The Impact of Climate Change and Financial Frictions on Agricultural Productivity

-Working Paper-

Latest version of the working paper

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Abstract

This paper studies how climate-induced declines in land productivity interact with financial frictions to shape agricultural productivity and welfare. I develop a two-sector general equilibrium model with heterogeneous farmers who choose between traditional and modern production technologies. Modern farming requires intermediary inputs that must be financed in advance, giving rise to endogenous borrowing constraints due to limited contract enforceability. Climate change is modeled as a reduction in land productivity, which lowers pledgeable income and tightens credit constraints. Qualitatively, climate damage leads to substantial welfare losses and lower agricultural productivity. Financial frictions further reduce welfare by limiting technology adoption, although their aggregate amplification effect is modest under the baseline parameterization. Partial equilibrium results show that financial constraints distort input use more severely when land productivity is high, amplifying productivity losses among modern farms. The findings highlight that financial market imperfections influence both the level and composition of agricultural productivity and can exacerbate the economic consequences of climate change.

1 Introduction

Agricultural productivity is a key predictor for international income differences. In developing economies, agricultural productivity is not only lower in absolute terms but also relative to the rest of the economy. Nevertheless, poor countries have a higher employment share in agriculture. At the same time, the agricultural sector is most exposed to climate related damages (**???**). Consequently, understanding how climate change effects agricultural productivity is of utmost importance.

While a large literature has documented the agricultural productivity gap, less attention has been paid to how climate change interacts with existing frictions in rural economies. More specifically, many developing economies are plagued by weak financial institutions. This is particular relevant in context of agricultural production which needs to purchase inputs in advance of production. Financial frictions impede the adoption of intermediary inputs in the production process. An extensive amount of empirical literature has shown that intermediary inputs are underemployed in the agricultural sector in many developing economies (**??**). Credit and borrowing play an important role of the agricultural sector since intermediary inputs such as fertilizers, pesticides and improved seeds must be purchased before production takes place. Empirical evidence shows that credit constraints hinder the adoption of modern inputs significantly and can explain part of the agricultural productivity gap. Consequently, this paper asks: to what extent do climate shocks amplify financial frictions and reduce agricultural productivity?

For this purpose I build a two sector general equilibrium economy with a rural and a urban population. In this model, farmers face an technological choice between operating a modern farm using intermediary inputs and a traditional farm which only uses farmer's labour and land as inputs. My model contributes to the literature by combining a dynamic occupational choice framework with agricultural productivity and climate change. I assume that climate change impedes the ability of farmers to borrow money since their pledge-able income declines. In consequence, the agricultural productivity is worsened by more than proportional to the decline in productivity caused by climate change. Therefore to mitigate the economic impact that climate change has policy should also focus on the financial side and provide the right tools for farmers.

Related Literature. This research is connected to several strands of the literature. Firstly, it relates to the development literature focusing on agricultural productivity. **?** and **?**, for instance focuses on the consequences of missing land-markets and institutional restrictions on land ownership for agricultural productivity. Both factors hinder the development of the agricultural sector. **?**, on the other hand, show that agricultural risk in combination with subsistence requirements for food lead to a lower adoption of intermediary inputs for agricultural use. This dampens productivity. Other papers focus on such as worker sorting across sectors (Lagakos and Waugh 2013), policy barriers to efficient farm size (**?**) or exposure to uninsurable shocks (**?**). More recently, using the insight of a spatial trade model, **?** highlight the effect of trade in intermediates and set-up cost for the adoption of modern agriculture. Similarly, **?** focus on domestic frictions in the distribution of goods combined with forces from international markets, that lead to lower agricultural productivity. My paper will focus on set up cost and fincancial frictions which hinder the adoption of modern agricultural goods. In contrast to the previous literature I amend their research by examining the effects of climate change on technology adoption. Climate change is modeled by an exogenous decline in agricultural productivity.

Secondly, my model uses the framework provided by occupational choice models. The modeling of the financial friction and entrepreneurship follows the standards introduced by **????**. **?** provides a good overview of financial frictions in the macro-development literature. The focus of this paper, will be the impact of financial friction on the uptake of intermediate technologies in the agricultural sector and its interaction with climate change. The latter will be modeled by a decreasing land productivity of farms caused by soil

degradation, droughts and increased frequency of extreme weather events, such as floods and heatwaves, which systematically reduce average crop yields and lower the efficiency of agricultural production. Farmers need to borrow from financial intermediaries to obtain agricultural inputs, yet financial markets are incomplete as contracts are not fully enforceable like **?**.

The remainder of the paper is organized as follows. Section 2 introduces the model, including preferences, technology, and the general equilibrium structure. Section 3 presents the survey data used to calibrate key parameters, drawing on detailed longitudinal cross-country data from the LSMS-ISA program by the World Bank, which covers agricultural productivity in Sub-Saharan Africa. SSection 4 examines both general equilibrium and partial equilibrium responses to climate-induced productivity shocks. In general equilibrium, climate damage reduces welfare and lowers the price of intermediary goods, while financial frictions have a limited aggregate effect under the current parameterization. In partial equilibrium, fixing prices highlights how financial constraints distort technology adoption and input use: tighter frictions reduce the adoption of modern farming, lowering productivity among modern farms, while productivity among traditional farmers can increase as high-ability farmers are displaced from modern technology. Section 5 concludes.

I find an interaction between climate-induced productivity declines and the modernization of agriculture. Two competing mechanisms may be at play. On the one hand, as farmers become poorer, and if financial contracts are not fully enforceable, they may be unable to borrow in order to access modern technologies. At the same time, the overall supply of assets in the economy declines due to falling incomes. This can trigger a negative feedback loop in which farmers who previously adopted modern inputs are forced to revert to traditional farming methods, thereby amplifying the productivity decline.

2 Model

This section introduces the baseline model, which I use to evaluate the interaction between financial frictions, and climate change. The economy has two sectors, a (agriculture) and m (manufacturing). The agricultural sector consists of modern farms that use intermediary inputs such as fertilizers and pesticides, and traditional ones that are solely dependent on labor and cultivated land. The manufacturing sector provides intermediary inputs to modern farms as well as manufacturing consumption and investment. The agricultural goods price is the numeraire.

The population of the economy is split between rural and urban $i \in \{r, u\}$. Rural workers are those who cultivate land to farm and urban workers provide their labour to the manufacturing sector. The share of rural agents is marked by μ and the corresponding share urban workers is $1 - \mu$. All agents are infinitely lived. I assume that urban agents are hand-to-mouth consumers. Hence there is no labour mobility between urban and rural regions. Rural workers are heterogenous in their wealth a_i and farming ability z_i. They face an intertemporal savings decision, which determines their asset holdings. Their farming ability follows a log-normal AR(1) process: $\log z_{t+1} = \rho \log z_t + \epsilon_{t+1}$.

In each period farmers choose the technology they want to operate: whether they want to adopt intermediary inputs and have a modern farm or whether they cultivate a traditional farm. The decision is based on their access to funds and their comparative advantage z_i in operating a farm. Access to funds is limited through an endogenous borrowing constraint, rooted in a contract enforcability problem. I model farms in tradition of span of control model **?**. Modern farms have a per period operational cost, similar to **?**.

2.1 Preferences

Time is discrete and there is the continuum of farmers indexed by i. They are endowed with some farming skill z which follows a log-AR(1) process. Furthermore, each farmer is endowed with the same amount of land, normalised to 1, which they can use for farming. **?** and **?** show that untitled land and the unequal distribution of land can explain a large portion of the agricultural productivity gap. However, the focus of this paper lies on financial frictions and technology adoption. Thus, I abstract from the distortionary effect of missing land markets. Individuals take expectations over future realisations of their productivity. Agents derive utility from consuming agricultural goods (c_a) and manufacturing goods (c_m) which are bundled in a CES aggregator similar to **???** . The intratemporal preferences can be represented by the following utility function:

$$U_i = \mathbb{E}\left[\sum_{t=0}^{\infty} \beta^t \frac{(C_t^i)^{1-\gamma}}{1-\gamma}\right], \text{ where } C_t^i = \left[\omega\,(c_a^i)_t^{\frac{\sigma-1}{\sigma}} + (1-\omega)\,(c_m^i)_t^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

The superscript i indexes whether the household belongs to the urban or rural population.

2.2 Technology

There are two production sectors, the agricultural and the manufacturing sector. The agricultural sector is run and owned by farmers. Secondly, the manufacturing sector supplies the agricultural input m, manufacturing consumption c_m and investment. This setup largely follows **?**. The manufacturing sector uses capital and labour as inputs for production. The latter is in-elastically supplied by the urban population.

Zooming in on the production function of traditional farms:

$$F_t^T(l) = \exp\{z_{it}\}(Dl)^\tau$$

which only use farmer's specific skill z and land l in the production process. D represents the damage caused by climate change. Secondly, agricultural goods can also be produced using modern inputs, such as fertilizers, pesticides/herbicides/fungicides and feed supplements, in addition to the farmers skill and land:

$$F_t^M(l, m) = \exp\{z_{it} + \nu\}(D_t l)^\theta m_t^\alpha$$

where l is again the land used in production, m are intermediary inputs produced by the non-agricultural sector. They fully depreciate after use. θ and α is the output elasticity with respect to land and intermediaries. In contrast to traditional farms, modern ones require a set-up cost κ^M, which is associated with the opportunity cost of traveling to the next market and purchasing intermediaries. This cost drives a wedge between optimal intermediary usage and actual usage as we will see later.

Given the interest rate and the price of intermediary goods, a modern farm's profit function is given by:

$$\pi^M = p_a F^M(l, m) - (1+r)(p_m m + p_a \kappa^M)$$

where r is the interest rate and p_a is the price of the agricultural good. The key feature is that farms need to borrow funds in advance to purchase the intermediary since they are bought before the harvest. This gives rise to the following first order equation:

$$m_{i,t}^* = \left(\frac{p_a \cdot \alpha \cdot \exp\{z_{it} + \upsilon\} \cdot (Dl)^\theta}{(1+r)p_m}\right)^{\frac{1}{1-\alpha}}$$

4

Note that this is the optimal quantity of intermediary inputs that farmers would purchase if they are unconstrained. Naturally the quantity is decreasing in the price p_m of intermediaries and its financing cost $(1 + r)$. If farmers choose to operate a traditional farm there profits are simply given by:

$$\pi^T = p_a F^T$$

The production function of the manufacturing sector is the following:

$$M = A_m K_m^\epsilon N_m^{1-\epsilon}$$

A_m is the sector specific total factor production technology, K_m is capital used in production and N_m is labour. ϵ constitutes the elasticity of output with respect to capital and $1 - \epsilon$ the elasticity with respect to labour. Capital is rented from financial intermediaries and labour is hired from a perfectly competitive labour market. The first-order conditions equate the marginal product of the production factor with its marginal cost, since we abstract from any frictions in this market:

$$w = (1 - \epsilon) A_m \left(\frac{K_m}{N_m} \right)^\epsilon \tag{1}$$

$$r = \epsilon A_m \left(\frac{N_m}{K_m} \right)^{1-\epsilon} \tag{2}$$

$$\tag{3}$$

2.3 Recursive formulation

Individuals maximise expected lifetime utility by choosing consumption and next periods assets. In addition, they choose a production technology - modern or traditional farming. Modern farmers also choose the intensity of intermediate inputs, subject to financial constraints.

Let the individual state be $s \equiv (a, z)$, where a denotes assets and z idiosyncratic agricultural productivity. At the beginning of each period workers observe their productivity and asset level as well as the prices. Next, they face a technological choice. This mirrors canonical models of occupational choice and financial frictions (**?**). The occupational choice can be stated as follows.

The individuals value function satisfies

$$v(a, z) = \max\{v^{mod}(a, z), v^{trad}(a, z)\} \tag{4}$$

$$\tag{5}$$

Modern Farming: An individual operating a modern farm solves:

$$v^{mod}(a, z) = \max_{a', c, m \in [0, \bar{m}(a, z; \phi)]} \left\{ u(c) + \beta \, \mathbb{E}_{z'|z}[v(a', z')] \right\} \tag{6}$$
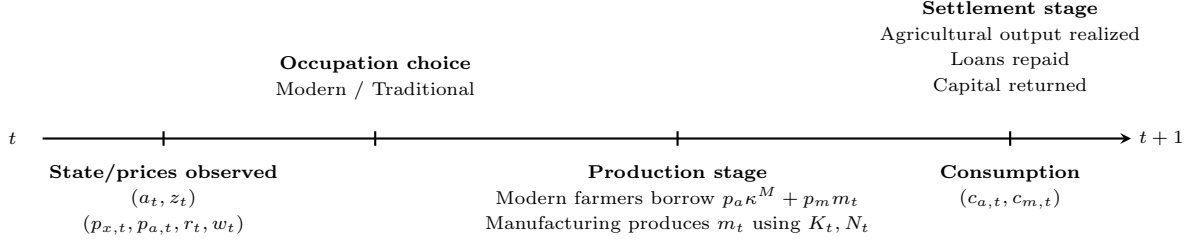
$$\text{s.t. } PC + a' \leq (1 + r)a + p_a z F^M(l, x) - (1 + r)(p_a \kappa^m + p_m m), \quad c \geq 0, \quad a' \geq 0 \tag{7}$$

Modern production requires a fixed cost κ^M and the purchase of intermediate inputs m at price p_m. These expenses must be financed up front, giving rise to an endogenous upper bound $\bar{m}(a, z; \phi)$ on input usage, which captures borrowing constraints parameterized by ϕ. Crucially, technology adoption depends not only on productivity but also on wealth. Poor but highly productive individuals may be unable to operate modern farms because they cannot finance the fixed cost or the optimal scale of intermediate inputs. This feature generates misallocation driven by financial constraints.

Traditional Farming: An individual operating a traditional farm solves

$$v^{trad}(a, z) = \max_{a', c} \left\{ u(c) + \beta \, \mathbb{E}_{z'|z}[v(a', z')] \right\} \tag{8}$$

$$\text{s.t. } PC + a' \leq (1+r)a + p_a z F^T(l), \quad c \geq 0, \quad a' \geq 0$$

Traditional farming does not require fixed costs or intermediate inputs and is therefore unconstrained by credit market frictions.

The Euler equation for households is given by:

$$u'(c_t) = \beta \mathbb{E}[(1 + r + \frac{\delta y(a, z)}{\delta a})u'(c_{t+1})]$$

The term $\frac{\delta y(a,z)}{\delta a}$ captures the marginal benefit of additional assets through the relaxation of borrowing constraints. When individuals are financially constrained, saving not only yields the market return r but also increases future profits by allowing operation at a larger and more efficient scale. In the absence of financial frictions, this term vanishes and the Euler equation collapses to the standard form. The consumption of the urban population is trivially given by $(1 - \mu)w_t = C_t^u$.

2.4 Financial markets

[1]

Farmers have access to perfectly competitive financial intermediaries, receiving deposits, rent capital k at rate R and lend the funds required to purchase intermediary goods $p_m m$. I restrict the analysis to the case where borrowing and capital rental are within a period, implying that financial wealth is nonnegative $(a \geq 0)$.

Financial frictions arise due to limited enforceability of financial contracts. In particular, farmers may renege on their financial commitments after production has taken place. In such a case they can keep a fraction of their revenues but loose their deposits a at the financial intermediary as a punishment. Farmers then regain access to financial markets in the following period. The farmers incentive constraint is thus given by [2]

$$p_a \exp\{z_{it} + \nu\}(Dl)^\theta m_t^\alpha - (1+r)(p_a \kappa^m + p_m m_t) + (1+r)a_t \geq$$
$$(1 - \phi)p_a \exp\{z_{it} + \nu\}(Dl)^\theta m_t^\alpha + a \tag{9}$$

The upper limit of such a contract can be solved implicitly for a maximum level $\bar{x}$. The parameter ϕ captures the extent of frictions in financial markets. $\phi = 1$ corresponds to the case of perfect credit markets, and $\phi = 0$ implies complete self-financing. The credit limits $\bar{m}(a, z_i, \phi)$ is the largest possible quantity extended consistent with entrepreneurs choosing to abide by their credit contracts. The static condition is sufficient

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[1] There are several papers using similar notions to justify the borrowing constraint. An elaborate example is: **??**

[2] also see **?**

since individuals gain full excess to financial market in the next period. From the equation it is evident that rental limits increase with farmers ability z_i. Similarly it increases with wealth a since the potential loss from defaulting becomes larger.

The financial constraint highlights the role of climate damage, captured by a lower D. A decline in D reduces realized output for any given input choice, which lowers the surplus available to service financial obligations. Since only a fraction ϕ of revenues is pledgeable, climate damage disproportionately reduces pledgeable income relative to total production. This weakens the incentive compatibility constraint and tightens borrowing limits $\bar{m}(a, z_i, \phi)$.

As a result, climate related productivity damages propagate through financial markets by endogenously amplifying credit frictions. Lower productivity reduces borrowing capacity, forcing farmers to scale back input use, which further depresses output. This feedback mechanism implies that climate damages generate effects beyond direct production losses, leading to persistent declines in productivity through constrained access to capital and intermediary inputs.

2.5 Stationary Competitive Equilibrium

A stationary competitive equilibrium is composed of: an invariant distribution of wealth and farming skill $G(a, z)$, with the marginal distribution of z denoted $\mu(z)$, policy functions $c(a, z)$ $a'(a, z)$, $o(a, z)$; rental limits $\bar{m}_j(a, z_j; \phi)$; and prices w, r, p_m and p_a such that:

1. **Individual Optimization:** Given $\bar{x}_j(a, z_j; \phi)$, w, r, p_m and p_a, the individual policy functions $c(a, z)$, $a'(a, z)$, $o(a, z)$, solve the household problems (X) and satisfy the manufacturing firm's FOC's (X).

2. **Rental Limits:** $\bar{x}_j(a, z_j; \phi)$ are the most generous limits satisfying condition (X), and:

$$\bar{m}_j(a, z_j; \phi) \leq m^*(z_j)$$

3. **Market Clearing Conditions:**

   - Agricultural goods market:

$$\mu \int c_a^r dG(a, z) + (1 - \mu)c_m^u = \int_{\{o(a,z)=F\}} z_{Ft}^{1-\upsilon}(l_t^{1-\alpha}m_t^\alpha)^\upsilon - \kappa^m + z_{Ft}^{1-\upsilon}(l_t^\beta)^\upsilon dG(a, z)$$

   - Intermediate goods market:

$$\int_{\{o(a,z)=FM\}} m_t dG(a, z) + \mu \int_{\{o(a,z)=FM\}} c_{m,t}^r dG(a, z) + (1 - \mu)c_{m,t}^u + \frac{\delta}{p_m}\frac{K}{N} = \int K_t^\beta N_t^{1-\beta} dG(a, z)$$

   - Capital markets :

$$K^d = \mu \int a dG(a, z)$$

   - Labour markets :

$$N_t^d = (1 - \mu)\bar{N}_t$$

4. **Stationary Distribution:** The joint distribution of wealth and farming skills is a fixed point of the equilibrium mapping:

$$g(a', z') = \int \delta_D(a' - a(a, z)) \cdot f(z' \mid z) \cdot g(a, z) \, da \, dz$$

Farming ability evolves according to the exogenous log-AR(1) process:

$$\log z_{t+1} = \rho \log z_t + \varepsilon_{t+1}$$

with $\varepsilon_{t+1} \sim \mathcal{N}(0, \sigma_\epsilon^2)$.

3 Quantitative Estimation

3.1 Data

I use a detailed longitudinal cross-country dataset on agricultural productivity in Sub-Saharan Africa from the "Standards Measurement Study–Integrated Surveys on Agriculture" (LSMS-ISA) program by the World Bank. The surveys are specifically designed to study the agricultural sector and provide an extensive collection of plot-level data, including important geographic variables as well as socioeconomic variables of farmers. I benefit from the harmonised panel dataset provided by **?**, which includes data from seven Sub-Saharan African countries, including Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania, and Uganda, from 2008 to 2021. This data allows for a profound analysis of farm characteristics over time and country. I utilise the data to estimate production functions.

3.2 Parameters and Moments

In total there are 16 parameters to be calibrated. 10 technology parameters: $(\{\nu, D, L, A, \theta, \alpha, \tau, \epsilon, \delta\, \kappa^M\})$, 4 preference parameters $\{\sigma, \omega, \gamma, \beta\}$, and 2 parameters governing the evolution of productivity $(\{\rho, \sigma_\epsilon\})$. At this stage, parameter values are chosen solely to illustrate the economic mechanisms of the model. Unless stated otherwise, parameters are not formally calibrated or estimated and should be interpreted as illustrative. The purpose of this parameterization is to demonstrate how financial frictions interact with technology adoption and productivity, not to match specific empirical moments.

Production. I estimate the production technology separately for traditional and modern plots using plot-level panel regressions. The empirical specification closely follows the production functions introduced before.

Traditional farms. For traditional plots, output is produced using land only. I estimate the following fixed-effects regression:

$$\ln y_{it} = \tau \ln l_{it} + \mathbf{X}_{it}'\beta + \mu_i + \varepsilon_{it}, \tag{10}$$

where y_{it} denotes plot-level output, l_{it} is cultivated land, and $\mathbf{X}_{it}$ includes labor inputs, weather shocks, manager characteristics, and detailed agro-ecological controls. Plot fixed effects μ_i absorb time-invariant productivity differences across plots. The coefficient τ identifies the land elasticity for traditional farms.

Modern farms. For modern plots, output depends on both land and intermediate inputs. I estimate:

$$\ln y_{it} = \theta \ln l_{it} + \alpha \ln x_{it} + \mathbf{X}_{it}'\beta + \mu_i + \varepsilon_{it}, \tag{11}$$

where x_{it} is a composite measure of modern intermediate inputs, including improved seeds and inorganic fertilizer expenditures. The coefficient θ identifies the land elasticity for modern farms, while α captures the elasticity with respect to modern inputs. All elasticities are identified from within-plot variation over time. Plot fixed effects remove time-invariant heterogeneity in land quality, farmer ability, and baseline productivity. As a consequence, the level productivity advantage of modern technology is not identified in these regressions and is calibrated separately to match cross-sectional output moments. The estimated elasticities correspond directly to the technology parameters of the model. From the data I obtain the

following values for θ, τ and α. The fixed cost of operating the modern production technology, κ^M, is calibrated to match the observed adoption rate of modern farms in the data. For a given value of κ^M, I solve the household problem under fixed prices and compute the stationary distribution of assets and productivity. Using this distribution, I evaluate farm profits under modern and traditional technologies and determine optimal technology choice at the plot level. The implied share of modern farms in the model is then compared to its empirical counterpart. I choose κ^m such that the model-generated adoption rate equals the observed adoption rate in the data (30%).

Preferences. $\{\sigma, \omega, \gamma, \beta\}$ - I follow the macro-development literature in setting the discount factor to $\beta = 0.95$ and the coefficient of relative risk aversion to $\gamma = 2.5$. The remaining preference parameters, σ and ω, govern the elasticity of substitution between agricultural and market consumption and the relative importance of agricultural goods in consumption, respectively. These parameters are not calibrated at this stage and will be disciplined using values from the existing literature in future quantitative exercises.

Table 1: Model Parameters, Values, and Calibration Strategy

Parameter	Description	Value	Calibration Target / Source
$a_{\min}$	Borrowing constraint	0	No borrowing in baseline
β	Discount factor	0.95	**?**
μ	Share of rural workers	40%	LSMS-ISA Data
γ	Risk aversion (CRRA)	2.5	Literature
L	Labor endowment of urban workers	1	Normalized
A_m	Productivity Manuf. sector	0.35	
ϵ	Capital elasticity (Manuf sector)	0.33	
D_t	Climate damage on land productivity	1	Normalized
θ	Labor elasticity (modern farms)	0.41	FE regression: modern plots
τ	Labor elasticity (traditional farms)	0.41	FE regression: traditional plots
α	Intermediate input elasticity	0.22	FE regression: modern plots
ν	Modern-farm productivity premium	1	
κ^m	Fixed cost of modern technology	30 %	Matches share of modern farms
δ	Capital depreciation	0.05	Literature
ρ	Persistence of productivity shocks	0.9	
σ_ϵ	Std. dev. of productivity shocks	0.2	

4 Results

I begin by solving the model in general equilibrium for five levels of climate-induced land damage, D, and five levels of financial frictions, ϕ. This yields 25 distinct economies. Welfare comparisons across these economies are summarized using consumption-equivalent variation (CEV), with the frictionless and undamaged economy ($\phi = 1$, $D = 1$) serving as the benchmark.

Figure **??** shows that welfare declines monotonically as climate damage increases, reflecting the direct negative effect of lower land productivity. Financial frictions also reduce welfare, although their quantitative impact is limited under the current parametrization. In particular, welfare remains relatively flat for high levels of financial development and only declines markedly once ϕ falls below 0.5. This pattern reflects the fact that financial constraints bind only for a small fraction of agents when borrowing conditions are

relatively loose. As expected, tighter financial frictions reduce welfare by limiting the adoption of modern agricultural inputs. Overall, financial frictions amplify the welfare costs of climate change, although this amplification effect is modest in magnitude.

The general equilibrium response of the price of the intermediary good is shown in Figure **??**. The price is highest in the benchmark economy, where demand for intermediary inputs is strongest. As climate damage increases, the price of the intermediary good falls, reflecting a reduction in its marginal productivity and thus lower demand. Similarly, weaker financial institutions reduce farmers' ability to borrow for intermediary purchases, further depressing demand and prices. Notably, the decline in prices is more pronounced in economies with higher climate damage, indicating that environmental degradation and financial frictions interact to reduce input demand.

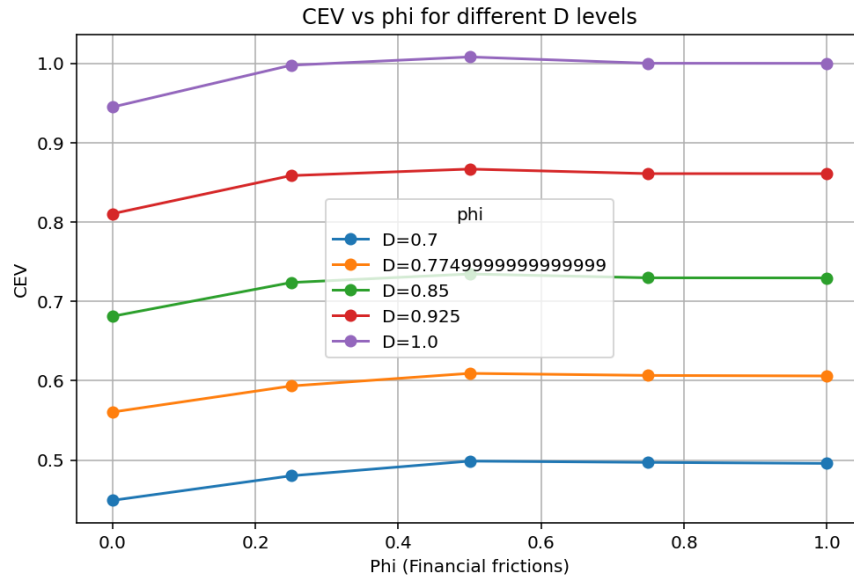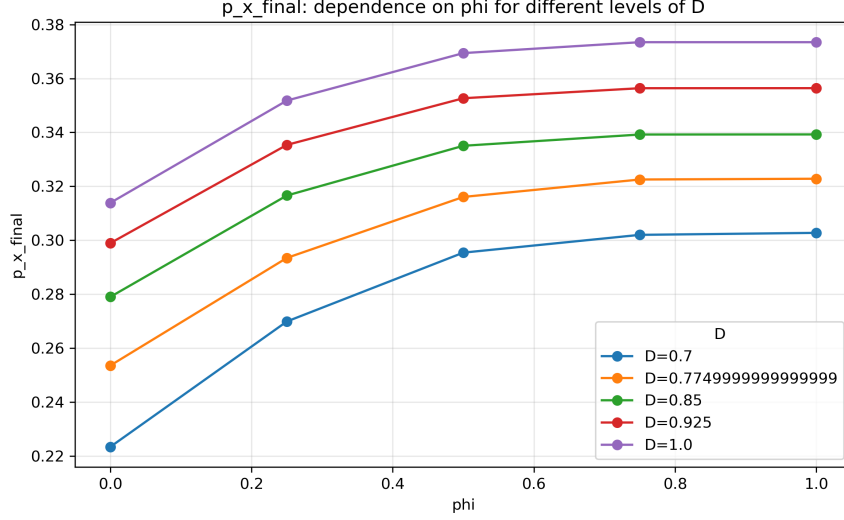Figure 1: Consumption-equivalent variation across climate damage and financial frictions

Figure 2: Equilibrium price of the intermediary good

Having characterized the general equilibrium outcomes, I next examine the partial equilibrium response of agricultural productivity. To this end, I fix prices at their benchmark equilibrium values and consider three levels of climate damage, $D \in \{0.8, 0.9, 1\}$. For each case, I solve households' technology adoption decisions as a function of financial frictions. Productivity is measured as output per farmer, with all productivity measures normalized to unity in the benchmark economy.
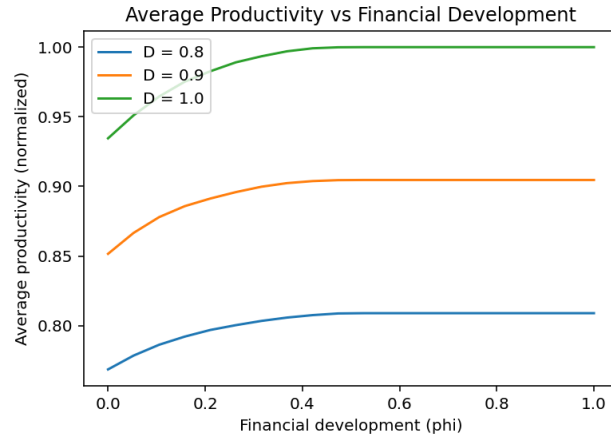
Figure ?? shows that average agricultural productivity declines as financial frictions increase. This decline is driven primarily by a reduction in modern farm productivity, as tighter borrowing constraints limit the use of intermediary inputs. Importantly, this effect is more pronounced in economies with higher land productivity (higher D). When land is more productive, the marginal productivity of intermediary inputs is higher, so financial constraints distort input use more severely in partial equilibrium.

At the same time, productivity among traditional farmers increases as financial frictions tighten. This occurs because high-productivity farmers who were previously able to adopt modern technologies are forced to revert to traditional production when borrowing becomes more difficult, raising average productivity within the traditional sector. Together, these results highlight that financial frictions not only reduce aggregate productivity but also reshape its composition across production technologies.
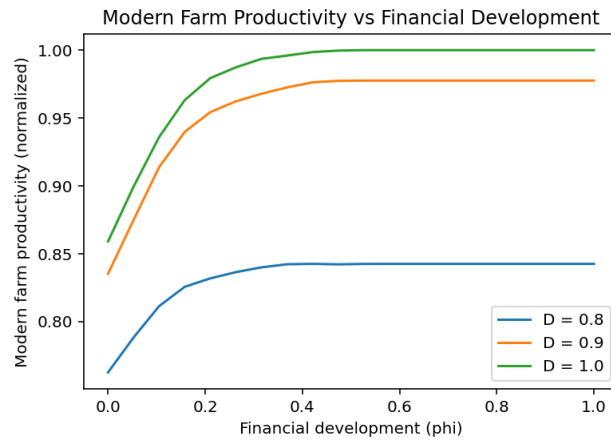
5   Conclusion

This paper studies how financial frictions interact with climate-induced land productivity losses in a heterogeneous-agent model of agricultural production with technology choice. The results show that climate damage leads to substantial welfare losses and lower agricultural productivity, both directly through reduced land productivity and indirectly through general equilibrium price adjustments. Financial frictions further reduce welfare by limiting access to modern agricultural inputs, thereby lowering productivity and technology adoption. While the amplification of climate damages through financial frictions is quantitatively modest under the current calibration, partial equilibrium results highlight that financial constraints become more distortionary when land productivity is high, as the marginal productivity of intermediates is then larger. Overall, the analysis emphasizes that financial market imperfections shape both the level and composition of agricultural productivity and can exacerbate the economic consequences of climate change.
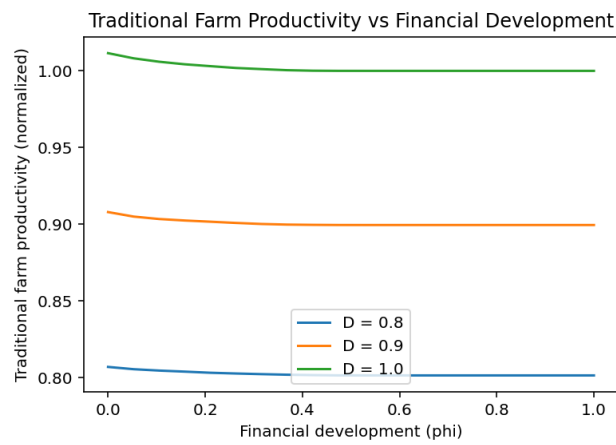
Figure 3: Productivity and Financial Development under Climate Damage

(a) Average productivity

(b) Modern farm productivity

(c) Traditional farm productivity