From Agriculture to Services: Development without Industrialization

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Motivation

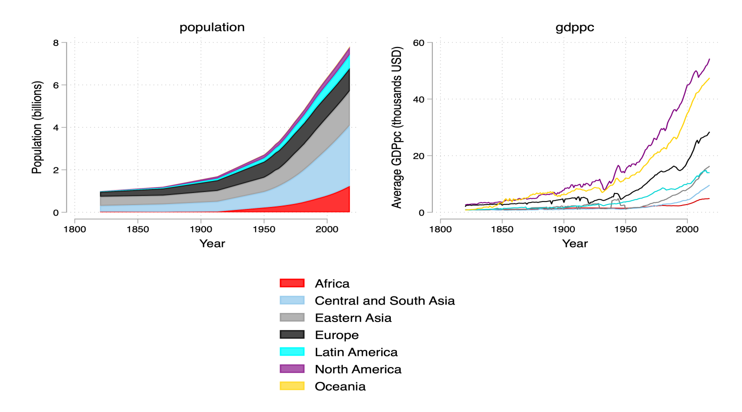


Figure 1: World distribution of population and GDP per capita over 1800-2019. Data source: Gapminder.

What I do

Data:

1. Compare developing countries over 1990-2018 to the US at the turn of the 20th century.
2. Document three stylized facts concerning the differences in patterns of sectoral composition and fertility rates.
3. Relate these differences to import-competition over 1990-2020 using shift-share regressions.

Theory:

1. Build a unified growth model to understand the implications of bypassing manufacturing on future growth possibilities.

Roadmap

The rest of this presentation:

- Literature review and contribution
- Data sources
- Stylized facts
- Model overview

Literature

Literature Review

I am contributing to several literatures:

- **Structural Change and Development**: Buera, Kaboski, Mestieri and O'Connell (2024), Kruse, Mensah and de Vries (2022); Rodrik (2016); McMillan, Rodrik, and Verduzco-Gallo (2014); Moro (2015); Duarte and Restuccia (2010); Syrquin Chenery (1989); Kuznets (1959).

➩ New stylized facts leading to a study SC jointly with fertility and trade.

- **Industrial Policy**: Juhàsz, Lane and Rodrik (2023); Chang and Andreoni (2020); Aghion, Cai, Dewatripont, Du, Harrison and Legros (2015); Rodrik (2008); Herrendorf, Rogerson and Valentinyi (2022).

➩ Analyze the role of trade openness in directing structural change.

- **UGT**: Galor and Weil (2000); Voigtlander and Voth (2013); Doepke (2004); Hansen and Prescott (2002); Parente and Prescott (2004).

➩ Incorporate sectoral differences in models of UGT.

Data Sources

Data Sources

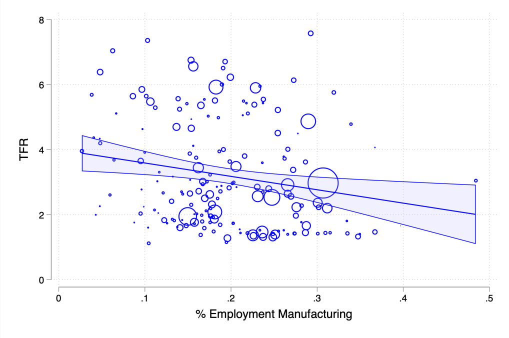
- **Groningen Growth and Development Center (GGDC)**:
  - Economic Transformation Database covers 41 low and middle income countries over 1990-2018 with data on sectoral composition of the economy at the employment and value added level.
  - Maddison Historical Statistics covers 190 countries historical data on GDP p.c. and population over 1000-present.
  - 10 Sector Database covers 33 middle/high/low income countries over 1960 - 2010 providing data on employment and value added shares disaggregated by sector.
- **US Census of Population**: microdata covering the universe of population with information on employment, occupation and industry at the county level over 1850-present.
- **IPUMS International**: microdata on fertility and employment sector for 211 country/year samples.

Stylized Facts

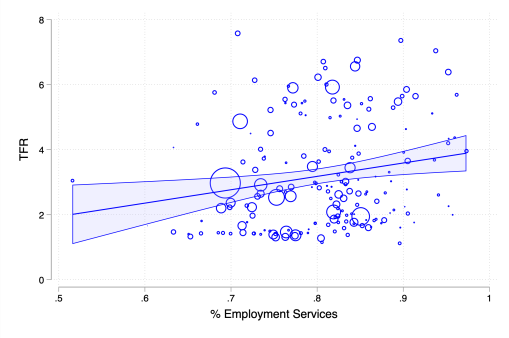
Three Stylized Facts

1. Fertility levels are positively (negatively) related to manufacturing (services) share of non-agricultural employment growth.
2. The structural change process is different today than it was for advanced economies in the 19th century: agricultural labor goes to services at a faster rate than manufacturing in today's LIC and MIC.
3. The extent to which labor moves to manufacturing (services) is negatively (positively) related to a country's openness to trade.

Stylized Fact 1: Fertility and Structural Change



(a) Manufacturing share

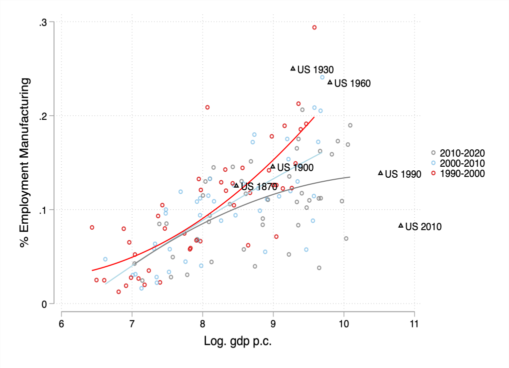


(b) Services share

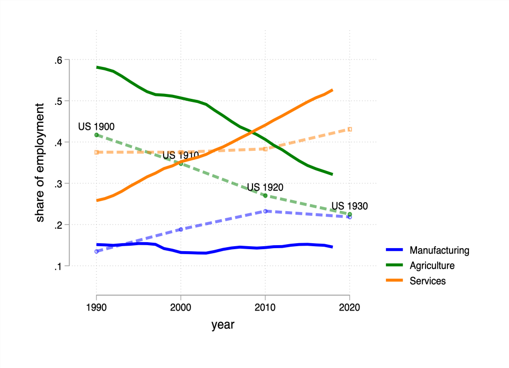
Figure 2: Scatterplot of total fertility rates (TFR) against the share of manufacturing (left) and services (right) in non-agricultural labor.

▸ Table ▸ Micro Data ▸ Self-Employed

Stylized Fact 2: Different Patterns of SC over Development



(a) Over development



(b) Over time

Figure 3: Scatter plots of Services against log. GDP per capita for the US (1870–2010) and 45 developing countries (1990–2020). Source: GGDC Economic Transformation Database, US Censuses of Population (1880–1930), and FRED.

Fact 3: Peak Manufacturing Employment and GDPPC

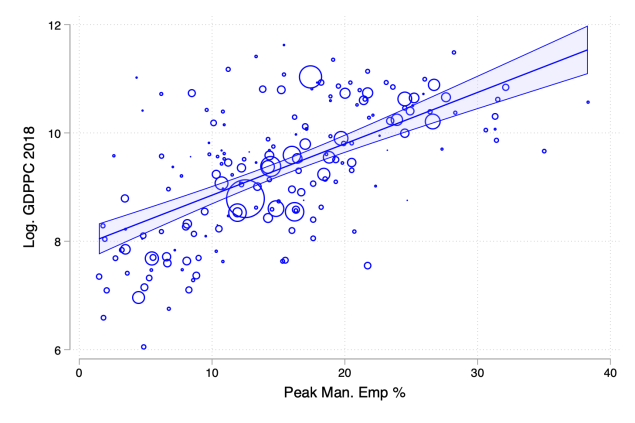


Figure 4: Scatter plot of log-gdp-p.c. in 2018 against peak manufacturing employment as a % of the labor force over 1800-2018. Source: Gapminder.

Model

Overview

The model is an extension of Galor and Weil (2000) and Lagerlof (2006).

Households:

- Homogeneous and live for two periods
- Receive education when young and make labor supply, consumption, fertility and educationn decisions when old.
- QQ tradeoff: the effect of education on human capital depends on the rate of technological progress.

Production:

- Representative firms produce agricultural, manufacturing and services in a competitive market.
- Technological progress is increasing in population (up until a threshold e.g. Kremer (1993)) and education.

Household Problem

Each period households solve the following problem:

$$\max_{c_{at}, c_{mt}, c_{st}, n_t, e_t, i_t} (1-\gamma)\ln(C_t - \bar{c}) + \gamma \ln(n_t h_{t+1}) \tag{1}$$

such that:

$$h_{t+1} = \frac{e_t + \rho\tau}{e_t + \rho\tau + g_t}$$

$$c_{at} + p_{mt} c_{mt} + p_{st} c_{st} \leq (1 - n_t(e_t + \tau)) \underbrace{h_t w_t}_{z_t}$$

$$\sum_{i=1}^{I} \omega_i^{\frac{1}{\sigma}} \left(\frac{C_{it}}{C_t^{\varepsilon_i}} \right)^{\frac{\sigma-1}{\sigma}} = 1$$

With $\gamma, \tau, \rho \in (0,1)$, $i \in \{a, m, s\}$, $\sigma \in (0,1)$, and p_a normalized to 1.

Production

Each sector produces using labor and land with the following CRS technology:

$$y_{it} = k_{it}^{1-\beta}((h_t l_{it})^{\alpha}(XA_{it})^{1-\alpha})^{\beta} \tag{2}$$

Where:

$$L_t = \sum_{i \in \{a,m,s\}} l_{it}$$

With $\alpha \in (0,1)$. The supply of land is fixed and there are no property rights. The capital stock is determined by an exogenous world interest rate $\bar{r}$.

Dynamics of Population and Technology

Population evolves according to fertility decisions:

$$L_{t+1} = n_t L_t \tag{3}$$

Technology evolves in each sector according to:

$$A_{i,t+1} = (1 + \underbrace{(e_t + \rho\tau)a_{i,t}}_{g_{i,t}})A_{i,t} \tag{4}$$

Where:

$$a_{i,t} = \min\{\theta L_t, \bar{a}_i\}$$

With $\bar{a}_s < \bar{a}_m \leq \bar{a}_a$. Technological progress is *endogenous* to population and human capital but *exogenously* lower in the service sector.

Competitive Equilibrium

A competitive equilibrium in this economy consists of household decisions c_a, c_m, c_s, n, e, i, firm decisions L_a, L_m, L_s, prices w_a, w_m, w_s, p_m, p_s, and sectoral technologies A_a, A_m, A_s. Such that, given prices:

- **Labor market:** Total labor supply equals total demand:

$$L = \sum_{i \in \{a,m,s\}} L_i.$$

- **Goods markets:** Each sector's output equals demand:

$$y_i = c_i, \quad i \in \{a, m, s\}.$$

- **Optimization:** The household decisions solve the problem given in 1.

The economy is on a BGP if $g_{i,t} = g_{i,t+1} \ \forall i$.

Fertility and Education Choices

Define $\tilde{w} \equiv \frac{\bar{c}}{1-\gamma}$, the level of w such that if the household allocates $(1-\gamma)$ of its resources to consumption, it can just satisfy the subsistence constraint.

$$n(\tau + e) = \begin{cases} \gamma & \text{if } w \geq \tilde{w}, \\ 1 - \frac{\bar{c}}{w} & \text{if } w \in (\bar{c}, \tilde{w}), \\ 0 & \text{if } w \leq \bar{c} \end{cases} \tag{5}$$

Implications for effective resources:

$$\underbrace{(1 - n(\tau + e))w}_{R_t} = \begin{cases} w(1-\gamma) & \text{if } n(\tau + e) = \gamma, \\ \bar{c} & \text{if } n(\tau + e) = 1 - \frac{\bar{c}}{w} \end{cases}$$

Optimal education choice:

$$e^* = \max\left\{0, \sqrt{g_t(1-\rho)\tau} - \rho\tau\right\}, \quad \text{where } g_t = \sum_i s_{it} g_{it}$$

Proposition 2

The economy achieves sustained growth in income per capita if and only if:

$$e^* > 0 \iff g_t > \frac{\rho^2 \tau}{1 - \rho}$$

where:

$$g_t = \sum_i s_{it} g_{it}$$

Proof: See appendix.

Model: Qualitative Patterns

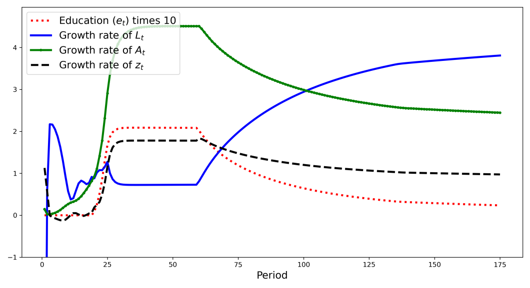


Figure 5: Growth process

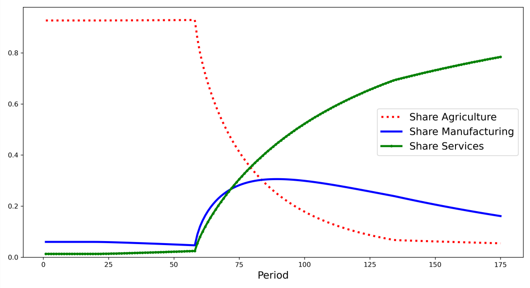


Figure 6: Structural Change

Calibration

Model vs Data

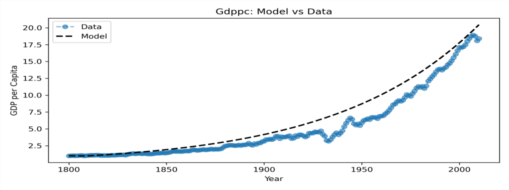


Figure 7: GDPPC

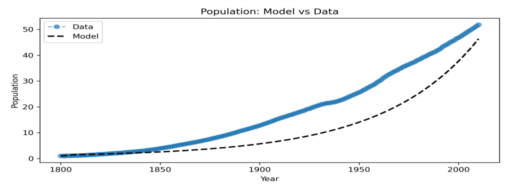


Figure 8: Population

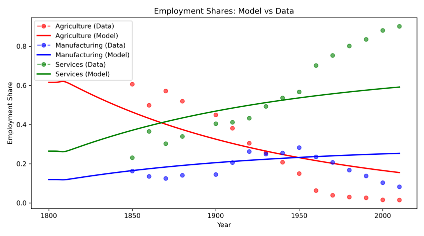


Figure 9: Emp. Shares

Counterfactual: Peak Employmen % in US

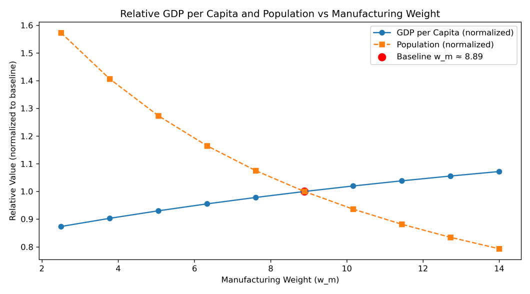


Figure 10: GDPPC and Population

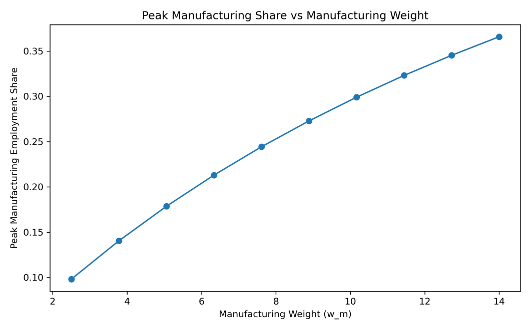


Figure 11: Manufacturing Peak

Cross-Country Education Gaps (Non Targeted)

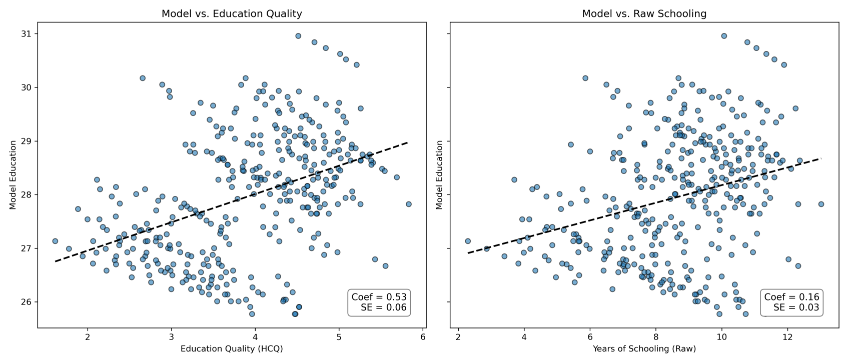


Figure 12: Each dot is a model at the country/year level, y axis shows the Barro Lee (2013) human capital quality index (left) and years of schooling (right) against the model's endogenous education decision.

Cross-Country Income and Population Gaps

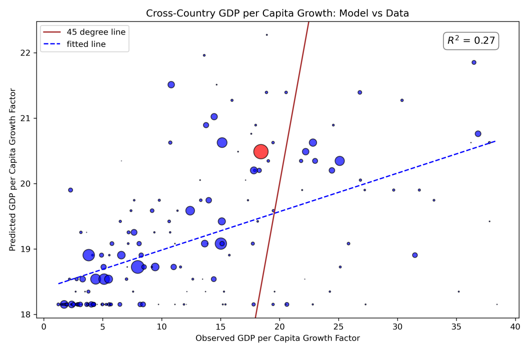


Figure 13: GDPPC Growth Factor

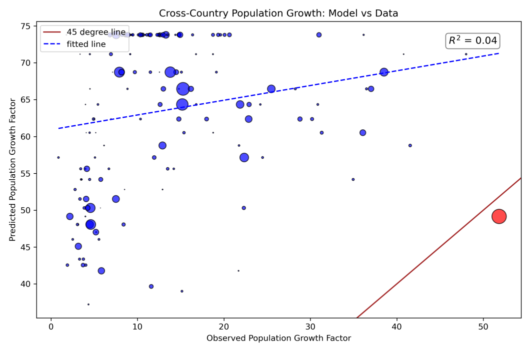


Figure 14: Population Growth Factor

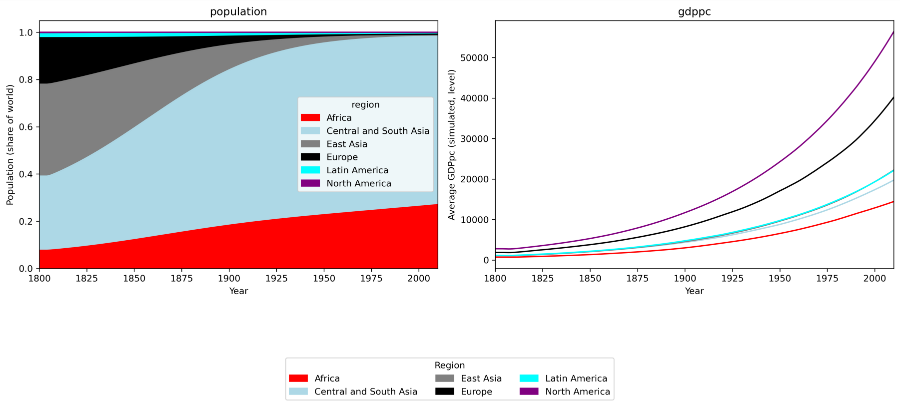


Figure 15: Path of income and population in 175 countries. A country's model implied path is determined by assigning it the model economy which achieves its peak-manufacturing employment share by chanding w_m with all other parameters anchored to the US calibration.

Conclusion

Still lots to do... Main takeaways:

- Structural change is an important driver of income and population dynamics.
- Variations in countries' peak employment share in manufacturing over the development process explain around **14% of cross-country income gaps** today.
- As the manufacturing sector becomes less labor intensive across the world, income growth is expected to decline, fertility is expected to rise and low-income countries will be expected to have low to moderate growth rates.
- The prospects for cross-country convergence in income are not promising.

Fact 1: Fertility and Structural Change

Table 1: OLS Regressions

	(1)	(2)	(3)	(4)	(5)
% Man./ (1-% Agr.)	-2.522*	-3.352***	-3.352***	-4.204***	-4.025***
	(-2.03)	(-4.22)	(-4.22)	(-4.80)	(-4.59)
Log GDP p.c.		-0.790***	-0.790***	-0.763***	0.399***
		(-5.60)	(-5.60)	(-5.35)	(3.91)
% Agr.		1.708*	1.708*	1.695*	1.759**
		(2.45)	(2.45)	(2.41)	(2.72)
N	5249	5249	5249	5249	5249
R2	0.0161	0.644	0.644	0.666	0.964
Country FE	no	no	no	no	yes
Year FE	no	no	no	yes	yes

t statistics in parentheses
Dependent variable is total fertility rate. Standard errors are clustered at the country level.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Empirical Analysis

Crosswalk creation

- Very few national statistical agencies classify according to a harmonized industrial standard (e.g. ISIC).
- In practice classifications vary not only by country but also by year. In 44 samples (country-year pairs) we observe over 5000 *different* industries, e.g.:

Sample	Industry Description	SITC4 Code
Ghana 2000	Agriculture and animal farming combined	0111, 0112, 0113,...
Ghana 2010	Agriculture and hunting	0111, 0112, 0113,...
Ethiopia 1984	Agriculture and livestock production	0111, 0112, 0113,...

- The crosswalk is created using the ChatGPT API.

Empirical Methods

Using this crosswalk, we can assess how trade shocks affect regional outcomes in all the countries covered by IPUMS International. We do this with the following regression model:

$$y_{i,c,>2000} - y_{i,c,1980-2000} = \alpha_c + \beta \times \ln(\text{shock}_{i,c}) + \epsilon_{i,c} \tag{6}$$

Where y is a regional level outcome, α is a country FE and:

$$\text{shock}_{i,c} = \sum_j \bar{s}_{i,c,j}(\mathrm{M}_{j,1990-2000} - \mathrm{M}_{j,1975-1990})$$

With $\bar{s}_{i,c,j}$ is the average share of employment in industry j, region i, country c over the entire sample.

Empirical Results

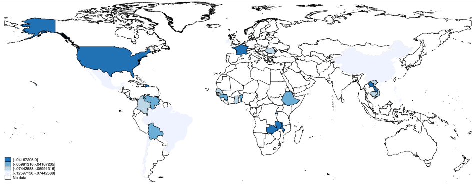
Table 2: OLS Regressions

	(1) Manufacturing	(2) Serv. High	(3) Serv. Low	(4) Agriculture	(5) Fertility
(mean) ln_shock	-0.0128*	-0.000743	0.0266**	-0.0140***	-0.00235
	(-2.22)	(-0.91)	(3.03)	(-3.42)	(-0.10)
N	566	566	566	566	566
R2	0.856	0.895	0.732	0.871	0.715
Country FE	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes

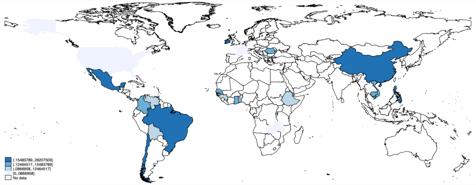
t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

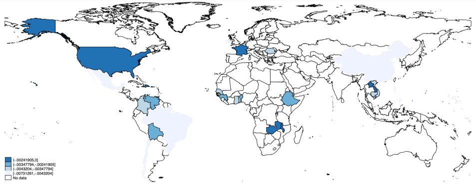
Heterogeneity



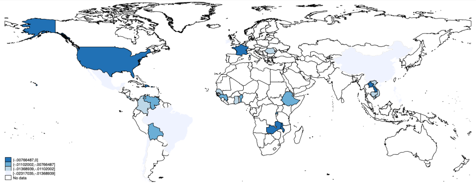
(a) Manufacturing



(b) Serv. Low



(c) FIRE



(d) Fertility

Equilibrium Wages and Employment Allocations

The equilibrium wage is:

$$w = \alpha \left(\frac{1-\beta}{\bar{r}} \right)^{\frac{1-\beta}{\beta}} h_t^{\alpha} \left(\frac{A_{mt} X}{l_{mt}} \right)^{1-\alpha}$$

While the K/L ratios are:

$$\frac{k_i}{l_i} = \frac{w}{\bar{r}} \cdot \frac{1-\beta}{\beta\alpha} \quad \Rightarrow \quad p_j = \left(\frac{A_m k_j}{A_j k_m} \right)^{(1-\alpha)\beta} \qquad j \in \{a, s\}$$

Stylized Fact 1: Fertility and Structural Change

To quantify differences in fertility across sectors I run the following regression on a sample of 46 million women between the ages of 15 and 45 from 89 low and middle income countries:

$$nchild_{i,c,t} = \alpha_{a,c,t} + \delta_{e,c,t} + \gamma_{n,c,t} + \xi_{u,c,t} + \varepsilon_{i,c,t} \tag{7}$$

Where $nchild_{i,c,t}$ is the number of children for a survey respondent in country c and year t, α is a country-year-age fixed effect, δ is a country-year-education fixed effect, γ is a country-year-non-working fixed effect and ξ is a country-year-urban fixed effect.

Stylized Fact 1: Fertility and Structural Change

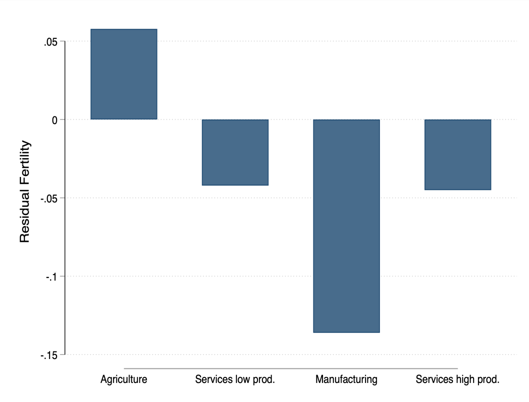


Figure 16: Average residual by sector from model 7.

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Stylized Fact 1: Fertility and Structural Change

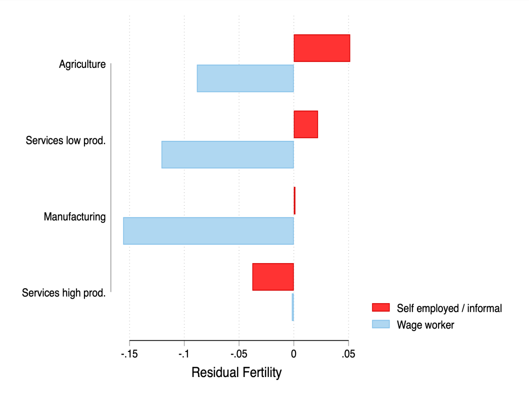

Figure 17: Average residual by sector from model 7

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