

Liquidity Constraints in Emerging Economies: Evidence from a Moroccan Credit Guarantee Program

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Motivation

Emerging countries suffer severely from insufficient financial development:

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- ▶ However, the severity of short-term external financial constraints (liquidity constraints) on firm growth in emerging countries is much less studied.

We focus on the role of short-term finance on firm growth in emerging countries:

- ▶ What mechanism links short-term external finance to firm growth?
- ▶ Could we validate such a mechanism empirically in the data?
- ▶ What kind of aggregate/policy implications could we learn?

Mechanism

Long-term external finance on firm growth:

- ▶ Long-term finance enlarges a firm's asset (scale) given its net worth.
- ▶ Given net worth n , a firm could enlarge scale: $(k = n) < (k' = n + b) < k^*$.
- ▶ Promote more efficient resource reallocation across firms

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Short-term external finance on firm growth:

- ▶ Short-term finance fulfills a firm's needs for liquidity (i.e., working capital).
- ▶ Short-term finance lowers the demand for unproductive cash holdings.
- ▶ Given net worth n , a firm could enlarge scale: $(k = n - c) < (k' = n - c') < k^*$
- ▶ Promote more efficient resource reallocation within firms

Our findings

We take three steps to answer the three questions on the first slide:

- ▶ Q1: What mechanism links short-term external finance to firm growth?

A1: We lay down a het. firm GE model to illustrate the mechanism:

- ▶ Relaxing short-term FCs \Rightarrow short-term cash (\downarrow) | capital (\uparrow) | output (\uparrow)
- ▶ Joint with profit erosion (tax, exit, etc.) \Rightarrow long-term capital and output (\uparrow)
- ▶ Participation rate in short-term credit guarantee is hump-shaped in size

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- ▶ Q2: Could we validate such a mechanism empirically in the data?

A2: We use a loan guarantee program in Morocco to test the mechanism:

- ▶ Using PSM + DID to compare guaranteed firms to their counter peers
- ▶ The above patterns are observed in the data.

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- ▶ Q3: What kind of aggregate/policy implications could we learn?

- ▶ A3-1: The aggregate effects are sizable, even in the long run.
- ▶ A3-2: The gains of enlarging loan guarantee programs are substantial.

[The Model and Mechanism in a Nutshell]

Model Setup

- ▶ **Heterogeneous production firms:**
 - ▶ Firm decides on capital, labor, debt, cash and dividends
 - ▶ Firm faces exogenous exit risk & Entrepreneur has incentive to consume
 - ▶ Idiosyncratic productivity shocks
- ▶ **Short-term finance:**
 - ▶ Working capital constraint (financed with short-term debt or cash)
 - ▶ Collateral constraint (borrow up to a proportion of capital value)
 - ▶ Potential access to government liquidity loan guarantees
- ▶ **Features in emerging market:**
 - ▶ Intertemporal distortions: high exogenous exit risk & net worth erosion
 - ▶ Participation frictions in liquidity loan guarantees
- ▶ **General equilibrium:**
 - ▶ Aggregate capital good producer
 - ▶ Other households (supply labor and consume)

Firm's Problem

Profit Optimization

Recursive Formulation

General Equilibrium

Fixed Parameters

Fitted Parameters

Essential Components

Credit Market and Loan Guarantee:

- ▶ Working capital constraint: $w_t l_{i,t} \leq c_{i,t} + \bar{b}_{i,t}$; Collateral constraint: $b_{i,t} \leq \Theta(k_{i,t})$
- ▶ Loan guarantee: $b_{i,t} \leq \begin{cases} (1 + (\chi - 1)s)\Theta(k_{i,t}) & \text{if } F = A \\ \Theta(k_{i,t}) & \text{if } F = N \end{cases}$

s : proportion of formal credit; χ : guarantee multiplier; $(\chi - 1)s$: guaranteed credit
 F : self-selection to participate subject to fixed cost ξ and commission fee μ

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Features in emerging market:

- ▶ Intertemporal distortions: exit risk ϵ & erosion τ

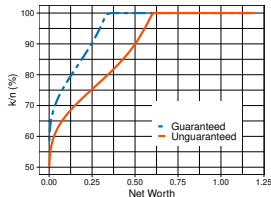
$$v(z_{i,t}, n_{i,t-1}, F_{i,t}) = \max_{d_{i,t}} \left\{ \frac{d_{i,t}(z_{i,t}, n_{i,t-1}, F_{i,t})^{1-\eta}}{1-\eta} + \beta \epsilon E_z[\tilde{v}(z_{i,t+1}, n_{i,t})] \right\}$$

$$n_{i,t}(z_{i,t}, n_{i,t-1}, F_{i,t}) = (1 - \tau) \{ \pi^*(z_{i,t}, n_{i,t-1}, F_{i,t}) - d_{i,t}(z_{i,t}, n_{i,t-1}, F_{i,t}) - \xi_{i,t} \}$$

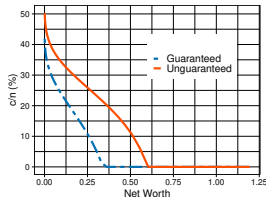
- ▶ Participation frictions in loan guarantees: ξ

$$\xi^*(z_{i,t}, n_{i,t-1}) = \frac{\pi^*(z_{i,t}, n_{i,t-1}, A) - \pi^*(z_{i,t}, n_{i,t-1}, N)}{w_t}$$

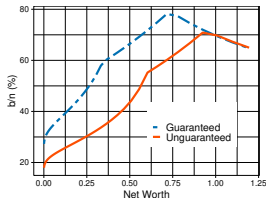
Model Prediction 1: Resource Reallocation (Cash to Capital)



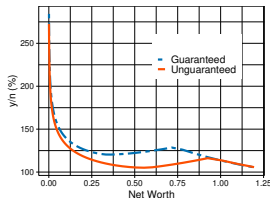
(a) Capital Policy



(b) Cash Policy

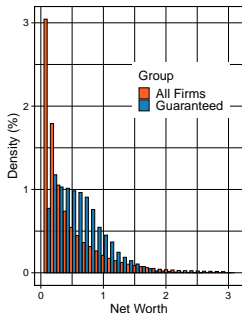


(c) Debt Policy

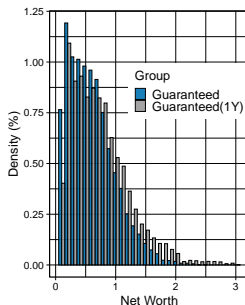


(d) Realized Output

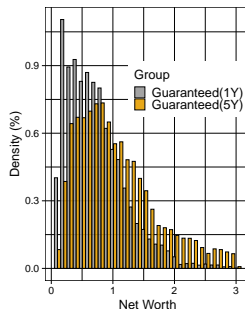
Model Prediction 2: Long-term Growth of Firms



(a) LGP Self-Selection



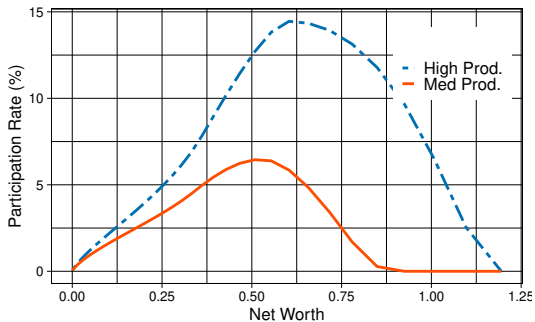
(b) One Year Growth



(c) Five Year Growth

Model Prediction 3: Hump-shaped LGP Participation

Figure: THE PARTICIPATION IN THE GUARANTEE PROGRAM



[Empirical Analysis on Moroccan Firms]

Data

Two databases:

1. Tamwilcom Guarantee Database: [Background](#)

- ▶ Unit of observation: firm-year
- ▶ 2012-2018
- ▶ A database of 23,017 guarantees, mobilizing an amount of 22 billion dirham loans (about 2.2 billion Euros) extended to credit-constrained firms

2. Orbis Database:

- ▶ A commercial database by Bureau van Dijk (BvD)
- ▶ Firm-level balance sheet data collected from the Office of Industrial and Commercial Property (OMPIC)
- ▶ About 1.58 million firms representing the business world of Morocco

Merge the two databases: identify guaranteed firms in Orbis data [Details](#)

Identification Strategy and Regression

- ▶ Endogeneity issue: **Selection Bias**
- ▶ Step 1: **Multivariate Distance Matching**
 - ▶ Find statistical twins for a guaranteed firm based on selected time-varying and observable variables that are relevant to selection into the program and outcomes. [Details](#)
- ▶ Step 2: **Difference-in-Difference**
 - ▶ Address firm-level unobservable fixed effects. [Trend Inspection](#)
- ▶ **Goal:** following the two steps, differences in outcome variables between treated and control firms can be effectively attributed to the guarantees.
- ▶ **Regression:**

$$\Delta Y_{igs} = \delta D_{it} + \lambda_{gs} + \epsilon_{igs}$$

- ▶ i indexes firms, g indexes groups of one guaranteed firm with its matched controls
- ▶ ΔY_{igs} : change in outcome variable compared to the year before obtaining guarantee;
 $\Delta Y_{igs} = Y_{igs} - Y_{igt-1}$, where $s = t + 1, t + 2, t + 3$
- ▶ D_{it} : a dummy variable indicating if firm i is guaranteed in year t
- ▶ λ_{gt} : group and year fixed effects
- ▶ ϵ_{igt} : error term

Empirical 1: Resource Reallocation (Cash to Capital)

Table: EFFECTS ON FIRM'S BALANCE SHEET

	Current Liabilities Growth			Cash Growth		
	(1) t+1	(2) t+2	(3) t+3	(4) t+1	(5) t+2	(6) t+3
Guaranteed	0.131*** (0.014)	0.122*** (0.015)	0.167*** (0.025)	-0.061 (0.069)	-0.210*** (0.054)	0.088 (0.070)
<i>N</i>	19299	11171	5969	18761	10683	5814
adj. R^2	0.252	0.276	0.243	0.321	0.304	0.291
Group \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table: EFFECTS ON FIRM'S PRODUCTION INPUTS

	Costs of Employees Growth			Fixed Assets Growth		
	(1) t+1	(2) t+2	(3) t+3	(4) t+1	(5) t+2	(6) t+3
Guaranteed	0.115*** (0.015)	0.106*** (0.023)	0.105*** (0.025)	0.116** (0.037)	0.230*** (0.062)	0.241** (0.079)
<i>N</i>	17852	10422	5416	18344	10624	5760
adj. R^2	0.252	0.223	0.239	0.183	0.174	0.236
Group \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes

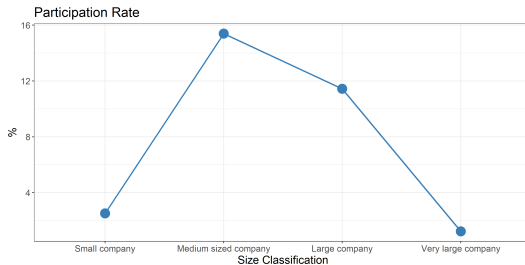
Empirical 2: Long-term Growth of Firms

Table: EFFECTS ON FIRM'S SALES AND TOTAL ASSETS

	Sales Growth			Total Assets Growth		
	(1) t+1	(2) t+2	(3) t+3	(4) t+1	(5) t+2	(6) t+3
Guaranteed	0.135*** (0.010)	0.101*** (0.021)	0.125*** (0.020)	0.092*** (0.011)	0.092*** (0.021)	0.166*** (0.014)
<i>N</i>	18503	10610	5585	18959	11018	5952
adj. R^2	0.332	0.315	0.357	0.299	0.264	0.268
Group \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Empirical 3: Hump-shaped LGP Participation

Figure: PARTICIPATION RATE BY SIZE (DATA)



[Quantitative Analysis]

Targeted Moments

Table: TARGET MOMENTS

Moments	Data	Model
<i>Output Dynamics</i>		
1-year autocorrelation of output	0.89	0.89
3-year autocorrelation of output	0.69	0.71
5-year autocorrelation of output	0.53	0.56
Size ratio of entrant relative to average	17%	16.4%
Annual exit rate of firms	9.0%	9.0%
<i>Financial Frictions</i>		
Mean debt/asset ratio (non-guaranteed)	51%	39%
Mean debt/asset ratio (guaranteed)	64%	64%
Mean cash/asset ratio (non-guaranteed)	22%	21%
Mean cash/asset ratio (guaranteed)	9%	6%
Guaranteed loan/current liability ratio	22%	22%
<i>Loan guarantee program</i>		
Guaranteed loan commission fee	0.5%	0.5%
Guaranteed percentage of bank loan	60%	60%
Percentage of firms participating LGP	3.4%	3.4%

Model Validation

- ▶ We validate the model with the exact Matched-DID on simulated data.
- ▶ Naive OLS would be overestimating the effects.

Effects of Credit Guarantee	Matched-DID (Data)			Matched-DID (Model)			Naive OLS (Model)		
	t+1	t+2	t+3	t+1	t+2	t+3	t+1	t+2	t+3
$\Delta \log(\text{Sales})$	0.135*** (0.010)	0.101*** (0.021)	0.125*** (0.020)	0.187*** (0.013)	0.163*** (0.016)	0.150*** (0.018)	0.524*** (0.007)	0.511*** (0.010)	0.461*** (0.012)
$\Delta \log(\text{TotalAsset})$	0.092*** (0.011)	0.092*** (0.021)	0.166*** (0.014)	0.143*** (0.010)	0.147*** (0.013)	0.139*** (0.014)	0.257*** (0.006)	0.238*** (0.008)	0.215*** (0.009)
$\Delta \log(\text{CurrentLiability})$	0.131*** (0.014)	0.122*** (0.015)	0.167*** (0.025)	0.191*** (0.012)	0.196*** (0.016)	0.187*** (0.019)	0.391*** (0.008)	0.371*** (0.011)	0.341*** (0.013)
$\Delta \log(\text{Cash})$	-0.061 (0.069)	-0.210*** (0.054)	0.088 (0.070)	-0.451*** (0.051)	-0.445*** (0.063)	-0.632*** (0.077)	-1.772*** (0.049)	-1.787*** (0.061)	-1.545*** (0.065)

Policy Counterfactuals and Aggregate Implications

Participation Cost Reduction (P.C.R.)

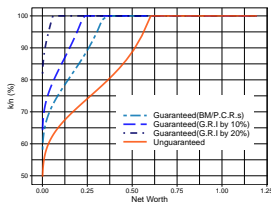
- ▶ Government guarantees agents requiring fewer financial documents, simplifying the evaluation procedures, directly assisting the application, and subsidizing the application fees on LGP.
- ▶ We consider two cases: $P.C.R.\downarrow_{by} \frac{1}{3}$ & $P.C.R.\downarrow_{by} \frac{2}{3}$

Guaranteed Ratio Increment (G.R.I.)

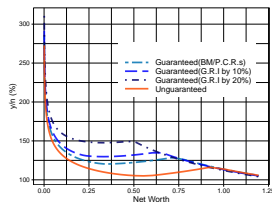
- ▶ The guaranteed ratio varies across countries: in Kazakhstan, it is up to 70%; in India, it is up to 75%; in Indonesia and Japan, it is up to 80%.
- ▶ We also consider two cases: $G.R.I.\uparrow_{by} 10\%$ & $G.R.I.\uparrow_{by} 20\%$

Policy Counterfactuals and Aggregate Implications

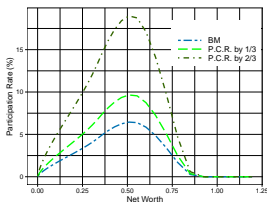
Figure: THE EFFECTS ON FIRMS' FINANCING, OUTPUT, AND PARTICIPATION



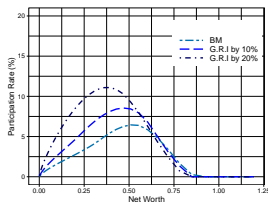
(a) Capital Policy



(b) Realized Output



(c) Participation Rate (Scale I)



(d) Participation Rate (Scale II)

Policy Counterfactuals and Aggregate Implications

Table: AGGREGATE IMPLICATION OF LGP EXPANSIONS

Model Outcomes (%)	Benchmark	$P.C.R. \downarrow_{by} \frac{1}{3}$	$P.C.R. \downarrow_{by} \frac{2}{3}$	$G.R.I. \uparrow_{by} 10\%$	$G.R.I. \uparrow_{by} 20\%$
Penal A: Firm Financing					
LGP participation rate	3.4	5.1	10.1	5.0	7.6
Guaranteed credit/total credit	1.3	2.0	3.8	3.1	8.0
Mean cash/asset ratio (guaranteed)	6.0	6.0	6.0	2.9	0.1
Mean cash/asset ratio (all firms)	20.0	19.8	19.3	19.6	18.8
Mean debt/asset ratio (guaranteed)	64.3	64.2	64.0	72.1	85.8
Mean debt/asset ratio (all firms)	40.0	40.3	41.3	40.8	42.7
Penal B: Aggregate Outcomes					
Changes in Total Credit	n.a.	0.28	1.25	0.60	1.63
Changes in Aggregate TFP	n.a.	0.04	0.14	0.08	0.25
Changes in Total Output	n.a.	0.01	0.10	0.05	0.09
Changes in Total Consumption	n.a.	0.06	0.29	0.15	0.47

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- ▶ How to understand the magnitudes?
- ▶ For $G.R.I.\uparrow_{by} 20\%$, guaranteed credit is $8.0\% * 1.63\% = 0.13\%$ of total credit.
- ▶ Gain in output is 0.09%; we would say it is quite effective!

Conclusion

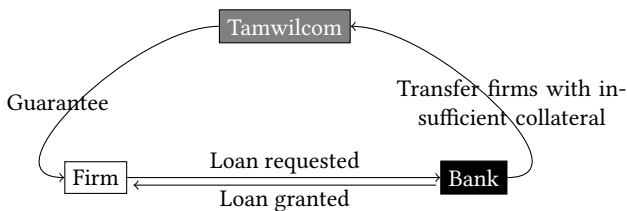
- ▶ We study the effect of short-term finance on firm growth and its aggregate implications both theoretically and empirically.
- ▶ Empirically, we find that firms with guaranteed loans expand their production scale and sharply decrease their cash holdings.
- ▶ Quantitatively, we show the gain of enlarging the loan guarantee programs (through a higher guaranteed ratio or lower inspection costs) is substantial.

Appendix

Institutional Background

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- ▶ **Tamwilcom**, the credit guarantee agency in Morocco, facilitates bank credit to under-collateralized SMEs.
- ▶ We focus on two products related to **working capital loans** (Damane Exploitation and Damane Express) [Details1](#) [Details2](#)



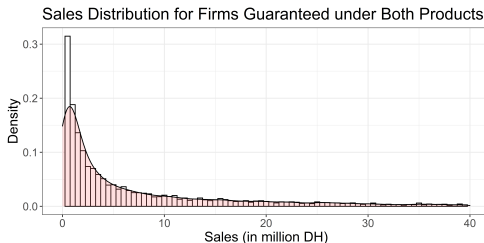
Details on Damane Exploitation and Damane Express (1)

We focus on two products related to **working capital loans**:

- ▶ **Damane Exploitation**: SMEs with sales below 175 million DH (about 17.5 million CHF)
- ▶ **Damane Express** (loan purpose: working capital): micro and small enterprises; loan size up to 1 million DH (100,000 CHF)



Details on Damane Exploitation and Damane Express (2)



- ▶ Sales distribution of firms guaranteed under both products are smooth. We don't see lumps and gaps.
- ▶ Firms self-select into different programs based on the amount of their liquidity needs.

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Merging Two Databases

- ▶ Guaranteed firms in **Tamwilcom** database are paired with their balance sheet data in **Orbis**.
 - ▶ We have a rate of successful pairing of **49.3%** (11,344 out of 23,017 CCG-guaranteed firms are identified in Orbis database.)
 - ▶ Only 4000 guaranteed firms have **data** for the year where it is granted the guarantee.
 - ▶ The number drops further when we would like to have data of **several consecutive years**.
 - ▶ Only **4.3%** of the CCG-guaranteed firms are in the final sample.
- ▶ Data attrition is consistent with existing literature in this field.
- ▶ Robustness check: inverse probability weights.

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Step 1: Multivariate Distance Matching

► Matching details:

- **Nearest neighbor matching** based on **Mahalanobis distance** of selected variables
 - One guaranteed firm is matched with **five** non-guaranteed firms with replacement.
 - **Variables for matching**: total assets (t-1, t-2, t-3), sales (t-1, t-2, t-3), current liabilities (t-1, t-2, t-3), cash (t-1, t-2, t-3) and firm age. (Note: year t refers to treatment year; all values are in log.)
 - **Exact match**: year, firm size, firm sector, city
 - **Re-scale of weight**: control firms are re-weighted based on their distance to the treated firm.
 - **Imposed caliper**: we impose maximum distance allowed in matching to exclude control firms that are not sufficiently similar to treated firm.
-
- **Final sample**: 991 guaranteed firms are matched with 4,577 control firms. (9,218 firm-year observations are matched with 56,202 observations.)

Sample Balancedness Check 1



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- ▶ Good balancedness is observed.
- ▶ Standardized mean differences are close to zero.
- ▶ Variance ratios are close to one.

Sample Balancedness Check 2

- ▶ **Logit model**: We evaluate the probability of obtaining a guarantee based on the variables used for the matching in both raw and matched samples.
- ▶ **Pseudo R^2** : a drop indicates good balance in the sample.
- ▶ **Purpose**: the loss of explanatory power of selected variables towards treatment status after matching
- ▶ **Indeed what we observe**: It drops from **0.66** of the raw sample to **0.01** of the matched sample.

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Trend Inspection: Weighted Means



[Back to Strategy](#)

- ▶ After the matching procedure, the two groups share parallel trends before the treatment year t .
- ▶ The changes in the trends of weighted means give some preliminary evidence at the treatment effects.

Empirical Results: Costs of Employees

	(1)	(2)	(3)	(4)	(5)	(6)
	Costs of Employees Growth			Costs of Employees/Sales		
	t+1	t+2	t+3	t+1	t+2	t+3
Guaranteed	0.116*** (0.016)	0.141*** (0.024)	0.151*** (0.042)	0.081 (0.076)	-0.016 (0.011)	0.052 (0.041)
<i>N</i>	28618	22810	17076	28488	22685	16958
Adjusted R^2	0.301	0.319	0.333	0.447	0.368	0.370
Group \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes

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Empirical Results: Fixed Assets

	(1)	(2)	(3)	(4)	(5)	(6)
	Fixed Assets Growth			Fixed Assets/Total Assets		
	t+1	t+2	t+3	t+1	t+2	t+3
Guaranteed	0.139*** (0.026)	0.281*** (0.041)	0.283*** (0.071)	0.000 (0.002)	0.006 (0.004)	0.004 (0.006)
<i>N</i>	27576	21862	16286	27576	21862	16286
Adjusted R^2	0.239	0.248	0.261	0.255	0.263	0.265
Group \times Year FE	Yes	Yes	Yes	Yes	Yes	Yes

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Production Firm's Problem

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Production:

$$y_{i,t} = z_{i,t} k_{i,t}^{\alpha} l_{i,t}^{\nu}, \quad \alpha + \nu < 1$$

$$\log(z_{i,t}) = \rho_z \log(z_{i,t-1}) + \sigma_z \varepsilon_{i,t}$$

Short-term financing:

- ▶ Working capital constraint:

$$w_t l_{i,t} \leq c_{i,t} + \bar{b}_{i,t}$$

- ▶ Collateral constraint (?):

$$b_{i,t} \leq \bar{b}_{i,t} \equiv \theta_0 k_{i,t} + \theta_1 \Psi(k_{i,t}) = \left[\theta_0 + \theta_1 \frac{\Psi(k_{i,t})}{k_{i,t}} \right] k_{i,t}$$

Loan guarantee program for SMEs:

$$b_{i,t} \leq \begin{cases} (1 + (\chi - 1)s) (\theta_0 k_{i,t} + \theta_1 \Psi(k_{i,t})) & \text{if } F = A \\ \theta_0 k_{i,t} + \theta_1 \Psi(k_{i,t}) & \text{if } F = N \end{cases}$$

Profit Optimization in the First Period [Back](#)

First period (maximize total profit):

$$\pi^*(z_{i,t}, n_{i,t-1}, F_{i,t}) = \max_{k,c,l} \left\{ z_{i,t} k_{i,t}^\alpha l_{i,t}^\nu - w_t l_{i,t} + (1 - \delta) q_t k_{i,t} + (1 + r_t) c_{i,t} - r_t b_{i,t} - F_{i,t} \cdot \mu \tilde{b}_{i,t} \right\}$$

subject to:

$$n_{i,t-1} = q_t k_{i,t} + c_{i,t}$$

$$w_t l_{i,t} \leq c_{i,t} + F_{i,t} \cdot (1 + (\chi - 1)s) (\theta_0 k_{i,t} + \theta_1 \Psi(k_{i,t})) + (1 - F_{i,t}) \cdot (\theta_0 k_{i,t} + \theta_1 \Psi(k_{i,t}))$$

$$\tilde{b}_{i,t} = (\chi - 1)s(w_t l_{i,t} - c_{i,t})$$

$$b_{i,t} = w_t l_{i,t} - c_{i,t}$$

Recursive Formulation in the Second Period [Back](#)

Value function:

$$v(z_{i,t}, n_{i,t-1}, F_{i,t}) = \max_{d_{i,t}} \left\{ \frac{d_{i,t}(z_{i,t}, n_{i,t-1}, F_{i,t})^{1-\eta}}{1-\eta} + \epsilon \beta E_z[v(z_{i,t+1}, n_{i,t})] \right\}$$

Net worth accumulation:

$$n_{i,t}(z_{i,t}, n_{i,t-1}, F_{i,t}) = \pi^*(z_{i,t}, n_{i,t-1}, F_{i,t}) - d_{i,t}(z_{i,t}, n_{i,t-1}, F_{i,t}) - \xi_{i,t}$$

LGP fixed cost threshold:

$$\xi^*(z_{i,t}, n_{i,t-1}) = \frac{\pi^*(z_{i,t}, n_{i,t-1}, A) - \pi^*(z_{i,t}, n_{i,t-1}, N)}{w_t}$$

Other Household:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\eta}}{1-\eta} - \theta \frac{L_t^{1+\omega}}{1+\omega} \right)$$

subject to:

$$C_t + \frac{1}{1+r_t} B_t \leq B_{t-1} + W_t L_t$$

Capital Good Producer:

Technology:

$$\Phi(I_t/K_t)K_t = \left(\frac{\delta/\phi}{1-1/\phi} \left(\frac{I_t}{K_t} \right)^{1-1/\phi} - \frac{\delta}{\phi-1} \right) K_t$$

Price of capital:

$$q_t = \frac{1}{\Phi'(I_t/K_t)} = \frac{I_t/K_t^{1/\phi}}{\delta}$$

Fixed Parameters

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Table: FIXED PARAMETERS

Parameter	Description	Value
<i>Firms</i>		
α	Capital coefficient	0.21
ν	Labor coefficient	0.64
δ	Capital depreciation	0.10
ϕ	Capital adjustment cost	4.0
<i>Households</i>		
β	Discount factor	0.96
η	Elasticity of intertemporal substitution	1
θ	Leisure preference	2
ω	Inverse Frisch	0.5

Table: FITTED PARAMETERS

Parameter	Description	Value
<i>Output Dynamics</i>		
ρ_z	Persistence of TFP shock	0.90
σ_z	Volatility of TFP shock	0.06
\underline{n}_0	Net worth of entrants	0.08
ϵ	Survival rate	0.91
τ	Net worth erosion	0.02
<i>Financial Frictions</i>		
s	Share of formal bank loans	0.20
θ_0	Collateral constraint (size-irrelevant)	0.01
θ_1	Collateral constraint (size-dependent)	0.26
γ	Collateral constraint (size-dependent)	1.35
<i>Loan guarantee program</i>		
μ	Guaranteed loan commission fee	0.005
χ	Multiplier of LGP on loans	2.5
$\bar{\xi}$	Upper bound of LGP fixed cost	0.35