A General Equilibrium Analysis of Consumption Dynamics in Rural Economies*

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Abstract

I explore the role of a fixed factor of production in shaping consumption dynamics in a general equilibrium model with uninsurable idiosyncratic income risk. A productive asset in fixed supply, like land, offers a particularly effective form of self-insurance through its effect on the share of safe to risky income in general equilibrium. I apply the model to explain consumption dynamics in land-intensive rural economies in developing countries. The theory rationalizes the puzzlingly low passthrough from income shocks to consumption, low intergenerational mobility, and overall low aggregate savings rates.

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1 Introduction

In this paper, I argue that the role of land as a fixed factor of production represents a quantitatively important force in shaping consumption dynamics. I then apply the theory to understanding consumption dynamics across rural and urban households in developing economies, where the rural sector is naturally more land-intensive. When combined with a standard model of household income risk and self-insurance in general equilibrium (Aiyagari, 1994), land intensity impacts consumption dynamics as follows. First, all else equal, consumption insurance is higher in the land-intensive sector. Second, intergenerational persistence, i.e., the correlation between parent and child life outcomes, is higher in the rural land-intensive sector. Third, aggregate savings are lower in the land-intensive sector. These patterns find strong support in the empirical literature referenced below. Land-intensive production in a general equilibrium model with idiosyncratic income risk offers a novel, simple, and quantitatively powerful explanation for understanding differences in consumption dynamics across rural and urban households.

The central theoretical insight is that, in general equilibrium incomplete market models with idiosyncratic income risk, the relationship between income and consumption volatility depends critically on the share of land in production. To see why, consider a stationary world with identical idiosyncratic risk across sectors. Idiosyncratic income risk raises households' precautionary savings and creates demand for safe assets. In the rural sector, savings pressure raises the equilibrium price of land, p_T, which is endogenous. An immediate implication is that more safe assets are created precisely when households demand them. By contrast, in the urban sector –which, for concreteness, employs only labor and physical capital in production– savings are directed toward the accumulation of physical capital. Because physical capital depreciates, this form of accumulation represents a less effective storage technology for the economy overall because savings in capital put comparatively greater downward pressure on the interest rate. Low interest rates then undermine self-insurance motives, and give rise to quantitatively large differences in consumption dynamics across sectors.

The main contribution of this paper is to explore this argument rigorously, both theoretically and quantitatively. In doing so, I highlight more broadly how the structure of production is an important determinant of consumption dynamics and aggregate savings rate, which addresses open questions in a large empirical literature. I develop this argument in three steps.

First, I build an incomplete-markets model in the spirit of Aiyagari (1994) and extend it to include land as a factor of production. I adopt a perpetual-youth framework (Yaari, 1965; Blanchard, 1985) with accidental bequests, which allows me to embed a unit-root income process in an infinite-horizon environment. This setup nests the neoclassical model exactly when income risk is shut down, and provides a tractable link between parental and child outcomes through inherited financial wealth. I consider each sector in autarky to isolate the theoretical mechanism.[1]

[1] Financial markets must be at least partially segmented so that the rural and urban interest rates can differ. Intermediate

The rural sector is, by definition, the land-intensive sector, and the goal is to highlight how sensitive micro and macro moments –i.e., consumption insurance, intergenerational persistence, and aggregate savings– are to the share of land in production.

Before I quantify the model, I prove that a more land-intensive production sector induces a higher equilibrium interest rate whenever physical capital depreciates. Land is distinct from capital because its price is not tied one-for-one to output: while additional output can always be converted into investment goods, the supply of land is fixed, and its price, therefore, endogenous. When income risk rises, land prices can appreciate, providing additional safe assets precisely when households demand them. This mechanism sustains relatively high interest rates, which, in turn, allows for effective self-insurance. The special role of land has been noted in the context of OLG economies and dynamic inefficiencies, see Tirole (1985). Here, I extend this idea by showing that what ultimately matters is depreciation, and not the assumption that land is in fixed supply.[2]

I formally show that low or zero depreciation—rather than fixed supply— is the key feature that turns land into a superior safe asset, and sustains high interest rates. Positive depreciation rates of accumulable factors render the production sides' asset demand relatively inelastic. Income risk in the presence of inelastic asset supply has a strong price effect, i.e., interest rates are low relative to the complete market benchmark. A higher land share lowers the average depreciation rate. This leads to a more elastic asset-demand schedule and, ultimately, higher equilibrium interest rates compared to a capital-intensive economy. Crucially, the mechanism extends beyond the rural–urban distinction: it applies to any environment in which effective depreciation rates vary. For instance, the ongoing shift from physical to rapidly depreciating intangible capital is likely to have quantitatively important implications for long-run real interest rates in the presence of idiosyncratic risk.

Land-induced differences in interest rates have quantitatively important implications for consumption dynamics because they matter for self-insurance. Higher interest rates allow for more stable consumption as the weight on safe financial asset income in total household income increases, while the weight on risky labor income falls. This will be true in any model building on the seminal framework of Aiyagari (1994). The result is a lower passthrough from labor income shocks to consumption, and thus lower risk-exposure. The impact of land-intensive production on consumption insurance lines up well with a large empirical literature following Townsend (1994), which finds that rural households display a surprisingly high degree of consumption insurance relative to households in urban and advanced economies.

Regarding intergenerational persistence, note that high interest rates have two distinct effects. First, they increase the likelihood that wealthy rural households remain wealthy, as they provide fa-

cases of imperfect integration seem realistic; see Kleinman et al. (2023). If rural and urban sectors are fully integrated, the basic logic of the paper still applies, but the unit of observation would be the country level, i.e., the more land-intensive country would feature a higher interest rate, ceteris paribus. The interaction of rural-urban migration and income risk is addressed in a companion paper in Trouvain (2025b).

[2]Clearly, any asset in a fixed supply in a stationary environment must not depreciate; however, the reverse is not true, as there may be accumulable factors with depreciation rates close to zero.

vorable intertemporal terms of trade to project financial wealth into the future. Second, because interest rates are high, asset income becomes a key determinant of household consumption. Combining this with the assumption that financial wealth can be easily transferred from parents to children yields a high degree of intergenerational persistence in consumption. In contrast, low interest rates in the urban sector make human capital more important. As human capital evolves stochastically, it induces greater income mobility within and across cohorts. Thus, the greater importance of inherited financial wealth and the lesser role of human capital –the more volatile component of income– both contribute to higher intergenerational persistence in rural consumption. This prediction aligns with recent empirical evidence showing lower intergenerational mobility in educational attainment among rural households across Africa (see Alesina et al. (2021)).

In the second step, I discipline the model by matching income and consumption dynamics for rural and urban households in South Africa. I build on Deaton and Paxson (1994)'s insight that the joint distribution of income and consumption contains information on the degree of consumption insurance. This idea also underpins the popular passthrough coefficients of Townsend (1994) and Blundell, Pistaferri, and Preston (2008), henceforth BPP. Consistent with prior literature, I find that rural consumption appears surprisingly smooth. I then quantify the importance of differences in land intensity in explaining the low passthrough from income shocks to consumption in rural South Africa. The model-implied urban passthrough is about 0.75, i.e., a 1% increase in permanent income raises consumption by 0.75%. If the rural sector is as capital-intensive as the urban one, then the passthrough in the rural sector would also be close to 0.75. The theoretical passthrough necessary to rationalize the low responsiveness of consumption for rural households in the data is about 0.5, and land-intensive production accounts for two-thirds of the gap. Ignoring differences in the structure of production leads to a substantial overstatement of the role of informal insurance in rural economies. Similarly, I find that differences in land intensity, and their impact on equilibrium interest rates, account for most of the lower social mobility in rural South Africa as proxied by intergenerational persistence in educational attainment.

I focus on the most parsimonious version of the benchmark Aiyagari model where land and physical capital are frictionlessly traded, and land intensity impacts consumption dynamics only through aggregate equilibrium objects –such as the interest rate, the relative supply of safe assets, and the endogenous asset distribution– to make a novel point about the structure of production on the supply side. In a robustness exercise, I consider a version of the model where land is indeed imperfectly traded, and quantify how "untradable" land has to be to overturn the mechanism.

I close the paper by exploring the implications of the model for aggregate savings. Laitner (2000) makes the qualitative argument that rising aggregate savings rates along the development spectrum could reflect a shift from land-intensive to capital-intensive production since only accumulation in reproducible capital is recorded as savings in the national accounts. I revisit this question quantitatively and find that differences in the structure of production in a standard Aiyagari-style model can account for most of the relationship between GDP per capita and aggregate savings.

Related Literature. The paper relates to the larger literature on the aggregate implications of idiosyncratic income risk in general equilibrium, building on Bewley (1986), Huggett (1993), and Aiyagari (1994).[3] Relative to these studies, I consider the role of land as a fixed factor of production, and explore the model's ability to account for differences in consumption dynamics across rural and urban households. Modeling the rural sector as land-intensive has many antecedents in the literature. Yet, land-intensive production is usually invoked in environments that either abstract away from idiosyncratic risk (Hansen and Prescott, 2002; Lucas, 2004) or are set in partial equilibrium (Lagakos, Mobarak, and Waugh, 2023), so that the link between land as a fixed factor of production and risk has been overlooked.

The special role of safe assets in the presence of idiosyncratic risk goes back to the seminal work of Bewley (1980). Woodford (1990) and Aiyagari and McGrattan (1998) study the optimal amount of government debt in this context. I highlight that land as a factor in fixed supply automatically generates more safe assets in the presence of idiosyncratic risk. When land is an important which under mild restrictions rules out the possibility of dynamic inefficiency where the interest rate is lower than the long-run growth rate.

Empirically, I relate to the works of Deaton and Paxson (1994), Townsend (1994), and Blundell, Pistaferri, and Preston (2008), which measures income and consumption dynamics jointly to infer consumption insurance. I compare these estimates with coefficients based on simulated data from the model to explore potential biases similar to Kaplan and Violante (2010). Kaplan and Violante (2022) summarize and extend recent work that models carefully the response of consumption to income shocks (Kaplan and Violante, 2010; Kaplan and Violante, 2014). My general equilibrium focus is complementary to their work set in partial equilibrium,[4] and useful for understanding how the economy responds to changes in income risk, which are counterfactual questions that turn out to be sensitive to the share of land in production.

A growing literature has been documenting household income and consumption dynamics in developing economies, see De Magalhaes and Santaeulalia-Llopis (2018), Santaeulalia-Llopis and Zheng (2018), Meghir et al. (2022), De Magalhaes, Martorell, and Santaeulalia-Llopis (2024), and Attanasio et al. (2025). A related literature has studied risk in two-sector rural-urban economies, see Banerjee and Newman (1998), Munshi and Rosenzweig (2016), and Lagakos, Mobarak, and Waugh (2023).[5] A

[3]See also Imrohoroğlu (1989), Deaton (1991), and Carroll (1997).

[4]Kaplan and Violante (2022) explain that the link between income and consumption can be effectively studied in partial equilibrium, and incorporate portfolio adjustment frictions and asset return heterogeneity to match households' marginal propensity to consume. Measuring rural financial wealth distributions and interest rates is, of course, much harder than in advanced economies as data is more scant.

[5]Ligon (1998) and Ligon, Thomas, and Worrall (2002) explore limits to full risk pooling in village economies based on limited commitment constraints, see Morten (2019) and Meghir et al. (2022) for related work in the context of rural-urban migration. Other central references in the development literature on risk in rural environments are Rosenzweig and Wolpin (1993), Fafchamps, Udry, and Czukas (1998), Fafchamps and Lund (2003), and Jayachandran (2006), Kinnan and Townsend (2012), Cole et al. (2013), Samphantharak and Townsend (2018), and Silva and Townsend (2023). Donovan (2021) studies the role of income

key difference to these works is the role of land in the presence of idiosyncratic income risk in general equilibrium. While I abstract away from rural-urban migration to focus on the role of land, I pick up this issue in related work that also provides more details on the South African data (Trouvain, 2025b).

2 Model

I next sketch out the model, which applies to both rural and urban sector, although the parameterization will differ.

2.1 Environment

Time is continuous, markets are competitive, and there is a constant mass of household L.[6] Households supply their labor inelastically and make consumption-saving choices.

Income Risk. The logarithm of household labor income follows a stochastic process with persistent and transitory component

$$dp = \sigma_p dZ, \tag{1}$$

$$d\epsilon = dN\left(\epsilon' - \epsilon\right) \tag{2}$$

where dZ is a Wiener process. Transitory shocks arrive at rate λ_ϵ, and involve an iid draw from a mean zero normal distribution $G\left(\epsilon'\right)$ with variance σ_ϵ^2. Household labor income reads

$$W_i\left(p, \epsilon\right) = we^{p_i + \epsilon_i}. \tag{3}$$

To render the income distribution stationary, I assume that households are hit with a death shock at rate ϕ.[7] This means that perpetually young households solve an infinite horizon problem, where the death shock is reflected in a higher effective discount factor[8] Each dying household is replaced by a newborn household, regarded as its offspring. The only intergenerational link is the accidental bequest, as the newborn inherits the parents' asset position. Newborn households draw their persistent type p from a normal distribution with mean $c_0 \leq 0$ and variance σ_0^2, and their transitory type from

risk in explaining low intermediate input shares in subsistence agriculture through the lens of an incomplete market model, while Cole et al. (2013) and Karlan et al. (2014) use an RCT to study the effect of formal insurance on agricultural outcomes. Manysheva (2022) and Rodrigues (2022) explore the role of land reallocation frictions in developing countries in incomplete market settings.

[6]The urban economy is neoclassical so population growth would only change the effective rate of depreciation. The rural sector features a fixed factor, land, so a constant population is a natural assumption consistent with Malthusian forces.

[7]See Gabaix et al. (2016) for a detailed discussion of how to stabilize stochastic processes that contain a random walk.

[8]The setup offers two advantages relative to including an explicit age structure. First, it eases the computational burden. Second, models with explicit age structure and life cycle savings dynamics run into conceptual problems when confronted with the reality of rural household dynamics where family units are closely knit, elderly parents reside with children in the same households and are supported directly in old age, which means standard life-cycle consumption models are not applicable.

$G(\epsilon')$. This formulation is convenient because it nests the standard neoclassical model, unlike in the alternative models of Yaari (1965) or Blanchard (1985) with annuity markets.

I introduce an informal insurance margin, which tractably captures village arrangements that help smooth consumption. The conjecture that there is some form of informal insurance in rural economies seems uncontroversial, at least in the development literature (see Rosenzweig and Stark, 1989). In my theory, informal insurance will be a residual needed to match the data. The size of this residual will be reduced substantially by incorporating land as a factor of production in general equilibrium. I model informal insurance by introducing the insurance coefficient $\kappa \in [0,1]$ that drives a wedge between labor income W_i observed by the econometrician, and effective household disposable labor incomeW_i^*, which equals

$$W_i^* = we^{(1-\kappa)(p_i+\epsilon_i)+d} \tag{4}$$

where the shifter d ensures that aggregate income remains unchanged, i.e., $\mathbb{E}[W_i^*] = \mathbb{E}[W_i]$, which requires $d = \log\left(\frac{\mathbb{E}\left[e^{p_i+\epsilon_i}\right]}{\mathbb{E}\left[e^{(1-\kappa)(p_i+\epsilon_i)}\right]}\right)$. A positive value of κ implies that income shocks pass through only partially to effective income, which is a simple way to capture informal insurance arrangements in rural village communities. The setting relates directly to the popular BPP estimator in the sense that for quadratic preference and unconstrained households, the passthrough of persistent shocks equals $\frac{\partial \log c}{\partial p} = 1 - \kappa$. This model of informal insurance mimics commonly used progressive tax functions, see Benabou (2000) and Heathcote, Storesletten, and Violante (2017). The subtle difference is that taxes are observed and subtracted to obtain net income. In contrast, informal insurance is unobserved and thus drives a wedge between consumption and income inequality.[9]

Household problem. Dynastic households solve a consumption-saving problem

$$V(b,p,\epsilon) = \max_{\{c,a\}} \mathbb{E}_t\left[\int_0^\infty e^{-(\rho+\phi)s}\frac{c^{1-\gamma}}{1-\gamma}ds\right] \tag{5}$$
$$\text{s.t.}$$
$$\dot{b} = rb + W^*(p,\epsilon) - c$$
$$b \geq 0,$$

with zero-borrowing constraint $b \geq 0$.[10]

Aggregates and Production. I follow Hansen and Prescott (2002) and assume a constant-returns-to-

[9] See Ligon (1998) for the role of informal contracts among villagers, and Munshi and Rosenzweig (2016) for the role of marriage markets. See also Morduch (1995) and Ligon, Thomas, and Worrall (2002) for succinct summaries of the many possible ways in which rural farming communities insure against income shocks. The novel insight I am contributing to this literature is the role of land as a factor in fixed supply in sustaining effective self-insurance in general equilibrium.

[10] The zero-borrowing constraint seems appropriate for the emerging market context as a first pass. The assumption does matter in that higher interest rates help build up bufferstock savings so a high interest rate environment is desirable when dealing with idiosyncratic income risk. The predictions would be more ambiguous with a natural borrowing limit as lower interest rates would expand the natural borrowing limit assuming it is proportional to $\frac{w}{r}$.

scale neoclassical production function that includes land T in fixed supply, labor $H = \int e^{p_i+\epsilon_i} di$, and reproducible capital K in a Cobb-Douglas fashion

$$Y = T^{\chi} K^{\nu} H^{1-\chi-\nu} \tag{6}$$

where χ and ν are land and capital share, respectively. I normalize the supply of land to one, $T = 1$, which is without loss. Output can either be consumed, or turned one-for-one into reproducible capital.[11] Together with a depreciation rate δ, the law of motion of capital is given by

$$\dot{K} = I - \delta K, \tag{7}$$

where $Y = C + I$. The rental rate of land, price of land, rental rate of capital, and wage rate per efficiency unit of labor are denoted by R_T, p_T, R, and w, respectively. Differences between rural and urban sector are confined to differences in land vs. capital-intensity, differences in the income process, and differences in informal insurance. All other aspects of the model are the same, and the labor share is held fixed.

2.2 Equilibrium.

I focus on a stationary equilibrium defined as follows.

Definition 1. A stationary equilibrium consists of aggregate output, capital, factor prices, consumption, and savings policy functions such that

- households solve (5) subject to constraints and transversality condition;
- final goods firms maximize profits, taking factor prices as given;
- goods, factor, and asset markets clear with $\int b_i di = K + p_T$ within each sector;
- a stationary distribution $g(x)$ obtains, defined over idiosyncratic income and wealth states $x = (b, p, \epsilon)$, consistent with aggregation constraints.

In next discuss the equilibrium properties of the model.

Wages and Asset Prices. Competitive production implies the following wage rate

$$w = (1 - \chi - \nu) \left(\frac{\nu}{r + \delta} \right)^{\frac{\nu}{1-\nu}} \left(L\tilde{h} \right)^{-\frac{\chi}{1-\nu}} \tag{8}$$

[11]This technological assumption is essential as it ties the price of capital to the price of final output, which is distinctively different from the endogenous price of land. I generalize the model in the appendix to show that what is important is not the "one-for-one" assumption, but the linear technology implicit in trading off consumption against investment. Countries or sectors can thus differ in their efficiency at producing investment goods, which has no bearing on consumption dynamics. Of course, low efficiency in producing capital goods leads to a reduction in wages.

where $\tilde{h} = \int h(x) g(x) dx$ is the average amount of efficiency units of labor per household.

Turning attention to the demand for assets, note that households only hold one risk free bond. A financial intermediary ensures that an arbitrage condition between physical capital and land holds

$$\frac{R_T}{p_T} + \frac{\dot{p}_T}{p_T} = R - \delta, \tag{9}$$

where $\dot{p}_T = \frac{d}{dt} p_T$ represents gains from land price appreciation. In the steady state, the price of land is constant. In that case, equation (9), together with profit maximization and land supply normalized to one, pins down the equilibrium price of land

$$p_T = \frac{\chi Y}{r}, \tag{10}$$

which implies a constant ratio of the value of land to the physical capital stock

$$\frac{p_T}{K} = \frac{\chi}{\nu} \frac{r+\delta}{r}. \tag{11}$$

Equation (11) is useful in deriving equilibrium demand for physical capital, which is a scaled-down version of total household demand for risk-free assets, $K = \frac{1}{1+\frac{\chi}{\nu}\frac{r+\delta}{r}} \int b(x) g(x) dx L$. Before I solve the model computationally using Achdou et al. (2022)'s finite difference scheme, I make several theoretical observations.

2.3 Analytical Results

A novel feature of the model is the special role of land as safe asset in the presence of idiosyncratic income risk. I emphasize that this effect is entirely driven by general equilibrium forces, and show that it is ultimately based on the fact that land's depreciation rate is zero.[12]

I start by stating a neutrality results under the complete markets benchmark to set the stage for the role of land when markets are incomplete.

Proposition 1. *In the case of fixed household types, i.e., $\sigma_p^2 = \sigma_\epsilon^2 = 0$, the interest rate equals the discount rate adjusted for death shocks, $r = \rho + \phi$, and is independent of the land share.*

The significance of proposition 1 is that, in the absence of income risk, the land share is irrelevant for the determination of equilibrium interest rates.[13] The model inherits this feature from the standard neoclassical model, which is nested. It follows that land intensity is inconsequential for

[12] My notion of land is thus one of "raw" land. Investment in land to make it amenable to agricultural production is captured by a positive reproducible capital share in rural.

[13] The proposition can be extended to one for insurance markets for idiosyncratic risk as long as there are no life cycle wage dynamics, see the appendix for details.

interest rates in representative agent frameworks. This is no longer true once households face uninsurable idiosyncratic risk, at which point the share of land vis-a-vis capital becomes important in the determination of equilibrium interest rates, and thus household consumption dynamics.

To make this point formally, I first introduce the notion of normalized asset demand $\tilde{b} := \frac{B}{wL}$ and maintain for the theoretical argument that average efficiency units of labor per household, $\tilde{h}$, are fixed at unity, so an increase in risk represents a mean-preserving spread.

Lemma 1. *Denote aggregate asset demand B as a function of exogenous parameters Θ as well as interest rate, wage, and total measure of households, $B(\Theta, r, w, L) := \int b(x)\, dG(x)\, L$, and note that B is homogenous of degree one in both w and L, so $B(\Theta, r, w, L) = B(\Theta, r, 1, 1)\, wL := \tilde{b}(\Theta, r)\, wL$.*

Lemma 1 is useful in two ways.[14] First, because household asset demand scales linearly in the wage rate, I can ignore effects of land-intensity on the mean level of income,[15] which is fully captured in the scalar w. I can thus focus on normalized household saving choices captured in the normalized aggregate asset supply function $\tilde{b}(\Theta, r)$. While it is difficult to characterize theoretically the shape of the normalized asset supply function,[16] in standard applications aggregate asset supply is upward-sloping in the interest rate. Second, lemma 1 illustrates what makes the Aiyagari model tractable as household saving dynamics, conditional on the interest rate, are divorced from the production side of the economy. In fact, household savings normalized by the wage bill only depend on preference parameters, structural parameters related to the income process, and the interest rate. This separation allows for the extremely simple argument that I develop next, which carries over to any general equilibrium incomplete market model with idiosyncratic labor income risk and safe assets.

To develop this argument, I first use the linearity of the asset supply function in the wage bill to simplify the asset market clearing condition. Normalized asset demand depends on firms' demand for capital and land normalized by the aggregate wage bill denoted by $\tilde{a} = \frac{K}{wL} + \frac{p_T}{wL}$. This asset demand schedule is negatively related to the interest rate. Furthermore, it depends on the share of land vs. capital, and the extent to which physical capital depreciates as stated in the next proposition. The slope of the asset demand schedule, in turn, shapes the semi-elasticity of the normalized aggregate asset demand with respect to the interest rate, defined as $-\frac{\partial \log \tilde{a}(r)}{\partial r}$.

Proposition 2. *Holding the labor share $1 - \theta := 1 - \chi - \nu$ fixed, the normalized asset demand schedule is*

[14] Lemma 1 exploits the well-known homogeneity property of the households' consumption-saving problem, which holds true as long as preferences are homothetic, labor income shocks are multiplicative, the borrowing constraint is proportional to the wage rate, and there is no capital income risk.

[15] That is to say, I do not consider the negative effect of high land shares on the link between precautionary savings and wages. In the welfare analysis of Davila et al. (2012), low income households earn most of their income in labor income, and thus would like precautionary savings for the economy as a whole to be higher since a higher capital stock raises the wage.

[16] See Achdou et al. (2022) for a proof that the asset supply function is upward-sloping in the interest rate when the coefficient of relative risk-aversion is below one.

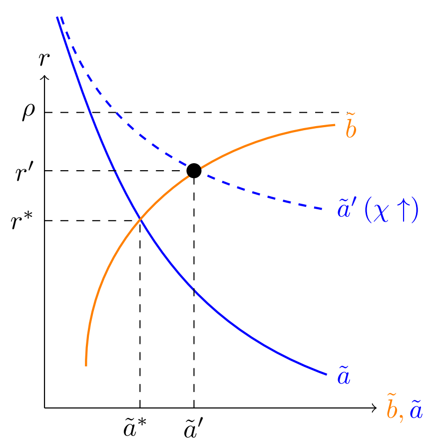
a downward-sloping function of the interest rate and reads

$$\tilde{a}(r) = \frac{1}{1-\theta}\left(\chi\frac{1}{r} + \nu\frac{1}{r+\delta}\right), \tag{12}$$

where the shares χ and ν sum up to the non-labor share, $\chi + \nu = \theta$. An increase in the land share, holding the non-labor share fixed, increases the semi-elasticity of firms' normalized asset demand with respect to the interest rate whenever $\delta > 0$, i.e., $\frac{\partial}{\partial \chi}\left|\frac{\partial \log \tilde{a}(r)}{\partial r}\right| > 0$.

In other words, proposition 2 states that a higher land share in production makes asset demand more elastic in the interest rate. This is quantitatively important for households' ability to self-insure as a more elastic demand for productive assets from the firm side sustains a higher interest rate in the presence of idiosyncratic risk. The easiest way to illustrate this argument is to trace out the implications of land-intensity using Aiyagari (1994)'s canonical asset market clearing diagram in figure 1. The diagram depicts the effect of an increase in the land share on the interest rate in steady state.

Figure 1. Normalized Asset Market Equilibrium



As the land share increases, demand for productive assets from the firm side becomes more elastic, and the $\tilde{a}(r)$ schedule flattens. This induces, ceteris paribus, a higher interest rate, which improves households' ability to smooth consumption.[17]

[17]This is the key benefit of government debt in Aiyagari and McGrattan (1998), which is traded off against a crowding out of capital. Aguiar, Amador, and Arellano (2024) highlight the scope for Pareto improving fiscal policy when the economy is dynamically inefficient with $r < 0$. Incorporating land as a factor of production rules out welfare-improving fiscal policy along the lines of Aguiar, Amador, and Arellano (2024) simply because the real rate cannot fall below zero. Tirole (1985) made this observation in the context of OLG models, see the overview in Hirano and Stiglitz (2025) for recent work along these lines. The proposition here highlights that they could swap land for non-depreciating physical capital and achieve results that are identical in most dimensions.

Three remarks are noteworthy. First, note that proposition 2 does not use the fact that land is in fixed supply, and the result would remain the same for a model with two types of capital where only one type depreciates. Consequently, the key feature that turns land into a superior safe asset, and physical capital into an inferior one, are their different depreciation rates. The realization that land is special not because it is in fixed supply but because it doesn't depreciate is important because it shows that the argument is more generally relevant for any economy that undergoes a secular shift that changes the average depreciation rate.[18]

Second, the result is robust to a number of extensions explored in the appendix. Of particular interest is to allow for differences in the relative price of investment vis-a-vis consumption, which differs along the development spectrum (Hsieh and Klenow, 2007). This extension has no bearing on any of the results. Another extension considers a more general CES production structure with $Y = \left(\left(\psi_\chi^{\frac{1}{\sigma}} T^{\frac{\sigma-1}{\sigma}} + \psi_\nu^{\frac{1}{\sigma}} K^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}\right)^\theta L^{1-\theta}$ where I maintain the Cobb-Douglas assumption between labor and non-labor factors of production in line with the findings of constant factor shares in Gollin (2002). When the elasticity of substitution between land and labor is non-unitary, the relative share, $\frac{\chi(R_T,R)}{\nu(R,R_T)} = \frac{p_T}{RK}$, is no longer constant, and depends on the rental rates. Yet, the demand for productive assets from the production sector otherwise takes the same form as in (12). A sufficient condition for the main result to go through is that capital and land are complements. Similarly, if non-labor and labor inputs are characterized by an elasticity of substitution below unity, then the mechanism is amplified.[19] Moreover, the qualitative result is likely robust to details of the household problem, such as portfolio adjustment frictions and non-convex adjustment costs, as in Kaboski and Townsend (2011) or Kaplan and Violante (2014). This is important as it shows that the argument is, in principle, robust to having fixed costs associated with trading capital and land. This conjecture is based on the convenient separation between the production side's demand for assets $\tilde{a}$ and the households' supply of assets $\tilde{b}$ in (12). Fixed adjustment costs impact the aggregate household asset supply schedule $\tilde{b}$, but don't interact with the shape of the asset demand schedule, which is the novel point I focus on.

Third, the insight that self-insurance improves as interest rates rise is not entirely accurate. The ability to self-insure depends on both the interest rate as well as the endogenous household wealth distribution. The central statistic capturing both aspects is the ratio of safe-to-risky household income. There is no closed-form solution for this object on the household level, but a complementary

[18] The insight that depreciating assets are inferior assets goes back at least to Samuelson (1958) in the context of overlapping generations models. The setup here is quite different and leverages a convenient normalization to focus on income and consumption dynamics in a stochastic environment. Consumption insurance turns out to be sensitive to the share of fixed assets in production, which find a direct empirical counterpart in consumption dynamics in rural economies.

[19] Boppart et al. (2023) find that the agricultural sector becomes more capital-intensive as countries get richer, suggesting a high elasticity of substitution across land, labor, and capital. Their finding reflects a long-run cross-country relationship, which likely differs from elasticity of substitution across factors within country at a point in time. More relevant is the study of Oberfield and Raval (2021), which finds elasticities of substitution between capital and labor below unity.

intuition can be gained from the aggregate safe-to-risky income ratio

$$\frac{rB}{wL} = \frac{\theta}{1-\theta} - \frac{\nu}{1-\theta}\frac{\delta}{r+\delta}. \tag{13}$$

It is easy to see that (13) is falling in the capital share ν, and increasing in the interest rate r. Intuitively, the higher this ratio, the smaller the share of volatile income in the economy. Consequently, for the same amount of income risk and otherwise identical calibration, the capital-intensive urban economy features a lower ratio of safe to risky income, which makes it harder for households to maintain a smooth consumption profile.

I next use both an approximate solution and a fully simulated model to show that household consumption dynamics are indeed sensitive to the share of land in the economy.

2.4 Consumption Volatility and Consumption Inequality

I first focus on the passthrough from persistent labor income shocks to consumption, which is a key object of interest in empirical and theoretical work. The structural passthrough coefficient from permanent income shocks to consumption is defined as

$$\mathbb{E}_i\left[\frac{\Delta \log c_i}{\Delta p_i}\right] = \beta_{c\_p}, \tag{14}$$

where $\Delta \log c$ and Δp is the change in log consumption and log permanent income measured over a discrete time interval.

This passthrough of permanent shocks to consumption depends crucially on the interest rate, which is not a new result. BPP and Kaplan and Violante (2010) discuss how the ratio of financial to human wealth matters for the passthrough. The more appropriate, yet slightly different, concept I focus on is based on the flow income generated by financial assets vis-a-vis human capital. To see why, focus on the case of financially wealthy households, so the consumption functions becomes approximately linear (Benhabib, Bisin, and Zhu, 2015)

$$c_t = \frac{\tilde{\rho} + r(\gamma - 1)}{\gamma}\left(a_t + E_t\right), \tag{15}$$

where $E_t = \mathbb{E}_t\left[\int_t^\infty e^{-rs} w h_s ds\right]$ represents the expected present discounted value of human wealth. If h_s follows a random walk, the expression would simplify to $c_t = \frac{\tilde{\rho}+r(\gamma-1)}{\gamma}\left(a_t + \frac{wh_t}{r}\right)$. The passthrough from permanent income shocks to consumption growth in (14) can then be expressed in discrete increments $\frac{\Delta c}{c}$ using (15)

$$\frac{\Delta c_t}{c_t} = \underbrace{\frac{ra_t}{ra_t + wh_t}}_{\text{trans. passthrough}} \frac{\Delta a_t}{a_t} + \underbrace{\frac{wh_t}{ra_t + wh_t}}_{\text{perm. passthrough}} \frac{\Delta wh_t}{wh_t}. \tag{16}$$

Change in the financial asset position, $\frac{\Delta a_t}{a_t}$, proxies for a transitory shock,[20] and Δwh_t is a permanent shock given the random walk in household labor income. Equation (16) shows what would correspond to the BPP passthrough coefficients for transitory and permanent shocks using $\frac{\Delta c_t}{c_t} \approx \Delta \log c$ and $\frac{\Delta wh_t}{wh_t} \approx \Delta p$.[21]

Clearly, this passthrough depends on the ratio of financial income to labor income, which, in turn, is a function of both the interest rate and the endogenous asset distribution, and is lower when the share of financial asset income is higher. It is now easy to see why rural households in a high-interest-rate environment will appear more insulated against persistent shocks, even if households in each sector were exposed to identical stochastic processes.

The flip side of high insurance from persistent labor income shocks is low income mobility. High interest rates ensure that financial income takes a larger share of total household income. Since financial income offers a safe return, while human capital is volatile, the rise and fall of dynasties driven by persistent income shocks will be slower in the high-interest-rate environment. Differences in initial endowment of financial wealth translates into relatively high consumption inequality for young cohorts, while the fanning out of consumption inequality as cohorts age is suppressed. Social mobility is lower in rural.

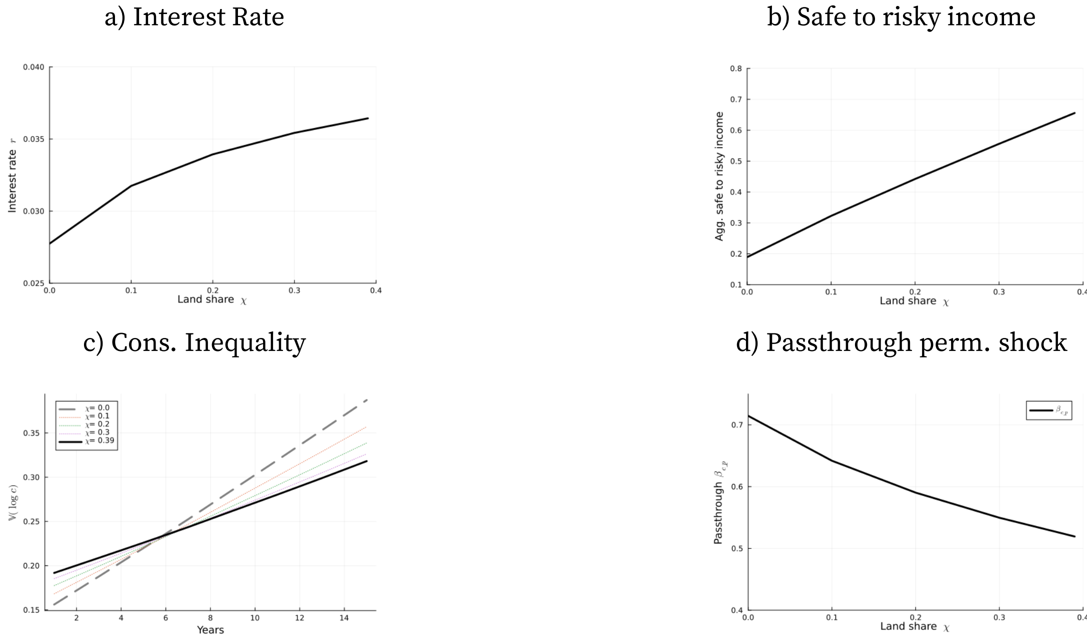
There are no results to characterize consumption inequality in incomplete market models analytically, so the previous derivation is only heuristic. I thus solve a version of the baseline model to demonstrate the impact of a changing land share on equilibrium interest rates and safe-to-risky income ratios. I provide a more detailed quantification in the next section; here, I want to highlight that for a reasonable calibration, a varying land share from 0.0 to 0.4 has substantial consequences for consumption volatility, inequality, and the pass-through of income shocks. To do so, I set informal insurance to zero ($\kappa = 0$) and hold the income process and labor share fixed. To study consumption dynamics, I simulate the evolution of income and consumption of a newborn cohort where there initial asset endowment is drawn from the stationary distribution consistent with the random-death process.

Figure 2 plots the results. The upper left panel displays the aggregate ratio of safe to risky income in the economy, which is increasing in the land share. Note that this ratio is bounded by $\frac{\theta}{1-\theta}$ when land is the only asset in the economy. This ratio, in principle, can turn negative when the marginal

[20] In the continuous time setup this transitory shock is somewhat ill-defined, and the reader can think of it as the case where the passing shock has a high arrival rate λ_ϵ. The discrete time version is more natural here, see Kaplan and Violante (2022) for a discussion.

[21] In the presence of borrowing constraints, advance information, or a misspecified income process, the BPP estimates do not generally coincide with this structural parameter, see Kaplan and Violante (2010).

Figure 2. Land Share, Interest Rates, and Consumption Dynamics



The calibration is based on $\sigma_p^2 = .015$, $\lambda_\epsilon = 2$, $\sigma_\epsilon^2 = .2$, $\delta = .07$, $1 - \chi - \nu = .6$ and there is no informal insurance, $\kappa = 0$.

product of physical capital is below the golden rule level defined by $\frac{\partial F}{\partial K} = \delta$. The safe to risky income ratio finds its mirror image in the equilibrium interest rate depicted in the upper right panel. The interest rate is clearly sensitive to the land share as it ranges from 2.7% to 3.7%. This is the quantitative equivalent of proposition 2. In addition, I verify that the difference between the interest rate for the no-land economy ($\chi = 0$) vs. the most land-intensive economy is increasing in the degree of income risk, i.e., $\frac{\partial^2 r}{\partial \chi \partial \sigma^2} > 0$. Intuitively, for low levels of income risk, the model's behavior is close to the complete markets benchmark. For high levels of income risk, land intensity has a large impact on equilibrium interest rate.[22]

I next compute the implied consumption dynamics using the entire cross-section of simulated households. The bottom left panel plots the evolution of the log variance of consumption for a newborn cohort. Consumption inequality of newborn cohorts is higher in cases where there is a high land share. This reflects that inequality early in life is partly driven by asset endowments, which are more important when the interest rate is high. Conversely, the rise in consumption inequality over the life cycle is suppressed since high returns to safe financial wealth reduce social mobility. For a capital-intensive economy with low interest rates, labor income is a relatively more important determinant

[22] For excessive amounts of risk, one can show that the gap between a land-only and capital-only economy can be as large as the depreciation rate, δ. The reason is that the interest rate in the land-only economy is bounded from below by zero, while it is bounded from below by δ for the capital-only economy.

of lifetime income. And since labor income features a random walk, income and consumption fan out more strongly over the life cycle, as indicated by a steeper slope in the bottom left panel.[23]

The bottom right panel plots the structural passthrough coefficient from permanent income shocks to consumption, log on log. The higher the land share, the lower the passthrough and the higher the degree of consumption insurance against persistent shocks. This effect is entirely driven by the changing equilibrium interest rate. Inspecting the scales of the y-axis of the left and the right plot, the reader can verify that the land share has a quantitatively large effect on this passthrough coefficient.

I next quantify a version of the model matched to South African household-level data to explore how quantitatively important land intensity is in explaining differences in consumption dynamics between rural and urban households in South Africa.

3 Quantification

3.1 Parameterization of the Model

I now describe the parameterization of the model.

Production, Preferences, Death Shock. Urban production follows the standard neoclassical model with a reproducible capital share of 40% and a labor share of 60%. I follow Hansen and Prescott (2002) and set the land share in rural to 30%, while labor and capital share are 60% and 10%, respectively. The land share is broadly consistent with estimates for the UK at the eve of the industrial revolution from Allen (2009) or Clark (2010), and substantially lower than the land share suggested in Weil and Wilde (2009), which contains more recent estimates for a set of African developing economies and a discussion of the measurement challenges associated with computing land shares in rural environments. I thus view my choice as a conservative one broadly in line with previous literature. Measured labor and non-labor shares (including returns to capital and land) across poor and rich countries are roughly stable after correcting for self-employment, see Gollin (2002).

I use a depreciation rate of 7%. The discount factor is 2.5%, and the coefficient of relative risk aversion equals 2, which are standard values in the literature. The arrival rate of death shocks equals $\phi = .025$, which ensures an average working life of 40 years.

Income Process and Informal Insurance. I pick the parameters governing the income process to be largely consistent with the results in Trouvain (2025b), which estimates the stochastic process in (1) separately for rural and urban households in South Africa. The theoretical moments implied by the postulated income process are

$$\mathbb{E}\left[\hat{y}_t \hat{y}_{t+k}\right] = \sigma^2_{\text{int}^*} + \sigma^2_p \cdot t + e^{-\lambda_\epsilon k}\sigma^2_\epsilon + \mathbb{1}_{\{k=0\}}\sigma^2_{x,t} \tag{17}$$

[23] Whether a newborn has a high or a low asset position is orthogonal to their initial labor income. There is strong evidence of persistence in human capital across generations, which I abstract away from to most cleanly illustrate the role of asset endowments and labor income risk in generating rural-urban differences in social mobility.

where $\mathbb{1}$ is an indicator function accounting for classical measurement. The moments are fully determined by the set of parameters $\theta = \{\sigma^2_{\text{int}^*}, \sigma^2_p, \lambda_\epsilon, \sigma^2_\epsilon, \{\sigma^2_{x,t}\}\}$. The parameter $\sigma^2_{\text{int}^*}$ captures initial dispersion and depends on inequality in labor income at birth (σ^2_0) as well as the average age of a cohort since persistent shocks accumulate over time. To keep the model focused on the role of land as a factor of production, I set the volatility of persistent shocks to be identical across rural and urban and equal to .01, i.e., $\sigma^2_p = .01$.[24] I also set average destruction of human capital at birth, c_0, and initial labor income inequality, σ^2_0, equal across sectors.

In contrast, the arrival rate of imperfectly transitory shocks, λ_ϵ, differs substantially across sectors. Imperfectly transitory shocks are larger and more persistent in rural South Africa. Taking this into account is important as it leads to a misspecification of the popular BPP estimator derived in detail in Trouvain (2025b). Intuitively, arrival rates are high in urban, which renders the income process indistinguishable from the standard transitory-persistent process used in BPP. In rural, however, arrival rates are lower. Consequently, part of the imperfectly transitory shock is wrongly attributed to persistent shocks, inducing a downward bias in the BPP estimator.

In the baseline model, I assume that informal insurance is zero in both urban and rural sector ($\kappa = 0$). I will then ask what degree of informal insurance is necessary to match low passthrough estimates, which means the parameter κ serves as a residual factor. Table 1 summarizes the calibration.

Table 1. Summary Baseline Parameters

Parameter	**Description**	**Rural**	**Urban**	**Target/Source**
ρ	Discount factor	0.02	0.02	Standard value
ϕ	Death shock	0.025	0.025	Avg. work life
γ	Risk aversion	2.0	2.0	Standard value
δ	Capital depreciation	0.07	0.07	Standard value
ν	Capital share	0.1	0.4	Hansen/Prescott (2002)
χ	Land share	0.3	0	Hansen/Prescott (2002)
κ	Informal insurance	0.0	0	See text
σ^2_p	Variance perm. shock	0.01	0.01	Trouvain (2025)
λ_ϵ	Arrival trans. shock	0.6	3.0	Trouvain (2025)
σ^2_ϵ	Variance trans. shock	0.25	0.2	Trouvain (2025)
σ^2_0	Variance init. p	0.13	0.13	Trouvain (2025)
c_0	Avg. init. p	-0.4	-0.4	Trouvain (2025)
$\sigma^2_{y,error}$	Income meas. error	0.1	0.1	Trouvain (2025)
$\sigma^2_{c,error}$	Cons. meas. error	0.15	0.15	Trouvain (2025)

I have chosen a conservative calibration in terms of preferences and income process. Regarding preferences, I could have relied on Epstein and Zin (1989) preferences to separate the intertemporal elasticity of substitution from risk aversion. One could then entertain a higher degree of risk aversion, as in Aguiar, Amador, and Arellano (2024). The more risk-averse households are, the more

[24] In the data, the persistent volatility is not precisely estimated, and setting them equal across sectors helps isolate the role of land. In Trouvain (2025b), I compile evidence from additional data sources to argue that the volatility of persistent shocks is actually higher in the urban sector.

critical land becomes in sustaining high interest rates. Regarding the income process, much of the literature estimates a larger volatility of persistent income shocks in developing economies,[25] which would elevate the role of land in keeping interest rates high in the presence of idiosyncratic risk. Lastly, I have chosen a relatively low depreciation rate of 7%, compared to recent quantitative work by Aguiar, Amador, and Arellano (2024). Increasing the rate of depreciation amplifies the results as stated in proposition 2.

Simulation. To simulate model-based moments, I proceed as follows. I simulate household income from their time of birth onwards. Newborn households draw their initial asset endowments from the stationary distribution, and I use the stochastic process described earlier to simulate household's labor income dynamics absent death shocks. That is to say, in the simulated data, death shocks don't materialize even though households use the effective discount factor $\rho + \phi$ to make saving-consumption choices. This implementation is both consistent with the theoretical model and with the empirical design, since household income dynamics are based on a balanced panel of surviving households.

I then obtain consumption and the evolution of household wealth using the solution to the household problem together with the simulated income process. I take the log of consumption and add mean-zero normally distributed measurement error. I do this over five biennial waves so that the simulated data mimics the South African household-level data, and I approximate the continuous-time process using small discrete time steps of $dt = .1$.[26]

When computing simulated passthrough coefficients, I match the average age of households to the age of households in the data, which is important since the distribution is fanning out as cohorts age. The variable age_min represents the average age of households in the first wave, normalized by the sample age cutoff of 27. Table 2 summarizes the details, and contains information underlying the computational routine to solve the model.

Table 2. Details Simulation

	Simulation
N	50000
Waves	5
dt	0.1
Rural min. age	11.2
Urban min. age	10.5
Age child	12

The finite difference scheme, using the method from Achdou et al. 2022, operates on the following grid space. Log income consists of two linearly spaced grids, p_grid = LinRange(-2.5 ,2.5 ,15), ϵ_grid = LinRange(-1.5 ,1.5 ,7). The asset grid is initially log-linearly spaced and turns into a linearly-spaced grid for more wealthy households using 100 grid points with a lower bound of zero. Note that household consumption choices and the evolution of assets is based on the budget constraint implied by W^*. In contrast, raw income is measured in terms of W, and the gap between the two is accounted for by informal insurance when $\kappa > 0$.

[25] See, for instance, Santaeulalia-Llopis and Zheng (2018). The discrepancy is explained by imperfectly transitory shocks, which are important in the rural sector, see Trouvain (2025b).

[26] Since the survey reports income and consumption on a monthly basis, issues of time aggregation can be ignored.

Simulated Moments. I focus on the passthrough of permanent shocks to consumption, the rate at which consumption inequality increases over the life cycle, and intergenerational persistence in log consumption across cohorts.

Regarding the passthrough from income shocks to consumption, I compute the structural passthrough coefficient $\beta_{c\_p} = \mathbb{E}\left[\frac{\Delta \log c}{\Delta p}\right]$ straight from the model where I observe p. I also compute the popular $\beta_{c\_p}^{\text{BPP}}$ coefficient defined as

$$\beta_{c\_p}^{\text{BPP}} = \frac{cov\left(\Delta c_t, \Delta y_{-2} + \Delta y_t + \Delta y_{+2}\right)}{cov\left(\Delta y_t, \Delta y_{-2} + \Delta y_t + \Delta y_{+2}\right)}, \tag{18}$$

where subscripts -2 and +2 refer to lagged and leading growth rates relative to the growth rate in t, here adjusted to the biennial nature of the South African data.[27] When interest rates are low, preferences are quadratic, households are sufficiently far away from the borrowing constraint, and transitory shocks are fully transitory, the popular passthrough coefficient from BPP would equal $\beta_{c\_p}^{\text{BPP}} = 1 - \kappa$. Under these assumptions, the BPP estimator would identify the degree of informal insurance. The fanning out of consumption inequality simply requires computing the log variance of consumption for the same cohort as households age, i.e., $\sigma_c^2\left(a\right) = \mathbb{V}\left(\log c | a_i = a\right)$.

Lastly, I compute intergenerational elasticities of log consumption across households using the simple log-linear regression

$$\beta_c^{\text{IGE}} = \frac{Cov\left(\log c_{\text{child},} \log c_{\text{parent}}\right)}{\mathbb{V}\left(\log c_{\text{parent}}\right)}, \tag{19}$$

where log child consumption is measured per year, and 12 years after birth (age 39), while parent consumption is measured at death. The parent-child connection derives from a new cohort taking over the assets of the old cohort, and bequests are accidental. Incorporating bequest motives would amplify the main findings, as it would raise savings pressure in the economy. I assume consumption of parents is measured without error to focus on the implications of differences in land intensity for properly measured intergenerational elasticities. While classical measurement error tends to push the estimated intergenerational elasticity towards zero, in practice, intergenerational elasticities are usually computed based on educational attainment, which reduces the impact of measurement error.

3.2 Results

I first analyze how the model-based passthrough compares to empirical estimates and use this moment to pin down the degree of informal insurance. I then decompose the contribution of land intensity and informal insurance in generating low passthroughs, and compute consumption inequality

[27] In practice, BPP use all income and consumption moments to efficiently estimate this passthrough using a GMM routine. Moreover, The expression works for annual and biennial data when the transitory shock is fully transitory. In many applications the transitory shock is modeled as an MA(1) process in discrete time, in which case (18) remains appropriate for the case of biennial data.

over the life cycle. Lastly, I explore the implications of land intensity on intergenerational mobility and compare it to empirical estimates.

Passthrough Persistent Shocks. The empirical estimates for the persistent BPP passthrough coefficient are reported in table 3. The estimated passthrough for the rural sector is extremely low, around .2, yet in line with the previous literature.[28] The estimated passthrough is much higher for the urban sector, around .6, which is very close to the estimate for US households in BPP.

Table 3. BPP Passthrough Persistent Shocks in South Africa

	Rural	Urban
Estimate	0.22	0.62
(SE)	(0.26)	(0.32)

Results are based on Trouvain (2025b).

I next compute model-based moments by replicating the empirical design on simulated data. Column one in table 3 reports the passthrough of persistent shocks for urban households. Row one reports the structural coefficient β_{c_p}, and row two reports the BPP passthrough coefficient $\beta_{c\_p}^{BPP}$ using the moment condition in (18). Both the structural coefficient and the BPP estimator agree on a passthrough of .74, which is not statistically different from the empirical estimate.

Table 4. Model-Implied Passthroughs

	Urban	Rural $(\chi = 0, \kappa = 0)$	Rural $(\chi = 0.3, \kappa = 0)$	Rural $(\chi = 0.3, \kappa = 0.2)$
β_{c_p}	0.74	0.72	0.57	0.49
$\beta_{c\_p}^{BPP}$	0.75	0.4	0.31	0.26

Column two is based on an economy that features imperfectly transitory shocks as the baseline rural economy, but is otherwise capital-intensive and absent informal insurance. I highlight this case first so that the contribution of land intensity, relative to differences in the income process, becomes obvious. The structural passthrough coefficient of .72 is extremely close to the urban one, and the minimal discrepancy is explained by the larger precautionary motive induced by imperfectly transitory shocks. In contrast, the BPP estimator equals .4 and is substantially below the structural passthrough β_{c_p}. The reason is that imperfectly transitory shocks are falsely attributed to persistent shocks. Since the consumption response to imperfectly transitory shocks is muted, the measured passthrough is low.[29] Even so, the passthrough is still twice as large as the empirical estimate.

Column three adds a realistic degree of land intensity of .3 for the rural sector while maintaining zero informal insurance. The structural passthrough coefficient falls substantially by about 15 per-

[28] See De Magalhaes and Santaeulalia-Llopis (2018), Santaeulalia-Llopis and Zheng (2018) or Attanasio et al. (2025) for recent work finding very high degrees of insurance in rural environments.

[29] See Trouvain (2025b) for a formal derivation of this bias.

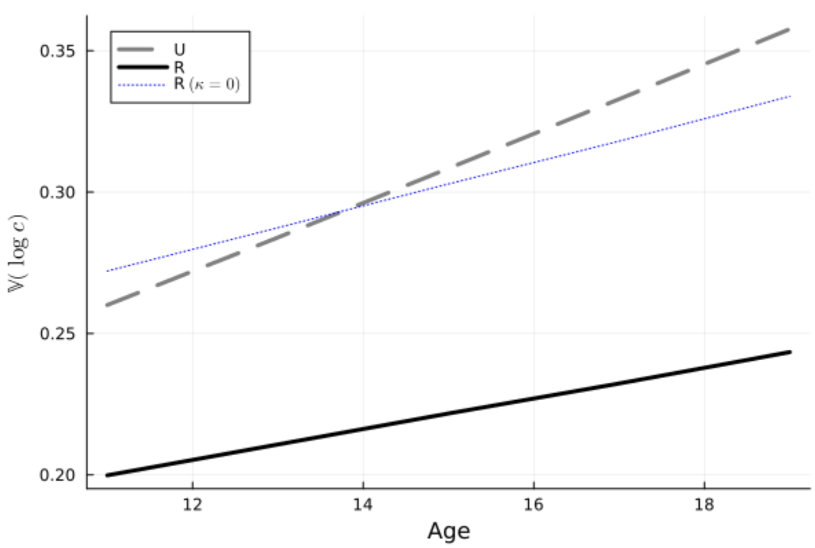
centage points. This is a substantial reduction, and together with the misspecified income process delivers a BPP estimate of around .3.

Column four then allows for informal insurance by setting $\kappa = .2$. This reduces the structural passthrough coefficient by an additional 10 percentage points. Note that the implied BPP passthrough coefficient now is approximately .25, and very close to the empirical estimate. Given the large standard errors around the empirical estimate, it is clear that no sharp identification is achieved by targeting this coefficient, and one could have argued $\kappa = 0$ describes the data just as well. Life cycle inequality patterns provide a separate moment to identify κ, which will be consistent with $\kappa = .2$.

One way to quantify the role of land vs. informal insurance is to simply split the fall of the passthrough coefficient from .72 to .49 into land and informal insurance margin based on the results in table 4. About two-thirds of the lower passthrough can be accounted for by the role of land in a general equilibrium model.

Consumption Inequality over the Life Cycle. I next simulate the log variance of consumption as cohorts age. As explained in Deaton and Paxson (1994), this object is of interest because it provides yet another complementary way to measure consumption insurance. Table 3 computes the evolution of life cycle inequality implied by the baseline model for urban and rural households. Since persistent

Figure 3. Consumption Inequality



This plot is based on simulated data and depicts the fanning out of consumption inequality over the life cycle. The gap between the dotted line and the thick black line is due to the role of informal insurance in rural. Simulated consumption is measured without error for this plot.

income shocks are the same across rural and urban sector, a naive guess would have been that inequality increases at the same rate over time. However, consumption inequality grows at markedly different rates, as indicated by the different slopes of the grey dashed line and the blue dotted line. Furthermore, initial inequality is higher in the rural economy without informal insurance, as the blue dotted line lies below the dashed line for cohorts that have been in the labor market for less than 13 years. The reason is that asset endowments are determined at birth. And since assets pay a relatively higher return in rural, consumption responds more strongly to differences in initial asset endowments. This ultimately translates into higher consumption inequality at birth. Over time, asset income is much more stable than stochastic labor income. Since labor income is relatively more important in the urban sector, within-cohort inequality grows at a higher rate in the urban economy.

In the data, rural consumption inequality for young households is not higher than urban consumption inequality.[30] The model replicates this feature of the data due to the role of informal insurance, with $\kappa = .2$, which gives rise to the thick black line. This line is not only below any other line, but also features a flatter profile, which means consumption inequality grows at a lower rate.

Intergenerational Persistence. I next study the implications of the theory for intergenerational persistence. To do so, I compute the regression coefficient of log child consumption on log parent consumption in the simulated data. Table 5 reports the results and, again, decomposes differences based on imperfectly transitory shock, land intensity, and informal insurance. I also report the equilibrium interest rate in row two, which is key to understanding the differences in intergenerational persistence.

Table 5. Model-Implied Intergenerational Persistence in Consumption

	Urban	Rural $(\chi = 0, \kappa = 0)$	Rural $(\chi = 0.3, \kappa = 0)$	Rural $(\chi = 0.3, \kappa = 0.18)$
β_c^{IGE}	0.2	0.24	0.43	0.43
r	3.25 %	2.67 %	3.57 %	3.83 %

The baseline model implies a relatively low intergenerational elasticity of .2 in the urban sector, as shown in column one. Column two produces a slightly higher intergenerational elasticity in the rural sector. In contrast, columns three and four, which feature land-intensive production as well as informal insurance, generate intergenerational elasticities in consumption of around .4.

Note that I do not allow for any direct dependence of a child's labor income type on parents' labor income type, so the persistence is entirely driven by the more important role of wealth in rural. Both the greater importance of financial wealth, which is partly inherited and a more powerful determinant of consumption as asset returns are higher, and the relatively minor role assigned to human capital, which is a fickle component of income, lead to high intergenerational persistence in consumption in the rural sector. Low risk exposure and low social mobility are two sides of the same

[30] There is a subtlety here as to whether inequality is measured as a residual after partialling out observables such as human capital, race, and so on. The inequality estimates I target pertain to this residual inequality. However, even unresidualized inequality in South Africa displays a similar life-cycle pattern. Consumption inequality is lower in rural areas, even among young households, and rises more sharply with age in urban areas.

coin.

Perhaps surprisingly, informal insurance matters little for intergenerational persistence. The reason is that two forces cancel each other out. On the one hand, lower overall inequality reduces the covariance between parent and child consumption. On the other hand, overall inequality falls, which reduces the variance in the denominator of (19).

The findings from this parsimonious model line up well with a growing literature documenting intergenerational elasticities, typically focused on educational attainment, across countries and rural and urban sector, see Weide et al. (2021) and Alesina et al. (2021). In the absence of parental consumption measures, I also rely on more readily available education measures to compute intergenerational persistence in South Africa, separately for rural and urban households.[31] Table 6 reports estimates for intergenerational persistence in years of schooling. The rural-urban gap in intergenerational persistence is .2 and lines up exactly with the implied gap in the model.

Table 6. Regression of years of schooling – Parent vs. Child

	Rural	Urban
Estimate	0.53	0.33
(SE)	(0.016)	(0.019)

Estimate is based on a regression of child years of schooling on parent years of schooling in South Africa including cohort, year, sex, and province fixed effects. The rural-urban gap is statistically significant (p<0.01) and details are deferred to the appendix. I also offer an income-based estimate using the method of Björklund and Jäntti (1997). Additional estimates of intergenerational mobility can be found in Piraino (2015), Sinha (2016), Fan, Yi, and Zhang (2021), and Syrichas (2022), which are largely consistent with my estimates.

Intergenerational persistence appears to be overall higher in the data, which is unsurprising since I have omitted many other features that likely contribute to intergenerational persistence, such as genetics, family values, or neighborhood effects. I focus on the role of wealth in producing higher intergenerational persistence in consumption, which crucially depends on the interest rate and is thus sensitive to the land share. This channel is also distinct from and complementary to the much-studied link between borrowing constraints and (lack of) human capital investments.[32]

3.3 Additional Evidence Consistent with the Mechanism

A key implication of the theory is that asset returns are relatively high in land-intensive economies. This observation is consistent with a vast literature in development economics that finds high returns to capital in rural settings, see for instance Udry and Anagol (2006) and Blattman, Fiala, and Martinez (2014). Of particular interest is a recent meta study by Crosta et al. (2024), which examines the impact of unconditional cash transfers. Through the lens of the model, such transfers add to the household

[31] Note that schooling, together with income, is the strongest predictor of household consumption in the data.

[32] See Atkinson (1983), Becker and Tomes (1986), Loury (1981), Galor and Zeira (1993), and Lochner and Monge-Naranjo (2011).

assets stock. Interestingly, the authors find a striking difference in the long-term effect of cash transfers on assets between rural and urban households, with the effect being larger for rural households. The fact that the RCT literature reports persistent positive effects with relatively larger increases in asset positions of rural households compared to urban ones for the same intervention suggests that the average rural household can channel their income into productive assets. Through the lens of the model, doing so is easier in rural than in urban precisely because high rural interest rates represent favorable intertemporal terms of trade.[33]

A second piece of evidence comes from the development accounting literature, particularly Caselli and Feyrer (2007), which computes the marginal product of capital across countries. After adjusting for differences in reproducible factor shares and the relative price of capital, the study finds that the marginal product of capital is roughly equal across countries, consistent with the conjecture in Lucas (1990). Note, however, that because land is such a big part of the wealth stock in rural economies, the net asset return, given identical marginal products, ought to be higher in countries with a large rural share. This follows because the net asset return is higher when depreciation is lower, given a fixed marginal product.[34]

3.4 Non-Tradable Land

I next generalize the model to include non-tradable land. To what extent land is tradable in poor rural economies context-specific, and controversial.[35] The model extension here is not designed to capture the richness of land tenure systems in developing economies. Instead, I offer a straightforward way to incorporate a share of subsistence farmers with non-tradable land endowments, which is to show that land intensity still matters in general equilibrium.[36]

There are two crucial implications of incorporating non-tradable land. First, if some land is non-tradable, one needs to adjust the total supply of traded land accordingly. Second, once a specific plot of land is non-tradable, one has to consider idiosyncratic capital risk since a law of large numbers is unlikely to hold for small plots. This plot-level risk is still distinct from aggregate risk, which is beyond the scope of the paper. The methods developed in Deaton and Paxson (1994), Townsend (1994), or Blundell, Pistaferri, and Preston (2008) have nothing to say about the role of aggregate risk since aggregate time effects are partialled out. Abstracting from aggregate risk remains a popular modeling

[33]The findings from the development literature contrast with models of entrepreneurial risk and financial frictions, see Song, Storesletten, and Zilibotti (2011) or Buera and Shin (2013). In such models, a gap emerges between the relatively low asset returns that households can obtain on their safe assets and the high returns of a small group of entrepreneurial households cut off from financial markets.

[34]In Caselli and Feyrer (2007), the depreciation rate is assumed to be constant across countries, which is unlikely to be true given the special role of land in developing economies.

[35]Arteaga et al. (2025) provide evidence of relatively quick changes in land ownership despite rigid land markets in Uganda. See Pande and Udry (2005) and Deininger and Binswanger (2001) for insightful reviews highlighting the complexity and context-specificity of land tenure systems in developing economies.

[36]Making progress on fitting richer incomplete market models to specific local contexts is an important task not taken up here. Any such attempt will have to take seriously the role of land in general equilibrium, which, thus far, has been ignored.

choice because idiosyncratic risk appears an order of magnitude larger than aggregate risk, which is true even in developing economies. [37]

Formally, suppose that households are endowed with a share $\zeta_i \geq 0$ of non-tradable land such that the aggregate share of non-tradable land is smaller one, $\int \zeta_i di = \zeta < 1$. I otherwise maintain the same setup as before with no informal insurance. In this scenario, non-tradable land ζ_i appears in the budget constraint as an additional idiosyncratic state variable

$$\dot{b} = rb + R_{T,i}\zeta_i + wh_i - c. \tag{20}$$

The returns to non-tradable land, $R_{T,i}$, now incorporate idiosyncratic land risk, which is modeled as follows. I introduce stochastic land-endowment shocks A_i, potentially capturing idiosyncratic weather shocks

$$R_{T,i}\zeta_i = R_T A_i \zeta_i,$$

where A_i is a stationary stochastic process orthogonal to ζ_i, with mean one, $\mathbb{E}[A_i] = 1$.[38] Note that the budget constraint in (20) is unchanged but the randomness now depends on both labor, h_i, and non-tradable land return $R_i\zeta_i$. It is convenient to rewrite the budget constraint using $w\widehat{h} = w\left(\frac{R_T}{w}\zeta_i A + h\right)$ such that

$$\dot{b} = rb + w\widehat{h} - c. \tag{21}$$

Equation (21) looks just like the standard budget constraint with a subtle but important redefinition of household labor income, $w\widehat{h}$, which now includes potentially risky returns to non-tradable land. Crucially, the way income risk is measured in the data is consistent with (20) since I have incorporated own-consumption and agricultural sales into household income. Consequently, no adjustments are needed on the household side.[39] Furthermore, the household problem is still homogeneous of degree one in the wage rate.[40]

The only adjustment left to be made is to account for the reduced supply of traded land, $K +$

[37] The role of aggregate risk also relates to a classic argument in Newbery and Stiglitz (1984) positing that the value of agricultural production in autarkic economies is implicitly insured through a market clearing mechanism. Arguments along these lines, while relevant, pertain to aggregate shocks since individual idiosyncratic shocks do not move equilibrium prices.

[38] The orthogonality assumption is without loss. If A_i and ζ_i are correlated, one could redefine the problem and think of effective land as $\widehat{\zeta}_i = \zeta_i \mathbb{E}[A_i|\zeta_i]$. The stochastic component then would only include the normalized term $\frac{A_i}{\mathbb{E}[A_i|\zeta_i]}$.

[39] When computing average efficiency units of labor per household, note that one is confounding the role of non-tradable land and actual labor income. I show in the appendix how to compute average efficiency units correctly in this scenario.

[40] To see this, note that capital and labor are mobile, so the return to land is equalized everywhere, including non-tradable land, and $R_T = \chi Y$ still holds for the economy as a whole. This implies $\frac{R_T}{w} = \frac{\chi}{1-\theta} L\tilde{h}$. Holding the aggregate labor supply, $L\tilde{h}$, fixed, it is easy to see that an increase in the wage rate doesn't impact the generalized notion of household human capital that now includes non-tradable land. At this point, lemma 1 applies to the wage rate, and the normalized aggregate asset supply function retains the same shape form as before, with the original stochastic process now capturing both labor income and asset income risk. There is a subtle issue whether asset demand is homogeneous of degree one in L. Conditional on the stochastic process in $\widehat{h}$, the answer is yes. However, changes in the size of the economy, holding land fixed, may change the stochastic process $\widehat{h}$. This issue is irrelevant for implementation, as the stochastic process associated with $\widehat{h}$ is directly inferred from the data and held fixed in all exercises.

$p_T(1-\zeta) = B$, which in normalized form equals

$$\frac{1}{r}\left(\frac{\theta}{1-\theta} - \zeta - \frac{\nu}{1-\theta}\left(\frac{\delta}{r+\delta} - \zeta\right)\right) = \tilde{b}. \tag{22}$$

For the case of $\zeta = 0$, I obtain the baseline model. For the case of $\zeta > 0$, the left-hand side of (22) is smaller as fewer tradable units of land are available.

Table 7 reports the results, where I compare the baseline rural scenario with different degrees of non-tradability ranging from 10% to 30%.

Table 7. Robustness exercise with non-tradable land

	$\zeta = 0$	$\zeta = .1$	$\zeta = .3$
β_{c_p}	0.57	0.59	0.64
β_c^{IGE}	0.43	0.4	0.33

Column one is the baseline without insurance, $\kappa = 0$, which is maintained throughout. Column two and three consider a scenario where 10% and 30% of land are non-tradable.

When only 10% of land is non-tradable, the results change very little, and the passthrough of around .58 is substantially below the passthrough of income shocks of .75 in the urban sector, whilst the intergenerational elasticity of consumption remains substantially higher in rural. In the extreme case of less than half of all land being non-tradable, rural consumption dynamics appear similar to the urban sector in terms of the passthrough of permanent income shocks to consumption. The main point of the paper is, of course, to explain the differences in consumption dynamics. Financial frictions and non-tradability of assets only make it harder to confront the empirical facts, which is why I don't elevate these aspects.

I emphasize that what matters for the robustness of the results is whether there is a relative abundance of low-depreciating assets in rural, not so much what exactly gives rise to the household income dynamics measured in the data. Land clearly satisfies this criterion, but there are other assets in rural areas –think of the role of gold in rural India– that could play this role.

4 Aggregate Savings and Interest Rates

I conclude the paper by highlighting an important macroeconomic implication of the model, specifically the positive correlation between the size of the rural sector and aggregate savings. In an influential paper, Laitner (2000) argues that rising aggregate savings rates along the development spectrum may be related to land-intensive production at early stages of development. The reason is that only physical capital investment is counted towards aggregate savings in the national accounts, while land valuation gains are ignored. As countries shift from land-intensive to capital-intensive production, savings increase mechanically due to this accounting practice, even when individual household saving rates remain constant. I revisit this idea quantitatively, which is amplified when taking account of the interaction of income risk, self-insurance, and land intensity.

First, I compute aggregate sectoral saving rates implied by my model for each sector, and decompose these sector savings rates into two margins. The first margin represents the pure effect of differences in the structure of production assuming markets are complete using $r = \rho + \phi$, while the second margin takes into account that, in the presence of idiosyncratic income risk, land-intensity matters for effective household insurance. This can amplify the gap in aggregate savings across sectors due to relatively high precautionary savings pressure in urban. Table 8 shows that these effects are large, and the urban saving rate is roughly 20% larger than the rural one.

Table 8. Agg. Savings across Sectors

	Urban	Rural $(\chi = .3, \kappa = 0)$	Rural $(\chi = .3, \kappa = .18)$
$s_{\text{agg}}^{\text{complete}}$	24.35	6.09	6.09
$s_{\text{agg}}^{\text{Aiyagari}}$	27.32	6.63	6.46

The results are based on the baseline calibration, see table 1.

Note that this in no way implies that net household saving rates differ across sectors – in the stationary environment these have to add up to zero by construction. Nonetheless, higher depreciation rates in urban necessitates higher investment, and thus higher aggregate savings. In fact, aggregate sectoral saving rates in a stationary closed economy by construction equal $s_{\text{agg},j} = \frac{K_j \delta}{Y_j}, j \in \{\text{R}, \text{U}\}$. Idiosyncratic risk increases the aggregate saving rate in the urban sector by about three percentage points, surprisingly close to the original finding in Aiyagari (1994). Relative to Aiyagari (1994), the results highlight that the structure of production, and depreciation rates are of first order importance for this finding. Income risk in rural only raises the aggregate saving rate by half of a percentage point.

Next, I explore the cross-country implications of the theory to assess to what extent the parsimonious model can match differences in aggregate savings rates across countries. To take the model to the data in the most straightforward way, assume each country consists of a rural and an urban sector existing in autarky.[41] To proxy for the size of the rural economy and consistent with model and accounting practice, I simply use the nominal value added share of agriculture $\omega_{\text{R}} := \frac{Y_{\text{R}}}{Y_{\text{R}} + Y_{\text{U}}}$. With Cobb-Douglas production, the aggregate savings rate equals

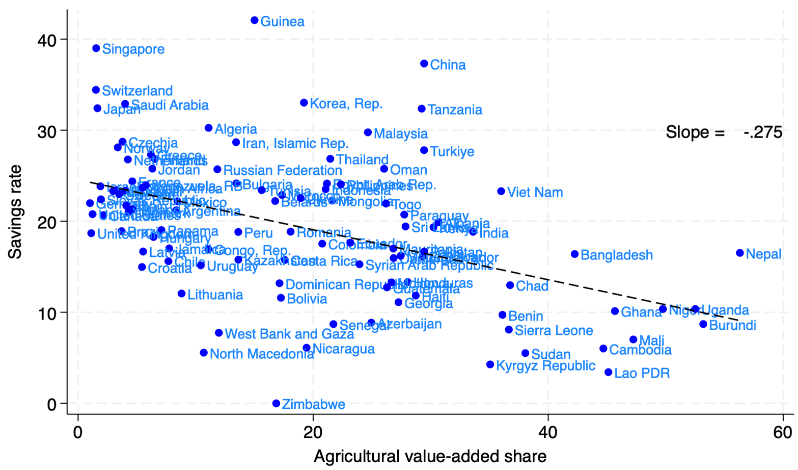
$$s_{\text{agg}} = \frac{\delta}{r_{\text{U}} + \delta} \nu_{\text{U}} - \omega_{\text{R}} \left(\frac{\delta}{r_{\text{U}} + \delta} \nu_{\text{U}} - \frac{\delta}{r_{\text{R}} + \delta} \nu_{\text{R}} \right), \tag{23}$$

[41] Differences in the relative price of capital goods, which are large across countries (Hsieh and Klenow, 2007), can be incorporated without any consequences for consumption and income dynamics as well as aggregate saving rates as shown in the appendix.

which depends on the relative size of each sector, sector specific capital intensity, depreciation, and interest rates ν_j, δ, r_j for $j \in \{\mathrm{R}, \mathrm{U}\}$. I ignore differences in depreciation rates or income risk across countries, and maintain my baseline calibration.

Surprisingly, this stylized two-sector model can account for most of the gap in savings across rich and poor countries. Equation (23) predicts a negative relationship between aggregate savings and the size of the rural economy as long as $\frac{\delta}{r_{\mathrm{U}}+\delta}\nu_{\mathrm{U}} > \frac{\delta}{r_{\mathrm{R}}+\delta}\nu_{\mathrm{R}}$. Using parameters from the baseline calibration, equation (23) implies that the slope coefficient of a simple bivariate regression with country-level savings on the left hand side and the share of agricultural value added on the right hand side should be about $-.21 = \frac{\delta}{r_{\mathrm{U}}+\delta}\nu_{\mathrm{U}} - \frac{\delta}{r_{\mathrm{R}}+\delta}\nu_{\mathrm{R}} = \frac{.07}{.0325+.07}.4 - \frac{.07}{.0383+.07}.1$. Figure 4 plots simple average aggregate saving rates across countries against average value added shares of agricultural activity from the period 1960 to 2000.[42]

Figure 4. Aggregate Savings Rate and Rural GDP Share



The scatter plot is based on data from the WDI and averages saving rates and agricultural value added shares across countries from 1960 – 2000. The time horizon is due to data limitations, and the confounding role of financial globalization that allows for gaps between between savings and invest, which are beyond the closed-economy model that is the focus of the paper at hand. Averaging helps to deal with short-run fluctuations and measurement error. I drop observations with a population below 2 mio. and I drop observations with saving rates that are more negative than minus 10%.

A simple bivariate regression delivers an intercept of around 25.5% and a slope coefficient of -.275, i.e., the most urban country has an average aggregate savings rate of 25.5%, and the average saving rate is steeply falling in the size of the rural sector. A country like Ghana, with an agricultural value-added share of about 50%, has a savings rate hovering just above 10%. Figure 4 reproduces the negative link between aggregate savings and GDP per capita featuring, which has features prominently

[42] The time horizon is chosen to avoid the confounding impact of financial globalization and large development aid flows, which drive a wedge between savings and investment in the more recent period that is beyond the scope of the paper.

in the cross-country growth literature (see Levine and Renelt (1992)). The negative relationship is unsurprising in light of the theory: low-income countries tend to have a high agricultural share and, by reasonable approximation, a high rural value-added share even if the two are not perfectly synonymous.

The baseline model accounts of roughly three-fourths of differences in savings rates across countries ($.21/.275 = 76\%$). Going back to the previous decomposition in table 8, the negative slope of the saving rate in agricultural value added share is .18 in the complete markets benchmark, which means the interaction of income risk and land intensity raises the absolute value of the slope by about 17%.

5 Conclusion

This paper studies the role of land as a fixed factor of production in an otherwise standard Aiyagari-style general equilibrium model with idiosyncratic income risk. The fixed supply of land gives rise to a novel general equilibrium channel that operates through the equilibrium interest rate, increasing the safe-to-risky income ratio relative to a more capital-intensive economy. The mechanism generates smoother consumption and higher intergenerational persistence in land-intensive economies, and accounts for much of the observed cross-country variation in aggregate savings.

The argument extends beyond the specific case of land as a factor of production. The key mechanism states that low average depreciation rates, in general equilibrium, allow for more effective self-insurance. A corollary is that the secular shift from physical to intangible assets in advanced economies should have first-order implications for self-insurance, as viewed through the lens of the theory.

Several avenues for future work remain. First, the simulations pertain to stationary environments, whereas most economies are experiencing a declining rural share. In ongoing work, I explore the transitional dynamics implied by the theory developed here, which help reconcile the relationship between aggregate savings and economic growth in fast-growing economies. Second, I abstract from aggregate risk, which may be particularly relevant in weather-dependent rural environments. Such a setting would also require specifying how different types of assets respond to aggregate shocks in developing economies.

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A Theory Appendix

A.1 Setup baseline model

Production Side. I derive the production side equilibrium in the rural economy, which nests the case for the urban economy with the share of land being zero ($\chi = 0$). The competitive final goods firms takes land and capital rental rates as well as wages as given, to maximize

$$\max_{T,K,H} T^{\chi} K^{\nu} (AH)^{1-\chi-\nu} - R_T T - RK - wH.$$

First order conditions imply

$$\begin{aligned} \chi Y &= R_T T \\ \nu Y &= RK \\ (1-\chi-\alpha) Y &= wH \end{aligned}$$

which follows from the convenient Cobb-Douglas production function.

The capital rental rate reads $R = r + \delta$, where r is the equilibrium interest rate coming from the household side after imposing asset market clearing. An arbitrage argument implies that

$$\frac{R_T}{p_T} + \frac{\dot{p}_T}{p_T} = R - \delta,$$

i.e., the real return on a unit of land equals the real return on a unit of capital where p_T is the price of a unit of land. In steady state, this equation simplifies to

$$R_T = r \cdot p_T,$$

where $r = R - \delta_k$ is the risk-free rate. Since land is in fixed supply and normalized to unity, land market clearing implies $\chi Y = R_T$. Combining this with the first order condition for capital implies

$$\frac{\chi}{\nu} \frac{r+\delta}{r} K = p_T,$$

i.e., the equilibrium price of land is proportional to the share of land in production, and the overall capital stock. The equilibrium stock of capital follows from inverting the first order conditions and substituting out land

$$K = \left(\tfrac{\nu}{r+\delta}\right)^{\frac{1}{1-\nu}} (AH)^{\frac{1-\chi-\nu}{1-\nu}}$$

where A is a labor augmenting TFP term. The equilibrium wage rate reads

$$
\begin{aligned}
w &= (1-\chi-\nu)\,(K)^{\alpha}\,\frac{(AH)^{1-\chi-\nu}}{H}\\
w &= (1-\chi-\nu)\left(\frac{\nu}{r+\delta}\right)^{\frac{\nu}{1-\nu}}(AH)^{-\frac{\chi}{1-\nu}}A,
\end{aligned}
$$

where the second line follows after substituting out capital. The fixed factor land leads to a negative link between labor supply and labor productivity.

Turning to asset market clearing, note that in steady state

$$
\begin{aligned}
K+p_T &= \int b_i di\\
K+\frac{\chi}{\nu}\frac{r+\delta}{r}K &= \int b_i di \Rightarrow\\
K &= \frac{1}{1+\frac{\chi}{\nu}\frac{r+\delta}{r}}\int b_i di,
\end{aligned}
$$

which means that the demand for capital can be directly inverted without solving for the price of land, which makes the algorithm simpler.

A.2 Extension with risky non-tradable land

To extend the model, consider that each household is endowed with a non-tradable amount of land x_i such that the total amount (and share since land is normalized to one) equals $\int x_i di = \zeta < 1$. This changes the budget constraint as follows

$$
\dot{b} = rb + wh + R_T x - c
$$

which can be rewritten as

$$
\dot{b} = rb + \underbrace{w\widehat{h}}_{:=w\left(\frac{R_T x}{w}+h\right)} - c.
$$

Next, note that I now allow for land to provide an uncertain return. One way to model this is to simply add stochastic productivity shifters such that the households' return on a unit of land is $R_{T,i} = R_T A_i$ with $A_i \perp x_i$ and $\mathbb{E}[A_i] = 1$. This is convenient because the solution routine applies largely unchanged. Specifically, the HJB equation still solves the household problem, and instead of applying Ito's lemma to h, I now apply it to $\widehat{h}$, which is just a relabeling. Moreover, the income process on which all exercises are based implicitly used the (potentially stochastic) returns to land in the form of own assumption and agricultural sales that I explicitly included.

I next turn to the aggregation constraints, which is the aspect of the model that changes. First, note that total asset supply in the economy is changed since a fraction ζ of land is not traded. Consequently, total asset demand equals

$$B^D = K^D + (1-\zeta)\,P_T$$

where demand of capital and demand for land comes from the production side, and is falling in the interest rate. The supply of assets comes from the household side and takes the same form as before, and again scales linearly in w. This linearity property survives because the ratio $\frac{R_T}{w}$ is constant and independent of the level of wages, which is ultimately an implication of the constant expenditure shares due to Cobb-Douglas production. I emphasize this because I exploit this property in my computational algorithm. Moreover, note that the price of land is again computed using $P_T = \frac{\chi Y}{r}$. I can thus again use $\frac{K^D}{P_T} = \frac{\nu}{\chi}\frac{r}{r+\delta}$,which implies

$$\begin{aligned} \int a_i di &= K^D + (1-\zeta)\,P_T \Rightarrow \\ K^D &= \frac{1}{1+(1-\zeta)\,\frac{\chi}{\nu}\frac{r+\delta}{r}}\int a_i di, \end{aligned}$$

which is identical to the expression in the previous section other than the factor $1-\zeta$.

What changes relative to the previous section, however, is the interpretation of $\tilde{h} = \mathbb{E}\,[h]$ because in the model we are no longer computing $\tilde{h}$ but instead $\tilde{\hat{h}} = \mathbb{E}\left[\hat{h}\right]$. Note that $\tilde{\hat{h}}L = \tilde{h} + \frac{R_T\zeta}{w}$ assuming $L=1$. Using $\frac{R_T\zeta}{w} = \frac{\chi Y\tilde{h}}{(1-\theta)Y}$, and inverting yields

$$\tilde{h} = \frac{\tilde{\hat{h}}}{1+\frac{\zeta\chi}{1-\theta}}.$$

To compute the real wage, we can now use

$$\begin{aligned} K &= \left(\frac{\nu}{r+\delta_k}\right)^{\frac{1}{1-\nu}}\left(A_{\text{tfp}}\tilde{h}\right)^{\frac{1-\chi-\nu}{1-\nu}} \\ w &= (1-\chi-\nu)\,K^{\nu}\,\frac{\left(A_{\text{tfp}}\tilde{h}\right)^{1-\chi-\nu}}{\tilde{h}}. \end{aligned}$$

This concludes the description of the extended model, and the key quantitative question is how the interest rate changes as we increase the share of non-tradable land. If the interest rate does not responds strongly, the results are robust to this extension. Again, all consumption dynamics measured in logs will only depend on the income process, which I am not changing, and the interest rate and asset distribution. If the interest rate is the same, so will be the asset distribution.

A.3 Generalized Model

A.3.1 CES Setup with Differences in Price of Investment

I generalize the baseline model along two extensions. First, I assume that the aggregate production function reads

$$\left(\left(\psi_\chi^{\frac{1}{\sigma}} T^{\frac{\sigma-1}{\sigma}} + \psi_\nu^{\frac{1}{\sigma}} K^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}\right)^\theta L^{1-\theta}.$$

Second, I assume that it takes $\tau \geq 1$ units of output to create one unit of investment good, which leads to a price of investment and capital $P_I = P_K = \tau$ that is potentially varying across countries as argued in Hsieh and Klenow (2007). If so, this requires an important adjustment when computing price-adjusted capital returns, see Caselli and Feyrer (2007). When the elasticity of substitution between land and labor is non-unitary, the relative share, $\frac{\chi(R_T,R)}{\nu(R,R_T)} = \frac{p_T}{RK}$, is no longer constant. I will show that the main result in the paper, namely that land-intensive production raises the effectiveness of self-insurance, becomes stronger when capital and land are imperfect substitutes in the sense that the elasticity of substitution between the two factors of production is below unity.

The standard first-order conditions based on competitive production imply

$$\frac{T}{K} = \frac{\psi_\chi}{\psi_\nu}\left(\frac{R_T}{R}\right)^{-\sigma}$$

and the cost shares spend on land and physical capital read

$$\begin{aligned} R_T T &= \frac{\psi_\chi R_T^{1-\sigma}}{\psi_\chi R_T^{1-\sigma} + \psi_\nu R^{1-\sigma}}\theta Y \\ RK &= \frac{\psi_\nu R^{1-\sigma}}{\psi_\chi R_T^{1-\sigma} + \psi_\nu R^{1-\sigma}}\theta Y. \end{aligned}$$

Given the return to land, I can compute the value of land and capital as before using the standard arbitrage condition in the steady state, $\frac{R_j}{P_j} = r + \delta_j,\ j \in \{T, K\}$, which in the case of land implies

$$\begin{aligned} P_T &= \frac{R_T}{r} \\ &= \frac{1}{r}\frac{\psi_\chi R_T^{1-\sigma}}{\psi_\chi R_T^{1-\sigma} + \psi_\nu R^{1-\sigma}}\theta Y \end{aligned}$$

Since it takes τ units of output to produce one unit of investment, the price of investment equals τ at all times. Together with the arbitrage condition, the rental rate of capital thus equals $R_K = \tau\,(r + \delta)$.

This implies that the share of land wealth to physical capital wealth reads

$$\begin{aligned}\frac{P_T T}{P_K K} &= \frac{\frac{1}{r}\frac{\psi_\chi R_T^{1-\sigma}}{\psi_\chi R_T^{1-\sigma}+\psi_\nu R^{1-\sigma}}\theta Y}{\frac{1}{r+\delta}\frac{\psi_\nu R^{1-\sigma}}{\psi_\chi R_T^{1-\sigma}+\psi_\nu R^{1-\sigma}}\theta Y} \\ &= \frac{r+\delta}{r}\frac{\psi_\chi R_T^{1-\sigma}}{\psi_\nu R^{1-\sigma}} \\ &= \frac{r+\delta}{r}\frac{\psi_\chi \left(r P_T\right)^{1-\sigma}}{\psi_\nu \left(\tau\left(r+\delta\right)\right)^{1-\sigma}} \\ &= \left(\frac{r+\delta}{r}\right)^{\sigma}\frac{\psi_\chi \left(P_T\right)^{1-\sigma}}{\psi_\nu \left(\tau\right)^{1-\sigma}}.\end{aligned}$$

Next, using the normalization $T=1$ and the fact that $P_K=\tau$,

$$\begin{aligned}P_T &= \tau K\left(\frac{r+\delta}{r}\right)^{\sigma}\frac{\psi_\chi \left(P_T\right)^{1-\sigma}}{\psi_\nu \left(\tau\right)^{1-\sigma}} \Rightarrow \\ P_T &= \tau\left(\frac{r+\delta}{r}\right)\left(\frac{\psi_\chi}{\psi_\nu}\right)^{\frac{1}{\sigma}} K^{\frac{1}{\sigma}}.\end{aligned}$$

It is now easy to see that the aggregate asset ratio of land vs. physical capital equals

$$\frac{P_T T}{P_K K} = \left(\frac{r+\delta}{r}\right)\left(\frac{\psi_\chi}{\psi_\nu}\right)^{\frac{1}{\sigma}} K^{\frac{1-\sigma}{\sigma}}, \tag{24}$$

and this ratio is increasing in the physical capital stock for the relevant parameter of $\sigma<1$. It is now easy to see that land intensity will be even more powerful in generating low passthrough from income shocks to consumption in the presence of idiosyncratic labor income risk for the following reason. Income risk leads to downward pressure on the interest rate, which implies an increase in K. Note that because land is a fixed factor and the physical capital stock increases, the share of net income from land relative to income from physical capital increases, as can be seen in (24). Consequently, the now endogenous relative share $\frac{\chi(R_T,R)}{\nu(R,R_T)}=\left(\frac{\psi_\chi}{\psi_\nu}\right)^{\frac{1}{\sigma}} K^{\frac{1-\sigma}{\sigma}}$ is increasing in K. That means if there is income risk, and households build up bufferstock savings, the share of land further increases, which is desirable from a self-insurance point of view as the average rate of depreciation falls. This lowers the overall passthrough of income shocks to consumption as the share of safe income relative to labor income rises in the economy.

One could could also break the Cobb-Douglas assumption across labor and non-labor inputs, see Auclert et al. (2021) for an application that pursues this. In that case, the result of the paper become stronger when non-labor and labor inputs feature an elasticity of substitution below unity. The reason is that precautionary savings drive up physical capital. Because labor is fixed and labor and non-labor are strongly complementary, the share of output accruing to labor income goes up. This means that the share of income accruing to risky income increases, which in turn elevates the role of a factor in fixed supply to cope with income risk.

A.3.2 Long-Run Growth

The model can accommodate long-run growth just as any standard Aiyagari model. Care must be taken to apply appropriate TFP growth rates in each sector as the presence of a fixed factor in rural requires an overall faster TFP growth rate to obtain the same wage growth as a more urban economy. Let g_A be the labor-augmenting TFP growth rate of an urban economy with land share of zero. The growth rate of the rural economy then must equal $g_{A_R} = \frac{1-\nu}{1-\theta} g_A > g_A$. In that case, both sectors grow at the same long-run per capita rate and a consistent balanced growth path can be defined.

The more interesting case is one with endogenous migration where productivity growth in urban leads to an ever-declining rural sector, which is the focus of Trouvain (2025a).

A.4 Proofs

Proposition 1 in the main text claims that in the absence of idiosyncratic income risk, the equilibrium interest rate equals the effective discount factor. To prove this claim, note that in the absence of idiosyncratic income risk, the usual Euler equation obtains

$$\frac{\dot{c}}{c} = \frac{r - (\rho + \phi)}{\gamma}, \tag{25}$$

where I focus on an environments with stationary aggregates. The difference to the setup in Blanchard (1985) is that there are no annuity markets, which is why the death rate shows up in (25). Moreover, the resulting accidental bequests mean that newborn cohorts enter the economy with inherited assets.

Households use the inter-temporal budget constraint, $\dot{a} = ra + wh - c$, together with an omitted transversality condition, to compute the present discounted value of their human and nonhuman wealth, W, which reads

$$\begin{aligned} W_t &= a_t + \int_t^\infty e^{-rs} hw ds \\ &= a_t + \frac{hw}{r}. \end{aligned}$$

Using the inter-temporal budget constraint, the usual linear consumption policy function obtains

$$c_t = \frac{\rho + \phi + r(\gamma - 1)}{\gamma} \left(a_t + \frac{wh}{r} \right). \tag{26}$$

If the interest rate is $r = \rho + \phi$, then consumption growth is optimally zero, and household consumption is given by (26). To see that this respects the economy wide resource constraint, aggregate up consumption and impose market clearing

$$\begin{aligned}
C &= Y - \delta_k K \\
\int_i \frac{\rho + \phi + r(\gamma - 1)}{\gamma}\left(a_t^i + \frac{wh^i}{r}\right) di &= wH + rK \\
r\left(A_t + \frac{wH}{r}\right) &= wH + rK \\
rA_t + wH &= wH + rK,
\end{aligned}$$

i.e., markets clear and $A = K$.

The previous derivation can be trivially used for the land-intensive economy as well simply by noting that the equilibrium interest rate is independent of the depreciation rate.

The result extends to the case of insurance markets for idiosyncratic income risk such that within a cohort, surviving households insure each other by trading a set of state-contingent assets as long as there are no life cycle wage dynamics. To see how such an equilibrium could come about, conjecture an equilibrium where each household obtains a constant amount of labor income consistent with their initial type at time zero. If labor income follows a martingale without drift, then households would prefer taking this constant income stream over the stochastic income process. Market clearing would be guaranteed by a law of large number such that negative shocks to households within a cohort cancel with positive shocks. A constant consumption stream just as in (26) would follow, where the interest rate would equal $r = \rho + \phi$. One can show that markets would clear within each cohort at such an interest rate, and thus would clear for the economy as a whole as well.

If there are life cycle wage dynamics, there is an additional savings motive related to consumption smoothing over the life cycle. The standard case considered in Blanchard (1985) is where labor income is declining so that younger households want to save for old age. If that is the case, the equilibrium interest rate will be sensitive to these wage dynamics and generically $r < \rho + \phi$. Markets won't clear within cohort, and young households' savings would put additional downward pressure on the interest rate.

B Empirical Appendix

B.1 Intergenerational Persistence

In this section I provide empirical evidence on differences in intergenerational persistence across rural and urban sector in South Africa. I consider that standard statistical model of intergenerational persistence in Becker and Tomes (1986), where children's outcome is regressed on parent's outcome

$$y_i^{\text{child}} = \alpha + \beta_{\text{IGE}} y_i^{\text{parent}} + \boldsymbol{\gamma}' \boldsymbol{X}_i + u_i \tag{27}$$

where the regression coefficient β is known as intergenerational elasticity, $\boldsymbol{X}$ is a set of control variables and u is an error term. All results are based on versions of (27) with different outcome variables and control variables.

Three remarks are in order before I report the results. First, all methods employed avoid the so-called cohabitation bias, which I view as particularly troubling in my context. This bias arises when parent-child pairs are observed only when children and parents live in the same households. This is true for most survey data, and leads to selection bias. One would think, for instance, that adult children who continue to live at home are less successful than the ones that moved out, which could bias the mobility estimates.[43] In addition, cohabitation is more common in the rural sector, which makes it impossible to tell apart genuine differences from differences in selection across the two sectors. To avoid this, I only use information on parent outcomes that are reported irrespective of whether the parent is in the baseline sample or not. For example, every household member has to report their father's education and occupation, so using this information avoids any cohabitation bias.

This approach works well for schooling outcomes, but runs into difficulties when estimating intergenerational income mobility, as income is simply not observed for parents that are not interviewed. To deal with this, I follow Björklund and Jäntti (1997)'s two stage procedure and first impute parents' income, based on reported characteristics in combination with survey data for the respective cohorts, before I estimate the IGE. Given the measurement error induced in the first stage, these estimates represent a lower bound of intergenerational persistence. Second, instead of applying this exercise to individuals, I estimate this on the household level. This is consistent with the theoretical model proposed, but more importantly, it is difficult to tell apart the earnings of different household members in rural agricultural production. The household level focus circumvents this issue.

Lastly, the dataset is based on the NIDS dataset used in Trouvain (2025b) where I offer a detailed description of the dataset and explore how it compares to aggregate and administrative statistics.

IGE Schooling. I begin by documenting differences in mobility in educational attainment where I regress years of schooling across generations. The benefit of focusing on schooling is that measurement is relatively straightforward and educational attainment is a good predictor of lifetime income, even though the ultimate parameter of interest remains the IGE.

Table 9 reports the results. The interaction term represents the coefficient $\beta_{\text{IGE,school}}$, which is between .5-.6 for rural households, and between .3-.4 for urban households. That is to say, intergen-

[43] In the South African survey it is difficult to measure household splits since there is no well-defined household identifier. See details in the appendix of how to identify a household head. The Chinese survey data allows for household splits, but the survey is too short to produce sufficiently many families that started out together where the children eventually moved out.

erational mobility in educational attainment is substantially higher for urban households. While the

Table 9. Intergenerational Persistence in Education in South Africa

	Years of schooling	Years of schooling	Years of schooling	Years of schooling
Years of schooling (parents)	0.680***	0.586***	0.554***	0.526***
	(0.0125)	(0.0134)	(0.0138)	(0.0155)
Urban X years of schooling (parents)	-0.213***	-0.224***	-0.214***	-0.195***
	(0.0154)	(0.0159)	(0.0162)	(0.0186)
Urban fe	Yes	Yes	Yes	Yes
Year fe	No	Yes	Yes	Yes
Race, sex, province fe	No	Yes	Yes	Yes
Urban X child cohort fe	No	No	Yes	Yes
Urban X parent cohort fe	No	No	No	Yes
N	11592	11075	11072	8178
R^2	0.329	0.386	0.417	0.411

I restrict individuals to be weakly older than 25 years to make sure that the individual's education is complete. I do not impose any additional restrictions. Note that this regression is run on the individual, cross-sectional level so every person shows up once. I pick an individual when it first appears in the sample given that it has non-missing educational information. Cohort effects are computed within 5-year age bins. Parents' education is the average between mother's and father's education, results with only one parent are similar. Standard errors are clustered on the individual level.

results for South Africa need to be interpreted with caution due to the issue of unobserved parental urban-rural status, they are in line with recent work in Alesina et al. (2021) which documents the urban-rural divide in intergenerational mobility in literacy.[44]

IGE Income. Income persistence is difficult to estimate because we usually do not have access to the household income of the parents of a household head when they were prime earners because the household panels in emerging markets are too short. To overcome this issue, I employ a two-stage procedure using independent samples of household income of fathers and household income of adult children. Using parent characteristics reported by the children, I first estimate the predicted household income of the father's household using separate cross-sectional data roughly two decades older than my main sample. I then use the imputed father household income measures to estimate the IGE. Estimating household income as opposed to individual income is important because individual income is often not well-defined in small-scale rural farming and could induce selection bias. Additional details are provided in the appendix. Table 10 reports the results.

[44] A related but distinct measure is intergenerational occupational mobility. I refer the reader to Sinha (2016) and Syrichas (2022), which offer evidence on occupational mobility broadly consistent with the idea that mobility is higher in the urban sector although their focus rests on high vs. low income countries. Another relevant study is Weide et al. (2021) which finds intergenerational mobility to be higher for high-income countries relative to low income countries. The finding that house-

Table 10. Intergenerational Income Persistence in South Africa

	log hh income	log hh income
log hh income (father)	0.528***	0.626***
	(0.0611)	(0.108)
Urban X log hh income (father)	0	-0.147
	(0)	(0.124)
Age (child)	Yes	Yes
Urban, Province, Race, Gender fe	Yes	Yes
N	1057	1057
R^2	0.269	0.270

Standard errors are bootstrapped to account for the first stage estimation procedure.

Intergenerational mobility is higher in urban areas. The estimated difference of roughly .2 is consistent with the previous differences in years of schooling. The results are not as precisely estimated with marginal significance close to the 10% level. Given the limited sample size and the two-stage estimation procedure that effectively relies only on three covariates, education, occupation, and household composition, I interpret the findings in table 10 as supportive of the main hypothesis.[45]

holds with zero years of schooling drive high persistence in schooling in rural communities seems new relative to the previous literature.

[45]The overall elasticities is consistent with the findings in Piraino (2015) for South Africa, and broadly in line with other estimates, see for instance Solon (1992).