Transfer Progressivity and Development*

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Abstract

With micro panel data from 32 countries including the poorest and the richest in the world we document (i) a negative relationship between the ability to insure consumption against income shocks and economic development and (ii) a negative relationship between the level of transfer progressivity and the stage of economic development. Importantly, our computation of transfer progressivity includes both *public* and *private* net transfers across households—e.g. food transfers. Using an overlapping generations model in which agents differ in permanent productivity, face income shocks and accumulate physical and human capital through learning-by-doing (a labor choice), we find that cross-country differences in transfer progressivity go a long way in explaining the larger ability to insure consumption in poor countries than in rich countries. Then, we use our model to assess the role of transfer progressivity in explaining income per capita differences across countries. We find that decreasing progressivity of poor countries to the levels of rich countries increases income per capita of poor countries by 62%. The opposite experiment, using the progressivity of poor countries on rich countries, reduces income per capita of rich countries by 30%. Since a decrease in transfer progressivity increases the incentives to work and accumulate (physical and human capital) while, at the same time, it reduces social insurance and redistribution, a reduction in progressivity is not necessarily welfare improving. For this reason, we also compute the optimal of transfer progressivity for rich and poor countries separately. We find that optimal progressivity is actually similar (for different reasons) across stages of development which implies that the *status quo* transfer progressivity for poor (rich) countries is too high (low). Reducing the progressivity of poor countries to optimal levels increases the GDP per capita of the poor by 46% and increases their welfare by 14% in consumption equivalent terms.

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1 Introduction

The finding that poor countries cannot fully insure consumption against income shocks (Townsend, 1994) has generated an important literature that aims to rationalize the high degree of insurance. The idea is that the observed consumption insurance can be sustained by transfers that potentially emerge by constrained-efficient arrengements (e.g. limited commitment or limited information) across households; see a recent discussion in Kinnan (2022). Importantly, the equilibrium transfers that emerge from constrained-efficient allocations are progressive. That is, the marginal transfer given (received) by individuals increase (decrease) with individuals' income, as it is the case in the data. In this context, whether the progressive transfers help or not generate aggregate accumulation and economic growth is an open question.

How does consumption insurance and transfer progressivity differ across countries? Here, we put together micro data from 32 countries including the poorest and richest world economies in order to document how the ability to insure consumption against income shocks evolves across stages of economic development. Using complete markets tests (or other, covariance tests) on our consumption and income panel data, we find that the ability to insure consumption is higher at lower stages of development. This is robust to country-fixed effects. Also, the composition of consumption into food and nonfood does not alter our results. Second, we document how in poor countries norms-based informal transfers arrangements provide insurance and, potentially, redistribution. Whereas, in richer countries, larger state capacity allows insurance and redistribution to be publicly provided through formal transfers (i.e. taxes and subsidies). Implicitly, the provision of insurance and redistribution—in both poor and rich countries—implies that transfers are, in some degree, progressive. That is, the marginal transfer given increases with the level of income. In this paper, we put together private and public transfers to carefully document how the level of transfers differs across the income distribution separately for poor and rich countries. We find that poor countries show a level of progressivity (an income-to-transfer elasticity) up to 0.40 (mostly driven by food transfers) which is twice as large as that of rich countries. That is, there is a negative relationship between the level of transfer progressivity and the stage of development. Importantly, the computation of transfer progressivity includes both *private* and *public* transfers, which is particularly relevant for poor countries where private transfers are dominant.

What are the aggregate effects of transfer progressivity for cross-country income per capita differences? To answer this question propose a macroeconomy with idiosyncratic income shocks in which agents accumulate physical and human capital (through learning-by-doing) and face a progressive income tax function that depends on the stage of development. We solve our model (a sequence of steady states) from poor to rich, that is, across different degrees of tax progressivity.[1] Our calibration consists of country-specific elements such as aggregate productivity, human capital productivity and the degree of tax progressivity which depends on the stage of development. We find that our framework based on cross-country heterogeneity in tax progressivity is able to largely explain the higher ability to insure consumption in poor countries compared with rich countries. Then use this economy to assess the role of transfer progressivity in explaining income per capita and welfare differences across countries. We quantitatively assess the implications of informal and formal tax progressivity on income per capita differences by imposing the US progressivity on the rest of the world. Lower progressivity implies higher aggregate physical and human capital at the expense of social insurance. Our results imply a relelvant the role of transfer progressivity in explaining income per capita differences across countries. We find that decreasing progressivity of poor countries to the levels of rich countries increases income per capita of poor countries by 62%. The opposite experiment, using the progressivity of poor countries on rich countries, reduces income per capita of rich countries by 30%.

What is the optimal level of transfer progressivity across countries Since a decrease in transfer progressivity increases the incentives to work and accumulate (physical and human capital) while, at the same time, it reduces social insurance and redistribution, a reduction in progressivity is not necessarily welfare improving. For this reason, we also compute the optimal of transfer progressivity for rich and poor countries separately. We find that optimal progressivity is actually similar (for different reasons) across stages of development which implies that the *status quo* transfer progressivity for poor (rich) countries is too high (low). Reducing the progressivity of poor countries to optimal levels increases the GDP per capita of the poor by 46% and increases their welfare by 14% in consumption equivalent terms.

Related literature. Our work is related to growing empirical evidence on the relationship between insurance and economic growth. In particular, our work relates to the experimental evidence on how informal transfers can forgo returns Jakiela and Ozier (2016). It also related the literature on migration and its relationship (or trade-off) with insurance (Munshi and Rosenzweig, 2016; Morten, 2016; Meghir et al., 2019). We contribute by providing cross-country evidence of consumption insurance in which a negative pattern emerges between insurance and economic development. In this context, our work also relates to the micro-macro evidence on how insurance correlates negatively with economic growth (Santaeulàlia-Llopis and Zheng, 2018; De Magalhães and Santaeulàlia-Llopis, 2018). Clearly, our work also relates to the vast literature on contsrained-efficient contracts that give rise to transfers (**??**Ligon et al., 2002; Krueger and Perri, 2006; Kinnan, 2022). In our context, we assess the optimatlity of these transfer arrengements using an

[1] The comparison across steady states resembles that in Conesa et al. (2009).

exogenously incomplete markets approach, which has the advantage that it allows us to study accumulation of diferent types and hence assess implications for aggregate development. The important role for progressivity in explaining income and welfare differences across countries which contributes to the literature on cross-country income per capita differences (Klenow and Rodríguez-Clare, 1997; Caselli, 2005; Lagakos et al., 2018). More generally, our work also relats to the growing literature that uses micro evidence to explore macro differences across countries (e.g. Hsieh and Klenow, 2009; Buera et al., 2011; Lagakos and Waugh, 2013; Lagakos et al., 2018). In our case, we show how insurance and, more generally redistribution—i.e. second order moments—can have a first order impact.

2 Empirical Evidence

For our empirical analysis on the ability to insure consumption, we use a data set currently comprising of 32 countries with at least 2 years of representative household surveys for consumption and income. Austria, Belgium, China, Cyprus, Estonia, Ethiopia, Croatia, Cyprus, Estonia, Ethiopia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Latvia, Luxembourg, Malawi, Mexico, Netherlands, Niger, Nigeria, Portugal, Russia, Slovakia, Slovenia, Spain, Tanzania, Uganda, United Kingdom, United States. For our empirical estimate of a progressivity parameter, we use a data set currently comprising of 12 countries for which representative household surveys data on income with detailed entries for taxes and transfers. Australia, China, India, Indonesia, Italy, Malawi, Mexico, Poland, South Korea, Spain, United Kingdom, United States.

2.1 Consumption Insurance and stages of development

We are interested in how the the transmission of unanticipated changes in income (i.e., income shocks) to consumption evolves across time and space along the development path. The larger is this transmission the lower is the ability to insure consumption. We focus on standard measures of this transmission à la Townsend (1994). To capture income shocks we use residual (within-group) measures of consumption and income that remove the between-group inequality generated by a set of deterministic observable variables. The idea is that the residual variation captures changes in income and consumption that are not anticipated (Krueger and Perri, 2006; Meghir and Pistaferri, 2010). We remove between-group variation in sex, age, education of the household head, household composition (size and number of children), area of residency (rural/urban) and within-country regions separately by country c and year t.[2]

The formulation of full risk sharing implies that the ratio of the marginal utility of consumption is constant across individuals for any period or state of the world (Townsend, 1994; Kinnan, 2022), that is,

$$\frac{U_{c_i}(c_i(s^t))}{U_{c_{-i}}(c_{-i}(s^t))} = \frac{\omega_{-i}}{\omega_i}$$

where U_{c_i} is the marginal utility of consumption of a household i, $U_{c_{-1}}$ is the marginal utility of another not-i household in the economy, ω_i and ω_{-i} are the respective weights in the social planner problem, and s^t captures a history of exogenous events from time zero to t.[3]

Assuming a specific shape for preferences over consumption further allows for the development of full risk sharing tests. In particular, under constant relative risk aversion preferences (CRRA) with coefficient σ, full risk sharing implies that individual changes in consumption are only affected by aggregate (average) changes in consumption.

$$\ln c_i(s^t) = \frac{1}{\sigma}\left[\ln \omega_i - \overline{\ln \omega}\right] + \overline{\ln c(s^t)}.$$

Notice that we can develop this further defining the log-deviations from aggregate (average) consumption as $\ln \hat{c}_i(s^t) = \ln c_i(s^t) - \overline{\ln c(s^t)}$, and their growth rates between t and $t-1$ as $\Delta \ln \hat{c}_i(s^t) = \ln \hat{c}_i(s^t) - \ln \hat{c}_i(s^{t-1})$. This way, we can write the full risk sharing result more compactly as $\Delta \ln \hat{c}_i(s^t) = 0$. That is, under full insurance, individual consumption growth follows aggregate consumption growth and nothing else. In particular, unanticipated changes in income should not affect consumption growth. This gives rise to the following and standard testable full risk sharing hypothesis,

$$\Delta \ln\left(\hat{c}_{it}\right) = \phi \Delta \ln(\hat{y}_{it}) + \varepsilon_{it} \tag{1}$$

where full insurance implies (the null hypothesis) that ϕ is zero. We can test (1) using consumption and income panel data. Clearly, the farther the estimate ϕ is from zero the lower is

[2] Specifically, residuals, $\varepsilon_{x,t}$, are computed by year and country using the regression:

$$\ln x_t = cons. + f(age;\Theta) + \beta_g \mathbf{1}_{gender} + \beta_n hhsize + \beta_u \mathbf{1}_{urban} + \beta_r \mathbf{1}_{region} + \varepsilon_{x,t}$$

for any variable $x = c, y$. We use a quadratic for age. We control for other characteristics such as education and marital status.

[3] To be precise, at time zero, the social planner solves an economy with n agents maximizing $\max_{\{\{c_i(s^t)\}_{i=1}^n\}\}_{t=0}^\infty} \sum_i^n \omega_i \sum_{t=0}^\infty \beta^t \sum_{s^t} \pi(s^t) U\left(c_i(s^t)\right)$ subject to an aggregate endowment $\sum_i c_i(s^t) = \sum_i y_i(s^t)$ for a an exogenous history of events s^t that occurs with probability $\pi(s^t)$. Notice that there is one aggregate constraint per period. There is a set of individual weights ω_i, and a discount factor β.

the ability of households to insure consumption against income shocks. If ϕ is equal to one then consumption moves one-to-one with income shocks which could be explained with households living in autarky and without storage technology.

Before testing the full insurance hypothesis in (1), we use one straightforward variant of the full insurance result. The covariance of the left hand side of (1) with respect to its income counterpart should be zero with full insurance, that is, $Covar(\Delta \ln(\hat{c}_{ict}, \Delta \ln(\hat{y}_{ict}))) = 0$. Panel (a) in Figure 1 shows the covariance of residual consumption and income growth over the level of development. The covariance of residual logged consumption and income increases with the GDP per capita from a value close to zero for poor countries to a value slightly above 0.4 in rich countries. This implies a correlation between consumption and income shocks of 0.4 in poor countries and 0.65 in rich countries.

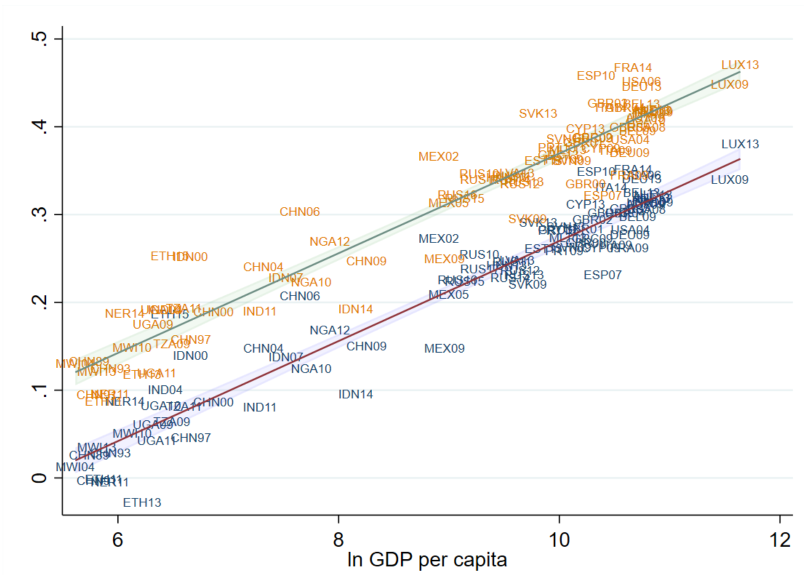
In panel (b) in Figure 1 we present the results of the Townsend full insurance test described in equation 1 separately by country and year. This implies an insurance parameter per country and year, ϕ_{ct}. Poor countries are closer to full insurance than rich countries. In poor countries we obtain a Townsend β of approximately 0.025 that is not significantly different from zero. In rich countries we obtain a Townsend β of approximately 0.30 that is significantly different from zero.

An important aspect concerning consumption and income data is potential measurement error in either of these variable (Meghir et al., 2019; De Magalhães and Santaeulàlia-Llopis, 2018). It is unclear whether the under-reporting of income is related to levels of development (Kukk et al., 2020). A relevant aspect of our analysis is that the statistics that we are interested in—i.e. our measures of consumption insurance—are constructed from either cross-sec or panel household data at the country-year level. In this manner, since our unit of measurement are country-year observations, if we control for country fixed effects, then our analysis strictly uses the within-country variation of consumption insurance across GDP per capita which is less prone to be subject to measurement error. Since our results stand strong with country-year effects, we argue that our results are unlikely to be driven by measurement error.

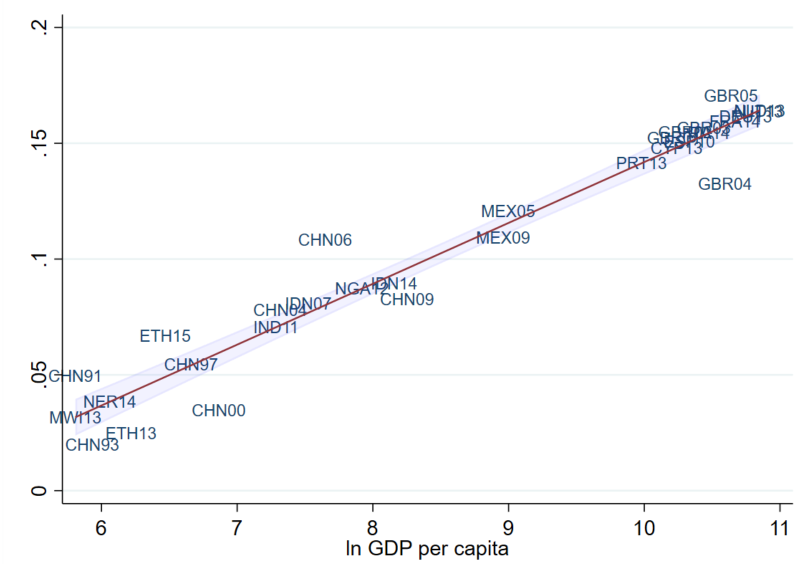
Across both statistics presented there is a clear deterioration of insurance across stages of development. In other words, a negative relationship between social insurance and development. This complements the experimental evidence in Jakiela and Ozier (2016). This is true whether we compare countries at different levels of development, or whether we control for fixed effects and focus on within country changes in income and consumption.

Figure 1: Consumption Insurance Across GDP per Capita

(a) Covariance of C and Y Across GDP per capita



(b) Full Insurance Tests Across GDP per capita



Note: Country fixed-effects have been removed. Figure 1a includes the 32 countries detailed in Table 5. Figure 1b includes the 22 countries for which we have a panel.

2.2 Tax-and-transfer progressivity: A Norm-Based Interpretation

To study the degree of progressivity we use a class of tax policies traditional in public finance (Feldstein (1969)) defined by:

$$T(y,Y) = y\left(1-\lambda(Y)y^{-\phi(Y)}\right), \tag{2}$$

where y is pre-tax and pre-transfer income, $T(y,Y)$ is the total tax ($\widetilde{y} = y - T(y,Y)$ is post-tax and post-transfer income). The parameters to be estimated are $\lambda(Y) \geq 0$, and $\phi(Y) \geq 0$. The parameter $\lambda(Y)$ determines the net revenue and $\phi(Y)$ the degree of progressivity. Importantly, notice that these parameters depend on the aggregate income per capita[4] That is, the degree of progressivity can change with development. This implies that disposable income is:

$$y^d = (1-\tau(y,Y))\,y$$

where $\tau(y,Y) = \frac{T(y,Y)}{y}$ is the average tax rate. This tax function has been recently used in quantitative macro with heterogeneous agents (Persson, 1983; Benabou, 2000, 2002). In the United States, Heathcote et al. (2017) estimate a degree of tax and transfers progressivity of 0.18.[5]

Various studies have used the above function to estimate the progressivity parameter ϕ, but their definition of *pre* and *post* income has varied. Some have focused solely on labor income to calculate an 'income-tax progressivity' (e.g., Holter et al. (2019), García-Miralles et al. (2019), Tran and Zakariyya (2021)). Whereas, Heathcote et al. (2017) and Fleck et al. (2021) estimate a 'tax and transfer progressivity', which includes other income sources (e.g., self-employment, capital income, pension income) and taxes (social security, medicare taxes) plus government transfers.

The above estimates have focused exclusively on high income countries, where the most common source of income is wages and the main source of tax revenue is the income tax. In low

[4] Two key restrictions are implicit in $T_y(y)$. First, it is either globally convex in income, if $\phi_y > 0$, or globally concave, if $\phi_y < 0$. As a result, marginal tax rates are monotonic in income. The same restriction applies to the average tax rate. Second, it does not allow for lump-sum transfers in cash, since $T_y(0) = 0$.

[5] Note also that we can write the Post-Tax/Pre-Tax Income Ratio as $\frac{\widetilde{y}}{y} = 1-\tau((y,Y)) = \lambda(Y)y^{-\phi(Y)}$. Hence, with data on post- and pre-tax income we can estimate $\lambda(Y)$ and $\phi(Y)$. In particular, taking logs we have the equation we estimate:

$$\ln\left(\frac{\widetilde{y}}{y}\right) = \ln\lambda(Y) - \phi(Y)\ln y.$$

income countries, however, the vast majority of households do not pay income taxes (or most formal taxes).[6] Nevertheless, there are substantial levels of private transfers among households in Sub-Saharan Africa. For example, received food gifts represent 17% of the total income for households on the bottom quintile of the income distribution in rural Malawi, whereas government transfers are no more than 3% (De Magalhães and Santaeulàlia-Llopis (2015)).

Herein, we incorporate these private transfers across households as a norms-base tax-and-transfer systems that functions along side a formal taxation system. We will therefore define the pre-tax and pre-transfer level of income as labor, self-employment, business, agricultural, and capital income. The post-tax and post-trasfer income will add not only formal taxes and government transfers but also private transfers given and received. The unit of analysis is the household.

In order to gain some understanding on whether this high level of private transfers do indeed function as a norms-based tax and transfers system, we discuss evidence from Malawi in more detail before comparing estimates of transfer progressivity across countries. Malawi is one of the World's poorest countries, it has a functioning democracy since 1994, and government revenue is not based on commodity exports. Approximately 80% of the population lives in rural areas and to some extend cultivate maize for subsistence (De Magalhães and Santaeulàlia-Llopis (2018)).

We interviewed 60 village chiefs in Balaka, Southern Malawi, in 2017. We asked the chiefs to 'Explain the procedures people follow when they approach others to ask for aid'. These are a few answers out of the 60 chiefs who were interviewed that characterize their views on village transfers:

> 'Mostly it is not very common to approach the village head. But relatives.'[...] 'from the others, they go buy from them.'[...] We do not state the amount[...] just ask them to help'.

> 'They start to the village head.'[...] 'we just get in the house and get maize'.[...] 'piece work [ganyu] in farms to find the food.'

> '[ask family to help another] Yes'; [amount to share]'No'. '[refuse to help when they have food?] No, that can not happen here.'

[6] Mayega et al. (2019) report that there are 1,218,316 individuals registered as potential tax payers in Uganda in 2017, approximately 10% of households, but less than half of those pay any income taxes.

These explanation by rural village chiefs make clear that food redistribution across household is common practice and based on strong norms. The remaining question is whether they are substantial in practice.

Therefore, in order to estimate the norms-based tax and transfers progressivity in Malawi we define pre-tax and pre-transfer (total gross income) as the sum of annualized labor income; business income; capital income including pensions, rental and sales of property, land, equipment, and livestock; fishery income net of costs; and agricultural income net of costs. Post-tax and post-transfer income (net income) includes private gifts given and received in cash or in kind; transfers received from government; transfers received from adult children living elsewhere; annualized value of weekly food consumption received as gift; food given as gift (available for 2016 only); and estimated income tax dues on wage and business income.[7]

Using household survey data from the LSMS-ISA for the years 2004, 2010, 2013, and 2016, we find transfer progressivit parameters of 0.21 to 0.30 [8] These estimates of the progressivity parameter ϕ match the estimates we retrieve from a survey we conducted with all 242 households of one particular village in Malawi, Geradi, in the region of Balaka in June 2019, i.e., two months after the main maize harvest. The survey asked households to report their wealth, income, and consumption in similar lines to the LSMS-ISA surveys for Malawi. Within the consumption questionnaire we asked households about the consumption of food gifts received in the last week - as in the LSMS-ISA. In addition, we asked about food gifts given in the last week. We also asked about whether they were given or gave away fertilizer subsidy vouchers and other private or government transfers. We estimate a progressivity parameter ϕ equal to 0.60.

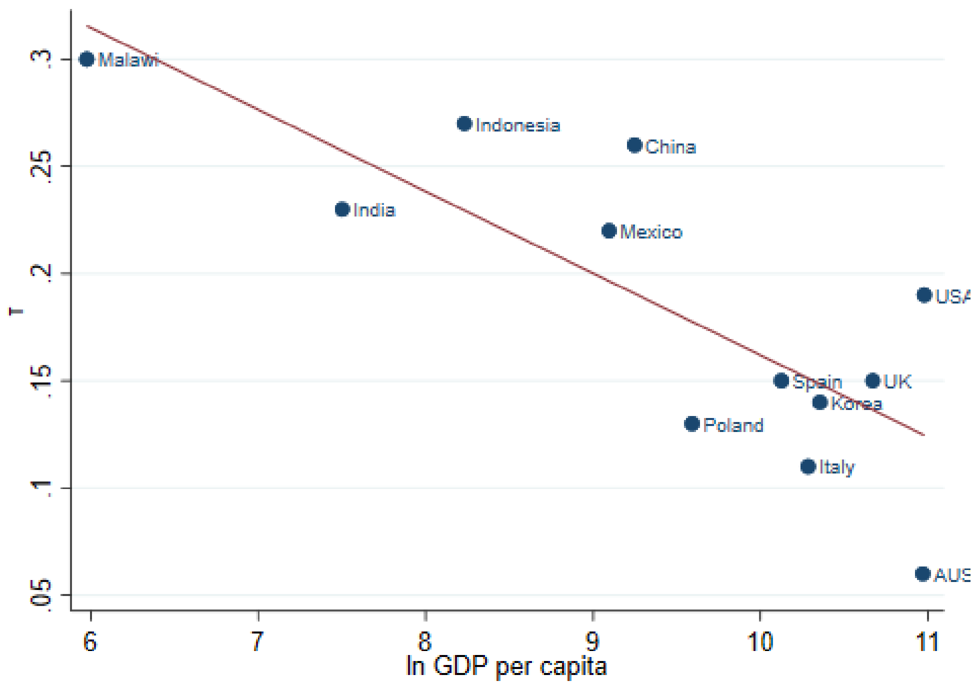
Some of the answers given by the chiefs in our qualitative survey, exemplified by the second quotation, suggests another way households provide help, by paying - mostly in kind - for informal odd jobs. This type of work has its own name in Malawi 'ganyu', and it so widespread and understood that the LSMS-ISA survey asks respondents specifically whether they engaged in any 'ganyu' and how much they received in return. Questions referring to other wage work deliberately exclude 'ganyu'.[9] This raises the issue whether 'ganyu' should be included in the tax and transfer estimates of progressivity. In some instances ganyu may function as payment for work done, but in some instances it could be a form of transfers that allows a household

[7] Household agricultural income is not taxed. Less than 5% of household in the 2016 IHS4 survey have income taxes dues according to our calculations. Brackets are calculated the 2006 Taxation Act, PWC World Wide Tax summaries for 2010/11, and KPMG Malawi Fiscal Guide for 2015/16.

[8] For more detail on data compilation see the section A in the appendix and De Magalhães and Santaeulàlia-Llopis (2018).

[9] Question E13 in the IHS4 is as follows 'How many hours in the last seven days did you do any work for a wage, salary, commission, or any payment in kind, excluding ganyu?'.

Figure 2: Transfer Progressivity Across GDP per Capita



Note: Norms-base transfer progressivity parameter ϕ estimate with most recent survey year. Malawi 2016; Indonesia 2014; India 2011; China 2009; Mexico 2009; Poland 2016; Korea 2014; Spain 2015; Italy 2016; UK 2009; Australia 2016, USA 2006. Data compiled by the authors with sources described in the appendix, except for the estimates for Australia (Tran and Zakariyya (2021)), Korea (Chang et al. (2015)), Spain (García-Miralles et al. (2019)), USA modified estimate of (Heathcote et al. (2017)) to remove private transfers received, as there is no data on transfers given in HSV's original estimate: 0.18. PPP GDP per capita in 2015 dollars.

to https://www.overleaf.com/project/5c7830ee2a2e5d2a46b8486eask and receive help without openly begging. Were we to move ganyu from the pre-tax and pre-transfers income into post income, our estimates for the progressivity parameter ϕ would increase to 0.41 in the village and be as high as 0.49 for the 2016 LSMS-ISA survey in Malawi. This highlights that our estimates used for cross-country comparisons (with ganyu treated as pre income) are a lower bound.

We expand our analysis to a series of countries for which household survey data allows pre-tax and pre-transfers income to be calculated: labor, business, self-employement, capital income and pensions. Ideally, both private and government transfers would be included in the post-tax post-transfer income. A clear pattern emerges in terms of progressivity across GDP per capita. In Figure 2 where we plot the country-year progressivity parameter 'ϕ' against income per capita. Low income countries have a a more progressive norms-based tax and transfers system than high income countries.

See also Table 6 in the Appendix.

3 An Illustrative Two-Age OLG Model

At every period, n individuals are born with an initial endowment ω_{0t} distributed according to an initial endowment distribution $\Psi(\omega_{0t})$, and an initial level of human capital s_{0t} which is the same across all agents in the economy. Agents live for two periods which makes the total population alive in each period equal to $L = 2n$. Agents also differ in labor income shocks in the second period that can take two values ε_{1t+1} and $-\varepsilon_{1t+1}$, with .5 probability.

3.1 Household Problem

Each price-taker households solve this two-age model.

First age ($a = 0$). For given (k_{0t}, s_{0t}), agents solve:

$$\max_{\{c_{0t}\geq 0, 0\leq h_{0t}\leq 1, k_{1t}, s_{1t}\}} \left(\log\left(c_{0t} - \overline{c}\right) - \kappa \frac{h_{0t}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}\right) + \beta \sum_{\varepsilon_{1t+1}} \pi(\varepsilon_{1t+1}) \left(\log\left(c_{1t+1} - \overline{c}\right) - \kappa \frac{h_{1t+1}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}\right) \tag{3}$$

subject to a set of first-period constraints,

$$\begin{aligned} c_{0t} + k_{1t} &= w_t s_{0t} h_{0t} + \omega_{0t} \\ s_{1t} &= z h_{0t}^{\alpha} + (1-\delta_s) s_{0t} \end{aligned}$$

Second age ($a = 1$). For given $(k_{1t}, s_{1t}, \varepsilon_{1t+1})$ agents solve

$$\max_{\{c_{1t+1}\geq 0, 0\leq h_{1t+1}\leq 1\}} \left(\log\left(c_{1t+1} - \overline{c}\right) - \kappa \frac{h_{1t+1}^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}\right) \tag{4}$$

subject to a second-period constraint,

$$c_{1t+1} = y_{1t+1}^{d} + (1-\delta_k) k_{1t} \tag{5}$$

where y_d^1 is disposable income,

$$y_{1t+1}^{d} = (1 - \tau(y_{1t+1})) y_{1t+1} \tag{6}$$

with pre-tax income,

$$y_{1t+1} = w_{t+1} s_{1t} h_{1t+1} \varepsilon_{1t+1} + r_{t+1} k_{1t} \tag{7}$$

The tax-subsidy scheme implies that above a given income threshold $\overline{y}$ individuals pay a tax that depends on their income y_1 and below that income threshold individuals receive a transfer. Notice that there is labor income risk only in the second period. Initial ω_0 and s_0 are given.

The tax code allows for tax progressivity as in HSV with:[10]

$$\tau(y) = 1 - \lambda y^{-\phi} \tag{8}$$

where the parameter ϕ determines the degree of progressivity. This implies that the threshold of income above which individuals pay a tax, i.e., $\tau(y) \geq 0$, is $\overline{y} = \lambda^{\frac{1}{\phi}}$.

This means that we can write disposable income (6) as,

$$y_1^d = \lambda y_1^{1-\phi} \tag{9}$$

Firms. A representative firm produces a consumption good with a CRS technology,

$$Y_t = B K_t^{1-\theta} N_t^{\theta}$$

with

$$K_t = \sum_a \sum_{i=1}^{n} k_{iat} = \sum_i^{n} k_{i1t} \text{ and } N_t = \sum_a \sum_{i=1}^{n} x_{iat}$$

where note that k_{i1t} is chosen in the previous period, and $x_{iat} = s_{iat} h_{iat} \varepsilon_{iat}$. This firm demands capital and labor in competitive markets $r_t = (1-\theta)\frac{Y_t}{K_t}$ and $w_t = \theta \frac{Y_t}{N_t}$.

[10] Recall that disposabie income as

$$y^d = y - T(y)$$

where y is pre-tax income and $T(y)$ is the total tax. We use Feldstein 1969 or HSV: $T(y) = y(1 - \lambda y^{-\phi})$ with $\lambda \geq 0$ and $\phi \geq 0$. Note than that we can write disposable income as

$$y^d = y - T(y) = (1 - \tau(y))y = \lambda y^{1-\phi}$$

where we have used the fact that $\tau(y) = \frac{T(y)}{y} = 1 - \lambda y^{-\phi}$.

Aggregate Transfer Budget. The economy satisfies an aggregate transfer budget constraint in the second period:

$$\sum_{i=1}^{n} \mathbf{1}_{y_1 \geq \overline{y}} \tau(y_1) y_1 = \sum_{i=1}^{n} \mathbf{1}_{y_1 < \overline{y}} \tau(y_1) y_1 + \mathcal{G} \tag{10}$$

with $\mathcal{G} = G + \mathcal{W}$. The amount G can be interpreted as the provision of a public good (or rent-seeking resources and corruption). We start by setting G its minimum, $G = 0$. In addition, part of the tax revenues are randomly allocated to the youngest individuals with $\omega_0 \sim N(0, \sigma_\omega^2)$ subject to the constraint that $\sum_i^n \omega_{i0} = \mathcal{W}$.

Parameters. We need to choose three preference parameters ($\overline{c}$, κ, $\nu = 1$), two production parameters (B, $\theta = .64$), the labor income shock ε, two human capital parameters (z, α, s_0), and the distribution of initial endowment $\Psi(\omega_0)$ and initial human capital $\Psi(h_0)$. We also need to choose the degree of tax progressivity ϕ and the size of the government budget through λ.[11]

3.2 Stationary OLG Equilibrium

Given a tax system $\tau(y)$ (i.e., λ and ϕ), government expenditure $(G, \mathcal{W})$, a joint initial distribution of initial wealth and schooling $\Phi(\omega_0, s_0)$, and a probability distribution $\pi(\varepsilon_1)$, a GE is a sextuplet $\{c_0^*, c_1^*, h_0^*, h_1^*, k_1^*, s_1^*\}$ of optimal choices, market wages (w^*) and interest rate (r^*) such that:

1. Given factor prices, households solve their maximization problem, that is, the sextuplet $\{c_0^*, c_1^*, h_0^*, h_1^*, k_1^*, s_1^*\}$ is the solution to the lifecycle problem (3)-(16).

2. Firms solve their optimization problem equating factor prices to marginal productivies.

[11] To see how λ determines the size of public expenditure we use the budget constraint (10),

$$\sum_{i=0}^{n} \mathbf{1}_{y_1 \geq \overline{y}} \tau(y) y = \sum_{i=0}^{n} \mathbf{1}_{y_1 \geq \overline{y}} y - \lambda \sum_{i=0}^{n} \mathbf{1}_{y_1 \geq \overline{y}} y^{1-\phi} = \mathcal{G}.$$

Therefore, for a given distribution of income $\Phi(y)$, the higher is λ, the lower is aggregate amount of taxes collected, $\sum_{i=0}^{n} \mathbf{1}_{y_1 \geq \overline{y}} \tau(y) y$, and hence the lower is public expenditure, $\mathcal{G}$. First, an increase in λ increases the income threshold ($\overline{y} = \lambda^{\frac{1}{\phi}}$) above which population gets taxed which reduces the aggregate tax revenue. Second, because the aggregate amount of tax revenue is reduced, so is the aggregate amount of transfers. In paricular, an increase in λ increases the number of individuals that get transfers while at the same time reducing public expenditure $\mathcal{G}$. Nevertheless, the distribution of income, $\Phi(y)$, potentially changes in equilibrium in response to λ and this makes the effects of λ on the size of the aggregate tax revenue (and aggregate transfers) ambiguous.

3. Markets clear,

$$K^* = \sum_{i=1}^{n} k_1^*,\ N^* = \sum_a \sum_{i=1}^{n} x_a^*,$$

where $x^* = sh^*\varepsilon$.

4. Government budget balances:

$$\sum_{i=1}^{n} \mathbf{1}_{y_1^* \geq \bar{y}} \tau(y_1^*) y_1^* = \sum_{i=1}^{n} \mathbf{1}_{y_1^* < \bar{y}} \tau(y_1^*) y_1^* + \mathcal{G}$$

where $\mathcal{G} = G + \mathcal{W}$ with $\sum_{i=1}^{n} \omega_0 = \mathcal{W}$.

3.3 Solution Algorithm

We solve the problem with the following algorithm:

STEP 1. Guess the stationary interest rates (r_m^*) (hence, (w_m^*)).

STEP 2. Given factor prices, solve the household problem (where m stands for the iteration number). (See Appendix B).

STEP 3. Compute the excess of demand of aggregate capital and labor per period,

$$K^* - \sum_{i}^{n} k_1^* = 0,\ \ N^* - \sum_a \sum_{i=1}^{n} x_a^* = 0,$$

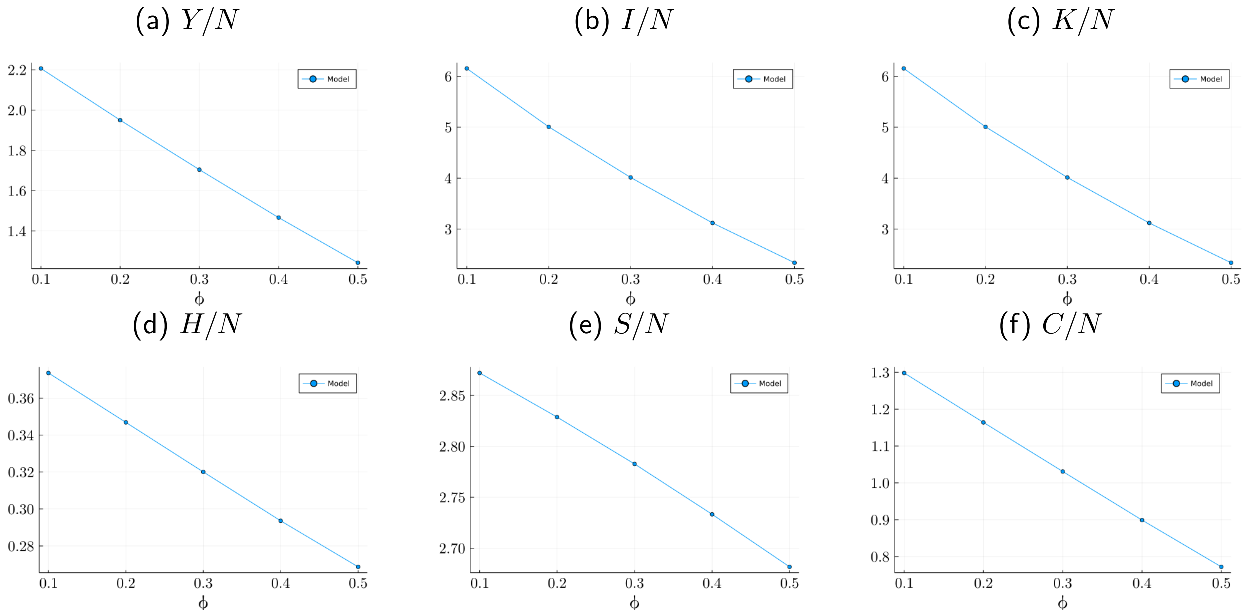
STEP 4. Check for the aggregate transfer budget balance,

$$\sum_{i=1}^{n} \mathbf{1}_{y_1^* \geq \bar{y}} \tau(y_1^*) y_1^* = \sum_{i=1}^{n} \mathbf{1}_{y_1^* < \bar{y}} \tau(y_1^*) y_1^* + \mathcal{G}$$

Notice that for the budget balance to clear we need to choose the adequate λ (that is we need to also iterate over λ together with the r_m^* loop or outside)

STEP 5. If factor markets clear and government budget balances, then STOP. Otherwise guess a new interest rate and transfers.

Figure 3: Progressivity Effects on Development



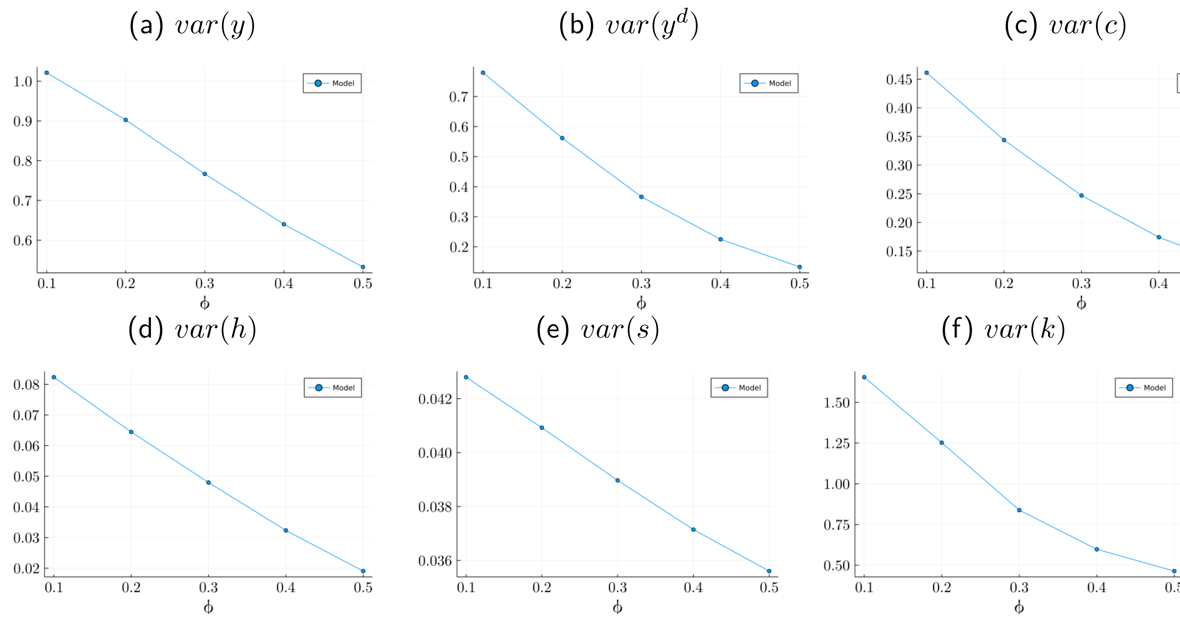
3.4 Illustrative Numerical Results

We now illustrate the implications of tax progressivity in aggregate variables and distributions. To do so we choose some model parameters, $A = 5.0$, $\theta = .66$, $z = 1.0$, $\alpha = 0.33$, $\delta_s = 0.001$, $\kappa = 5.0$, $\nu = 1.0$, $\bar{c} = 0.5$. We also assume that all individuals are born with the same initial human capital $s_0 = 1.0$. In this manner, individuals differ in the amount of initial wealth they are born with k_0 which is drawn from a log normal distribution with mean 0.0 and variance 0.1.

We now show the effects of changing tax progressivity from $\phi = 0.1$ to $\phi = 0.3$. This implies changing λ to satisfy tax reveneu neutrality across scenarios. In particular, the aggregate transfer scheme implies that 5% of all tax revenue is devoted is transferred as initial wealth to the youngest individuals with an evenly distributed lump sum.

The effects of tax progressivity on development are in Figure 3. Focusing on the effects from moving progressivity from 0.1 to 0.3, we find clear effects. The higher the progressivity lowers income per capita by 17.3% (see panel (a)). This is due to the drop in investment and aggregate capital (32.5%) and a smaller drop in efficient labor supply (-0.8%). Because there are no taxes for young individuals, a higher progressivity makes households work more in the first period and accumulate human capital which explains the rise in human capital (though small, 0.6%). The overall effects on hours is a decrease of 1.5% in response to increases in progressivity. This decline in aggregate hours is driven by the old adults that reduce hours supplied in response to increases in progressivity. The decline in consumption per capita is similar to that of output.

Figure 4: Progressivity Effects on Inequality



Note: Computed by the authors

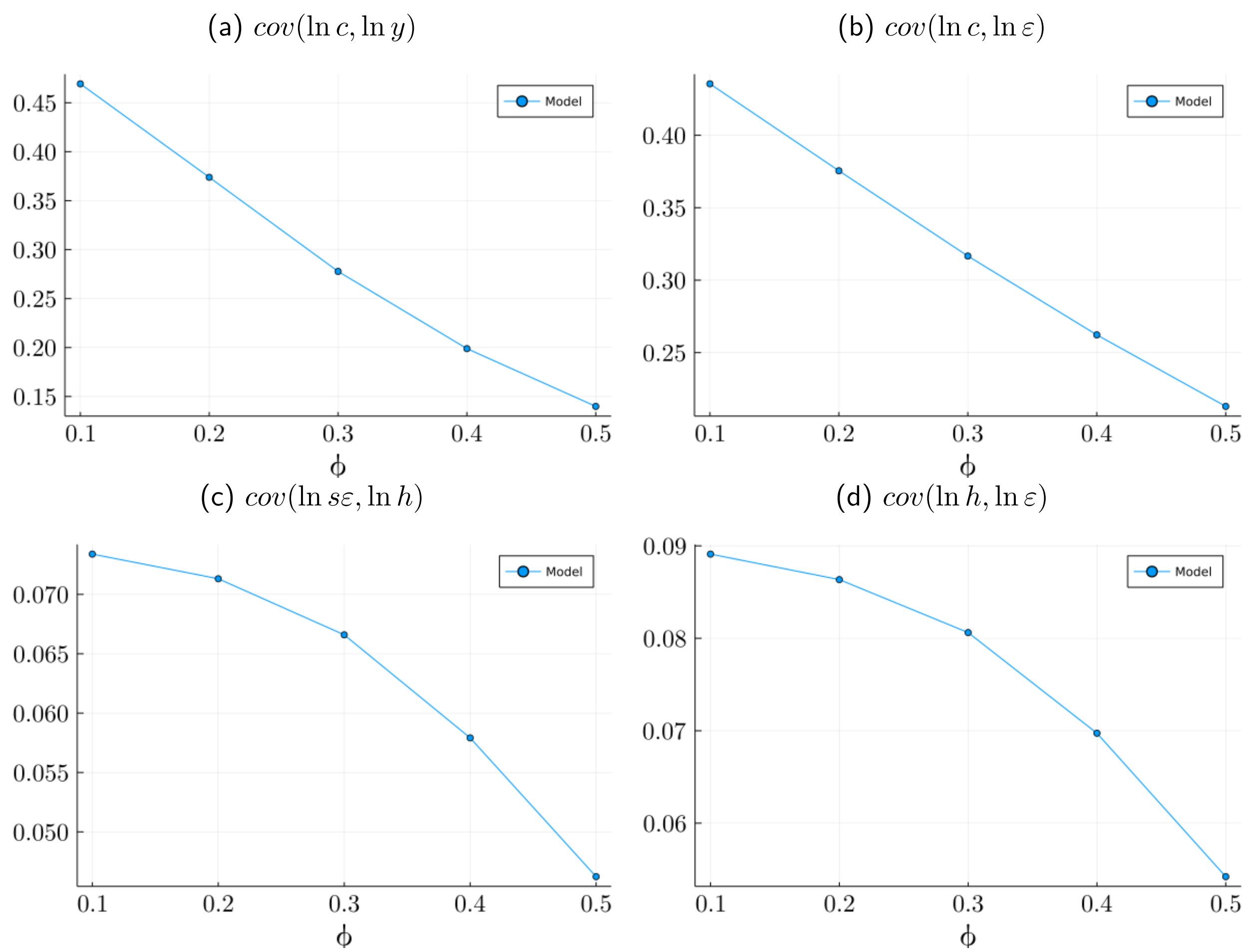
Wages follow labor productivity that goes down with progressivity due to the larger decline of output than hours. The opposite occurs to the interest rate which increases due to the larger decline of capital than output.

The effects of progressivity show up in the average tax rate (ATR) across the income distribution. Higher progressivity from 0.1 to 0.3 increases the income subsidies received by the bottom 1% by 349.9% (from an ATR of -0.11% to -52.6%). On the other side of the income distribution the top 1% income earners see their ATR increase by 74.7% (from 0.08% to 14.2%). The increase in progressivity in turn implies that the fraction of tax payers goes down. Looking at the implications of increases in progressivity for the behavior of household y, x, k, h, s and c is also important.

Inequality in income and consumption is reduced with progressivity, see Figure 4. Increasing ϕ from 0.1 to 0.3, he variance of logged income goes down by 6.5% and that of consumption by 20%. This implies a reduction in the inequality ratio between consumption and income of 14.4%, which is our first evidence of consumption insurance improvement due to increases in progressivity. This is directly related to the decrease in the variance of disposable income with respect to pre-tax income by 37.1% (from 0.81 with $\phi = 0.1$ to 0.51 with $\phi = 0.3$). Part of the reduction in consumption inequality is related to the increase in the inequality of the labor supply that is also used as insurance mechanism.

An alternative measure of consumption insurance is the comovement of consumption and

Figure 5: Progressivity Effects on Consumption Insurance



Note: Computed by the authors

income. Clearly, higher progressivity implies lower covariance between consumption and income which is reduced by 25.4% (from 0.460 with $\phi = 0.1$ and 0.343 with $\phi = 0.3$), see panel (a) in Figure 5. A perhaps more direct measure of consupmtion insurance is the covariance between the income shock ε and consumption. Again, the results are clear. Higher progressivity implies lower covariance between consumption and income shocks which is reduced by 21.1% (from 0.057 with $\phi = 0.1$ and 0.045 with $\phi = 0.3$), see panel (a) in Figure 5. Analogously, the higher is the progressivity the lower is the comovement between wages (or wage income shocks) and hours.

4 The Model

This is an OLG economy with J generations. That is, at every period there is a continuum of ex-ante identical households being born that lives for J periods. Let us cast the problem of these households recursively and then explain it. At any given age $j \in (0, J)$, agents with physical capital $k \in \mathcal{K}$, human capital $s \in \mathcal{S}$, labor productivity shock $\varepsilon \in \mathcal{E}$ solve the following problem,

$$V_t(k, s, \varepsilon, j, \Phi) = \max_{\{c \geq \bar{c}, 0 \leq h \leq 1, k' \geq \underline{k}, s' \geq 0\}} \left(\log(c - \bar{c}) - \kappa \frac{h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right) + \sum_{j=0}^{J} \delta^j \beta^j \sum_{\varepsilon'} \pi(\varepsilon' | \varepsilon) V_{t+1}(k', s', \varepsilon', j+1, \Phi') \tag{11}$$

subject to individual constraints,

$$c + i = (1 - \tau(y))(w(\Phi) s h \varepsilon + r(\Phi) k) \tag{12}$$
$$i = k' - (1 - \delta_k) k \tag{13}$$
$$s' = z h^{\alpha} + (1 - \delta_s) s \tag{14}$$

and to the aggregate law of motion,

$$\Phi' = H(\Phi) \tag{15}$$

where the joint distribution of individual states $\Phi(k, s, \varepsilon, j)$ is the aggregate state of the economy which evolves following a law of motion H defined below.

Households derive utility from consumption c and leisure $1-h$. We assume a subsistence level in consumption $\bar{c}$ which will be helpful later on to pin down the negative relationship between labor supply and development. Labor is supplied elastically with an elasticity with respect to effective wages determined through ν. The degree of disutility of labor, relative to the joy of consumption, is guarded by κ and it is allowed to be age dependent. The future is discounted with a factor β. Agents survive with probability δ

The flow of household resources consists of labor income and capital income, which are taxed at an endogenous rate $\tau(y)$ defined as,

$$\tau(y) = 1 - \lambda y^{-\phi} \tag{16}$$

where the parameter ϕ determines the degree of progressivity. This implies that the threshold of income above which individuals pay a tax, i.e., $\tau(y) \geq 0$, is $\overline{y} = \lambda^{\frac{1}{\phi}}$

Households differ in labor income through three different components: the level of human capital, labor supply, and a labor productivity shock. Each individual faces the same stochastic labor productivity process $\varepsilon \in \{\varepsilon_1, ..., \varepsilon_N\}$ that follows a stationary Markov process with conditional transition probabilities denoted by $\pi(\varepsilon'|\varepsilon)$.[12] Human capital is accumulated through a learning-by-doing that depends on the amount of labor supplied. The ability to accumulate human capital is defined by the parameter z and its curvature by α. Human capital depreciates at some rate δ_s. There is investment in physical capital which will be rent out to firms in exchange of a common capital return. Physical capital is subject to a depreciation δ_k.

In the beginning and end of life the problem is slightly different due to changes in the budget constraint. At age $j = 0$ agents are born without capital and their resources consists of after-tax labor earnings plus a lump sum transfer. That is, at age $j = 0$ the budget constraint is $c + k' = (1 - \tau_Y(y))w(\Phi)sh\varepsilon + \omega$. In the last period of life $k' = 0$ and households consume the entire income and wealth. That is, at age J, the budget constraint is $c = (1 - \tau(y))(w(\Phi)sh\varepsilon + r(\Phi)k) + (1 - \delta_k)k$.

There are four individual states: $\{k, s, \varepsilon, j\} \in \mathcal{K} \times \mathcal{S} \times \mathcal{E} \times \mathcal{J}$. The set $\mathcal{K} = [\underline{k}, +\infty)$ contains the possible asset holdings, $\mathcal{S} = [0, +\infty)$ is the possible values of human capital, $\mathcal{E}$ contains the possible realizations of the labor productivity shock, $\mathcal{J} = \{0, J\}$ contains the ages where the first and last possible ages are 25 and 90, that is, $J = 65$. Define by $\mathcal{M}$ the set of all probability measures on the measurable space $M = (Z, \mathcal{B}(Z))$ where $Z = \mathcal{K} \times \mathcal{S} \times \mathcal{E} \times \mathcal{J}$ and $\mathcal{B}(Z) = \mathcal{B}(\mathcal{K}) \times \mathcal{B}(\mathcal{S}) \times \mathcal{P}(\mathcal{E}) \times \mathcal{P}(\mathcal{J})$.[13] This is relevant because our measures Φ are required to be elements of $\mathcal{M}$.

The aggregate law of motion $H : \mathcal{M} \to \mathcal{M}$ maps distributions onto distributions. It basically summarizes how agents move within the distribution of physical assets, k, human capital, s,

[12] We assume a law of large numbers to hold. This means that $\pi(\varepsilon'|\varepsilon)$ is also the deterministic fraction of the population that goes through this particular transition (from ε to ε').

[13] Notice that $\mathcal{B}(\mathcal{K})$ is the Borel σ-algebra of $\mathcal{K}$, $\mathcal{B}(\mathcal{S})$ is the Borel σ-algebra of $\mathcal{S}$, $\mathcal{P}(\mathcal{E})$ is the power set of $\mathcal{E}$ (i.e., the set of all subsets of $\mathcal{E}$), and $\mathcal{P}(\mathcal{J})$ is the power set of $\mathcal{J}$.

income shocks, ε, and age, j, from one period to the next.[14] Then, the evolution of the physiical asset-human capital-productivity-age distribution is,

$$\Phi'(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J}) = H(\Phi)(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J}) = \int_{k,s,\varepsilon,j} Q((k,s,\varepsilon,j)(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J}))d\Phi$$

The fraction of people with assets in $\mathcal{K}$, human capital in $\mathcal{S}$, productivity shock in $\mathcal{E}$, and age $\mathcal{J}$, as measured by Φ, that transit to $(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J})$ as measured by Q.

The evolution of the aggregate state is important because it provides a forecast of the evolution of the future rate of return on aggregate capital which is identical across households. Capital and labor demand are determined competitively by a representative firm that maximizes profits producing consumption goods using a constant returns to scale technology,

$$Y = BK_t^{1-\theta}N_t^{\theta} \tag{17}$$

The competitive capital and labor market factor prices are $r(\Phi) = (1-\theta)\frac{Y}{K}$ and $w(\Phi) = \theta\frac{Y}{N}$, respectively.

The economy satisfies an aggregate transfer budget constraint in every period:

$$\int_{k,s,\varepsilon,j} \mathbf{1}_{y\geq\overline{y}}\tau(y)yd\Phi = \int_{k,s,\varepsilon,j} \mathbf{1}_{y<\overline{y}}\tau(y)yd\Phi + \mathcal{G} \tag{18}$$

with $\mathcal{G} = G + \mathcal{W}$. The amount G can be interpreted as the provision of a public good (or rent-seeking resources and corruption). We start by setting G its minimum, $G = 0$. In addition, part of the tax revenues are randomly allocated to the youngest individuals with $\omega \sim N(0,\sigma_\omega^2)$ subject to the constraint that the youngest individual wealth is: $\int_{k=0,s,\varepsilon,j=1}\omega d\Phi(k=0,s,\varepsilon,j=1) = \mathcal{W}$.

4.1 Stationary Recursive OLG Competitive Equilibrium

Definition. A stationary recursive OLG competitive equilibrium is a value function $V : Z \to R$, policy functions for the household $c : Z \to R$, $h : Z \to R$, $k' : Z \to R$ and $s' : Z \to R$, policies for the firm K, L, prices r, w and a measure $\Phi \in \mathcal{M}$ such that,

[14] That is exactly what a transition function tells us. Define the transition function $Q : Z \times \mathcal{B}(Z) \to [0,1]$ by

$$Q((k,s,\varepsilon,j)(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J})) = \begin{cases} \pi(\varepsilon'|\varepsilon) & \text{if} \quad g_k(k,s,\varepsilon,j;\Phi)\in\mathcal{K},\ g_s(k,s,\varepsilon,j;\Phi)\in\mathcal{S} \text{ and } \varepsilon'\in\mathcal{E} \\ 0 & \text{else} \end{cases}$$

for all $(k,s,\varepsilon,j) \in Z$ and $(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J}) \in \mathcal{B}(Z)$. That is, $Q((k,s,\varepsilon,j)(\mathcal{K},\mathcal{S},\mathcal{E},\mathcal{J}))$ is the probability that an agent with current physical assets k, current huma capital s, and current shock ε and current age j ends up with assets k' in $\mathcal{K}$ tomorrow, human capital s' in $\mathcal{S}$ tomorrow, income shocks $\varepsilon \in \mathcal{E}$ tomorrow, and age j' in $\mathcal{J}$ tomorrow.

1. V, c, h, k' and s' are measurable with respect to $\mathcal{B}(Z)$, V satisfies the household's Bellman equation and c, h, k', s' are the associated policy functions, given r and w.

2. K and L satisfy, given r and w,

$$r = F_K(K, L)$$
$$w = F_L(K, L)$$

3. Markets clear,

$$K = \int_{k,s,\varepsilon,j} k'(k, s, \varepsilon, j) d\Phi$$
$$N = \int_{k,s,\varepsilon,j} s'(k, s, \varepsilon, j) h(k, s, \varepsilon, j) \varepsilon d\Phi$$

and

$$\int_{k,s,\varepsilon,j} c(k, s, \varepsilon, j) d\Phi + \int_{k,s,\varepsilon,j} k'(k, s, \varepsilon, j) d\Phi = F(K, N) + (1 - \delta) K$$

4. The economy satisfies the aggregate transfer budget:

$$\int_{k,s,\varepsilon,j} \mathbf{1}_{y \geq \bar{y}} \tau(y) y d\Phi = \int_{k,s,\varepsilon,j} \mathbf{1}_{y < \bar{y}} \tau(y) y d\Phi + \mathcal{G} \tag{19}$$

with $\mathcal{G} = G + \mathcal{W}$, and $\int_{k=0,s,\varepsilon,j=1} \omega d\Phi(k = 0, s, \varepsilon, j = 1) = \mathcal{W}$.

Note that value functions (decision rules) and prices are not any longer indexed by measures Φ, all conditions have to be satisfied only for the equilibrium measure Φ. The last requirement states that the measure Φ reproduces itself: starting with measure physical capital, human capital, productivity, and ages today generates the same measure tomorrow.

5 Calibration Strategy

This section is summarized in Table 1.

Common parameters Here we describe the calibration of the parameters that have a constant shared value across stages of development. We assume log-utility in consumption utility, and for the elasticity of labor supply of the intensive margin, we use the micro-estimate of 1.0 which is in the range of the estimates in the macro development literature. The discount factor is set to 0.96. The subsistence level of consumption, $\underline{c}$ is not active in the preliminary calibration. The labor share in the production function, θ is set to 0.66 as standard in the literature. Finally we assume that the initial distribution of human capital follows a log normal distribution with mean μ_s equal to 1.0.

Country-specific parameters Country-specific parameters are divided in two groups. The first set of parameters are the ones that come from the data used in Section 2 and further detailed in Appendix A. Those are the degree of progressivity ϕ, the persistance ρ and the variance σ_ε of the income process.

We are left with the total factor productivity level B, physical capital depreciaton δ_k, learning productivity z,learning curvature parameter α, human capital depreciation δ_s and the variance of the initial distribution of human capital σ_s. Also, we fit a second order polynomial to the age profile of κ^j which gives us three more parameters $\{\kappa_1, \kappa_2, \kappa_3\}$. This leaves us a total of 9 parameters to be calibrated using the Simulated Method of Moments (SMM) for each country.

Table 1: Calibration

	Low	Middle	High	Description	Source
Country-specific parameters:					
ϕ	0.4	-	0.1	Tax Progressivity	Micro Data
B	0.20	-	7.3	Productivity	SMM
δ_k	0.052	-	0.058	Depreciation of Human Capital	SMM
z	0.13	-	0.51	Learning Productivity	SMM
α	1.89	-	1.95	Learning Curvature	SMM
δ_s	0.003	-	0.002	Depreciation of Human Capital	SMM
ρ	0.2	-	0.8	Persistence of income shocks	Micro Data
σ_ε	1.2	-	0.4	Variance of income shocks	Micro Data
σ_s	0.8	-	0.5	Initial Human Capital (variance)	SMM
λ	1.4	-	1.6	Budget Balancing	Model
r	0.08	-	0.14	Market Clearing	Model
Common parameters:					
μ_s	1.0	-	1.0	Initial Human Capital (mean)	-
β	0.96	-	0.96	Discount factor	-
$\bar{c}$	0.0	-	0.0	Subsistence Consumption Function	-
ν	1.00	-	1.00	Elasticity of Labor Supply	-
θ	0.66	-	0.66	Labor Share	-

5.1 Model Performance

Table 2: Model Fit

	Poor		Rich	
	Data	Model	Data	Model
*Y/N	1.0	1.0	71	71
*K/Y	2.9	2.9	3.33	3.33
*H/N	0.39	0.39	0.28	0.29
*$var(\ln c)$	0.26	0.25	0.79	0.81
$var(\ln y)$	1.12	1.28	0.97	1.53
$var(\ln k)$	1.96	1.03	4.53	7.69
$\{c_m, c_o\}$	$\{1.20, 0.90\}$	$\{1.57, 1.80\}$	$\{1.4, 1.1\}$	$\{3.48, 3.10\}$
$\{y_m, y_o\}$	$\{1.75, 1.11\}$	$\{1.71, 1.12\}$	$\{4.0, 3.5\}$	$\{5.4, 2.01\}$
$\{k_m, k_o\}$	$\{1.50, 1.40\}$	$\{2.14, 1.41\}$	$\{15, 23\}$	$\{5.9, 2.9\}$
*$\{w_m, w_o\}$	$\{1.22, 1.22\}$	$\{1.21, 1.22\}$	$\{1.91, 1.85\}$	$\{1.92, 1.86\}$

Note: * are targeted moments. For details on the data estimates check Appendix A

6 Quantitative Experiment: The Effects of Progressivity

We compute through counterfactuals the effects of progressivity on income per capita differences across countries and on welfare differences across countries.

6.1 Income per capita differences across countries

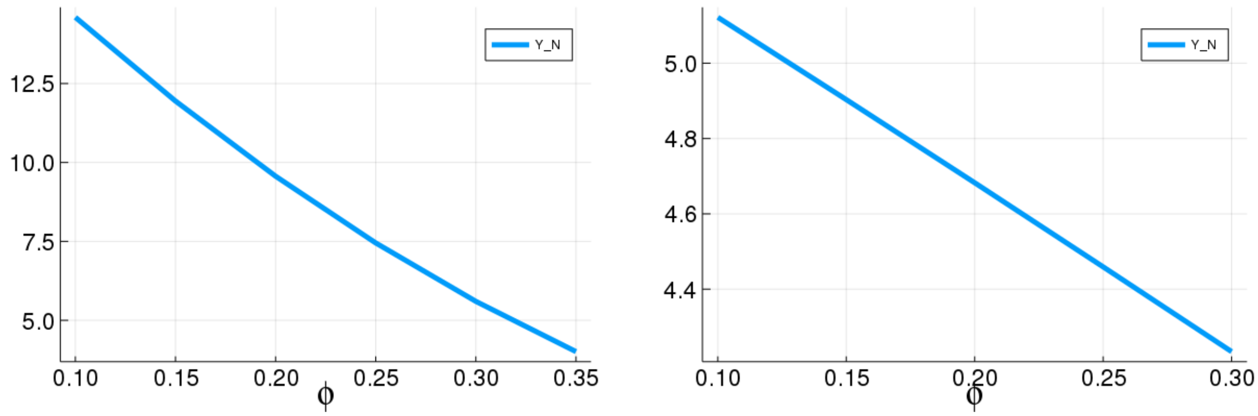
We conduct our first counterfactual of changing ϕ in poor countries to ϕ in rich countries. Our preliminary results are depicted in Figure 6. We find that moving poor countries to the tax progressivity of rich countries implies an increase in income per capita of approximately 5.1/4.2-1=25%, which explains roughly 8% of the total income per capita differences between rich and poor countries. The gain in income per capita generated by reducing income tax progressivity comes at the cost of loosing insurance, see Figure 7. Moving poor countries to the US tax progressivity increases the covariance between income and consumption substantially explaining approximately 1- (0.475-0.455)/(0.475–.325)=85% of the difference between in consumption insurance between rich and poor countries.

6.2 Welfare differences across countries

Table 3 shows the welfare gains for both countries of moving from its status quo to their optimal levels of progressivity as depicted in Figure 8. As shown in Figure 4 the implied increase in income (and consumption) per capita rises welfare, , while the loss of consumption insurance reduces welfare. We find that the first two effects dominate the loss in insurance.

Figure 6: Effects of Tax Progressivity on Income Per capita

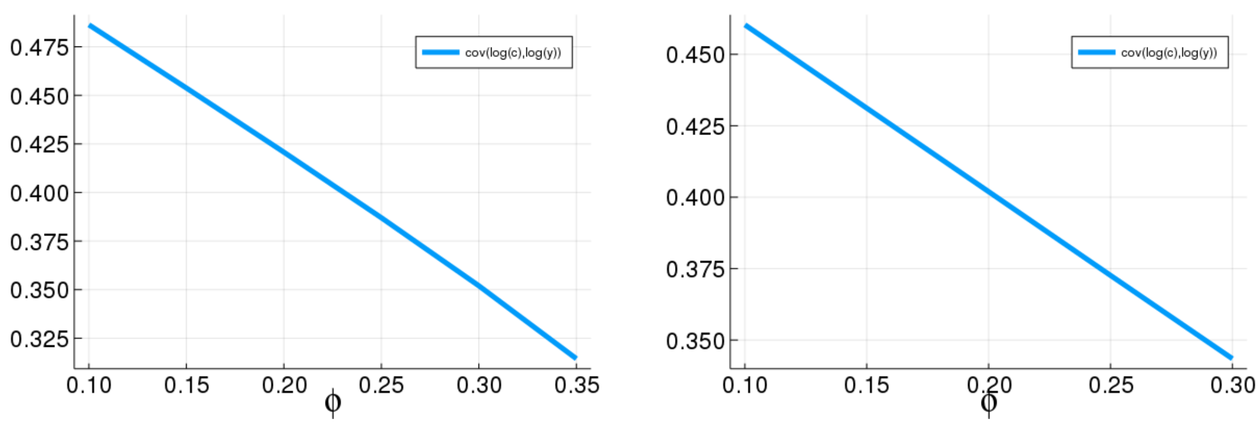
(a) Status Quo (b) Counterfactual



Notes: Computed by the authors

Figure 7: Effects of Tax Progressivity on Consmption Insurance

(a) Status Quo (b) Counterfactual



Notes: Computed by the authors

Figure 8: Optimal Progressivity

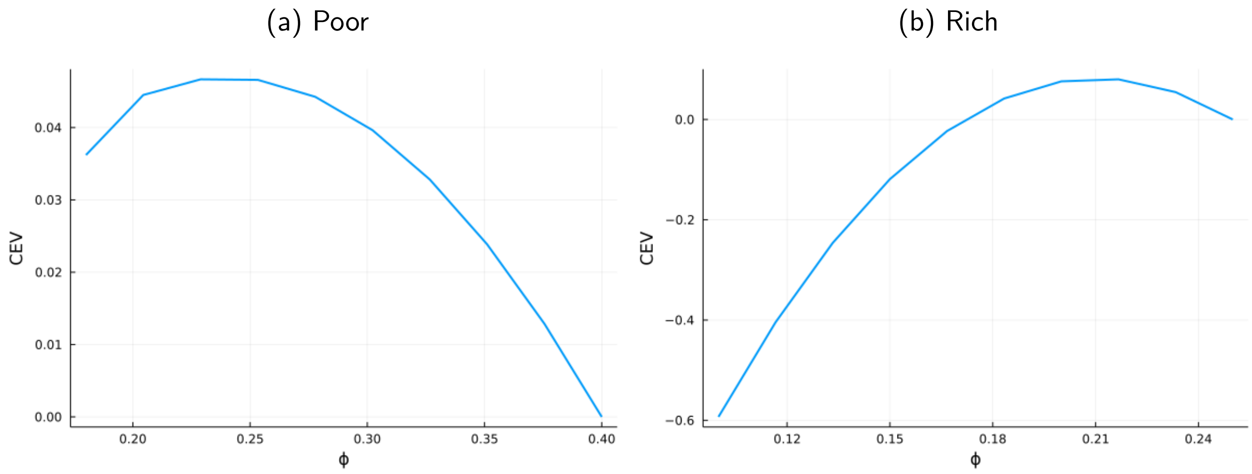


Table 3: Welfare decomposition

		Poor	Rich
Total Change		0.144	4.23
Consumption	Total	0.165	1.94
	Level	0.193	-0.63
	Distribution	-0.028	2.57
Labor	Total	-0.021	2.29
	Level	-0.010	2.10
	Distribution	-0.011	0.16

Table 4: Conterfactual: Optimal Progressivity

	Benchmark		Optimal for Poor		Optimal for Rich	
	$\phi = 0.4$	$\phi = 0.1$	$\phi = 0.21$		$\phi = 0.21$	
Moments	Poor	Rich	Poor	% Δ	Rich	% Δ
Y/N	1.0	71.0	1.46	46.3%	54.26	-24.5%
K/N	2.90	219.6	5.04	73.1%	160.9	-26.7%
H/N	0.39	0.28	0.47	20.5%	0.27	-3.5%
S/N	4.24	4.40	4.60	8.4%	4.17	-5.2%
Townsend β	0.14	0.51	0.19	35%	0.47	-7.8%
$Cov(\ln c, \ln y)$	0.40	1.03	0.73	82.5%	0.82	-20.3%
$Cov(\ln c, \ln e)$	0.19	0.53	0.31	63.5%	0.44	-16.9%

7 Further Discussion: Two Goods and Public Vs. Private Transfers

Here, we extend our analysis to a two-good structural transformation economy in Section **??**. We also assess the separate behavior of public and private transfers in Section 7.2

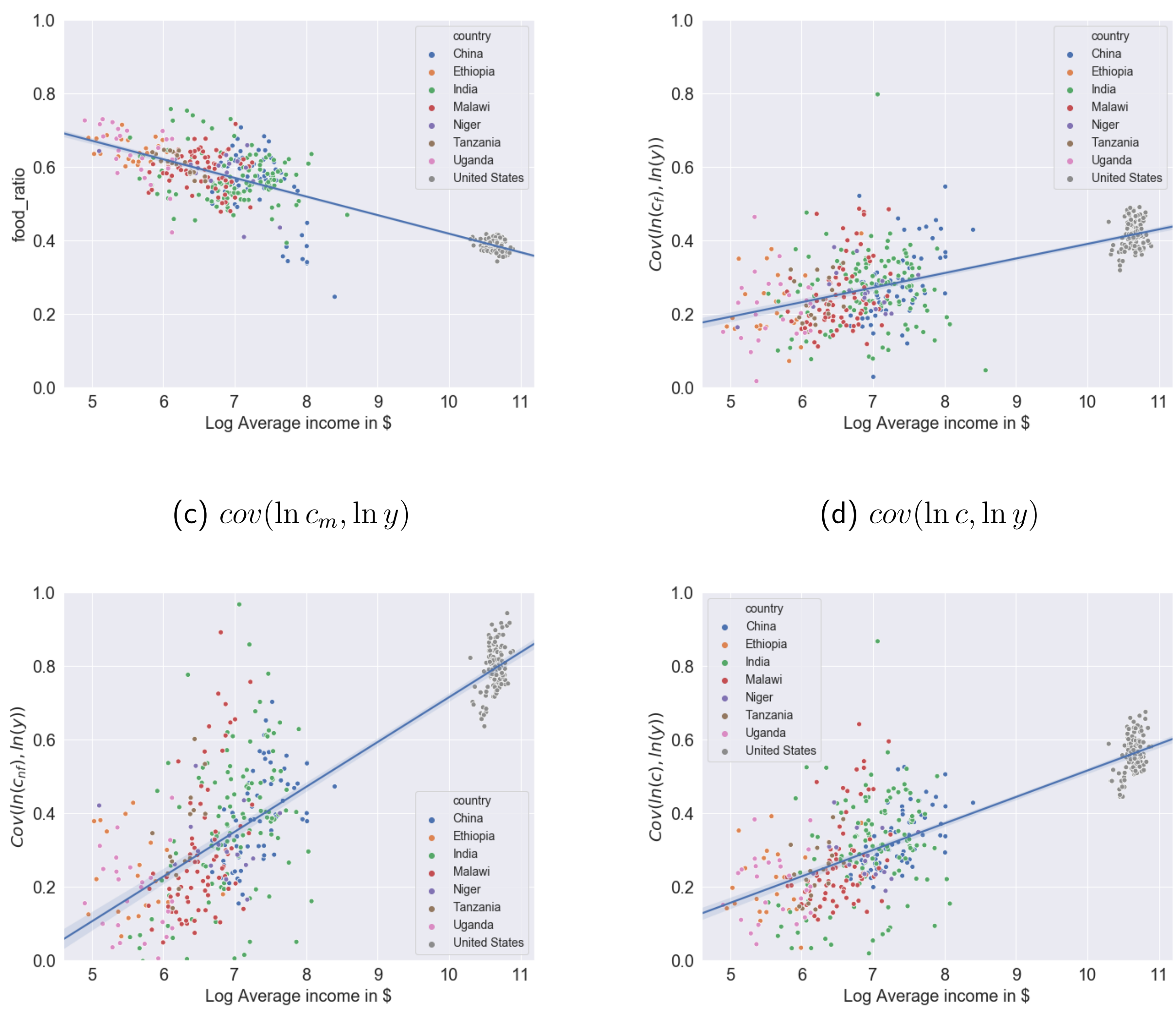
Figure 9: Food Vs. Nonfood Consumption

(a) Share of Food Consumption

(b) $cov(\ln c_a, \ln y)$

(c) $cov(\ln c_m, \ln y)$

(d) $cov(\ln c, \ln y)$



Notes: Computed by the authors

7.1 Extension to 2-Good-2-Sector Economy

The composition of consumption and value added implies a drop in the amount of food consumption as the economy develops, see Panel (a) in Figure 9. This decompition is relavant to understand the evolution of consumption insurance with development if the the degree of insurance depens on the composition of the consumption basket, which we find it does. The rise in the covariance of nondurable consumption and income with development (Panel (d)) from 0.1 to 0.6 between rich and poor countries, is largely driven by the rise in the covariance of nonfood consumption (from 0.1 to 0.8). While that the rise in the covariance of food consumption and income is one fourth less from 0.2 to 0.4 between rich and poor countries.

We incorporate these elements into our model using the following structure for preferences,

$$u(c_a, c_m, h) = \log(c_a - \bar{c}_a) + \gamma \frac{c_m^{1-\sigma}}{1-\sigma} - \kappa \frac{h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}$$

The idea is that the preferences penalize risk in c_a more than risk in c_m.

We also modify the budget constraint,

$$p_a c_a + c_m + k' = (1 - \tau(y))y + (1 - \delta)k$$

where pre-tax income incorporates income from the production of both sectors,

$$y = \sum_{a,m} wsh\varepsilon + rk$$

with both sectors following a CRS technology and equalitazion of factor prices across sectors $w = w_a = w_m$ and $r = r_a = r_m$.

We now reconduct our quantiative experiments in Section 6 using our 2-good-2-sector.

7.2 Decomposing Private and Public Transfers

Here we isolate the part that is formal (public sector) and informal (private transfers). We find that the role of private (public) transfers decreases (increases) with development which speaks to the work of Attanasio and Ríos-Rull (2000) regarding the crowding-out effect of private transfers due to public transfers. We formalize the decomposition of informal (private) taxes from family (or peers and neighbours) and formal (public) taxes from government. To do so we define

$$1 - \tau(y, Y) = (1 - \tau_I(y^d, Y))(1 - \tau_F(y, Y)) \tag{20}$$

where τ_F denotes formal taxation and τ_I informal taxation. Disposable income y^d is income after formal taxation, that is, $y^d = (1 - \tau_F(y))y$, where

$$\tau_F(y, Y) = \left(1 - \lambda_F(Y) y^{-\phi_F(Y)}\right), \tag{21}$$

and

$$\tau_I(y, Y) = \left(1 - \lambda_I(Y) y^{d - \phi_I(Y)}\right), \tag{22}$$

8 Conclusion

After carefully documenting the evolution of consumption insurance and transfer progressivity across stages of development, we find that the decline in progressivity along the development path goes a long way in explaining the loss of consumption insurance that we see in the data. Second, we show that this progressivity has first order implications on the cross-country differences in income per capita. Decreasing progressivity of poor countries to the levels of rich countries increases income per capita of poor countries by 62%. The opposite experiment, using the progressivity of poor countries on rich countries, reduces income per capita of rich countries by 30%. Finally, optimal progressivity is actually similar across stages of development which implies that the *status quo* transfer progressivity for poor (rich) countries is too high (low). In particular, reducing the progressivity of poor countries to optimal levels increases the GDP per capita of the poor by 46% and increases their welfare by 14% in consumption equivalent terms.

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A Data description

A.1 Consumption and Income

We use nationally representative panel survey data for 32 countries and XXX country-year observations. We construct a measure of annualized nondurable expenditures and income in the same fashion as in De Magalhães and Santaeulàlia-Llopis (2018).

Country	Obs	From	To	Source
Austria	5,376	2009	2013	HFCN-ECB
Belgium	4,558	2009	2013	HFCN-ECB
China	17,222	1989	2009	CHPS
Cyprus	2,526	2009	2013	HFCN-ECB
Estonia	2,220	2013	2013	HFCN-ECB
Ethiopia	10,225	2011	2015	LSMS-ISA
Finland	11,029	2013	2013	HFCN-ECB
France	15,622	2009	2014	HFCN-ECB
Germany	7,844	2009	2013	HFCN-ECB
Greece	5,942	2009	2013	HFCN-ECB
Hungary	5,670	2013	2013	HFCN-ECB
India	71,953	2004	2011	IHDS
Indonesia	38,072	2000	2014	IFLS
Ireland	3,989	2013	2013	HFCN-ECB
Italy	16,107	2009	2014	HFCN-ECB
Latvia	1,201	2013	2013	HFCN-ECB
Luxemburg	2,551	2009	2013	HFCN-ECB
Malawi	25,383	2004	2013	LSMS-ISA
Malta	874	2013	2013	HFCN-ECB
Mexico	24,343	2002	2009	MXFLS
Netherlands	2,510	2009	2013	HFCN-ECB
Niger	5,475	2011	2014	LSMS-ISA
Nigeria	8,537	2010	2012	LSMS-ISA
Portugal	10,563	2009	2013	HFCN-ECB
Russia	67,711	1995	2017	RLMS
Slovak Republic	4,049	2009	2013	HFCN-ECB
Slovenia	2,890	2009	2013	HFCN-ECB
Spain	12,300	2007	2010	HFCN-ECB
Tanzania	5,862	2009	2011	LSMS-ISA
Uganda	5,091	2009	2011	LSMS-ISA
United Kingdom	101,525	1991	2005	BHPS
United States	33,888	2004	2010	PSID

Table 5: Data summary

A.2 Transfer Data

For each country we use nationally representative surveys. We construct a measure of pre-transfers income and a measure of post-transfer income. Transfers can be either given or received, and our measure of net transfers that we use for estimation can be positive or negative. We include all available transfers that are given or received, private (informally or formally) or public is included when available.

A.2.1 Malawi

We use the Living Standards Measurement Study - Integrated Agricultural Survey (LSMS-ISA) for Malawi in 2004, 2010, 2013, and 2016. We use variables from the 2016 to describe income. Household total gross income is the sum of gross annualized labor income (`hh_e25 hh_e27 hh_e39 hh_e59`); business income (`hh_n32 hh_n25 hh_n41 hh_n14`); capital income including pensions, rental and sales of property, land, equipment, and livestock (`hh_p02 ag_b217a ag_b217b fs_e16 fs_i16`); fishery income net of costs (`fs_e06a fs_d06 fs_d12 fs_d13 fs_d14 fs_d24`); agricultural income net of costs of rain (`ag_i02a ag_i03 ag_b209a  ag_b209b ag_f09 ag_f10 ag_f40 ag_e04 ag_e14 ag_e15 ag_d46a`
dry season, permanent crops, and livestock.

Net income includes private gifts received in cash or in kind (`hh_p03a hh_p03b hh_p03c`); gifts given in cash or in kind (`hh_q02a hh_q02b hh_q02c`); transfers received from government (`hh_r02a hh_r02b hh_r02c`
transfers received from adult children living elsewhere (`hh_o11 hh_o15`); annualized value of weekly food consumption received as gift (`hh_g07a`).

Income tax dues are calculated based on wage and business income, but not on agricultural income as most household agricultural income is not taxed. Slightly over 10% of household have income tax dues. Brackets are calculated the 2006 Taxation Act, PWC World Wide Tax summaries for 2010/11, and KPMG Malawi Fiscal Guide for 2015/16.

In an alternative definition of gross income, ganyu (`hh_e59`) is coded as a transfer and therefore appears in post-income and not in pre-tax-transfer income.

For more details on the data construction for Malawi, see De Magalhães and Santaeulàlia-Llopis (2018).

A.2.2 United Kingdom

We use the British Household Panel Survey (BHPS) waves 1-18 (1991-2008); a set of derived variables described in Levy and Jenkins (2012). Household total gross income is the sum of gross labour income (hhyrlg), investment income (hhyri), state pensions (hhyrb), and pension income (hhyrp). Total tax is the sum total income taxes paid net of tax credits (yrtaxnt), national insurance (yrni) and pension contributions (yrcontr). Net income is the difference plus income from private transfers (hhyrt). Main missing variable: private transfers given. XXXXX Enric: Has Y been defined as such for the Covariance and Townsed test? Household consumption is XXXXX.

A.2.3 Poland

We use the 2016 Household Finance and Consumption Survey (HFCS) by the European Central Bank. Household total gross income is the sum yearly values rental income (hg0310), financial investment (hg0410), business investment (hg0510), lump sum sales/prizes/insurance payout (hg0610), labor income (pg0110), self-employed income (pg0210), state pension (pg0310), and private pension (pg0410).

Household net income is the sum of the following net variables: social transfers (hng0110), rental income (hng0310), financial investment (hng0410), business investment (hng0510), lump sum sales/prizes/insurance payout (hng0610), labor income (png0110), self-employed income (png0210), state pension (png0310), private pension (png0410), unemployment benefit (png0510), regular private tranfers/child support received (hng0210), and private transfers given per month (hi0310).

A.2.4 Italy

We use the 2016 Household Finance and Consumption Survey (HFCS) by the European Central Bank. Household total gross income is the sum yearly values of rental income (hg0310), financial investment (hg0410), business investment (hg0510), lump sum sales/prizes/insurance payout (hg0610), labor income (pg0110), self-employed income (pg0210), state pension (pg0310), and private pension (pg0410).

Household net income is the sum of the following net variables: social transfers (hng0110), rental income (hng0310), financial investment (hng0410), business investment (hng0510), lump sum sales/prizes/insurance payout (hng0610), labor income (png0110), self-employed income (png0210), state pension (png0310), private pension (png0410), unemployment benefit (png0510), regular private tranfers/child support receivved (hng0210), and private transfers given per month (hi0310). A separate measure of income taxes with health, pension, and social insurance contribution included is available (hng0710). So net income can be calculated also as the gross income estimated above net of taxes and social contributions. Both yield the same estimate.

A.2.5 Finland

We use the 2016 Household Finance and Consumption Survey (HFCS) by the European Central Bank. Household total gross income is the sum yearly values of social transfers (hg0110), rental income (hg0310), financial investment (hg0410), business investment (hg0510), lump sum sales/prizes/insurance payout (hg0610), labor income (pg0110), self-employed income (pg0210), state pension (pg0310), private pension (pg0410).

Net income is unavailable but data on income taxes with health, pension, and social insurance contribution included is available (hng0710). We estimate net income as gross income net of taxes and social contributions.

A.2.6 India

We use the India Human Development Survey - I/II (IHDS) 2004-05/2011-12. Household total gross income is the sum yearly values of wage income (INCSALARY), farm income (INCFARM), business income (INCBUS), agricultural wage (INCAGWAGE), non-agricultural wage (INCNONAG), other income (INCOTHER and INCNONNREGA). For net income we impose income tax dues on INCSALARY and add the following sources: remittances (INCREMIT), government transfers (INCGOVT) and National Rural Employment Guarantee Act income (INCNREGA). We use the site caclubindia (https://www.caclubindia.com/forum/income-tax-rates-slabs-from-a-y-2001-02-to-a-y-2013-14-132138.asp) to identify income brackets and estimate income taxes dues per household. We restrict the estimate to the 60% of households for whom pre and post income differ. In all other countries pre and post income differ for almost entirety of the sample.

A.2.7 Indonesia

We use the Household Survey Questionnaire for the Indonesia Family Life Survey, Wave 4 (2007) and 5 (2014). Household total gross income is the sum of yearly values of wage income (tk25), other labor income (tk26), net agricultural income (ut08 ut07), net business income (nt07 nt08), and pension income, lottery, scholarship, and insurance payout (hi14). For net income we add food transfers given (ks04), regular cash transfer given (ks06), gifts given (ks08 G), government transfers received (ksr21), food subsidy (ksr31 ksr32 ksr29 ksr26), fuel subsisdy (ksr40 ksr45 ksr43), tranfers received from NGO/church (ksr50), disaster relief (nd05y), credit rotation given/received (pm01 pm04 pm05), transfers given/received to/from parents (ba20 ba22), transfers given/received to/from siblings (ba55 ba57), transfers given/received to/from children (ba88 ba90), and transfers given/received to/from other households (tf04 tf06). We use PWC 'Indonesia Pocket Tax Book' to identify income brackets and estimate income taxes dues per household.

A.2.8 China

We use the XXXXXXXXXXX. Household total gross income is the sum of yearly values of agricultural income (ai), business income (bi), capital income (ci), labor income (lmi), and pension income (pi).

A.2.9 Mexico

We use the Mexican Family Survey (MXFLS) for 2002, 2005, and 2009. Variable names follow 2009. Household total gross income is the sum of yearly values of labor income (`ls13_2 tb36a_2 tb36aa_2 tb36ab_2 tb36a` business income (`nna22_12`), sales of assets (`in01h_2 in01i_2 in01j_2 in01k_21`), renting out assets(`ah06a_2 ah06b_2  ah06g_2 ah06h_2 ah06n_2`), pension/inheritance (`in01e_2 in01f_2 in01g_2`), and agricultural income: sales of products (`inr03a inr03b inr03c inr03d inr03e inr03f inr03g inr03h inr03` plus value of non sold produced using from sales priced (`su141_21 su142_21 su143_21`), minus cost (`su231 su232 su233 su234 su235 su236 su238 su239  su2311_1`).

For net income we add annualized values of private transfers received: transport (`cs04e_22`), food(`cs04b_12 cs04b_22 cs04b_52 cs04c_32 cs04c_42  cs04d_22 cs04d_32 cs04d_42 cs04e_32 cs04e_42` gifts (`cs18_2`), other family gifts including remittances (`in01d_2 in01g_2`), firm transfers (`in01c_2`), received from parents (tp26), siblings (th20d), children (thi24d), others (to04); private transfers given: food (`cs06_2`), gifts(`cs20_2 cs26_2 cs29_2 cs31_2`), given to parents (tp24), siblings (th20b), children (thi24b), others (to02); government transfers received: Progressa and others (`in01a2_2 in01a3_2  in01a5_2 in` income taxes dues calculated using brackets as described in Vázquez and Martínez (2016).

Table 6: Progressivity and GDP per capita

Country	Progressivity $\phi(Y)$ per year of survey
Malawi	0.27, 0.21, 0.24, 0.30
India	0.22, 0.23
Indonesia	0.17, 0.27
Mexico	0.30, 0.20, 0.22
China	0.26, 0.41, 0.26
Poland	0.13
Spain	0.12**, 0.15**
Italy	0.11
Korea	0.14*
UK	0.13*, 0.13*, 0.13*, 0.14*, 0.15*, 0.17*, 0.17*, 0.15*
Australia	0.06**
USA	0.19*,

Note: Norms-based transfer progressivity is estimated using pre-tax and pre-transfers as gross income and post-tax and post-transfers as net income. Government and private transfers are included. * indicates that private transfers are missing; ** indicate measures of tax-only progressivity. Malawi village 2019; Malawi 2004, 2010, 2013, 2016; Indonesia 2007, 2014; India 2004, 2011; China 2004-2009; Mexico 2002-2009; Poland 2016; Korea 2006-2014; Spain 2013-2015; Italy 2016; UK 2001-2009; Australia 2001-2016, USA 2000-2006. Data compiled by the authors with sources described in the appendix, except for the estimates for Australia (Tran and Zakariyya (2021)), Korea (Chang et al. (2015)), Spain (García-Miralles et al. (2019)), USA modified estimate of (Heathcote et al. (2017)) to remove private transfers received, as there is no data on transfers given in HSV's original estimate: 0.18.

B 2-Period Model: Solution Algorithm for Households (Backwards)

This is a OLG model with uncertainty. We solve the problem backwards from last (second) period to the initial (first) period. In addition, to solve the problem we choose to plug c_0, c_1 and s_1 into the per-period objective functions. Our households take factor prices w and r as given.

Second Period. In the second period, for given $(k_1, s_1, \varepsilon_1)$, agents solve

$$\max_{\{0\le h_1\le 1\}} \left(\log\left(\underbrace{y_1^d + (1-\delta_k)k_1}_{c_1\ge 0} - \bar{c} \right) - \kappa \frac{h_1^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right) \tag{23}$$

where disposable income is,

$$y_1^d = \lambda y_1^{1-\phi},$$

with pre-tax income,

$$y_1 = w_1(\underbrace{zh_0^\alpha - (1-\delta_s)s_0}_{s_1})h_1\varepsilon_1 + r_1 k_1.$$

This implies the following FOC(h_1) for the second period:

$$FOC(h_1): \quad \left(\underbrace{\frac{1}{c_1 - \bar{c}}}_{MU(c_1)} \underbrace{1}_{\frac{\partial c_1}{\partial y_1^d}} \underbrace{(1-\phi)\lambda y_1^{-\phi}}_{\frac{\partial y_1^d}{\partial y_1}} \underbrace{w_1 s_1 \varepsilon_1}_{\frac{\partial y_1}{\partial h_1}} - \underbrace{\kappa h_1^{\frac{1}{\nu}}}_{-MU(\ell_1)} \right) = 0 \tag{24}$$

with $c_1 = \lambda y_1^{1-\phi} + (1-\delta_k)k_1$ and $y_1 = w_1(\underbrace{zh_0^\alpha - (1-\delta_s)s_0}_{s_1})h_1\varepsilon_1 + r_1 k_1$. Notice that we solve this FOC for each triplet and all triplets $(k_1, s_1, \varepsilon_1)$.

Remark. Notice that the choice of h_1 depends on the values of k_1, s_1 and ε_1. Clearly, at this point we do not know the optimal (k_1, s_1) because these will be chosen in the previous period. For this reason, when solving for h_1 we do it for all feasible pairs (k_1, s_1). In terms of timing we assume that the shock ε_1 is realized after the choices k_1 and s_1 are done, and before h_1 is chosen. This implies that we solve for h_1 in (24) for each and all triplets $(k_1, s_1, \varepsilon_1)$.

First Period. In the first period, for given (k_0, s_0), agents solve

$$\max_{\{0\leq h_0\leq 1,k_1\}} \left(\log\left(\underbrace{w_0 s_0 h_0 + r_0 k_0 - k_1}_{c_0\geq 0} - \bar{c} \right) - \kappa \frac{h_0^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right. \\ \left. + \beta \sum_{\varepsilon_1} \pi(\varepsilon_1) \left(\log\left(\underbrace{y_1^d + (1-\delta_k)k_1}_{c_1\geq 0} - \bar{c} \right) - \kappa \frac{h_1^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right) \right)$$

where disposable income is,

$$y_1^d = \lambda y_1^{1-\phi},$$

with pre-tax income,

$$y_1 = w_1 (\underbrace{z h_0^\alpha - (1-\delta_s)s_0}_{s_1}) h_1 \varepsilon_1 + r_1 k_1.$$

This implies that households face these two first order conditions with two unkowns h_0 and k_1:

$$FOC(h_0): \quad \underbrace{\frac{1}{c_0 - \bar{c}}}_{MU(c_0)} \underbrace{w_0 s_0}_{\frac{\partial c_0}{\partial h_0}} - \underbrace{\kappa h_0^{\frac{1}{\nu}}}_{-MU(\ell_0)} + \beta \sum_{\varepsilon_1} \pi(\varepsilon_1) \left(\underbrace{\frac{1}{c_1 - \bar{c}}}_{MU(c_1)} \underbrace{1}_{\frac{\partial c_1}{\partial y_1^d}} \underbrace{(1-\phi)\lambda y_1^{-\phi}}_{\frac{\partial y_1^d}{\partial y_1}} \underbrace{w_1 h_1 \varepsilon_1}_{\frac{\partial y_1}{\partial s_1}} \underbrace{\alpha z h_0^{\alpha-1}}_{\frac{\partial s_1}{\partial h_0}} \right) = 0 \tag{25}$$

$$FOC(k_1): \quad \underbrace{\frac{1}{c_0 - \bar{c}}}_{MU(c_0)} \underbrace{(-1)}_{\frac{\partial c_0}{\partial k_1}} + \beta \sum_{\varepsilon_1} \pi(\varepsilon_1) \left(\underbrace{\frac{1}{c_1 - \bar{c}}}_{MU(c_1)} \underbrace{\left(\underbrace{1}_{\frac{\partial c_1}{\partial y_1^d}} \underbrace{(1-\phi)\lambda y_1^{-\phi}}_{\frac{\partial y_1^d}{\partial y_1}} \underbrace{r_1}_{\frac{\partial y_1}{\partial k_1}} + (1-\delta_k) \right)}_{\frac{\partial c_1}{\partial k_1}} \right) = 0 \tag{26}$$

with $c_0 = w_0 s_0 h_0 + r_0 k_0 - k_1$, $c_1 = \lambda y_1^{1-\phi} + (1-\delta_k)k_1$ and $y_1 = w_1(\underbrace{z h_0^\alpha - (1-\delta_s)s_0}_{s_1}) h_1 \varepsilon_1 + r_1 k_1$.

Remark. Notice that the system (25)-(26) needs to be solved as many times as the number of initial conditions (i,e., pairs (k_0, s_0)). Also, notice that to solve for the system (25)-(26) we make use of the optimal allocation, h_1, obtained earlier for the next period from (24) defined for each triplet $(k_1, s_1, \varepsilon_1)$.

C Full Model: Solution Algorithm for Households (Backwards)

This is a lifecycle model with uncertainty. We solve the problem backwards from last period to the initial period. Our households take factor prices w and r as given.

$$u(c-\bar{c},h) = \begin{cases} \ln(c-\bar{c}) - \frac{\kappa(j)h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} & \sigma = 1 \\ \\ \frac{\left((c-\bar{c})(1-h)^{\kappa(j)}\right)^{1-\sigma}}{1-\sigma} & \sigma \neq 1 \end{cases} \tag{27}$$

If $\sigma = 1$:

$$MU(c) = \frac{1}{c-\bar{c}}$$
$$MU(h) = -\kappa(j)h^{\frac{1}{\nu}}$$

If $\sigma \neq 1$:

$$MU(c) = \left((c-\bar{c})(1-h)^{\kappa(j)}\right)^{-\sigma}(1-h)^{\kappa(j)}$$
$$MU(h) = \left((c-\bar{c})(1-h)^{\kappa(j)}\right)^{-\sigma}(c-\bar{c})\kappa(j)(1-h)^{\kappa(j)-1}(-1)$$

Working Age. In the working periods $j = \{0, ..., J^{RET}-2\}$, for given (k,s,ε), agents solve

$$V_t(j,k,s,\varepsilon) = \max_{\{0\leq h\leq 1,k'\}} \log\left(\underbrace{y_d + Rk - k'}_{c\geq 0} - \bar{c}\right) - \kappa(j)\frac{h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} + \beta\sum_{\varepsilon_{j+1}}\pi(\varepsilon'|\varepsilon)V_{t+1}(j+1,k',s',\varepsilon')$$

where disposable income is,

$$y_d = \lambda y^{1-\phi},$$

with labor income,

$$y = wsh\varepsilon$$

This implies that households face these two first order conditions with two unkowns h_t and k_{t+1}:

$$FOC(h): \quad \underbrace{\frac{1}{c-\bar{c}}}_{MU(c)} \underbrace{(1-\phi)\lambda y^{-\phi}}_{\frac{\partial y_d}{\partial y}} \underbrace{ws\epsilon}_{\frac{\partial y}{\partial h}} - \underbrace{\kappa(j)h^{\frac{1}{\nu}}}_{-MU(\ell)}$$

$$+\beta \sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon) \left(\underbrace{\frac{1}{c'-\bar{c}}}_{MU(c')} \underbrace{1}_{\frac{\partial c'}{\partial y'_d}} \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{wg_h(k',s',\varepsilon')\varepsilon'}_{\frac{\partial y'}{\partial s'}} \underbrace{\alpha z h^{\alpha-1}}_{\frac{\partial s'}{\partial h}} \right) = 0 \quad (28)$$

$$FOC(k'): \quad \underbrace{\frac{1}{c-\bar{c}}}_{MU(c)} \underbrace{(-1)}_{\frac{\partial c}{\partial k'}} + \beta \sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon) \left(\underbrace{\frac{1}{c'-\bar{c}}}_{MU(c')} \underbrace{(1+r(1-\phi)\lambda(y')^{-\phi}-\delta_k)}_{\frac{\partial c'}{\partial k'}} \right) = 0 \quad (29)$$

with $c = \lambda y^{1-\phi} + (1+r)k - k'$, $c' = \lambda(y')^{1-\phi} + (1+\delta_k)k' - g_k(k',s',\varepsilon')$ and $y' = w(\underbrace{zh^{\alpha} - (1-\delta_s)s}_{s'})g_h(k',s',\varepsilon')\varepsilon' + rk'$.

Remark. Notice that the system (25)-(26) needs to be solved as many times as the number of initial conditions (i,e., triplets $(k_t, s_t, \varepsilon_t)$). Also, notice that to solve for the system (39)-(31) we make use of the optimal allocation, h_{t+1} and k_{t+2}, obtained earlier for the next period from (**??**) defined for each triplet $(k_{t+1}, s_{t+1}, \varepsilon_{t+1})$.

Working Age (last period before retirement). At age $j = J^{RET} - 1$, for given (k, s, ε), agents solve

$$V_t(j,k,s,\varepsilon) = \max_{\{0 \le h \le 1, k'\}} \log \left(\underbrace{y_d + Rk - k'}_{c \ge 0} - \bar{c} \right) - \kappa(j) \frac{h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} + \beta \cancel{\sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon)} V_{t+1}(j+1, k' \cancel{, s', \varepsilon'})$$

where disposable income is,

$$y_d = \lambda y^{1-\phi},$$

with labor income,

$$y = wsh\varepsilon$$

This implies that households face these two first order conditions with two unkowns h_t and k_{t+1}:

$$FOC(h): \quad \underbrace{\frac{1}{c - \bar{c}}}_{MU(c)} \underbrace{(1-\phi)\lambda y^{-\phi}}_{\frac{\partial y_d}{\partial y}} \underbrace{ws\epsilon}_{\frac{\partial y}{\partial h}} - \underbrace{\kappa(j) h^{\frac{1}{\nu}}}_{-MU(\ell)}$$
$$\cancel{+\beta \sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon) \left(\underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{1}_{\frac{\partial c'}{\partial y'_d}} \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{wg_h(k', s', \varepsilon')\varepsilon'}_{\frac{\partial y'}{\partial s'}} \underbrace{\alpha z h^{\alpha-1}}_{\frac{\partial s'}{\partial h}} \right)} = 0 \tag{30}$$

$$FOC(k'): \quad \underbrace{\frac{1}{c - \bar{c}}}_{MU(c)} \underbrace{(-1)}_{\frac{\partial c}{\partial k'}} + \beta \cancel{\sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon)} \left(\underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{(1 + r - \delta_k)}_{\frac{\partial c'}{\partial k'}} \right) = 0 \tag{31}$$

with $c = \lambda y^{1-\phi} + (1+r)k - k'$, $c' = \cancel{\lambda(y')^{1-\phi}} + (1 + r - \delta_k)k' - g_k(k', s', \varepsilon')$ and $y' = w(\cancel{\underbrace{zh^{\alpha} - (1-\delta_s)s}_{s'}) g_h(k', s', \varepsilon')\varepsilon'}$
$0.$

Retirement. When retired $j = \{J^{RET}, ..., J-1\}$, for given $(k_j, s_j, \varepsilon_j)$, agents solve

$$V_t(j,k) = \max_{0 \le k' \le} \log \left(\underbrace{Rk - k'}_{c \ge 0} - \bar{c} \right) + \beta V_{t+1}(j+1, k') \tag{32}$$

This implies the following FOC(k_{t+1}) for the retirement periods:

$$FOC(k'): \quad \underbrace{\frac{1}{c - \bar{c}}}_{MU(c)} + \beta \underbrace{(1 + r - \delta_k)}_{\frac{\partial c'}{\partial k'}} \underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} = 0 \tag{33}$$

with $c = (1 - \delta_k)k - k'(j,k)$. Notice that we solve this FOC for each (k).

Remark. Notice that the choice of k' depends on the values of k. Clearly, at this point we do not know the optimal (k) because these will be chosen in the previous period. For this reason, when solving for k' we do it for all feasible (k).

Last Period. At $j = J$, a retired household consumes all its assets.

$$V_t(j,k) = \log\left((1+r-\delta)k - \overline{c}\right) \tag{34}$$

with optimal decisions:

$$k'(j,k) = 0 \tag{35}$$

$$c(j,k) = (1+r-\delta)k \tag{36}$$

D Full Model: Solution Algorithm for Households (Backwards) with Capital Income Taxation

This is a lifecycle model with uncertainty. We solve the problem backwards from last period to the initial period. Our households take factor prices w and r as given.

Working Age. In the working periods $j = \{0, ..., J^{RET} - 2\}$, for given (k, s, ε), agents solve

$$V_t(j,k,s,\varepsilon) = \max_{\{0 \le h \le 1, k'\}} \log\left(\underbrace{y_d + (1-\delta)k - k'}_{c \ge 0} - \bar{c}\right) - \kappa(j)\frac{h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} + \beta \sum_{\varepsilon_{j+1}} \pi(\varepsilon'|\varepsilon) V_{t+1}(j+1, k', s', \varepsilon')$$

where disposable income is,

$$y_d = \lambda y^{1-\phi},$$

with total income,

$$y = wsh\varepsilon + rk$$

This implies that households face these two first order conditions with two unkowns h_t and k_{t+1}:

$$FOC(h): \quad \underbrace{\frac{1}{c-\bar{c}}}_{MU(c)} \underbrace{(1-\phi)\lambda y^{-\phi}}_{\frac{\partial y_d}{\partial y}} \underbrace{ws\epsilon}_{\frac{\partial y}{\partial h}} - \underbrace{\kappa(j)h^{\frac{1}{\nu}}}_{-MU(\ell)}$$
$$+ \beta \sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon) \left(\underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{1}_{\frac{\partial c'}{\partial y'_d}} \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{wg_h(k', s', \varepsilon')\varepsilon'}_{\frac{\partial y'}{\partial s'}} \underbrace{\alpha z h^{\alpha-1}}_{\frac{\partial s'}{\partial h}} \right) = 0 \quad (37)$$

$$FOC(k'): \quad \underbrace{\frac{1}{c-\bar{c}}}_{MU(c)} \underbrace{(-1)}_{\frac{\partial c}{\partial k'}} + \beta \sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon) \left(\underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{\left(1 + \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{r}_{\frac{\partial y'}{\partial k'}} - \delta_k \right)}_{\frac{\partial c'}{\partial k'}} \right) = 0 \quad (38)$$

with $c = \lambda y^{1-\phi} + (1-\delta)k - k'$, $c' = \lambda(y')^{1-\phi} + (1-\delta)k' - g_k(k', s', \varepsilon')$ and $y' = w(\underbrace{zh^{\alpha} - (1-\delta_s)s}_{s'})g_h(k', s', \varepsilon')\varepsilon' + rk'$.

Remark. Notice that the system (25)-(26) needs to be solved as many times as the number of initial conditions (i,e., triplets $(k_t, s_t, \varepsilon_t)$). Also, notice that to solve for the system (39)-(31) we make use of the optimal allocation, h_{t+1} and k_{t+2}, obtained earlier for the next period from (**??**) defined for each triplet $(k_{t+1}, s_{t+1}, \varepsilon_{t+1})$.

Working Age (last period before retirement). At age $j = J^{RET} - 1$, for given (k, s, ε), agents solve

$$V_t(j,k,s,\varepsilon) = \max_{\{0 \leq h \leq 1, k'\}} \log\left(\underbrace{y_d + (1-\delta)k - k'}_{c \geq 0} - \bar{c}\right) - \kappa(j)\frac{h^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} + \beta \cancel{\sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon)} V_{t+1}(j+1, k', \cancel{s'}, \cancel{\varepsilon'})$$

where disposable income is,

$$y_d = \lambda y^{1-\phi},$$

with total income,

$$y = wsh\varepsilon + rk$$

This implies that households face these two first order conditions with two unkowns h_t and k_{t+1}:

$$FOC(h): \quad \underbrace{\frac{1}{c-\bar{c}}}_{MU(c)} \underbrace{(1-\phi)\lambda y^{-\phi}}_{\frac{\partial y_d}{\partial y}} \underbrace{ws\epsilon}_{\frac{\partial y}{\partial h}} - \underbrace{\kappa(j)h^{\frac{1}{\nu}}}_{-MU(\ell)}$$
$$\cancel{+\beta \sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon) \left(\underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{1}_{\frac{\partial c'}{\partial y'_d}} \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{wg_h(k', s', \varepsilon')\varepsilon'}_{\frac{\partial y'}{\partial s'}} \underbrace{\alpha z h^{\alpha-1}}_{\frac{\partial s'}{\partial h}} \right)} = 0 \qquad (39)$$

$$FOC(k'): \quad \underbrace{\frac{1}{c-\bar{c}}}_{MU(c)} \underbrace{(-1)}_{\frac{\partial c}{\partial k'}} + \beta \cancel{\sum_{\varepsilon'} \pi(\varepsilon'|\varepsilon)} \left(\underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{\left(1 + \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{r}_{\frac{\partial y'}{\partial k'}} - \delta_k\right)}_{\frac{\partial c'}{\partial k'}} \right) = 0 \qquad (40)$$

with $c = \lambda y^{1-\phi} + (1-\delta)k - k'$, $c' = \lambda(y')^{1-\phi} + (1-\delta)k' - g_k(k', s, \varepsilon)$ and $y' = w(\underbrace{zh^{\alpha} - (1-\delta_s)s}_{s'}) \cancel{g_h(k', s', \varepsilon')\varepsilon'} + rk'$.

Retirement. When retired $j = \{J^{RET}, ..., J-1\}$, for given $(k_j, s_j, \varepsilon_j)$, agents solve

$$V_t(j,k) = \max_{0 \leq k' \leq} \log\left(\underbrace{y_d + (1-\delta)k - k'}_{c \geq 0} - \bar{c}\right) + \beta V_{t+1}(j+1, k') \qquad (41)$$

where disposable income is,

$$y_d = \lambda y^{1-\phi},$$

with total income,

$$y = rk$$

This implies the following FOC(k_{t+1}) for the retirement periods:

$$FOC(k') : \qquad \underbrace{\frac{1}{c - \bar{c}}}_{MU(c)}(-1) + \beta \underbrace{\frac{1}{c' - \bar{c}}}_{MU(c')} \underbrace{\left(1 + \underbrace{(1-\phi)\lambda(y')^{-\phi}}_{\frac{\partial y'_d}{\partial y'}} \underbrace{r}_{\frac{\partial y'}{\partial k'}} - \delta_k \right)}_{\frac{\partial c'}{\partial k'}} = 0 \tag{42}$$

$$\tag{43}$$

with $c = y_d + (1-\delta)k - k'$ and $c' = \lambda(y')^{1-\phi} + (1-\delta)k' - g_k(k')$ and $y' = rk'$. Notice that we solve this FOC for each (k).

Remark. Notice that the choice of k' depends on the values of k. Clearly, at this point we do not know the optimal (k) because these will be chosen in the previous period. For this reason, when solving for k' we do it for all feasible (k).

Last Period. At $j = J$, a retired household consumes all its assets.

$$V_t(j, k) = \log\left(\lambda(rk)^{1-\phi} + (1-\delta)k - \bar{c}\right) \tag{44}$$

with optimal decisions:

$$k'(j, k) = 0 \tag{45}$$

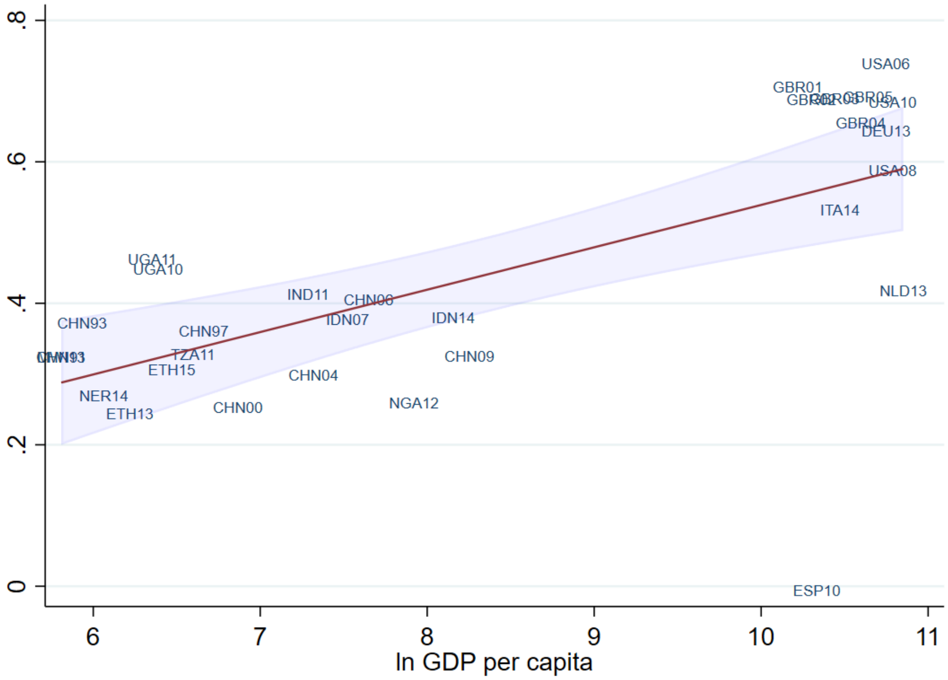
$$c(j, k) = \lambda(rk)^{1-\phi} + (1-\delta)k \tag{46}$$

E Income Risk

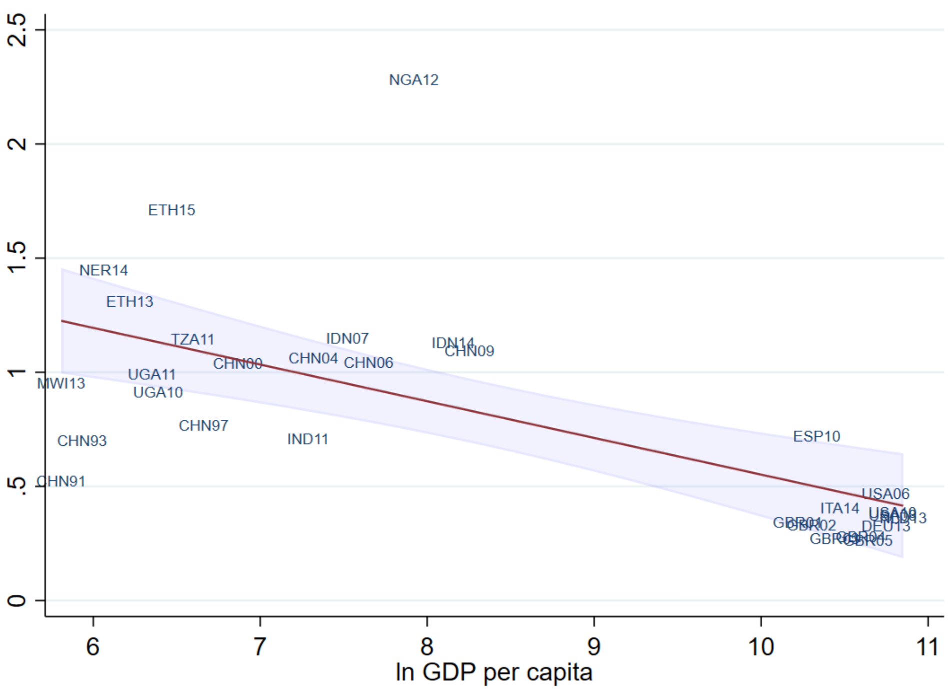
F Transmission of Income Inequality to Consumption Inequality: Alternative Measures

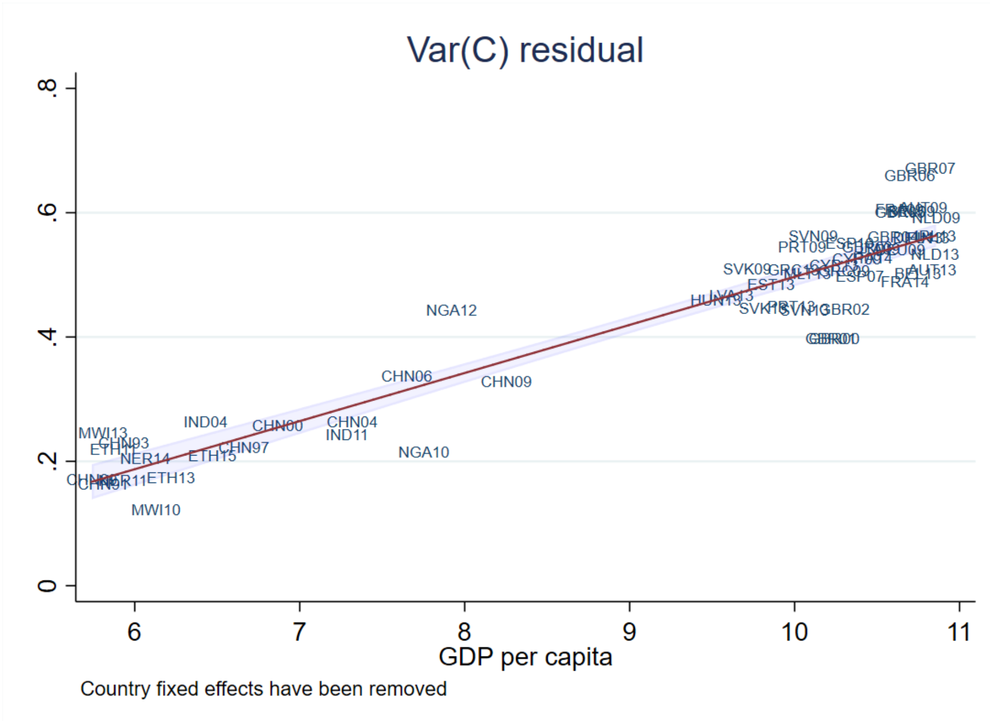
Figure 10: Income risk

(a) ρ against GDP

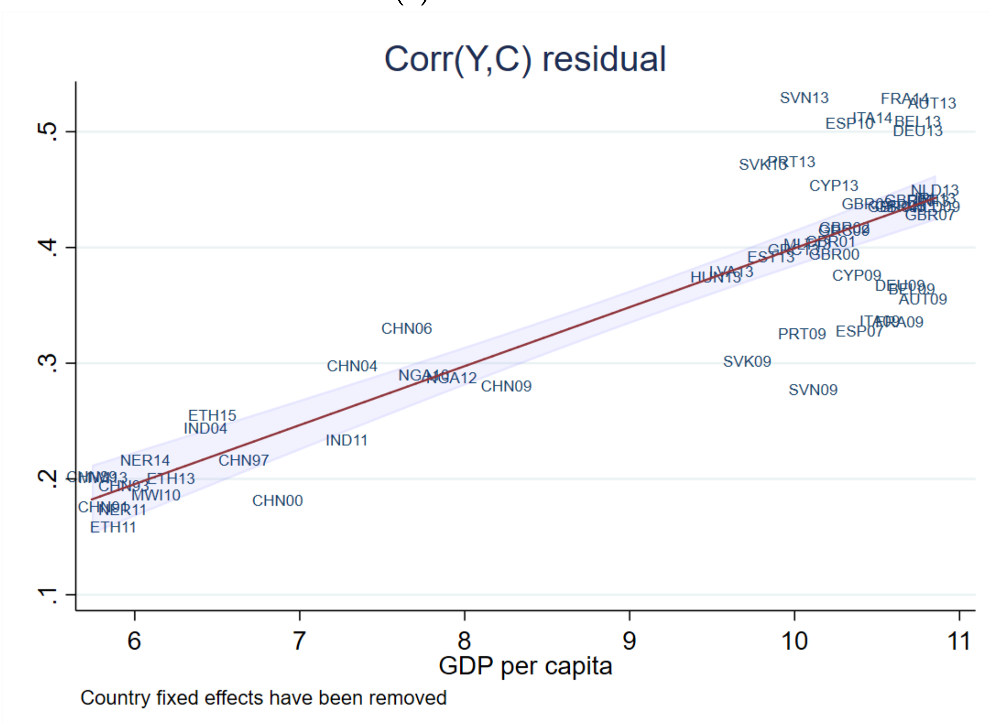


(b) σ against GDP





(a) Variance of C



(b) Correlation of C and Y

G Income Vs. Employment Shocks

A recurring concern that arises with these measures is that part of the changes in income can be attributed to measurement error (Grosh and Deaton, 2000; **?**). In the Appendix, we also adopt an additional approach less prone to measurement error by focusing on observable income shocks (unemployment) as in Cochrane (1995). We find similar inisghts in this alternative approach. This relates to the recent work of Lagakos (2018) that documents an increase in unemployment across the level of development. Building on this result we document the effects that a rise in unemployment has on consumption insurance.

$$\Delta \ln \left(\hat{c}_{it}\right) = \phi \mathbf{1}_u + \varepsilon_{it} \tag{47}$$

where $\mathbf{1}_u$ is a dummy equal to one if household i is unemployed in period t, and zero otherwise.