivity weights on female labor inputs in the formal sectors (at values calibrated for low-income countries). In this scenario, the male/female ratio in formal hours falls by 9%, from 2 in low- to 1.82 in high-income countries. Note that this translates into a decline of the gender gap in formal hours of (0.82-1.0)/1.0 = -18%, compared to (0.47-1.0)/1.0 = -53% in the data.

Rows (3)-(4) show that alone, modernization is associated with a decline of

the male/female ratio in formal hours (-11%). However, structural transformation alone is associated with a rise of the ratio. The reason is that I hold the gender weights in formal sectors fixed at values calibrated for low-income countries. Keep in mind that in low-income countries, the ordering condition is not fulfilled. Structural transformation causes a decline of the formal agricultural sector. This is, however, where women in low income countries have their sectoral comparative. At the same time, structural transformation gives rise to the one *traditional* sector where the relative demand for female labor is highest (traditional services). All in all, this pulls women out of formal work into traditional work, so that the male/female ratio in formal hours increases (rather than declines).

In the final scenario, I neither allow for marketization nor for structural transformation. Only the weights on female labor inputs in the three market sectors change across country income groups. Quantitatively, this is associated to a decline of the male/female formal hours ratio of 14%. However, the pattern follows an inverse hump-shape, with the ratio rising to 2.23 in middle-income countries. Note that when the female-specific productivity weight changes in a given sector, the main consequence is that hours within that sector are re-allocated across genders. If the weight falls, women's competitive position deteriorates (compared to men). Then female hours in that sector are replaced by male hours. The opposite is true if the female-specific productivity weight increases, such that women's competitive position improves. Then, male hours in this sector are replaced by female hours.

According to the calibration, the relative competitive position of women first deteriorates in the formal agricultural and manufacturing sectors. As a result, women's (men's) formal hours in agriculture and manufacturing decrease (increase). On the other hand, in the formal service sector the competitive position of women improves. But the decline in women's formal agricultural and manufacturing hours dominates the rise of women's hours in formal services. Thus, from low- to middle-income countries the male/female ratio in hours of formal work increases. However, from middle- to high-income countries the relative competitive position of women in the formal agricultural sector improves again. And it further improves in the formal service sector. The corresponding increases in formal agricultural and formal service hours dominate the decline in formal manufacturing hours. Overall, women's hours in formal work increase again, while men's decrease. Accordingly,

the male/female ratio in formal hours falls.

# 6 Conclusion

In this work, I examine the extent to which the faster rise of women's hours in formal work may be due to structural change when structural change is generated by gender-biased technological progress. The key is that under this form of technological progress, sectoral shifts in working hours are different for men and women. This is because the sectoral comparative advantages of both genders do not necessarily lie in the same sectors. As structural change gives rise to a formal service sector, this enables women, in particular, to enter formal work.

Until now it was not clear whether gender differences in the division of labor across industries exist at all levels of development, and especially also in low-income countries. I show that they do. Women, whether in low-, middle-, or high-income countries, specialize in services. This suggests that women's sectoral comparative advantage lies in services. Based on these findings, I develop a multi-sector general equilibrium model in which men and women make endogenous labor supply choices. Labor productivity varies by gender, to incorporate the existence of sectoral comparative advantages. I show analytically that structural change is associated with a decline of the gender gap in formal hours if the sectors that arise are the ones where women have their sectoral comparative advantage. To gauge how important structural change may be quantitatively, I calibrate the model and perform counterfactual exercises. These suggest that the two between-sector forces of structural change alone cannot explain the observed decline of the male/female formal hours ratio. The ratio would decline by 9%, as opposed to 27% in the data. Instead, across country income groups there must also be forces at work that affect the relative demand for female labor.

I stress that these are preliminary results. This is because other forces that shape the gender gap in formal hours are not considered in the model, but may be captured in the calibration. This limits the quantitative contribution of this work. But it leaves open the possibility, in future, to test the model using actual data on how unevenly labor productivities improve across countries or country income groups. For this reason, I consider this model a promising starting point for future research that attempts to quantify the actual role of (gender-biased) structural change in shaping

the male/female ratio in hours of formal work. And, one might then reflect on how structural change may shape other phenomena highlighted in the development literature. Examples include declining fertility rates. I presume that this may be closely connected to the increased availability of formal childcare that comes along with the rise of services. In a related work, I also assess how the decline in the gender gap in formal hours is associated with a decline in the gender gap in years of schooling, and how both declines may be related to structural change.

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# Appendix (For Online Publication Only)

## A Data Sources

**Table A.1:** Data sources: 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 | - |
| Kyrgyzstan | 1998 | Living Standards Measurement Survey (LSMS) | - |
| Lao PDR | 2007 | Expenditure and Consumption Survey | - |
| Lesotho | 2008 | Integrated Labor Force Survey | Yes |
| Mali | 2010 | Permanent Household Survey (EPAM) | Yes |
| Nicaragua | 2005 | National Household Survey Measurements on Living Standards (EMNV) (LSMS) | - |
| 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:** Data sources: Middle income countries

| Country | Year | Survey | Time-Use |
|---|---|---|---|
| Albania | 2012 | Labor Force Survey | - |
| Angola | 2008 | Inquerito Integrado sobre o Bem-Estar da Populacao (IBEP) | - |
| Armenia | 2008 | Labor Force Survey | - |
| 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 |
| El Salvador | 2007 | VI Population and V Housing Census | - |
| 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 |
| Jamaica | 2001 | Population Census (IPUMS) | - |
| Jordan | 2004 | Population and Housing Census (IPUMS) | - |
| Kazakhstan | 1996 | Living Standards Measurement Survey (LSMS) | Yes |
| Latvia | 2005 | European Union Labor Force Survey | - |
| Lithuania | 2005 | European Union Labor Force Survey | - |
| Malaysia | 1991 | Population and Housing Census (IPUMS) | - |
| Mauritius | 2010 | Continuous Multi Purpose Household Survey (CMPHS) | - |
| Mexico | 2010 | Population and Housing Census (IPUMS) 2010 | - |
| 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 | - |
| Serbia | 2007 | Living Standards Measurement Survey (LSMS) | - |
| South Africa | 2008 | Combined Quarterly Labor Force Surveys | MTUS |
| Tunisia | 2010 | Enquete Nationale sur la Population et l'Emploi | - |
| Venezuela | 2001 | Population and Housing Census (IPUMS) | - |

**Table A.3:** Data sources: High income countries

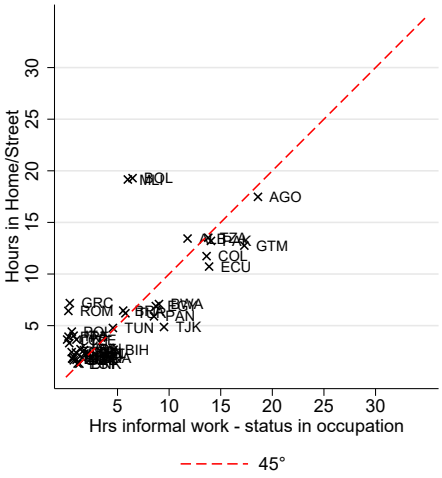
| Country | Year | Survey | Time-Use |
|---|---|---|---|
| Austria | 2005 | European Union Labor Force Survey | MTUS |
| Belgium | 2005 | European Union Labor Force Survey | - |
| Canada | 2011 | Census of Canada (IPUMS) | - |
| Chile | 2009 | National Socioeconomic Survey (CASEN ) | - |
| Cyprus | 2005 | 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

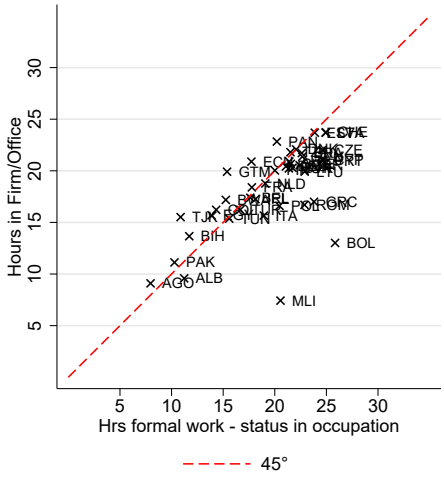
## B.1 Classifying hours worked

**Figure B.1:** Classifying hours worked

**(a)** Hours in traditional work




**(b)** Hours in formal work




*Notes:* Non-market and hours in formal work as computed from the status in occupation, versus non-market and market as computed based on the location, respectively. Based on a subset of 44 countries.

I use a subset of countries for which I know both, the status in occupation as well the location of hours worked. For these countries, I can compute hours in traditional and formal work if based on either variable, and see in how far hours overlap. Figure B.1a plots mean hours worked in unpaid/ family/ household work or in self-employment without paid employees (x-axis), against mean hours worked at home or on a mobile location in the street (y-axis). On the other hand, Figure B.1b plots hours of individuals who are paid employees or employers, against mean hours worked in a firm, an office or a store. Except for Mali and Bolivia, the status in occupation does reasonably well as a proxy for location: average traditional (formal) hours based on the status of occupation are 1.2 hours higher (lower) than based on location. This evidence suggests that the status in occupation is a reasonable proxy, which is reassuring.

## B.2 Hours in household services

**Table B.1:** Non-NIPA-Hours

| | **Country Income Group** | | |
|---|---|---|---|
| | Low | Middle | High |
| Cooking | 9.0 | 7.9 | 5.4 |
| | (4) | (7) | (8) |
| Cleaning | 6.5 | 6.9 | 5.7 |
| | (5) | (7) | (8) |
| Childcare | 4.9 | 6.1 | 3.2 |
| | (5) | (7) | (8) |
| Shopping | 2.1 | 2.0 | 3.8 |
| | (5) | (7) | (8) |
| Collecting water & firewood | 3.0 | 2.1 | - |
| | (6) | (4) | |
| Total hours in household services | 25.5 | 25.1 | 18.2 |

*Notes:* Weekly hours spent cooking or cleaning at home, in childcare, shopping and collecting water or firewood. The number of countries used to compute mean hours in each activity is in brackets. For high-income countries, surveys do not ask how much time individuals spent collecting water and firewood. I assume them to be zero, given that these are likely to be very low.

To compute mean house in household services by country income group, I proceed in three steps: First, for each activity that is available in a country, compute mean hours worked per adult. Second, average hours worked per adult in each activity across low, across middle and across high-income countries. These averages and the number of countries they are based on are presented in Table (B.1). For each activity and country income group, I have data for at least 4 countries (numbers in brackets). Third, sum mean hours of all activities by country income group. This yields average weekly non-NIPA hours as presented in the last row.

## B.3 Age

**Table B.2:** Hours in formal work, by age

| | Country Income Group | | |
|---|---|---|---|
| | Low | Middle | High |
| ***Actual (ages 15-64)*** | | | |
| Men | 16.2 | 22.5 | 24.3 |
| Women | 8.1 | 11.8 | 16.5 |
| *Ratio* | 2.0 | 1.9 | 1.5 |
| ***Young (ages 15-24)*** | | | |
| Men | 10.7 | 13.2 | 12.7 |
| Women | 7.1 | 7.6 | 9.7 |
| *Ratio* | 1.5 | 1.8 | 1.3 |
| ***Prime (ages 25-54)*** | | | |
| Men | 20.4 | 28.3 | 29.8 |
| Women | 9.4 | 14.9 | 20.6 |
| *Ratio* | 2.2 | 1.9 | 1.4 |
| ***Old (ages 54+)*** | | | |
| Men | 8.3 | 10.1 | 8.6 |
| Women | 2.7 | 2.9 | 3.9 |
| *Ratio* | 3.0 | 3.4 | 2.2 |
| ***US age composition*** | | | |
| Men | 17.4 | 23.5 | 24.5 |
| Women | 8.1 | 12.1 | 16.8 |
| *Ratio* | 2.1 | 2.0 | 1.5 |

*Notes:* Formal hours of men and women and the male/female formal hours ratio, for age subgroups. Averages are based on data for 16 low, 34 middle and 24 high income countries. For the remaining two countries, I only know hours in household services. The last rows yields formal hours and the formal hours ratio in a counterfactual exercise where I hold population age-characteristics constant across countries (as in the US).

This table yields formal hours of men and women in different age-subgroups. The first row repeats the values for men and women aged 15-64 years, then I provide mean formal hours of men and women (and the ratio) aged 15-24 (the young), aged 25-54 (prime aged) and 54-99 (old). The gender gap in formal hours is most visible for those aged 25 or older (prime and old aged individuals). For younger individuals, the male/female ratio is smaller, especially also in low income countries, where the share of young people is higher.

To check in how far cross-country differences in the age-composition of populations shape the male/female ratio in formal hours, I do a counterfactual exercise. For each country I compute mean formal hours by gender and in five-year age groups (aged 15-19, 20-24 up to 60-64). I then multiply mean hours in those age-groups with the shares of men and women aged respectively in the US-population. The sum of those weighted means yield counterfactual hours measures that correct for cross-country differences in the age-composition of populations. The share of young individuals is higher in low- than in high-income countries. That means that in this exercise, in low-income countries a higher weight is placed on the non-young (those aged older than 24), for whom the male/female ratio in formal hours is higher. Because of this, the counterfactual male/female ratio in formal hours is even higher than the actual one.

### B.4 Parenthood and controlling for fertility

One factor that might explain why the male/female ratio in formal hours is so high in low-income countries and falls across country income groups are changes in fertility. Typically, it is more common for women than for men to take care of children. And, it is easier to take care of children at home or in the household than in a formal workplace. Across country income groups, fertility falls. Here, I measure fertility by looking at the average number of children per household: In low income countries, households comprise on average 2.1 kids, as opposed to 1.2 in middle and 0.5 in high income countries. Across country income groups, this might give especially women more freedom in choosing whether or not to engage in formal work.

In the first three rows of Table B.3, I present formal hours of men and women (and the ratio) based on all countries for which I observe whether individuals live in a household with a child aged less than 5 years old. If so, I presume that these individuals have parental responsibilities. The patterns are in line with those computed from the main sample of countries. The next rows show that the male/female formal hours ratio is lower for non-parents than for parents (for example 1.8 versus 2.3 in low income countries). And across country income groups, the fall in the male/female formal hours ratio is most pronounced for non-parents.

The last row yields hypothetical hours in formal work and the ratio in another counterfactual exercise. The idea is to control for fertility by holding the population shares of men and women who have children constant across country income groups. To do so, I proceed in two steps: First, for each country I compute mean formal hours by gender, and disaggregated by age (in five-year age-bins) and by parental status. The reason I also disaggregate by age is because this ensures that the share of women in childbearing age is constant across countries. I then multiply mean hours in those age-parenthood subgroups with the share of men and women who are parents/non-parents and are aged respectively in the male/female US-population. The sum of those weighted means yields a counterfactual hours measure that corrects for cross-country differences in the age-parenthood composition of populations. Especially, in low income countries it places more weight on non-parents aged older than 24.

Holding population characteristics constant across countries does not affect the

main patterns in the male/female formal hours ratio, although in levels both genders' formal hours do increase in low and middle income countries (for example from 17.5 to 18.8 for men and 8.4 to 9.0 for women). This is because holding population shares constant as in the US means putting more weight on the population aged 25 and older, those parts of men and women who work most in the population (above 20 hours per week). Overall, because both genders' formal hours increase more or less proportionally, the ratios remains unchanged in all country income groups.

**Table B.3:** Hours in formal work, by parenthood status

| | **Country Income Group** | | |
|---|---|---|---|
| | Low | Middle | High |
| ***Non-missing parenthood status*** | | | |
| Men | 16.9 | 22.9 | 24.3 |
| Women | 8.5 | 12.0 | 16.2 |
| *Ratio* | 2.0 | 1.9 | 1.5 |
| ***Not parents*** | | | |
| Men | 16.2 | 21.8 | 23.3 |
| Women | 9.2 | 13.1 | 16.9 |
| *Ratio* | 1.8 | 1.7 | 1.4 |
| ***Parents*** | | | |
| Men | 17.7 | 25.3 | 30.0 |
| Women | 7.8 | 10.2 | 13.0 |
| *Ratio* | 2.3 | 2.5 | 2.3 |
| ***US age-parenthood composition*** | | | |
| Men | 18.5 | 23.9 | 24.6 |
| Women | 9.1 | 12.8 | 16.2 |
| *Ratio* | 2.0 | 1.9 | 1.5 |

*Notes:* Formal hours of men and women and the male/female formal hours ratio, by parenthood. Averages are based on data for 15 low, 32 middle and 21 high income countries. The last rows yields formal hours and the formal hours ratio in a counterfactual exercise where I hold population age-parenthood characteristics constant across countries (as in the US).

### B.5 Marital status

Across countries, populations also differ in their composition of married and unmarried (single, divorced/separated or widowed) people. For a subgroup of countries, I can infer the marital status of individuals. In Table (B.4), I show that the main formal hours patterns are as in the main sample. Clearly, formal hours are substantially different for married versus unmarried men and women. Across country income groups, married men work more hours in formal work than men living alone (for example 20.5 versus 12.6 in low income countries). On the other hand, married women in low and middle income countries spend less hours in formal work than single women.

I wonder how important differences in the marital composition of populations are for the main patterns in the male/female formal hours ratio. To answer this, for each country I compute mean formal hours by gender, and disaggregated by age (in five-year age-bins) and by marital status. I then multiply mean hours in those age-marital subgroups with the share of men and women who live alone/together and are aged respectively in the male/female US-population. The sum of those weighted means yields a counterfactual hours measure that corrects for cross-country differences in the age-marital composition of populations. Especially, in low and middle income countries it places more weight on men and women living alone.

Holding population characteristics constant, the male/female formal hours ratio falls somewhat in all country income groups: From 2.1 to 1.9 in low, from 1.9 to 1.8 in middle and from 1.5 to 1.4 in high income countries. Still, in low income countries men spend nearly twice as many hours as women in formal work. Across country income groups, the ratio falls, but in high income countries men still spend 40% more hours in formal work than women. So overall, the main patterns in formal hours are robust to differences in the marital composition of populations.

**Table B.4:** Hours in formal work, by marital status

| | Country Income Group | | |
|---|---|---|---|
| | Low | Middle | High |
| ***Non-missing marital status*** | | | |
| Men | 16.9 | 22.6 | 24.3 |
| Women | 8.5 | 11.9 | 16.5 |
| *Ratio* | 2.0 | 1.9 | 1.5 |
| ***Single, Separated/Divorced, Widowed*** | | | |
| Men | 12.4 | 16.6 | 19.9 |
| Women | 9.7 | 12.2 | 16.1 |
| *Ratio* | 1.3 | 1.4 | 1.2 |
| ***Married, Living together*** | | | |
| Men | 20.5 | 27.9 | 28.0 |
| Women | 7.6 | 11.6 | 16.7 |
| *Ratio* | 2.7 | 2.4 | 1.7 |
| ***US age-marital status composition*** | | | |
| Men | 17.6 | 23.0 | 24.4 |
| Women | 9.2 | 12.7 | 17.0 |
| *Ratio* | 1.9 | 1.8 | 1.4 |

*Notes:* Formal hours of men and women and the male/female formal hours ratio, by marital status. Averages are based on data for 15 low, 33 middle and 24 high income countries. The last rows yields formal hours and the formal hours ratio in a counterfactual exercise where I hold population age-marital compositions constant across countries (as in the US).

**Table B.5:** Targeted moments in the calibration

| | $\frac{L^f_{A_m}}{L^f_{A_n}}$ | $\frac{L^f_{M_m}}{L^f_{M_n}}$ | $\frac{L^f_{S_m}}{L^f_{S_n}}$ | $\frac{L^f_{A_m}}{L^f_{S_m}}$ | $\frac{L^f_{M_m}}{L^f_{S_m}}$ | $\frac{L^m_{A_m}}{L^f_{A_m}}$ | $\frac{L^m_{M_m}}{L^f_{M_m}}$ | $\frac{L^m_{S_m}}{L^f_{S_m}}$ | $\frac{L^m_{A_n}}{L^f_{A_n}}$ | $\frac{L^m_{M_n}}{L^f_{M_n}}$ | $L^f_l$ | $L^m_l$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low | 0.24 | 1.33 | 0.11 | 0.06 | 0.30 | 2.00 | 1.96 | 2.01 | 1.17 | 1.21 | 0.48 | 0.60 |
| Middle | 0.21 | 5.08 | 0.23 | 0.02 | 0.24 | 4.81 | 2.42 | 1.59 | - | - | - | - |
| High | 0.54 | 20.02 | 0.48 | 0.01 | 0.21 | 3.08 | 3.30 | 1.06 | - | - | - | - |

*Notes:* Relative allocations of productive time, women (first five columns), and male/female relative sectoral hours (next five columns). The last two columns yield female and male leisure.