Financial Frictions and Capital Misallocation

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Introduction

Capital misallocation has an adverse impact on aggregate productivity

$\rightarrow$ important to understand the causes of capital misallocation

$\rightarrow$ financial frictions as one contributing factor, but difficult to quantify

- This paper provides a novel method to quantify the impact of financial constraint on capital misallocation measured by the dispersion of MRPK.

Introduction

Capital misallocation has an adverse impact on aggregate productivity

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$\rightarrow$ financial frictions as one contributing factor, but difficult to quantify

- This paper provides a novel method to quantify the impact of financial constraint on capital misallocation measured by the dispersion of MRPK.

Applying this method to large panels of manufacturing firms for 20 countries from the 1990s to 2015, for most countries and industries:

- dispersions and means of MRPK for financially constrained firms are much larger than those for unconstrained firms
- $>$ 25% of firms are classified as constrained
- presence of constrained firms accounts for $>$ 50% of MRPK dispersion

Dispersion of Marginal Revenue Product of Capital

Var(lnMRPK$_i$) as a measure of capital misallocation

Assuming a Cobb-Douglas production function, define firm i's MRPK$_i$ as:

$$\text{MRPK}_i \equiv \frac{\partial p_i y_i}{\partial k_i} = \beta_k \frac{p_i y_i}{k_i}$$

where $\beta_k \in (0, 1)$ and MRPK$_i$ is measured by nominal revenue $p_i y_i$ over fixed tangible assets k_i. Under efficient allocation, Var(MRPK$_i$) $= 0$, since MRPK$_i = r \ \ \forall \ i$.

Many causes for static MRPK to differ across firms, including:

- capital adjustment cost
- financial constraint

$\Rightarrow$ This paper estimates the fraction of Var(lnMRPK$_i$) that can be explained by the presence of financially constrained firms.

Methodology

Step 1. Divide firms into financially constrained (C) and unconstrained (U) using a switching regression approach

Step 2. Let s^U and $s^C = 1 - s^U$ denote the fraction of unconstrained and constrained firms, respectively. Decompose the dispersion of MRPK:

$$\begin{aligned}\text{Var}(\text{lnMRPK}_i) =& s^U \text{Var}(\text{lnMRPK}_i^U) + s^C \text{Var}(\text{lnMRPK}_i^C) \\ &+ s^U s^C \left[\text{E}(\text{lnMRPK}_i^U) - \text{E}(\text{lnMRPK}_i^C)\right]^2\end{aligned}$$

$$\Downarrow$$

$$\text{Credit Distortion} \equiv \frac{\text{Var}(\text{lnMRPK}_i) - s^U \text{Var}(\text{lnMRPK}_i^U)}{\text{Var}(\text{lnMRPK}_i)} \in [0, 1]$$

e.g. $s^U = 1 \Rightarrow$ credit distortion $= 0$

smaller $\text{E}(\text{lnMRPK}_i^C) - \text{E}(\text{lnMRPK}_i^U) \Rightarrow$ lower credit distortion

Literature Review

Empirical finance literature on financial frictions and firm investment:

- Ex-ante division of firms (e.g. Hubbard et al., 1995; Fazzari et al., 1988)
- Index-based approach (e.g. Whited and Wu, 2006; Lamont et al., 2001)
- Switching regression (e.g. Almeida and Campello, 2007; Hovakimian and Titman, 2006)

▶ This paper: use switching regression to empirically identify the financially constrained firms in a sample of both listed and **unlisted** firms.

Macro literature on the causes of capital misallocation:

e.g. David and Venkateswaran (2019); Bai et al. (2018); Gopinath et al. (2017); Midrigan and Xu (2014); Moll (2014); Gilchrist et al. (2013)

▶ This paper: new method to estimate the impact of financially constrained firms, which relies on fewer restrictive assumptions

Outline

- Theoretical framework
- Switching regression model
- Data
- Empirical results
- Conclusions

Theoretical Framework

Net investment $\Delta \ln k_{i,t}$ differs between financially constrained and unconstrained firms

Assume M monopolistically competitive firms in a manufacturing industry:

- Firm i produces a differentiated product $p_{i,t}y_{i,t}$ using labor, materials, and pre-installed capital via a Cobb-Douglas production function
- Capital $k_{i,t}$ is financed by net worth $n_{i,t}$ (and borrowing $b_{i,t}$)
- Financial friction: costly debt enforcement leads to a collateral constraint

$$b_{i,t} \leqslant \underbrace{\phi(1-\delta)k_{i,t}}_{\substack{\text{fraction } \phi \text{ of} \\ \text{undepreciated capital}}} \quad \xRightarrow{\text{equivalently}} \quad k_{i,t} \leqslant \frac{n_{i,t}}{1-\phi(1-\delta)}$$

$\Rightarrow$ Investment $\Delta \ln k_{i,t}$ differs for unconstrained (U) and constrained (C) firms:

- $\Delta \ln k_{i,t}^{U}$ depends on **expected sales growth** $\Delta \ln \mathrm{E}_t \left[p_{i,t+1}y_{i,t+1}\right]$
- $\Delta \ln k_{i,t}^{C}$ depends on **cash flow** $\frac{\mathrm{CF}_{i,t}}{k_{i,t-1}}$, where $\mathrm{CF}_{i,t} = \Delta n_{i,t} + \delta k_{i,t-1}$

Switching Regression Model

Classify firms into constrained (C) and unconstrained (U) types in a two-digit industry

Firms follow two different investment regimes depending on their type:

$$\Delta \ln k_{i,t}^{C} = \boldsymbol{x}_{i,t}\gamma^{C} + \varepsilon_{C,i,t} \quad \text{if} \quad s_{i,t}^{*} > 0$$

$$\Delta \ln k_{i,t}^{U} = \boldsymbol{x}_{i,t}\gamma^{U} + \varepsilon_{U,i,t} \quad \text{if} \quad s_{i,t}^{*} \leqslant 0$$

$$s_{i,t}^{*} = \boldsymbol{x}_{S,i,t}\gamma^{S} + \varepsilon_{S,i,t}$$

where latent variable $s_{i,t}^{*}$ determines firm i's constrained status. Assume $\varepsilon_{C,i,t}$ and $\varepsilon_{U,i,t}$ are normally distributed and are independent of $\varepsilon_{S,i,t} \sim Logit$.

$\boldsymbol{x}_{i,t}$: lagged sales growth, lagged cash flow

$\boldsymbol{x}_{S,i,t}$: age, size, MRPK, leverage, liquidity

$\Rightarrow$ Identifying constrained investment regime requires theoretical priors:

younger, smaller firms with higher MRPK more likely to be constrained

Likelihood function

Data

This paper focuses on manufacturing sector in 20 countries (1990s–2015):

- Orbis annual firm-level financial data for listed **and** unlisted firms
- $>$ 98% of observations are from unlisted firms for most countries

	Median number of employees		Median age	
Country	Unlisted	Listed	Unlisted	Listed
Bulgaria	13	201	8	46
Croatia	5	261	11	56
Czech Republic	23	750	12	14
Finland	8	957	15	26
France	6	342	14	26
Germany	26	752	21	44
Italy	12	413	15	27
Japan	15	784	31	61
Korea	15	168	8	21
Norway	9	406	12	14

Data description

Outline for Empirical Results

This presentation focuses on the results for fabricated metal industry:

- Estimated parameters from the switching regression model
  - Selection equation
  - Investment regimes
- Classify firms as constrained (C) or unconstrained (U) to calculate the proportion of $\text{Var}(\ln \text{MRPK}_i)$ caused by presence of constrained firms:

$$\text{Credit Distortion} \equiv \frac{\text{Var}(\ln \text{MRPK}_i) - s^U \text{Var}(\ln \text{MRPK}_i^U)}{\text{Var}(\ln \text{MRPK}_i)} \in [0, 1]$$

Selection Equation

The signs of age, size, and MRPK are jointly consistent with expectations

Country	Age	ln(Assets)	ln(MRPK)
Bulgaria	-0.024***	-0.846***	0.656***
	(0.0063)	(0.2097)	(0.1116)
Croatia	-0.021***	-0.871***	1.027***
	(0.0049)	(0.0901)	(0.0576)
Czech Republic	-0.080***	-0.842***	0.921***
	(0.0047)	(0.0770)	(0.0479)
Finland	-0.019***	-0.959***	1.375***
	(0.0022)	(0.0626)	(0.0582)
France	-0.014***	-1.094***	2.089***
	(0.0009)	(0.0412)	(0.0297)
Germany	-0.006***	-0.942***	1.585***
	(0.0013)	(0.2625)	(0.1432)
Italy	-0.013***	-0.845***	1.084***
	(0.0007)	(0.0254)	(0.0156)
Japan	-0.016***	-0.579	1.388***
	(0.0032)	(0.3534)	(0.2184)
Korea	-0.026***	-0.729***	1.163***
	(0.0024)	(0.0465)	(0.0370)
Norway	-0.017***	-0.608***	1.016***
	(0.0050)	(0.0945)	(0.0572)

Robust standard errors reported in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Year and 4-digit industry fixed effects are included. To control for firm fixed effects, firm-specific means of $\boldsymbol{x}$ over time are included, following Hu and Schiantarelli (1998).

$\Rightarrow$ Younger, smaller firms with higher MRPK are more likely to be constrained

Investment Regimes

Constrained firms' investment is more sensitive to cash flow $\frac{CF_{i,t-1}}{k_{i,t-2}}$

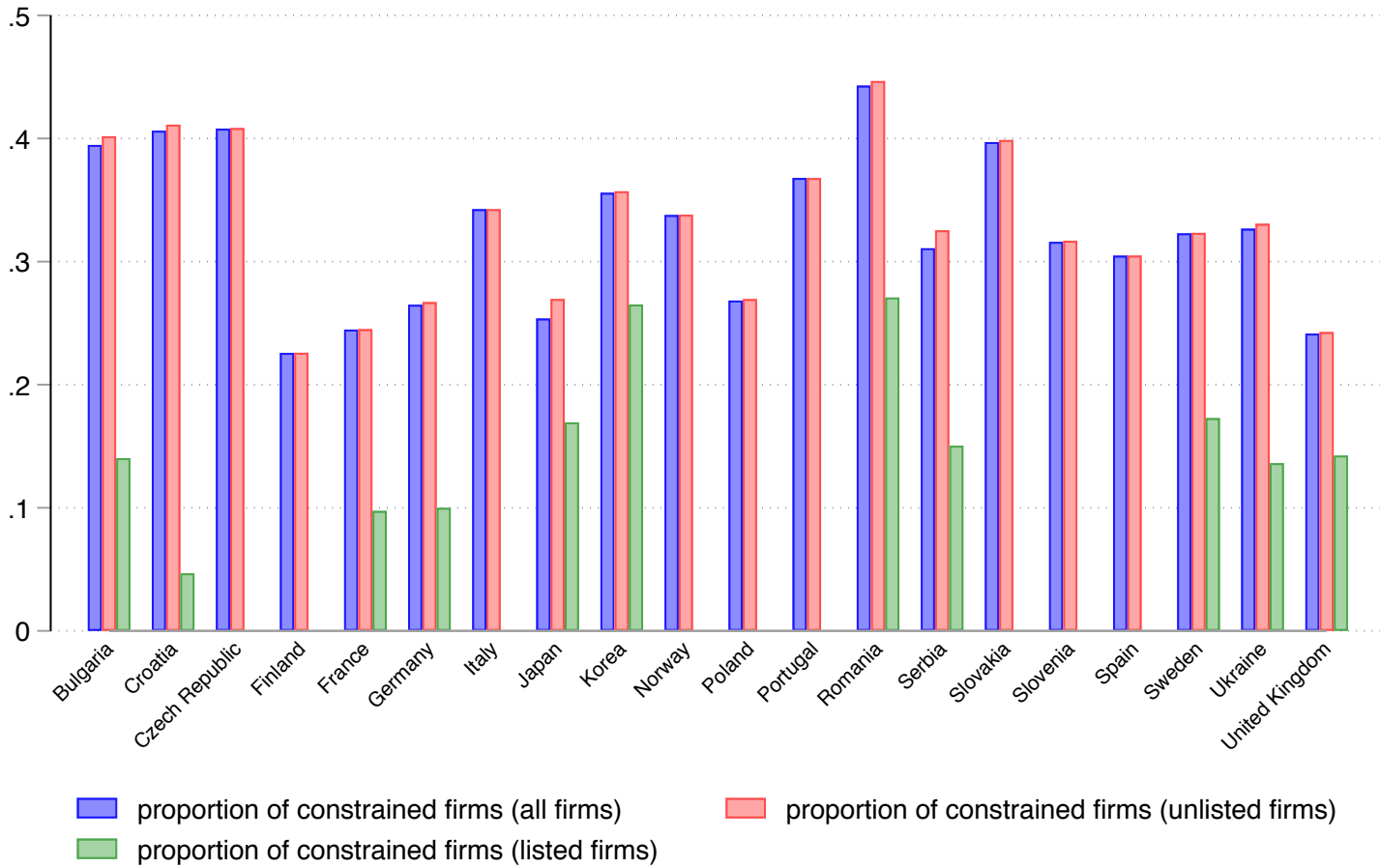
	Unconstrained Regime		Constrained Regime		
Country	$\Delta \ln Sales_{i,t-1}$	$\frac{CF_{i,t-1}}{k_{i,t-2}}$	$\Delta \ln Sales_{i,t-1}$	$\frac{CF_{i,t-1}}{k_{i,t-2}}$	Observations
Bulgaria	0.010	0.007*	0.050	0.025***	4,243
	(0.0060)	(0.0042)	(0.0410)	(0.0066)	
Croatia	0.014**	-0.002	0.156***	0.025***	12,652
	(0.0057)	(0.0015)	(0.0277)	(0.0038)	
Czech Republic	0.021***	-0.002	0.023	0.031***	25,421
	(0.0043)	(0.0015)	(0.0249)	(0.0028)	
Finland	0.024***	-0.000	0.007	0.033***	27,429
	(0.0039)	(0.0011)	(0.0257)	(0.0047)	
France	0.111***	0.010***	0.124***	0.039***	170,850
	(0.0048)	(0.0006)	(0.0217)	(0.0015)	
Germany	0.067***	0.003***	0.073	0.018***	12,100
	(0.0099)	(0.0011)	(0.0501)	(0.0041)	
Italy	0.020***	0.002***	0.123***	0.045***	246,989
	(0.0015)	(0.0007)	(0.0083)	(0.0017)	
Japan	0.013**	0.016	0.024	0.061*	6,830
	(0.0063)	(0.0103)	(0.0546)	(0.0332)	
Korea	0.009***	0.000	0.064***	0.059***	55,900
	(0.0026)	(0.0011)	(0.0194)	(0.0039)	
Norway	0.028***	0.001	0.136***	0.028***	12,676
	(0.0078)	(0.0007)	(0.0434)	(0.0028)	

Robust standard errors reported in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Year and 4-digit industry fixed effects are included. To control for firm fixed effects, firm-specific means of $\boldsymbol{x}$ over time are included, following Hu and Schiantarelli (1998).

Proportion of Constrained Firms

More than 25% of firms are constrained in most countries

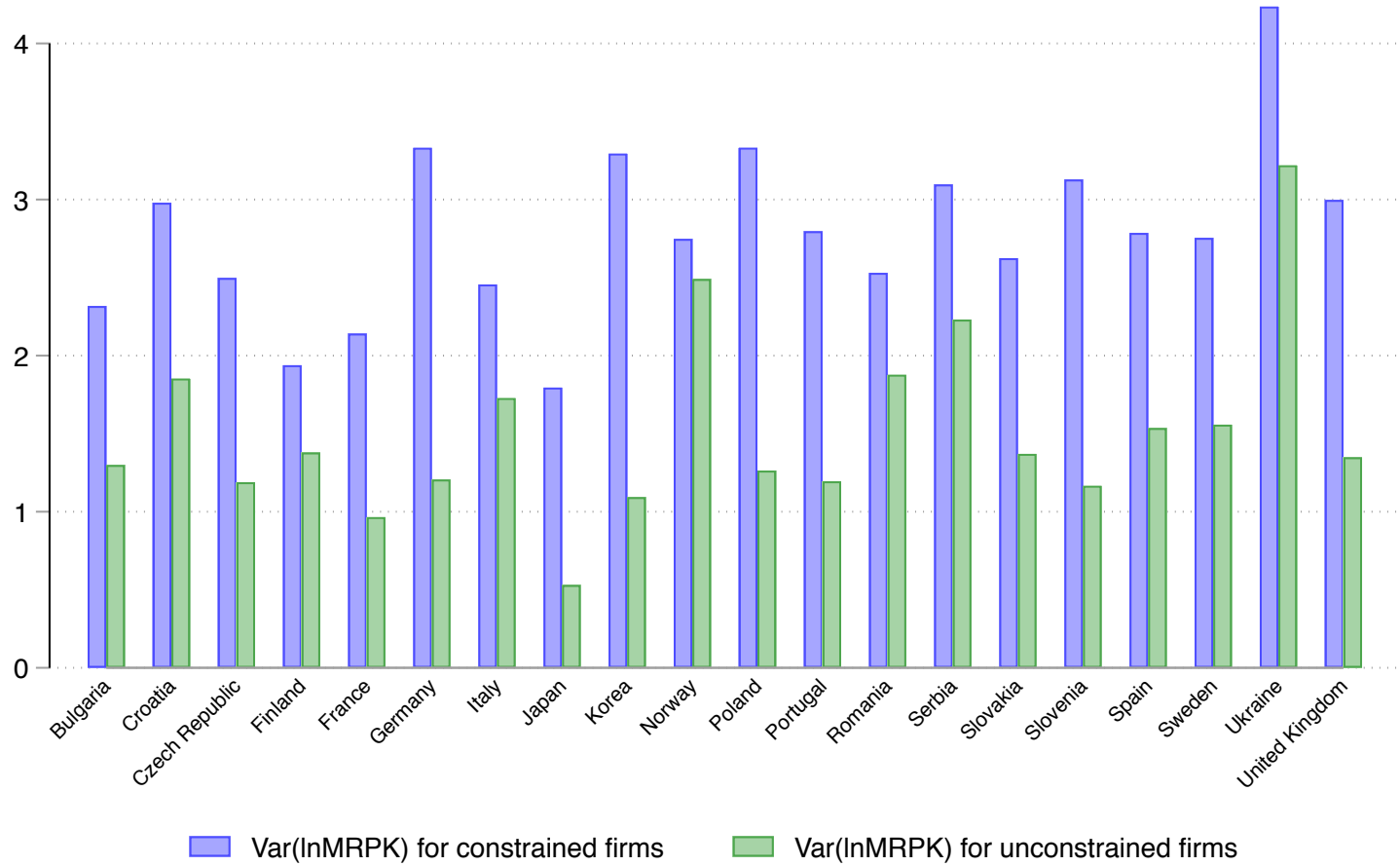


Note: Missing green bars are due to the number of observations being below 100.

$\Rightarrow$ The proportion of constrained firms in the subsample of listed firms is lower, which serves as validation of the results.

Dispersion of MRPK

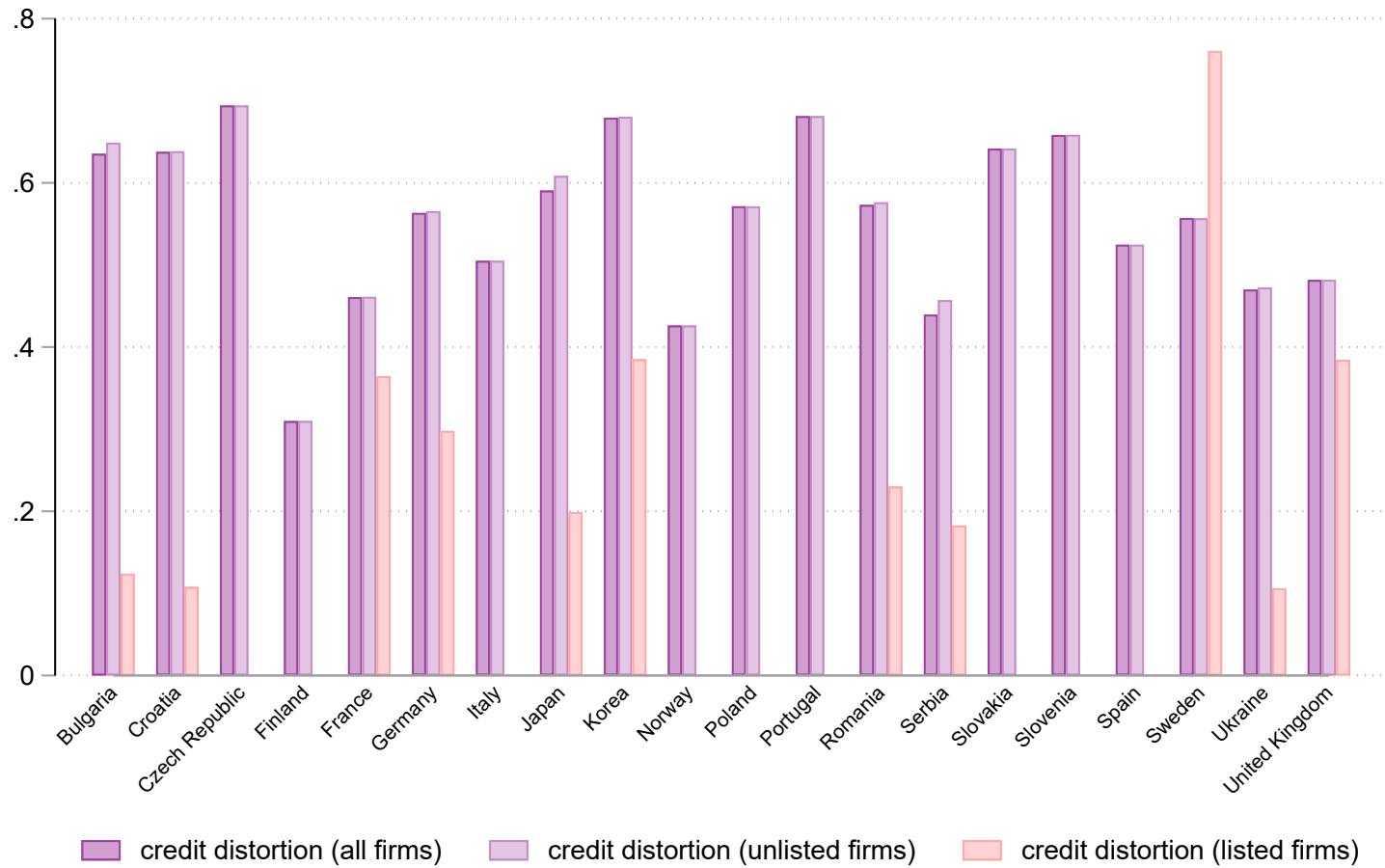
Constrained firms have higher dispersion of MRPK, which is consistent with theoretical results



Mean of MRPK | Consistent with theoretical prediction

Credit Distortion

Presence of constrained firms explains more than 50% of observed dispersion of MRPK



Note: Missing bars are because the number of observations being below 100.

$\Rightarrow$ Credit distortion in the subsample of listed firms is lower in most countries, which serves as validation of the measure.

Robustness Checks

Baseline results on proportion of constrained firms and credit distortion are robust to:

- Applying method to 14 different two-digit manufacturing industries
- Using nominal value added to compute MRPK
- Removing firm fixed effects
- Using other model-based measures of investment opportunity, i.e., productivity growth or value added growth, instead of sales growth

Conclusions

This paper provides a novel method to quantify the impact of constrained firms on capital misallocation measured by the dispersion of MRPK.

Applying this method to large panels of manufacturing firms for 20 countries from the 1990s to 2015, for most countries and 2-digit industries:

- dispersions and means of MRPK for financially constrained firms are much larger than those for unconstrained firms
- $>$ 25% of firms are classified as constrained
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Likelihood Function $L_{i,t}$

$L_{i,t}$ is the weighted sum of the likelihoods of being in each latent class:

$$L_{i,t} = f(\varepsilon_{C,i,t}) \underbrace{P(\varepsilon_{S,i,t} > -\boldsymbol{x}_{S,i,t}\gamma^S)}_{\text{Prob(C)}} + f(\varepsilon_{U,i,t}) \underbrace{P(\varepsilon_{S,i,t} \leqslant -\boldsymbol{x}_{S,i,t}\gamma^S)}_{\text{Prob(U)}}$$

where $f(.)$ is the marginal normal density. Estimate the parameters by maximizing the log-likelihood function:

$$L = \sum_{i=1}^{M} \sum_{t=1}^{T_i} \ln(L_{i,t})$$

To classify firms into constrained (C) and unconstrained (U) types:

- Constrained investment regime if P(C) $\downarrow$ in age and size, and $\uparrow$ in MRPK
- Firm i is constrained if $P(C \mid \Delta \ln k_{i,t}) > 0.5$

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Data Description

Country	Period	Observations	Obs/Year	Industries	Unlisted Firms
Bulgaria	1995-2015	119,346	5,683	223	0.983
Croatia	1998-2015	124,184	6,899	220	0.981
Czech Republic	1994-2015	176,420	8,019	289	0.995
Finland	1995-2015	163,600	7,790	227	0.992
France	1995-2015	1,316,144	62,674	229	0.994
Germany	1990-2015	255,056	9,810	298	0.975
Italy	1995-2015	1,716,653	81,745	302	0.998
Japan	1989-2015	593,512	21,982	199	0.959
Korea	2001-2015	817,068	54,471	198	0.973
Norway	1996-2015	109,826	5,491	217	0.990
Poland	1994-2015	167,273	7,603	236	0.981
Portugal	1998-2015	372,214	20,679	227	0.999
Romania	1995-2015	558,739	26,607	231	0.984
Serbia	1999-2015	165,237	9,720	235	0.930
Slovakia	1995-2015	76,190	3,628	228	0.980
Slovenia	1997-2015	93,570	4,925	213	0.991
Spain	1994-2015	1,428,899	64,950	230	0.999
Sweden	1997-2015	299,408	15,758	229	0.988
Ukraine	2001-2015	422,144	28,143	227	0.985
United Kingdom	1994-2015	294,092	13,368	230	0.966

Note: The sample from each country consists of manufacturing firms only. Industries shows the number of unique four-digit NACE Rev.2 industries over the period covered in each country. The last column shows the fraction of observations coming from unlisted firms.

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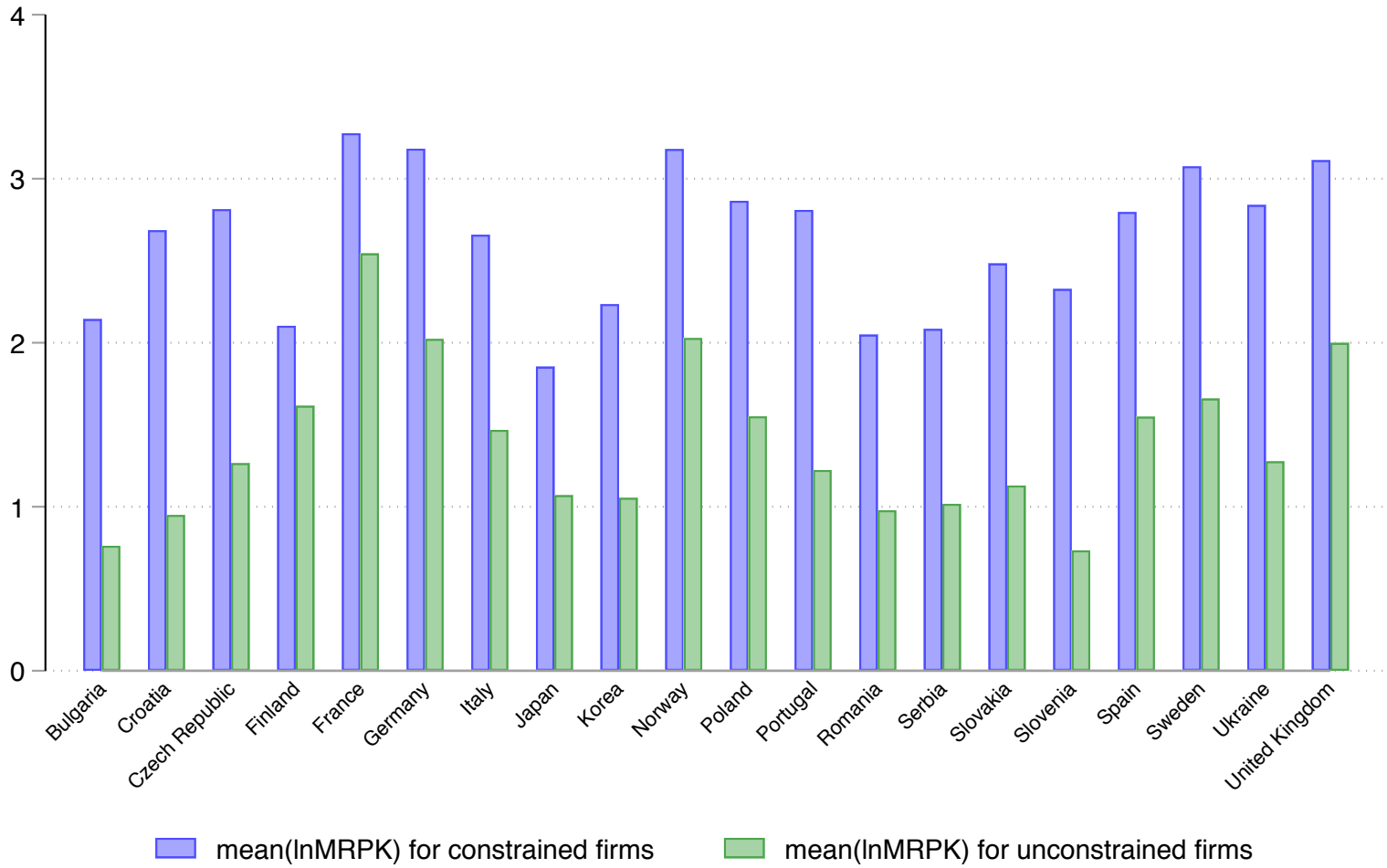
Mean of MRPK

Constrained firms have higher mean of MRPK, which is consistent with theoretical results



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Dispersion of MRPK in the Model

Constrained firms have higher dispersion of MRPK based on the theoretical model

Define firm i's period-t marginal revenue product of capital $\text{MRPK}_{i,t}$ as:

$$\text{MRPK}_{i,t} \equiv \frac{\partial p_{i,t} y_{i,t}}{\partial k_{i,t-1}} = \beta_k Z_{i,t} k_{i,t-1}^{\beta_k - 1} l_{i,t}^{\beta_l} m_{i,t}^{\beta_m}$$

Assume $Z_{i,t} \equiv Z_t z_i z_{i,t}$, where $\ln z_{i,t} = \rho \ln z_{i,t-1} + e_{i,t}$, then

$$\text{Var}_i(\ln \text{MRPK}_{i,t}^U) = \psi_1 \text{Var}_i(e_{i,t})$$

$$\begin{aligned}
\text{Var}_i(\ln \text{MRPK}_{i,t}^C) =& \psi_1 \text{Var}_i(e_{i,t}) + \psi_1 \text{Var}_i(\ln z_i) + \psi_1 \rho^2 \text{Var}_i(\ln z_{i,t-1}) \\
&+ \psi_2 \text{Var}_i(\ln n_{i,t-1}) - \psi_3 \text{Cov}_i(\ln z_i + \rho \ln z_{i,t-1}, \ln n_{i,t-1}) \\
=& \psi_1 \text{Var}_i(e_{i,t}) + \underbrace{\text{Var}_i(\psi_1^{\frac{1}{2}} \ln z_i + \psi_1^{\frac{1}{2}} \rho \ln z_{i,t-1} - \psi_2^{\frac{1}{2}} \ln n_{i,t-1})}_{\geqslant 0}
\end{aligned}$$

$\Rightarrow$ Constrained firms' dispersion of MRPK depends on the dispersion of productivity innovation $\text{Var}_i(e_{i,t})$, as well as firm heterogeneity in productivity and net worth.

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