

# BREAD-IGC Virtual PhD Course on Firms

## Lecture 2: Upgrading

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## Relation to Course as a Whole

- ▶ Big question for the course: why are some countries rich and some countries poor?
  - ▶ Why do some countries have low aggregate output per person?
- ▶ David/Dave in Lecture 1 pointed to two broad reasons:
  1. Individual firms are not reaching production frontier:

$$Q_i = F(x_i, A_i)$$

Output for a given set of inputs,  $x_i$ , is below what it could be, given knowledge in the world. Current  $A_i$  is below potential  $A$ .

2. Misallocation of resources across firms.
    - ▶ Inputs,  $x$ , don't flow to where they have highest returns.
- ▶ This lecture (and the next) focus on 1. Subsequent lectures will focus on 2.

## Topic Today: Drivers of Upgrading

- ▶ One definition of firm upgrading: process of reaching production frontier within firm.
- ▶ In principle, the fact that knowledge exists in rich countries should be a boon to firms in poor ones.
  - ▶ Gerschenkron (1962): “advantages of backwardness.”
- ▶ But for many developing-country firms, these advantages have remained elusive.
- ▶ What is getting in the way?
- ▶ Restated in a positive way: What are the drivers of upgrading at the firm level?
- ▶ I'll draw on a new review paper (Verhoogen, forthcoming).

# Roadmap

- ▶ Introduction
- ▶ Conceptual framework
- ▶ Measurement issues
- ▶ Evidence on drivers of upgrading
  - ▶ Output-side drivers
  - ▶ Input-side drivers
  - ▶ Drivers of know-how
- ▶ Closing thoughts

## Conceptual Framework

- ▶ What is  $A_i$ ? Let's go even more micro.
  - ▶ I will stick to notation in Verhoogen (forthcoming)
- ▶ Firm-product-technique-level production function:

$$Y_{ijkt} = F_{ijk}(\vec{M}_{ijkt}, \lambda_{ijkt}) \quad (1)$$

- ▶  $i, j, k, t$  index firms, products, techniques, time.
  - ▶  $\vec{M}_{ijkt}$ : vector of inputs.
  - ▶  $\lambda_{ijkt}$ : “capability”, has to be “home-grown” (Gibbons, 2010; Dessein and Prat, forthcoming).
  - ▶ Different quality varieties considered different outputs/inputs; products; let  $\varphi_{ijt}$ ,  $\vec{\alpha}_{ijkt}$  be output/input quality.
- ▶ Let  $J_{it}$ ,  $K_{it}$  be sets of products, techniques for which the firm knows  $F_{ijk}(\cdot)$ .
- ▶ Refer to  $\Lambda_{it} := \{\lambda_{ijkt}\}$ ,  $J_{it}$ , and  $K_{it}$  together as “know-how.”

## Conceptual Framework (cont.)

- ▶ Destination markets indexed by  $b$ .
- ▶ Fixed costs:  $f_{ijkt}$ ,  $f_{ijbt}$ ,  $f_{ijt}$ ,  $f_{ibt}$ ,  $f_{it}$ ,
- ▶ Investments in know-how:  $\mathcal{I}_{it}^{\Lambda}$ ,  $\mathcal{I}_{it}^J$ ,  $\mathcal{I}_{it}^K$ .
- ▶ Inverse output-demand curve:  $P_{ijbt} = D_{jb}(Y_{ijbt}, \varphi_{ijt}; \vec{\Gamma}_{bt}^y)$ .
  - ▶  $\vec{\Gamma}_{bt}^y$ : external-to-the-firm factors.
- ▶ Inverse input-supply curve:  $\vec{W}_{ijkt} = S_{jk}(\vec{M}_{ijkt}, \vec{\alpha}_{ijkt}; \vec{\Gamma}_t^m)$ .
- ▶ Firm's problem is to maximize the PDV of profits:

$$\Pi_{i\tau} = \sum_{t=\tau}^{\infty} \delta_t \left\{ \sum_{b \in B_{it}^*} \left[ \sum_{j \in J_{ibt}^*} \left( P_{ijbt} F_{ijk}(\vec{M}_{ijkt}, \lambda_{ijkt}) - \vec{W}'_{ijkt} \vec{M}_{ijkt} - f_{ijkt} - f_{ijbt} - f_{ijt} \right) - f_{ibt} \right] - f_{it} - \mathcal{I}_{it}^{\Lambda} - \mathcal{I}_{it}^J - \mathcal{I}_{it}^K \right\}$$

- ▶ Firm chooses destinations  $B_{it}^*$ , products  $J_{ibt}^*$ , technique  $k_{ijt}^*$  for each  $j \in J_{ibt}^*$ , inputs  $(\vec{M}_{ijkt})$ ,  $\mathcal{I}_{it}^{\Lambda}$ ,  $\mathcal{I}_{it}^J$ ,  $\mathcal{I}_{it}^K$  for each  $t$ .

## Conceptual Framework (cont.)

- ▶ Four main dimensions of upgrading highlighted in literature:

1. Learning.

- ▶ Gains of know-how: capability (for some  $\lambda_{ijkt} \in \Lambda_{it}$ ), knowledge of products ( $J_{it}$ ) or techniques ( $K_{ijt}$ ).

2. Quality upgrading.

- ▶ Increase in average quality  $\bar{\varphi}_{it}$ , where

$$\bar{\varphi}_{it} = \sum_{b \in B_{it}^*} \sum_{j \in J_{ijt}^*} \nu_{ijbt} \varphi_{ijt}, \quad \nu_{ijbt} = \frac{Y_{ijbt}}{\sum_{b' \in B_{it}^*} \sum_{j' \in J_{ij'b't}^*} Y_{ij'b't}}$$

3. Product innovation.

- ▶ Production of a new product,  $j \notin J_{ibt-s}^* \forall b \in B_{it-s}^*, s > 0$ .

4. Technology adoption.

- ▶ Use of new technique,  $k_{ijt}^* \notin K_{ijt-s}^* \forall s > 0$ .

- ▶ Dimensions are related but distinct.

- ▶ Can have quality upgrading without product innovation, technology adoption without learning etc.

## Conceptual Framework (cont.)

- ▶ Standard practice is to “aggregate” to the firm level and write production functions such as:

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_\ell} M_{it}^{\beta_m} \quad (2)$$

- ▶ Issue: can product-technique-level functions like (1) be aggregated into a firm-level function like (2)?
  - ▶ Parallels old debate about firm-level → economy-level (Houthakker, 1955; Fisher, 1969).
    - ▶ Generally only possible under special conditions (Fisher, 1969; Felipe and Fisher, 2003).
  - ▶ Recent work on aggregating within firm includes Jones (2005), Boehm and Oberfield (2020).
    - ▶ More to be done here.
- ▶ Imposing (2), all four dimensions of upgrading may show up as changes in  $A_{it}$ .



## Conceptual Framework (cont.)

- ▶ LDC firms face different conditions than firms in rich countries.
  - ▶ Different product demand curves/prices.
    - ▶ e.g. Poorer consumers, less willing to pay for quality.
  - ▶ Different input supply curves/prices.
    - ▶ e.g. High-quality inputs, high-skill workers expensive.
  - ▶ Different levels of know-how.
- ▶ Upgrading may or may not be optimal.
  - ▶ Foster and Rosenzweig (2010):  
*"[I]t cannot be inferred from the observation that farmers using high levels of fertilizer earn substantially higher profits than farmers who use little fertilizer that more farmers should use more fertilizer."*
  - ▶ Know-how is unambiguously good for the firm, but also costly to acquire.

## Conceptual Framework (cont.)

- ▶ “Management” encompasses three distinct things:
  - ▶ Know-how, including entrepreneurial ability.
  - ▶ Skill of employed managers (a purchased input).
  - ▶ Management practices.
    - ▶ Practices should be thought of like any other technique (Van Reenen, 2011; Bloom et al., 2011).
- ▶ Question: can practices be ranked?
  - ▶ “Vertical” view: some practices better than others across contexts (Van Reenen, 2011; Bloom et al., 2014).
    - ▶ Claim is that  $\Pi_{i\tau}(k, \cdot) > \Pi_{i\tau}(k', \cdot)$  for all  $D_{bj}(\cdot)$ ,  $S_{jk}(\cdot)$ ,  $\Lambda_{it}$ ,  $J_{it}$ .
  - ▶ “Horizontal” / “contingency” view: which is best depends on the context (market conditions, know-how).
  - ▶ Ultimately an empirical question, not yet resolved.
  - ▶ Normally, if we see firms using different technologies, we don’t assume that some are making mistakes.
    - ▶ We should ask what constraints firms are facing that lead them to make the choices they do.

## Measurement Issues

- ▶ Main ways researchers have attempted to capture upgrading empirically:
  - ▶ Patents/R&D expenditures.
    - ▶ Manipulable (Chen et al., 2021).
    - ▶ Unlikely to capture catching-up.
  - ▶ Total factor productivity (TFP).
    - ▶ Plus: aims directly to estimate  $\{\lambda_{ijkt}\}$ .
    - ▶ Minus: methods require strong structural assumptions, have various biases (coming next).
  - ▶ Direct measures of technology adoption, quality upgrading, product innovation.
    - ▶ Minus: upgrading on these dimensions is not necessarily optimal.
    - ▶ Minus: typically they can be observed directly only in specific (maybe special?) sectors.
    - ▶ Plus: Don't require strong theoretical assumptions.
  - ▶ Indirect measures of quality, based on inferences from prices, market shares.

# TFP Issue #1: Monotonicity Assumption

- ▶ Rewrite (2) in logs:

$$y_{it} = \vec{z}_{it}' \vec{\beta} + \left\{ \underbrace{\omega_{it}}_{\text{"ex ante"}} + \underbrace{\varepsilon_{it}}_{\text{"ex post"}} \right\} \quad (3)$$

where  $\vec{z}_{it} = (k_{it} \ell_{it} m_{it})'$ ,  $\vec{\beta} = (\beta_k \beta_\ell \beta_m)'$ .

- ▶ Define  $TFP := y_{it} - \vec{z}_{it}' \hat{\vec{\beta}}$ .
- ▶ Transmission bias:  $m_{it}$ ,  $\ell_{it}$  chosen after  $\omega_{it}$  observed.
- ▶ Proxy-variable strategies require monotonicity with scalar  $\omega_{it}$ :
  - ▶  $\iota_{it} = \iota(k_{it}, \omega_{it}) \Rightarrow \omega_{it} = \iota^{-1}(k_{it}, \iota_{it})$  (Olley and Pakes, 1996).
  - ▶  $m_{it} = m(k_{it}, \omega_{it}) \Rightarrow \omega_{it} = m^{-1}(k_{it}, m_{it})$  (Levinsohn and Petrin, 2003; Akerberg et al., 2015).
- ▶ Monotonicity assumption is very strong.
  - ▶ Invalidated e.g. by heterogeneity in credit constraints, input-market frictions, or just firm fixed effects.
  - ▶ Particularly unlikely to hold in LDCs.

## TFP Issue #2: Price Biases

- It is rare to observe physical quantities. More common to observe revenues ( $r_{it} = y_{it} + p_{it}$ ), expenditures ( $\vec{e}_{it} = \vec{z}_{it} + \vec{w}_{it}$ ).

- Suppose:

$$p_{it} = \bar{p}_t + \check{p}_{it}$$

$$\vec{w}_{it} = \vec{\bar{w}}_t + \vec{\check{w}}_{it}$$

- Plugging into (3), the standard regression is:

$$\{r_{it} - \bar{p}_t\} = \{\vec{e}_{it} - \vec{\bar{w}}_t\}' \vec{\beta} + \{\check{p}_{it} - \vec{\check{w}}_{it}' \vec{\beta} + \omega_{it} + \varepsilon_{it}\}$$

- $\text{Cov}(\vec{e}_{it} - \vec{\bar{w}}_t, \check{p}_{it}) \neq 0 \Rightarrow$  output price bias.
- $\text{Cov}(\vec{e}_{it} - \vec{\bar{w}}_t, \vec{\check{w}}_{it}) \neq 0 \Rightarrow$  input price bias.
- Recently, quantity information is becoming available (Foster et al., 2008; Atalay, 2014). But ...

## TFP Issue #3: Quality/Variety Biases

- ▶ When outputs or inputs vary in quality or variety, there will still be biases even if one observes physical quantities.
- ▶ de Roux et al. (2021) use within-firm CES assumptions and index-number theory to show: [▶ details](#)

$$\tilde{y}_{it}^{SV} = \beta_m \tilde{m}_{it}^{SV} + \beta_\ell \ell_{it} + \beta_k k_{it} + \eta_i + \xi_t + u_{it}$$

$$u_{it} = (\beta_m q_{it}^m - q_{it}^y) + (\beta_m v_{it}^m - v_{it}^y) + \omega_{it} + \epsilon_{it}$$

where  $\tilde{y}_{it}^{SV}$ ,  $\tilde{m}_{it}^{SV}$  are quantity indexes,  $q_{it}^m$ ,  $q_{it}^y$  capture input/output quality,  $v_{it}^m$ ,  $v_{it}^y$  capture input/output variety.

- ▶ Correlation of  $\tilde{m}_{it}^{SV}$ ,  $\ell_{it}$ ,  $k_{it}$  with  $q_{it}^m$ ,  $q_{it}^y$ ,  $v_{it}^m$ ,  $v_{it}^y \Rightarrow$  quality/variety biases. E.g. if high  $q_{it}^y$  requires high  $\ell_{it}$ :

$$\text{Cov}(\ell_{it}, q_{it}^y) > 0 \Rightarrow \text{plim}(\hat{\beta}_\ell^{OLS}) < \beta_\ell$$

- ▶ Most sectors not homogenous, single-output/-input.
  - ▶ Quality changes especially salient in LDCs.

## Measurement – The Way Forward

- ▶ Growing number of studies have paid the shoe-leather costs to get direct measures of technology adoption, quality.
  - ▶ Several mentioned below.
  - ▶ Measurement of management practices has taken off, to good effect (Bloom et al., 2014).
  - ▶ World Bank is conducting technology surveys, which will stimulate work in this area (Cirera et al., 2020, 2022).
- ▶ The way forward is to find settings that combine:
  - ▶ Credibly exogenous variation.
  - ▶ Direct measures of upgrading.
- ▶ Caveat: given that upgrading is not necessarily optimal, we need to interpret results carefully.

# Roadmap

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## Selling to Richer Consumers

- ▶ Growing evidence that selling to richer consumers  $\Rightarrow$  upgrading
  - ▶ directly, by exporting
  - ▶ indirectly, by selling into value chains that sell eventually to richer consumers
- ▶ Early papers:
  - ▶ TFP (with mixed results): Clerides et al. (1998), Bernard and Jensen (1999), De Loecker (2007).
  - ▶ Prices, quantities: Verhoogen (2008), Bastos and Silva (2010), Kugler and Verhoogen (2012), Manova and Zhang (2012), Brambilla et al. (2012), Bastos et al. (2018).
- ▶ Recent work is particularly convincing, has raised some important new questions.

## Egyptian Rugs (Atkin, Khandelwal and Osman, 2017a)



- ▶ Randomized initial export orders among Egyptian rug producers.
- ▶ Tracked detailed quality indicators.
- ▶ Kept track of conversations between buyer (intermediary) and producers.
- ▶ Had producer weave identical rugs under laboratory conditions.

Exports  $\uparrow \Rightarrow$  Output, Input Quality  $\uparrow$ TABLE VIII  
IMPACT OF EXPORTING ON QUALITY LEVELS

	Control mean	(1) ITT	(2) TOT
Panel A: Quality metrics			
Corners	2.98	1.11*** (0.12)	1.70*** (0.11)
Waviness	2.99	1.10*** (0.12)	1.68*** (0.10)
Weight	3.08	1.07*** (0.11)	1.63*** (0.11)
Touch	3.12	0.40*** (0.06)	0.66*** (0.07)
Packedness	3.11	0.89*** (0.11)	1.59*** (0.12)
Warp thread tightness	3.05	0.83*** (0.10)	1.49*** (0.12)
Firmness	2.98	0.87*** (0.11)	1.60*** (0.12)
Design accuracy	3.17	0.79*** (0.10)	1.41*** (0.12)
Warp thread packedness	3.05	1.07*** (0.11)	1.65*** (0.11)
Inputs	3.07	0.89*** (0.10)	1.62*** (0.12)
Loom	2.02	0.03 (0.02)	0.05 (0.04)
<i>R</i> -squared		0.44	0.60
Observations		6,885	6,885
Panel B: Stacked quality metrics			
Stacked quality metrics	2.96	0.79*** (0.09)	1.35*** (0.08)
<i>R</i> -squared		0.39	0.54
Observations		6,885	6,885

► Price paid for weft thread also  $\uparrow$ .

Exports  $\uparrow \Rightarrow$  Profits  $\uparrow$ , but TFPQ  $\downarrow$

TABLE V  
IMPACT OF EXPORTING ON FIRM PROFITS

	Log direct profits		Log (reported revenues – reported costs)		Log (constructed revenues – constructed costs)		Log hypothetical profits	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ITT	TOT	ITT	TOT	ITT	TOT	ITT	TOT
Panel A: Profits (in month prior to survey)								
Treatment	0.26*** (0.05)	0.42*** (0.08)	0.21*** (0.06)	0.37*** (0.10)	0.19*** (0.06)	0.34*** (0.10)	0.37*** (0.11)	0.68*** (0.19)
R-squared	0.21	0.22	0.16	0.18	0.16	0.18	0.19	0.19
Control mean (in levels)	929	929	931	931	951	951	541	541
Observations	573	573	644	644	685	685	687	687
Panel B: Profits per owner hour (in month prior to survey)								
Treatment	0.20*** (0.05)	0.32*** (0.08)	0.17*** (0.05)	0.29*** (0.09)	0.16*** (0.05)	0.28*** (0.09)	0.25*** (0.07)	0.46*** (0.12)
R-squared	0.14	0.14	0.12	0.13	0.13	0.13	0.19	0.18
Control mean (in levels)	3.53	3.53	3.54	3.54	3.55	3.55	5.56	5.56
Observations	573	573	637	637	684	684	687	687

TABLE IX  
IMPACT OF EXPORTING ON UNADJUSTED PRODUCTIVITY

	Log unadjusted output per hour		Log unadjusted TFP	
	(1)	(2)	(3)	(4)
	ITT	TOT	ITT	TOT
Treatment	−0.24*** (0.09)	−0.42*** (0.16)	−0.28*** (0.09)	−0.50*** (0.16)
R-squared	0.18	0.16	0.26	0.24
Control mean (in levels)	0.26	0.26	0.49	0.49
Observations	687	687	674	674

Notes. Table reports treatment effects for the two productivity measures: log unadjusted output per labor hour (in  $\frac{m^2}{hour}$ ) and log unadjusted TFP. See text and Appendix for the methodology used to obtain unadjusted TFP. The TOT specifications instrument takeup with treatment. Control group means are reported in levels. Regressions control for baseline values of the variable, round and strata fixed effects. Standard errors are clustered by firm. Significance: \*, .10; \*\*, .05; \*\*\*, .01.

Exports ↑ ⇒ Know-how ↑

TABLE XI  
QUALITY AND PRODUCTIVITY ON IDENTICAL-SPECIFICATION DOMESTIC RUGS (STEP 2)

	Master artisan			Professor		
	Control mean	(1) ITT	(2) TOT	Control mean	(3) ITT	(4) TOT
Panel A: Quality metrics						
Corners	3.23	0.72*** (0.14)	1.05*** (0.17)	3.31	0.29** (0.13)	0.43** (0.18)
Waviness	3.17	0.55*** (0.14)	0.80*** (0.18)	3.31	0.25** (0.12)	0.36** (0.16)
Weight	3.60	0.62*** (0.13)	0.91*** (0.16)	3.64	0.58*** (0.17)	0.86*** (0.25)
Packedness	3.30	0.77*** (0.13)	1.14*** (0.15)	3.28	0.28** (0.11)	0.42*** (0.15)
Touch	3.29	0.52*** (0.11)	0.76*** (0.14)	3.27	0.36*** (0.12)	0.52*** (0.16)
Warp thread tightness	3.00	0.51*** (0.09)	0.74*** (0.11)	3.30	0.25** (0.12)	0.36** (0.16)
Firmness	3.21	0.71*** (0.14)	1.04*** (0.17)	3.23	0.29** (0.12)	0.43*** (0.16)
Design accuracy	3.65	0.53*** (0.11)	0.77*** (0.15)	3.45	0.27** (0.11)	0.40*** (0.15)
Warp thread packedness	3.05	0.87*** (0.14)	1.28*** (0.17)	3.20	0.39*** (0.12)	0.58*** (0.16)
R-squared		0.21	0.34		0.11	0.14
Observations		1,680	1,680		1,667	1,667

	Control mean	(1) ITT	(2) TOT
Time (in minutes)	247.0	−5.67 (6.6)	−8.3 (9.5)
R-squared		0.84	0.84
Observations		748	748

## Egyptian Rugs (cont.)

- ▶ Verhoogen (2008), Bastos et al. (2018), largely for convenience, modeled upgrading as driven by shifts in output-demand curves:

$$P_{ijbt} = D_{jb}(Y_{ijbt}, \varphi_{ijt}; \vec{\Gamma}_{bt}^y)$$

leading to increases in average quality ( $\bar{\varphi}_{it} \uparrow$ ).

- ▶ But the evidence here is strong that there was learning involved, i.e. an accumulation of  $\lambda_{ijkt}$ .
- ▶ Interesting question (not fully answered): is the gain of capability specific to particular product-techniques ( $jk$ ) or more general (i.e. applicable to other products, techniques)?

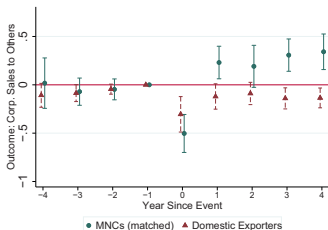
## Peruvian Fishmeal (Hansman et al., 2020)

- ▶ Use quotas in main competitor countries (Denmark, Iceland, Chile) as source of variation in premium for (observed) quality.
- ▶ Positive effect on vertical integration: plants buy boats.
  - ▶ Different  $k$  (with different  $\vec{M}$ ) to produce higher- $\varphi$   $j$ .
- ▶ Integrated boats stay closer to port, deliver smaller loads  $\Rightarrow$  fresher fish.
- ▶ That firms vertically integrate suggests quality supply is an important constraint.
- ▶ Promising research direction: how contracting frictions influence upgrading decisions.
  - ▶ Information particularly asymmetric about quality.
  - ▶ Development economists well-placed to advance this agenda.



# Costa Rican MNC Suppliers (Alfaro-Urena et al., 2022)

- ▶ Firm-to-firm data from tax systems opens new analytical possibilities.
- ▶ Matching design: compare suppliers to MNCs vs. suppliers to other types of firms.



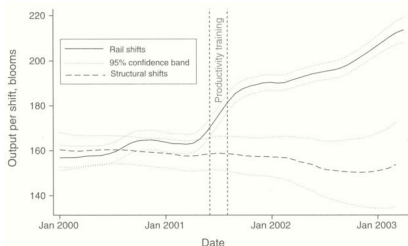
(F) Domestic Exporter, Corp Sales to Others

- ▶ Sales, employment, TFP of new MNC suppliers ↑.
- ▶ Other buyers of new MNC suppliers:
  - ▶ Larger.
  - ▶ Higher export/import shares.
  - ▶ Longer relationships with suppliers.
- ▶ Suppliers appear to learn from (and gain reputation from) MNCs.



# Competition?

- ▶ Commonly considered a primary driver of upgrading, including within firms. (Bloom and Van Reenen, 2007, 2010; Bloom et al., 2016).
- ▶ Clearly matters in some cases:
  - ▶ Das et al. (2013): Public-sector firm (SAIL) long had monopoly on rails for Indian railroads.
  - ▶ Government considered allowing entry by others 1999-2001.
  - ▶ Output of rails/shift  $\uparrow$  28% (vs. non-rail items, “structurals”).



- ▶ Theory not obvious: why don't firms already optimize?

## Competition? (cont.)

- Evidence less than definitive.
  - Difficult to distinguish between killing off of low performers and within-firm upgrading (Holmes and Schmitz, 2010).
  - Competition may reduce scale effects (Juhász, 2018),
  - Competition may hinder relational contracts (Macchiavello and Morjaria, 2021).

TABLE III  
UNPACKING COMPLEMENTARY RELATIONAL PRACTICES

Dependent variable	Received input from mill (1)	Given inputs to farmers (2)	RC pre-harvest z-score (3)	Expects to receive a second payment (4)	Has made a second payment in the past (5)	RC harvest z-score (6)	Expects to receive help/loan (7)	Provides help/loans to farmers (8)	RC post-Harvest z-score (9)	RC index (10)	RC index, farmer outcomes (11)	RC index, mill outcomes (12)	Placebo: short-term credit (13)
Panel A: IV													
Competition	-0.064*** (0.014)	-0.085** (0.036)	-0.220** (0.112)	-0.063*** (0.017)	-0.077** (0.035)	-0.203*** (0.074)	-0.066*** (0.020)	-0.026 (0.034)	-0.180* (0.099)	-0.283*** (0.098)	-0.237*** (0.045)	-0.215** (0.094)	0.017 (0.082)
Panel B: OLS													
Competition	-0.011** (0.005)	-0.030** (0.012)	-0.062*** (0.022)	-0.038*** (0.006)	-0.041*** (0.013)	-0.121*** (0.038)	-0.021*** (0.007)	-0.015 (0.014)	-0.065** (0.033)	-0.116*** (0.029)	-0.086*** (0.016)	-0.102*** (0.029)	-0.041 (0.033)
Score within 5 km of mill	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mill controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Farmer controls	Yes	—	—	Yes	—	—	Yes	—	—	—	Yes	—	—
Adjusted R <sup>2</sup>	0.05	0.13	0.11	0.15	0.16	0.21	0.03	-0.01	0.00	0.10	0.07	0.12	0.04
Observations	869	176	176	869	176	176	865	175	175	175	869	176	172

- Also find that costs rise, quality falls with competition.
- Highlights role of contracting issues.

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# Input-Side Drivers

- ▶ So far, we have focused on “demand pull” effects.
  - ▶ Are there “input push” effects on upgrading?
- ▶ Some existing work, mainly in trade:
  - ▶ Input quality: in China, import tariffs  $\downarrow \Rightarrow$  export prices  $\uparrow$ , especially to/from rich countries (Bas and Strauss-Kahn, 2015; Fan et al., 2018)
  - ▶ Input variety: availability of imported inputs  $\uparrow \Rightarrow$  product innovation, in India (Goldberg et al., 2010), Ecuador (Bas and Paunov, 2019).
- ▶ New project: Raza, Khandelwal, Atkin, Chaudhry, Verhoogen and Chaudry (2022)
  - ▶ Randomized vouchers for high-quality imported rexine (artificial leather) to soccer-ball producers in Sialkot, Pakistan.
  - ▶ Firms improved quality of other inputs, produced higher-quality balls.

# Input Quality Complementarities (Preliminary)

**Panel A: Non-rexine Material Characteristics**

	non-rexine material quality index (1)	latex (%) (2)	layers (3)	butyl bladder (4)	imported bladder (5)
eligible rexine	2.83** (1.24)	46.3* (25.30)	1.88* (1.04)	0.41 (0.35)	0.28 (0.25)
projected subsidized share	-1.91** (0.92)	-28.9 (18.96)	-1.56** (0.72)	-0.23 (0.29)	-0.18 (0.22)
baseline controls	x	x	x	x	x
non-eligible mean	-0.02	69.8	3.1	0.12	0.14
N	[181, 44]	[176, 42]	[179, 44]	[180, 44]	[180, 43]

**Panel B: Non-rexine cost Breakdown**

	bladder cost (1)	latex and chemicals cost (2)	layer cost (3)	stitching cost (4)	printing cost (5)	other cost (6)
eligible rexine	64.2** (27.05)	26.1*** (10.07)	62.3 (39.79)	26.9 (24.13)	33.1*** (10.96)	43.3** (19.50)
projected subsidized share	-42.6** (20.44)	-16.6* (8.73)	-41.5 (30.24)	-8.12 (19.95)	-20.2** (8.05)	-30.0** (14.13)
baseline controls	x	x	x	x	x	x
non-eligible mean	47.5	24.6	32.7	76.3	19.8	23.4
N	[172, 41]	[161, 37]	[146, 32]	[179, 43]	[145, 39]	[165, 38]

- ▶ Overall costs ↑, ball price ↑. (Pass-through is negative.)
- ▶ Inputs can push upgrading. Not seeing persistence (so far).

# Supply of Capital?

- ▶ Perhaps surprisingly, relatively little evidence of effect of capital supply matters for within-firm upgrading outcomes:
  - ▶ Rotemberg (2019):
    - ▶ Expansion of subsidized credit in India had little within-firm effect on TFPQ.
  - ▶ Bau and Matray (forthcoming):
    - ▶ Loosening of restrictions on foreign investment in India had little within-firm effect on TFPQ. High-MRPK firms added products relative to low-MRPK.
  - ▶ Cai and Harrison (2021):
    - ▶ VAT reduction on capital goods in China increased investment but not product introductions or productivity.
- ▶ Concerns about TFP estimation apply here. Need more research using direct measures of upgrading.

# Roadmap

- ▶ Introduction
- ▶ Conceptual framework
- ▶ Measurement issues
- ▶ Evidence on drivers of upgrading
  - ▶ Output-side drivers
  - ▶ Input-side drivers
  - ▶ **Drivers of know-how**
- ▶ Closing thoughts

## Drivers of Know-How

- ▶ Firms may fail to upgrade even when output-demand and input-supply conditions are favorable. Why?
- ▶ Framework points to lack of know-how:  $\Lambda_{it} = \{\lambda_{ijkt}\}, J_{it}, K_{it}$ .
- ▶ Factors that affect acquisition of know-how:
  - ▶ Agency issues.
  - ▶ Entrepreneurial ability/family control.
  - ▶ Learning from others (other firms, external consultants).
  - ▶ Behavioral issues?



## Agency Issues: Soccer/Footballs in Pakistan



- ▶ We came up with a new technology and gave it out (Atkin, Chaudhry, Chaudry, Khandelwal and Verhoogen, 2017b).
- ▶ Discovered (unexpectedly) that misalignment of incentives within firms can impede information flows, and hence learning.

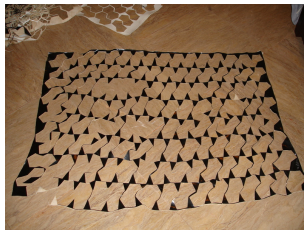


## Existing Technology

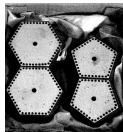
Hexagons tessellate. ~8%  
of rexine wasted.



Pentagons don't. ~20-24%  
of rexine wasted.



Existing dies:

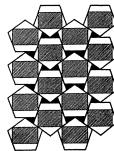


## New Technology

Chinese video:

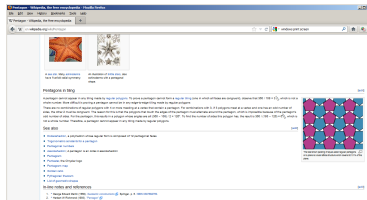


G. Kuperberg and W. Kuperberg,  
"Double-Lattice Packings of Convex  
Bodies in the Plane," *Discrete & Com-  
putational Geometry*, 5: 389-397, 1990.



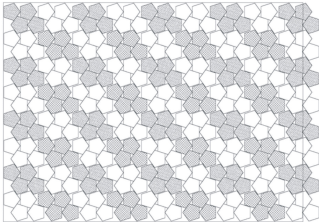
**Fig. 7.** Maximum density double-lattice packing with regular pentagons.

Wikipedia “Pentagon” page:



# Blueprint

Annalisa Guzzini (an architect) and I developed a blueprint and die that implemented the optimal pentagon packing.



## Summary of Interventions

- ▶ We gave out new dies to 35 of 135 firms in Sialkot.
- ▶ As of 15 months later, 6 firms had adopted total.
  - ▶ 5 received die directly from us.
  - ▶ 1 firms, > 1,000 employees, was a spillover, bought > 30 dies.
- ▶ We asked owners why they hadn't adopted. Their #1 answer: worker resistance.
  - ▶ Issue: cutters paid per ball, new die slowed them down.
- ▶ We did second experiment:
  - ▶ Gave cutter one month's salary as bonus to demonstrate that technology works in presence of owner.

## Results of Second Experiment

	First Stage (1)	OLS (2)	Reduced Form (ITT) (3)	IV (TOT) (4)
<b>Panel A: Short-Run (within 6 months)</b>				
received treatment		0.48*** (0.15)		0.48*** (0.15)
assigned to group A	0.68*** (0.12)		0.32** (0.12)	
stratum dummies	Y	Y	Y	Y
mean of group B (control group)		0.19	0.19	0.19
R-squared	0.57	0.69	0.60	0.69
N	31	31	31	31
<b>Panel B: Medium-Run (within 1 year)</b>				
received treatment		0.41** (0.16)		0.37** (0.17)
assigned to group A	0.72*** (0.12)		0.27* (0.14)	
stratum dummies	Y	Y	Y	Y
mean of group B (control group)		0.27	0.27	0.27
R-squared	0.60	0.61	0.52	0.61
N	29	29	29	29

# Soccer/Footballs: Discussion

- ▶ Some tentative generalizations:
  - ▶ Inertia in labor contracts hinders technological change.
    - ▶ Piece rates may be optimal in technologically stable environments but not dynamic ones.
    - ▶ Contract stickiness may be intended (e.g. avoiding ratchet effect) or unintended.
  - ▶ There are complementarities between technological and organizational innovations.
  - ▶ Workers need to expect to share in gains to adoption in order for adoption to be successful.
- ▶ Why didn't firms re-contract on their own? Possibilities:
  - ▶ Firms were unaware of new practice.
  - ▶ Firms were aware, but re-contracting costs outweighed expected benefits.
- ▶ Points to need for research to track what entrepreneurs know and what benefits they expect.

## Agency Issues (cont.)

- ▶ Cai and Wang (forthcoming):
  - ▶ Chinese auto manufacturer elicited employee's evaluations of their supervisors.
  - ▶ 20% weight in promotion/salary decisions for supervisors.
  - ▶ Employees report that supervisors became nicer.
  - ▶ Turnover declined, team-level productivity increased.
  - ▶ Firm extended program to all plants (~20,000 workers).
- ▶ Evaluation system arguably increased information flow from employees to upper-level management.



# Entrepreneurial Ability/Family Control

- ▶ Some robust patterns:
  - ▶ CEOs/managers differ in management styles, in ways that are correlated with performance (Bertrand and Schoar, 2003; Bandiera et al., 2020; Adhvaryu et al., forthcoming).
  - ▶ Family-managed firms have worse performance (Pérez-González, 2006; Bertrand et al., 2008), less “structured” practices (Bloom and Van Reenen, 2007)
  - ▶ Child-composition IV:
    - ▶ 1st born male, or any son  $\Rightarrow$  family succession  $\Rightarrow$  lower profitability/worse performance (Bennedsen et al., 2007) lower management scores (Lemos and Scur, 2019).
- ▶ Then why is family control so prevalent?
  - ▶ Family control may help solve agency problems in short term.
    - ▶ Pakistani surgical firms with more brothers larger (Ilias, 2006).
    - ▶ Family have lower-powered incentives (Cai et al., 2013).
  - ▶ But it may outlive its usefulness in the longer term.

# Learning from Other Firms

- ▶ Cai and Szeidl (2018):
  - ▶ Randomly assigned 2,820 Chinese managers into groups that met monthly for one year (or no-meetings control).
    - ▶ Large effects on revenues (8.1%), also positive effects on profits, management practices.
  - ▶ Randomly provided information about a government grant and savings opportunity to some participants.
    - ▶ Other participants in treated groups more likely to apply.
    - ▶ Information spread more if it was non-rival (savings opportunity, not government grant).
    - ▶ Consistent results in Hardy and McCasland (2021).

## Learning from Trainers/Consultants

- ▶ Strong evidence that tailored, “high-touch” advice can have positive effects on firm performance.
  - ▶ Bloom, Eifert, Mahajan, McKenzie and Roberts (2013):
    - ▶ Randomized consulting services among 17 Indian textile firms.
    - ▶ 1-month diagnostic (all), 4-month implementation (treatment)
    - ▶ Market value of services ~ \$250k.
    - ▶ Clear effects on management practices, quality defects.
  - ▶ Bruhn, Karlan and Schoar (2018):
    - ▶ Randomized consulting services, provided by private consulting firms, to SMEs in Puebla, Mexico.
    - ▶ One-on-one meetings, four hours per week for one year.
    - ▶ Moderately positive effects on productivity, return on assets, (over five years) employment.
  - ▶ Iacovone, Maloney and McKenzie (2022):
    - ▶ Group/individual consulting to Colombian autoparts suppliers.
    - ▶ Positive impacts of both, group consulting more cost-effective.

# Learning from Trainers/Consultants (cont.)

- ▶ Frontier issues:
  - ▶ Are some management practices better across contexts?
    - ▶ I think we still don't know (exclusion restriction an issue in consulting experiments).
  - ▶ Better to train or encourage out-/in-sourcing?
    - ▶ Anderson and McKenzie (2022): outsourcing/insourcing marketing/finance dominate business training, are more cost-effective than consulting.
    - ▶ In framework, where is boundary between capabilities (that must be homegrown) and inputs (that can be purchased)?
  - ▶ Why are consulting/professional service markets so thin?
    - ▶ Providing info/quality ratings not sufficient (Anderson and McKenzie, 2022).

## Behavioral Firms?

- ▶ I have emphasized lack of know-how as barrier to upgrading. Could also be that:
  1. Entrepreneurs hold goals besides profit-maximization.
  2. Entrepreneurs make mistakes.
- ▶ May be important! Need more evidence (Kremer et al., 2019).
- ▶ But a word of caution:
  - ▶ If behavior appears to be non-optimizing, maybe we have not understood the problems individuals face.
    - ▶ Schultz (1964) on agricultural producers: “poor but rational.”
    - ▶ Update for LDC firms: “lacking know-how, but populated by rational individuals.”
  - ▶ What looks like non-profit-maximizing behavior may reflect:
    - ▶ Agency/contracting/organizational issues.
    - ▶ Cost of acquiring know-how.

# Roadmap

- ▶ Introduction
- ▶ What is upgrading?
  - ▶ Conceptual framework
  - ▶ Measurement issues
- ▶ Evidence on drivers of upgrading
  - ▶ Output-side drivers
  - ▶ Input-side drivers
  - ▶ Drivers of know-how
- ▶ **Closing thoughts**

# Summing Up

- ▶ Should de-emphasize TFP as metric for upgrading.
  - ▶ Better to focus on things we can measure directly: technology adoption, quality upgrading, product innovation.
  - ▶ Will require focusing on particular sectors, building up slowly.
- ▶ Some drivers that seem to be important:
  - ▶ Selling to rich consumers, directly or indirectly.
  - ▶ Availability of high-quality inputs.
  - ▶ Ability to resolve contracting frictions, within and across firms.
  - ▶ Exposure to information from other firms, trainers/consultants.
- ▶ Key challenge is how to promote learning in firms.
- ▶ Notes of caution on competition, capital, behavioral firms.

# Thoughts on the Way Forward

- ▶ Research design:
  - ▶ Find sources of exogenous variation in conditions facing firms: demand and supply conditions, information flows.
    - ▶ Experiments great, but quasi-experiments also useful.
  - ▶ Directly observable outcomes.
- ▶ Some specific research questions:
  - ▶ Does what you produce affect how fast you learn?
    - ▶ Old idea (Prebisch, 1950; Hausmann et al., 2007), ripe for investigation at the firm level.
  - ▶ How does knowledge diffuse across firms?
    - ▶ Strength relative to other channels for agglomeration effects?
  - ▶ What are effects of particular management practices?
    - ▶ Some work here (Bandiera et al., 2011; Gosnell et al., 2020) but not extensive.
  - ▶ What works and doesn't work in industrial/innovation policy when state capacity is low?



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## Bonus Slides for TFP Issue #3: Quality/Variety Biases

- Consider “aggregate” firm-level production function (de Roux, Eslava, Franco and Verhoogen, 2021).

$$\tilde{Y}_{it} = \tilde{M}_{it}^{\beta_m} L_{it}^{\beta_\ell} K_{it}^{\beta_k} e^{\omega_{it} + \eta_i + \xi_t + \epsilon_{it}} \quad (4)$$

$$\tilde{Y}_{it} = \left[ \sum_{j \in \Omega_{it}^y} (\varphi_{ijt} Y_{ijt})^{\frac{\sigma_i^y - 1}{\sigma_i^y}} \right]^{\frac{\sigma_i^y}{\sigma_i^y - 1}}$$

$$\tilde{M}_{it} = \left[ \sum_{h \in \Omega_{it}^m} (\alpha_{iht} M_{iht})^{\frac{\sigma_i^m - 1}{\sigma_i^m}} \right]^{\frac{\sigma_i^m}{\sigma_i^m - 1}}$$

- CES aggregators are one way to deal with unobserved mapping from inputs to outputs.

## Bonus Slides for TFP Issue #3 (cont.)

- Using existing CES results, turns out that:

$$\underbrace{\ln \left( \frac{\tilde{Y}_{it}}{\tilde{Y}_{it-1}} \right)}_{\text{real output change}} = \underbrace{\sum_{j \in \Omega_{it}^{y*}} \delta_{ijt} \ln \left( \frac{Y_{ijt}}{Y_{ijt-1}} \right)}_{\text{"Sato-Vartia" quantity change}} + \underbrace{\sum_{j \in \Omega_{it}^{y*}} \delta_{ijt} \ln \left( \frac{\varphi_{ijt}}{\varphi_{ijt-1}} \right)}_{\text{quality change}} + \underbrace{\frac{\sigma_i^y}{\sigma_i^y - 1} \ln \left( \frac{\chi_{it-1,t}^y}{\chi_{it,t-1}^y} \right)}_{\text{variety change}}$$

where \* means common goods and:

$$S_{ijt}^y = \frac{P_{ijt} Y_{ijt}}{\sum_{j' \in \Omega_{it}^y} P_{ij't} Y_{ij't}}, \quad S_{ijt,t-1}^{y*} = \frac{P_{ijt} Y_{ijt}}{\sum_{j' \in \Omega_{it,t-1}^{y*}} P_{ij't} Y_{ij't}}, \quad S_{ijt-1,t}^{y*} = \frac{P_{ijt-1} Y_{ijt-1}}{\sum_{j' \in \Omega_{it,t-1}^{y*}} P_{ij't-1} Y_{ij't-1}}$$

$$\delta_{ijt} = \frac{\left( \frac{S_{ijt,t-1}^{y*} - S_{ijt-1,t}^{y*}}{\ln S_{ijt,t-1}^{y*} - \ln S_{ijt-1,t}^{y*}} \right)}{\sum_{j \in \Omega_{it}^{y*}} \left( \frac{S_{ijt,t-1}^{y*} - S_{ijt-1,t}^{y*}}{\ln S_{ijt,t-1}^{y*} - \ln S_{ijt-1,t}^{y*}} \right)}, \quad \chi_{it,t-1}^y = \sum_{j \in \Omega_{it,t-1}^{y*}} S_{ijt}^y, \quad \chi_{it-1,t}^y = \sum_{j \in \Omega_{it,t-1}^{y*}} S_{ijt-1}^y$$

- Summing across periods with initial normalization (in logs):

$$\boxed{\tilde{y}_{it} = \tilde{y}_{it}^{SV} + q_{it}^y + v_{it}^y} \quad (5)$$

## Bonus Slides for TFP Issue #3 (cont.)

- Similarly on input side:

$$\underbrace{\ln \left( \frac{\widetilde{W}_{it}}{\widetilde{W}_{it-1}} \right)}_{\text{real mat. input change}} = \underbrace{\sum_{h \in \Omega_{it,t-1}^{m*}} \psi_{iht} \ln \left( \frac{W_{iht}}{W_{iht-1}} \right)}_{\text{"Sato-Vartia" quantity change}} - \underbrace{\sum_{h \in \Omega_{it,t-1}^{m*}} \psi_{iht} \ln \left( \frac{\alpha_{iht}}{\alpha_{iht-1}} \right)}_{\text{quality change}} - \underbrace{\frac{1}{\sigma_i^m - 1} \ln \left( \frac{\chi_{it-1,t}^m}{\chi_{it,t-1}^m} \right)}_{\text{variety change}}$$

$$S_{iht}^m = \frac{W_{iht} M_{iht}}{\sum_{h' \in \Omega_{it}^m} W_{ih't} M_{ih't}}, \quad S_{iht,t-1}^{m*} = \frac{W_{iht} M_{iht}}{\sum_{h' \in \Omega_{it,t-1}^{m*}} W_{ih't} M_{ih't}}, \quad S_{iht-1,t}^{m*} = \frac{W_{iht-1} M_{iht-1}}{\sum_{h' \in \Omega_{it,t-1}^{m*}} W_{ih't-1} M_{ih't-1}}$$

$$\psi_{iht} = \frac{\left( \frac{S_{iht,t-1}^{m*} - S_{iht-1,t}^{m*}}{\ln S_{iht,t-1}^{m*} - \ln S_{iht-1,t}^{m*}} \right)}{\sum_{h \in \Omega_{it,t-1}^{m*}} \left( \frac{S_{iht,t-1}^{m*} - S_{iht-1,t}^{m*}}{\ln S_{iht,t-1}^{m*} - \ln S_{iht-1,t}^{m*}} \right)}, \quad \chi_{it,t-1}^m = \sum_{h \in \Omega_{it,t-1}^{m*}} S_{iht}^m, \quad \chi_{it-1,t}^m = \sum_{h \in \Omega_{it,t-1}^{m*}} S_{iht-1}^m$$

- Summing across periods (again in logs):

$$\boxed{\widetilde{m}_{it} = \widetilde{m}_{it}^{SV} + q_{it}^m + v_{it}^m} \quad (6)$$

## Bonus Slides for TFP Issue #3 (cont.)

- ▶ Plug boxes (5) and (6) into production function (4):

$$\tilde{y}_{it}^{SV} = \beta_m \tilde{m}_{it}^{SV} + \beta_\ell \ell_{it} + \beta_k k_{it} + \eta_i + \xi_t + u_{it}$$

$$u_{it} = (\beta_m q_{it}^m - q_{it}^y) + (\beta_m v_{it}^m - v_{it}^y) + \omega_{it} + \epsilon_{it}$$

- ▶ Correlation of  $\tilde{m}_{it}^{SV}$ ,  $\ell_{it}$ ,  $k_{it}$  with  $q_{it}^m$ ,  $q_{it}^y$ ,  $v_{it}^m$ ,  $v_{it}^y \Rightarrow$  quality/variety biases.
  - ▶ Ex.: single-output/-input producer ( $\tilde{y}_{it}^{SV}$ ,  $\tilde{m}_{it}^{SV}$  are log physical quantities).
    - ▶ If higher-quality output requires more labor hours:
 
$$\text{Cov}(\ell_{it}, q_{it}^y) > 0 \Rightarrow \text{plim}(\hat{\beta}_\ell^{OLS}) < \beta_\ell$$
    - ▶ If firm uses more units when input quality  $\uparrow$ :
 
$$\text{Cov}(\tilde{m}_{it}^{SV}, q_{it}^m) > 0 \Rightarrow \text{plim}(\hat{\beta}_m^{OLS}) > \beta_m$$
- ▶ Biases may be present even with perfect proxy for  $\omega_{it}$ .
- ▶ Most sectors not homogenous, single-output/-input.
  - ▶ Quality changes especially salient in LDCs.

## Bonus Slides for TFP Issue #3 (cont.)

- ▶ de Roux et al. (2021) propose new method:
  - ▶ External instruments for  $\tilde{m}_{it}^{SV}$ ,  $\ell_{it}$  using:
    - ▶ Exchange rates.
    - ▶ Minimum wages.
  - ▶ Supplemented by “internal” instruments (lagged levels or differences).
  - ▶ Jury still out on how much influence the proposal will have.
- ▶ But it seems clear that standard TFP methods are on shaky ground (for differentiated-product sectors).
  - ▶ Algebra above is for CES, but quality/variety likely to be confounders in other frameworks.
  - ▶ de Roux et al. (2021) find empirical similar results for other aggregators.
  - ▶ Quality/variety bias is not just a theoretical curiosity [evidence coming].