The joint dynamics of capital and employment at the plant level

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Preliminary and incomplete

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Motivation

- Macro models often study one friction at a time.
  - **Prices:** Nakamura and Steinsson (2008).
  - **Capital**: Kahn and Thomas (2008).
  - **Employment**: Bachmann (2011).

- But firms make many decisions.
  - Need to integrate models to analyze *joint* dynamics.
  - Recent interest: Bloom (2009), Bloom, et al (2011), Sveen and Weinke (2010)

This paper's goals

- Integrate canonical models of dynamic capital and labor demand.
  - Characterize plant-level dynamics in steady state.

- Test implications at the plant level.
  - **Hypothesis**: *Both* factors are adjusted in the same direction whenever the more costly-to-adjust factor is changed.

Main result

Investment a weak predictor of employment growth at the plant level.

- Stands in sharp contrast to the baseline model.
- Withstands challenges to measurement and extensions to factor-biased shocks.

Baseline model

- Plant maximizes present value of profits,

$$y - wn - C_k(k, k_{-1}) - C_n(n, n_{-1})$$

- **Production**: $y = x^{1-\alpha-\beta} k^{\alpha} n^{\beta}$

- **Driving process:** $x' = x e^{\varepsilon'}, \ \varepsilon' \sim N(-\sigma^2/2, \sigma^2)$

Constant returns + random walk $\Rightarrow$ value function is linearly homogeneous in x. Can re-cast problem as choice of k/x and n/x.

Baseline model

- Plant maximizes present value of profits,

$$y - wn - C_k(k, k_{-1}) - C_n(n, n_{-1})$$

- **Adjustment costs**:

$$C_k(k, k_{-1}) = \begin{cases} p_b(k - k_{-1}) & if \quad k > k_{-1} \\ -p_s(k_{-1} - k) & if \quad k < k_{-1} \end{cases}$$

$p_b > p_s$: Cannot recover purchase price at sale

Baseline model

- Plant maximizes present value of profits,

$$y - wn - C_k(k, k_{-1}) - C_n(n, n_{-1})$$

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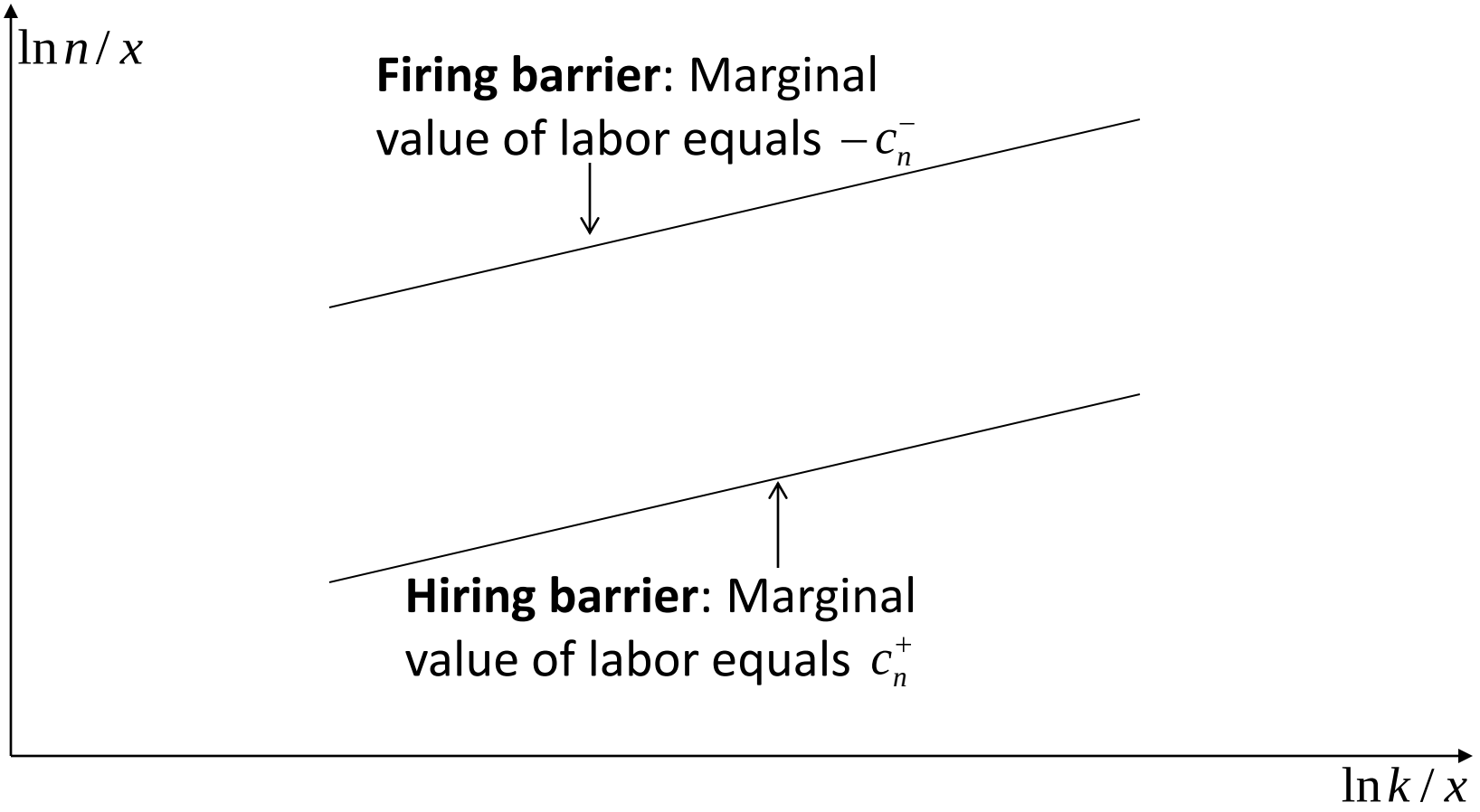
$$C_n(n, n_{-1}) = \begin{cases} c_n^+(n - n_{-1}) & if \quad n > n_{-1} \\ c_n^-(n_{-1} - n) & if \quad n < n_{-1} \end{cases}$$

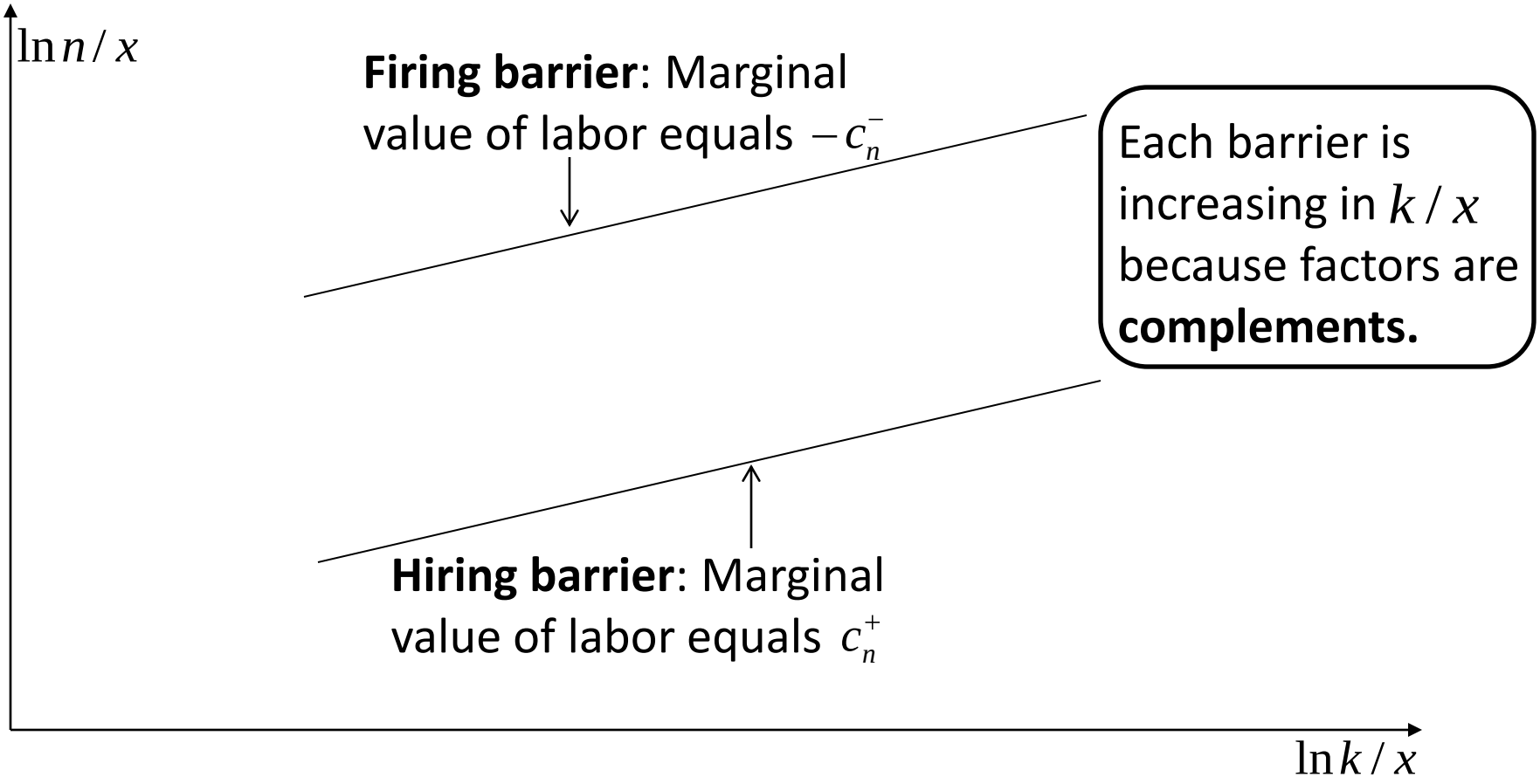
Costly to hire and fire

Factor demand policy



See Dixit (1997) and Eberly and van Mieghem (1997)

Factor demand policy



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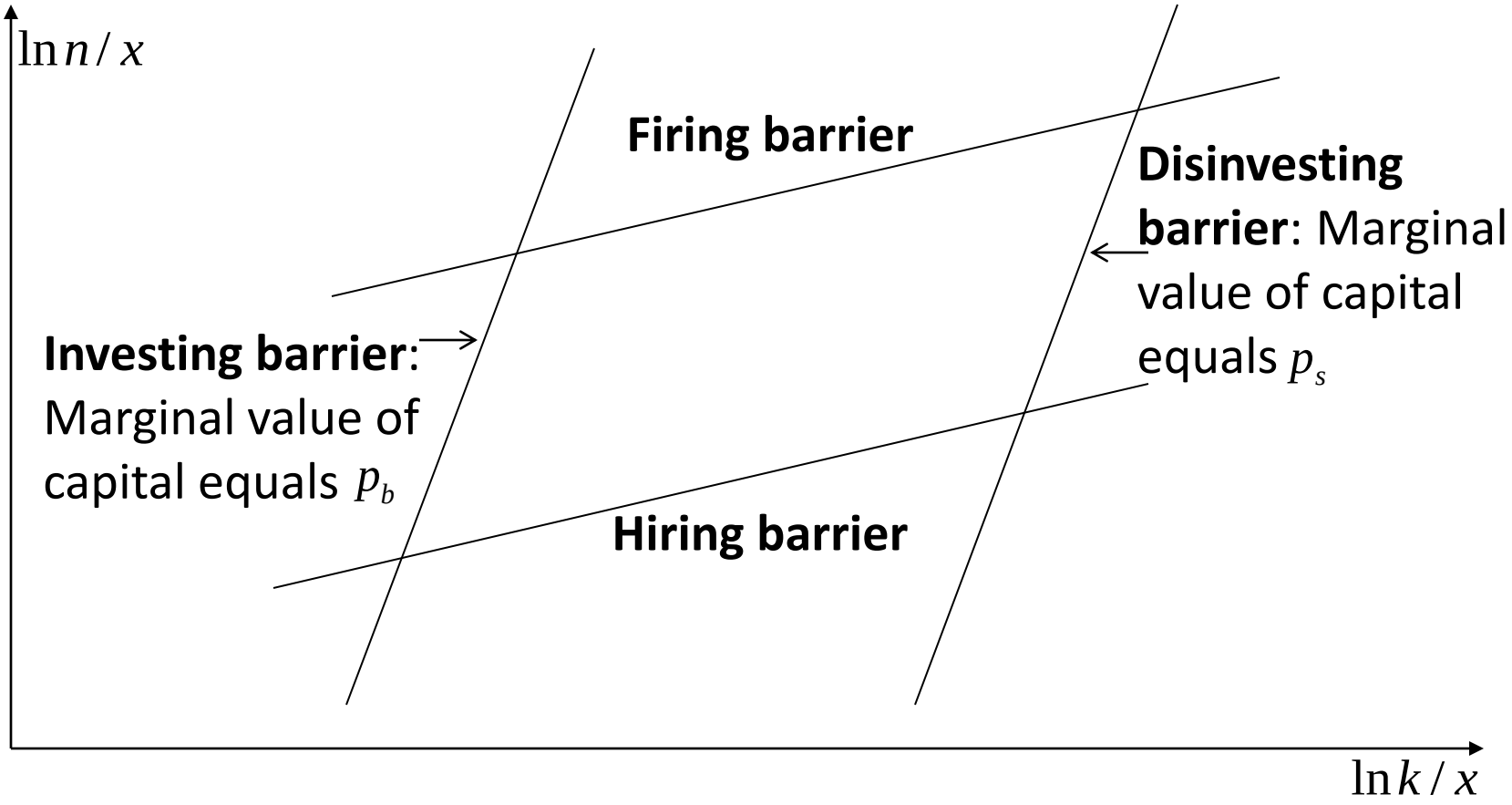

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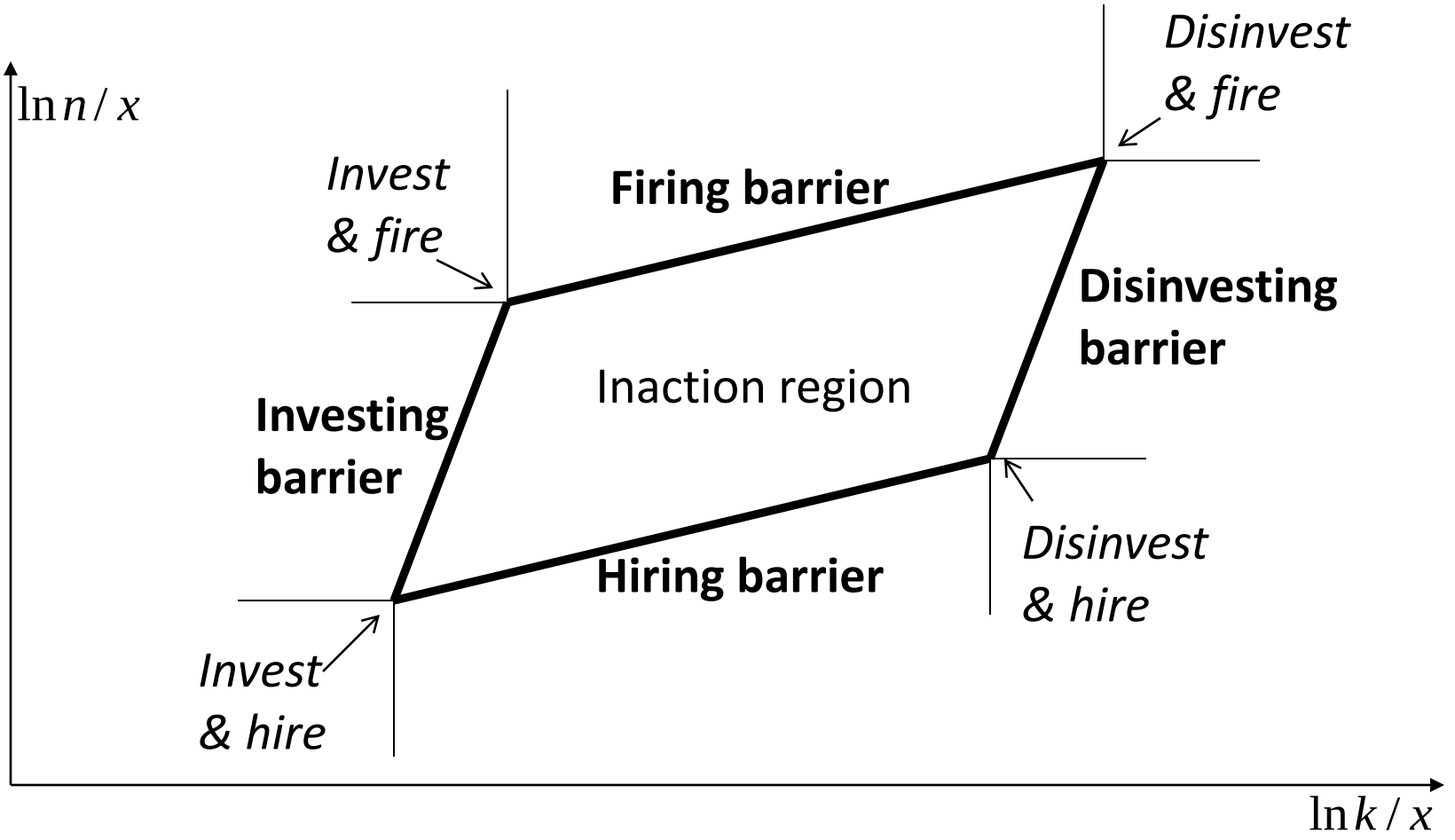
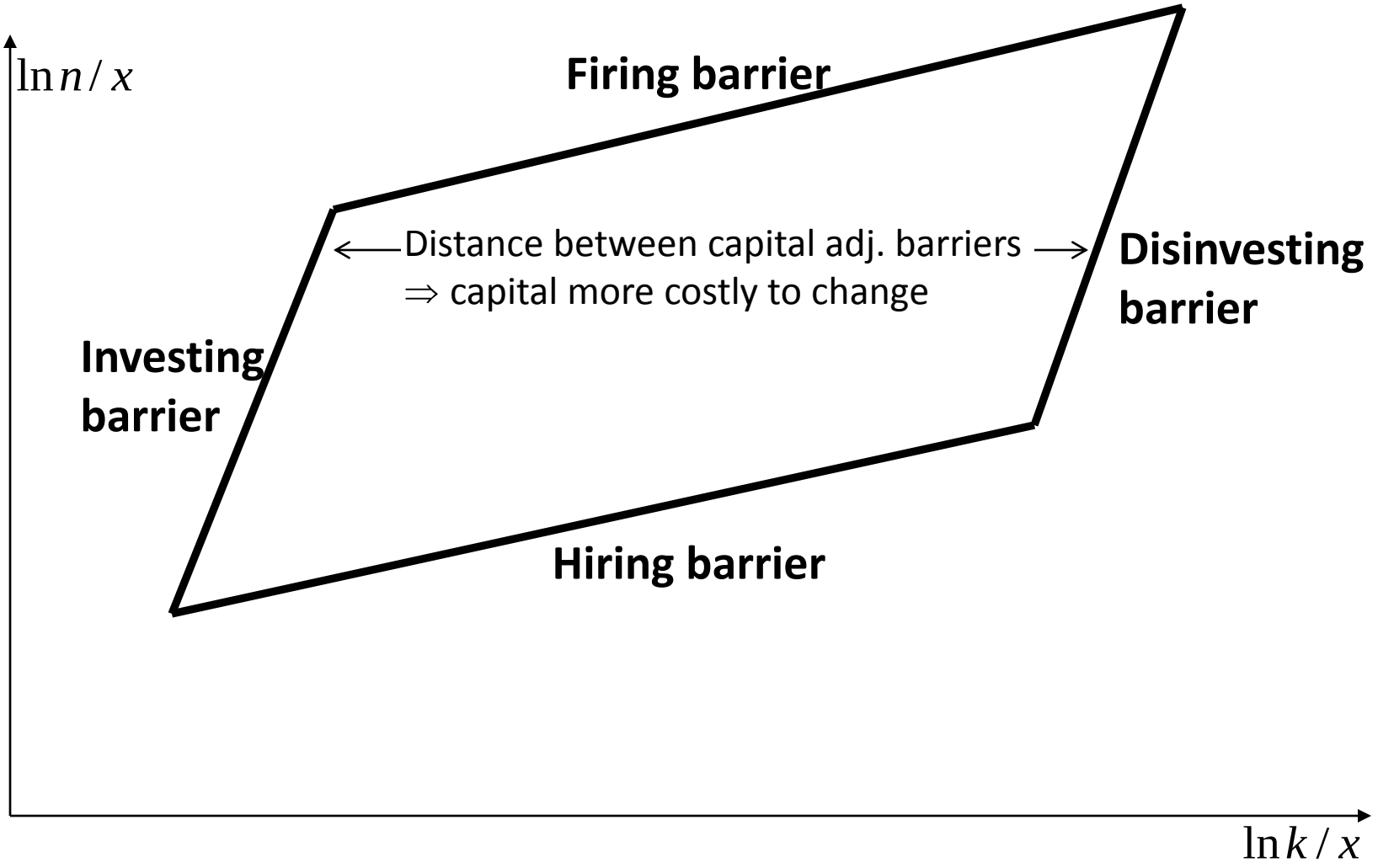


Dynamics of factor demand



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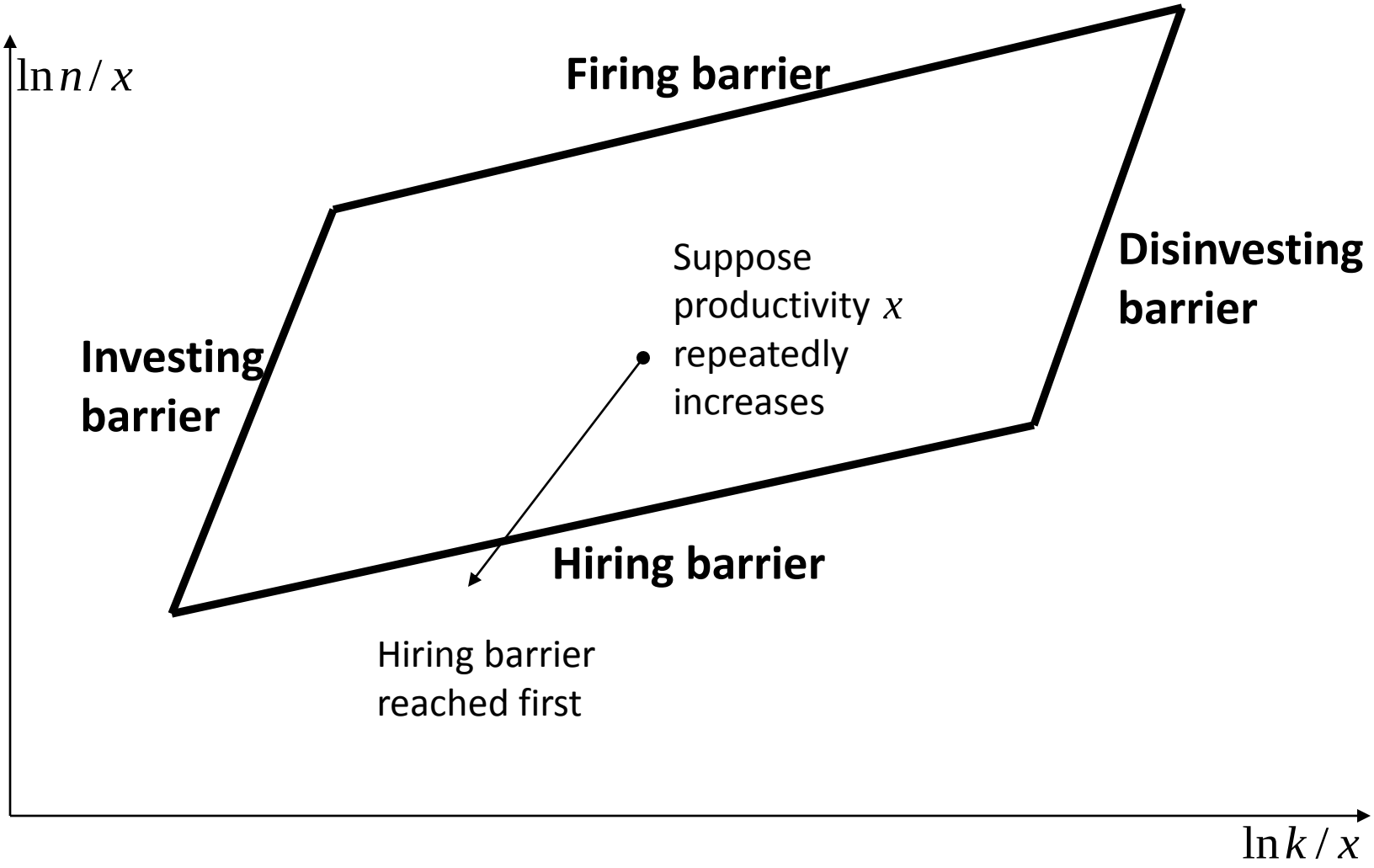

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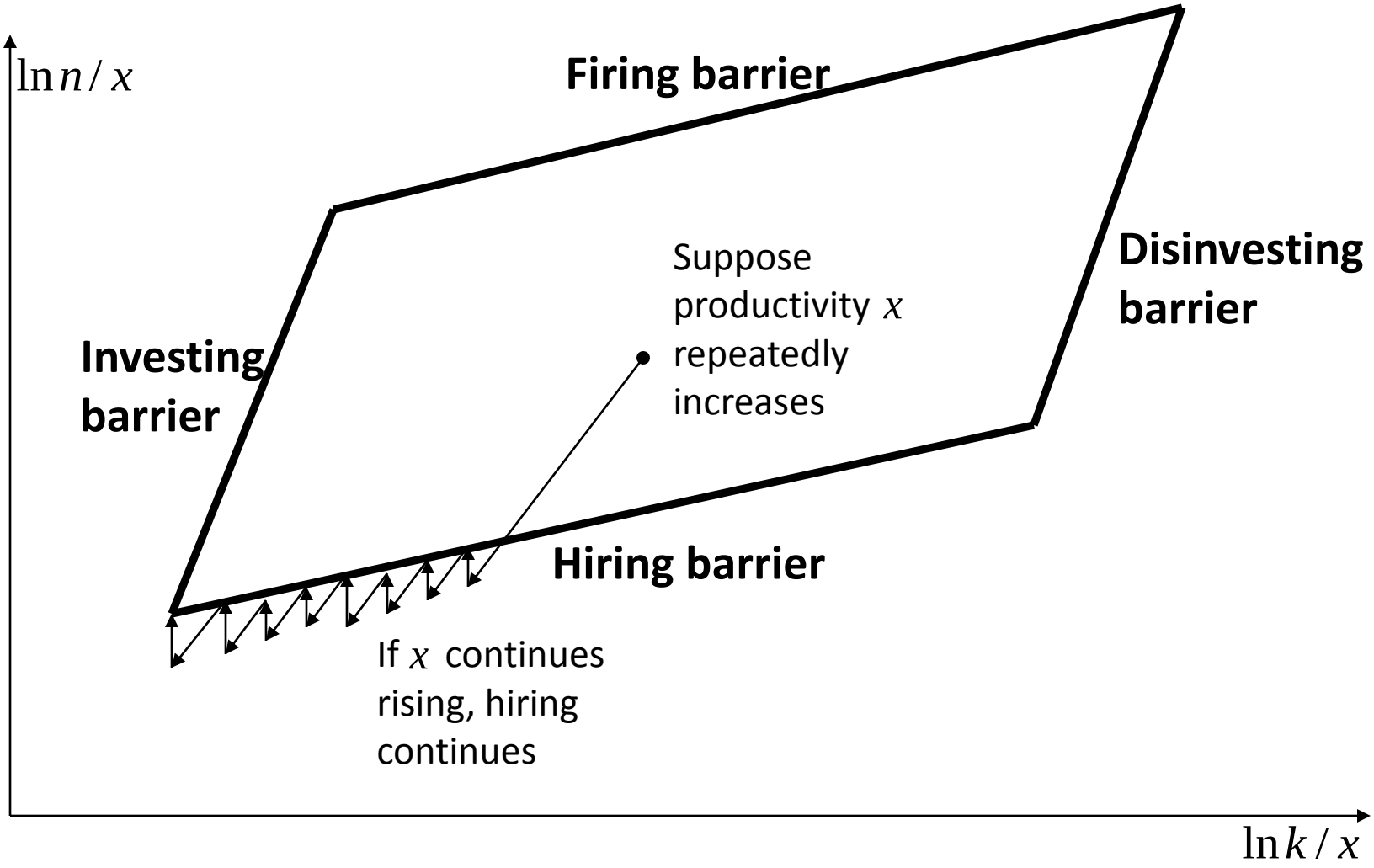

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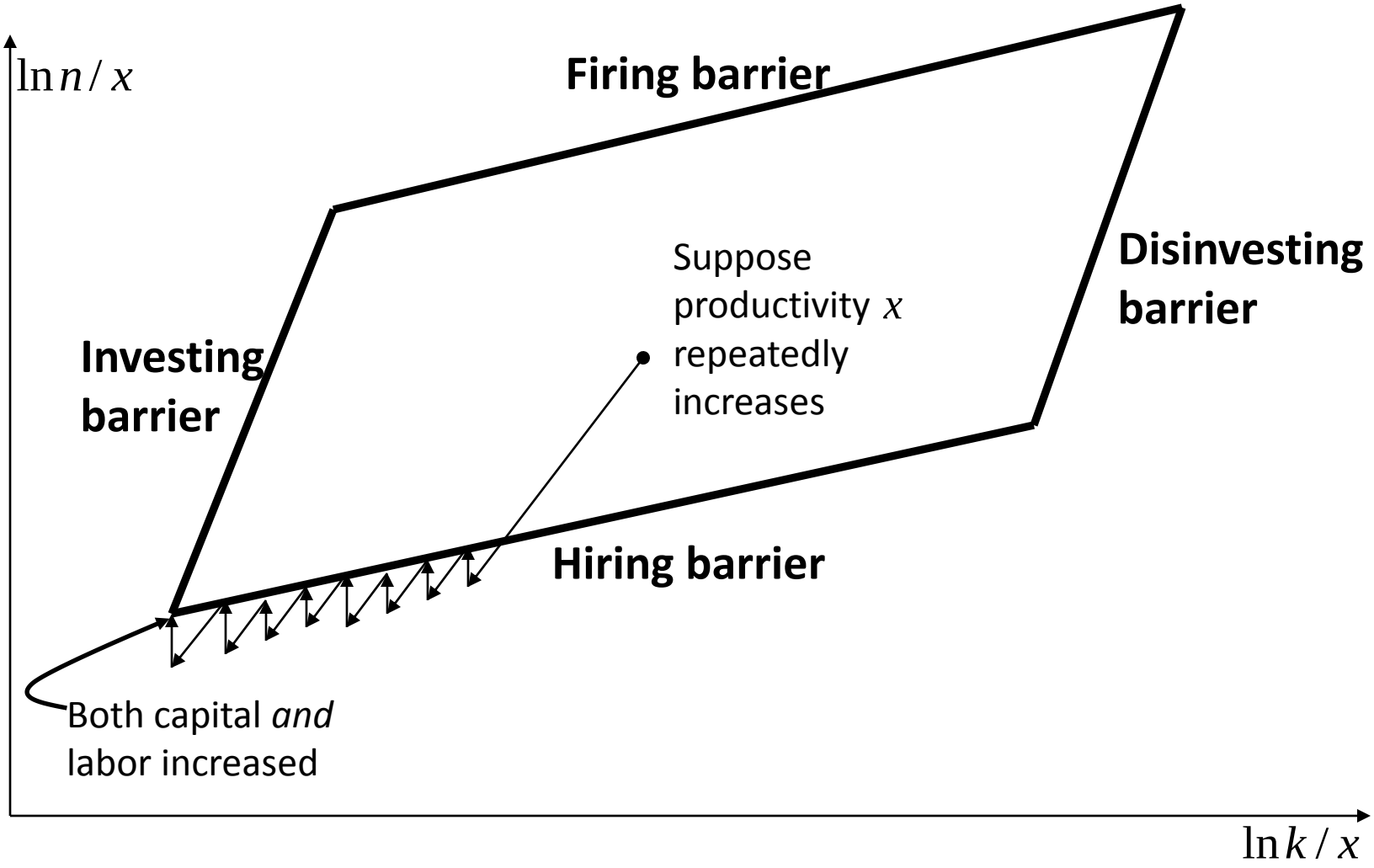


Dynamics of factor demand

Proposition: The adjustment of the most costly-to-change factor always coincides with an adjustment (in the same direction) of the least costly-to-adjust factor.

Empirical implication: Employment growth among investing plants is strictly positive.

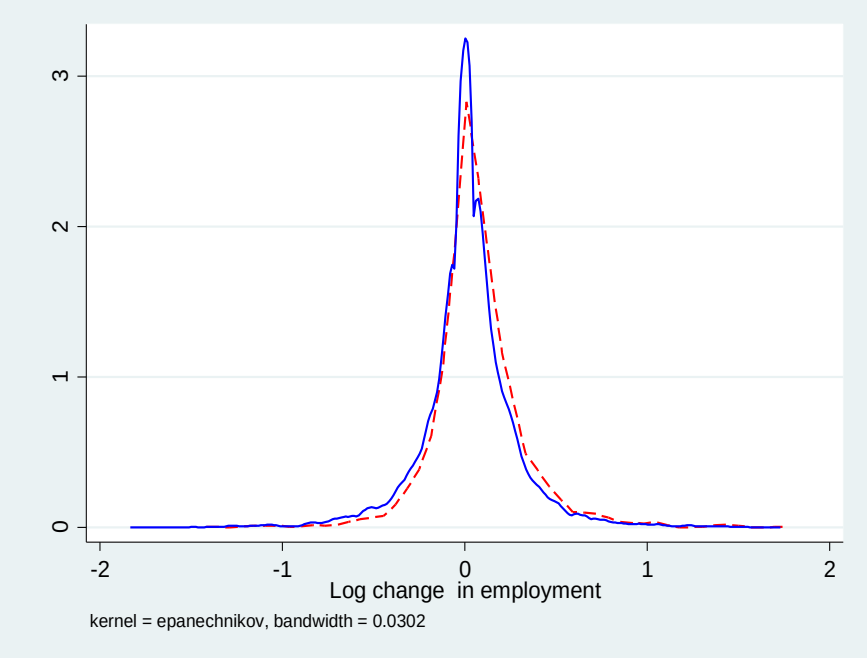
Empirical analysis: Data

- Chilean manufacturing census, 1979-96
- Korean annual manufacturing survey, 1990-06
  - Each is a census of manufacturing plants with at least 10 workers.
  - Contains annual observations on equipment investment and employment growth.

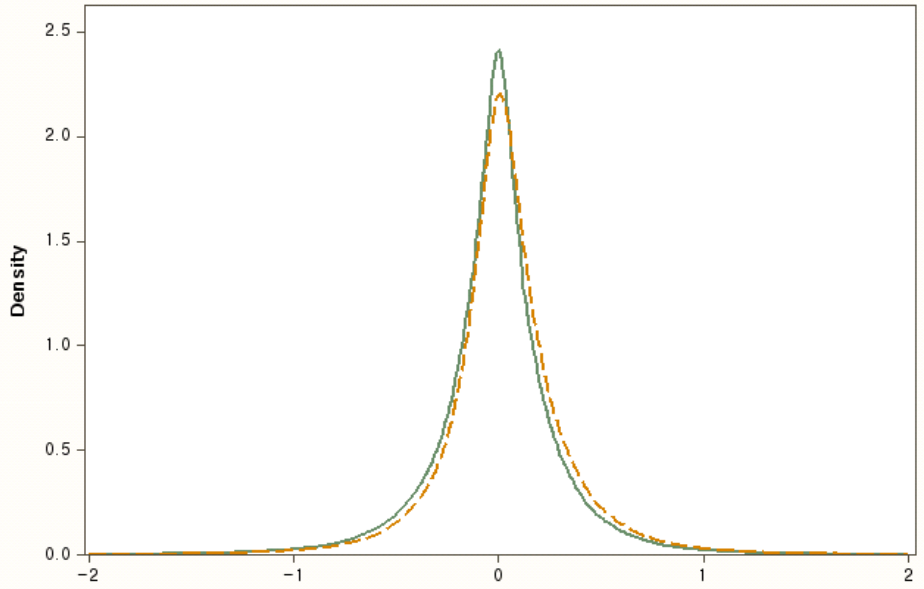
Empirical analysis: Results

The distribution of employment growth

Chile



S. Korea



Solid line **-** unconditional distribution of the log change in employment
Dashed line - distribution of $\Delta \ln n$ conditional on $I / K_{-1} > 10\%$

Empirical analysis: Results

- Investment a weak predictor of employment growth at plant level

	Chile	**Korea**
Share of plants which reduce employment (*n*), given $I/K_{-1} > 10\%$	30.4%	39.3%
Avg. **decline** in *n*, given $I/K_{-1} > 10\%$	16.4%	21.6%
Avg. **increase** in *n*, given $I/K_{-1} > 10\%$	20.7%	23.8%

What accounts for results?

- **Time to build**: Investment takes time, new workers hired next year.
  - Correlation between *current* investment and *future* employment growth just as low.

- **Unobserved heterogeneity**: Co-movement obscured by aggregation over distinct units.
  - Most likely a problem at *large* establishments.
  - But correlation is weak across *all* size classes.

What accounts for results?

- **Time aggregation**: Plants hire and invest in one quarter, but fire later in the year.
  - Simulate model to judge if time aggregation is quantitatively significant.

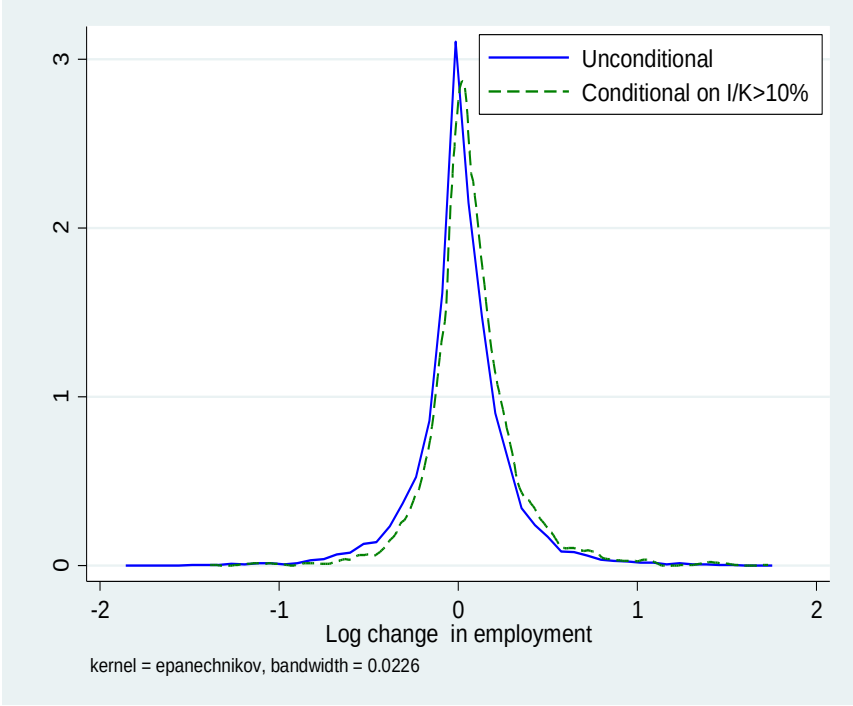
Model simulation: Calibration

Parameter	Value	Reason
p_b	1	Normalization
p_s	0.96	$\Pr[\quad] = 0$
$c_n^+ = c_n^- \equiv c_n$	9.6% of qtly. wage	$\Pr[\Delta n = 0]$
σ	0.15	Dispersion in employment growth

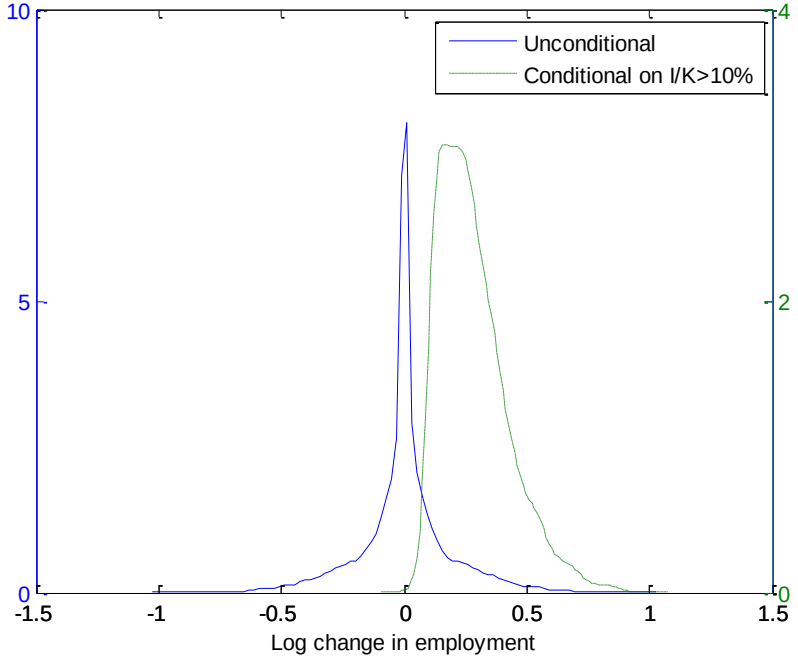
Model simulation: Results

The distribution of employment growth

Chile



Model



Time aggregation *does* ***not*** *account for the poor fit of the model.*

Robustness

Result is robust to

- Physical capital depreciation
  - Constant geometric decay
  - Modified “one-hoss-shay”
- Worker attrition
- Fixed costs

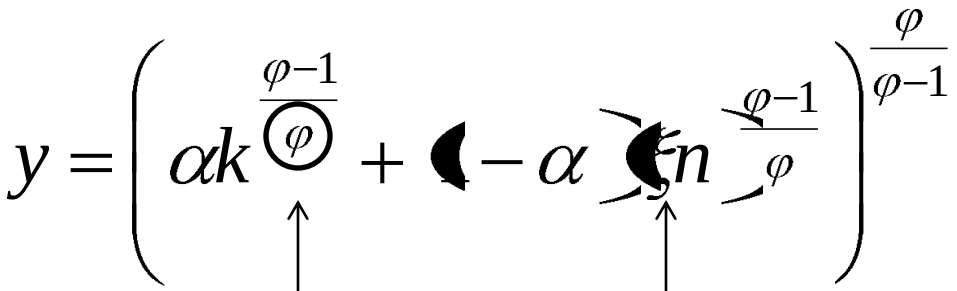
Robustness

- Bottom line: Neutral shock + complementarity $\Rightarrow$ tight positive co-movement of capital and labor even w/ frictions.

- Suggests we relax assumption of a single neutral shock.
  - Analyze labor-augmenting technical change.
  - Alternative: factor price shocks. But these preserve positive comovement.

Factor-biased technical change

- Production w/ labor-augmenting productivity



Elasticity of substitution between capital & labor

Labor-augmenting productivity shock

Factor-biased technical change

- Production w/ labor-augmenting productivity

$$y = \left(\alpha k^{\frac{\varphi-1}{\varphi}} + (1-\alpha)(\xi n)^{\frac{\varphi-1}{\varphi}} \right)^{\frac{\varphi}{\varphi-1}}$$

- Isoelastic demand schedule,

$$y = \zeta p^{-\varepsilon}$$

ε ← Elasticity of demand

ζ ← Demand shifter

Factor-biased technical change

- Demand shifter is neutral $\Rightarrow$ induces positive co-movement between capital and labor.

- Labor-augmenting productivity *can* induce positive investment and employment contraction *if*
  - Capital is highly complementary
  - Labor share is sufficiently low
  - Product demand is inelastic

Factor-biased technical change

- Demand shifter is neutral $\Rightarrow$ induces positive co-movement between capital and labor.

- Labor-augmenting productivity *can* induce positive investment and employment contraction *if*
  - Capital is highly complementary
  - Labor share is sufficiently low
  - Product demand is inelastic

But for plausible calibration, increase in ξ induces **positive comovement.**

Ongoing work

Capital-skill complementarity

- Skilled-labor-augmenting technical change induces substitution away from unskilled labor.

- Neutral (demand) shifters induce positive co-movement across all factors.

$\Rightarrow$Distribution of employment growth, conditional on investment, reflects a combination of shocks.

Ongoing work

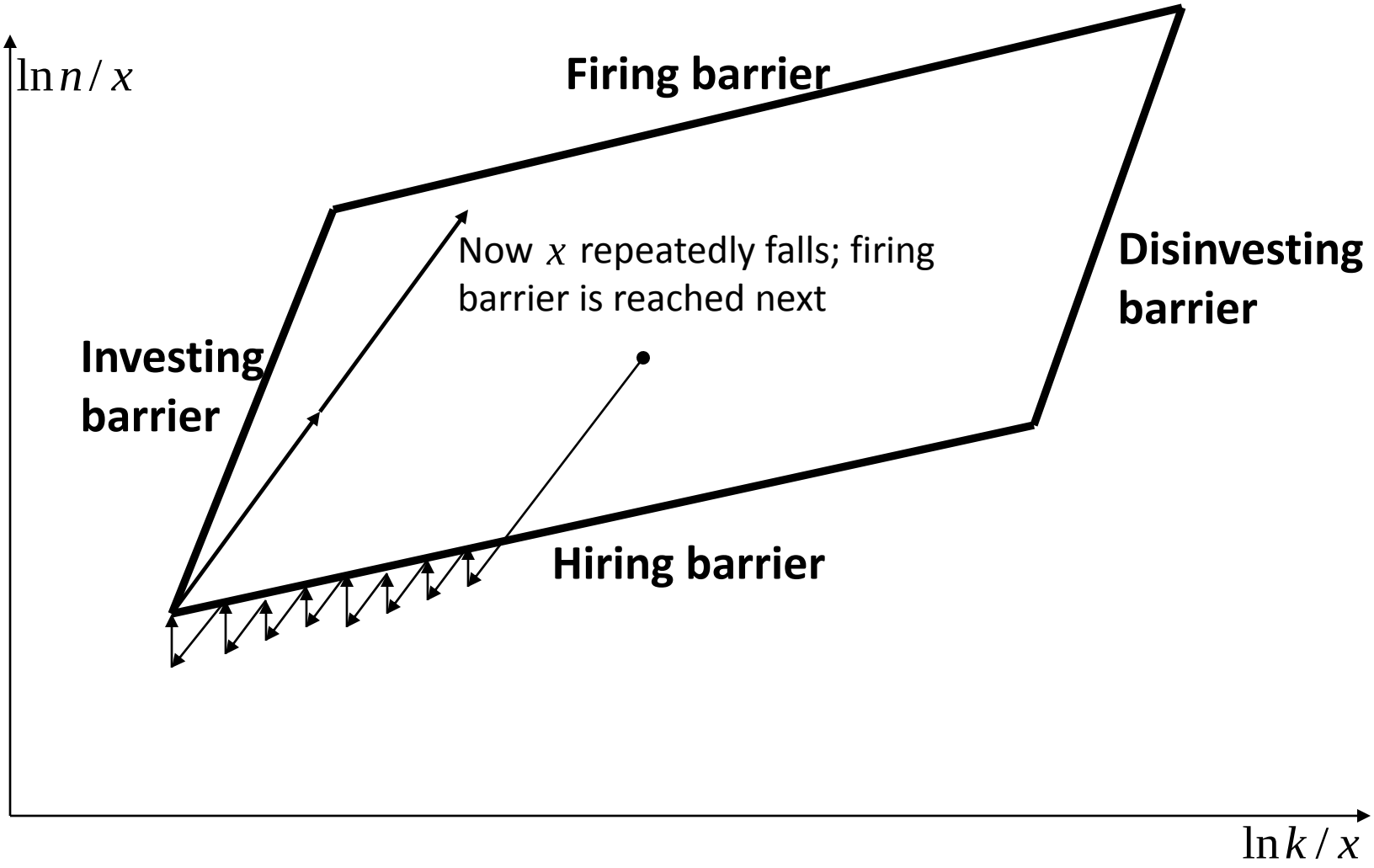
Challenge to this interpretation:

Literature uses non-production workers to proxy for skilled labor (Berman, Bound, Griliches, 1994).

- But capital and nonproduction labor weakly correlated.
- If we depart from assumption that nonproduction = skilled, how to identify skilled labor?

Extra Slides

Dynamics of factor demand



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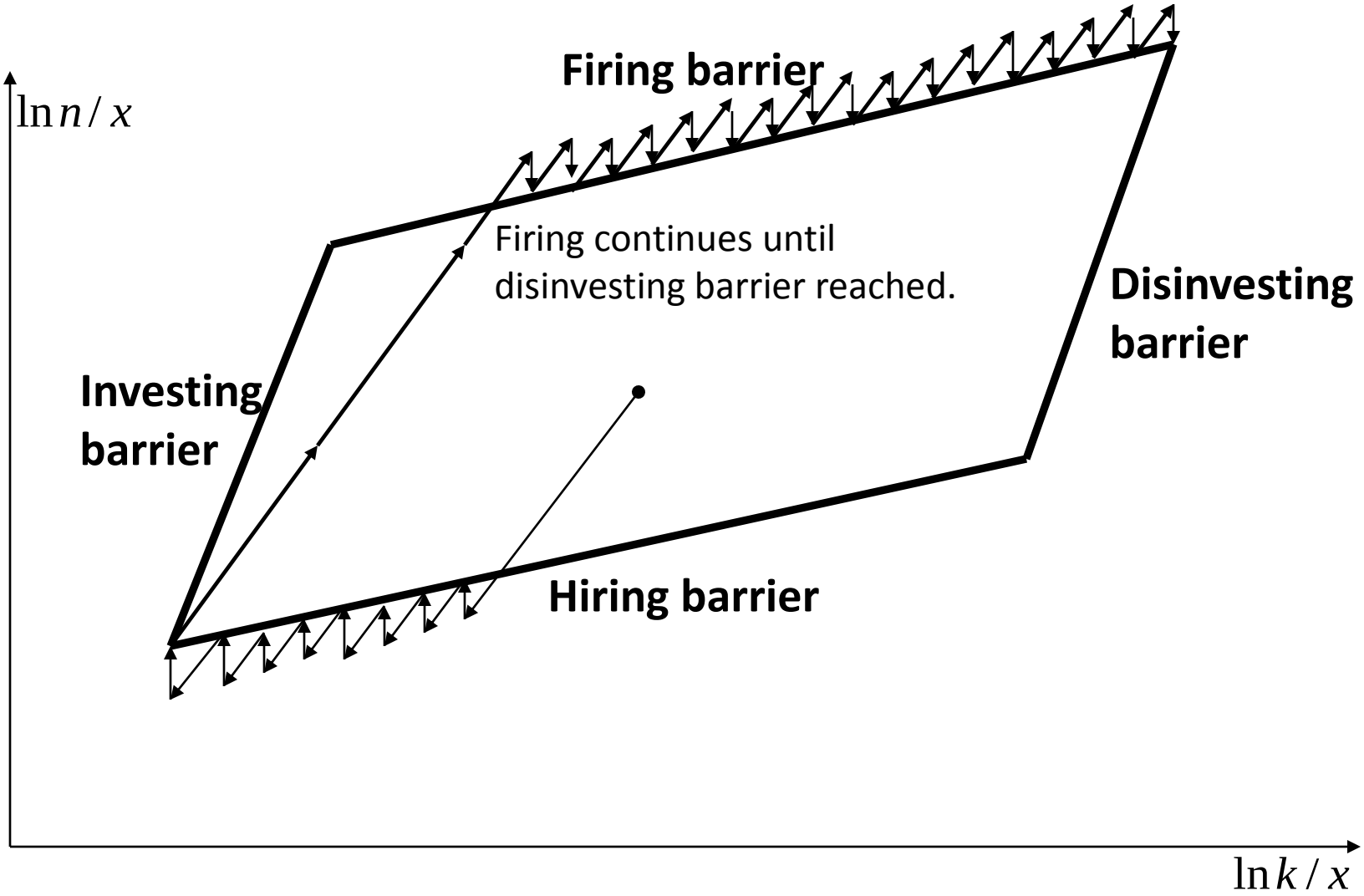

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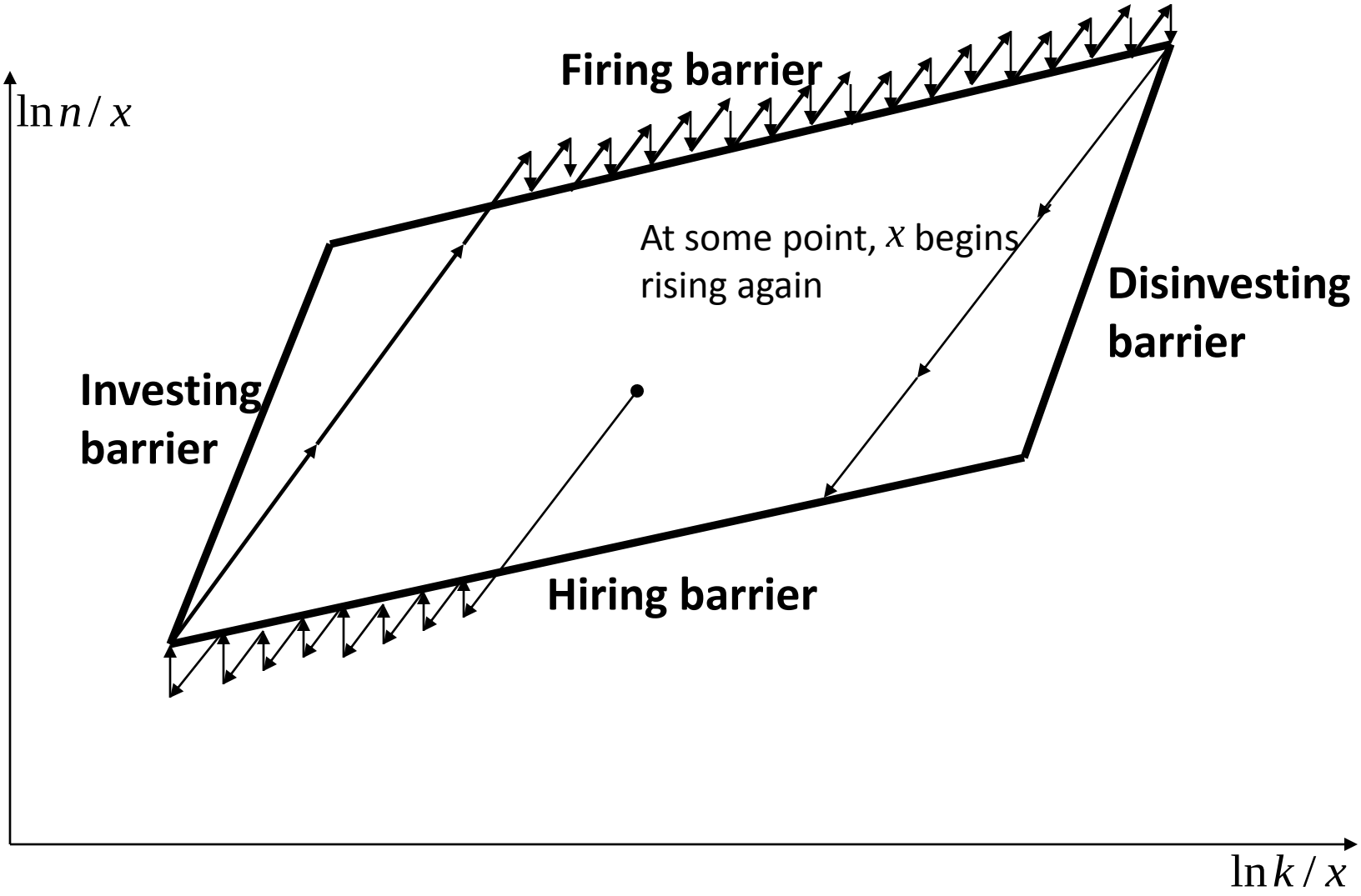

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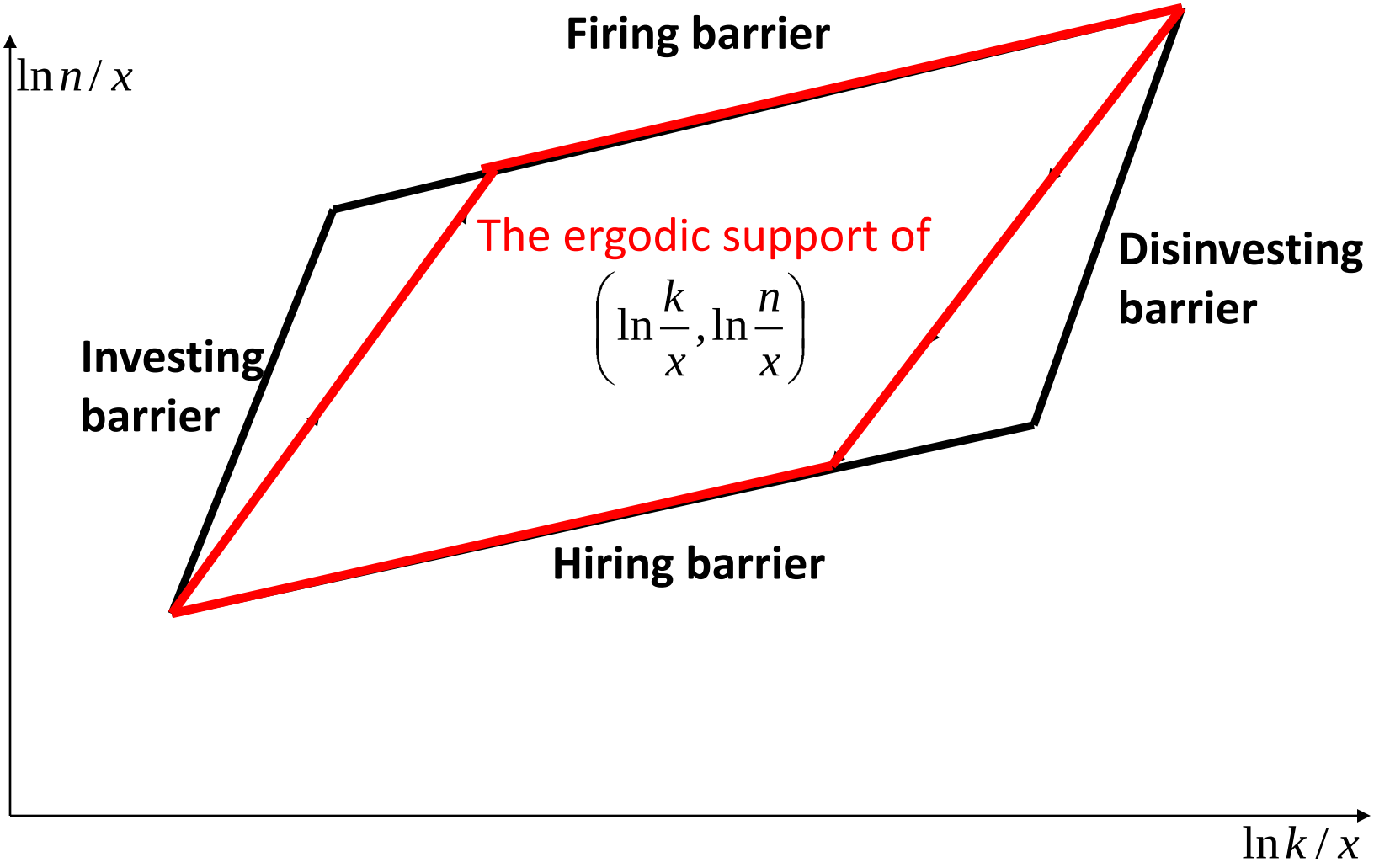


Model simulation: Robustness

Depreciation

- When x rises, *investment* undertaken more often.

- When x falls, depreciation constrains increase in k/x so there is relatively more "excess labor" $\Rightarrow$ *firing* is undertaken more often.

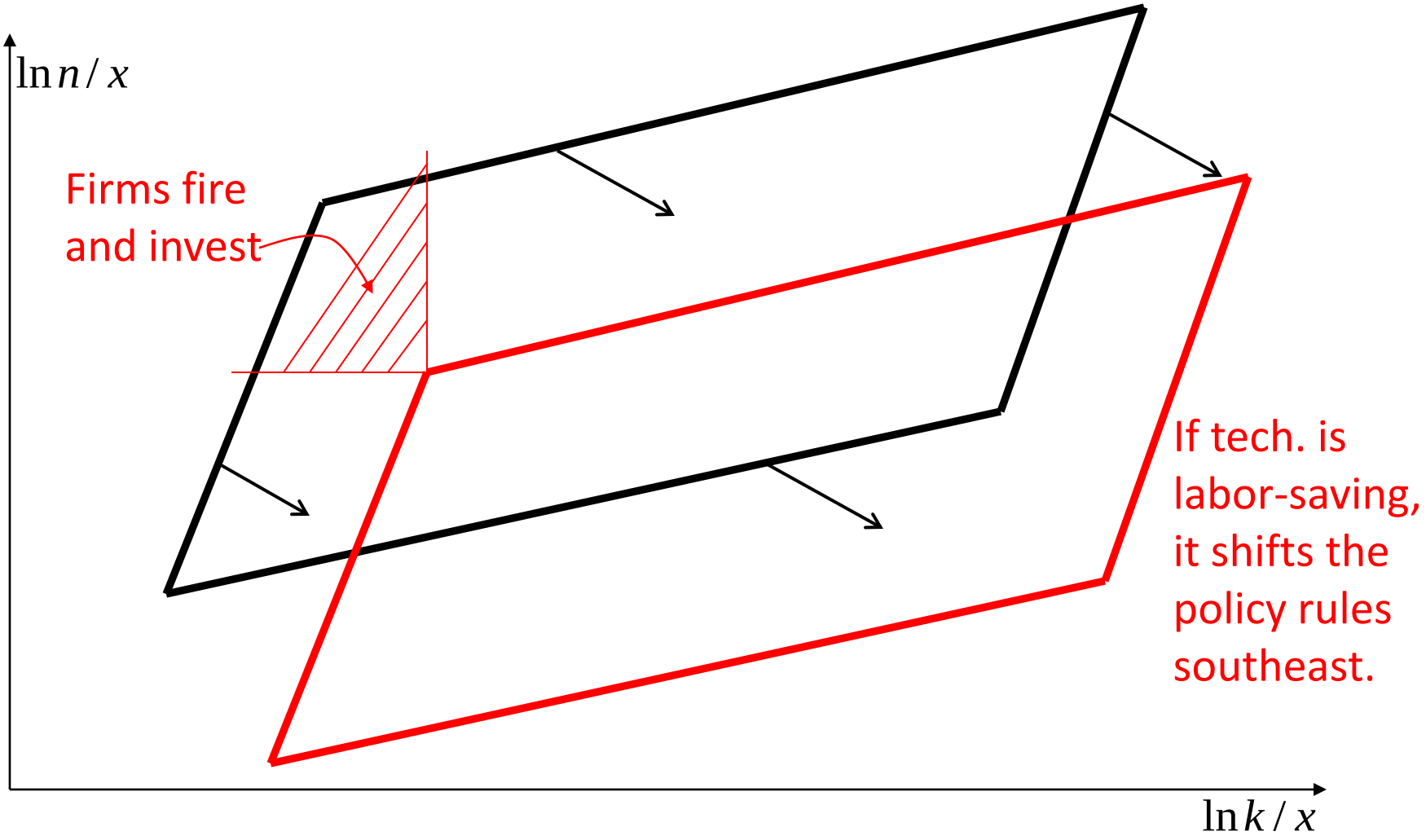
- These dynamics interact with time aggregation: more likely to invest and hire now but fire later.

Model simulation: Robustness

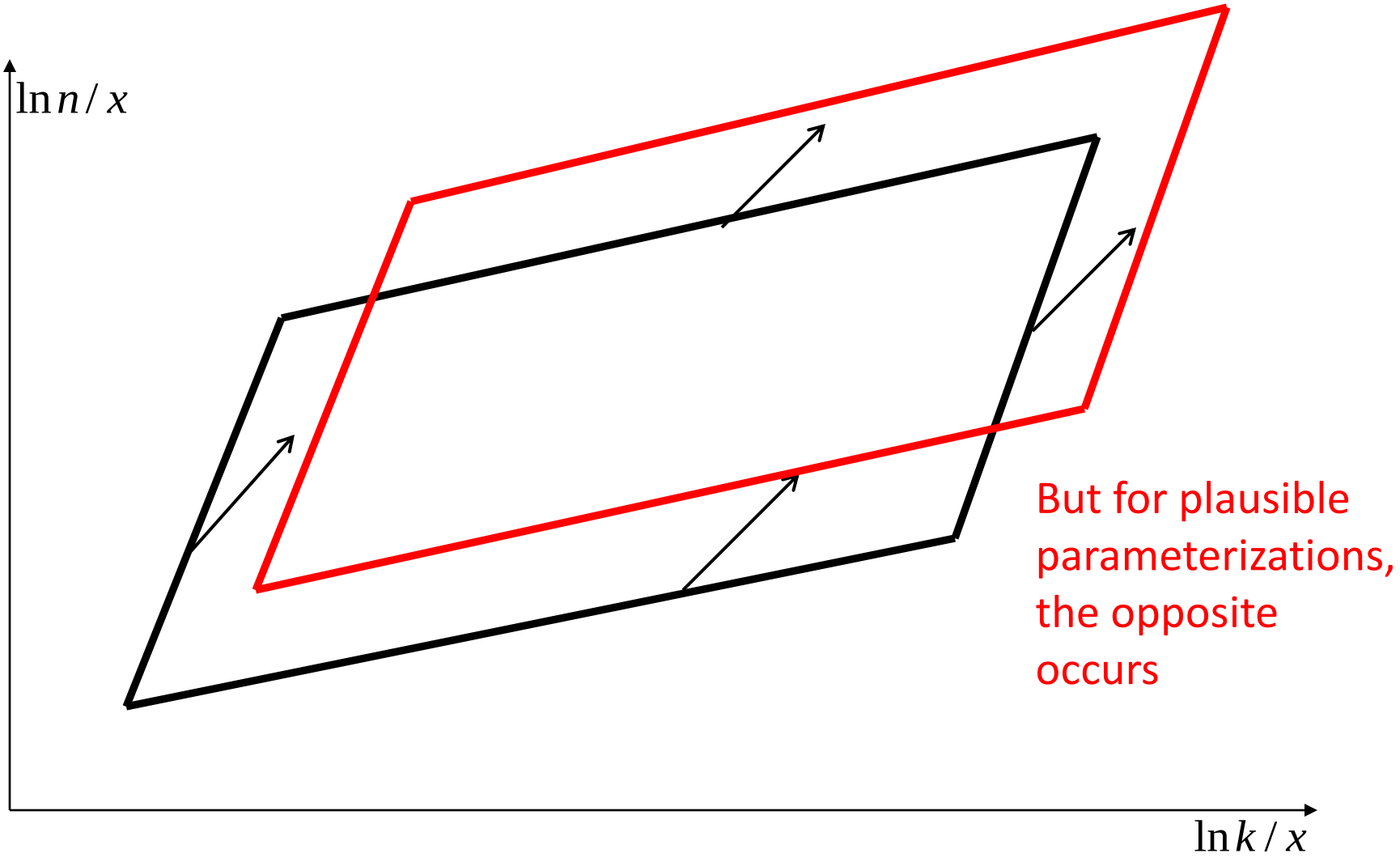
	Model w/ δ=0	**Model w/ δ>0**	**Chile**	**Korea**
Share of plants which reduce employment (*n*), given I/K_{-1} > 10%	0.0004	0.056	30.4%	47%
Avg. **decline** in *n*, given I/K_{-1} > 10%	-0.0174	-0.025	16.4%	21.8%
Avg. **increase** in *n*, given I/K_{-1} > 10%	0.282	0.204	20.7%	24.4%

Depreciation provides only slight quantitative improvement.

Factor-biased technical change



Factor-biased technical change



Labor-augmenting technical change

Comparative static from frictionless model:

$$\frac{\mathrm{d}\ln n}{\mathrm{d}\ln \xi} = \frac{1}{s+1}\varepsilon - \left(1 - \varphi\frac{s}{s+1}\right)$$

$$s = \frac{\text{Capital rental bill}}{\text{Wage bill}}$$

Derived demand for labor rises because of increase in output

Higher effective labor input induces substitution toward capital

Capital-augmenting technical change

Comparative static from frictionless model:

$$\frac{\mathrm{d}\ln k}{\mathrm{d}\ln \xi} = \underbrace{\frac{s}{s+1}\varepsilon}_{\text{Derived demand for labor rises because of increase in output}} - \underbrace{\left(1-\varphi\frac{1}{s+1}\right)}_{\text{Higher effective labor input induces substitution toward capital}}$$