A General Equilibrium Analysis of Consumption Risk and Inequality in Rural Economies*

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Abstract

I explore the role of land as a fixed factor of production in shaping consumption volatility and consumption inequality in the presence of idiosyncratic uninsurable labor income risk. Land as an asset in fixed supply offers a particularly effective form of self-insurance through its effect on the share of safe to risky household income in general equilibrium. I use the theory to explain consumption dynamics in land-intensive rural economies. The model helps explain the puzzlingly low passthrough from income shocks to consumption as well as low intergenerational mobility found for rural households in developing economies.

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1 Introduction

Income and consumption dynamics of rural households in developing economies differ substantially from urban ones: For one, rural households' consumption appears well insulated from income risk as indicated by a low measured passthrough from income shocks to consumption, see Townsend (1994). Consistent with this, consumption inequality tends to be low relative to income inequality, and changes little over the life cycle. Lastly, intergenerational mobility in income or education is relatively low in rural environments, see for instance Alesina et al. (2021). In this paper, I argue that the role of land as a fixed factor of production is a quantitatively important force in shaping the link between income and consumption, which is particularly helpful in explaining differences in consumption dynamics across rural land-intensive vs. urban capital-intensive economies.

The key insight in the paper is that the link between income and consumption volatility is sensitive to the share of land in a general equilibrium Bewley-Hugget-Aiyagari style model where households self-insure against idiosyncratic labor income shocks, and final output is produced according to

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

which combines land T, physical capital K, and labor H where the labor share $1-\theta := 1-\chi-\nu$ is fixed throughout. The importance of land and reproducible capital varies depending on χ vs. ν, and, for concreteness, think of a rural economy as one with $\nu = 0$, and an urban economy as one with $\chi = 0$ in a stationary environment. To see why the land share matters, consider a stationary economy with idiosyncratic risk. As income risk increases, households' precautionary savings pick up, and demand for safe assets rises. In the rural economy, savings pressure ends up raising the equilibrium price of land, p_T, which is endogenous. This turns out to be convenient for rural households as more safe assets are created through a land price appreciation. Contrast this with the urban sector, where savings are channeled into physical capital accumulation. Whenever physical capital depreciation is non-zero, saving in capital represents an inferior storage technology because additional savings reduce the share of safe to risky income in the economy, i.e., total asset income vis-a-vis labor income. The reader can verify this claim by computing the ratio of safe to risky income in a competitive stationary environment given by

$$\frac{(R-\delta_k)\,K + R_T T}{wH} = \frac{\theta}{1-\theta} - \frac{\nu}{1-\theta}\frac{\delta_k}{r+\delta_k}, \tag{2}$$

where R and R_T is return to capital and land, respectively. It is easy to see that in the land-only economy, the ratio is fixed at $\frac{\theta}{1-\theta}$, and strictly larger than the ratio in the urban economy as long as physical capital depreciates, i.e., $\delta_k > 0$. What is more, a risk-induced fall in the interest rate in a capital-intensive economy further reduces the share of safe to risky income as expression (2) is increasing in the interest rate for $\nu > 0$. These aggregate aspects of the economy induce distinct household consumption dynamics: they shape the passthrough from labor income shocks to consumption, the evolution of consumption inequality within cohorts, and the intergenerational persistence of consumption across cohorts in a way that is consistent with the empirical literature documenting differences in consumption dynamics across rural vs. urban and developing vs. advanced economies reviewed below.

I develop this argument in four steps. First, I build an incomplete market model with infinitely-lived dynastic households that make consumption-saving choices in the presence of idiosyncratic labor income risk as in Aiyagari (1994). Relative to this canonical framework, I include land as a factor of production and allow for informal insurance schemes, which have been found to be important in rural communities.[1] I use a model of perpetual youth (Yaari, 1965; Blanchard, 1985) with accidental bequest to tractably embed a unit-root income process into an infinite horizon model and generate meaningful intergenerational persistence,[2] and consider each sector in autarky.[3] Three aspects differentiate rural from urban: the role of land in production, the income process, and the degree of informal insurance. The rural sector is by definition the land-intensive sector, and the other two dimensions will be informed by household-level panel data on income and consumption from South Africa.

Before I quantify the model I prove formally that as long as the rural sector is more land-intensive and physical capital depreciates, the gradient of the equilibrium interest rate with respect to income risk is steeper in urban than in rural, all else equal. Put differently, an equal amount of labor income risk puts more downward pressure on the equilibrium interest rate in the capital-intensive urban economy. This has important feedback effects on consumption volatility. Note that labor income is the volatile component of income, and higher interest rates imply that future labor income is more heavily discounted rendering the volatile component of household wealth relatively less important whilst elevating household financial wealth, which is a source of safe income, as relatively more important. This shift reduces the passthrough from persistent labor income shocks to consumption, and ultimately risk exposure.[4] This is the microeconomic analogue of the relatively larger aggregate safe to risky income ratio in a land-intensive economy.

A flip side of this is that financially wealthy rural households are more likely to remain wealthy in

[1] See Rosenzweig and Stark (1989).

[2] I drop the assumption of perfect annuity markets so that newborn cohorts enjoy accidental bequests, which is convenient for two reasons. First, I will nest the neoclassical model exactly when shutting down income risk, which is not the case in the standard perpetual youth model. Second, the framework allows for a straightforward and empirically plausible link between parental and child life outcomes, driven by the role of financial wealth.

[3] Financial markets must be at least partially segmented so that the rural and urban interest rates can differ. Intermediate cases of imperfect integration seem realistic, see Kleinman et al. (2023). If rural and urban sector are fully integrated, the basic logic of the paper still goes through, 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).

[4] Of course, on net, asset accumulation reduces household consumption volatility in urban, which is the point of self-insurance. But in general equilibrium, asset accumulation in the capital-intensive sector leads to a decline in the interest rate, which partly undermines self-insurance motives.

the future. This persistence of rural inequality is due to the larger role of financial wealth in shaping life outcomes enabled by the relatively high and safe asset return. In contrast, human capital wealth plays a more important role in the urban sector, which evolves stochastically and induces greater income mobility within and across cohorts. Both the greater importance of financial wealth, which is partly inherited, and the smaller role assigned to human capital, which is the fickle component of income, induce higher intergenerational persistence in consumption in rural.

In the second step, I quantify the model. I calibrate the income process to match income dynamics for rural and urban households in South Africa based on a companion paper in Trouvain (2025b). Differences in land-intensity, the income process, and informal insurance are all quantitatively important in shaping consumption risk, and I bring in consumption-level data to discipline these different margins building on Deaton and Paxson (1994)'s insight that the joint distribution of income and consumption contains information on the degree of insurance. This idea also underpins the popular passthrough coefficients of Townsend (1994) and Blundell, Pistaferri, and Preston (2008), henceforth BPP, which I compute as well. Consistent with prior literature, I find that rural consumption appears surprisingly smooth. In contrast to the literature, I highlight how land-intensity in this general equilibrium setup impacts the structural interpretation of these commonly used methods.[5] The fact that a larger share of household income derives from asset income lowers the passthrough from labor income shocks to consumption substantially.

It is worth highlighting that the role of land entirely operates through its impact on aggregate equilibrium objects, such as the interest rate and the relative supply of safe assets, and has nothing to do with any particularities of the market for land, of which of course there are many.[6] Moreover, the argument is one of degrees and does not require that the capital share in rural is zero. In fact, my rural economy will feature a non-zero physical capital share consistent with the data, and the key findings hinge on the aggregate depreciation rate being lower in rural than in urban.

In the third step, I consider counterfactual scenarios where I explore how important differences in land-intensity, informal insurance, and income risk are in explaining different consumption dynamics across rural and urban sector. I find that both differences in informal insurance, and differences in land intensity are quantitatively important in generating low passthroughs of income shocks to consumption. Interestingly, the two interact because the role of land will be more pronounced the larger effective income risk is, which in turn depends on the degree of informal insurance. Moreover, note that imperfectly transitory shocks, which my empirical analysis suggests are especially relevant in the rural sector, further lower the estimated passthrough from persistent labor income shocks to

[5] For recent applications of either BPP's or Townsend (1994)'s approach in developing economies see De Magalhaes and Santaeulalia-Llopis (2018), Santaeulalia-Llopis and Zheng (2018), Meghir et al. (2022), Attanasio et al. (2022), and De Magalhaes, Martorell, and Santaeulalia-Llopis (2024).

[6] I focus on the most simple version of the model in the main body of the paper where land, just like capital, is frictionlessly traded and households can be thought of as trading one risk-free bond. There are, of course, complex formal and informal norms governing land access in developing economies, see Pande and Udry (2005) for a review, and I consider an extension with partially fixed risky land endowments in the robustness section.

consumption since mean-reverting shocks are easier to ensure through bufferstock savings.

Lastly, I consider the impact of aggregate shocks including transition dynamics to highlight how they interact with the land-intensity of the economy, and I offer an extension of the baseline model where land is imperfectly traded and potentially subject to idiosyncratic productivity shocks. Regarding aggregate shocks, I consider two scenarios where the first analyzes a temporary aggregate productivity shock, while the second explores a secular increase in risk. Note that a land-intensive economy is particularly vulnerable to a negative TFP shock in the sense that aggregate consumption takes a more severe hit. The reason is that the capital-intensive urban economy can temporarily reduce investment to shield consumption, a strategy less available in rural as investment rates are low to being with due to a low physical capital share. With regard to the second scenario, note that the price of land can appreciate in the face of rising income risk, while the price of physical capital is fixed. As income risk goes up, the land-intensive economy converges more quickly to the new long-run equilibrium with a higher safe asset to labor income ratio relative to the capital intensive economy.

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).[7] Relative to these studies, I consider the role of land as a fixed factor of production in shaping consumption volatility, and explore the model's ability to account for differences in consumption dynamics across rural and urban sector. Note that 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, and Aguiar, Amador, and Arellano (2024) consider robust Pareto-improving fiscal policy in such environments. I highlight that land as a factor in fixed supply automatically generates more safe assets in the presence of idiosyncratic risk, which also means there is less scope for welfare-improving fiscal policy.

Empirically, I build on the seminal works of Deaton and Paxson (1994), Townsend (1994), and Blundell, Pistaferri, and Preston (2008) to measure income and consumption risk in the data. I compare these estimates with coefficients based on simulated data from the model to explore potential biases similar to Kaplan and Violante (2010).[8] Kaplan and Violante (2022) summarize and extend recent work that models carefully the response of consumption to income shocks (Kaplan and Violante,

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

[8]An important difference to Kaplan and Violante (2010) is that I operate in an infinite horizon framework, which has a number of benefits. First, I reduce the computational burden by ridding the model of an explicit age structure with life-cycle consumption smoothing motive. Second, this also is a natural starting point since rural family units are closely knit, pension schemes are often non-existent, and elderly parents reside with children in the same households. A standard life-cycle model is not a good fit for such an environment.

2010; Kaplan and Violante, 2014; Aguiar, Bils, and Boar, 2024). My general equilibrium focus is complementary to their work set in partial equilibrium,[9] and useful for understanding how the economy responds to changes in income risk or aggregate shocks, which are counterfactual questions that turn out to be sensitive to the share of land in production.

A growing literature has been documenting the micro-dynamics of income and consumption in developing economies, see De Magalhaes and Santaeulalia-Llopis (2018), Santaeulalia-Llopis and Zheng (2018), De Magalhaes, Martorell, and Santaeulalia-Llopis (2024), Lagakos, Mobarak, and Waugh (2023) and Attanasio et al. (2022). My findings are, on a high level, consistent with theirs. A related literature has studied risk in two-sector rural-urban economies, see Banerjee and Newman (1998) and Munshi and Rosenzweig (2016).[10] A key difference to these works is the role of land in the presence of idiosyncratic income risk. While I abstract away from rural-urban migration to focus on the role of land in general equilibrium, I consider how income risk shapes selection into rural-urban migration in related work (Trouvain, 2025b). Moreover, I explore the transition dynamics of the theory developed here in a more involved non-stationary two-sector model with long-run growth and endogenous migration to explain aggregate savings in fast-growing emerging markets (Trouvain, 2025a).

2 Model

2.1 Environment

Time is continuous, markets are competitive, and there is a constant mass of household L.[11] Infinitely-lived dynasties supply their labor inelastically and make consumption-saving choices.[12]

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

[9] 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 wealth distributions and interest rates is, of course, much harder than in advanced economies as data is more scant. Aguiar, Bils, and Boar (2024) highlight that even for a model with return heterogeneity and portfolio adjustment costs, it is difficult to match household consumption dynamics without preference heterogeneity.

[10] 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 risk in explaining low intermediate input shares in subsistence agriculture using a quantitative model, while Cole et al. (2013) and Karlan et al. (2014) considers the effect of formal insurance on agricultural outcomes based on experimental variation. Manysheva (2022) and Rodrigues (2022) explore the role of land reallocation frictions in developing countries in incomplete market settings.

[11] Note that the urban economy is neoclassical so population growth would only changes the effective rate of depreciation. The rural sector features a fixed factor, land, so a constant population is a natural assumption that could be micro-founded using Malthusian forces.

[12] The infinitely-lived dynastic household assumption abstracts away from limits to risk sharing within families, see for instance Dercon (2002). A related literature has explored the extent of risk sharing in the family, see Cox (1990), McGarry (2016), Ameriks et al. (2011), Attanasio, Meghir, and Mommaerts (2015) and Boar (2021).

and transitory component

$$dp = \sigma dZ, \tag{3}$$

$$d\epsilon = dN\left(\epsilon' - \epsilon\right) \tag{4}$$

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

$$W_i\left(p, \epsilon\right) = we^{p_i + \epsilon_i}. \tag{5}$$

To render the income distribution stationary, I assume that dynasties are hit with a death shock at rate ϕ.[13] Households are then replaced by new dynasties that draw their persistent type in logs from a normal distribution with mean $c_0 \leq 0$ and variance σ_0^2, their transitory type from $G\left(\epsilon'\right)$, and that take over the asset position from the dying dynasty. This setup is convenient because it nests the neoclassical model, which is not the case in the alternative setup of Yaari (1965) or Blanchard (1985) where annuity markets give rise to asset accumulation and consumption dynamics even in the absence of risk.[14]

I introduce informal insurance in a simple fashion by assuming that unobserved effective household labor income, W_i^*, reads

$$W_i^* = we^{(1-\kappa)(p_i + \epsilon_i) + d} \tag{6}$$

where $\kappa \in [0, 1]$ represents an implicit insurance coefficient in the following sense. I assume income is redistributed across households within the same sector while leaving aggregate income unchanged so $\mathbb{E}\left[W_i^*\right] = \mathbb{E}\left[W_i\right]$, and redistribution takes the form of a percentage increase in effective disposable household income of size $d = \log\left(\frac{\mathbb{E}\left[e^{p_i+\epsilon_i}\right]}{\mathbb{E}\left[e^{(1-\kappa)(p_i+\epsilon_i)}\right]}\right)$.[15] A positive value of κ implies that income shocks pass through only partially to effective income, which serves as a simple way to capture informal insurance arrangements in rural village communities including, for example, implicit contracts amongst villagers (Townsend, 1994; Ligon, 1998) or marriage markets (Rosenzweig and Stark, 1989; Munshi and Rosenzweig, 2016).[16] The setting maps directly to the popular BPP estimator concerned

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

[14] Note that asset accumulation over the life cycle together with a changing time horizon as households age would induce an age-dependent passthrough of income shocks to consumption. Surprisingly, Blundell, Pistaferri, and Preston (2008) do not find evidence in favor of an age-dependent passthrough.

[15] This model of informal insurance is very similar to commonly used progressive tax functions, see Benabou (2000) and Heathcote, Storesletten, and Violante (2017). The subtle difference is that taxes are observed, and then subtracted to obtain net income, while informal insurance and redistribution is unobserved and thus driving a wedge between consumption and after tax income inequality. In a model with endogenous human capital investment, one can envision how informal insurance could induce underinvestment, see recent work of Carli et al. (2025) along these lines.

[16] The presumption that there is some form of informal insurance in rural economies seems uncontroversial, going back at least to Rosenzweig and Stark (1989). See Ligon, Thomas, and Worrall (2002) and Morduch (1995) for succinct summaries of the many possible ways in which rural farming communities insure against income shocks: plot diversification, planting low yield low risk crops, delaying investment in face of uncertainty, informal transfer and credit schemes, and inter-temporal

with the passthrough from persistent income shocks to consumption.

Household problem. Dynastic households solve a consumption-saving problem

$$V(a,p,\epsilon) = \max_{\{c,a\}} \mathbb{E}_t \left[\int_t^\infty e^{-(\rho+\phi)s} \frac{c^{1-\gamma}}{1-\gamma} ds \right] \tag{7}$$

$$\text{s.t.}$$

$$\dot{a} = ra + W^*(p,\epsilon) - C$$

$$a \geq 0,$$

with $a \geq 0$ is a zero-borrowing constraint on the risk-free asset.[17]

Aggregates and Production. I build on Hansen and Prescott (2002) with constant-returns-to-scale neoclassical production that includes land T in fixed supply and normalized to one, labor $H = \int e^{p_i+\epsilon_i} di$, and reproducible capital K in a Cobb-Douglas fashion

$$Y = T^\chi K^\nu H^{1-\chi-\nu} \tag{8}$$

where χ and ν are land and capital share, respectively. Output can either be consumed, or turned one-for-one into reproducible capital. Together with a depreciation rate δ_k, the law of motion of capital is given by

$$\dot{K} = I - \delta_k K, \tag{9}$$

where $Y = C + I$. The rental rate of land, price of land, rental rate of capital, and wage rate per efficiency unit are denoted by R_T, p_T, R, and w, respectively. Differences between urban and rural economy comprise differences in land vs. capital intensity while holding the labor share fixed,[18] differences in the income process, and differences in informal insurance. All other aspects of the model are the same, and each sector is considered in autarky.

2.2 Equilibrium.

I focus on a stationary equilibrium defined as follows.

labor substitution. Temporary migration is another prominent strategy to cope with income shocks (Kleemans, 2015; Lagakos, Mobarak, and Waugh, 2023) although the subsequent income streams should in principal be observed in which case the mechanism would not constitute informal insurance as defined here.

[17] The zero-borrowing constraint seems appropriate for the emerging market context as a first past. 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 $\frac{w}{r}$.

[18] This is consistent with the evidence in Gollin (2002) documenting that the aggregate labor share is unrelated to income per capita.

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

- households solve (7) subject to constraints and transversality condition;
- final goods firms maximize profits, taking factor prices as given;
- goods, factor, and asset markets clear with $\int a_i di = K + p_T$ within each sector;
- a stationary distribution $g(x)$ obtains, defined over idiosyncratic income and wealth states $x = (a, p, \epsilon)$, consistent with aggregation constraints.

In next discuss the equilibrium properties of the model, and highlight novel feature of the framework.
Wages and Asset Prices. Competitive production implies the following wage rates

$$w = (1 - \chi - \nu) \left(\frac{\nu}{r + \delta_k} \right)^{\frac{\nu}{1-\nu}} \left(L\tilde{h} \right)^{-\frac{\chi}{1-\nu}} \tag{10}$$

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, and a financial intermediary in the background ensures that an arbitrage condition between the returns to physical capital and land holds

$$\frac{R_T}{p_T} + \frac{\dot{p}_T}{p_T} = R - \delta_k, \tag{11}$$

where $\dot{p}_T = \frac{d}{dt} p_T$ represents gains from land price appreciation. In the steady state the price of land will be constant. In that case equation (11), together with profit maximization and land supply normalized to one, pins down the equilibrium price of land

$$p_T = \frac{\chi Y}{r}, \tag{12}$$

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

$$\frac{p_T}{K} = \frac{\chi}{\nu} \frac{r + \delta_k}{r}. \tag{13}$$

Equation (13) is useful in deriving equilibrium demand for physical capital, which is a scaled-down version of total household demand for risk-free assets, $K = \frac{1}{1 + \frac{\chi}{\nu} \frac{r + \delta_k}{r}} \int a(x) g(x) L dx$. 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, i.e., has nothing to do with any particularity about land as factor of production other than that it being in fixed supply. I will show formally that, in the steady state, the role of land as a superior safe asset is ultimately based on the fact that land does not depreciate.

I start out stating a neutrality results when markets are complete 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 share of land.*

The significance of proposition 1 is that in the absence of income risk the land share is irrelevant for the determination of interest rates in steady state.[19] The model inherits this feature from the standard neoclassical model, which is nested. The main point, of course, is that this is no longer true once households face idiosyncratic risk. To make this point formally, I first introduce the notion of normalized asset demand $b := \frac{B}{wL}$ and assume for convenience that average efficiency units of labor per household, $\tilde{h}$, is fixed at unity, so increases in risk represent mean-preserving spreads.[20]

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,* $B(\Theta, r, w, L) := \int a(x)\, dG(x)\, L$*, and note that* B *is homogenous of degree one in both* w *and* L*, so* $B(\Theta, r, w, L) = B(\Theta, r, 1, 1)\, wL := b(\Theta, r)\, wL$.

Lemma 1 is useful in two ways. First, note that because household asset demand scales linearly in the wage rate I can ignore effects of the mean level of income,[21] which is fully captured in the scalar w, and focus on normalized household saving choices captured in the normalized aggregate asset supply function $b(\Theta, r)$. While it is difficult to characterize the normalized asset supply function,[22] in most applications aggregate asset supply is upward-sloping in the interest rate, which I assume to be the case. Second, I can use the linearity of the asset supply function to simplify the asset market clearing condition since the firms' demand for capital and land, conditional on rental rates, is a linear function of the wage bill wL due to convenient Cobb-Douglas production, i.e., $\frac{K}{wL} = \frac{1}{r+\delta_k} \frac{\nu}{1-\chi-\nu}$ and

[19] 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.

[20] 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, all of which hold in my setup.

[21] 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 in 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 as higher savings raise the real wage. If there is a fixed factor of production, this link is much weaker since capital accumulation runs into diminishing returns faster.

[22] 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 weakly below one.

$\frac{p_T}{wL} = \frac{1}{r}\frac{\chi}{1-\chi-\nu}$. Using this together with the market clearing condition, $K + p_T = B$, and lemma 1, leads to a normalized market clearing condition

$$\frac{1}{r}\left(\frac{\theta}{1-\theta} - \frac{\nu}{1-\theta}\frac{\delta_k}{r+\delta_k}\right) = b\left(\Theta, r\right), \tag{14}$$

where I used $\theta = \chi + \nu$ and $R = r + \delta_k$. I next compute the derivative of the interest rate with respect to an increase in household income risk, which is implicitly defined by (14), and establishes a link between the sensitivity of the interest rate to income risk. While it is well-known that the presence of idiosyncratic labor income risk pushes the equilibrium interest rate below the discount rate, see Huggett (1993), the next proposition states a new result showing that the extent to which income risk lowers the interest rate is sensitive to the land share and capital depreciation.

Proposition 2. *Holding the labor share $1-\theta := 1-\chi-\nu$ fixed, and totally differentiating (14) with respect to r and σ^2, implicitly defined the general equilibrium effect of an increase in income risk on the interest rate, $\frac{dr}{d\sigma_p^2}$, which reads*

$$\frac{dr}{d\sigma_p^2} = -\frac{\frac{\partial b}{\partial \sigma_p^2}}{\frac{1}{r}b + \frac{\partial b}{\partial r} - \frac{1}{r}\frac{\nu}{1-\theta}\frac{\delta_k}{r+\delta_k}\frac{1}{r+\delta_k}}.$$

Given $\frac{\partial b}{\partial \sigma_p^2} > 0$ and $\frac{\partial b}{\partial r} > 0$, the responsiveness of interest rates to household income risk is increasing in reproducible capital share ν and depreciation rate δ_k.

In the well-behaved case where aggregate normalized asset demand is upward-sloping in the interest rate, $\frac{\partial b}{\partial r} > 0$, it turns out that reliance on land in production, or any other fixed factor, attenuates the negative link from income risk to the equilibrium interest rate whenever reproducible capital depreciates.[23] Why do we care that interest rates respond differently to income risk depending on the share of land? The reason is that the ability of households to self-insure improves in the interest rate, i.e., a higher interest rate environment allows for more consumption smoothing.[24]

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.[25] The intuition for this results is as follows. Suppose households want to save an extra dollar. In general equilibrium, the financial sector accommodates this

[23]The reader should not that a non-reproducible factor in a stationary equilibrium does not depreciate by construction, otherwise the production factor would disappear in the long-run. My notion of land is thus one of "raw" land. Investment in land quality, which surely depreciates, is captured by a positive reproducible capital share in rural.

[24]This is the key benefit of government debt in Aiyagari and McGrattan (1998), which is traded off against a crowding out of capital. Perhaps most surprisingly, this is even true in an environment where aggregate consumption is fixed, as in Aguiar, Amador, and Arellano (2024), where higher interest rates induce wealthy households to defer consumption to the future, which allows constrained households to consume more today and magically improves welfare for everyone.

[25]Interestingly, the implications of a model where capital does not depreciate vs. a model with an asset in fixed supply are quite different off the steady state. Intuitively, to in the capital-intensive economy households need to lower consumption to

by investing in real assets. To maintain this higher asset ratio, however, a fraction of asset income needs to be reinvested to compensate for depreciation. If income risk is high, and the demand for bufferstock savings large, the income needed to undo depreciation can become so large that the net asset income generated by the safe asset becomes negative, i.e., the capital stock is below the golden rule level, and self-insurance becomes extremely expensive. Vice versa, if land was the only factor of production, which trivially implies that depreciation is zero, it is easy to see that the interest rate can never be negative.[26]

While I will consider extensions to the baseline model later on, it is worth pointing out that the qualitative result is likely robust to details of the household problem like portfolio adjustment frictions.[27] This conjecture is based on the convenient separation between production side, the left hand side of (14), and household side, the right hand side of (14). Since the proposition centers on the link between the structure of production and the equilibrium interest rate, and only imposes mild assumptions on the aggregate normalized asset supply schedule, namely that it is upward-sloping in the interest rate, $\frac{\partial b}{\partial r} > 0$, and increases in income risk, $\frac{\partial b}{\partial \sigma_p^2} > 0$, it is robust to extensions on the household side that generate a more complicated aggregate asset supply function. For instance, while a richer model with portfolio adjustment costs will change the precise shape of the normalized aggregate asset supply schedule $b\left(\Theta, r\right)$, it won't overturn the result as long as $\frac{\partial b}{\partial r} > 0$ and $\frac{\partial b}{\partial \sigma_p^2} > 0$ remain true, which any well behaved asset supply function ought to obey.

Safe to risky income shares. The general result that self-insurance improves as interest rates rises, while well-known, is somewhat opaque. A simple complementary intuition can be gained by the following observation. Note that the share of safe income to risky income in the economy equals

$$\frac{rB}{wL} = \frac{\theta}{1-\theta} - \frac{\nu}{1-\theta}\frac{\delta_k}{r+\delta_k}, \tag{15}$$

which is implicitly used in proposition 2. It is easy to see that (15) is falling in the capital share ν, and increasing in the interest rate r. In the absence of uninsurable income risk, this ratio is inconsequential. Yet, once households wish to self-insure against idiosyncratic shocks, the asset income to labor income ratio begins to matter. Intuitively, the higher this ratio, the smaller is 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 will feature a lower ratio of safe income to risky income, which will make it harder for households to maintain a smooth consumption profile.

The idea that aggregate safe to risky income matters for households' ability to smooth consump-

reach the higher asset level in contrast to the land-intensive economy where land price adjustments automatically create more safe assets without the same kind of consumption adjustment. I will return to this issue when simulating transition dynamics in section 4.

[26] An implication of this is that in land-intensive economies there is less scope for welfare-improving fiscal policy, see for instance Aguiar, Amador, and Arellano (2024), simply because the real rate is unlikely to be below zero.

[27] In fact, I abstract away from non-convex asset adjustment costs, see Kaboski and Townsend (2011) and Kaplan and Violante (2014).

tion, while intuitive, is incomplete for individual and not aggregate safe to risky income ratios determine consumption dynamics, which in turn depend on the entire endogenous wealth distribution. I next use both an approximate solution and a fully simulated model to show that, indeed, household consumption dynamics are sensitive to the share of land in the economy, and that self-insurance is more effective in land-intensive economies.

2.4 Consumption Volatility and Consumption Inequality

Foreshadowing the quantitative analysis, I first focus on the passthrough from labor income shocks to consumption building on BPP. The passthrough coefficient from permanent income shocks to consumption is defined as

$$\mathbb{E}_i \left[\frac{\Delta c_i}{\Delta p_i} \right] = \beta_p, \tag{16}$$

where Δc and Δp is the change in log consumption or log permanent income measured over a discrete time interval.

This passthrough of permanent shocks on consumption depends crucially on the interest rate, which is not a new result,[28] but has received relatively little attention. To see why the interest rate matters, let's focus on the case of a financially wealthy households so the consumption policy function is well approximated by a linear solution of the form[29]

$$C_t = \frac{\tilde{\rho} + r\left(\gamma - 1\right)}{\gamma} \left(a_t + W_t\right), \tag{17}$$

with $W_t = \mathbb{E}_t \left[\int_t^{\infty} e^{-rs} wh_s ds \right]$ representing the expected present discounted value of human wealth. If h_s follows a random walk in levels, 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 (16) can be expressed in discrete increments $\frac{\Delta C}{C}$ using (17)

$$\frac{\Delta C_t}{C_t} = \underbrace{\frac{r}{ra_t + wh_t}}_{\text{trans. passthrough}} \Delta a_t + \underbrace{\frac{wh_t}{ra_t + wh_t}}_{\text{perm. passthrough}} \frac{\Delta wh_t}{wh_t}, \tag{18}$$

where the change in the asset position proxies for a transitory shock,[30] and Δwh_t is a permanent

[28] In Blundell, Low, and Preston (2013) the passthrough coefficient is analyzed, and its dependence on the share of financial assets to human wealth is discussed. Similarly, BPP and Kaplan and Violante (2010) discuss how the ratio of financial to human wealth matters for the passthrough. The related but slightly different concept I use focuses on the income generated by financial assets vis-a-vis labor.

[29] See Benhabib, Bisin, and Zhu (2015) for a proof.

[30] 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. The numerical implications in either case are similar.

shock given the random walk in household labor income. Equation (18) shows what would correspond to the BPP passthrough coefficients for transitory and permanent shocks using $\frac{\Delta C_t}{C_t} \approx \Delta c$ and $\frac{\Delta wh_t}{wh_t} \approx \Delta p$.[31]

Clearly, this passthrough depends on the interest rate. Note that the passthrough coefficient for transitory shocks is increasing in the interest rate, while the reverse is true for permanent shocks as the coefficient is falling in the interest rate. Intuitively, as the interest rate increases future human capital wealth is more heavily discounted, which means that the present discounted value of human wealth constitutes a smaller share of total household wealth. Consequently, shocks to human wealth have a smaller effect on household consumption in a high interest rate environment holding the asset distribution fixed. In contrast, a transitory shock, which through the budget constraint raises the household's asset level, has a larger effect simply because the propensity to consume out of household wealth is tied to the annuity value of financial wealth, which is increasing in the interest rate. It is now easy to see why rural households in a high interest rate environment will appear more insulated against persistent shocks and thus produce lower passthrough coefficients,[32] even if they were exposed to identical stochastic processes and there are no differences in informal insurance across rural and urban.

Second, 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 as initial endowment of financial wealth are a more important determinant of household resources. This 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.

The previous statement is not sharp as there are no analytical results to characterize consumption inequality. I thus solve a version of the baseline model to show how much bite a changing land share can have through its impact on equilibrium interest rate and safe to risky income ratios. I provide details on the quantification in the next section, here I simply want to point out that for a reasonable calibration, a varying land share can have striking consequences for consumption volatility, inequality, and passthrough of income shock. Importantly, informal insurance is set to zero ($\kappa = 0$), and the the volatility of the income process is held fixed. I vary the land share from 0.0 to 0.38, with a constant labor share of 0.6.

Figure 1 plots the results, and before inspecting the implied household consumption dynamics, take account of the upper left panel depicting the aggregate share of safe to risky income in the economy, which is falling in the share of physical capital. Note that this share is bounded by $\frac{\theta}{1-\theta}$ when

[31] 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).

[32] That is, lower passthrough coefficients for persistent shocks, but higher passthrough coefficients for transitory shocks.

Figure 1. Land Share, Interest Rates, and Consumption Volatility in Steady State

Figure 2. Safe to risky income

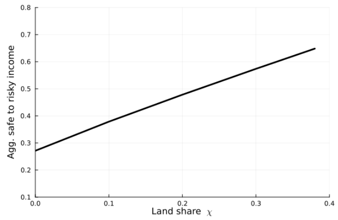


Figure 3. Interest rate

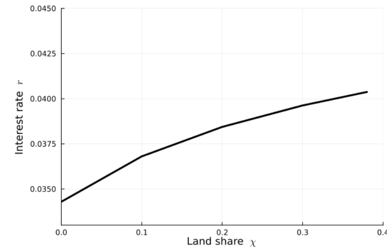


Figure 4. Cons. Inequality

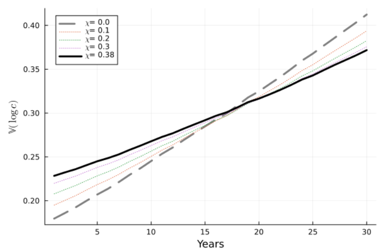
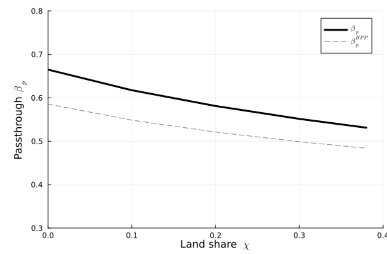


Figure 5. Passthrough perm. shock



The calibration is based on $\sigma_p^2 = .017, \lambda_\epsilon = 2, \sigma_\epsilon^2 = .15, \delta_k = .05, 1 - \chi - \nu = .6$ and there is no informal insurance, $\kappa = 0$.

land is the only asset in the economy, and can in principal turn negative when capital is below the gold rule level defined by $\frac{\partial F}{\partial K} = \delta_k$. The falling share of safe to risky income 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 and ranges from 3.5% to 4.1%, which is the quantitative equivalent of proposition 2. The interest rate is bounded by the neoclassical interest rate of $\rho + \phi = .05$, and the gap between neoclassical and incomplete market equilibrium interest rate equals $-\int_0^{\sigma^2} \frac{\partial r}{\partial \sigma^2} d\sigma^2$, which is falling in the land share.[33] Moreover, 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., $\frac{\partial^2 r}{\partial \chi \partial \sigma^2} > 0$. This is intuitive since for low levels of income risk the behavior of the model is close to the neoclassical benchmark with complete markets. For high levels of income risk, land intensity makes a substantial difference to the equilibrium interest rate.[34]

It is intuitive that a larger share of safe income, driven by differences in equilibrium interest rates, allows for more effective self-insurance. I next compute the implied consumption dynamics. The bottom left panel plots the evolution of the log variance of consumption for a newborn cohort. Inequality

[33] Changing the land share does impact the real wage. Note that this changing real wage does not show up in any of the distributional statistics as it is differenced out in passthrough and log variance estimates. When setting $\delta_k = 0$ every plot in figure 1 turns into a horizontal line consistent with the role of depreciation in proposition 2.

[34] In the limit for where risk is so large that households want to hold nearly unlimited amounts of savings, the only-land economy will feature an interest rate of zero while the only-capital economy will feature an interest rate of $-\delta_k$.

of newborn cohorts is higher in the case with 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 for high returns to safe financial wealth reduce social mobility. For a capital intensive economy with low interest rates, human capital is a much more important determinant of lifetime income, and since human capital is fickle and features persistent shocks, income and consumption fan out more strongly over the life cycle generating a steeper slope of the log variance of consumption as a function of time.[35]

The bottom right panel plots the structural passthrough coefficient from permanent income shocks to consumption, log on log.[36] The higher the land share, the lower is the passthrough and the higher is the degree of consumption insurance with respect to persistent shocks. This effect is entirely driven by the changing equilibrium interest rate. In contrast, the bottom right panel plots the passthrough of transitory shocks to consumption. This passthrough coefficient is rising with the interest rate, which is consistent with the standard permanent income hypothesis. Note that because there is some persistence in the transitory shock, the passthrough is higher than the interest rate.[37] 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 structural passthrough coefficient where structural means that the moment is simulated from the model where I observe transitory and permanent type and can run a simple regression that uncovers (16).

BPP Estimator. I also apply the method of BPP to estimate $\beta^{\text{BPP}}_{c\_p}$, which is reported in the lower left panel using a dashed line. The popular moment restriction of BPP that identifies the passthrough from permanent shocks to consumption reads[38]

$$\beta^{\text{BPP}}_{c\_p} = \frac{cov\left(\Delta c_t, \Delta y_{-1} + \Delta y_t + \Delta y_{+1}\right)}{cov\left(\Delta y_t, \Delta y_{-1} + \Delta y_t + \Delta y_{+1}\right)}, \tag{19}$$

where subscripts -1 and +1 refer to lagged and leading growth rates relative to the growth rate in t.[39] Kaplan and Violante (2010) highlight how gentle mean reversion in the form of an AR1 with coeffi-

[35] Whether a newborn has a high or a low asset position is orthogonal to their initial human capital. I simply transfer the wealth from a dying dynasty to a newborn dynasty. If this capital was destroyed, instead of reshuffled, I would not be able to nests the neoclassical model the way I do in proposition 1.

[36] By structural I mean a regression of the change in log consumption on the change in log permanent income, which I observe when I simulate the income process. The passthrough coefficient based on the moment conditions in BPP, which aims to uncover the same structural relationship, will be downward biased due to the passing shocks, i.e., the fact that transitory shocks display some persistence. I will return to this issue when I estimate the degree of informal insurance in the next section.

[37] I provide additional details on this, and relate these structural coefficients to BPP, and show how both time aggregation and imperfectly transitory shocks lead to important departures from their benchmark, and bias their estimator. I build on and extend results from Crawley (2020).

[38] In practice, BPP use all income and consumption moments to efficiently estimate this passthrough using a GMM routine. Regarding informal insurance, note that when interest rates are low, and transitory shocks are fully transitory, it is easy to see that the popular passthrough coefficient from BPP equals $\beta^{\text{BPP}}_{c\_p} = 1 - \kappa$ for households that are sufficiently far away from the borrowing constraint. All results in this exercise are based on a scenario without any informal insurance, i.e., $\kappa = 0$.

[39] 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 (19) remains appropriate for the case of biennial data but not for annual data.

cient of autocorrelation close to one can generate a lower passthrough, and has been proposed as a candidate explanation for the "excess smoothness" found in BPP with passthrough coefficients for persistent shocks as low as .6.[40] Even so, Kaplan and Violante (2010) show that the BPP estimator still uncovers the correct passthrough coefficient. This is not true here. The reason is that the income process is misspecified in a way that confounds imperfectly transitory and fully persistent income shocks, see Crawley, Holm, and Tretvoll (2022).

I plot in grey what the BPP estimator would produce by running (19) on the simulated data for the case of annual data, which shows a large downward bias leading researchers to conclude that insurance is higher than it actually is. I derive the bias in closed form in the appendix, which reads

$$\beta_{c\_p}^{BPP} = \beta_p - \frac{(2\beta_p - \beta_\epsilon)\,\mathbb{E}\left[\tilde{\epsilon}_t \tilde{\epsilon}_{t-1}\right]\left(1 - e^{-\lambda_\epsilon}\right)}{\sigma_p^2 + 2 \cdot \mathbb{E}\left[\tilde{\epsilon}_t \tilde{\epsilon}_{t+1}\right]\left(1 - e^{-\lambda_\epsilon}\right)}$$

where $\tilde{\epsilon}_t = \int_{t-1}^{t} \epsilon_s ds$ is the transitory shock aggregate up from continuous time to annual observation. It is easy to see that if transitory shocks are fully transitory, there is no bias $\mathbb{E}\left[\tilde{\epsilon}_t \tilde{\epsilon}_{t-1}\right]$. Once this is no longer true, a potentially large bias arises. Intuitively, imperfectly transitory passing shocks –which I will find to be important in emerging markets, and Crawley, Holm, and Tretvoll (2022) argue play an important role for advanced economies as well– lead the estimator to overstate income volatility $cov\left(\Delta y_t, \Delta y_{-1} + \Delta y_t + \Delta y_{+1}\right) > \sigma_p^2$, which in turn leads to a low ratio of consumption growth to mismeasured income growth inducing a low passthrough estimate. The extent of this bias depends on the gap between β_p and β_ϵ. If there is a strong consumption response to the imperfectly transitory shock, the bias is relatively weaker as both income growth and consumption growth attributed to the persistent component through the lens of the misspecified moment condition are larger. However, in the more relevant case with $\beta_p \geq .5$ and $\beta_\epsilon < .2$, a large downward bias emerges.[41] I next quantify a version of the model to explore how important differences in land intensity, income risk, and informal insurance are in shaping consumption dynamics in South Africa.

3 Quantification

3.1 Parameterization of the Model

I now describe the parameterization of the model combining a mix of indirect inference and calibration describing each model block in turn.

Production and Preferences. Production and preference parameters are calibrated based on previous work. Urban production follows the standard neoclassical model with a reproducible capital

[40] The estimator carries over the the case of biennial data by simply using differences over two years.

[41] Consistent with the role of imperfectly transitory shock, the bias gets worse if income and consumption growth is measured at higher frequency as the correlation of income driven by imperfectly transitory shocks dies out as the gap between observations increases.

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. Measured labor vs. non-labor shares (including returns to capital and land) across the development spectrum are roughly stable after correcting for measurement problems due to self-employment, see Gollin (2002).[42] I use a depreciation rate of 5%. The discount factor is 3.5%, and the coefficient of relative risk aversion is set to 2, consistent with recent evidence in Choukhmane and Silva (2022).

Income Process. I pick the parameters governing the income process consistent with the results in Trouvain (2025b) where I estimate the stochastic process in (3) separately for rural and urban households in South Africa. The theoretical moments implied by the income process I have postulated are

$$\mathbb{E}\left[\hat{y}_t \hat{y}_{t+k}\right] = \sigma^2_{\text{int}^*} + \sigma^2_p \cdot t + e^{-\lambda_\epsilon k}\sigma^2_\epsilon + \mathbb{1}_{\{k=0\}}\sigma^2_{x,t} \tag{20}$$

where $\mathbb{1}$ is an indicator function accounting for classical measurement error that appears only on diagonal entries of the covariance matrix and varies by year. The moments are fully determined by the set of parameters $\theta = \{\sigma^2_{\text{int}^*}, \sigma^2_p, \lambda_\epsilon, \sigma^2_\epsilon, \{\sigma^2_{x,t}\}\}$. I report the autcovariance of residualized household income in table 1, which is the data counterpart. The key thing to notice is that the the autocovarianes are increasing for later waves, i.e., as one moves from the upper left to the lower right corner, which is indicative of persistent shocks. Moreover, moving vertically from top left to bottom left shows a declining auto-covariance for rural households in contrast to urban ones, suggesting important imperfectly transitory income shocks that die out eventually but generate a relatively high covariance for several years.

Table 1. Income Covariance Matrix – South Africa

(a) Rural

	y_t	y_{t+2}	y_{t+4}	y_{t+6}	y_{t+8}
y_t	0.52				
y_{t+2}	0.27	0.55			
y_{t+4}	0.23	0.27	0.49		
y_{t+6}	0.22	0.18	0.25	0.48	
y_{t+8}	0.18	0.16	0.23	0.34	0.57

(b) Urban

	y_t	y_{t+2}	y_{t+4}	y_{t+6}	y_{t+8}
y_t	0.52				
y_{t+2}	0.27	0.63			
y_{t+4}	0.24	0.26	0.58		
y_{t+6}	0.26	0.25	0.32	0.53	
y_{t+8}	0.23	0.26	0.32	0.34	0.56

Log household income is total earned labor income broadly defined plus net government transfers, i.e., welfare payments minus taxes. This measure includes income from own consumption in subsistence agriculture as well as profits but excludes investment, rental income, and remittances. Income is residualized using a first-stage regression controlling for age, education, sex, race, and household size as well as time effects, separately for urban and rural households. Cross-sectional weights are applied, and additional details are provided in Trouvain (2025b).

[42]The land share is broadly consistent with estimates for the UK at the eve of the industrial revolution from Allen (2009) or Clark (2010), albeit the land share is a little bit higher in my rural economy. Note that the agricultural employment share in the UK around 1800 was already substantially below 40%. See for instance the long-run agricultural employment series of the Our World In Data webpage. Take into account that the aggregate land share already is a weighted average between rural and urban, so the rural land share ought to be even higher.

The resulting estimates, rounded, are summarized in table 2.

Table 2. Income Risk in South Africa

	Rural	Urban
σ_p^2	0.005	0.01
λ_ϵ	.6	3.0
σ_ϵ^2	0.3	0.2
σ_{int}^2	0.13	0.13
$\sigma_{y,\text{error}}^2$	0.10	0.10
$\sigma_{c,\text{erro}}^2$	0.15	0.15

The arrival rate of the death shock equals $\phi = .015$, which ensure a stationary distribution obtains given the random walk in income. The implied tail inequality of permanent income, with complementary CDF $1 - p^{-\zeta}$ for large p, equals

$$\zeta = \sqrt{\frac{2\phi}{\sigma_p^2}}, \tag{21}$$

which will be consistent with reasonable degrees of tail inequality between 1.5 and 2.5 depending on the size of σ_p^2.[43] Newborn cohorts' average permanent type at entry, $c_0 < 0$, is pinned down by the overall shape of the cross-sectional income distribution, with a larger negative shock shifting more mass to the left. There is more mass on both the left and the right tail in urban due to larger shocks to human capital.

Informal Insurance. Lastly, I pin down the degree of informal insurance κ in the rural sector while assuming $\kappa = 0$ in urban. To estimate this parameter I utilize consumption expenditure, from the household survey. Conceptually I follow the logic in Deaton and Paxson (1994) and use the fanning out of inequality in both income and consumption to infer insurance. My approach is slightly different in that I use household-level panel data and a structural model to infer a specific parameter, κ. Identification comes from the fact that for larger κ, consumption inequality is overall lower, and rises more slowly over the life cycle, in contrast to the rise in labor income inequality unrelated to κ.[44]

Table 3 reports the autocovariance matrices for log real household consumption in South Africa, respectively, which can be interpreted analogous to the ones reported for income. Three findings stand out. First, consumption inequality appears larger in urban than in rural, which is consistent with the role of permanent shocks driving urban inequality. Second, the gap between consumption

[43] Note that income and wealth tail inequality are tied together in the standard incomplete markets model, which appears not to be the case in the data, see Gaillard et al. (2023) for recent evidence. I largely abstract away from this issue but note that one could think of high entrepreneurial returns, which are needed to generate a fat right tail for wealth inequality, as human capital rents (Smith et al., 2019). Measurement is challenging but, at least theoretically, this would tie together income and wealth inequality.

[44] Using the long-run consumption profile is also more robust to advance information, i.e., the case where households have information about future income shocks unknown to the econometrician as modeled in Kaufmann and Pistaferri (2009) since advance information is likely to be more important over short horizons.

Table 3. Consumption Covariance Matrix – South Africa

(a) Rural

	y_t	y_{t+2}	y_{t+4}	y_{t+6}	y_{t+8}
y_t	0.54				
y_{t+2}	0.21	0.62			
y_{t+4}	0.17	0.23	0.43		
y_{t+6}	0.13	0.13	0.22	0.41	
y_{t+8}	0.10	0.09	0.10	0.20	0.37

(b) Urban

	y_t	y_{t+2}	y_{t+4}	y_{t+6}	y_{t+8}
y_t	0.54				
y_{t+2}	0.27	0.69			
y_{t+4}	0.21	0.22	0.52		
y_{t+6}	0.27	0.24	0.26	0.44	
y_{t+8}	0.22	0.23	0.25	0.26	0.46

Log household consumption includes food and non-food items measured within a month (30 days). Included are food, non food, rental expenditure (imputed for owners). There is unfortunately no distinction between more or less durable consumption. Consumption is residualized using a first-stage regression controlling for age, education, sex, race, and household size as well as time effects, separately for urban and rural households. Cross-sectional weights are applied, and additional details are provided in Trouvain (2025b).

inequality and income inequality is large in the rural sector, consistent with the prior that informal insurance plays an important role in rural communities. Third, the correlation of consumption in the vertical dimension falls in rural – some of which is accounted for by the role of imperfectly transitory shocks, but not all of it.[45]

Table 4 summarizes identification and calibration of parameters. It is worth pointing out that I

Table 4. Summary Parameters

Parameter		Value	Target/Source
Preferences			
ρ	Discount factor	0.025	Standard value
ϕ	Death shock	0.025	Tail inequality
γ	Risk aversion	2.0	Standard value
Technology Rural			
ν	Capital share	0.1	Hansen/Prescott (2002)
χ	Land share	0.3	Hansen/Prescott (2002)
δ_k	Capital depreciation	0.05	Standard value
κ	Informal insurance	0.3	SMM
Technology Urban			
ν	Capital share	0.4	Standard value
χ	Land share	0	Standard value
δ_k	Capital depreciation	0.05	Standard value
κ	Informal insurance	0	Standard value
Income Processes Rural			
σ_p^2	Variance perm. shock	0.005	GMM
λ_ϵ	Arrival trans. shock	0.6	GMM
σ_ϵ^2	Variance trans. shock	0.3	GMM
$\sigma_{y,error}^2$	Measurement error income	0.1	GMM
$\sigma_{c,error}^2$	Measurement error consumption	0.25	GMM
Income Processes Urban			
σ_p^2	Variance perm. shock	0.01	GMM
λ_ϵ	Arrival trans. shock	3.0	GMM
σ_ϵ^2	Variance trans. shock	0.2	GMM
$\sigma_{y,error}^2$	Measurement error income	0.1	GMM
$\sigma_{c,error}^2$	Measurement error consumption	0.15	GMM

have chosen a conservative calibration in terms of preferences, income process, and technology. Re-

[45]The model cannot match steeply falling autocovariances in consumption, which is inconsistent with consumption smoothing.

garding preferences, I could have relied on Epstein and Zin (1989) preferences to separate out intertemporal elasticity of substitution, and risk-aversion. This would allow me to entertain a higher degree of risk aversion, and thus raise precautionary savings motives, see for example the calibration in Aguiar, Amador, and Arellano (2024). The more risk there is, the more important is the role of land in sustaining high interest rates.[46] Similarly, regarding the income process, much of the empirical literature estimates a larger volatility of persistent income shocks in developing economies,[47] which again would elevate the role of land in keeping interest rates high in the presence of idiosyncratic risk. Regarding technology, note that I use the land share calibration from Hansen and Prescott (2002), which is likely a lower bound.[48] Lastly, and again compared to Aguiar, Amador, and Arellano (2024), I have chosen a relatively low depreciation rate of 5%. Increasing the rate of depreciation amplifies the results since the depreciation rate is what induces a low safe to risky income share.

Simulation. To simulate model-based moments I proceed as follows. I simulate N=12000 households from their time of birth, here normalized to zero corresponding to 27 years in the data, and simulate their income process using the stochastic process described earlier but absent death shocks.[49] Households' initial asset income is drawn from the stationary distribution, consistent with the Poisson death shock. I then obtain consumption and the evolution of household wealth using the solution to the household problem together with the simulated income process. I assume that a time increment over which income and consumption is measured is 0.1 , so every calendar year is split into 10 time units, which I aggregate up to obtain annual income and consumption. I then take the log and and tack on mean-zero normally distributed measurement error. I do this for five waves so that the simulated data mimics the South African household level data.

When computing simulated passthrough coefficients or autocovariance matrices, 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 get older. The variable age_min represents the average age of households in the first wave normalized by the sample cutoff 27. This number is significant because the value σ^{2*}_{int} consist of a piece that represents initial dispersion in the human capital type of newborn households, and persistent shocks that have accumulated before the household appeared in the sample, i.e., $\sigma^2_{\text{int}^*} = \sigma^2_{\text{int}} + age \times \sigma^2_p$. An implication of this is that differences in average household age across rural and urban need to take into account when matching model to data since, for example, the same

[46] To gain intuition for this result, consider an economy that only uses land and labor for production. The interest rate can never fall below zero no matter how high income risk is. Contrast that with a capital-intensive economy where the interest rate converges to the $-\delta_k$ as risk becomes arbitrarily large.

[47] See for instance Santaeulalia-Llopis and Zheng (2018) and other works cited in in the introduction. The discrepancy is explained by imperfectly transitory shocks, which I find to be important in the rural sector, see Trouvain (2025b).

[48] Weil and Wilde (2009) summarize estimates for land's share in agricultural output in developing economies, which can exceed 50% in Sub-Saharan Africa. This contrasts with the much lower factor shares of land hovering around 20% in US agriculture, see Valentinyi and Herrendorf (2008), which is unsurprising given the high capital intensity of the agricultural sector in the US.

[49] 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.

amount of volatility will create more inequality amongst an older cohort. I take account of this issue when estimating the income process in Trouvain (2025b). However, average age of rural vs. urban households in South Africa for my sample is very similar, and equals 10.5+27 vs. 11.2+27 years, respectively. I simplify by using the same age level of 11, which means that I use simulated annual income from age 10 to age 11 as my first element in the simulated data vector for some household. I then add income over the interval 12-13, and so forth, to simulate annual income measured on a biennial basis.[50]

Lastly, since I compute intergenerational elasticities of consumption across dynasties, I need to specify at which age consumption of newborn households is measured. I assume that households have have reached age 15, which is somewhere in the middle of a household's work life, and measure their annual income from age 14-15.[51] I assume consumption of parents is measured without error to focus on the implications of differences in land intensity for properly measured intergenerational elasticities.[52] Table 5 summarizes the details, and contains information underlying the computational routine to solve the model.[53]

Table 5. Details Simulation

	Simulation
N	12000
Waves	5
dt	0.1
age_min	11
age_child	15

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(-1.0 ,1.0 ,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 and an upper bound sufficiently large that high-asset households want to dissave. Note that household consumption choices and the evolution of assets is based on the budget constraint implied by W^*, while raw income is measured in terms of W, and the gap between the two is accounted for by informal insurance for the case of $\kappa > 0$.

[50] This sort of time aggregation is in principal not needed because income and consumption in reported on an monthly basis. Since the main point of this paper is conceptual, and most household level data still is reported using annual aggregation, I preferred to aggregate up income and consumption onto the annual level. In Trouvain (2025b) I use both Chinese and South African data to estimate the income process, and I explore the role of time aggregation, which is relevant for the Chinese data where income is an annual aggregate.

[51] Unsurprisingly, the elasticity is falling the age of the child. Since we are dealing with stationary stochastic process, the correlation has to be zero in the limit for old children, whose age is unbounded due to the perpetual youth structure.

[52] It is clear that classical measurement error would push the measured intergenerational elasticity towards zero. In practice, intergenerational elasticities are usually computed based on educational attainment or a proxy for lifetime income based on several years of panel data, which reduce the role of measurement error.

[53] The finite difference scheme is defined on a grid. Note that log income consists of two linearly spaced grids, p_grid = LinRange(-2.5 ,2.5 ,15), ϵ_grid = LinRange(-1.0 ,1.0 ,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 and an upper bound sufficiently large that high-asset households want to dissave. Note that household consumption choices and the evolution of assets is based on the budget constraint implied by W^*, while raw income is measured in terms of W, and the gap between the two is accounted for by informal insurance for the case of $\kappa > 0$.

3.2 Results

In this subsection I report the implications of the model for consumption volatility and consumption inequality across sectors. I first analyze how the passthrough coefficients implied by the model compare to their empirical counterparts. The exercise serves two purposes. One, the empirical passthrough coefficients reinforce that rural consumption appears relatively smooth. Two, comparing the results implied by the model to their non-targeted empirical counterparts serves as an external validation test. The model does a good job, and I will decompose the distinct role of land intensity, income risk, and informal insurance to match the low passthrough coefficients. Second, I explore the implications of the model for consumption volatility and consumption inequality within and across cohorts.

BPP and Townsend-lite. I report empirical estimates using BPP's approach, and simplified version of Townsend (1994), based on the same household-level data used to estimate income processes. The original Townsend (1994) approach runs a passthrough regression of log consumption on log income while controlling for average village outcomes. The idea is that complete risk sharing within villages implies that, once average village income is controlled for, individual income plays no role in determining individual consumption. In many contexts,[54] like mine, village income is not available and a related passthrough regression of the form

$$c_{i,t} = \alpha_i + \beta_{c\_y} y_{i,t} + \underbrace{\gamma' X}_{\text{controls}} + u_{i,t} \tag{22}$$

is employed to assess how income shocks transmit to consumption. Note that in the presence of measurement error, it is easy to see that (22) will suggest low passthroughs even if there is no informal insurance whatsoever. This insight carries over to the original specification in Townsend (1994). This point is a simple one, but given the large measurement error and mean reversion I estimate in the data, the point matters quantitatively.

The empirical estimates for both passthrough coefficients are reported in table 6. The estimated passthrough from permanent income shocks to consumption, using the BPP method, is overall low, and lower for rural households than for urban ones consistent with both informal insurance and GE forces. The simple passthrough regression of log consumption on income, with and without controls, paints a similar picture: the passthrough is overall low, and lower in rural compared to urban in line with the previous literature.[55]

[54] See for instance De Magalhaes, Martorell, and Santaeulalia-Llopis (2024).

[55] See for instance Santaeulalia-Llopis and Zheng (2018) or Attanasio et al. (2022) for estimates using the BPP approach in the Chinese context, and De Magalhaes and Santaeulalia-Llopis (2018) for simple passthrough regressions for African countries.

Table 6. Passthrough in South Africa

(a) $\beta^{\text{BPP}}_{c\_p}$

	Rural	Urban
$\hat{\beta}$	0.257	0.426**
	(0.281)	(0.206)
N	379	613

(b) β_{c_y}

	Log consumption	Log consumption
Log income	0.268***	0.148***
	(0.0139)	(0.0210)
Log income $\times \mathbb{1}\_urban$	0.148***	0.0686**
	(0.0182)	(0.0292)
controls	Yes	No
time-sector fe	Yes	Yes
N	22936	18750
R^2	0.652	0.830

I next simulate income and consumption dynamics for 12,000 households in each sector using the model. I then run the same regression as I run in the data. The results are reported in table 6.

Table 7. Model-Implied Passthroughs

	Rural	Urban
β_{c_p}	0.486	0.69
$\beta^{BPP}_{c\_p}$	0.141	0.62
β_{c_y}	0.061	0.052

Comparing β_{c_p} in the first row across rural and urban reveals how important informal insurance and the factor land jointly are in generating differences in the passthrough of permanent income shocks: the urban sector features a passthrough of around .7, which is roughly 40% higher that the rural one. The second row computes the passthrough using the method of BPP. The presence of imperfectly transitory long-lived shocks in rural induces a severe downward bias in the estimator. In fact, the simulated model has no trouble matching extremely low estimates common in the literature. The key issue is that the denominator in the BPP estimator is overstated as some of the transitory shocks are wrongly attributed to persistent income shocks. Overstating the denominator then means that the overall expression is biased towards zero. With regard to the simple passthrough estimate of income on consumption, β_{c_y}, the implied estimate is extremely low due to large measurement error and passing shocks. The simulation cautions against interpreting simple passthrough regressions with a coefficient close to zero as evidence in favor of strong insurance.

Consumption Volatility and Consumption Inequality. I next compute model-implied consumption dynamics, and explore how they would change in counterfactual scenarios. I focus on consumption volatility $\mathbb{V}(\Delta \log c)$, the increase in the log variance of consumption within a cohort from birth to age 15, $\Delta\sigma^2_{c,15}$, and the intergenerational persistence in consumption defined as

$$\beta_c^{\text{IGE}} = \frac{Cov\left(c_{\text{child}}, c_{\text{parent}}\right)}{\mathbb{V}\left(c_{\text{parent}}\right)}, \tag{23}$$

where log child consumption is measured per year, and 15 years after birth, while parent consumption is measured at death.[56] Note that in this stylized model of intergenerational persistence previous dynasties (parents) do not care about the dynasty that replaces them (children), and labor income draws are uncorrelated. Yet, accidental bequests lead to a transmission of wealth that generates intergenerational persistence in consumption. This happens both in the rural and urban sector, put the implied intergenerational persistence of consumption is quite different.

Table 8. Consumption Dynamics

	Rural	Urban
$\sigma^2_{c,0}$	0.147	0.155
$\sigma^2_{c,15}$	0.159	0.221
$\mathbb{V}\left(\Delta \log c\right)$	0.003	0.004
β^{IGE}_c	0.543	0.258

Consistent with the data, the model generates a much steeper consumption inequality age profile in urban implies by the jump of consumption inequality from the first two the second row in table 8. This is true even though consumption volatility is not that different as indicated by the third row. The reason is that imperfectly transitory shocks move rural consumption without impacting overall cross-sectional inequality in the long run, while persistent shocks to human capital in urban do just that.

The model produces very different intergenerational elasticities of consumption across sectors. There is much more persistence in rural, i.e., there is more mobility in urban. The finding lines up well with a growing literature that documents intergenerational elasticities, usually focused on schooling, across the development spectrum, see Weide et al. (2021) and Alesina et al. (2021).[57] I do not have any direct dependence of a child's labor income type on parents' labor income type, and the persistence is accounted for i) by the important role of wealth in rural, and ii) by the lack of income mobility in rural, relative to urban. Both the greater importance of financial wealth, which is partly inherited, and the smaller role assigned to human capital, which is the fickle component of income, lead to a high intergenerational persistence in consumption in the rural sector. Loosely speaking, low risk exposure and low social mobility within and across cohorts are two sides of the same coin.

Interestingly, the role of wealth in producing higher intergenerational persistence in consumption

[56] The simple log-linear regression used here is consistent with the commonly used regression of children on parental schooling (Hertz et al., 2008) given the log-linear relationship between years of schooling and earnings. Alternative measures of intergenerational mobility involve rank-rank correlation coefficients, see for instance Chetty et al. (2014), which are susceptible to measurement error, see Mogstad et al. (2024).

[57] Since there is usually no consumption measure available for the parent generation there is little direct evidence on the intergenerational persistence of consumption. However, schooling and income is strongly associated with household consumption suggesting that the estimates of intergenerational mobility in Piraino (2015), Sinha (2016), Fan, Yi, and Zhang (2021), Syrichas (2022) are qualitatively consistent with the model. Running a regression with years of schooling amongst parent-child pairs for rural vs. urban households in South Africa using the same data as before generates estimates quantitatively consistent with the baseline model.

is distinct from and complementary to the much-studied link between borrowing constraints and (lack of) human capital investments.[58] Since I do not model human capital investment, the borrowing constraint plays no role for intergenerational persistence. The only mechanism at play is that the annuity value of wealth is higher in a high interest rate environment, which means wealth has a stronger influence on household consumption.

Both a relatively low passthrough from labor income shocks to consumption, and a higher intergenerational persistence of consumption, are driven by relatively high interest rates in rural environments, which is consistent with the empirical evidence, see Guzman et al. (2024) for recent work. Moreover, the high rural interest rates also induce a relatively higher marginal propensity to consume, which is a straightforward implication of consumption smoothing: the same cash transfer in a high vs. low interest rate environment will boost consumption much more in the former than the latter.[59]

Counterfactuals & Decomposition.
I next explore counterfactual scenarios where I change i) the share of land in production is set to zero, or ii) informal insurance is set to zero, or iii) both to decompose the role of the income process, informal insurance, and land intensity in generating different consumption dynamics across sectors. I compute the same statistics as before focusing on the rural sector, and table 9 reports the results.

The first thing to note is that when both informal insurance and land intensity are shut down, the passthrough coefficient of persistent shocks to income is virtually identical across rural and urban, despite differences in the income process, which can be seen from the very last entry in the first row. This is reassuring because it means that the income process alone is not sufficient to generate the consumption dynamics observed in the rural sector.

Table 9. Passthrough Decomposition

	baseline	$\kappa = 0$	$\chi = 0$	$\kappa = 0, \chi = 0$
β_{c_p}	0.486	0.597	0.496	0.698
$\beta_{c\_p}^{BPP}$	0.141	0.144	0.163	0.175

In a first exercise I shut down informal insurance by setting $\kappa = 0$. Relative to the baseline value in column 1, the passthrough coefficient rises substantially. This is unsurprising since I have modeled informal insurance with the goal in mind to change precisely this passthrough coefficient. Note, however, that even though the loss of informal insurance raises the passthrough, rural households are still substantially less exposed to persistent shocks than urban ones by roughly 10 percentage points. The

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

[59] I abstract away from access to banking, which is severely restricted for poor rural communities, see for instance Dupas and Robinson (2013) or Dupas et al. (2018). It is unclear, however, whether the lack of a formal large-scale banking sector deprives rural communities of the ability to save. Particularly relevant in this context is the role of livestock as highlighted in Rosenzweig and Wolpin (1993), land rights, or precious metals. The fact that consumption is relatively smooth suggests that the lack of professional financialization cannot be the only key feature distinguishing rural and urban communities.

actual BPP estimator responds little simply because the bias due to the misspecified income process is so dominant.

Next, consider how a reduction in land-intensity and an increase in capital-intensity shapes the passthrough coefficient. It turns out that for the current calibration the impact of a change in land share is seemingly minor as the passthrough coefficient only increases by one percent. The reason is that effective income risk already is very low because of the low overall volatility combined with substantial informal insurance. Recall that the role of land is tied to the importance of income risk. If there is no risk, the land share becomes irrelevant. This interpretation is then borne out int he final column: shutting down both informal insurance and land-intensity generates a substantial increase in the passthrough, now at part with the urban passthrough, and far beyond the initial increase obtained by shutting down informal insurance alone. The quantitative results thus emphasize the interaction between income risk, and land intensity. Moreover, note that relative to much of the previous literature I have estimated relatively low persistent income risk in the rural sector – the role of land would thus be elevated if other studies' estimates were employed.

Table 10 reports the results for other consumption moments and intergenerational persistence based on the same approach as before. Shutting down informal insurance, unsurprisingly, increases consumption inequality. Intergenerational persistence is lower because labor income shocks become more important, which are unrelated to parental variables. Relative to the previous results, note that land-intensity seems especially important for intergenerational persistence as can be seen in the second row where a more capital intensive income generates substantially less intergenerational persistence. The reason is that a less land-intensive economy, all else equal, features substantially lower interest rates, and interest rates are key to generate income out of inherited assets. In the final column I again shut down both informal insurance and land-intensity. Unlike in the previous exercise, shutting down both forces does not bring the consumption dynamics nor the intergenerational elasticity to the level of the urban economy. The gap is accounted for by differences in the income process.

Table 10. Consumption Inequality Decomposition

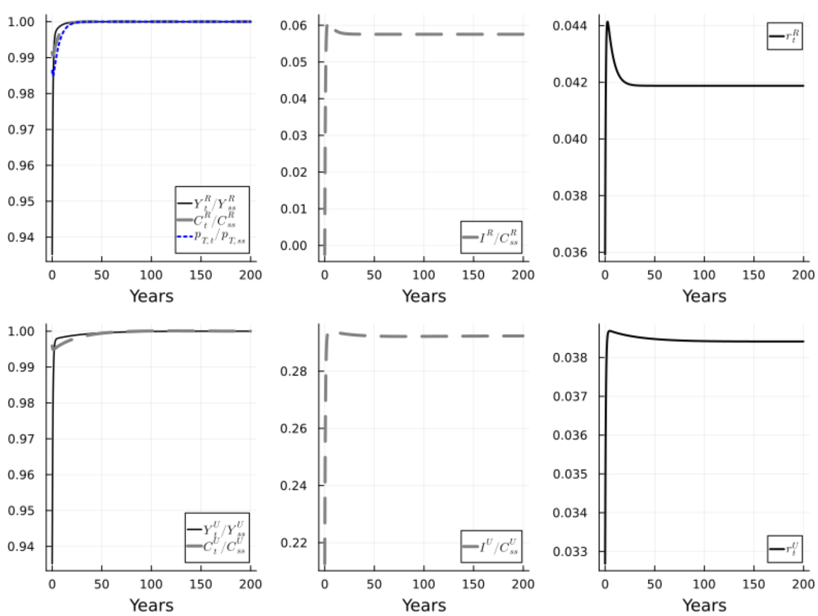
	baseline	$\kappa = 0$	$\chi = 0$	$\kappa = 0, \chi = 0$
$\sigma^2_{c,0}$	0.147	0.189	0.116	0.166
$\sigma^2_{c,15}$	0.159	0.216	0.137	0.207
$\mathbb{V}(\Delta \log c)$	0.003	0.003	0.004	0.005
β_c^{IGE}	0.543	0.46	0.351	0.289

4 Aggregate Shocks

In this final section I consider how land-intensive economies responds to transitory aggregate shocks, and study transition dynamics after a secular increase in the volatility of persistent shocks ($\sigma_p^2 \uparrow$).

First, consider a negative productivity shock that leads to a drop in TFP of around 10% in the first quarter, while TFP mean-reverts to its long-run level after around 2.5 years as depicted in figure 9. After the initial surprise, I solve for the perfect-foresight path using global solution methods, i.e., this shock is a so-called MIT shock. The results are plotted in figure 6. Interestingly, a negative TFP shock has more adverse consequences for the rural sector as aggregate consumption falls by roughly 1% vis-a-vis a drop of .5% in the urban sector. The reason for these asymmetric effects, yet again, is to be found in the special role of land as a fixed factor of production. During the recession, households would like to smooth consumption. In the urban sector, investment is relatively high and can take a hit to shield consumption. In the rural sector, this is a less viable strategy since investment rates are low to begin with. This intuition is confirmed by the second column of figure 6, which plots the difference between current investment and steady state consumption. The drop is almost twice as large in urban compared to rural, which explains the relatively weak impact of the TFP shock on urban consumption. Remarkably, this result obtains even though the recession is endogenously more long-lived in the urban sector since a higher capital share works as a multiplier that amplifies the initial negative shock.[60] The result lines up with the overall more devastating effect of aggregate shocks

Figure 6. Temporary TFP Shock



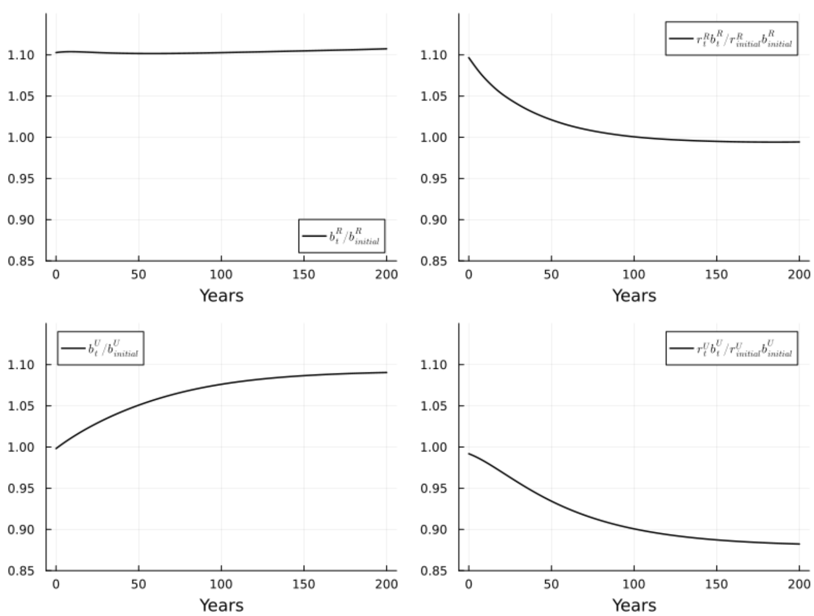
The calibration is based on $\sigma_p^2 = .017$, $\lambda_\epsilon = 2$, $\sigma_\epsilon^2 = .15$, $\delta_k = .05$, $1 - \chi - \nu = .6$ and there is no informal insurance, $\kappa = 0$.

[60] Recall that the speed of convergence to first order is tightly linked to the share of reproducible capital, see for instance Mankiw, Romer, and Weil (1992).

in rural economies. Formal and informal consumption insurance helps little in the presence of aggregate shocks, which is amplified by the low investment level in rural, and consistent with work by Kazianga and Udry (2006) who find little consumption smoothing during droughts in developing economies.[61]

An increase in income risk. Consider next an increase in σ_p^2, from .017 to .02. The transition dynamics, based on a global solution method, are depicted in figure 7, and the dynamics are plotted on the same y-scale.

Figure 7. Secular Increase in σ_p^2



The calibration is based on $\sigma_p^2 = .02$, $\lambda_\epsilon = 2$, $\sigma_\epsilon^2 = .15$, $\delta_k = .05$, $1 - \chi - \nu = .6$ and there is no informal insurance, $\kappa = 0$.

Two observations stand out. First, the normalized asset demand, and normalized asset income, defined as $\frac{B}{wH}$ and $\frac{rB}{wH}$,[62] grow much quicker in the rural economy, which is due to the fact that the land price can jump, while capital accumulation is a relatively slow process. In fact, a large jump on impact of the asset position of the land-intensive economy is entirely due to a revaluation of land.

[61] Note that differences in the structure of production across rural and urban provides a simple explanation for why investment rates are low in poor countries as documented in several studies (Levine and Renelt, 1992; Martin, 1997), an observation first made in Laitner (2000). Laitner (2000) notes that measurement practices in the national accounts differ across land and physical capital understating aggregate savings in rural economies. Relative to Laitner (2000), the issue is amplified here because income risk and capital depreciation lead to additional capital accumulation in urban relative to rural, and hence additional investment in steady state.

[62] I know have to keep account of the fact that average efficiency units $\mathbb{E}[h]$ are rising, alternatively one could introduce the negative drift term $-\frac{\sigma_p^2}{2}$ to prevent this from happening, see for instance Carroll (1997).

Put differently, asset price appreciation meets the rising demand for safe assets in a riskier world.[63] Second, note that the same increase in income risk leads to a much larger deterioration of safe asset income, relative to labor income, in the capital intensive economy falling by more than 10% whilst relative asset income hardly moves in the land intensive economy. This is driven by a different response of equilibrium interest rates, and an instance of proposition 2.

5 Robustness

In this section, I generalize the model to include non-traded land, which seems particularly relevant for subsistence farmers operating in environments with ill-defined property rights. To be clear, land tenure systems in developing economies are extremely complex, and differ greatly even within the same country.[64] The model here is not designed to capture this richness. The model does, however, allow for a straightforward extension where some land may not be traded, and I explore next whether the key insight of the role of a fixed production factor in shaping the link between income and consumption dynamics is robust to this extension.

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. Because I have chosen a relatively low land-share in rural areas to begin with, this concern is largely addressed in the baseline model. Second, once a specific plot of land is non-traded, one begins to worry about idiosyncratic capital risk that does not wash out since a law of large numbers is unlikely to hold for small plots of land.[65][66] Fortunately, my measure of household labor income precisely incorporates this sort of risk since own-consumption of agricultural goods and business profits are included.[67] Consequently, the structure of the model hardly needs any changing to incorporate non-traded land since idiosyncratic risk associated with non-tradable land is already captured by the stochastic labor income process. What is crucial for the main point to go through is that there is a market for some assets, and the

[63] These differences in convergence speed remain even when capital does not depreciate because the accumulation process itself takes time and requires temporarily reduced consumption. This argument is distinct from the well-known insight that the speed of convergence to the steady state is a function of the capital share, see Mankiw, Romer, and Weil (1992). It is difficult, however, to tell them apart because whenever the land share is larger, the capital share has to be lower.

[64] See Pande and Udry (2005) and Deininger and Binswanger (2001) for insightful reviews.

[65] While I can consider this sort of capital income risk, aggregate risk remains beyond the scope of the paper. Note that 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 choice because idiosyncratic risk appears an order of magnitude larger than aggregate risk, which is true even in developing economies.

[66] 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 whereby a negative shock to agricultural output raises the price of agricultural goods, which in turn reduces volatility of farm income, see Allen and Atkin (2022) for a quantification of this idea in the context of India. Arguments along these lines, while relevant, pertain to aggregate shocks since individual idiosyncratic shocks are unlikely to shift aggregate supply sufficiently much to move the equilibrium price.

[67] The role of volatile but mean-reverting shocks in the rural sector seems suggestive of the role of agricultural risk

average rate of depreciation of such assets is relatively lower than in the urban sector. Land clearly satisfies this criterion, but there are other assets in rural areas, think of the role of livestock (Rosenzweig and Wolpin, 1993) in Subsaharan Africa, or the role of gold in rural India, that could play this role.

Non-Traded Land. Formally, suppose that households are endowed with $x_i \geq 0$ units of non-tradable land. The aggregate share of non-tradable land equals $\zeta < 1$, and I otherwise maintain a similar setup as before with informal insurance set to zero, $\kappa = 0$. In this scenario, non-tradable land x_i becomes an idiosyncratic state variable, and appears in the budget constraint

$$\dot{a} = ra + R_T x + wh - c. \tag{24}$$

Moreover, the aggregate asset market clearing condition changes to

$$K + p_T (1 - \zeta) = B$$

to account for the fact that only some land is traded. Since capital and labor are mobile, the return to land is equalized everywhere including non-traded land so $R_T = \chi Y$ still holds. In addition, the aggregate asset supply function B is still homogenous of degree one in w and L. To see this, it is convenient to rewrite the budget constraint using $w\widehat{h} = w\left(\frac{R_T}{w}x + h\right)$. After noting that $\frac{R_T}{w} = \frac{\chi}{1-\theta}L\tilde{h} = \frac{\chi}{1-\theta}$ for $\tilde{h}$ normalized to one, it is easy to see that the new stochastic process, $\widehat{h}$, is similar to the previous one, h, but shifted to the right by a constant household-specific term $\frac{\chi}{1-\theta}x$. At this point, proving that the aggregate asset supply function is homogenous of degree one is identical to proving lemma 1. I can then proceed as before and derive the normalized aggregate asset market clearing condition

$$\frac{1}{r}\left(\frac{\theta}{1-\theta} - \zeta - \frac{\nu}{1-\theta}\left(\frac{\delta_k}{r+\delta_k} - \zeta\right)\right) = b, \tag{25}$$

where it is understood that normalized asset demand $b(\Theta, r)$ now also depends on the distribution of non-tradable land. For the case of $\zeta = 0$, I am back to the standard model. For the case of $\zeta > 0$, households have an additional stream of safe income from their fixed land endowment possibly reducing the demand for precautionary savings. At the same time, the left hand side of (25) is smaller as fewer tradable units of land are supplied. Whether the interest rate is lower or higher relative to the frictionless benchmark depends on whether the left hand side of (25) falls more than the right hand side. Moreover, note that as long as $\frac{\delta_k}{r+\delta_k} > \zeta$, which seems a mild restriction given that the ratio of depreciation relative to rental rate easily exceeds 50% for any reasonable calibration, it is still true that a relatively more land-intensive economy will feature a lower passthrough from income risk to equilibrium real rate, i.e., proposition 2 goes through.

Idiosyncratic Land Risk. While idiosyncratic land risk washes out in the aggregate by a law of large numbers argument, such a logic would not necessarily apply to the case of small non-traded plots of land common in subsistence farming. To extend the previous analysis along those lines, assume that the returns to non-traded land are stochastic and equal

$$R_i x_i = R_T A_i x_i,$$

where A_i is a stationary stochastic process orthogonal to x_i and normalized to unity, i.e., $x \perp A$ and $\mathbb{E}[A_i] = 1$.[68] Note that the budget constraint in (24) is unchanged but the randomness now depends on both labor, h_i, and non-traded land x_i. Crucially, the way income risk is measured in the data is consistent with (24) since I have incorporated own-consumption and agricultural sales into household income. The only adjustment left to be made is the reduced supply of traded land on the left hand side of (25).[69]

Table 11 reports the results where I compare the baseline rural scenario with one where 10% of land is non-tradable, which is a crude compromise for most land being imperfectly traded, and I also consider an extreme version where half of land is not traded. To benchmark the results against the urban sector and distill the importance of land, I assume that the income process follows the baseline urban income process and informal insurance is zero.

Table 11. Robustness exercise with non-traded land

	$\zeta = 0$	$\zeta = .1$
β_{c_p}	0.552	0.578
$\sigma^2_{c,0}$	0.174	0.167
$\sigma^2_{c,15}$	0.217	0.214
β_c^{IGE}	0.378	0.338

When only 10% of land is non-traded, the results change very little, and the passthrough of around .58 is substantially below the passthrough of income shocks of .67 in the urban sector, whilst the intergenerational elasticity of consumption remains substantially higher in rural.[70] 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.

I conclude this section by pointing out that the role of land as a fixed factor of production and the small amount of persistent income risk found for rural households gives rise to an equilibrium with little land trade even if there were no land reallocation frictions whatsoever. To see why, consider the limiting case without any persistent income shocks. Households would be able to use a small amount

[68] The orthogonality assumption can be relaxed by simply redefining the problem, i.e., A_i and x_i could be correlated, in which case one could think of effective land $\widehat{x} = x\mathbb{E}[A|x]$, and the stochastic component would involve the normalized term $\frac{A}{\mathbb{E}[A|x]}$.

[69] 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.

[70] For values of $\zeta \approx \frac{1}{2}$ when half of all land is non-tradable, rural consumption dynamics appear similar to the urban sector.

of bufferstock savings to shield consumption from temporary shocks. The overall level of household consumption would be pinned down by endowments assigned at birth, and consumption would be roughly constant consistent with an interest rate close to the neoclassical benchmark. The wealthy stay wealthy and the poor stay poor. Limited trade in land then becomes an equilibrium outcome independent of the degree of land trading frictions.

6 Conclusion

This paper studies the impact of income risk in a general equilibrium model when land is a fixed factor of production. This gives rise to a novel general equilibrium channel operating through the equilibrium interest rate and the safe to risky asset income ratio in the aggregate economy. The framework is helpful in understanding relatively smooth rural consumption and high intergenerational persistence.

There are several caveats and avenues for future work. First, the simulations pertain to stationary environments, which is clearly at odds with the declining rural share in most countries. In ongoing work I am exploring the transitional dynamics of the theory developed here. These dynamics are non-trivial and helpful in reconciling the relationship between aggregate savings and economic growth in fast-growing economies, see Trouvain (2025a). Second, differences in income risk and insurance ought to matter for selection into migration and rural-urban structural change more broadly, an issue I take up in Trouvain (2025b). Third, I abstract away from aggregate risk, which may be particularly relevant in weather-dependent rural environments and warrants further work.

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