Firm-Level Upgrading in Developing Countries*

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Forthcoming, *Journal of Economic Literature*

Abstract

In principle, firms in developing countries benefit from the fact that advanced technologies and products have already been developed in industrialized countries and can simply be adopted, a process often referred to as industrial upgrading. But for many firms this advantage remains elusive. What is getting in the way? This paper reviews recent firm-level empirical research on the determinants of upgrading in developing countries. The first part focuses on how to define and measure various dimensions of upgrading — learning, quality upgrading, technology adoption, and product innovation. The second part takes stock of recent evidence on the drivers of upgrading, classifying them as output-side drivers, input-side drivers, or drivers of know-how. I conclude with some thoughts about promising directions for research in the area.

*I am grateful to David Alfaro-Serrano, David Atkin, Maria Bas, Serguey Braguinsky, Paula Bustos, Nicolás de Roux, Garth Frazer, Alvaro Garcia-Marin, Florian Grosset, Juan Carlos Hallak, Rema Hanna, Morgan Hardy, Jonas Hjort, Beata Javorcik, Seema Jayachandran, Amit Khandelwal, Gianmarco León, Rocco Macchiavello, Florian Mayneris, David McKenzie, Pepita Miquel-Florensa, Ben Olken, Caroline Paunov, Alexandros Ragoussis, Verónica Robert, Matthieu Teachout, Jim Tybout, Bruno Velloso, Nico Voigtländer, Jack Willis, Chris Woodruff, participants in the Seminario Interuniversitario sobre Desarrollo Productivo Argentino (SIDPA), the editor (Steven Durlauf) and four anonymous referees for comments that have significantly improved the paper. I remain responsible for any errors.

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1 Introduction

At least since Gerschenkron (1962), the "advantages of backwardness" — above all, the accumulation in developed countries of advanced technologies and products, which are then available for developing-country firms to adopt — have been well appreciated. But for many firms in developing countries, the purported advantages have remained elusive. Something seems to be getting in the way of the adoption of advanced technologies and products, a process often referred to as industrial upgrading. What are these barriers? Since to identify a barrier is implicitly to identify a factor that promotes upgrading (if only by removing or mitigating the barrier), the question can be restated in a positive way: What are the drivers of firm-level upgrading in developing countries? This paper reviews recent micro-empirical research on firms that sheds light on this question.

Any attempt to characterize the determinants of upgrading must first confront thorny issues of measurement. There is little consensus about how to capture upgrading empirically. The empirical literature on firm-level innovation in developed countries relies heavily on patents and R&D expenditures, but in developing countries, where firms' innovative activities aim primarily at catching up to the world frontier rather than pushing it forward, these measures are less informative. Perhaps the most common approach has been to use changes in estimated total factor productivity (TFP) to measure upgrading. There is a clear logic to this choice, and I will include studies with TFP as an outcome in the review. But I will also argue that the assumptions required by standard TFP estimation methods are strong, perhaps stronger than commonly recognized, and are particularly unlikely to hold in many developing-country settings. An attractive alternative is to use directly observable measures of firms' technology and product choices, although such measures are harder to come by and bear a more ambiguous relationship to firm performance.

The first goal of this paper (in Section 2) is to clarify the ways in which upgrading has been defined and measured, and to show how they are both distinct and related. To do so, it is useful to consider a simple organizing framework that is general enough to accommodate the main measures and mechanisms the literature has highlighted. The framework helps to define conceptually the four senses in which the term upgrading has typically been used by economists: learning, quality upgrading, technology adoption, and product innovation. With the conceptual definitions in hand, I review the ways that researchers have sought to measure upgrading. As we will see, the mapping between the conceptual definitions and the empirical measures is less than perfect and existing measures have different strengths and weaknesses.

The second goal of the paper (in Section 3) is to take stock of what is known empirically about the drivers of firm-level upgrading. Motivated by the conceptual framework, I classify them into three categories: drivers on the output side, including consumer preferences and the degree of competition in output markets; drivers on the input side, including conditions in credit, labor, and intermediate-input markets; and drivers of "know-how," including factors that affect entrepreneurial ability and the knowledge possessed by firms. The categorization is necessarily somewhat loose, because some mechanisms (and some papers) span more than one category. My strategy is to focus on *proximate* drivers of upgrading, which impinge directly on firms, fully acknowledging that the drivers may themselves be consequences of deeper economic forces.

A number of themes emerge from the review. A first is that the demand side matters: selling directly to richer buyers, or supplying inputs in value chains that sell eventually to richer buyers, appears to be robustly associated with upgrading. This is especially true for quality upgrading, but there is increasing evidence that demand matters for other dimensions of upgrading as well. A second theme is that access to high-quality inputs also appears to be a robust driver of upgrading. Reductions in the cost of imported inputs are an important way to increase such access. A third theme is that developing-country firms are often constrained by a lack of know-how. Several types of informational interventions have been successful in improving firm performance. But a fourth theme is that a lack of upgrading should not be attributed simply to a failure of individual entrepreneurs or managers to optimize. With some limited exceptions, the available evidence is consistent with optimization by entrepreneurs and managers, but under constraints imposed by market conditions, contracting frictions, and their own lack of know-how. A fifth theme is that studies using direct measures of upgrading have generally been more successful in addressing the challenges of measurement and identification than those using residual-based measures such as TFP, and that the literature would do well to focus more on such measures in the future, even if it requires building up slowly from analyses of specific sectors in which they are available. Additional insights will be highlighted as we proceed.

Any review has to make difficult decisions about how to define the area of literature to be considered. Perhaps the most draconian here is to focus on the behavior of individual firms, rather than the allocation of resources across firms. Misallocation across firms is clearly an important drag on economic performance and is the subject of a very active literature, reviewed by Restuccia and Rogerson (2013, 2017) and Hopenhayn (2014). But I feel that it would not be possible to do justice to the literatures both on within-firm upgrading and on misallocation in a single review. This limits the scope of the conclusions the current review can draw about development more generally. A second hard choice has been to focus primarily on studies of larger private-sector firms (with more than a handful of employees) outside of agriculture. Given data constraints, this mainly means larger firms in manufacturing. This choice reflects a number of judgments: that larger non-agricultural firms, although they make up a small share of the total firm population in most countries, are crucial for growth; that the issues facing them are distinct from those facing very small firms and agricultural producers; and that the literatures on micro-enterprises and agricultural producers have been well covered by other recent reviews.[1] A third important choice has been to focus on studies that consider upgrading (in one of the senses defined in Section 2) as an outcome. Finally, I have had to omit a large literature in sociology and related fields that is also concerned with upgrading but that uses very different vocabulary and conceptual frameworks, and that (in my reading) tends to be more descriptive and less focused on estimating particular causal determinants of upgrading than the applied-microeconomic literature I focus on here (Gereffi, 1999; Humphrey and Schmitz, 2002; Fernandez-Stark and Gereffi, 2019).

This paper is related to a number of existing reviews beyond those cited above. In its focus on firms in developing countries, it is similar in spirit to Tybout (2000) but with different topical emphases. Several reviews from the perspective of international trade have covered work on developing-country firms, including Tybout (2003), De Loecker and Goldberg (2014), Goldberg and Pavcnik (2016), Shu and Steinwender (2019), and Atkin and Khandelwal (2020); the current

[1] See McKenzie and Woodruff (2014), Quinn and Woodruff (2019), McKenzie (2021), and Jayachandran (2021) on small firms and entrepreneurship, and Foster and Rosenzweig (2010), Jack (2013), de Janvry et al. (2017), and Magruder (2018) on agricultural producers.

review is broader in considering drivers of upgrading unrelated to trade, but also narrower in focusing on firm-level upgrading outcomes. Also related are the handbook chapter of Harrison and Rodríguez-Clare (2010) on the theory and practice of industrial policy in developing countries, and the policy-oriented overviews by Crespi et al. (2014), Cirera and Maloney (2017), Harrison et al. (2017), Cusolito and Maloney (2018), Ciani et al. (2020), and Lane (2020). The current review focuses on what we know about how firms behave, which is relevant to policy design, but not specifically on the practical issues of what works or does not work in industrial policy.

2 What Do We Mean by Upgrading?

This section aims to clarify, conceptually and empirically, the various ways the term upgrading has been used by economists and to highlight the strengths and weaknesses of existing empirical measures.

2.1 A Simple Framework

To frame the discussion, some notation and a simple, general framework will be useful. We can think of a firm, indexed by i, as a collection of production lines, each producing a single product, indexed by j, using a single production technique, k, at time t, and characterized by a product-technique-specific (and twice-differentiable) production function:

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

where Y_{ijkt} is physical output, $\vec{M}_{ijkt}$ is a vector of physical inputs (e.g. various types of materials, labor, and machines) and λ_{ijkt} is what Sutton (2007, 2012) and others call the *capability* of firm i in product-technique jk, which is assumed to raise output conditional on inputs (i.e. $\partial Y_{ijkt}/\partial \lambda_{ijkt} > 0$). Let $\Lambda_{it} = \{\lambda_{ijkt}\}$ be the set of capabilities possessed by a firm. This set can be understood to incorporate what Dessein and Prat (forthcoming) term "organizational capital," a firm-specific asset that must be produced within the firm and that changes slowly over time. We can think of j as indexing products at the barcode level, and of each product as having quality, φ_{ijt}, a single-dimensional index that captures the appeal of product j to consumers, which for now we treat as observable. Products with different physical attributes (or with different packaging or marketing for different destination markets) should be thought of as having different j's; φ_{ijt} is indexed by t not because physical attributes of a product change over time, but because consumer valuations of a product can vary, holding those attributes constant. The fact that the attributes of product j are being represented by a single index is a fairly drastic simplification, but the single dimension is sufficient to capture many key ideas in the literature and hence serves our current purpose. A (product-specific) technique, k, can be thought of as a list of inputs (which determines the rows of the $\vec{M}_{ijkt}$ vector) and a set of instructions for combining them to make a product j, similar to what Boehm and Oberfield (2020) call a "recipe." (I will use the term "technology" as a synonym for "technique.") Techniques that use different inputs (including inputs of different qualities) should be thought of as having different k's. Let J_{it} and K_{it} be the sets of products and corresponding techniques for which the firm knows $F_{ijk}(\cdot)$. I will refer to Λ_{it}, J_{it}, and K_{it} together as "know-how." To keep things simple, I assume that there is no partial knowledge of products or techniques, and that output of a firm's other production lines does not enter $F_{ijk}(\cdot)$.

The firm can choose to enter a set of destination markets, B, indexed by b. It faces fixed costs of production, which may be at the level of a product-technique, f_{ijkt}, a product-destination, f_{ijbt}, a product, f_{ijt}, a destination, f_{ibt}, or the firm, f_{it}, and may vary across firms. The firm can increase its future capabilities or expand the sets of products and techniques that it knows about by making investments I_{it}^{Λ}, I_{it}^{J}, and I_{it}^{K}, respectively. A firm's future know-how may also be affected by the set of products it chooses to produce, or the techniques it uses to produce them, without explicit investments. Let P_{ijbt} be the price of product j in destination b, and $P_{ijbt} = D_{jb}(Y_{ijbt}, \varphi_{ijt}, \vec{\Gamma}_{bt}^{y})$ be the corresponding inverse demand curve, where $\vec{\Gamma}_{bt}^{y}$ reflects external factors in output markets and Y_{ijbt} is output of product j for market b. Let $\vec{W}_{ijkt}$ hold prices for the inputs used in product-technique jk, with vector of input qualities, $\vec{\alpha}_{ijkt}$, and let $\vec{W}_{ijkt} = S_{jk}(\vec{M}_{ijkt}, \vec{\alpha}_{ijkt}, \vec{\Gamma}_{t}^{m})$ be the corresponding inverse input-supply curve, where $\vec{\Gamma}_{t}^{m}$ reflects external factors in input markets.[2] Again in the interests of simplicity, I assume that the inverse demand and supply functions, $D_{jb}(\cdot)$ and $S_{jk}(\cdot)$, do not depend on output or inputs of other production lines in the firm.

The firm's present discounted profit at time τ can then be written as:

$$\begin{aligned} \Pi_{i\tau} &= \textstyle\sum_{t=\tau}^{\infty} \delta_t \left\{ \sum_{b \in B_{it}^*} \left[\sum_{j \in J_{ibt}^*} \left(P_{ijbt} F_{ijk}(\vec{M}_{ijkt}, \lambda_{ijkt}) - \vec{W}_{ijkt}' \vec{M}_{ijkt} - f_{ijkt} - f_{ijbt} \right.\right.\right. \\ &\qquad \left.\left.\left. - f_{ijt} \right) - f_{ibt} \right] - f_{it} - I_{it}^{\Lambda} - I_{it}^{J} - I_{it}^{K} \right\} \end{aligned} \tag{2}$$

where δ_t is a discount factor, B_{it}^* is the set of markets the firm chooses to enter, and $J_{ibt}^* \subset J_{it}$ is the set of products the firm chooses to sell in destination b. The firm's decision problem in any period is to choose destinations B_{it}^*, products for each destination J_{ibt}^*, a technique $k_{ijt}^* \in K_{it}$ for each $j \in J_{ibt}^*$, the amount of each input used for each product-technique, $\vec{M}_{ijkt}$, and investments in future know-how, I_{it}^{Λ}, I_{it}^{J}, and I_{it}^{K}, in order to maximize the firm's present discounted profit, $\Pi_{i\tau}$.

At several points below, it will be useful to distinguish between the roles of output quality (which may carry requirements for input quality and cost) and markups in determining output prices, and it is convenient to derive an expression for markups here. Given our assumptions on production and demand, the optimal markup for each product in each market can be written in a simple way. Let $C_{ijbt}(Y_{ijbt})$ be the minimized total cost of producing Y_{ijbt},[3] and η_{ijbt} be the elasticity of demand for product j in market b: $\eta_{ijbt} = -\partial \ln Y_{ijbt} / \partial \ln P_{ijbt}$. Then for each product

[2] The $\vec{\Gamma}_{bt}^{y}$ and $\vec{\Gamma}_{t}^{m}$ terms may incorporate output prices charged or input prices paid by other firms, to which firm i may respond strategically. $\vec{W}_{ijkt}$ is indexed by k not because prices for a particular input vary by technique, but because different techniques (which may vary over time for a given firm-product) may require different sets of inputs.

[3] That is, assuming the input-supply functions $\vec{W}_{ijkt} = S_{jk}(\vec{M}_{ijkt}, \vec{\alpha}_{ijkt}, \vec{\Gamma}_{t}^{m})$ are twice differentiable,

$$C_{ijbt}(Y_{ijbt}) = \underset{\vec{M},\, k}{\operatorname{argmin}} \left\{ \vec{W}_{ijkt}' \vec{M}_{ijkt} | F_{ijk}(\vec{M}_{ijkt}, \lambda_{ijkt}) = Y_{ijbt} \right\} \tag{3}$$

in each market, the firm will choose quantity sold, Y_{ijbt}, such that the markup, μ_{ijbt}, is:

$$\mu_{ijbt} = \frac{P_{ijbt}}{MC(Y_{ijbt})} = \frac{\eta_{ijbt}}{\eta_{ijbt} - 1} \tag{4}$$

where $MC(Y_{ijbt}) = \partial C_{ijbt}(Y_{ijbt})/\partial Y_{ijbt}$ is marginal cost.[4]

In its current form, the framework is too general to be able to generate falsifiable predictions about firm behavior, but it is helpful to define terms and to organize our thinking about mechanisms. The most common definitions of upgrading in the economics literature can be classified conceptually under four headings, which I will refer to as *learning*, *quality upgrading*, *technology adoption*, and *product innovation*.

We can think of *learning* as an accumulation of know-how: an increase in capabilities, $\lambda_{ijkt} \in \Lambda_{it}$, for some set of product-techniques, an expansion of the set of products the firm knows about, J_{it}, or an expansion of the set of techniques the firm knows about, K_{it}. Implicit in the framework is a distinction between skilled labor that can be purchased on the labor market (and hence shows up in $\vec{M}_{ijkt}$) and capabilities and knowledge that must be acquired through other means, which may include conscious investments (I_{it}^{Λ}, I_{it}^{J}, and I_{it}^{K}) or incidental learning from one's own experience or the experiences of others.

Quality upgrading can be defined simply as an increase in the output-weighted average quality of goods produced: that is, an increase in $\overline{\varphi}_{it}$, where $\overline{\varphi}_{it} = \sum_{b \in B_{it}^*} \sum_{j \in J_{ijbt}^*} \nu_{ijbt}\, \varphi_{ijt}$, with $\nu_{ijbt} = Y_{ijbt}/(\sum_{b \in B_{it}^*} \sum_{j \in J_{ijbt}^*} Y_{ijbt})$.

Technology adoption can be thought of as the adoption of a technique not previously employed by the firm. In our notation, if we let K_{it}^* be the set of techniques in use by firm i at time t (that is, $K_{it}^* = \{k_{ijt}^* | j \in J_{ibt}^* \text{ for some } b \in B_{it}^*\}$), then technology adoption is the use of a $k_{ijt}^* \notin K_{it-s}^* \,\forall\, s > 0$. Use of a new input or use of a new process to combine existing inputs, even for an existing product, would both qualify as technology adoption under this definition. Here I use a broad definition of techniques that includes management practices. These are considered to be chosen by firms, given their know-how.[5] It is tempting to limit the definition of technology adoption to adoption of technologies that are "better" than the technologies a firm is currently using (in the spirit of e.g. the OECD's Oslo Manual (2018)), but technologies are rarely better in a global sense — for all possible output-demand functions, input-supply functions, and levels of know-how — so I maintain a more agnostic definition.

Product innovation, also commonly referred to as an expansion of product scope, can be thought of as the production of a good not previously produced by a firm: that is, production of a $j \notin J_{ibt-s}^* \,\forall\, b \in B_{it-s}^*, s > 0$.

[4] To see this, note that conditional on selling product j in market b, the firm's problem is to choose Y_{ijbt} to maximize $P_{ijbt}Y_{ijbt} - C(Y_{ijbt})$, for which the first order condition is:

$$\frac{\partial}{\partial Y_{ijbt}}\left[P_{ijbt}Y_{ijbt} - C(Y_{ijbt})\right] = P_{ijbt} + Y_{ijt}\frac{\partial P_{ijbt}}{\partial Y_{ijbt}} - \frac{\partial C_{ijbt}(Y_{ijbt})}{\partial Y_{ijbt}} = \left(1 - \frac{1}{\eta_{ijbt}}\right)P_{ijbt} - \frac{\partial C_{ijbt}(Y_{ijbt})}{\partial Y_{ijbt}} = 0$$

Equation (4) follows immediately.

[5] In treating management practices as techniques (or components of techniques), I am following, among others, Van Reenen (2011), who argues that the choice of management practices should be analyzed like any other technology choice, and Bloom et al. (2011), who write, "Modern management is a technology that diffuses slowly between firms."

These dimensions of upgrading are related and often occur together but are conceptually distinct. A firm can quality-upgrade by shifting output toward higher-quality products already being produced, without gaining know-how, using a new technique, or producing a new good. Similarly, a firm may adopt a new technology or produce a new good that it already knew about (i.e. $k^*_{ijt} \in K_{it-1}$ or $j \in J_{it-1}$) without learning or increasing the average quality of goods produced. Acquisition of know-how may not lead a firm to make changes on the other dimensions.

This framework motivates the categorization of drivers of upgrading in Section 3 below. One set of drivers has to do with conditions in output markets, here summarized by the inverse demand curves $D_{jb}(\cdot)$. Another set has to do with conditions in input markets, summarized by the inverse supply curves $S_{jk}(\cdot)$. A third has to do with the know-how of firms, summarized by Λ_{it}, J_{it} and K_{it}.

In addition to helping to define terms, the framework already highlights three key conceptual points. First, the conditions facing developing-country entrepreneurs may differ from those facing developed-country ones along a number of dimensions, including demand patterns, availability (and prices) of inputs, and know-how of the entrepreneurs themselves. These factors shape firms' choices of which products to produce and which techniques to use. What is optimal for a developed-country firm may not be optimal for a developing-country one.

Second, relatedly, there should be no presumption that upgrading in any of these four senses is optimal. More know-how is unambiguously a good thing for firms, but if acquiring that know-how is costly, a firm must weigh the required investment against the future benefits of learning. The optimal degree of technology adoption, quality upgrading, and product innovation will similarly depend on firms' know-how and the output-demand and input-supply curves they face.[6]

Third, understood through the lens of this framework, the popular conception of "management" reflects three conceptually distinct elements: entrepreneurial ability, which we can think of as a component of capabilities that is common across products and techniques and embodied in an entrepreneur; the skill of employed managers, which can be thought of as a component of the input vectors, $\vec{M}_{ijkt}$; and the management practices chosen by the firm, which are components of the selected techniques, k^*_{ijt}. From this perspective, it is not sufficient to attribute poor firm performance to "bad management"; one needs specify how each of these three elements play a role in the poor outcomes.[7] We will return to these issues in Section 3.3 below.

2.2 Measurement Issues

With this framework in mind, we turn to the measurement of upgrading. The most commonly used measure is TFP in various forms, which has several shortcomings.[8] We also consider approaches to measurement of quality upgrading, technology adoption, and product innovation.

[6] As Foster and Rosenzweig (2010) put it succinctly in an agricultural context, "it 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" (p. 399).

[7] There may of course be interactions between these elements: for instance, low-ability entrepreneurs may choose low-skill managers, who in turn choose sub-optimal management practices.

[8] Many of the issues raised in this section are discussed in more detail in previous reviews by Bartelsman and Doms (2000), Ackerberg et al. (2007), Katayama et al. (2009, Sec. 2), Syverson (2011), De Loecker and Goldberg (2014), and De Loecker and Syverson (2021).

2.2.1 Measures of Productivity

The standard approach to TFP estimation begins by positing a firm-level production function, most commonly Cobb-Douglas, for instance:

$$y_{it} = \vec{z}_{it}{}'\vec{\beta} + \{\omega_{it} + \varepsilon_{it}\} \tag{5}$$

where y_{it} is log output; $\vec{z}_{it} = (k_{it}\ \ell_{it}\ m_{it})'$ contains log capital, log labor (employment or hours), and log materials, with corresponding coefficients $\vec{\beta} = (\beta_k\ \beta_\ell\ \beta_m)'$; ω_{it} is an "ex ante" productivity shock, which the firm knows before choosing the flexible inputs ℓ and m; and ε_{it} is an "ex post" shock, realized after the firm has made its input decisions.[9] The coefficients $\vec{\beta}$ are then estimated by one of several methods (discussed briefly below), and TFP is estimated as $\widehat{TFP}_{it} = y_{it} - \vec{z}_{it}{}'\widehat{\vec{\beta}}$. In principle, this represents a firm-level measure of capability.

One under-appreciated issue with this approach is that if the firm is actually a collection of production lines, as in our framework, then it is not obvious that there exists an "aggregate" production function that fully summarizes the relationship between inputs and outputs at the firm level. Under certain conditions, product-technique-level functions such as the $F_{ijk}(\cdot)$ in equation (1) aggregate into a firm-level function such as equation (5).[10] This observation echoes earlier results on the aggregation of firm-level production functions to a macro-level production function (e.g. Houthakker (1955)). But the assumptions required in the earlier literature have been criticized as special and unlikely to hold in practice (Fisher, 1969), and a similar point could be made about firm-level production functions. The caveat of Mairesse and Griliches (1988) still seems apt: "[T]he simple production function model ... is at best just an approximation to a much more complex and changing reality at the firm, product, and factory floor level" (p. 28).

Much of the recent production-function literature has been concerned with a different problem, "transmission bias": if a firm observes that it has high ex-ante productivity, then it may use more labor and/or materials, generating a correlation between ω_i and ℓ_i and/or m_i in (5) and biasing OLS estimates. The most common solution is to construct a proxy for the ex-ante productivity term, using either investment (Olley and Pakes, 1996) or materials (Levinsohn and Petrin, 2003; Ackerberg et al., 2015).[11] These approaches have recently been criticized by Gandhi et al. (2020), who argue that they are not non-parametrically identified[12] and propose using the first-order

[9] This is a "gross output" production function; an alternative is to estimate a "value-added" production function; for advantages and disadvantages, see Ackerberg et al. (2015) and Gandhi et al. (2017, 2020).

[10] For instance, Jones (2005) considers an environment in which a firm produces a single product and chooses over Leontief techniques drawn from independent Pareto distributions. As the set of techniques over which the firm chooses becomes large, the maximum output for a given set of factor choices can be expressed as a Cobb-Douglas function. Subsequent research has derived similar results, with specific assumptions on functional forms and distributions of technique draws (see e.g. Boehm and Oberfield (2020)).

[11] In Olley and Pakes (1996) (with a value-added production function), if investment is a function of productivity and existing capital stock, $\iota_i = \iota(\omega_i, k_i)$, and ω_i is a scalar and strictly monotonically related to ι_i then this function can be inverted, and the productivity term can be expressed as a function of investment and capital: $\omega_i = h(\iota_i, k_i)$. A flexible polynomial in ι_i and k_i can then serve as a proxy for ω_i in an equation similar to equation (5). Levinsohn and Petrin (2003) propose a similar approach for materials. Ackerberg et al. (2015) also invert a materials-demand equation, but (in contrast to Levinsohn and Petrin (2003)) one that conditions on labor inputs.

[12] Gandhi et al. (2017) note that their criticism does not apply in a setting where a linear function of materials is a perfect complement to other inputs in producing output; this setting yields the value-added specification employed by Ackerberg et al. (2015).

condition for the choice of materials as an additional source of identification (as for instance in Doraszelski and Jaumandreu (2013)). Also, the proxy-variable methods require a monotonic relationship between underlying productivity and investment or materials demand, which is a strong assumption. In the Olley-Pakes version, for instance, heterogeneity across firms in the extent to which they are credit constrained or face adjustment costs of capital would violate the required assumption, as would measurement error in inputs (Griliches and Mairesse, 1998; Ackerberg et al., 2015; Shenoy, 2020).

A separate issue arises because it is rare to observe physical quantities of outputs or inputs. The typical approach is to deflate sales (or value-added) and expenditures by sector-level price indexes. This can give rise to potentially severe biases (De Loecker and Goldberg, 2014). To see this, consider a single-product firm with production function (5). Let p_{it} and $\vec{w}_{it}$ be log output price and a vector of log input prices, and $r_{it} = y_{it} + p_{it}$ and $\vec{e}_{it} = \vec{z}_{it} + \vec{w}_{it}$ be log revenues and log expenditures, and suppose that $p_{it} = \overline{p}_t + \breve{p}_{it}$ and $\vec{w}_{it} = \vec{\overline{w}}_t + \vec{\breve{w}}_{it}$, where $\overline{p}_t$ and $\vec{\overline{w}}_t$ are observed sector-level price indexes and $\breve{p}_{it}$ and $\vec{\breve{w}}_{it}$ are unobserved firm-level deviations. Then rewriting (5) in the form of the regressions that are usually run, we have:

$$\{r_{it} - \overline{p}_t\} = \{\vec{e}_{it} - \vec{\overline{w}}_t\}'\vec{\beta} + \{\breve{p}_{it} - \vec{\breve{w}}_{it}{}'\vec{\beta} + \omega_{it} + \varepsilon_{it}\} \tag{6}$$

If deflated expenditures ($\vec{e}_{it} - \vec{\overline{w}}_t$) are correlated with $\breve{p}_{it}$ or $\vec{\breve{w}}_{it}$ — for instance because firms produce more (and hence use more inputs) when they are able to charge a high mark-up, or because they purchase less of an input with a high price — then OLS estimates of (6) will be inconsistent, even if one is able to find a valid proxy for ω_{it}. De Loecker and Goldberg (2014) refer to such biases as output- and input-price biases. Equation (6) also makes clear that even if one were able to estimate $\vec{\beta}$ consistently, TFP calculated from the residual would still incorporate the idiosyncratic firm-level price deviations, $\breve{p}_{it}$ and $\vec{\breve{w}}_{it}$. As equation (4) in our framework indicates, variation in the elasticities of demand faced by individual firms — because of demand shocks, differences in entry into destination markets, or simply differences in product composition — would be expected to yield firm-specific differences in mark-ups and hence in measured TFP. Idiosyncratic differences in input-supply curves can generate similar biases on the input side.

Datasets with physical quantities at the firm-product level are increasingly available and can help to address these biases. In US data, Foster et al. (2008) consider 11 arguably homogeneous products and estimate a function with physical output on the left-hand side, to yield what they call TFPQ (Q for quantity), which differs from the more common TFPR (R for revenues). Although Foster et al. (2008) do not use physical quantities of inputs, it is straightforward to extend their approach to do so (Atalay, 2014). Observing physical quantities convincingly removes the output- and input-price bias for single-product firms using homogeneous inputs to produce homogeneous outputs.

But quantity-based TFP measures may be a misleading indicator of firm capability if quality or variety of outputs or inputs vary across firms and over time. This point has been made by Katayama et al. (2009) and others, and recently given a new formalization by de Roux et al. (2021). Even in datasets where input and output quantities and prices are observed (as in the Colombian data de Roux et al. (2021) use), it is generally not possible to map particular inputs directly to particular outputs within the firm. Rather than imputing such a mapping, de Roux et al. (2021)

aggregate from the firm-product to the firm level using constant elasticity of substitution (CES) aggregators for outputs and material inputs. The within-firm CES structure, while restrictive, allows them to use existing index-number results to show that the output and input aggregates can be expressed as sums of observable quantity aggregates and unobservable terms capturing quality and variety. The unobserved quality and variety terms end up in the error term in a regression of output quantity on input quantities; if they are correlated with input choices, they generate omitted-variable biases, which the authors refer to as quality and variety biases. These biases also show up in TFPQ. The authors present an approach to estimation that arguably addresses them, broadly in the spirit of Blundell and Bond (1998, 2000), but taking advantage of exchange-rate changes and minimum-wage changes to create external instruments for material and labor choices.

Quality bias is not just a theoretical curiosity. In an experiment with Egyptian rug producers, Atkin et al. (2017a, 2019) randomly allocated initial export contracts and found that the producers increased exports, quality, and profits, as might be expected, but *decreased* square meters of rug woven per hour and TFPQ, because the producers were taking more care in producing the exported rugs. In laboratory conditions, sewing identical rugs, the treated weavers were no slower than the non-treated weavers and sewed higher-quality rugs, suggesting that exporting generated learning. In this setting, it seems clear that TFPQ is misleading as a measure of firm capabilities or performance.[13]

A natural response to the issues of quality and variety bias is to revert to using revenues on the left-hand side and expenditures on the right-hand side. Since quality is reflected in higher prices, using price times quantity takes into account quality differences. But prices also reflect things other than quality, in particular markups. In imperfectly competitive industries, TFPR is a measure both of technical efficiency — the ability to transform physical inputs into physical outputs — and of the ability to sell at a price above marginal cost (De Loecker and Goldberg, 2014). It may well be the best measure of firm performance currently available for many quality-differentiated industries, but one should not interpret it as a measure of technical efficiency alone.

In sum, although standard TFP measures have the attractive property that they aim directly at estimating firm capabilities, which in theory bear an unambiguously positive relationship to firm performance, the assumptions required by standard methods seem strong and unlikely to hold in many developing-country settings. Credit constraints, commonly thought to be pervasive, are likely to violate the monotonicity assumption required by the Olley and Pakes (1996) method, and input-market frictions are likely to have a similar effect in the Levinsohn and Petrin (2003) and Ackerberg et al. (2015) methods. In many countries and sectors, markets are thin and firms have significant market power, generating markups that will show up in revenue-based TFP measures. Quality bias is likely to be particularly salient in developing countries as firms enter world markets, because of the large differences in incomes between domestic and rich-country consumers. Some new methods have been advanced, and we will consider others below in Section 3.1.1.2, but the literature has not converged on a consensus approach to addressing these difficult issues.

[13] In another illustration, De Loecker et al. (2016) estimate production-function parameters and markups in multi-product firms allowing for quality differences on both the input and output sides. They find plausible estimates when they control for quality differences, but estimates they describe as "nonsensical" when they do not (Table V). See the further discussion in Sections 3.1.1.2 and 3.2.1 below.

2.2.2 Measures of Quality

The literature has taken three main approaches to drawing inferences about quality choices: a more theory-reliant approach using a specification of demand in combination with information on output prices and market shares to construct explicit measures of quality, a more reduced-form approach using information on output and input prices to draw indirect inferences about quality, and direct observation of product quality for particular sectors.

In the first category, a leading example is the study by Khandelwal et al. (2013), who use trade-transactions data on exports of Chinese textile and clothing firms to construct quality measures at the firm-product level. Using our notation, their approach is to specify that the demand functions, $D_{jb}(\cdot)$, are characterized by a constant elasticity of substitution, σ, both across and within firms, such that demand can be written $\ln Y_{ijbt} = -\sigma \ln P_{ijbt} + a_j + a_{bt} + \epsilon_{ijbt}$, where a_j and a_{bt} are product and destination-year fixed effects and the residual, ϵ_{ijbt}, captures product quality (scaled by $\sigma - 1$). The authors set $\sigma = 4$, the median elasticity of substitution for clothing and textile products from Broda et al. (2006), and rewrite the expression as $\ln Y_{ijbt} + \sigma \ln P_{ijbt} = a_j + a_t + \epsilon_{ijbt}$. They run this regression in the Chinese export data, where products correspond to 8-digit harmonized-system categories, and interpret $\widehat{\epsilon}_{ijbt}/(\sigma - 1)$ as a measure of quality at the firm-product-destination level. The intuition is straightforward: conditional on price, higher quality products have higher market share (and hence a higher residual, $\widehat{\epsilon}_{ijbt}$). This method is akin to methods to recover quality at a higher level of aggregation by Hummels and Klenow (2005), Khandelwal (2010), Hallak and Schott (2011), and Feenstra and Romalis (2014), among others. Variants of this method have been used by Bas and Strauss-Kahn (2015), Fan et al. (2015, 2018), Stiebale and Vencappa (2018), and Bas and Paunov (2021a,b).

While the Khandelwal et al. (2013) method has proven useful, it requires several non-innocuous assumptions, both in the specification of demand and in the estimation of σ carried out by Broda et al. (2006). A second approach in the literature has been to use reduced-form relationships between prices and other observables to argue indirectly that quality differences appear to be playing an important role, without imposing the functional-form assumptions required to construct explicit measures of quality. To motivate this approach, Kugler and Verhoogen (2012) develop a model of endogenous choice of input and output quality by heterogeneous (single-output, single-input) firms, extending (a simplified version of) the workhorse Melitz (2003) model. In our notation, the key implication is that, in equilibrium, more-capable firms (with a higher λ) use higher-quality and hence more costly inputs (i.e. with greater $\vec{\alpha}$ in $\vec{M}(\cdot)$ and hence higher $\vec{W}$) to produce higher-quality and higher-priced outputs (i.e. higher φ and hence higher P).[14] Using data on output and input prices from the Colombian manufacturing census, the authors document three facts. First, on average within narrow product categories, larger plants charge higher prices for their outputs. Second, perhaps more surprisingly, larger plants also pay more for their material inputs — a fact that generalizes the well-known "size-wage effect" (Brown and Medoff, 1989). Third, the size-price correlations are more positive in sectors with greater scope for quality differentiation, proxied,

[14] Kugler and Verhoogen (2012) present two variants of the model. In one, there is a complementarity between firm capability and input quality in producing output quality. In the other, there is a fixed cost of producing quality and high-quality output is assumed to require high-quality inputs, but there is no direct complementarity between capability and input quality.

following Sutton (1998), by R&D and advertising intensity in US data. These facts suggest that producing high-quality outputs requires high-quality inputs and are difficult to reconcile with models that lack a quality dimension. This conclusion has been corroborated by several studies. Manova and Zhang (2012) show in Chinese customs data that firms that export more and charge higher export prices on average also pay higher prices for their imported inputs.[15] Exploiting barcode-level scanner data from the US, Faber and Fally (forthcoming) show that richer households purchase products from larger firms than poorer households within detailed product categories. Demir et al. (2021) show that larger, higher-wage Turkish firms tend to purchase goods from higher-wage suppliers than smaller, lower-wage firms. An important caveat in this approach is that it is not sufficient simply to document a positive correlation between input and output prices. In our framework, exogenous shocks to input prices (i.e. shocks to $\vec{\Gamma}_t^m$ affecting $\vec{W}_{ijkt}$) would be expected to be passed through to marginal costs ($MC(Y_{ijt})$) and hence to output prices, generating a positive correlation between input and output prices even in the absence of quality differences. It is the positive correlation of both input and output prices with plant size that most strongly suggests that higher quality has shifted out the demand for the larger firms' products.[16]

The third approach has been to take advantage of directly observable information on quality. Such direct measures have been used, for instance, for wine (Macchiavello, 2010; Crozet et al., 2012; Chen and Juvenal, 2016, 2022); rugs (Atkin et al., 2017a); watermelons (Bai, 2021); dairy products (Bai et al., forthcoming); automobiles (Bai et al., 2020); fishmeal (Hansman et al., 2020); cotton yarn (Braguinsky et al., 2021); soccer balls (Atkin et al., 2015); and coffee (Macchiavello and Miquel-Florensa, 2018, 2019; Macchiavello and Morjaria, 2021).[17] Verhoogen (2008) proxies for quality using ISO 9000 certification, an international production standard. We return to several of these studies when discussing drivers below. At this point, we can simply observe that the direct measures, when they are available, make it possible to draw inferences about quality upgrading without relying on assumptions about the functional form of demand or the relative contributions of quality and markups to output prices.

2.2.3 Measures of Technology Use

Direct information on technologies used by firms is often difficult to obtain, especially in developing countries. One branch of the literature has taken a macroeconomic approach, fitting models to data on rates of adoption at the level of countries or sectors. The inferences that can be drawn about the behavior of individual firms from this branch of work are often unclear, and rather than consider it in depth I refer readers to the review by Comin and Mestieri (2014).

[15] Manova and Yu (2017) further show that, across products within firms, export prices are positively correlated with an index of input prices, constructed using a sector-level input-output table.

[16] A related point is that it is also not sufficient simply to document a positive correlation between output prices and plant size, since it could also be that larger firms face lower elasticities of demand, η_{ijbt}, in each market. This is true, for instance, in Atkeson and Burstein (2008), where larger firms place more weight on a (lower) cross-sector elasticity of demand than a (higher) within-sector elasticity, and hence charger a higher markup, generating a positive correlation between size and output price in the absence of quality differences. But on its own this story would not account for higher input prices in larger firms.

[17] Sutton (2000, 2004) conducts detailed quality-benchmarking studies in Indian machine-tool and Chinese and Indian autoparts producers. In an important early contribution, Goldberg and Verboven (2001) use detailed data on product attributes in the European car market to control for quality differences.

Among studies taking more microeconomic approaches, much of the development literature has focused on agriculture, where information on technology use is more readily available than in other sectors (see e.g. the review by Foster and Rosenzweig (2010)). In manufacturing, there have been a number of studies of developed-country firms, for instance the "insider econometrics" studies reviewed by Ichniowski and Shaw (2013) and studies of adoption of energy-efficient technologies reviewed by Allcott and Greenstone (2012). Studies of technology adoption by non-agricultural firms in developing countries have been much scarcer, but include the recent papers on Pakistani soccer-ball producers by Atkin et al. (2017b) and on Ghanaian garment producers by Hardy and McCasland (2021a), to which we will return below. The World Bank has undertaken detailed surveys of technology use in a number of developing countries, which are likely to stimulate work in the area (Cirera et al., 2020). A challenge in this line of research is that machines and other physical technologies are often specific to particular sectors and can only be captured by narrowly tailored surveys.

One area that has been advancing rapidly is the measurement of management practices, following the influential work of Bloom and Van Reenen (2007, 2010). The World Management Survey (WMS), first implemented in the US and Europe, has been extended to 35 countries, including low-income countries such as Ethiopia and Mozambique (Bloom et al., 2014). Using open-ended questions on monitoring, production targets, and incentives, posed by skilled interviewers, the survey's management scores have proven to be robustly correlated with a variety of independent measures of firm performance. Information on management practices has also been collected using "closed-ended" (i.e. multiple-choice) questions in the Management and Organizational Practices Survey conducted by the US Census and in similar surveys in Mexico, Pakistan, and other countries (Bloom et al., 2016b, 2019).[18] An advantage of focusing on management practices as a form of technology use is that similar practices are applicable across a wide range of contexts. It has been possible to construct consistently measured management scores for many countries and sectors, and this in part explains the substantial impact of this research agenda on several fields.

There is an important debate in this literature about whether particular practices can be considered better than others in some absolute or context-independent sense. On one hand, there is a long tradition in management research, often referred to as the "horizontal" (or "design" or "contingency") view, that sees the best management practices as contingent on many features of a firm's environment (e.g. Woodward (1958)). On the other hand, leading researchers in this literature argue for a "vertical" view that some practices are better than others across settings (see e.g. Van Reenen (2011) and Bloom et al. (2014)).[19] In the context of our framework, the "vertical" claim is that a particular technique, k, is more profitable for a firm for all the configurations of demand curves, $D_{jb}(\cdot)$, supply curves, $S_{jk}(\cdot)$, and know-how (Λ_{it}, J_{it}, K_{ijt}) that firms might face. This is ultimately an empirical question, one that in my view is not yet resolved. As with other technologies, one should not infer from the mere fact that successful firms use a particular practice that all firms should adopt it. Firms may lack the know-how to implement the practice effectively,

[18] Relatedly, McKenzie and Woodruff (2017) review findings from seven countries using a battery of questions designed for smaller developing-country firms.

[19] For example, Bloom et al. (2014, p. 852) write, "The focus of the WMS questions is on practices that are likely to be associated with delivering existing goods or services more efficiently. We think there is some consensus over better or worse practices in this regard."

or may face different output market or input market conditions than those that use the practice successfully. It seems very possible that some firms are making mistakes by not adopting some higher-scoring practices (e.g. tracking inventories), but for other practices (e.g. performance pay) the situation is less clear-cut. It is important to consider carefully firms' capabilities and the market conditions they face before concluding that one particular management practice is a better fit than another for the context.

2.2.4 Measures of Product Innovation

Product-level information is increasingly available in firm- or plant-level datasets, and has been used to good effect to analyze for instance the impact of trade liberalization on product scope (e.g. Goldberg et al. (2010), Bas and Paunov (2021a).) But the product categories in industrial and trade datasets (e.g. at the 8- or 10-digit level) still lump together products with very different attributes. It seems clear that the way forward will be to access barcode-level information that can be linked to firms, as for instance in the US Nielsen scanner data used by Faber and Fally (forthcoming). Scanner data are just starting to become available in developing countries (see e.g. Aguilar et al. (2021)). This is clearly an important frontier for empirical work.

2.2.5 Discussion

None of the measures of upgrading we have discussed is ideal. TFP in its various forms is conceptually attractive in that it is aimed directly at measuring firm capability, but the assumptions required by standard methods are quite stringent, and seem especially unlikely to apply in many developing-country settings. Direct indicators of product quality, product innovation, and technology adoption are increasingly available, and are arguably more credible measures of the dimensions of upgrading they seek to capture. But such indicators are typically only available in particular sectors, raising questions about external validity. Going forward, the literature will need to continue to consider various measures of upgrading, and we should have the most confidence in patterns that show up consistently across measures. But as will become clear below, my sense is that the most compelling recent studies are those that have focused on directly observable measures, and that expanding the settings in which such information is available should be a priority.

3 Drivers of Upgrading

We now turn to our central question: what are the drivers of firm-level upgrading? Motivated by the framework above, I categorize drivers into three groups: (1) *output-side drivers* that affect product demand curves (the $D_{jb}(\cdot)$ functions); (2) *input-side drivers* that affect input-supply curves (the $S_{jk}(\cdot)$ functions); and (3) *drivers of know-how* that affect firms' capabilities or knowledge of products or techniques (the Λ_{it}, J_{it}, and K_{ijt}).

3.1 Output-Side Drivers

On the output side, I focus first on the effects of exporting on upgrading outcomes, because the literature is perhaps the most fully developed, and then turn to the effects of local demand from multinational enterprises, competition in output markets, and other factors.

3.1.1 Exports

Early studies on exporting and productivity — Bernard and Jensen (1995, 1999) using US data and Clerides et al. (1998) using Mexican, Colombian, and Moroccan data — found little evidence that firms increase productivity when they start exporting; the superior performance of exporters in cross-section was explained by the selection of already-higher-performing firms into exporting. The influential Melitz (2003) model was written with these results in mind and is consistent with them: firms with a sufficiently high initial productivity draw enter the export market, but increases in exporting have no within-firm effects on productivity, output quality, or wages. More recent work, however, has found robust within-firm effects of exporting on a number of upgrading outcomes.

3.1.1.1 Exports and Quality

A first-order feature of the world economy, from the perspective of firms in developing countries, is that consumers in international markets are on average richer and hence more willing to pay for product quality than domestic consumers. A natural corollary is that a given developing-country firm will produce higher-quality goods for export to rich countries than for sale in its home market. Verhoogen (2008) develops this idea in a Melitz (2003)-type heterogeneous-firm framework.[20] Using the notation from above, the idea is that greater responsiveness of demand, $D_{jb}(\cdot)$, to quality, φ_{ijt}, in a richer, developed country ("North") than in a poorer, developing one ("South") leads a given firm to sell a higher-quality variety in North than in South. On each product line, firm capability (λ_{ijt}) and input quality ($\vec{\alpha}_{ijkt}$) are assumed to be complements in generating output quality (φ_{ijt}), leading more-capable firms to use higher-quality inputs (here labor) to produce higher-quality outputs, as in Kugler and Verhoogen (2012). There is a fixed cost of entering the export market (f_{ibt}) and only more-capable firms find it profitable to enter. An exogenous increase in the incentive to export leads firms that are already exporting to increase export share and induces some firms on the extensive margin to enter the export market; both sets shift production toward higher-quality varieties, generating an increase in average quality. Given that the production of high-quality varieties requires high-quality inputs, average input quality also rises in more-capable firms relative to less-capable ones.[21] The paper tests this prediction in

[20] Several earlier empirical papers explore the role of quality in trade at a more aggregate level. In addition to Hummels and Klenow (2005), cited above, Schott (2004) shows that the US imports higher-priced products within narrow trade categories from richer countries, suggesting quality differences. In a cross-country setting, Hallak (2006) shows that richer countries tend to demand relatively more from exporters with higher prices (and presumably higher quality). Notable early theoretical papers on quality and trade include Gabszewicz et al. (1982) and Flam and Helpman (1987). It appears that Verhoogen (2008) was the first to use a heterogeneous-firm model to formalize the idea that a given firm will sell a higher-quality variety in a richer market and to explore its implications in firm- (or plant-) level data. The related but distinct idea that firms' quality choices respond to per-unit trade costs has been developed by Feenstra (1988), Hummels and Skiba (2004), Feenstra and Romalis (2014) and others.

[21] Bastos et al. (2018) provide a parsimonious partial-equilibrium formalization of this mechanism in an Atkeson and Burstein (2008)-type framework with exogenous entry and endogenous markups. Other papers that have developed heterogeneous-firm models with endogenous output and input quality choice include Hallak and Sivadasan (2013) (discussed below), Johnson (2012), Fan et al. (2015), and Blaum et al. (2019).

Mexican data using initial plant size as a proxy for capability (since more-capable plants grow to be larger) and examining the differential response of plants to the late-1994 peso devaluation. Initially larger plants increased exports, were more likely to acquire ISO 9000 certification, and increased wages relative to initially smaller plants within the same industry. The differential response was not present in periods without devaluations. The differential quality upgrading generates a link between trade and wage inequality, since the initially larger plants already paid higher wages and further increased wages relative to initially smaller plants within industries.[22]

This basic story has held up reasonably well and has been extended by subsequent research. One source of evidence is price correlations in more disaggregated data. Using trade-transactions data, several papers have documented that firms charge higher prices in richer destinations, within narrow product categories. Bastos and Silva (2010) first documented this pattern in Portuguese data, and it has been shown to hold in Chinese (Manova and Zhang, 2012), French (Martin, 2012), and Hungarian (Görg et al., 2017) data. As mentioned above, positive correlations across firms between firm/plant size and output and input prices (or export volumes and export and import prices) have been found in Colombian, Chinese, and Ecuadorean data (Kugler and Verhoogen, 2012; Manova and Zhang, 2012; Manova and Yu, 2017; Bas and Paunov, 2021b).[23]

A subtle complication is introduced by Hallak and Sivadasan (2013), who document in Indian data that exporters have higher average output prices and are more likely to have ISO 9000 certification than non-exporters conditional on plant size. These facts are difficult to reconcile with a model where firm heterogeneity is one-dimensional, but fit naturally with a model they develop with heterogeneity in two dimensions: in "process productivity," which reduces variable costs conditional on quality (similar to capability, λ_{ijkt} in our notation), and in "product productivity," which reduces the fixed costs of producing quality (i.e. which, in our notation, reduces the fixed costs, f_{ijt}, required to produce high-quality varieties).

An important question in this literature has been whether the upgrading response is attributable to the greater willingness of richer consumers to pay for quality or to two other mechanisms: scale effects, if for instance producing high quality requires paying fixed costs; or distance effects, if for instance per-unit shipping costs are higher for more distant destinations. A small literature has used exogenous changes in export demand from different destinations to separate these channels. Brambilla et al. (2012) show that the Brazilian devaluation of 1999 shifted the composition of export destinations of Argentinian firms toward richer destinations, particularly for those firms previously exporting to Brazil. Estimating separately the effect of exporting to a richer destination and the effect of exporting per se, they find that the former is associated with an increase in skill intensity and wages while the latter is not.[24] In Portuguese data, Bastos et al. (2018) also use the initial composition of destinations together with exchange-rate movements to

[22]The within-plant wage change was stronger for white-collar workers than blue-collar workers, hence wage inequality also increased within plants, a finding further explored in employer-employee data in Frías et al. (2012).

[23]In Chinese and US data, Bloom et al. (2021a) document positive correlations between management scores from the WMS (refer to Section 2.2.3) and various dimensions of exporting behavior, including export quality, consistent with the idea that more-capable plants tend both to select higher-scoring management practices and to produce higher quality than less-capable plants. Eckel et al. (2015) document a positive correlation between sales and output prices across products within firms in Mexican data, consistent with a model in which firms invest more in the quality of their core products.

[24]See also Rankin and Schöer (2013).

show that exogenous increases in exports to richer countries led countries to pay more for their material inputs, again consistent with a quality story. They find no evidence that exogenous changes in exports per se or in average destination distance led firms to pay more for inputs. Although as noted above (refer to equation 4), firms may charge different markups in different markets, and this may in part explain the output-price patterns, the authors argue that differences in markups alone are unlikely to account for the response of *input* prices to the export shocks. Using firm-to-firm data from Turkey, Demir et al. (2021) show not only that that there is assortative matching of high-wage buyers and high-wage suppliers in cross-section (as mentioned above), but also that arguably exogenous increases in export demand from rich countries (reflected by those countries' imports from the rest of the world interacted with Turkish firms' initial composition of export destinations) led to an increase in firms' own wages and in the average wage of their suppliers. The authors also develop a structural model with assortative matching by quality and endogenous network formation and show that it fits well the patterns of firm-to-firm matching.

The above studies have not had access to direct information on quality and have had to draw indirect inferences from prices and other observables. In the absence of direct quality information, it is difficult to rule out other explanations for the price patterns definitively. But a promising literature with access to direct quality measures has corroborated several of the above points. Using wine-guide quality ratings of French champagnes, Crozet et al. (2012) show that firms with higher overall quality ratings charge higher prices, are more likely to export, export higher volumes, and export to more countries. Using similar ratings from Chile, research by Ana Cusolito, Álvaro Garcia-Marin, and Luciana Juvenal, summarized in Cusolito and Maloney (2018), shows that higher-rated wines carry higher prices and are associated with higher material costs. Among soccer-ball producers in Pakistan, where several quality types are directly reported, Atkin et al. (2015) show that larger producers produce a higher share of high-quality balls, at higher average cost, and charge higher prices and markups.

Two recent papers present particularly convincing evidence of a causal effect of exporting on direct measures of product quality. Focusing on Peruvian fishmeal producers, where protein content is an observable indicator of quality, Hansman et al. (2020) use two sources of arguably exogenous variation in the demand for quality on export markets: fishing quotas imposed by the main competing producers of high-quality fishmeal (Denmark, Iceland, and Chile); and destination-market-specific demand shocks for fishmeal interacted with firms' initial composition of exports by destination. They find not only that firms sold higher-protein fishmeal in response to increases in the demand for quality, but also that firms were more likely to integrate vertically, arguably solving a quality-assurance problem due to imperfect observability of input quality.[25] Perhaps the cleanest study of the effect of exporting on quality choices is the experiment with Egyptian rug producers by Atkin et al. (2017a), mentioned in Section 2.2.1 above. The authors paid a local master artisan to evaluate the quality of rugs on a number of dimensions, including the straightness of corners and thread tightness. They find clear increases in product quality among firms that randomly received the initial export contracts.

Overall, the evidence that exporting to richer countries induces firms to upgrade quality seems

[25] This argument echoes earlier research by Woodruff (2002), who found in cross-sectional data among Mexican footwear producers that vertical integration is more likely in firms producing higher-quality shoes.

strong and most consistent with the idea that the driver is the greater willingness of rich-country consumers to pay for quality. That preferences of richer end-consumers matter is reinforced by case studies of Argentinian export industries by Artopoulos et al. (2013), who note that export pioneers often have direct knowledge of end-consumer tastes in developed-country markets.[26] This observation echoes the sociology literature on global value chains which observes that industrial upgrading in many industries has been "buyer-driven," that is, driven by the demands of big retailers selling mainly to rich-country consumers (Gereffi, 1999).

3.1.1.2 Exports and Productivity

In contrast to the literature on exporting and quality, which consistently finds positive within-firm effects, the literature on exports and productivity is mixed. As mentioned above, early papers found little evidence of within-firm effects (Bernard and Jensen, 1995, 1999; Clerides et al., 1998). More recently, De Loecker (2007) compares Slovenian firms that started exporting to firms that remained only in the domestic market, matching on the propensity to export and controlling for common trends, and finds that the productivity of new exporters rose significantly (i.e. that there was learning by exporting), especially for firms that started exporting to richer markets. The paper modifies the Olley and Pakes (1996) procedure by including export status in the construction of the proxy for unobserved productivity in the first stage. (See also De Loecker (2011).) Other papers that have found positive effects of exporting on productivity among developing-country firms include Bigsten et al. (2004), Van Biesebroeck (2005), Álvarez and López (2005), Blalock and Gertler (2004), and Park et al. (2010). By contrast, Aw et al. (2000) find little evidence for learning by exporting in Korea (although they find some evidence in Taiwan), and Luong (2013) implements the De Loecker (2007) approach in China but finds no learning-by-exporting effects. (See also Lopez Cordova (2003) and Iacovone (2012).)

The findings in this literature need to be interpreted with caution, because of the measurement difficulties highlighted in Section 2.2.1 above. Two issues are particularly salient. First, as equation (4) above makes clear, if the elasticity of demand for a firm's products, η_{ijbt}, varies between the domestic and export market, the firm will optimally charge different markups in the two markets. Exporting may bring about changes in standard TFPR estimates by changing average markups, rather than by changing technical efficiency. Second, if firms supply higher-quality products for export than for domestic sale, then a change in average quality produced may affect TFPQ through a change in the degree of quality bias.

Two influential recent papers, De Loecker et al. (2016) and Garcia-Marin and Voigtländer (2019), have sought to address these issues by estimating markups in firm-product-level data. De Loecker et al. (2016) focus more on the response to import tariff reductions than on exports, but it is convenient to discuss the paper here as it forms the basis for Garcia-Marin and Voigtländer (2019); we consider the paper again in Section 3.2.1 below. The authors extend an approach to estimating markups due to Hall (1988) and De Loecker and Warzynski (2012) to apply it at the firm-product level. The key requirement is that among the inputs used to produce a particular output, there is at least one "static" (i.e. costlessly adjustable) input for which a first-

[26] See also Fafchamps et al. (2008).

order condition holds exactly. Returning to our framework, and assuming that firms are price-takers in input markets and that there is a single output market, the first-order condition for cost minimization with respect to the static input (refer to equation (3) in footnote 3) can be re-arranged to yield:

$$\mu_{ijbt} = \frac{\beta^v_{ijt}}{s^v_{ijt}} \tag{7}$$

where v indicates the static input, $\beta^v_{ijt} = \partial \ln Y_{ijt} / \partial \ln M^v_{ijkt}$ and $s^v_{ijt} = W^v_{ijkt} M^v_{ijkt} / P_{ijt} Y_{ijt}$.[27] That is, the product-level markup can be expressed as the output elasticity with respect to the flexible input divided by expenditures on the input as a share of sales of the corresponding product. In Indian data, the authors focus on the subset of single-product firms, for which the expenditure shares s^v_{ijt} are observable, and do a selection-correction to address the fact that single-product firms may not be representative. They estimate the output elasticity, β^v_{ijt}, using a modified version of the Ackerberg et al. (2015) procedure, using output prices, market shares and product fixed effects to proxy for input quality.[28] This method and the earlier work by De Loecker and Warzynski (2012) have come under some criticism. Raval (2020) notes that if there is more than one static input, the calculation for each should yield the same markup, but this prediction is rejected in several datasets. Traina (2018) argues that the estimated markups are likely to reflect management and marketing costs, rather than pure mark-ups. Bond et al. (2021) argue that if the output elasticities such as β^v_{ijt} are calculated using revenue data rather than physical output (as must often be done, given data constraints) then in theory the ratio in (7) will not be informative about markups. The Gandhi et al. (2020) criticisms of the Ackerberg et al. (2015) method of production-function estimation (discussed above) apply here as well (Flynn et al., 2019). At the same time, the markup estimates that the method generates appear to be reasonable and display plausible correlations with other observables; for instance, the estimated markups are positively correlated with the quantity of output, consistent with the reduced-form findings of Atkin et al. (2015).[29] Despite the criticisms, the paper has become a key point of reference for the literature.

Focusing on the relationship between exporting and productivity, Garcia-Marin and Voigtländer (2019) use the De Loecker et al. (2016) method to estimate product-level markups and to correct productivity estimates. They use plant-product data from Chile which report total variable costs at the product level, so the s^v_{ijt} in (7) can be estimated by assuming that materials are used across products in the same proportion as in total variable costs, without having to focus on the subset of single-product firms. The authors then combine the estimated markups

[27] To see this, note that the first-order condition is:

$$\frac{\partial \mathcal{L}_{ijt}}{\partial M^v_{ijkt}} = W^v_{ijkt} - \psi_{ijt} \frac{\partial Y_{ijt}}{\partial M^v_{ijkt}} = 0 \tag{8}$$

where $\mathcal{L}_{ijt}$ is the corresponding Lagrangian, M^v_{ijkt} is the static element of the vector $\vec{M}_{ijkt}$ (used in profit-maximizing technique k^*_{ijt}), W^v_{ijkt} is the corresponding input price, and ψ_{ijt} is the Lagrangian multiplier. Noting that $\psi_{ijt} = \partial \mathcal{L}_{ijt} / \partial Y_{ijt} = MC(Y_{ijt})$, a re-arrangement of (8) yields (7).

[28] The proxy relies on the argument from Kugler and Verhoogen (2012) that producing high-quality output requires high-quality input. If input and output quality are perfectly correlated, then the procedure arguably proxies for output quality differences as well.

[29] See also Gupta (2021).

with observed product prices to calculate product-level marginal cost, an inverse measure of productivity. Using several different identification strategies, including a propensity-score matching estimator and an instrumental-variables (IV) estimator using tariff changes in export destinations, the authors find that marginal costs declined by 15-25% for plants that entered the export market. Strikingly, they find no effect of exporting using a standard TFPR measure, arguably because increases in efficiency were passed on in the form of lower output prices and hence did not show up in revenues. Given that the analysis relies heavily on De Loecker et al. (2016), it is subject to the criticisms mentioned above. But using their rich data, the authors are able to compare their estimated marginal costs to average variable costs at the product level and show that they are highly correlated, which is reassuring. The authors acknowledge the concern that exporting might lead firms to increase product quality, but they argue that increased quality would be expected to lead to higher marginal costs, not the lower marginal costs they find.

The most direct evidence of an effect of exporting on productivity is provided by the study by Atkin et al. (2017a) on Egyptian rugmakers, discussed above. In part for analytical convenience, Verhoogen (2008) and Bastos et al. (2018) model quality upgrading as a shift between lower- and higher-quality goods that a firm already knows how to produce (in our notation, a choice between two products with different φ_{ijt} already in J_{it}, with no change in capabilities, $\Lambda_{it} = \{\lambda_{ijkt}\}$). But Atkin et al. (2017a) argue that the rugmakers learned something in the process of exporting, using two main approaches. In the first, they estimate the effect of treatment on productivity controlling for detailed product attributes and find that it raised TFP. A possible concern, acknowledged by the authors, is that producers chose the product attributes endogenously in response to treatment.[30] This concern does not apply to their second approach, in which the rugmakers produced identical rugs using the same looms in a laboratory. The authors find that treated producers made rugs that scored more highly on observable quality dimensions but took no more time to produce them. They further document that quality improved particularly on dimensions about which the producers communicated with an intermediary who organized the initial export contracts. In the context of our framework, one could ask whether the learning represents a general acquisition of capabilities applicable to all types of rugs (i.e. an increase in λ_{ijkt} for all product-techniques jk) or specifically an increase in capabilities for export varieties (which might include simply learning how to appeal to the tastes of foreign buyers). But it seems clear that some sort of learning has occurred. This study is a nice example of the advantages of collecting direct information on quality and productivity in a controlled setting. This paper and Garcia-Marin and Voigtländer (2019) address the shortcomings of standard TFP estimates in different ways, but tell a consistent story that exporting to richer countries generates productivity improvements in developing-country firms.

3.1.1.3 Exports and Other Dimensions of Upgrading

The literature on the effects of exporting on technology adoption and product scope in developing countries is relatively small. One influential paper is Bustos (2011), which analyzes technology choices by Argentinian firms in response to a regional trade agreement. The author develops a

[30] Conditioning on a set of covariates that respond to treatment may break the balance on unobservables between treatment and control groups; see e.g. Angrist and Pischke (2009, Section 3.2.3).

Melitz (2003)-type model in which firms choose between two technologies: a traditional technology with low fixed cost and high variable cost (in our notation, low f_{ijkt} and low physical output $F_{ijk}(\cdot)$ for a given set of inputs), and a modern technology with high fixed cost but low variable cost (high f_{ijkt} and high physical output $F_{ijk}(\cdot)$ for a given set of inputs).[31] The theoretical predictions are driven by scale effects: a reduction of tariffs by a trading partner leads some firms to increase exports and produce at a larger scale, which raises the incentive to adopt the modern technology. Empirically, sectors with greater reductions in Brazilian tariffs saw greater increases in exporting, in spending on technology, and in indexes of self-reported indicators of process and product innovation. These effects were driven primarily by firms in the third quartile of the size distribution (just above the median) in each sector, which in the Argentinian context tended to be the ones that move from non-exporting to exporting.

Another notable paper is Aw et al. (2011), which develops a structural model of the decisions of Taiwanese electronics producers to invest in research and development (R&D) and to export. In the context of our framework, we can think of R&D expenditures as an investment in future capabilities, I_{it}^{Λ}, and of export market entry, which requires fixed cost f_{ibt}, as also having feedback on future capabilities. The authors allow for one-time sunk costs (i.e. the fixed cost f_{ijbt} is larger the first time a firm exports to market b than in future periods), which require a dynamic analysis. The model can capture rich patterns of interactions between firms' underlying productivity and R&D and exporting decisions. Fitting the model to data on firms' export and domestic sales, capital stocks and R&D decisions, the estimates suggest that, among other things, an expansion of the export market (due, for instance, to a reduction in tariffs by a trading partner) led firms to increase R&D investment and to increase productivity over time. The data unfortunately do not include measures of product innovation or technology adoption, and so it is not possible to relate the findings directly to upgrading outcomes as we have defined them, but the paper is certainly consistent with other evidence that exporting tends to lead firms to be more innovative.

On the whole, the effects of exporting on technology adoption and product innovation in developing countries seem somewhat under-researched. There are several high-quality papers in developed countries — for instance, Lileeva and Trefler (2010) consider the effect of exporting on adoption of advanced technologies and other outcomes among Canadian firms, Aghion et al. (forthcoming) consider effects on patenting by French firms, and Coelli et al. (2022) consider effects on patenting by firms in 65 countries (with the results driven by results in developed countries) — but the marginal value of additional research in developing countries seems high.

3.1.2 Demand from Local Buyers, Foreign and Domestic

The literature on domestic demand conditions and upgrading has tended to focus on the role of multinational corporations (MNCs), considered by many to be a primary driver of upgrading. Foreign entry may generate technological learning spillovers or increased demand (especially for high-quality products) from local firms, but it may also have a "business-stealing" effect (i.e. foreign firms may capture market share in output markets), making it harder for local firms to reap scale economies. The literature has made progress in separating these effects, but has struggled with

[31] Yeaple (2005) previously considered a similar choice in a model with perfect competition and ex-ante-homogeneous firms.

some of the measurement issues discussed above.

In an influential early paper in Lithuanian data, Javorcik (2004) used a sector-level input-output matrix to construct measures of exposure to FDI in a firm's own sector, downstream sectors, and upstream sectors. She found that sectors that supplied the FDI sector experienced productivity gains ("backward" spillovers),[32] but that there was little evidence of a productivity effect in the same sector ("horizontal" spillovers) or in sectors that bought from the FDI sector ("forward" spillovers).[33] In US data, Greenstone et al. (2010) introduce a compelling matching design: they compare counties that won competitions to host large plants (referred to as "million dollar plants," many of them part of MNCs) to counties on the shortlists of candidate locations that lost the competitions. They find that incumbent plants in winning counties saw significant TFP increases, and that the spillovers appeared to occur through worker-flow and technological linkages rather than supplier linkages. A similar strategy has been implemented in Ethiopia by Abebe et al. (2022) who compare areas where a large greenfield foreign plant entered to areas where a new foreign plant was licensed but was not yet operational and find positive productivity effects.

An important limitation of the above studies is that until recently it has not been possible to see input-output linkages at the firm level, and the measures of linkages have had to be constructed using sector- and/or region-level information. A recent paper by Alfaro-Urena et al. (2022) takes advantage of firm-to-firm links in administrative tax data from Costa Rica. The authors implement an event-study design for starting to supply to an MNC and find positive effects on sales to other firms, employment, and standard TFP measures. They also implement two matching estimators, one comparing new MNC suppliers to other candidate suppliers shortlisted by a government agency and one matching on the propensity to begin supplying to an MNC based on observable firm characteristics, and find similar results. In a supplemental survey, firms reported that the MNCs demand high product quality, which in turn requires using high-quality inputs and changes in hiring, sourcing, and organizational practices.

A persistent challenge in this literature has been to estimate effects on local firm performance in a way that is not confounded by the effects of demand shocks on markups. In general, one would expect a new MNC plant to affect the elasticity of demand faced by local suppliers and hence their markups (refer again to equation (4) in our framework) and hence, in turn, standard revenue-based TFP measures. Since selling to an MNC also often involves quality upgrading, simply estimating TFPQ, if quantity information were available, would not solve the problem, for the reasons discussed above.

One promising way forward is to focus on upgrading outcomes that can be directly observed, rather than TFP. Bloom et al. (2019), using the Greenstone et al. (2010) million-dollar-plant design in the US, consider spillovers in management practices, finding some evidence of spillovers but only for firms in sectors with high rates of cross-migration for managers in household data.

[32]Javorcik suggested that pressure on local suppliers to raise the quality of goods sold to foreign-owned firms may have been part of the reason for this effect.

[33]In a recent paper using Romanian data, Bajgar and Javorcik (2020) find forward spillovers on the quality of exports by domestic firms, measured either using unit values or the method of Khandelwal et al. (2013) discussed above, consistent with the idea that greater availability of high-quality inputs induces firms to upgrade output quality.

In Colombia, Macchiavello and Miquel-Florensa (2019) show that the quality-upgrading program of a large MNC buyer, which provided training to farmers and guaranteed a price premium for quality, was successful in increasing the supply of high-quality coffee. More research along these lines would be valuable.

Although the MNC spillovers literature has primarily been focused on manufacturing, there is a small but growing literature on the effects of MNCs in retail. Javorcik et al. (2008) present case-study evidence that Wal-Mart's entry into Mexico had a heterogeneous effect on local suppliers in the soap and detergent industry: the best suppliers began selling to Wal-Mart and faced pressure to reduce prices but also received advice on how to upgrade; weaker suppliers continued to sell through traditional retail channels and just faced increased price competition.[34] Iacovone et al. (2015) develop a dynamic industry-evolution model that captures this effect and find reduced-form evidence consistent with it: in regions with more Wal-Mart stores, and in sectors more likely to be selling to Wal-Mart (e.g. frozen foods), larger plants (presumed to produce products of greater "appeal") increased sales, R&D spending, wages, and imported input shares (presumed to be correlated with product quality) relative to smaller plants. Although the measurement of upgrading is challenging in retail, the sector is modernizing quickly in many countries and will be an important subject for research going forward.

Another sort of buyer-driven effect arises when customers have preferences directly over the technologies used by firms. A nice example is provided by Higgins (2020), who shows that when a large Mexican social program (Progresa/Prospera) began disbursing funds on debit cards, corner stores responded by adopting electronic payment technologies. This in turn increased demand by non-beneficiary consumers for debit cards, creating a two-sided feedback loop. Another example is provided by consumer pressure on MNCs, and hence their suppliers, regarding working conditions: several studies have found evidence that anti-sweatshop pressure has increased wages and improved working conditions (Harrison and Scorse, 2010; Tanaka, 2020; Boudreau, 2021).

3.1.3 Reputation in Output Markets

Our framework and the quality models discussed above treat quality as observable and enforceable in contracts. But in the real world, information is often asymmetric. Buyers may only learn about the quality of a good after a transaction has taken place, and, if quality is specified in a contract, may have difficulties getting a court to enforce the contract. These issues are especially severe in developing countries, where quality and reliability vary greatly across firms and legal institutions are often weak. In such settings, firms typically rely on repeated interactions and the threat of discontinuing a relationship to enforce agreements; in other words, they enter into relational contracts (MacLeod and Malcolmson, 1989; Baker et al., 2002). But establishing a relational contract, and developing a reputation for quality and reliability, can take time and require up-front investments. Buyers may use average quality in a country or country-sector to form expectations about the quality of a particular firm, making it more difficult for the firm to establish a good reputation. Given this collective-reputation issue, it may not optimal for individual firms to upgrade: there may be a low-quality equilibrium trap (Tirole, 1996). In such

[34] Atkin et al. (2018) document that foreign retailers in Mexico charge prices that are on average 12% lower than modern domestic retailers, for the same barcode-level product in the same location in the period they study.

situations, mechanisms that help firms to build individual reputations may stimulate upgrading. In addition, networks of firms may facilitate contracting, by providing information about potential trading partners, enhancing a firm's ability to sanction partners who renege, and giving the group an incentive to police its own members in order to maintain a good group reputation. Quality standards, in the form of either regulatory requirements or voluntary certifications, can also help to move an economy out of a low-quality trap.

A small but growing literature has explored these issues empirically in developing countries. Early papers focused primarily on carefully documenting correlations consistent with relational-contracting models. Among Vietnamese firms, McMillan and Woodruff (1999) showed that firms' willingness to supply trade credit was correlated with, among other things, how easy it was for the partner to find another supplier, how long the two parties had been transacting, and the density of network links. Among Indian software firms, Banerjee and Duflo (2000) showed that older firms and firms with a long-term, open-ended relationship with a buyer were offered more attractive contracts, in the sense that the buyer accepted more responsibility for cost overruns. More recently, Macchiavello (2010) shows that Chilean wineries receive more attractive terms from UK wine distributors over time, controlling for such factors as quality and winery-distributor match effects, suggesting that the wineries acquire improved reputations over time. Examining the response of Kenyan rose exporters to a major supply disruption brought about by ethnic violence in 2008, Macchiavello and Morjaria (2015) find an inverted-U relationship between relationship age and the exporters' compliance with agreements to provide flowers during the violence, consistent with a model in which the value of a relationship increases with age, but once sellers have established their reputations with buyers they do not have to worry as much about damaging their reputation by not complying.

Several recent papers have exploited quasi-experimental or experimental designs to make stronger causal statements about the role of reputation. Focusing on the Chinese dairy industry, Bai et al. (forthcoming) show that a quality scandal — a subset of producers were found to have added the industrial chemical melamine to baby formula — had a group-reputation effect. Comparing the dairy industry to other 2-digit industries in a difference-in-differences design, they find that exports dropped by 68% overall for the sector and that even firms that were inspected by the Chinese authorities and found to be innocent were negatively affected, with similar declines in sales as for those found to be guilty. Two recent experiments provide convincing evidence that technologies that enable firms to differentiate themselves from the mass of low-quality firms can facilitate upgrading. Among watermelon sellers in Chinese produce markets, Bai (2021) shows that simply giving sellers a hard-to-counterfeit way of marking their watermelons was sufficient to induce them to upgrade the quality of goods sold with that mark. On the e-commerce platform AliExpress, Bai et al. (2021) randomly allocated orders among producers of observably identical children's T-shirts. They find that the orders increased sellers' visibility to buyers and had lasting effects on firms' sales. The fact that such a small intervention had a lasting effect is consistent with the idea that new firms, even those with viable products, face difficulties initially in establishing a reputation. The algorithm by which AliExpress ranks sellers matters in this context and remains something of a black box. But the paper is notable in illustrating how rich data from online platforms can be leveraged to explore reputation mechanisms. Tadelis (2016) reviews other studies using such data, mostly from developed countries. This area is very fertile ground for research.

3.1.4 Competition in Output Markets

Competition in output markets is also commonly perceived to be an important driver of upgrading. Competition clearly has important effects on the allocation of resources across firms and hence on overall economic performance (Restuccia and Rogerson, 2013, 2017; Hopenhayn, 2014). For the purposes of the current review, however, the key question is to what extent competition has *within-firm* effects on behavior. As memorably phrased in the title of Lawrence (2000), the question is: "Does a kick in the pants get you going or does it just hurt?" The conceptual link between increased competition and upgrading within firms is not obvious. In our framework, competition would be expected to increase the elasticity of demand and reduce markups (refer again to equation (4)), but it is not clear why it would affect upgrading outcomes. A common argument is that firms do not maximize profits prior to the increase in competition and are spurred to do so by the competitive threat. But that begs the question of why firms were not maximizing profits in the first place. One also needs a mechanism strong enough to overcome the possible reduction in scale — and hence in scale economies — by firms facing stronger competition. Holmes and Schmitz (2010) review the theoretical research on these issues, focused mainly on developed countries, and find little consensus about theoretical mechanisms.

There is reasonably convincing evidence of a positive within-firm effect of competition on performance in particular cases. For instance, Schmitz (2005) finds significant increases in productivity of US iron ore firms in response to the lower prices of Brazilian ore in the 1980s, and argues that they were mainly due to changes in work practices, as the competitive threat led unions to be more flexible about work rules. Schmitz marshals direct evidence from collective bargaining contracts and staffing levels, in addition to more conventional productivity estimation. Das et al. (2013) focus on a public-sector rail mill in India which was for many years the exclusive producer of long rails for Indian railroads. In the late 1990s, the Indian government invited private companies to enter. Output per shift in the rail plant, measured in physical units, rose by 30% in a matter of months. Jensen and Miller (2018) study boat-builders in Kerala, India, where the expansion of cellphone coverage led fishermen to travel farther to sell their fish (to markets with the highest prices), increased their knowledge of boat-builders in other villages, and arguably increased competition in the boat-building market. This led to an expansion of higher-skilled (and higher-quality) boat-builders and a contraction of lower-skilled ones, raising average quality and enabling greater capacity utilization and labor specialization within the higher-skilled firms. Fang et al. (2020) show that the expansion of high-speed rail in China led airline firms to reduce flight delays (a dimension of quality) on competing flights. In the Chinese footwear industry, Qian (2008), shows that, following a decline in enforcement of anti-counterfeiting rules in 1995, there was increased entry of low-quality producers selling counterfeit brands. To differentiate themselves, more-productive, higher-quality producers upgraded quality and vertically integrated downstream by opening company stores.

There is also now a substantial literature on the effects of reductions in import tariffs on standard TFP measures, with somewhat mixed findings. Shu and Steinwender (2019) provide a thorough review; here let me just highlight a few key papers. An early paper by Pavcnik (2002) used the Olley and Pakes (1996) methodology to estimate TFP in Chilean data and found that, following a unilateral liberalization in the late 1970s, productivity increased in import-competing industries relative to non-traded industries. Amiti and Konings (2007) also apply the Olley and Pakes (1996) methodology, in Indonesian data, and innovate by estimating separately the effects of tariffs on outputs and inputs. The effects of output-tariff reductions on productivity are positive but modest, especially relative to the input-tariff effects (which we return to in Section 3.2.1 below). Brandt et al. (2017) estimate the effect of China's accession to the World Trade Organization on TFP and markups in Chinese firms, using the methods of Ackerberg et al. (2015) and De Loecker and Warzynski (2012), with corrections published two years later (Brandt et al., 2019); in the corrected version, there is no significant effect of output tariffs on productivity within firms. Bas and Paunov (2021a) have access to quantities and prices at the firm-product level in Ecuador, and are able to estimate effects of output and input tariff changes on TFPR and TFPQ as well as on markups, prices and product quality, using the methods of De Loecker et al. (2016) and Khandelwal et al. (2013). They find positive effects of output-tariff reductions on both TFPR and TFPQ. Using similar data from Chile, Cusolito et al. (2021) find a negative impact of the "China shock" on TFPQ on average.

The literature on output tariffs and firm performance has remained subject to two persistent concerns. First, as noted by Holmes and Schmitz (2010), many studies focus on surviving firms, which may be a selected sample. The effect of competitive pressure may be to kill off less-capable firms, rather than to spur firms to improve their performance. In that case, regressions of within-firm TFP changes on output tariff reductions may spuriously indicate productivity improvements only because non-improving firms drop out of the data. Second, at least some subset of the concerns with TFP estimates raised in Section 2.2.1 — regarding price, quality, and variety biases, and the strength of the required monotonicity assumptions — apply even to the best papers in this literature.

There is also credible evidence suggesting that competition can be bad for within-firm performance in some cases. In an historical context, Juhász (2018) shows that temporary protection from British imports during the Napoleonic wars promoted adoption of mechanized cotton spinning in Northern France relative to Southern France (where the protection was less effective). In the Rwandan coffee sector, Macchiavello and Morjaria (2021) use Rwanda's rugged geography to construct an instrument for the location of mills and find that an additional mill within 10 km is associated with higher operating costs, lower output, and lower-quality coffee. The authors argue convincingly that greater competition reduces the rents available to sustain relational contracts, which are required in a context with weak contract enforcement such as Rwanda. It is also worth noting that the evidence on output-market competition and innovation in developed countries is mixed: Bloom et al. (2016a) find positive effects of the China shock on innovation in a group of European countries, but Autor et al. (2020) and Aghion et al. (2021) find negative effects in the US and France, respectively.[35]

Overall, the preponderance of recent evidence is consistent with a modest positive effect of output-market competition on within-firm upgrading on average. But there are enough empir-

[35] See also Campbell and Mau (2021) and Bloom et al. (2021b) on Bloom et al. (2016a), and the review of earlier work by Cohen (2010).

ical issues and contrasting results that in my view the evidence has to be considered less than definitive. More research is needed to better understand the conditions under which competition stimulates within-firm upgrading. One interesting idea, which has not been extensively explored at the firm level, is that competition provides more of a positive stimulus for firms closer to the world technological frontier than for those further away.[36] It is also worth keeping in mind that competition may have important effects on aggregate economic performance by reducing misallocation of resources across firms, separate from the within-firm effects considered here.

3.2 Input-Side Drivers

We turn now to drivers on the input side (i.e. that influence the input-supply curves $S_{jk}(\cdot)$), considering first the role of imported inputs and then factors that influence the prices and availability of domestic inputs.

3.2.1 Imported Inputs

Similar to the way firms sell higher-quality varieties on the export market, it appears that they buy higher-quality inputs on international markets than on domestic ones. In Colombian data, for instance, Kugler and Verhoogen (2009) document that plants systematically pay higher prices for imported inputs, controlling for detailed product effects.[37] In the context of our framework, a reduction in import costs will shift out the supply functions ($S_{jk}(\cdot)$) of higher-quality inputs, with higher α_{ijkt}, relative to lower-quality inputs. If higher-quality inputs are required to produce higher-quality output, as suggested above, we would expect this to lead firms to produce higher-quality outputs. Bas and Strauss-Kahn (2015) provide evidence for this mechanism in Chinese trade-transactions data. Comparing processing firms (which are exempt from tariffs) to non-processing firms, they find that tariff reductions on inputs led non-processing firms to increase the prices they paid for inputs and to increase the prices they charged for outputs. The results are primarily driven by firms that imported most of their inputs from, and exported most of their outputs to, developed countries. Results are similar if they use the Khandelwal et al. (2013) methodology to construct measures of input and output quality. A roughly contemporaneous paper by Fan et al. (2015) also finds that Chinese firms responded to reduced tariffs on imported inputs by raising export prices and quality, and that this effect is stronger in more differentiated sectors. (See also Feng et al. (2016) and Abeberese (2016).) An obvious limitation of trade-transactions data is that they include only international transactions, which may not be representative. However, Bas and Paunov (2021b) find broadly similar results with representative data from Ecuador (linking customs data to a more traditional plant panel survey), and find in addition that imported-input-driven upgrading is stronger in more skill-intensive firms and is in turn associated with increases in skill intensity.

[36] See Aghion et al. (2005a,b, 2021), Amiti and Khandelwal (2013), and Cusolito et al. (2021); Fieler and Harrison (2020) develop a related idea of escape from import competition to less-competitive market segments.

[37] Importing plants also pay more on average for their inputs than non-importing plants, even for domestic inputs, consistent with the ideas that there are fixed costs of importing and that more-capable plants use imported inputs, which tend to be higher-quality, to produce higher-quality products. See also Blaum et al. (2019).

In an interesting extension of this line of work, Fieler et al. (2018) develop a theoretical model in which there is an amplification effect in upgrading: tariff reductions on inputs lead firms to upgrade the quality of outputs, which increases their demand for other high-quality inputs, which gives incentives for local suppliers to upgrade, which gives final-good producers further incentives to upgrade. Empirically, the authors calibrate their model to Colombian data before a round of unilateral tariff reductions and do counterfactual simulations of the effects of tariff reductions. Now that datasets with firm-to-firm links are increasingly available, a promising line of research would be to investigate this mechanism in a less theory-dependent way.

Tariff reductions not only reduce costs of high-quality imported inputs, they also expand the variety of inputs available (or at least make it less costly for firms to import new varieties), which may in turn enable firms to produce new outputs. Focusing on India's liberalization in the early 1990s, Goldberg et al. (2010) document a reduced-form relationship between import-tariff reductions and expansions of output variety. They also impose a simple theoretical structure to separate the price and variety effects of the tariff reductions, inferring that a substantial share of the increase in product scope was driven by the expansion of imported input variety. Although Goldberg et al. (2010) do not have access to information on inputs at the firm level, Bas and Paunov (2019) directly observe both inputs and outputs of Ecuadorean firms and confirm that import tariff reductions led firms to use more varieties of inputs and to expand product scope. Overall, the evidence seems strong that increased access to imported inputs can stimulate upgrading through both the quality and variety channels.[38]

There also appears to be a robust causal relationship at the firm level between reductions of tariffs on imported inputs and increases in standard measures of revenue TFP. This relationship has been documented for instance by Schor (2004) in Brazil, Amiti and Konings (2007) in Indonesia, Topalova and Khandelwal (2011) and Nataraj (2011) in India, Brandt et al. (2017, 2019) in China, and Bas and Paunov (2021a) in Ecuador. For a more complete discussion, readers are referred again to Shu and Steinwender (2019), who observe that papers that have considered tariffs on outputs and inputs separately have tended to find stronger effects of input-tariff reductions than of output-tariff reductions. At the same time, a recurrent issue in this literature is the extent to which the results reflect changes in markups. As discussed in Section 3.1.1.2 above, De Loecker et al. (2016) estimate firm-product-level markups and find that Indian import tariff reductions caused a reduction of marginal cost that was only partially passed through to consumers: product prices declined, but by less than marginal costs, and hence markups rose. This suggests that the estimated effects of import tariff reductions on standard TFPR measures — which incorporate both technical efficiency and markups (as discussed in Section 2.2.1) — overstate the true effect on technical efficiency. Moreover, if import-tariff changes affect input- and output-quality choices, as suggested at the beginning of this subsection, they may exacerbate quality biases in estimated TFPQ.

[38] Relatedly, the presence of MNCs can increase the thickness of local input markets, which can be beneficial for domestic firms. Among Bangladeshi garment firms, Kee (2015) finds that local "siblings" of foreign-owned firms, which shared a local supplier, increased productivity and product scope when, for arguably exogenous reasons, the market share of the foreign-owned sibling expanded, consistent with an input-market-thickness effect.

3.2.2 Domestic Inputs

Several papers have investigated how changes in the cost of labor, capital, or other inputs on the domestic market affect firms' upgrading decisions. Supply shocks of workers of different skill levels are one possible driver. In our framework, if newer vintages of product-techniques (jk) are particularly intensive in higher-skill workers (as suggested by Goldin and Katz (1998) and others), then we would expect outward shifts in the supply functions $S_{jk}(\cdot)$ for higher skill levels (or inward shifts is supply functions for lower skill levels) to be associated with new technology adoption.[39] Some of the best work on this topic is from the US: using a shift-share instrument for immigration, Lewis (2011) shows that US manufacturing firms in regions with greater inflows of low-skilled migrants were less likely to adopt advanced technologies, and Hornbeck and Naidu (2014) show that greater outflows of low-skilled workers from the US South, in response to a major flood in 1927, led farms to increase mechanization.[40] In a similar vein in a developing-country context, Imbert et al. (forthcoming) use agricultural price shocks combined with historical migration patterns in China as a source of exogenous inflows of low-skilled migrants to urban areas. Firms in areas that receive more low-skilled migrants are less likely to file domestic patents and shift toward products with low human-capital intensity (defined as the average share of the workforce with a high-school degree among firms that produce a given product).[41]

Two recent papers using city-level minimum-wage variation in China provide evidence that minimum-wage regulations, which raise the relative cost of less-skilled labor (in addition to raising wage costs overall), can have effects similar to an increase in relative supply of more-skilled labor. Mayneris et al. (2018) find that firms more exposed to the minimum-wage hikes (whose average wage in the previous year was below the new minimum wage) saw increases in productivity relative to less-exposed firms. Hau et al. (2020) also find that firms more affected by minimum wage changes (whose average wages were closer to the minimum) tended to see increases in measured TFP and shifted to more capital-intensive production, with some heterogeneity based on firm characteristics. The usual caveats about TFP estimation apply, but broadly these papers suggest that higher wages overall (which induce firms to substitute capital for labor) and/or higher relative costs of low-skilled workers (which induce firms to substitute high-skilled for low-skilled labor) can lead firms to upgrade.[42]

Using a regulatory change in India that removed size-based entry barriers in certain products and hence reduced the price of certain inputs, Boehm et al. (forthcoming) find that reduced input prices induced firms to start producing new products that are intensive in the use of the liberalized inputs. They find, moreover, that firms already using those inputs had a comparative advantage in moving into the new products.

Given the effects of shocks to the relative supply of high-skill workers, one might expect to

[39]To the extent that there is capital-skill complementarity, we would also expect relative increases in the supply of skill to be associated with capital investment and hence rising capital intensity. Since new technology is often embedded in capital, empirically these hypotheses are difficult to distinguish. But in principle, greater supply of higher-skill worker could induce technology adoption without capital deepening or vice-versa.

[40]See also Clemens et al. (2018).

[41]Related work by Bustos et al. (2022), with data at a regional level in Brazil, suggests that such shifts into low-skill-intensive manufacturing may have lock-in effects, with negative growth consequences in the long run.

[42]To be clear, although higher minimum wages appear to have spurred upgrading in these cases, they may well have reduced profits for individual firms.

find similar results for shocks to the supply of capital. For instance, if capital is complementary to skilled labor, and skilled labor is instrumental in the adoption of new technology or other forms of upgrading, one would expect increases in the supply of capital to stimulate upgrading. Greater access to capital might also lead firms to purchase new machines embodying technologies that are new to the firm. But there have been few studies linking credit shocks directly to firm-level productivity, quality, technology adoption, or product scope among larger non-agricultural firms,[43] and those few have mostly failed to find evidence of such an effect. In a difference-in-differences framework, Bau and Matray (forthcoming) examine the effect of a policy reform in India that removed some restrictions on foreign investment, increasing the supply of capital, in a staggered way across industries. They primarily focus on misallocation, but they also estimate the impact of the reform on measures of TFPR and TFPQ and do not detect an effect. Also in India, Rotemberg (2019) examines the effects of a 2006 broadening of the set of firms in India eligible for subsidies to small and medium-sized businesses, similar to an earlier change studied by Banerjee and Duflo (2014). The affected firms became eligible for a range of programs, but the most important (70% of the budget for such programs) appears to have been subsidized credit. Rotemberg focuses primarily on quantifying the direct and indirect contributions of the subsidies to aggregate productivity, but he also examines their direct effects on firm-level TFPQ and finds no evidence of an effect. Cai and Harrison (2021) study a reform in China that reduced the value-added tax on investment goods, with the goal of encouraging technology adoption. They find an increase in capital intensity but no effects on fixed investment, product introductions, or productivity. It may be that the measurement issues highlighted in Section 2.2.1 are obscuring an underlying relationship between capital inputs and upgrading, but existing research does not provide convincing support for such a link.

Energy inputs are often measured reasonably well in manufacturing surveys in developing countries, and a small literature has examined the role of shocks to energy supply or prices on firm-level upgrading outcomes. Abeberese (2012, 2017) examines the relationship between electricity prices and various dimensions of firm behavior, using arguably exogenous variation in coal prices interacted with the initial share of thermal generation (which uses coal) in states' electricity generation. She finds that higher electricity prices induced firms to shift their product mix toward less electricity-intensive products (as proxied by the average electricity use of firms producing a given product), which were plausibly less technologically advanced. She also finds a negative (although not significant) relationship between electricity prices and the level of productivity, and a negative and significant relationship between electricity prices and the growth rate of productivity.[44] A subsequent paper by Allcott et al. (2016) pursues a related strategy. Using rainfall at higher elevations (which determines hydro-electric power generation capacity) as an instrument for shortages (rather than electricity prices), the authors find that shortages led Indian firms to contract in terms of sales and input purchases but they do not find a significant effect on TFPR. Simulations suggest that there is more of a negative effect for firms that do not already have

[43] There are small literatures on credit availability and technology adoption in agriculture (see e.g. Giné and Klonner (2008) and the review in Jack (2013, Section 5)) and households (see e.g. Berkouwer and Dean (forthcoming)).

[44] In related work in Chinese data, Fisher-Vanden et al. (2015) find that firms respond to higher electricity prices by outsourcing more inputs, but the effects on productivity are muted.

generators, which are smaller on average.[45]

A number of government interventions have sought to stimulate upgrading by subsidizing inputs. One popular policy is to offer matching grants, which typically allow firms to choose which inputs to use the subsidy on. These interventions have been difficult to analyze rigorously. Campos et al. (2014) report on seven planned randomized evaluations, none of which was carried through to a successful conclusion, because of political pressures, delays in implementation, or low take-up. By contrast, McKenzie et al. (2017) successfully randomized matching grants for business services in Yemen and found short-term positive effects on new investment and new product introductions. (War subsequently broke out in Yemen, making follow-up impossible.) Input-subsidy programs have also been important in agriculture. For instance, Carter et al. (2021) randomly offered subsidies for a package maize seeds and chemical fertilizer in Mozambique and find large effects, including approximately a 29% increase in use of the technology package and 23% increase in yields. More research evaluating similar interventions among non-agricultural firms would be very valuable. In this context, it will be important to pay attention to exactly which inputs are being subsidized; the discussion above suggests that we would expect upgrading to result from subsidies for certain types of inputs (skilled workers, high-quality materials) but not necessarily all types.

3.3 Drivers of Know-How

This section reviews research on drivers of firm capabilities and knowledge. A first issue that must be confronted is the motivation of entrepreneurs, in particular whether or not they can be presumed to maximize profits. We then turn to various factors that influence firms' capabilities and knowledge.

3.3.1 Objectives of Entrepreneurs

The framework in Section 2.1 assumes that firms seek to maximize the discounted present value of profits. Is this a plausible assumption? One reason it may not be is that entrepreneurs consciously hold other objectives, for instance to live a quiet life (Bertrand and Mullainathan, 2003), to empire-build (Williamson, 1964), or to gain (or simply to preserve) status for oneself or one's family in the broader society outside the firm (Bloom and Van Reenen, 2007; Lemos and Scur, 2019).[46] One evocative piece of evidence on the family-status concern comes from Lemos and Scur (2019), who show that family-managed firms bearing the family name tend to have lower-scoring management practices in the World Management Survey than family-managed firms not bearing the family name. But on the whole, the direct evidence on the objectives of entrepreneurs remains thin. The recent review by Kremer et al. (2019) devotes a section to "behavioral firms" but asserts that "we have a limited understanding of what the objectives of firm-owners in developing countries are"

[45]Relatedly, Abeberese et al. (2021) find negative impacts of outages on productivity among small and medium-sized Ghanaian firms. (See also Hardy and McCasland (2021b), which focuses on microenterprises.) Ryan (2018) finds that randomized energy audits in Indian manufacturing firms, which appear to have increased energy efficiency, led firms to expand their use of energy. In related work on the role of infrastructure, Hjort and Poulsen (2019) focus on the effect of the arrival of fast internet in Africa on skill upgrading, but also find positive effects on productivity in Ethiopia (as well as on exports from several countries).

[46]Although the quiet-life and empire-building motivations are typically attributed to non-owner managers, they might also characterize owner-entrepreneurs themselves.

(p. 418). Direct elicitations of entrepreneurs' consciously held objectives would be valuable in this regard.

Another reason why entrepreneurs may not profit-maximize is simply that (although they would like to maximize profits) they have behavioral biases that lead them to make mistakes. There is evidence that mistakes are made by small shopkeepers, in the form of lost sales due to holding insufficient change (Beaman et al., 2014), and by agricultural producers, in the sense of failing to notice relevant information about production (Hanna et al., 2014) or failing (because of time-inconsistent preferences) to invest in fertilizer (Duflo et al., 2011). But more research on such behavioral biases among owners of larger non-agricultural firms is needed.

Two words of caution are in order here. First, the question of whether an individual *entrepreneur* seeks to maximize profits is distinct from the question of whether a *firm* does so. As we will see below, a firm may fail to take advantage of an apparent profit-making opportunity, even if all individuals within the firm are behaving rationally in pursuit of standard objectives. Second, it appears to have become more common in recent years to attribute poor firm performance in developing countries to failures of entrepreneurs to profit-maximize. But as noted above, entrepreneurs in developing countries often face very different conditions in product and input markets, and hold different amounts of know-how, from rich-country entrepreneurs. We need to examine very closely the constraints they face before we can conclude that they have failed to optimize. In an agricultural context, Schultz (1964) and others have argued for a "poor but rational" view: if we observe behavior that appears to be non-optimal, we should ask ourselves what problem is being solved, and what constraints producers face, before concluding that they are not optimizing. A similar point applies to entrepreneurs in larger non-agricultural firms. This is not to say that all developing-country entrepreneurs are perfect exemplars of *Homo Economicus*, but rather that we should exercise caution before concluding that they are not.

3.3.2 Entrepreneurial Ability

We can think of entrepreneurial ability as a fixed characteristic of an individual entrepreneur — in our framework, as a time-invariant component of capabilities that is common across products and techniques. Recent research has taken several approaches to evaluating its importance. One branch has carefully documented cross-sectional correlations between manager characteristics and firm performance. For instance, there is evidence from a range of countries, including Brazil and India, that firm performance is positively correlated with the amount of time CEOs spend in high-level meetings, rather than production activities (Bandiera et al., 2020). Focusing on six factories of an Indian garment firm, Adhvaryu et al. (forthcominga) find that factor-analytic summary measures they interpret as capturing managers' attentiveness and sense of internal locus of control correlate positively with levels of productivity and the rate of productivity improvement on production lines.[47] In US data, Bertrand and Schoar (2003) find that manager fixed effects have significant explanatory power for various corporate decisions, even controlling for rich sets of

[47]Relatedly, Adhvaryu et al. (2022) find that more "attentive" managers (i.e. who monitor frontline workers more frequently and have higher values of an index of active personnel management) are more likely to reallocate workers in response to negative worker-level productivity shocks from pollution exposure and are better able to mitigate productivity losses on their lines.

firm observables.

Two quasi-experimental approaches to examining the relationship between entrepreneurial ability and firm performance have been particularly successful. One has focused on CEO successions, from founders to family members or to professional managers. It has long been recognized that inherited family control is associated with worse performance (Pérez-González, 2006; Bertrand et al., 2008) and with lower scores on the World Management Survey index (Bloom and Van Reenen, 2007, 2010; Bandiera et al., 2017). Bennedsen et al. (2007) have the additional insight that the gender of the departing CEOs first-born child affects the probability of family succession but plausibly has no direct effect on firm performance and hence can serve as an instrument. Using such an IV strategy, they find that family succession had a large negative effect on firm profitability in Danish data. Lemos and Scur (2019) pursue a similar strategy, using indicators for the number of sons and for whether there is at least one son among a given CEO's children, and find that family successions led to less adoption of "structured" management practices (of the sort that score highly on the World Management Survey). The gender-composition instrument is credible and the evidence seems strong that inherited family control leads to worse performance.[48] This raises a question of why family control is so prevalent, a topic to which we return in the next subsection.

Another successful approach has been to focus on changes in ownership. Using detailed data on ownership and physical inputs and outputs in the Japanese cotton spinning industry in the Meiji era, Braguinsky et al. (2015) find that acquisitions were associated with increases in TFPQ in the acquired firms. Interestingly, the acquiring firms typically did not have higher physical productivity than the acquired firm prior to purchase, but they were more profitable, in part, the authors suggest, because they were able to manage demand fluctuations to maintain higher levels of capital utilization. Using a propensity-score matching estimator in Spanish data, Guadalupe et al. (2012) find that acquisition by an MNC firm led to upgrading on a number of directly observable dimensions, including indicators for process and product innovations, purchases of new machinery, and the introduction of new organizational practices. Studies in developing countries have largely found positive effects of foreign ownership on productivity (Arnold and Javorcik, 2009; Javorcik and Poelhekke, 2017; Stiebale and Vencappa, 2018), although there is still a debate about whether acquisition by MNCs has larger impacts than acquisition by domestic firms (Wang and Wang, 2015). In Indian data, Stiebale and Vencappa (2018) also find evidence of a positive effect of foreign acquisition on quality upgrading, indicated both by an increase in input prices and by a measure of product quality along the lines of Khandelwal et al. (2013). Ownership changes are not randomly assigned, and it is difficult to rebut definitively the objection that changes are associated with unobserved characteristics of the acquired firm, but the preponderance of evidence suggests that foreign acquisition leads to upgrading. It will be useful to investigate further the role played by the characteristics of the acquiring firms, in particular whether it is especially acquisitions by MNCs from richer countries that generate upgrading.

[48] In line with our framework, I am interpreting the poor performance of family-managed firms primarily as evidence of low entrepreneurial ability, although it is important to acknowledge that non-profit-maximizing objectives of family managers (discussed in Section 3.3.1) could lead to similar outcomes.

3.3.3 Organizational Issues

Firms are collections of people with sometimes aligned and sometimes conflicting interests. Even if an entrepreneur is rational and of high ability, she may still have difficulties in getting employees to act in a desired way. In the context of our framework, these agency issues can be thought of as influencing a firm's capabilities, Λ_{it}. There is increasing evidence that the extent to which firms are able to resolve such issues matters for their ability to upgrade. The literature on organizations and how they seek to resolve agency issues is vast;[49] here I focus on a few particularly relevant empirical studies in developing-country firms.

The study of Pakistani soccer-ball producers by Atkin et al. (2017b) highlights the importance of organizational barriers to technology adoption. Through a series of fortuitous events, the research team came up with a new technology — a design for cutting more pentagons from a rectangular sheet and a piece of equipment, an "offset" die, to implement the design. An advantage of the context is that all firms use the same, simple production process, at least for part of their production, and it is possible to calculate directly the benefits of adoption, which are positive on net for essentially all firms.[50] The researchers gave out the technology to 35 firms, expecting the treated firms to adopt quickly and planning to track the channels of spillovers. But 15 months later, only 5 treated firms and 1 control firm had adopted, despite the fact that the technology appeared to be working as expected. Conversations with firm owners and employees suggested the reason: the key employees, cutters, were paid piece rates based on the number of pentagons cut, with no incentive to reduce waste, and the offset die slowed them down initially. Although the reductions of waste were much larger than the increases in labor costs, under the existing payment scheme the cutters' incomes would have declined with adoption and so they found various ways to discourage it. The researchers conducted a second experiment which effectively solved the agency problem for the firm: employees received a bonus of a month's salary if they demonstrated the productivity benefits of the new die in the presence of their employer. The second experiment generated a statistically significant increase in adoption by firms, suggesting that a conflict of interest within the firm had been at least in part responsible for the initially slow adoption of the offset dies. A natural question is why firm owners did not adjust their payment schemes to reward the employees for adopting the new technology on their own. One possibility is that owners simply did not understand the problem; another, consistent with qualitative evidence gathered by the authors, is that they understood the problem but that there are costs to changing employment contracts, even informal ones, and that owners calculated (perhaps with low priors about the value of the technology) that the expected benefits would not compensate for the re-contracting costs. In the latter interpretation, the failure to adopt the new dies is an example of what Garicano and Rayo (2016) call an "organization failure" — the firm as a whole failed to adopt a more-efficient technology, even though all individuals in the firm appear to have been acting rationally, given their knowledge (a possibility alluded to in Section 3.3.1 above). The case is also arguably an

[49] See for example the reviews by Gibbons (2010), Gibbons and Henderson (2013), Lazear and Oyer (2013), and Garicano and Rayo (2016). Bandiera et al. (2011) review related work on how social connections and incentives can affect productivity.

[50] The cost reduction is modest, approximately 1% of total costs, but the fixed costs of adoption are also modest. The authors calculate the time required to recoup the fixed costs to be less than 8 weeks for 75% of firms in the treatment group.

example where contracts that were optimal in a technologically static environment (here, piece rates before the new die) were not optimal in a technologically dynamic one (once the new die was available), and the stickiness of contracts generated a sort of organizational inertia.

Just as relational contracts matter for firm-to-firm contracting (see Section 3.1.3), they play a role in mitigating agency issues within firms. Two recent experimental studies, de Rochambeau (2020) and Kelley et al. (2021), provide novel evidence on the role of such relational contracts. The contexts are similar: in both studies, the researchers gave out GPS monitors, to Liberian trucking firms in de Rochambeau (2020) and to two-person minibus firms in Nairobi, Kenya, in Kelley et al. (2021). de Rochambeau (2020) finds that the effect of such monitoring technology can be heterogeneous, depending on the nature of the relationship between firm owners and their employees. In particular, the monitors reduced unauthorized breaks and average travel times for the trucks on which they were installed, as classic effort-extraction models (e.g. Shapiro and Stiglitz (1984)) would suggest, but owners were less likely to install the monitors for drivers with better performance at baseline, who tended to be from the same county (an analogue of co-ethnicity in the Liberian context). Moreover, the high-initial-performance drivers who did receive the monitors subsequently performed less well on non-monitored tasks. It appears, in other words, that the monitoring had a perverse negative effect on drivers with whom owners had stronger relational contracts at baseline. The independent, roughly contemporaneous study by Kelley et al. (2021) finds that the effects of giving owners access to the GPS information were again in line with classic theoretical predictions: drivers worked longer hours and spent less time off-route (which increases driver income but tends to damage the minibuses). The authors also develop and estimate a structural relational-contracting model which allows them to estimate the welfare effects of the improved monitoring. The results suggest that surplus at the firm level increases but drivers are worse off on net, since they lose the information rent they formerly enjoyed due to the unobservability of effort to the owners. Taken together, these two papers suggest that a reduction in information asymmetries within firms can have positive effects on firm performance, but also that new information technologies can interact with existing relational contracts in surprising ways. Care needs to be taken to understand the institutional details in particular cases.

The extent to which firms are able to mitigate conflicts among employees (as opposed to between employees and owners or managers) also appears to matter for upgrading outcomes. In a flower firm in Kenya, Hjort (2014) argues that the assignment of workers to teams was quasi-random and considers how the ethnic composition of teams affected output. Consistent with a model of taste-based discrimination by workers against non-co-ethnics, ethnically homogeneous teams were more productive than heterogeneous ones, and this tendency was stronger during a period of ethnic strife in Kenya. The impact on firm productivity was substantial.[51] In an experiment in Bangladeshi garment factories, where most line workers are female and most supervisors are male, Macchiavello et al. (2020) randomly assigned newly trained female and male supervisors to production lines. They find that the new female supervisors had lower productivity and ratings from subordinates than the male supervisors initially but not in the longer term (4-6 months). Surveys and lab-in-the-field experiments suggest that the low initial productivity and ratings were

[51] Ghosh (2021) makes a similar point in the context of an experiment in an Indian food-processing plant. The author manipulated the Hindu/Muslim composition of work teams and found that mixed teams were less productive in tasks requiring substantial coordination (but not in tasks requiring less coordination).

due to the fact that both male and female employees believed, incorrectly, that female supervisors had less technical knowledge, and that this incorrect belief faded with exposure to female supervisors. The findings suggest both that discriminatory behavior among employees can hinder firm performance and that overcoming such barriers (like other means of gaining know-how) may require investments by firms which may or may not be profit-maximizing.

Returning to the question of why family ownership is so prevalent, a number of authors have argued that family control is in part a response to agency issues within firms, in particular to the problems that owners may have in inducing desirable behavior from non-family managers.[52] Focusing on the surgical goods industry in Sialkot, Pakistan, Ilias (2006) argues that the tendency of non-family managers to move to other firms and take clients and production knowledge with them leads families to favor family members as managers. One consequence of this behavior is that founders of firms who have more brothers end up with larger firms.[53] Cai et al. (2013) present evidence from Chinese firms that family members who are managers are paid more but have lower-powered incentives than non-family-member managers, consistent with the idea that family members are trusted more to act in the interests of the firm. These observations do not contradict the findings above that continued family control after the founder dies is bad for performance, but they do suggest a reason why family control persists. Like piece rates in the soccer-ball example, family control may be a solution to an agency problem that is initially beneficial (in the sense of reducing malfeasance under the founder) but that outlives its usefulness (once the founder dies).

3.3.4 Learning

In our framework, the learning process is conceptualized in a simple way: firms make investments I_{it}^{Λ}, I_{it}^{J}, and I_{it}^{K} and they gain know-how. But in practice, the process can be messy and difficult. Know-how typically cannot be purchased on an open market or downloaded from the internet. Much of it is tacit, not written down anywhere — an idea that goes back at least to Katz (1984) and Pack and Westphal (1986). In addition, many organizational capabilities need to be honed in the practice of producing; as Gibbons (2010) puts it, they need to be "homegrown." This subsection reviews recent work that has given us a more nuanced understanding of the process of acquisition of know-how, classified by the source of the gains: within-firm learning, learning from other firms, or learning from external trainers or consultants.

3.3.4.1 Learning within Firms

Studies of within-firm learning in developed countries have the advantage that an important component of firms' investments in learning, R&D expenditures, are reasonably well measured. But in developing countries, not only do fewer firms engage in what is commonly considered R&D (since they are not aiming to push the world frontier), but reported R&D information, when available, is often unreliable. For instance, Chen et al. (2021) show that a Chinese policy granting lower corporate tax rates to firms above certain levels of R&D expenditures led both to bunching in reported R&D and to lower reported administrative spending of other types just above the cutoffs,

[52] See Tsoutsoura (2021) for a review.

[53] Bloom et al. (2013) make a similar observation about the Indian textile firms they study.

suggesting substantial re-labeling of administrative expenses as R&D.[54]

Given the data constraints, the literature on within-firm learning in developing countries has focused less on the effects of explicit investments in learning (which are almost entirely unobserved) and more on other aspects of the learning process. One area that has received increasing attention is the role of internal communication (and barriers thereto). The Atkin et al. (2017b) soccer-ball study, discussed above, provides an example of how agency issues can impede communication between managers and frontline workers. Several recent experiments have directly manipulated the extent of communication. An influential recent experiment in a US call center by Sandvik et al. (2020) randomly required salespeople to meet to discuss sales techniques; the meetings significantly improved employee performance as measured by revenue per call. Menzel (2021) conducts a similar experiment in three Bangladeshi garment firms: supervisors overseeing a production line starting to produce a "non-first" style (i.e. a style of garment already produced elsewhere in the factory) were randomly required to meet with the supervisor of the original line. Productivity on the first day on the new line was higher as a result. Both studies are consistent with the idea that employees may be hesitant to ask for advice from peers and that encouragement from upper management can reduce such communication frictions. Relatedly, Cai and Wang (forthcoming) conduct an experiment in a Chinese auto manufacturer in which workers evaluated their direct supervisors, increasing communication between workers and top management. The evaluations had real consequences for supervisor salaries (up to 4% of their total pay during the intervention) and improved productivity of worker teams, mainly by reducing turnover. Reductions in turnover (but not significant effects on productivity) are also found by Adhvaryu et al. (forthcomingb) and Adhvaryu et al. (2021) in two interventions in an Indian garment firm, one which randomly conducted a confidential attitude survey and one which gave workers the ability to send text messages anonymously to the company's human-resources department. In a Bangladeshi garment factory, Schreiber (2021) finds that meetings with free lunches to encourage employees to share ideas increased the number of employee suggestions and improved their self-reported well-being but had no detectable effects on firm performance. These results are consistent with the ideas that simply giving employees an ability to voice their opinions can have positive effects on morale, but that voice mechanisms are more likely to generate productivity gains when workers' messages have real consequences for firms' decisions (consistent with Hirschman (1970)'s original argument about exit and voice).

A natural question about learning within firms is whether firms can fully "internalize" the learning gains, and hence can be expected to invest optimally in learning, or whether there is a market failure that a policy intervention might help to resolve. Building on a large literature in organizational economics, Guillouet et al. (2021) highlight one possible source of market failure: contracting frictions in communication. In their model, domestic managers in an MNC learn skills from foreign ones, but the foreign managers cannot capture the full benefit because some of the skill is general, applicable elsewhere; if communication effort of the two managers is complementary, then both types expend less effort in communicating than would be true under full contractibility. In two experiments among MNCs in Myanmar, the authors provide evidence for the two key com-

[54] Chen et al. (2021) also present structural estimates which suggest that not all of the reported R&D spending represents re-labeling, and in an appendix find a modest effect on TFP of affected firms.

ponents of this argument: that human-resource managers place value on experience of recruits at other MNCs (suggesting skills learned at MNCs are general) and that English classes for domestic managers increase communication with foreign managers (suggesting that their efforts are complementary). The paper is not able to manipulate the degree of contracting frictions directly, but provides novel indirect evidence that such frictions are likely to be important.

Learning from production experience (i.e. learning by doing) is also clearly an important source of knowledge gains for firms (and, as noted above, is allowed for in our framework — learning need not only arise from explicit investments). There is extensive evidence for learning by doing from detailed internal firm production data in developed-country firms (see e.g. Irwin and Klenow (1994), Levitt et al. (2013), and Hendel and Spiegel (2014)) but much less evidence at a similar level of detail in developing countries. The Atkin et al. (2017a) rugs study, discussed above, is arguably an example of learning by doing in production of higher-quality varieties. More research on this topic is needed, for instance on whether learning by doing is slower in developing countries, possibly because the agency issues highlighted above are more severe.

3.3.4.2 Learning from Other Firms

Much of the best-known research on learning from other firms comes from developed countries (e.g. Irwin and Klenow (1994)) or agriculture in developing countries (e.g. Conley and Udry (2010), BenYishay and Mobarak (2019), Beaman et al. (2021), Carter et al. (2021)), but there is growing evidence that non-agricultural firms in developing countries learn from other firms, through peers, workers, joint ventures, buyers and/or suppliers.

Learning from peers, widely believed to be important, is challenging to document empirically, because of well-known econometric problems in estimating social effects (Manski, 1993). But recent studies have been able to manipulate experimentally the peer groups of entrepreneurs, to gain leverage for identification. In an influential contribution, Cai and Szeidl (2018) randomly assigned managers from 2,820 Chinese firms into groups that met monthly for one year. The meetings had a large effect on firm revenues (8.1%) and also had positive effects on profits and a management practice index similar to the World Management Survey score. To explore the learning channel directly, the authors randomly allocated information about a government grant and a high-return savings opportunity for managers, and found that not-directly-informed managers in groups where others had received the information were more likely to apply for both programs than not-directly-informed managers in groups where others had not received the information. In addition, they find that information about the government grant, which was plausibly perceived as more rival than the savings opportunity, was less likely to spill over when more firms in the group were direct competitors. No such difference is evident for the manager savings opportunity, which was less rival. Together, the results provide compelling evidence of learning spillovers between firms.[55]

[55]The Cai and Szeidl (2018) results contrast somewhat with an earlier intervention by Fafchamps and Quinn (2018). By randomly assigning local entrepreneurs as judges in business-plan competitions in Ethiopia, Tanzania, and Zambia, Fafchamps and Quinn successfully generated in experimental variation in the judges' peer networks. But the effects overall were quite modest, with no significant effects on diffusion (within groups of judges) of management practices, client and supplier relations, or innovation, although with positive effects on tax registration and having a bank account (correcting for multiple hypothesis testing). The weaker results compared to Cai and Szeidl (2018) are likely due in part to less-intensive peer interactions (only one meeting versus monthly for a year)

Two other notable recent studies have explored learning from peer firms in an experimental or quasi-experimental setting. Hardy and McCasland (2021a) randomly allocated a new technology for weaving garments and experimentally generated demand for products that required the technology. As in Cai and Szeidl (2018), they find that entrepreneurs were more likely to share information with one another when they faced less head-to-head competition. Although not focused on developing-country firms, Giorcelli (2019) is one of the few studies able to examine long-term outcomes of exposure to other firms. Under the Marshall plan in the 1950s, the US government sponsored trips of Italian managers to US firms and subsidized purchases of advanced US technology. Giorcelli compares the set of participating firms to a set of firms that were accepted but because of subsequent budget cuts were not able to participate. The sales, employment, and productivity of firms that participated in the trips rose quickly and continued to rise steadily for at least 15 years. The productivity of firms that only received the technology subsidies also rose but reached a plateau after ten years. Outcomes for firms that received both were significantly greater than the sum of the effects for each alone, suggesting that there were complementarities between the trips and the subsidies.

Another channel through which firms may learn from other firms is employee flows. In one famous example, employees of a single Bangladeshi garment firm, Desh Garment Company, a joint venture with Daewoo Corporation, were sent to Korea for training in production techniques. More than 100 Korea-trained Desh employees subsequently moved to new firms and served as an important catalyst for the growth of the Bangladeshi garment sector (Rhee, 1990; Rhee and Belot, 1990; Mostafa and Klepper, 2018). Recent papers have provided evidence on several types of spillovers through worker flows, although not (for the most part) on upgrading outcomes. Using Brazilian employer-employee data, Poole (2013) finds that when Brazilian firms hire workers who have previously worked in an MNC, the wages of incumbent workers rise.[56] Researchers have also found evidence that employee movements lead "receiving" firms to export to similar destinations (e.g. Mion and Opromolla (2014) and Mion et al. (2016) in Portugal) and import from similar origins (e.g. Bisztray et al. (2018) in Hungary) as "sending" firms. Econometric identification of spillovers is always a challenge, but the accumulation of consistent findings raises one's confidence that worker flows are an important channel for knowledge flows.

Two recent papers on Chinese firms suggest that joint ventures (a major component of Chinese industrial policy) have also led to transfers of know-how. Jiang et al. (2018) find that Chinese firms that participated in joint ventures with foreign firms saw increases in sales, export shares, and patenting (in the non-joint-venture part of the firm), controlling for firm fixed effects, following the establishment of the joint venture. Bai et al. (2020) exploit a similar idea in the Chinese auto industry, comparing characteristics of indigenous models produced by firms engaged in joint ventures with characteristics of models produced by firms not engaged in joint ventures. The key finding is that the firms with joint ventures tended to excel on the same characteristics (e.g. engine performance, or fuel efficiency) as their joint-venture partners. As the authors of both papers acknowledge, the joint ventures were not randomly assigned, and so questions may naturally arise about whether foreign firms chose to enter partnerships with firms that were going to do well

and in part to smaller sample size (345 versus 2,820).

[56] See also Stoyanov and Zubanov (2012) and Labanca et al. (2014).

anyway, but the patterns suggest strongly that joint ventures can be a vehicle for learning.[57]

Learning from buyers and suppliers was discussed briefly above in the context of the FDI spillovers and exporting literatures (Section 3.1.2). To date, there have been relatively few studies in developing countries of learning from buyers or suppliers who are not MNCs or on international markets. Evaluating the magnitude of spillovers from domestic versus international buyers or suppliers, and how these relate to product quality, seems a promising area for research.

As noted above, the literature on social learning in agriculture is more developed than the literature on firms. Notable recent papers have documented, for instance, that knowledge about new technologies is more likely to be communicated between farmers with similar characteristics (Conley and Udry, 2010; BenYishay and Mobarak, 2019) and that network theory can provide important insights about how new technologies can be seeded in order to maximize diffusion (Beaman et al., 2021). Similar approaches could in principle be implemented among larger non-agricultural firms and seem likely to yield useful insights.

3.3.4.3 Learning from Trainers/Consultants

In addition to learning from their own experiences and from other enterprises, firms can also learn from external trainers and consultants, whether their services are subsidized by governments or NGOs or purchased privately. An influential review of training experiments by McKenzie and Woodruff (2014), focused on small and medium-sized enterprises (SMEs), finds that most studies have very wide confidence intervals, with the result that it is rarely possible to reject a null hypothesis of no impact.[58] McKenzie (2021) conducts a meta-analysis and finds that point estimates of effects on sales and profit are on average in the 5-10% range; the issue is that most studies are underpowered to detect effects of that magnitude. (See also the reviews by Grimm and Paffhausen (2015) and Quinn and Woodruff (2019).) Because the literature has been thoroughly discussed in these previous reviews, here I highlight just a few contributions that seem particularly relevant.

Bruhn et al. (2018) randomly allocated subsidized consulting services to SMEs (average employment: 14) in Puebla, Mexico. The intervention was of moderately high intensity: the firms met one-on-one with consultants for four hours per week for one year. There was not a uniform body of advice given; the consultants tailored their messages to the needs of the individual firms. The authors estimate positive short-term effects on an index of entrepreneurial spirit as well as on productivity and return on assets, although the latter are not robust in all specifications. They find no significant short-term effects on sales, employment, or assets. To examine longer-term impacts, the authors examine employment in administrative data from the Mexican social security agency, and find a 50% increase in employment in treated firms after five years. These findings are not entirely free of concerns. Because of confidentiality restrictions, the authors were not able to access the administrative microdata directly; they had access only to means and standard deviations for the approximately 57% of treatment and control firms that staff of the social-security

[57] There is also evidence that knowledge flows between subsidiary firms within multinationals; see e.g. Branstetter et al. (2006) and Bilir and Morales (2020).

[58] Strikingly, in two interventions with tailors in Ghana, the impact on profits dipped negative before firms reverted to their previous practices (Karlan et al., 2015).

agency were able to find in the microdata. It is conceivable that the linked firms were a selected sample, although the match rates were similar between the treatment and control groups. Also, as noted by Quinn and Woodruff (2019, fn. 12), it is possible that the results may be driven by a small number of medium-sized firms (i.e. the largest firms in their sample). Despite these caveats, the paper has been influential and is clearly an important contribution.

Perhaps the most important contribution in this area has been the consulting experiment of Bloom et al. (2013) in 17 Indian textile firms. The intervention was intensive: it provided one month of consulting from a multinational consulting firm to both treatment and control firms (the "diagnostic phase") and then four months of consulting to treatment firms only (the "implementation phase"). The market value of the consulting services for the treated plants was approximately $250,000 USD per firm. The authors tracked 38 specific management practices, including performing regular maintenance on machines, tracking inventories at least weekly, monitoring quality defects daily, and offering performance pay to non-managerial and managerial staff. Using several methods to address concerns about small sample size, the authors find clear evidence that the implementation-phase consulting was effective both in increasing the share of the 38 management practices that firms adopted and in improving firm performance, measured in terms of output, TFP, or reductions of quality defects and inventory. The authors also use the consulting treatment as an instrument for the share of the 38 management practices adopted, to estimate the effect of the practices on performance, and find significant coefficients on the management-practices variable. In a follow-up paper, Bloom et al. (2020) find that the effects were still present nine years later: treated firms continued to employ more of the management practices, had greater worker productivity and higher-quality looms, and were more likely to be exporters.

This project has broken significant new ground in the study of firm behavior, and has rightfully been influential. But three notes of caution are in order. First, to interpret the instrumental-variables (IV) results as evidence for a causal effect of the specified management practices requires the exclusion restriction that the consulting affected performance only through its effect on the 38 management practices that were tracked. If one believes that the four months of intensive consulting had effects on firm behavior that are not captured by those 38 practices (more precisely, by the share of the 38 management practices adopted), then one should not interpret the IV estimates as causal effects of the management practices themselves.[59] Note that this exclusion-restriction concern does not apply to the reduced-form (Intent-to-Treat) estimates of the effects of the consulting itself on performance, which are compelling. Second, the returns to the intervention are imprecisely measured. The authors did not have access to internal accounting data from the firms, and instead estimated profits based on their own performance estimates and assumptions about the cost savings from reduction of waste fabric, profits expected to be derived from increased output, and other factors. They estimate a return of $325,000 USD per year on the $250,000 USD worth of consulting services. Estimating profits in this way is an inexact science, and there is

[59]For the same reason, this study should not be considered definitive evidence for the "vertical" view, discussed in Section 2.2.3 above, that the 38 practices (or some subset of them) are better than existing practices across contexts. The Atkin et al. (2017b) soccer-ball study provides one example where performance pay (in the form of piece rates) got in the way of technology adoption, and a less high-powered incentive scheme appeared to be more conducive to learning. See also Verhoogen (2016).

likely to be both significant heterogeneity and significant ex ante uncertainty in the profit effects.[60] Third, relatedly, it is not clear that firms were making mistakes prior to the intervention by not adopting the management practices on their own. Although the authors themselves are careful to attribute the lack of adoption to a lack of information, the paper appears to have been interpreted by others as showing that firms left money on the table, since the management practices themselves were cheap to implement (about $3,000 USD). But if we interpret the cost of consulting as part of the cost of adopting the new management practices (in our framework, as an investment in acquiring capabilities, I^{Λ}_{it}, or in gaining knowledge of production techniques, I^{K}_{it}, or simply as part of the per-period fixed cost, f_{ijkt}, of producing using a technique that includes structured management practices), and we allow for heterogeneity and uncertainty in the returns, then it is not obvious that firms left money on the table.[61]

The Bloom et al. (2013) intervention was expensive, and it is worth investigating whether similar outcomes can be achieved more cheaply. Partnering with the Colombian government and focusing on autoparts firms, Iacovone et al. (forthcoming) do this by comparing an intervention involving one-on-one consulting provided by local consultants (as opposed to more-expensive international consultants) to an intervention involving group consulting. The aim of the group consulting was to reduce costs and to take advantage of firms learning from one another. The authors find that both interventions had an effect on management practices, and that the group-consulting intervention (but not the individual consulting) had positive effects on employment and sales. Neither intervention had a significant positive effect on productivity, although the confidence bands are wide. Given that the group-consulting intervention was less costly, the study suggests that it would be the preferable design for scaling up.

Overall, although several studies have documented positive impacts, the effects of training and consulting interventions appear to be sensitive to the content of the advice and the details of implementation. The most successful interventions have tailored advice to the particular needs of firms, rather than providing cookie-cutter guidelines. In some cases, it has often been important to follow firms over several years to see significant effects. The most successful interventions have been intensive, and in several cases expensive. Questions remain about whether firms leave money on the table by not purchasing training or consulting services and about which approaches are most cost-effective. In addition, a recent experiment by Anderson and McKenzie (forthcoming) in Nigeria suggests that purchasing training or consulting for entrepreneurs is less cost-effective than hiring in accounting or marketing specialists and/or contracting out such functions to external business-service providers.

[60] The follow-up paper, Bloom et al. (2020), was unfortunately unable to measure profits or productivity.

[61] Recent work by Alfaro-Serrano (2019) emphasizes these required investments in know-how and and shows that a Peruvian program to subsidize certifications such as ISO 9001, which require formalization and documentation of processes but not particular management practices, had the indirect effect of increasing adoption of higher-scoring management practices. The idea that the costs of adopting structured management practices may be greater than the benefits appears for instance in Bloom and Van Reenen (2007), who write, "Upgrading management is a costly investment and some firms may simply find that these costs outweigh the benefits of moving to better practices" (p. 1356).

4 Conclusion

This paper has reviewed recent firm-level evidence on the drivers of upgrading in larger, non-agricultural firms in developing countries. From a measurement perspective, the literature faces a number of challenges. TFP measures have the conceptual advantage that they aim directly at capturing firm capabilities, but they have a number of well-known shortcomings. I have argued that the most convincing studies are ones that have used directly observable information on upgrading outcomes — technology use (including management practices), quality ratings, product scope, and benchmarked output under controlled conditions — and that the literature would do well to focus more on such measures in the future. At the same time, such measures are typically available only for particular sectors, and increases in them are not necessarily optimal either for firms or for the broader economies in which they are embedded. It seems clear that there is value both in improving indirect measures such as TFP and in expending shoe-leather to collect direct measures of upgrading for a greater range of sectors.

Despite the difficulties of measurement, several empirical patterns emerge. Increases in sales to developed-country consumers, either directly through exports or indirectly through supplying in value chains with developed-country end-consumers, appear to robustly generate increases in the average quality of goods produced. Evidence is accumulating that they generate increases in productivity as well. Increased availability of high-quality inputs also appears to promote upgrading. It is not clear that developing-country firms are making mistakes by not upgrading, but there is growing evidence that tailored, intensive consulting interventions can improve firm performance. Developing-country firms appear to be constrained by a lack of know-how. A key challenge, perhaps *the* key challenge, in promoting upgrading is to promote learning by firms.

What is the way forward? I have tried to identify particular areas where additional work would have high value-added. But more broadly, as may be evident from the organization of the review, I believe that a promising general approach is to identify plausibly exogenous variation in proximate drivers of upgrading — in demand-market conditions, in supply-market conditions, or in factors that affect know-how — and to estimate their effects on directly observable indicators of upgrading. The body of work in this area is substantial and growing quickly, but much more remains to be done.

Within this broad agenda, a number of specific issues deserve particular attention. One is how shifts in product composition at the firm level affect learning. Does producing higher-quality products, for instance, generate greater accumulation of know-how than producing low-quality products? The hypothesis that there is a link between the pattern of product specialization and learning was central to the thinking of an early generation of development economists (e.g. Prebisch (1950)). In recent years, it has been advanced by Dani Rodrik, Ricardo Hausman and others (see e.g. Hausmann et al. (2007, 2014)) and investigated largely at the country-sector level. Now that firm-product-level datasets are increasingly available, the time seems ripe to investigate the link at the level of individual firms, using research designs that identify plausibly exogenous variation in product composition.

Another specific question to be investigated is how local availability of consultants and skilled managers affects the accumulation of know-how within firms. In many developing-country settings, consulting markets are puzzlingly thin and skilled managers are scarce. But even where the supply of consultants and skilled managers is more robust, incorporating new knowledge or practices into the everyday functioning of an organization requires time and effort. Under what circumstances does greater availability of consultants and skilled managers translate into increased firm capabilities? What are the barriers? Several notable studies have been discussed above, but there is more to be done to investigate these issues.

Finally, it is natural to ask how policy interventions can most effectively promote firm-level upgrading, especially in light of the limited capacity of many developing-country governments. Government policy can affect upgrading through a number of different channels, for instance by influencing the cost of accessing different output markets, by increasing the supply of or directly subsidizing different inputs, or by directly providing extension services or other consulting, as discussed in the policy-oriented reviews cited in the introduction. More research is needed both to evaluate particular policies and to begin to compare the effectiveness of marginal dollars spent on different interventions, obviously a difficult task. If policies are to be implemented at scale, designers will also need to confront the general-equilibrium effects of interventions, which have not been the focus here. Analyzing these issues will likely require more guidance from economic theory than the primarily reduced-form studies discussed in this review have relied on.

Although much work obviously remains to be done, there are many reasons for optimism about the prospects for research on firm-level upgrading in developing countries. The data frontier has been expanding quickly, with information on customs transactions, firm-to-firm trade, quantities and prices at the product level, banking relationships, and other sorts of transactions becoming increasingly available. Appreciation is growing in a number of fields — macroeconomics, industrial organization, and international trade, as well as development — for careful firm-level empirical work on the determinants of innovative behavior. And policymakers in many countries are hungry for rigorous, evidence-based advice about how to promote upgrading. It is an exciting time for the field.

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