Vertical Integration and Firm Productivity

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This paper uses three cross-industry datasets from China and other developing countries to study the effect of vertical integration on firm productivity. Our findings suggest that vertical integration has a negative impact on productivity, in contrast to recent studies based on U.S. firms. We argue that in settings with poor corporate governance, vertical integration reduces firm productivity because it enables inefficient rent-seeking by insiders.

1. Introduction

This paper examines the impact of vertical integration on firm productivity. To do so, we analyze two different cross-industry datasets of Chinese manufacturing firms and another dataset of firms in developing countries, drawn from various surveys conducted between 1998 and 2006.

We find that firm productivity, as measured by labor productivity, *decreases* with vertical integration in each of our datasets. Our results are in contrast to recent empirical findings, largely based on U.S. data (e.g., Hortaçsu and Syverson, 2007; Forbes and Lederman, 2010) that vertical integration improves firm efficiency. We propose a simple explanation for this negative relationship: in developing-country settings characterized by poor legal protections for firms' investors, vertical integration may serve as an inefficient means for parties in control to extract private benefits.

A number of problems arise when estimating the causal impact of vertical integration. One concern is the *endogeneity* problem, whereby omitted-variable bias arises because firms' vertical integration decisions are nonrandom. In particular, such nonrandomness may arise because firms condition their integration decisions on unobserved factors. A special case of the endogeneity problem is what Gibbons (2005) aptly

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labels the "Coase-meets-Heckman" problem: if integration is comparatively advantageous at high-difficulty transactions (which are likely to produce inefficient outcomes relative to the first-best), and if transaction difficulty is unobserved, then simple correlations will naively produce a negative relationship between vertical integration and firm productivity.

A second concern is the *mismeasurement* problem: the extent of vertical integration may be mismeasured in conventional (indirect) measures for vertical integration. For example, the value-added ratio is used extensively in the literature as a measure of vertical integration, but may be sensitive to the stage of the production process in which a given firm specializes.[1] Mismeasurement of vertical integration may lead to estimation biases even when the integration decisions are randomly determined (i.e., even in the absence of endogeneity problems). For example, when both the integration decision and the mismeasurement of vertical integration are uncorrelated with unobserved firm characteristics, estimates of the effect of vertical integration may be biased toward zero.

For each of our three datasets, the mismeasurement problem and the endogeneity problem may emerge in various forms. We tailor our approach accordingly. Section 2 analyzes our first dataset, the *Survey of Chinese Enterprises* (SCE). The SCE is a cross-section of Chinese manufacturing firms based on a 2003 World Bank survey. It contains a direct measure of vertical integration: the percentage of parts that are produced in-house. This measure allows us to avoid the mismeasurement problem, which may arise with indirect measures of vertical integration. Further, to mitigate the endogeneity problem, we use the degree of local purchase (a proxy for the extent of site-specificity) as an instrument for vertical integration.

Section 3 analyzes our second dataset, the *Annual Survey of Industrial Firms* (ASIF). The ASIF is a panel of Chinese industrial firms based on comprehensive annual surveys between 1998 and 2005. We rely on the value-added ratio as a measure of vertical integration. To control for the mismeasurement problem introduced by our use of the value-added ratio, we perform our analysis with a detailed set of 4-digit industry dummies, and then with firm dummies. Further, the panel analysis allows us to control for unobserved persistent firm-level heterogeneity, and thus mitigates the endogeneity problem.

Section 4 analyzes our third dataset, the *Private Enterprise Survey of Productivity and the Investment Climate* (PESPIC). The PESPIC is a cross-sectional dataset with some time-series elements. It consists of firms in six developing countries (Brazil, Ecuador, Oman, the Philippines, South Africa, and Zambia), and is based on World Bank surveys conducted from 2002 to 2006. In particular the PESPIC contains firm-level survey information about *changes* in a direct measure of the integration of major production activities as well as changes in firm productivity. We control for unobserved firm-level heterogeneity by performing first-difference estimation, thus mitigating the endogeneity problem. The PESPIC's direct measure of vertical integration alleviates the mismeasurement problem in our analysis.

Our results do not constitute a "smoking gun" for causality. We summarize the limitations of each of the three datasets in Section 4.2. That said, our overall analysis paints a picture of a significant negative relationship between vertical integration and firm productivity that is robust to various specifications and measures of vertical integration, and holds in a variety of cross-industry developing-country contexts. In particular, the

1. For example, the value-added ratio may be lower for firms specializing in later stages of the production process (Holmes, 1999).

ASIF and PESPIC datasets allow for tight empirical identification of within-firm variation in vertical integration, which is relatively rare in such cross-industry studies. Taken as a whole, our results provide suggestive evidence of a general negative relationship from vertical integration to firm productivity in the developing-country context.

In light of our empirical results, in Section 5, we develop a simple, stylized model where vertical integration increases firm insiders' ability to extract private benefits, and thus strengthens their incentives to engage in expropriatory activities. Consequently, in poor legal environments where insiders can easily expropriate, vertical integration has a *negative* effect on firm productivity. The model thus provides a potential causal mechanism to explain why vertical integration may be associated with lower productivity.

On the other hand, when corporate governance is strong and expropriation is difficult, our model predicts that vertical integration improves insiders' incentives to take productive actions, and thus has a *positive* effect on productivity. This model allows us to reconcile existing findings of a positive relationship between vertical integration and firm productivity in the United States (where investors' legal protections are strong) with our findings of a negative relationship in China and other developing economics (where investors' protections are relatively weak).

This paper is part of a developing literature that studies the relationship between vertical integration and organizational outcomes.[2] In particular, and in contrast to our results, a number of papers find a positive relationship between vertical integration and organizational productivity. We discuss these papers briefly, but first we note a key distinction between these papers and our analysis: these papers mostly study U.S. firms (and other developed-country settings), whereas we study China and other developing countries. We argue in Section 5 that differences in corporate governance between developing and developed countries may explain the differences between their results and ours.

Gil (2009) exploits a natural experiment in the Spanish movie industry to show that vertically integrated distributers make more efficient decisions about movie run length. Forbes and Lederman (2010), studying U.S. airlines, find that vertical integration increases operational efficiency. David et al. (2013), studying U.S. health organizations, show that integrated organizations exhibit less task misallocation and produce better health outcomes relative to unintegrated entities. Besides the distinction between developed- and developing-country settings, these papers focus on a single industry, whereas our data allow us to draw broader conclusions about the integration-productivity relationship across manufacturing firms.[3]

Atalay et al. (2014) systematically document differences between integrated and non-integrated U.S. manufacturing plants.[4] Perhaps most interestingly, they find that vertical integration is associated with higher firm productivity, but argue that this relationship is due to a selection effect (more productive firms happen to be larger, and larger firms tend to be more vertically integrated), rather than a causal effect of vertical integration.[5] Atalay et al. (2014) also find that vertical ownership structures do not imply

2. A number of other papers study the impact of vertical integration on market outcomes. Chipty (2001) argues that vertical integration results in market foreclosure in the cable television industry, and that such foreclosure actually improves consumer welfare. Gil (2015) shows empirically that vertical disintegration results in higher prices for movie tickets, and attributes this change to a double marginalization effect.

3. More broadly, limited by data availability, existing studies of the integration-productivity relationship are generally industry-specific (e.g., Levin, 1981; Mullainathan and Scharfstein, 2001).

4. See Hortaçsu and Syverson (2007) for a related analysis of cement manufacturing plants in the U.S.

5. They write, "these disparities [between vertically integrated plants and non-integrated ones] ... primarily reflect persistent differences in plants that are started by or brought into firms with vertical structures. In other

substantial production linkages (i.e., in-house shipments) from upstream divisions to downstream divisions, thus challenging conventional notions about vertical integration. We skirt this issue by instead using the proportion of in-house production as a measure of vertical integration.

2. Survey of Chinese Enterprises

The *Survey of Chinese Enterprises* (SCE) was conducted by the World Bank in cooperation with the Enterprise Survey Organization of China in early 2003. The SCE consists of two questionnaires. The first is directed at senior management, and focuses on enterprise-level information such as market conditions, innovation, marketing, supplier and labor relations, international trade, finances and taxes, and top management. The second is directed at the senior accountant and personnel manager, and focuses on ownership, various financial measures, and labor and training. A total of 18 Chinese cities were chosen, and 100 or 150 firms from each city were randomly sampled from the 9 manufacturing industries and 5 service industries.[6] In total, 2,400 firms were surveyed. We focus on the sub-sample of 1,566 manufacturing firms, for which our instrumental variable for vertical integration (discussed below) can be calculated.

The SCE dataset contains a survey question explicitly designed to measure the degree of vertical integration: "what is the percentage of parts used by the firm that are produced in-house (measured by the value of parts)?" Our measure of vertical integration, *Self-Made Input Percentage*, is based on the response to this question. As a direct measure of vertical integration, *Self-Made Input Percentage* mitigates the mismeasurement problem, which may arise with the conventional alternatives.[7] However, this measure is self-reported and subjective: managers at different companies may have a different understanding of what constitutes an input, or how to enumerate parts. In fact, *Self-Made Input Percentage* is reported to be 100% for some firms and zero for others, resulting in substantial variation: the variable has a mean value of 0.339 and a standard deviation of 0.401. Consequently, industry dummies are included in the regression analysis to reduce subjectivity: among firms in the same industry, managers have a (more or less) common understanding of what constitutes parts used in their production activities.[8]

2.1. Dependent Variable

In all three datasets, we focus on labor productivity as a simple, standard measure of firm productivity. Following Hortaçsu and Syverson (2007), we measure labor productivity

words, while there are some modest changes in plants' type measures upon integration, most of the cross-sectional differences reflect selection on pre-existing heterogeneity."

6. The 18 cities are: (1) Benxi, Changchun, Dalian, and Haerbin in the Northeast; (2) Hangzhou, Jiangmen, Shenzhen, and Wenzhou in the Coastal area; (3) Changsha, Nanchang, Wuhan, and Zhengzhou in Central China; (4) Chongqing, Guiyang, Kunming, and Nanning in the Southwest; (5) Lanzhou and Xi'an in the Northwest. The 14 industries are: (1) manufacturing: garment and leather products, electronic equipment, electronic parts making, household electronics, auto and auto parts, food processing, chemical products and medicine, biotech products and Chinese medicine, and metallurgical products; and (2) services: transportation services, information technology, accounting and non-banking financial services, advertising and marketing, and business services.

7. We consulted with the designer of the SCE, who explained that the rationale for including a survey question on the degree of vertical integration was precisely because of the well-known problems associated with the conventional measure of vertical integration.

8. The actual survey was carried out by the Enterprise Survey Organization of China's National Bureau of Statistics—an authoritative and experienced survey organization. Further, as far as we are aware, the survey participants did not raise any issues about potential ambiguity of the question on vertical integration.

TABLE I.
SUMMARY STATISTICS

Variable	Obs	Mean	Std. Dev.	Min	Max
			SCE Dataset		
Labor Productivity	1,557	4.322	1.562	−3.989	11.893
Vertical Integration	1,459	0.339	0.401	0.000	1.000
			ASIF Dataset		
Labor Productivity	1,115,452	4.917	1.193	−8.120	13.017
Vertical Integration	1,016,918	0.244	0.164	0.000	1.000
			PESPIC Dataset		
Change in Labor Productivity	6,212	0.154	0.799	−8.177	13.080
Change in Vertical Integration	31,107	0.097	0.296	0.000	1.000

as the logarithm of output per worker (denoted by *Labor Productivity*). Table I presents summary statistics. The mean and standard deviation of *Labor Productivity* are 4.322 and 1.562, respectively, for the SCE.[9]

2.2. Results

Benchmark Results: OLS

To investigate the relationship between vertical integration and firm productivity in the cross-sectional SCE dataset, we estimate the following equation:

$$Y_f = \alpha + \beta \cdot VI_f + X'_{fic}\,\xi + \varepsilon_f, \tag{1}$$

where f, i, c denote firm, industry and city, respectively; Y_f is firm f's productivity; VI_f is firm f's degree of vertical integration (specifically, *Self-Made Input Percentage*, constructed on the basis of firm f's reply to the survey question "what is the percentage of parts used by the firm that are produced in-house (measured by the value of parts)?"); X'_{fic} is a vector of control variables including firm characteristics,[10] CEO characteristics,[11] city dummies and industry dummies; and ε_f is the error term. Standard errors are clustered at the industry-city level to correct for potential heteroskadasticity.

The OLS regression results for various specifications of equation (1) are reported in Table II. For all specifications, the estimated coefficients of *Self-Made Input Percentage* are consistently negative and statistically significant: a higher degree of vertical integration is associated with lower firm productivity. Taking the most conservative estimate, a one-standard-deviation increase in the degree of vertical integration leads to a 2.2% decrease in firm productivity at the mean level.

9. Although both the SCE and the ASIF cover Chinese manufacturing firms, mean productivity in the ASIF is higher than that in the SCE, presumably because the ASIF covers non-state-owned enterprises above a certain sales threshold.

10. Variables related to firm characteristics include: *Firm Size* (measured as the logarithm of firm employment), *Firm Age* (measured as the logarithm of years of establishment), *Percentage of Private Ownership* (measured as the percentage of equity owned by parties other than government agencies) and *Capital Intensity* (measured as the logarithm of assets per worker).

11. The CEO characteristics include measures of human capital—*Education* (years of schooling), *Years of Being CEO* (years as CEO) and *Deputy CEO Previously* (an indicator of whether the CEO had been the deputy CEO of the same firm before becoming CEO); and measures of political capital—*Government Cadre Previously* (an indicator of whether the CEO had previously been a government official), *Communist Party Member* (an indicator of whether the CEO is a member of the Chinese Communist Party) and *Government Appointment* (an indicator of whether the CEO was appointed by the government).

Table II.
Analysis of the SCE Dataset, OLS Benchmark

	1	2	3	4
Dependent Variable		Labor Productivity		
Self-Made Input Percentage	−0.307***	−0.278***	−0.298***	−0.237***
	[0.100]	[0.079]	[0.079]	[0.086]
Firm Characteristics				
Firm Size		0.200***	0.181***	0.110***
		[0.037]	[0.038]	[0.036]
Firm Age		−0.526***	−0.458***	−0.413***
		[0.062]	[0.069]	[0.066]
Percentage of Private Ownership		0.442***	0.253*	0.268**
		[0.130]	[0.132]	[0.122]
Capital Intensity		0.383***	0.384***	0.347***
		[0.037]	[0.034]	[0.036]
CEO Characteristics				
Human Capital				
Education			0.041***	0.040**
			[0.016]	[0.016]
Years of Being CEO			0.018**	0.007
			[0.007]	[0.007]
Deputy CEO Previously			−0.004	−0.008
			[0.070]	[0.068]
Political Capital				
Government Cadre Previously			0.019	0.090
			[0.222]	[0.231]
Communist Party Member			−0.192**	−0.096
			[0.082]	[0.077]
Government Appointment			−0.348***	−0.317***
			[0.088]	[0.092]
Industry Dummy	Yes	Yes	Yes	Yes
City Dummy				Yes
No. of Observation	1,451	1,431	1,410	1,410

Note: Robust standard errors, clustered at industry-city level, are reported in the bracket.
*, **, and *** represent significance at 10%, 5%, and 1% level, respectively.

Note that the regressions produce reasonable estimates for the effects of control variables. For example, younger firms and those with higher capital intensity have higher productivity, consistent with findings in the literature. Firms with a higher percentage of private ownership also have higher productivity. This is consistent with the observation that state-owned enterprises in China are charged with multiple mandates: they are required to focus not only on profit maximization, but also on maintaining social stability, the latter of which involves excessive hiring and results in lower productivity (Bai et al., 2000). The coefficient on *Firm Size* is positive and significant in all specifications, suggesting the presence of economies of scale. This is consistent with evidence of local protectionism within China (Young, 2000; Bai et al., 2004), which results in production at a sub-optimal scale. Finally, government appointments have a negative impact on firm productivity. This result is consistent with the view that government appointments of CEOs in China are based on political considerations rather than managerial talent.

IV Estimates

Our cross-sectional analysis does not control for unobserved firm-level heterogeneity, and thus is susceptible to the endogeneity problem: as discussed in the introduction, unobserved factors that affect both *Self-Made Input Percentage* and *Labor Productivity* may generate omitted-variable bias. In response, we instrument for *Self-Made Input Percentage* with the first stage

$$VI_f = \delta + \theta \cdot Z_f + X'_{fic}\lambda + \zeta_f, \tag{2}$$

where the instrument Z_f is *Local Purchase*: the ratio of inputs purchased from the province where the firm is located to all purchased inputs.

As an instrument, *Local Purchase* is plausibly relevant: firms with higher site-specificity (as measured by *Local Purchase*) vis-à-vis their suppliers are more vulnerable to hold-up,[12] which leads to a higher degree of vertical integration; see, for example, Williamson (1983, 1985).[13] The exclusion restriction is more difficult to establish; we discuss our attempts to control for potential instrument endogeneity later in this section.

The basic results from our IV estimations are presented in Table III. Only the industry dummy is included in Column 1, and additional control variables are included in Column 2. In particular, industry dummies are used to control for technological differences across industries, and city dummies are used to control for any locational advantages that may simultaneously affect local purchases, vertical integration and firm productivity. In both columns, the IV estimate of *Self-Made Input Percentage* is negative and statistically significant. In fact, the IV estimates are substantially larger than the OLS estimates. One possibility is that the self-reported degree of vertical integration involves some measurement errors, which biases the OLS estimates downward (toward zero).

Instrument Relevance

As shown in Panel B, *Local Purchase* is found to be positive and statistically significant. The Anderson canonical correlation LR statistic and the Cragg-Donald Wald statistic (reported in Panel C) further confirm that our instrument is relevant. The *F*-test of excluded instrument is statistically significant at the 5% level, but has a value of around 5, which is below the critical value of 10—a value suggested by Staiger and Stock (1997) as the "safety zone" for a strong instrument. This raises possible concerns of a weak instrument for our analysis. In response, we conduct two additional tests: the Anderson–Rubin Wald test and the Stock–Wright LM *S*-statistic, which offer reliable statistical inferences under a weak instrument setting (Anderson and Rubin, 1949; Stock and Wright, 2000). Both tests produce statistically significant results (also reported in Panel C), implying that our main results are robust to the presence of a weak instrument.

Instrument Exogeneity

Our instrument, *Local Purchase*, may have causal effects on *Labor Productivity* besides the vertical integration channel. Here, we identify and control for four potential channels.

12. Site specificity could go hand in hand with asset specificity. For example, an electricity-generating plant located next to a coal mine may adjust its production technology to suit the quality of locally obtained coal, which may lead to severe holdup problems *ex post*. Nonetheless, we control for input specificity in one of our robustness checks and find similar results.
Moreover, even in the absence of asset specificity, monopolistic suppliers may hold up their nearby customers by demanding higher prices because such customers would have to pay higher transport costs if purchasing from alternative and more distant suppliers. Indeed, BHP and Rio Tinto of Australia demanded extra price increases for iron ore purchased by Chinese steel makers in 2005 and 2008 respectively, simply because they are geographically closer to China than is CVRD of Brazil, despite the same free-on-board prices of iron ore applying (Png et al., 2006, 2009). Subsequently, many Chinese steel makers have been trying to acquire iron ore mines in Australia. Meanwhile, within China, due to high transport costs and local protectionism, both of which inhibit cross-regional trade, firms have limited options other than purchasing locally, which further exacerbates the holdup problems associated with local purchases.

13. This theoretical prediction has been supported empirically, for example, by Masten (1984), Joskow (1985), Spiller (1985), and González-Daz et al. (2000).

TABLE III.
ANALYSIS OF THE SCE DATASET, IV ESTIMATES

	1	2
Panel A: Second Stage: Dependent Variable is Labor Productivity		
Self-Made Input Percentage	−13.290** [6.360]	−5.182* [2.803]
Firm Characteristics		
Firm Size		0.180*** [0.063]
Firm Age		−0.291** [0.127]
Percentage of Private Ownership		0.371 [0.234]
Capital Intensity		0.323*** [0.054]
CEO Characteristics: *Human Capital*		
Education		0.061** [0.030]
Years of Being CEO		0.033* [0.020]
Deputy CEO Previously		0.096 [0.146]
CEO Characteristics: *Political Capital*		
Government Cadre Previously		−0.451 [0.448]
Communist Party Membership		−0.24 [0.180]
Government Appointment		−0.408** [0.173]
Industry Dummy	Yes	Yes
City Dummy		Yes
Panel B: First Stage: Dependent Variable is Self-Made Input Percentage		
Local Purchase	0.066** [0.030]	0.067** [0.029]
Firm Characteristics		
Firm Size		0.016* [0.009]
Firm Age		0.021 [0.018]
Percentage of Private Ownership		0.019 [0.033]
Capital Intensity		−0.003 [0.008]
CEO Characteristics: *Human Capital*		
Education		0.005 [0.005]
Years of Being CEO		0.005** [0.003]
Deputy CEO Previously		0.025 [0.025]
CEO Characteristics: *Political Capital*		
Government Cadre Previously		−0.105* [0.059]
Communist Party Membership		−0.029 [0.030]
Government Appointment		−0.022 [0.025]
Industry Dummy	Yes	Yes
City Dummy		Yes
Panel C: Various First-Stage Statistical Tests		
Relevance Test		
Anderson Canonical Correlation LR Statistic	[4.96]**	[4.57]**
Cragg–Donald Wald Statistic	[4.83]**	[4.48]**
Weak Instrument Test		
F-Test of Excluded Instrument	[4.95]**	[5.25]**
Anderson–Rubin Wald Test	[43.67]***	[9.13]***
Stock–Wright LM S Statistic	[23.07]***	[8.05]***
Number of Observations	1,445	1,404

Note: Robust standard errors, clustered at industry-city level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively.

First, when a firm sources more of its parts and components locally, it may incur lower transportation costs, which subsequently leads to higher firm productivity. Second, the shorter distance to suppliers under local sourcing implies lower inventory requirements, leading to higher productivity. Third, locally purchased inputs may be made to firms' unique specifications, which adds more value to their final products. Fourth, local purchases could reduce delays in delivery and consequently minimize lost sales.

From the SCE dataset, we construct four variables corresponding to each of these four possible alternative channels: *Transportation Cost* (measured by transportation costs divided by sales), *Inventory* (measured by inventory stocks of final goods over sales), *Input Specificity* (measured by the percentage of a firm's inputs made to the firm's unique specifications) and *Delivery Loss* (measured by the percentage of sales lost due to delivery delays in the previous year). We include linear and quadratic terms for each of these channel variables. As shown in Columns 1–5 of Table IV, our main results regarding the impact of vertical integration on firm productivity remain robust to these additional controls for potential alternative channels in the IV estimation.

Beyond these direct causal effects, the endogeneity problem still persists to some extent: *Local Purchase* is itself a management choice, and thus may be correlated with unobserved factors that also affect firm productivity.[14] Such omitted-variable bias cannot be completely excluded in our analysis, and thus constitutes a limitation of the SCE results.

Further Robustness Checks

As robustness checks, we repeat our analysis for three subsamples. Our finding that vertical integration and firm productivity are negatively related continues to hold in each of these subsamples.

First, to check whether our results are driven by outliers, we exclude the top and bottom 1% of observations by firm productivity and repeat the analysis using both OLS and IV regression methods. These results are shown in Columns 1 and 2 of Table V.

Second, for firms with many businesses, the degree of vertical integration could vary from one business to another. Thus, our measure of vertical integration may reflect the average degree of vertical integration across various businesses, which may bias our estimates of the impact of vertical integration on firm productivity. To address this concern, we restrict attention to the subsample of firms with focused businesses (defined as firms whose main business accounts for more than 50% of total sales); these results are reported in Columns 3 and 4 of Table V.

Third, China's state-owned enterprises, as legacies of its central planning system, are burdened with social responsibility mandates, and thus tend to be vertically integrated and inefficient. To check that our results are not driven by state-owned enterprises, we focus on the subsample of private firms; these results are reported in Columns 5 and 6 of Table V.

3. Annual Survey of Industrial Firms

The *Annual Survey of Industrial Firms* (ASIF) was conducted by the National Bureau of Statistics of China during the 1998–2005 period. This is the most comprehensive

14. For example, firms that are beholden to local politicians may buy more local inputs and also engage in excessive hiring of local workers, leading to a negative correlation between *Local Purchase* and *Labor Productivity*. We thank an anonymous referee for highlighting this point.

Table IV.
Analysis of the SCE Dataset, IV Estimates, Checks on Identification

	1	2	3	4	5
Dependent Variable			Labor Productivity		
Estimation Method			IV		
			Panel A: Second Stage		
Self-Made Input Percentage	−5.205*	−5.023*	−6.844*	−4.729*	−5.652*
	[2.803]	[2.735]	[3.827]	[2.465]	[3.107]
Transportation Cost	−3.590				−8.829*
	[3.804]				[4.774]
Transportation Cost ˆ2	−0.865				57.651**
	[4.020]				[29.392]
Inventory		−0.150***			−0.347***
		[0.047]			[0.066]
Inventory ˆ2		0.001***			0.005***
		[0.000]			[0.001]
Input Specificity			0.602		0.905
			[1.588]		[1.220]
Input Specificity ˆ2			−0.821		−1.034
			[1.741]		[1.359]
Delivery Loss				−0.177	−1.574
				[2.423]	[2.544]
Delivery Loss ˆ2				−0.946	5.125
				[9.232]	[8.398]
	Panel B: First Stage: Dependent Variable is Self-Made Input Percentage				
Local Purchase	0.068**	0.068**	0.063**	0.073**	0.068**
	[0.029]	[0.030]	[0.029]	[0.030]	[0.030]
		Panel C: Various First Stage Statistical Tests			
Relevance Test					
Anderson Canonical Correlation LR Statistic	[4.66]**	[4.65]**	[3.83]**	[5.35]**	[4.41]**
Cragg-Donald Wald Statistic	[4.58]**	[4.55]**	[3.80]**	[5.25]**	[4.37]**
Weak Instrument Test					
F-Test of Excluded Instrument	[5.34]**	[5.27]**	[4.69]**	[6.19]**	[5.42]**
Anderson–Rubin Wald test	[9.88]***	[9.05]***	[12.99]***	[8.81]***	[11.90]***
Stock–Wright LM S statistic	[8.70]***	[8.22]***	[10.69]***	[7.80]**	[10.68]***
Included Control Variables					
Firm Characteristics	Yes	Yes	Yes	Yes	Yes
CEO Characteristics	Yes	Yes	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes	Yes	Yes
City Dummy	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,401	1,403	1,307	1,391	1,290

Note: Robust standard errors, clustered at industry-city level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively. The first stage of the two-step GMM estimation contains the same controls as the second stage, but the results of these control variables are not reported to save space (they are available upon request).

Table V.
Analysis of the SCE Dataset, Robustness Checks

	1	2	3	4	5	6
Dependent Variable			Labor Productivity			
Sample	Exclusion of Outliers		Focused Businesses		Private Firms	
Estimation Method	OLS	IV	OLS	IV	OLS	IV
Self-Made Input Percentage	−0.200**	−5.897*	−0.302***	−4.051*	−0.210**	−7.246
	[0.085]	[3.174]	[0.087]	[2.225]	[0.099]	[7.301]
Included Control Variables						
Firm Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
CEO Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes
City Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	1,380	1,374	1,298	1,292	1,151	1,148

Note: Robust standard errors, clustered at industry-city level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively.

firm-level dataset in China; it covers all state-owned and non-state-owned industrial enterprises with annual sales of at least five million Renminbi.[15] The number of firms varies from over 140,000 in the late 1990s to over 243,000 in 2005. This panel dataset allows us to exploit within-firm time-series variation in the degree of vertical integration. Consequently, we control for the endogeneity problem by eliminating unobserved permanent firm heterogeneity from our regressions.

The ASIF consists of standard accounting information on firms' operations and performance. Our analysis of the ASIF dataset thus relies on the conventional, albeit objective, measure of vertical integration: *Value-Added Ratio*. This variable has a mean value of 0.244 and a standard deviation of 0.164. To mitigate the mismeasurement problem, we control for a full set of 4-digit industry dummies.

The ASIF analysis uses the same measure of firm productivity, *Labor Productivity* as the SCE. The mean and standard deviation of *Labor Productivity* in the ASIF are 4.917 and 1.193, respectively; see Table I.

3.1. Results

Panel Analysis

The ASIF is a panel dataset, so we use the following regression specification:

$$Y_{f,t} = \alpha_f + \beta \cdot VI_{f,t} + \gamma_t + \varepsilon_{f,t}, \tag{3}$$

where $Y_{f,t}$ is the productivity of firm f in year t; $VI_{f,t}$ is the value added ratio of firm f in year t, measuring the degree of vertical integration; α_f is the firm dummy, capturing all time-invariant firm characteristics; and γ_t is the year dummy, capturing all the effects affecting firms in year t. Standard errors are clustered at the firm-level to deal with the potential heteroskadasticity problem.

As an initial benchmark, pooled OLS estimation results are reported in Column 1 of Table VI, Panel A. There, we replace the firm dummy α_f in equation (3) with a full set of 4-digit industry and province dummies. We find that *Value-Added Ratio* has a negative

15. As of July 2016, the exchange rate was approximately 1 Renminbi to 0.15 U.S. dollars.

Table VI.
Analysis of the ASIF Dataset, Main Results

	1	2	3	4
Dependent Variable		Labor Productivity		
Estimation	Pooled OLS	Panel Fixed-Effect	Panel Fixed-Effect	Anderson–Hsiao IV
		Panel A: Contemporaneous Effects		
Value Added Ratio	−1.274***	−0.627***	−0.552***	−0.470***
	[0.011]	[0.008]	[0.009]	[0.015]
Lagged Labor Productivity			0.176***	0.286***
			[0.003]	[0.007]
Number of Observations	943,257	943,257	634,141	398,380
		Panel B: One-Year Lagged Effects		
Value Added Ratio	−1.061***	−0.549***	−0.523***	−0.369***
	[0.012]	[0.010]	[0.010]	[0.018]
Lagged (1 year) Value	−0.494***	−0.108***	−0.013*	0.104***
Added Ratio	[0.010]	[0.008]	[0.008]	[0.010]
Lagged Labor Productivity			0.172***	0.318***
			[0.003]	[0.008]
Number of Observations	614,697	614,697	567,524	360,405
		Panel C: Two-Year Lagged Effects		
Value Added Ratio	−0.982***	−0.520***	−0.501***	−0.352***
	[0.016]	[0.013]	[0.012]	[0.029]
Lagged (1 year) Value	−0.404***	−0.102***	−0.030***	0.117***
Added Ratio	[0.014]	[0.011]	[0.010]	[0.017]
Lagged (2 years) Value	−0.349***	−0.041***	−0.031***	0.004
Added Ratio	[0.014]	[0.010]	[0.009]	[0.011]
Lagged Labor Productivity			0.150***	0.399***
			[0.005]	[0.013]
Number of Observations	362,045	362,045	360,795	223,174
Year Dummy	Yes	Yes	Yes	Yes
Industry Dummy	Yes			
Province Dummy	Yes			
Firm Dummy		Yes	Yes	Yes

Note: Robust standard errors, clustered at firm level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively.

and statistically significant estimated coefficient, consistent with our findings obtained using the SCE dataset.

Returning to equation (3), panel fixed effect estimation results are reported in Column 2 of Table VI. The estimated coefficient of *Value Added Ratio* is still negative and statistically significant: a within-firm increase in vertical integration is associated with a decrease in firm productivity. Note, however, that the magnitude of the estimated coefficient falls from −1.274 to −0.627 when we move from pooled OLS to panel fixed-effects. This drop in magnitude could be attributed to the control for time-invariant firm-level unobserved characteristics (e.g., the level of transaction difficulty) being correlated with both the degree of vertical integration and firm productivity. It is also possible that some of the variation in the degree of vertical integration occurs across firms rather than within firms, and thus that the within-firm variation exploited by our panel fixed-effect estimation has a muted impact on firm productivity.

Although we have controlled for all permanent firm-level unobservables through the panel fixed-effect estimation, the endogeneity problem may persist due to time-varying omitted-variable bias. Proxying for time-varying omitted variables using the lagged dependent variable (Wooldridge, 2002), we estimate the following equation:

$$Y_{f,t} = \alpha_f + \beta \cdot VI_{f,t} + \delta \cdot Y_{f,t-1} + \gamma_t + \varepsilon_{f,t}. \tag{4}$$

The estimation results are reported in Column 3 of Table VI. After controlling for time-varying unobservables, the impact of vertical integration on firm productivity remains negative and statistically significant.

Further, with the inclusion of the lagged dependent variable in the panel estimation, dynamic estimation bias—whereby the lagged dependent variable is correlated with the error term—may arise, leading to biased estimates. To address this concern, we conduct a panel instrumental-variable estimation, as in Anderson and Hsiao (1982). Specifically, in the First-Difference transformation of equation (4), we instrument $\Delta VI_{f,t}$ and $\Delta Y_{f,t-1}$ with $VI_{f,t-1}$ and $Y_{f,t-2}$, respectively. The Anderson-Hsiao IV estimation results are reported in Column 4 of Table VI. Our main finding that vertical integration has a negative impact on firm productivity continues to hold here.

Delayed Effects of Vertical integration

Our analysis so far focuses on the contemporaneous effects of vertical integration on firm productivity. However, the effects of vertical integration may be delayed, either because new processes associated with integration and disintegration may take time to learn, or because post-integration investments may take time to be implemented. To investigate the possibility of any delayed effects, we further add one-year-lagged values (Panel B) and two-year-lagged values (Panel C) of the vertical integration measure, *Value Added Ratio*, to our specification. We find that the lagged effects are small relative to contemporaneous effects, with signs that change across specifications. Further, in these specifications, our estimates of contemporaneous effects barely change in significance and magnitude. Overall, the estimates for contemporaneous effects seem more robust and economically more significant than the estimates for delayed effects. Our tentative interpretation of these findings is that the effects of changes in vertical integration on firm productivity are relatively contemporaneous, and are largely realized within one year.

Robustness Checks

We conduct a number of robustness checks on both the panel fixed-effect and Anderson-Hsiao IV estimation results. Our finding that vertical integration and firm productivity are negatively related continues to hold in each alternative specification.

To address the concern that firm entry and exit during the sample period may drive our findings, we restrict our analysis to a balanced panel, comprising firms present for the whole sample period (Columns 1–2 of Table VII).

Mirroring the robustness checks from the SCE analysis, we exclude the top and bottom 1% of observations for firm productivity to check whether our results are mainly driven by outlying observations (Columns 3–4 of Table VII). And, we exclude state-owned enterprises by restricting our analysis to the sub-sample of private firms (Columns 5–6 of Table VII).

Table VII. Analysis of the ASIF Dataset, Robustness Checks

	1	2	3	4	5	6	7	8
Dependent Variable	Labor Productivity							
Sample	Balanced		Exclusion of Outliers		Private Firms		Whole	
Estimation	Panel Fixed-Effect	Anderson–Hsiao IV	Panel Fixed-Effect	Anderson–Hsiao IV	Panel Fixed-Effect	Anderson–Hsiao IV	Panel Fixed-Effect	Anderson–Hsiao IV
Value Added Ratio	-0.460^{***}	-0.467^{***}	-0.397^{***}	-0.679^{***}	-0.479^{***}	-0.485^{***}	-0.558^{***}	-0.502^{***}
	[0.014]	[0.023]	[0.007]	[0.016]	[0.011]	[0.017]	[0.009]	[0.016]
Lagged Labor Productivity	0.347^{***}	0.374^{***}	0.164^{***}	0.529^{***}	0.126^{***}	0.334^{***}	0.175^{***}	0.381^{***}
	[0.005]	[0.013]	[0.002]	[0.007]	[0.003]	[0.008]	[0.003]	[0.007]
Capital Intensity							0.193^{***}	0.026^{***}
							[0.002]	[0.001]
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	187,992	148,344	575,174	362,682	395,902	253,080	630,027	396,066

Note: Robust standard errors, clustered at firm level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively.

Finally, to control for the endogeneity problem arising from within-industry firm heterogeneity in technological capability (which could affect firm productivity and ownership structure), we include *Capital Intensity* (measured as the logarithm of assets per worker) as an additional control (Columns 7–8 of Table VII).

4. Private Enterprise Survey of Productivity and the Investment Climate

The *Private Enterprise Survey of Productivity and the Investment Climate* (PESPIC) is a standardized cross-sectional firm-level dataset based on *World Bank Enterprise Surveys* (WBESs) conducted by the World Bank's Enterprise Analysis Unit in 68 developing economies during the 2002–2006 period.[16] The PESPIC's structure is similar to that of the SCE. The first part is a general questionnaire directed at senior management, focusing on firm structure and performance, sales and suppliers, investment and infrastructure, government relations, innovation, and labor relations. The second part is directed at the senior accountant, and focuses on various financial measures.

The PESPIC is cross-sectional—each firm in the dataset is surveyed only once, sometime between 2002–2006—but has some time-series aspects. The survey reports many relevant time-varying firm-level variables (such as sales and employment) for each of the previous three full fiscal years, which we label as $t-1$, $t-2$, and $t-3$. In particular, our dependent variable, *Change in Labor Productivity*, is constructed as the change in the firm's labor productivity over that period: that is, $\Delta Y_{f,t} = Y_{f,t-1} - Y_{f,t-3}$.

Importantly, the PESPIC contains a survey question designed to directly measure changes in the degree of vertical integration: "Has your company brought in-house major production activities in the last three years?" The reply to this survey question is used to construct a dummy variable, *Change in Vertical Integration* ($\Delta VI_{f,t}$), which equals 1 if the firm answers yes and 0 otherwise.

The PESPIC thus allows us to exploit within-firm variation in the degree of vertical integration and avoid the endogeneity problem that might arise from permanent firm-level heterogeneity. As with the SCE, the PESPIC's measure of vertical integration is direct and less prone to the mismeasurement problem. Further, by focusing only on "major production activities," the PESPIC measure is arguably less prone to subjective interpretation by managers than the corresponding SCE measure.

As the PESPIC was compiled from a series of WBESs employing different questionnaire designs and survey methodologies in different countries, information about the change in the sourcing strategy adopted for major production activities is available in only 6 countries (i.e., Brazil, Ecuador, Oman, the Philippines, South Africa, and Zambia). After deleting observations missing valid information about vertical integration choices, we have a final sample of 3,958 firms in these 6 developing countries. The mean value of *Change in Vertical Integration* is 0.097 and the standard deviation is 0.296. The mean and standard deviation of *Change in Labor Productivity* are 0.154 and 0.799, respectively; see Table I.

16. More information about the dataset can be found at http://www.enterprisesurveys.org/

TABLE VIII.
ANALYSIS OF THE PESPIC DATASET, MAIN RESULTS

	1	2	3	4	5	6
Dependent Variable	Change in Labor Productivity					
Change in Vertical Integration	−0.091**	−0.095**	−0.095**	−0.095**	−0.092**	−0.076**
	[0.036]	[0.037]	[0.037]	[0.037]	[0.036]	[0.037]
Initial Firm Size	0.085***	0.084***	0.084***	0.085***	0.085***	0.076***
	[0.026]	[0.026]	[0.026]	[0.026]	[0.026]	[0.025]
Initial Sales Change	0.027***	0.026***	0.027***	0.027***	0.027***	0.017**
	[0.008]	[0.008]	[0.009]	[0.009]	[0.009]	[0.008]
Introduction of New Technology		0.018	0.019	0.018	0.022	0.005
		[0.028]	[0.028]	[0.028]	[0.029]	[0.029]
Introduction of New Joint Venture			−0.024	−0.029	−0.027	0.014
			[0.058]	[0.064]	[0.064]	[0.056]
Introduction of New Licensing Agreement				0.016	0.018	−0.003
				[0.054]	[0.054]	[0.052]
Introduction of New Major Product Line					−0.018	−0.002
					[0.027]	[0.026]
Change in Capital Intensity						0.258***
						[0.045]
Number of Observations	2,672	2,671	2,670	2,670	2,670	2,583

Note: Robust standard errors, clustered at firm level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively.

4.1. PESPIC: RESULTS

FIRST-DIFFERENCE ESTIMATION

The key independent variable in our analysis of the cross-country PESPIC dataset is *Change in Vertical Integration*, which provides a source of within-firm variation in vertical integration. We estimate the following First-Difference equation:

$$\Delta Y_{f,t} = \alpha + \beta \cdot \Delta VI_{f,t} + X^{'}_{f,t-3}\gamma + \Delta\varepsilon_{f,t}, \quad (5)$$

in which $\Delta Y_{f,t}$ is the change in firm productivity, $\Delta VI_{f,t}$ is the change in the degree of vertical integration for major production activities,[17] and $X^{'}_{f,t-3}$ is a vector of firm-level variables (*Initial Firm Size* and *Initial Sales Change*, reflecting firm size and year-on-year sales growth for the year $t-3$). Standard errors are clustered at the firm-level.

First-Difference estimates of equation (5) are reported in Column 1 of Table VIII. The coefficient of the *Change in Vertical Integration* is negative and statistically significant, suggesting that bringing major production activities in-house leads to a decrease in firm productivity.

Although First-Difference estimation allows us to effectively control for all permanent firm-level characteristics, the endogeneity problem could still arise from unobserved within-firm time-varying factors. To control for such factors, we include several measures of important operational changes in the past three years as robustness checks.

17. Some mismatch in the time periods for $\Delta VI_{f,t}$ and $\Delta Y_{f,t}$ may potentially arise due to ambiguity in the survey question about $\Delta VI_{f,t}$. Specifically, the survey was conducted at some point during fiscal year t, so—depending on the respondent's interpretation—responses to the question ("Has your company brought in-house major production activities in the last three years?") may account for production changes during part of year t (up until when the survey took place). On the other hand, $\Delta Y_{f,t}$ only captures changes in productivity until the end of year $t-1$; the survey does not include information about productivity changes in year t. In other words, a version of the mismeasurement problem may arise if $\Delta VI_{f,t}$ incorporates noise, in the form of "future" year-t changes in vertical integration that should not cause $\Delta Y_{f,t}$.

Table IX.
Analysis of the PESPIC Dataset, Robustness Checks

	1	2
Dependent Variable	Change in Labor Productivity	
Sample	Exclusion of Outlying Observations	Private Firms
Change in Vertical Integration	−0.057***	−0.090**
	[0.021]	[0.036]
Initial Firm Size	0.084***	0.085***
	[0.022]	[0.026]
Initial Sales Change	0.035***	0.026***
	[0.006]	[0.008]
Number of Observations	2,637	2,658

Note: Robust standard errors, clustered at firm level, are presented in the bracket.
*, **, *** represent significance at 10%, 5%, 1% level, respectively.

The PESPIC dataset contains the following questions: (1) "Has your company introduced any new technology that has substantially changed the way that the main product is produced in the last three years?"; (2) "Has your company agreed any new joint venture with a foreign partner in the last three years?"; (3) "Has your company obtained any new licensing agreement in the last three years?"; and (4) "Has your company developed any major new product line in the last three years?". Accordingly, we construct four control variables—*Introduction of New Technology*, *Introduction of New Joint Venture*, *Introduction of New Licensing Agreement*, and *Introduction of New Major Product Line*—each of which takes the value of 1 if the firm replies affirmatively to the respective question and 0 otherwise. In addition, we construct a variable related to the change in capital intensity (i.e., measured as the change in logarithm of assets per worker) to control for possible within-industry heterogeneity in technology.

We include these five additional control variables in the model in a stepwise manner in Columns 2–6 of Table VIII. Our regressor of interest, *Change in Vertical Integration*, continues to produce a negative and statistically significant impact on firm productivity, implying the robustness of our findings in Column 1 to possible time-varying characteristics.

Robustness Checks

Mirroring our robustness checks of the SCE and the ASIF, we repeat our first-difference estimations for the following subsamples. First, we exclude the top and bottom 1% of observations for firm productivity to check whether our results are mainly driven by outlying observations (Column 1 of Table IX). Second, we exclude state-owned enterprises by restricting our analysis to the sub-sample of private firms (Column 2 of Table IX). Our main finding remains robust to these robustness checks.

4.2. Comparing Datasets: Econometric Tradeoffs

Regarding the *mismeasurement* problem: the SCE and PESPIC analyses control for the mismeasurement problem by including direct (but potentially subjective) measures of vertical integration. However, as we discuss in footnote 17, the mismeasurement problem may arise in the PESPIC from a different source: ambiguity about the time period over which the independent variable, *Change in Vertical Integration*, is reported. The ASIF analysis relies on *Value Added* as a measure of vertical integration, which is susceptible to the mismeasurement problem; this issue is partially alleviated by our inclusion of a detailed set of 4-digit industry dummies (and, in some specifications, firm dummies).

Regarding the *endogeneity* problem: for the cross-sectional analysis of the SCE, we are concerned with firm-level heterogeneity. We utilize *Local Purchase* as an instrument for vertical integration, and control for a large set of variables including industry dummies, city dummies and CEO and firm characteristics. In particular, we attempt to identify and control for potential channels through which *Local Purchase* may have causal effects on *Labor Productivity*. Nonetheless, we cannot completely exclude the possibility that omitted-variable bias (either permanent or time-varying) affects our IV results. The ASIF and PESPIC datasets allow us to conduct panel analyses that control for permanent firm-level heterogeneity, but cannot completely eliminate potential firm-specific time-varying shocks that may drive both vertical integration decisions and firm productivity.

5. A Simple Model: Vertical Integration, Rent-Seeking, and Firm Performance

This section presents a simple and very stylized model of vertical integration. In the model, integration corresponds to firm insiders (e.g., firm management) retaining key decision-rights that determine the outcome of production, whereas outsourcing corresponds to the partial transfer of decision rights to outside suppliers.

As a quick preview: the key source of inefficiency in the model is that integration gives insiders more control over the production process, and thus enables their rent-seeking activities. Outsourcing, by reducing insider control, reduces incentives for such rent-seeking because the returns to rent-seeking have to be shared between insiders and suppliers. The dark side of outsourcing is that it also suppresses managerial incentives for productive but costly actions.

Our model assumes that rent-seeking benefits accrue to the insider, and that *ex post* bargaining over the implementation of actions is efficient. We relax these assumptions in the Appendix, and show that our qualitative results continue to hold.

There is a single insider (who we may think of as an entrenched CEO, or the firm's majority shareholder), and a unit mass of infinitesimally weighted tasks to be managed. Each task is assigned a manager, and requires some task-specific assets. Mass $m \in (0, 1)$ of tasks are integrated: the insider manages the task, and the firm owns the task-specific assets. The remaining $1 - m$ tasks are outsourced: an outside supplier manages the task, and owns the task-specific assets. Outside suppliers are specialized, so each supplier can manage a maximum of one (infinitesimal) task for the firm. Each task θ produces net revenue π_θ, which we specify later and takes into account action costs and/or transfers to the supplier. Firm revenue equals net task revenue integrated over all tasks:

$$\Pi = \int_0^1 \pi_\theta d\theta. \tag{6}$$

The insider receives fraction $b \in (0, 1)$ of total revenue Π,[18] as well as some private benefits to be specified later. Revenue π_θ and private benefits are not contractible, so formal incentive contracts cannot be offered to outside suppliers.[19]

18. Think of the remaining share of revenue as going to passive shareholders who have no say in firm decision-making.

19. We may allow for a verifiable, noisy signal of firm revenue $y = \Pi + \varepsilon$ to be available. However, because each task is infinitesimal, firm revenue would be uncorrelated with revenue from each task, and thus incentive contracts for suppliers based on firm revenue would be ineffective. The premise is that because there are many suppliers who each make only a small contribution to firm revenue, incentive provision based on firm revenue becomes prohibitively costly, especially in the presence of contracting frictions such as supplier risk-aversion.

For each task θ, there are two costly, noncontractible actions chosen by the task's manager: a **p**roductive action $p_\theta \geq 0$ that increases firm revenue, and a **r**ent-seeking action $r_\theta \geq 0$ that produces private benefits for the insider at the expense of firm revenue. These actions have to be implemented, and implementation requires the cooperation of the insider; the underlying premise is that insourcing of task θ corresponds to the insider having sole control over θ, whereas outsourcing corresponds to joint control by insider and supplier. Specifically, if actions p_θ and r_θ are successfully implemented, then gross task revenue is $p_\theta - r_\theta$ whereas the insider receives r_θ in private benefits from that task. If implementation fails, then gross task revenue and private benefits equal zero.

The cost of these actions $c_\theta = \frac{1}{2}p_\theta^2 + \frac{1}{2\alpha}r_\theta^2$ is incurred by the owner of the task-specific assets: the firm for integrated tasks, and the supplier for outsourced tasks. Parameter α represents the ease of expropriation: higher α represents weaker legal protections which allow the player performing the task to expropriate from the firm more easily.

The overall timing of the model is as follows:

1. For each outsourced task θ, the insider makes the outside supplier a participation offer $\kappa_\theta \in \mathbb{R}$. If the supplier accepts, then he receives κ_θ from the firm;[20] otherwise the task is not performed, and the supplier receives an outside option payoff normalized to zero.

2a. For each task θ, the manager (the insider under integration, the supplier under outsourcing) chooses costly actions p_θ and r_θ, and cost c_θ is sunk.

2b. For each outsourced task θ, the insider bargains with the supplier over (i) whether to implement the action, and (ii) a transfer $\mu_\theta \in \mathbb{R}$ from firm to supplier.[21] Assume efficient Nash bargaining, so the insider and supplier share the bargaining surplus equally.

Notice that the manager's costly, noncontractible actions are taken *ex ante*, with *ex post* efficient bargaining over implementation of these actions. In interpreting the model, we are agnostic about the time span over which these noncontractible actions are made and implemented: they may be long-term investments (e.g., human capital investments) or short-term choices (e.g., choosing the quality of raw materials purchased). Further, the efficient *ex post* bargaining step is not crucial to our results: in the Appendix, we consider an alternative assumption where the non-contractible actions are taken *ex post* (with no subsequent bargaining), and show that our qualitative findings remain unchanged. This alternative assumption may better capture settings where decisions are implemented rapidly and thus have relatively contemporaneous effects on output.[22]

To recap, we summarize some key quantities. Net task revenue accounts for action costs under integration, and transfers to the supplier under outsourcing:

$$\pi_\theta = \begin{cases} p_\theta - r_\theta - c_\theta & \text{under integration,} \\ p_\theta - r_\theta - (\kappa_\theta + \mu_\theta) & \text{under outsourcing.} \end{cases} \tag{7}$$

20. If $\kappa_\theta < 0$, then the payment is from the supplier to the firm.

21. Our results remain qualitatively unchanged if we assume that payments are made "under-the-table," between insider and supplier; such a change simply corresponds to a shift in relative bargaining power between the two parties.

22. One interpretation of our finding in Section 3—that the effects of vertical integration are relatively contemporaneous—is that, at least in some settings, the relevant noncontractible actions are short-run in nature.

The insider's payoff u consists of her share of firm revenue, plus private benefits:

$$u = b\,\Pi + \int_0^1 r_\theta \, d\theta = \int_0^1 (b\pi_\theta + r_\theta)\, d\theta.$$

Each outsourcing supplier's payoff v_θ is his net transfer, less action costs:

$$v_\theta = \kappa_\theta + \mu_\theta - c_\theta.$$

Total surplus is gross revenue, plus private benefits, less action costs c_θ:

$$\text{surplus} = \int_0^1 \left[p_\theta - \left(\frac{1}{2} p_\theta^2 + \frac{1}{2\alpha} r_\theta^2 \right) \right] d\theta.$$

Note that the first-best (surplus maximization) is achieved when $p_\theta \equiv 1$ and $r_\theta \equiv 0$.

5.1. Integration versus Outsourcing

We start with a convenient observation which allows for a straightforward comparison between integration and outsourcing. An asterisk denotes equilibrium outcomes; for example, c_θ^* denotes the equilibrium level of c_θ.

Lemma 1: *In equilibrium, under both integration and outsourcing, net task revenue equals gross task revenue less action cost c_θ:*

$$\pi_\theta^* = \left(p_\theta^* - r_\theta^*\right) - \left(\frac{1}{2} p_\theta^{*2} + \frac{1}{2\alpha} r_\theta^{*2} \right). \tag{8}$$

Proof: In the case of integration, (8) is simply a restatement of (7). In the case of outsourcing, note that in step 1, the insider maximizes his payoff for task θ by minimizing the payment κ_θ. The insider thus holds the supplier to his zero outside option in equilibrium, so that the supplier is indifferent between accepting and rejecting the step 1 offer: $v_\theta^* = \kappa_\theta^* + \mu_\theta^* - c_\theta^* = 0$. (In words, the equilibrium net transfer $\kappa_\theta^* + \mu_\theta^*$ to the supplier equals the equilibrium action cost c_θ^*.) Substituting this expression into (7), we get (8).

The next two lemmas calculate the equilibrium actions under integration and outsourcing. Denote equilibrium outcomes under integration (resp. outsourcing) with a subscript I (resp. S); for example, net task revenue for an integrated task is denoted as π_I^*.

Lemma 2: *Suppose task θ is integrated. Then the insider chooses $p_I^* = 1$ and $r_I^* = \alpha \frac{1-b}{b}$ for that task. Net task revenue is $\pi_I^* = \frac{1}{2} - \alpha \frac{1-b^2}{2b^2}$.*

Proof: Under integration, the insider chooses p_θ and r_θ to maximize his payoff $b(p_\theta - r_\theta - \frac{1}{2} p_\theta^2 - \frac{1}{2\alpha} r_\theta^2) + r_\theta$, that is, $p_I^* = 1$ and $r_I^* = \frac{\alpha(1-b)}{b}$. Net revenue for the task is thus $p_I^* - r_I^* - \frac{1}{2} p_I^{*2} - \frac{1}{2\alpha} r_I^{*2} = \frac{1}{2} - \alpha \frac{1-b^2}{2b^2}$.

Under integration, the insider appropriately internalizes the costs and benefits of the productive action, and chooses the first-best productive action $p_\theta^* = 1$. On the other hand, because she appropriates all benefits from rent-seeking but only bears fraction $b < 1$ of the costs, she engages in inefficient rent-seeking. This rent-seeking action, and the resultant inefficiency, is increasing in the ease of expropriation α.

Lemma 3: *Suppose task θ is outsourced. Then the supplier for that task chooses $p_S^* = \frac{b}{1+b}$ and $r_S^* = \alpha \frac{1-b}{1+b}$. Net revenue from the task is $\pi_S^* = \frac{b}{1+b} \frac{2+b}{2+2b} - \alpha \frac{1-b}{1+b} \frac{3+b}{2+2b}$.*

Proof: The insider's disagreement payoff is $-b\kappa_\theta$, whereas the supplier's disagreement payoff is $\kappa_\theta - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$. On the other hand, given a bargaining payment μ_θ (paid by the firm) to the supplier, the insider's payoff (following implementation) is $b(p_\theta - r_\theta - \mu_\theta - \kappa_\theta) + r_\theta$, whereas the supplier's payoff becomes $\kappa_\theta + \mu_\theta - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$. The two parties Nash bargain to an equal-surplus outcome: $bp_\theta + (1-b)r_\theta - b\mu_\theta = \mu_\theta$. Solving for the bargaining payment, $\mu_\theta = \frac{bp_\theta+(1-b)r_\theta}{1+b}$; so the supplier's net payoff is $\kappa_\theta + \frac{bp_\theta+(1-b)r_\theta}{1+b} - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$. To maximize this payoff, the supplier chooses actions $p_S^* = \frac{b}{1+b}$ and $r_S^* = \alpha\frac{1-b}{1+b}$. Net revenue from task θ is thus $\pi_S^* = p_S^* - r_S^* - \frac{1}{2}p_S^{*2} - \frac{1}{2\alpha}r_S^{*2} = \frac{b}{1+b}\frac{2+b}{2+2b} - \alpha\frac{1-b}{1+b}\frac{3+b}{2+2b}$.

Compared to the insider's choices under integration, the (supplier's) productive and rent-seeking actions under outsourcing are each diminished by a factor $\frac{b}{1+b}$.[23] Under outsourcing, the supplier has to share the returns from his productive and rent-seeking actions with the insider; thus his incentives for both actions are suppressed relative to the insider's incentives under integration, where the insider keeps the "full" returns from his actions.

The tradeoff between integration and outsourcing is thus as follows: integration increases productive actions ($p_I^* > p_S^*$), but also results in more costly rent-seeking ($r_I^* > r_S^*$). An increase in the ease of expropriation α increases the extent of rent-seeking, and consequently makes outsourcing more profitable relative to integration.

Proposition 1: *Firm revenue Π is increasing in the extent of integration m if*

$$\alpha < \frac{b^2}{(1-b)(1+3b)}, \tag{9}$$

and decreasing in m otherwise.

Proof: From Lemmas 2 and 3, integrated tasks contribute $\pi_I^* = \frac{1}{2} - \alpha\frac{1-b^2}{2b^2}$ of revenue per unit mass, whereas outsourced tasks contribute $\pi_S^* = \frac{b}{1+b}\frac{2+b}{2+2b} - \alpha\frac{1-b}{1+b}\frac{3+b}{2+2b}$ of revenue per unit mass. Mass m of tasks are integrated and mass $1-m$ are outsourced, so firm revenue is $\Pi = m\pi_I^* + (1-m)\pi_S^* = \pi_S^* + m(\pi_I^* - \pi_S^*)$. Consequently, Π is increasing in m if and only if $\pi_I^* - \pi_S^* > 0$. Using the expressions for π_I^* and π_S^* from Lemmas 2 and 3, some manipulations reveal that this is the case if and only if $\alpha < \frac{b^2}{(1-b)(1+3b)}$.

Thus integration is more profitable than outsourcing if and only if the ease of expropriation α is small.[24]

In other words: the effect of an increase in the degree of firm integration on revenue depends on the quality of the legal environment. In good (bad) legal environments where expropriation is difficult (easy), an increase in firm integration results in an increase (decrease) in firm revenue and total surplus. In particular, the case of high α matches our setting of China and other developing countries, where legal protections are

23. Note that if transfers were paid by the manager (rather than the firm) to the supplier, then the supplier's incentives would instead by diminished by a factor $\frac{1}{2}$. This assumption corresponds to a setting where *ex post* renegotiation takes place under-the-table, with bribes paid by the insider to the supplier. The results do not change qualitatively in this alternative setting.

24. Similarly, we may show that total surplus (revenue plus managerial and supplier payoffs) is increasing in the degree of integration if and only if α is small, that is, expropriation is difficult. Each task θ produces surplus $p_\theta - p_\theta^2/2 - r_\theta^2/(2\alpha)$. In particular, integrated tasks produce $\frac{1}{2} - \frac{(1-b)^2\alpha}{2b^2}$ of surplus per unit mass, and outsourced tasks produce $\frac{b(2+b)}{2(1+b)^2} - \frac{\alpha(1-b)^2}{2(1+b)^2}$ of surplus per unit mass. Consequently, total surplus is $m(\frac{1}{2} - \frac{(1-b)^2\alpha}{2b^2}) + (1-m)(\frac{b(2+b)}{2(1+b)^2} - \frac{\alpha(1-b)^2}{2(1+b)^2})$, which is increasing in m if and only if $\alpha < \frac{b^2}{(1+2b)(1-b)^2}$.

relatively weak and expropriation is easy. In that case, Proposition 1 predicts that firm productivity (as measured by revenue) is decreasing in the degree of vertical integration. This matches our empirical findings.

5.2. Managerial Ability and the Integration Decision

So far, we have exogenously specified the degree of integration m.[25] We now allow the insider to choose m at the start of the game (i.e., before step 1). To introduce variation in the integration decision across firms, suppose that insiders differ in managerial ability: more capable insiders can easily handle more tasks via integration without relying on suppliers. To model the difficulty of managing integration, suppose that the insider incurs a private cost of integration $C(m) = \frac{m^2}{2\eta}$, where $\eta \geq 0$ captures the manager's ability.

Proposition 2: *The equilibrium degree of integration m^* is increasing in managerial ability η and in the ease of expropriation α. Further, firm revenue Π is increasing in η (and thus with m^*) if $\alpha < \frac{b^2}{(1-b)(1+3b)}$, and is decreasing in η (and thus with m^*) otherwise.*

Proof: The insider's payoff if mass m of tasks are integrated is $m(b\pi_I^* + r_I^*) + (1 - m)(b\pi_S^* + r_S^*) - \frac{m^2}{2\eta}$, which we may rewrite as $b\pi_S^* + r_S^* + m(b(\pi_I^* - \pi_S^*) + (r_I^* - r_S^*)) - \frac{m^2}{2\eta}$; so the insider optimally chooses $m^* = \min\{1, \eta(b(\pi_I^* - \pi_S^*) + (r_I^* - r_S^*))\}$. Note that m^* is increasing in managerial ability η (strictly so if $m^* \in (0, 1)$). Further, some manipulations reveal that

$$b(\pi_I^* - \pi_S^*) + (r_I^* - r_S^*) = \frac{b}{2(1+b)^2} + \alpha\frac{3(1-b)}{2(1+b)^2} \tag{10}$$

is increasing in the ease of expropriation α; thus, so is m^*. Now, because the cost $\frac{m^2}{2\eta}$ is privately borne by the insider, the expression for equilibrium firm revenue remains unchanged from Section 5.1: $\Pi^* = m^*\pi_I^* + (1 - m^*)\pi_S^*$. The result of Proposition 2 thus follows from Proposition 1.

Proposition 2 states that more capable insiders can handle more integrated tasks without relying on suppliers, and thus choose a greater degree of integration for the firms they manage. The effect on firm productivity of this increased integration depends on whether the insider invests more in productive or rent-seeking activities. In particular, in poor legal environments (high α), high-ability managers actually decrease firm-level productivity, because they apply their capabilities toward rent-seeking rather than productive activities. (But their ability only affects m here. There may be counter-acting forces.)

Proposition 2 predicts that revenue increases with integration m if and only if expropriation is easy: $\alpha < \frac{b^2}{(1-b)(1+3b)}$. The threshold for α is identical to that of Proposition 1, which considers the effect of an *exogenous* shift in m on firm revenue. This is because the integration cost—being privately incurred by the insider—affects firm revenue only via the choice of m, and is otherwise orthogonal to the production

25. We also assume that the insider's share of revenue $b \in (0, 1)$ is exogenously specified. In fact, firm revenue Π would be maximized at the upper bound $b = 1$, in which case the insider is a residual claimant. We adopt the premise that b is limited by exogenous factors such as wealth constraints on the insider's shareholdings.

function (7). In the Appendix, we consider a simple variation of the model where managerial ability directly affects the revenue from integrated tasks, and show that our predictions remain qualitatively unchanged.

Further, Proposition 2 highlights two countervailing forces that may drive equilibrium integration decisions in developing countries. Poor corporate governance (high α) produces more integration, because insiders integrate more tasks to take advantage of easier rent-seeking. On the other hand, a relative dearth of managerial talent (low η) in developing economies may result in less integration. Consequently, taking both forces into account, the effect on equilibrium integration m^* of moving from a developed-country to a developing-country setting is ambiguous.

6. Conclusion

This paper investigates the impact of vertical integration on firm productivity using firm-level data from China and other developing countries. Mismeasurement and endogeneity problems pose challenges in this line of research. Our approach is to analyze, separately, three different datasets that address the mismeasurement and endogeneity problems in different ways. Throughout our analysis, we consistently find that the degree of vertical integration has a negative and statistically significant impact on firm productivity. This consistency, as well as the cross-industry nature of our samples, suggests that our findings may be quite broadly applicable to the developing-country context.

Our results contrast with recent empirical findings (largely based on U.S. firms) that vertical integration is positively correlated with firm productivity. We propose that the differences between their results and ours are driven by differences in the ease of rent-seeking in developed versus developing countries. In particular, weak legal environments complement integrated firm structures in enabling rent-seeking by firm insiders, so the costs of integration outweigh the benefits of integration in developing countries where legal protections are weak.

Appendix A: Model Extensions and Robustness

This appendix considers three variants of the basic model. It shows that our basic results remain qualitatively robust to these modifications. In particular, the basic force animating the model remains the same. Integration provides stronger incentives than outsourcing for both productive and rent-seeking actions, because integration gives sole control to the decision-maker (insider), whereas outsourcing forces the decision-maker (supplier) to share control with the insider. Consequently, task revenue is higher under integration than outsourcing if and only if the ease of expropriation α is low.

To simplify the expressions, assume without loss that given degree of integration m, tasks $\theta \in [0, m)$ are integrated and tasks $\theta \in [m, 1]$ are outsourced.

Manager-Specific Private Benefits

Section 5 assumes that regardless of the integration decision, all private benefits from rent-seeking activities accrue to the insider. This seems natural, as an entrenched insider would likely have more avenues than outside suppliers to enjoy the fruits of rent-seeking activities, such as managerial perks or expense accounts. That said, we consider below the alternative assumption that private benefits always accrue to the manager of the task (i.e., by the insider under integration, and by the supplier under outsourcing); so that suppliers' and insider's payoffs become

$$v_\theta = r_\theta + \kappa_\theta + \mu_\theta - c_\theta,$$
$$u = b\,\Pi + \int_0^m r_\theta\, d\theta.$$

This change affects the outcome of *ex post* bargaining and thus the supplier's incentives to invest under outsourcing. However, p_I^* and r_I^* remain unchanged.

Proposition 3: *With manager-specific private benefits: under outsourcing,* $p_S^* = \frac{b}{1+b}$ *and* $r_S^* = 0$*. Consequently,* $p_I^* > p_S^*$ *and* $r_I^* > r_S^*$*. Further, firm revenue* Π *is increasing in* m *if and only if* $\alpha < \frac{b^2}{(1-b)(1+b)^3}$.

Proof: The insider's disagreement payoff is $-b\kappa_\theta$, whereas the supplier's disagreement payoff is $\kappa_\theta - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$. On the other hand, given a bargaining payment μ_θ (paid by the firm) to the supplier, the insider's payoff (following implementation) is $b(p_\theta - r_\theta - \mu_\theta - \kappa_\theta)$, whereas the supplier's payoff becomes $r_\theta + \kappa_\theta + \mu_\theta - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$. The two parties Nash bargain to an equal-surplus outcome: $bp_\theta - br_\theta - b\mu_\theta = r_\theta + \mu_\theta$. Solving for the bargaining payment, $\mu_\theta = \frac{bp_\theta - (1+b)r_\theta}{1+b}$; so the supplier's net payoff is $\kappa_\theta + \frac{bp_\theta}{1+b} - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$. To maximize this payoff, the supplier chooses $p_S^* = \frac{b}{1+b}$ and $r_S^* = 0$. Net revenue from task θ is thus $\pi_S^* = p_S^* - r_S^* - \frac{1}{2}p_S^{*2} - \frac{1}{2\alpha}r_S^{*2} = \frac{b}{1+b}\frac{2+b}{2+2b}$. Using this and the fact from Lemma 2 that $\pi_I^* = \frac{1}{2} - \alpha\frac{1-b^2}{2b^2}$, some further manipulations show that firm revenue $\Pi = \pi_S^* + m(\pi_I^* - \pi_S^*)$ is increasing in m if and only if $\alpha < \frac{b^2}{(1-b)(1+b)^3}$.

Ex Post Decision-Making

Section 5 assumes that the costly actions p_θ, r_θ are *ex ante* investments, and that *ex post* bargaining over implementation of those actions takes place for outsourced tasks. An alternative modeling approach is to posit that efficient bargaining over implementation does not take place. Specifically, assume that in step 2b, no transfers are allowed and the insider simply decides whether to implement the actions p_θ and r_θ. If not, then the outcome is zero task revenue and private benefits.

In this setting, we may think of steps 2a and 2b as an *ex post* adaptation stage, with joint control over decision-making by insider and supplier. One interpretation may be that the time window for steps 2a and 2b is short, so that renegotiation is infeasible. Thus it may better capture the premise of short-run decision-making than does the setting of Section 5.

By excluding bargaining over implementation, the supplier has zero incentive to make costly decisions, because he is not paid for them *ex post*. Consequently, we obtain the following stark characterization of the outsourcing outcome.[26]

Proposition 4: *With inefficient ex post implementation: under outsourcing,* $p_S^* = 0$ *and* $r_S^* = 0$*. Consequently,* $p_I^* > p_S^*$ *and* $r_I^* > r_S^*$*. Further, firm revenue* Π *is increasing in* m *if and only if* $\alpha < \frac{b^2}{1-b}$.

Proof: The supplier's payoff is $\kappa_\theta - \frac{1}{2}p_\theta^2 - \frac{1}{2\alpha}r_\theta^2$, so he optimally chooses $p_S^* = r_S^* = 0$. This immediately implies $\kappa_\theta = 0$. Consequently, net revenue from an outsourced

26. We assume here that private benefits always accrue to the insider, but the result remains the same if private benefits accrue to the task manager instead.

task is zero. Using this and the fact from Lemma 2 that $\pi_I^* = \frac{1}{2} - \alpha\frac{1-b^2}{2b^2}$, some further manipulations show that firm revenue $\Pi = \pi_S^* + m(\pi_I^* - \pi_S^*)$ is increasing in m if and only if $\alpha < \frac{b^2}{1-b^2}$.

Costly Integration

Section 5.2 assumes that integration costs are privately borne by the insider. Here, we consider a variant where increasing the degree of integration m directly results in reduced revenue from integrated tasks. Specifically, suppose that integrating mass m of tasks reduces total revenue from integrated tasks by $C(m) = \frac{m^2}{2\eta}$, so that firm revenue becomes

$$\Pi = \int_0^1 \pi_\theta \, d\theta - C(m). \tag{A1}$$

The insider does not bear any cost of integration privately.[27]

The main point of this variant is that the comparative statics from Proposition 2 continue to hold qualitatively: higher-ability managers integrate more tasks, and firm revenue increases (decreases) with the degree of integration m for low (high) α.

Proposition 5: *Under costly integration, the equilibrium degree of integration m^* is increasing in managerial ability η and in the ease of expropriation α. Further, firm revenue π is increasing in η (and thus with m^*) if $\alpha < \frac{b^2}{3(1+b)}$, and is decreasing in η (and thus with m^*) otherwise.*

Proof: First, note that in this setting, the expressions for equilibrium task revenue, π_I^* and π_S^*, remain unchanged from the basic model. Given m, firm revenue is $\Pi = m\pi_I + (1-m)\pi_S - \frac{m^2}{2\eta}$, and the insider's payoff is $m(b\pi_I^* + r_I^*) + (1-m)(b\pi_S^* + r_S^*) - b\frac{m^2}{2\eta}$, which we may rewrite as $b\pi_S^* + r_S^* + m(b\tilde{\pi}^* + \tilde{r}^*) - b\frac{m^2}{2\eta}$ where $\tilde{\pi}^* = \pi_I^* - \pi_S^*$ and $\tilde{r}^* = r_I^* - r_S^*$. The insider optimally chooses $m^* = \eta(\tilde{\pi}^* + \frac{\tilde{r}^*}{b})$. From equation (10), $\tilde{\pi}^* + \frac{\tilde{r}^*}{b} > 0$, so m^* is increasing in η. Thus, firm revenue is $\pi_S^* + m^*\tilde{\pi}^* - \frac{m^{*2}}{2\eta} = \pi_S^* + \frac{\eta}{2}(\tilde{\pi}^{*2} - \frac{\tilde{r}^{*2}}{b^2})$. Again, $\tilde{\pi}^* + \frac{\tilde{r}^*}{b} > 0$, so firm revenue is increasing in η iff $\tilde{\pi}^* - \frac{\tilde{r}^*}{b} = \frac{b}{2(1+b)^2} - \alpha\frac{3(1+b)}{2b(1+b)^2}$ is positive; that is, iff $\alpha < \frac{b^2}{3(1+b)}$.

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27. An alternative interpretation of this model is that within the firm, tasks vary in their returns to integration. Specifically, suppose that net revenue under integration of task $\theta \in [0,1]$ is $p_\theta - r_\theta - \frac{\theta}{\eta}$; whereas the gross revenue under outsourcing of task θ remains $p_\theta - r_\theta$. In other words, high-θ tasks are relatively unsuited for integration. If the insider integrates the m easiest tasks $\theta \in [0, m]$, then (applying Lemma 1) equilibrium net revenue is $\Pi = \int_0^1 p_\theta^* - r_\theta^* - c_\theta^* \, d\theta - \int_0^m \frac{\theta}{\eta} d\theta$, with the last term $\int_0^m \frac{\theta}{\eta} d\theta = \frac{m^2}{2\eta}$ being an endogenous "integration cost." Thus, equation (A1) is reproduced. Under this interpretation, η is a firm-specific parameter which captures the degree heterogeneity in the costs of integration across tasks.

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