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Essays on Effects of Skill Mix on Productivity and Determinants of Foreign Ownership in Developing Countries

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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Statement of conjoint work: Chapter 1 of my PhD thesis, titled “"Productivity As If Space Mattered: An Application to Factor Markets Across China”, is joint work with Wenya Cheng of LSE and Dr. John Morrow of CEP and LSE. This work was motivated by Dr Morrow’s job market paper which explains how skill mix affects firm-level productivity and trade. Wenya and myself saw the possibility of using her Chinese datasets to explore whether skill mix can explain the differences in productivity levels in China and Dr Morrow kindly agreed to share his expertise and coauthor this paper with us. Dr Morrow, Wenya and myself have contributed to this paper equally and the general decisions about the direction of the paper were made equally between the three authors.

Kitjawat Tacharoen

Abstract

The first chapter is titled "Productivity As If Space Mattered: An Application to Factor Markets Across China”. Optimal production decisions depend on local market characteristics. This chapter develops a model to explain firm labour demand and firm density across regions. Firms vary in their technology to combine imperfectly substitutable worker types, and locate across regions with distinct distributions of workers and wages. Firm technologies which best match regional labour markets explain both productivity differences and firm density. Estimating structural model parameters is simple and relies on a two stage OLS procedure. The first stage estimates local market conditions using firm employment and regional data, while the second incorporates regional costs into production function estimation. The method is applied to Chinese manufacturing, population census and geographic data to estimate local market costs and production technologies. In line with the model, we find that labour markets which provide cost advantages explain substantial differences in firm productivity. Furthermore, regions which have lower optimal hiring costs attract more firms per capita. This is a joint work with Wenya Cheng and Dr John Morrow.

The second chapter is called “Foreign Ownership Share and Property Rights: Evidence from Thai Manufacturing Firms”. Existing work based on property-rights theories treat ownership as binary and the degree of integration as exogenous. This chapter proposes a property-rights model where the degree of integration is endogenised and treated as a continuous variable. The model makes two predictions for firm behaviour under vertical integration. Firstly, foreign ownership shares should increase with the significance of foreign investors’ investment. Secondly, the effect of investors’ investment on ownership increases with the elasticity of substitution across product varieties. Both predictions find considerable support in firm-level data from Thailand.

The third chapter, “Product Quality and Intra-firm Trade”, presents a partial equilibrium model with product quality differentiation where heterogeneous firms choose whether to vertically integrate their foreign suppliers or outsource input production. Quality is non-verifiable by third parties which causes the well-known hold-up problem. The severity of the problem increases with product quality. The model yields a closed form expression for the productivity threshold that assigns firms into different ownership structures. The impact of quality related parameters on the threshold is analysed in detail.

Contents

Contents 4

List of Figures 9

List of Tables 10

I Introduction 13

II Productivity As If Space Mattered: An Application to Factor Markets Across China 15

1 Introduction 15

2 The Role of Skill Mix in Production 18

2.1 Firm Production . . . 19

2.2 Optimal Hiring by Region and Technology . . . 21

2.3 Cost Minimisation . . . 23

2.4 Unit Labour Costs under Pareto Match Quality . . . 23

3 Firm Production under Monopolistic Competition 26

3.1 Model Setting . . . 26

3.2 Aggregate Income, Demand and Budget Shares . . . 27

3.3 Regional Factor Market Clearing . . . 28

3.4 Relative Concentration of Firms . . . 30

4 Estimation Strategy 30

4.1 First Stage Estimation . . . 31

4.2 Second Stage Estimation . . . 31

4.3 Estimation Procedure Summary . . . 32

5 Data 33

5.1 Data Overview . . . 33

5.2 Regional Variation 34
5.3 Worker Types 36

6 Estimation Results **37**
6.1 Estimates of Market Conditions and Production Technologies 37
6.2 Implied Productivity Differences Across Firms 39
6.3 Firm Location 40
6.4 Comparison with Conventional Labour Measures 41

7 Conclusion **43**

8 Appendix **44**
8.1 Further Model Discussion and Proofs 44
8.1.1 Relative Prices and Limited Factor Price Equalisation 44
8.1.2 Existence of Regional Wages to Clear Input Markets 45
8.2 Model Simulation and Estimator Viability 46
8.3 Further Details on Regional Variation In China 48
8.3.1 Educational Summary Statistics 48
8.3.2 Provincial Summary Statistics 50
8.3.3 Industrial Summary Statistics 51
8.4 Estimates Referenced in Main Text 51
8.4.1 Verisimilitude of Census and Firm Wages 51
8.4.2 First Stage Results By Industry 53
8.4.3 First and Second Stage Models Parameter Estimates 55
8.4.4 Residual Comparison: Unit Labour Costs vs Substitutable Labour 55
8.4.5 Firm Performance Characteristics and Productivity 56
8.5 Supplemental Appendix 57
8.5.1 Derivation of Region-Techonology Budget Shares 57
8.5.2 Regional Variation in Input Use 58
8.5.3 Regional Variation in Theory: Isoquants 60
8.5.4 Derivation of Unit Labour Costs 60
8.5.5 Derivation of Employment Shares 62

III Foreign Ownership Share and Property Rights: Evidence from Thai Manufacturing Firms **63**

1 Introduction **63**

2 The Model **70**

2.1 Demand . . . 71
2.2 Production . . . 71
2.3 Incompleteness of Contracts . . . 72
2.4 Production Timeline . . . 73
2.5 Subgame Perfect Equilibrium . . . 74

3 Estimation Strategy **79**

3.1 Estimation Strategy to Test the First Prediction . . . 79
3.2 Estimation Strategy to Test the Second Prediction . . . 83

4 Data **84**

4.1 Data Overview . . . 84
4.2 Firm-level Trade . . . 85
4.3 Capital, Skill and R&D Intensity . . . 86
4.4 Foreign Ownership Share and Characteristics of the Foreign Investors . . . 87
4.5 Integration Types . . . 88
4.6 Elasticity of Substitution . . . 89

5 Empirical Results **90**

5.1 Empirical Results on the First Prediction . . . 90
5.2 Empirical Results on the Second Prediction . . . 93

6 Robustness Checks **95**

6.1 Robustness Checks on the Results from the First Prediction . . . 95
6.1.1 Stricter Definitions of Vertical Integration . . . 95
6.1.2 Exclusion of Industries with Low Maximum Foreign Ownership Share . . . 96
6.1.3 Capital is Total Value of Fixed Assets Less Cost of Land . . . 98
6.1.4 Division of Exporting Foreign Affiliates into Four Quantiles . . . 98

6.2 Robustness Checks on the Results From the Second Prediction . . . 99
6.2.1 Division of Firms into Three Groups . . . 99
6.2.2 Deviation From Weighted Average Elasticities . . . 100

7 Conclusion **102**

8 Appendix **103**
8.1 Correlation Matrix . . . 103
8.2 Additional Parent Country Characteristics . . . 103

IV Product Quality and Intra-firm Trade **105**

1 Introduction **105**

2 The model **107**
2.1 Demand . . . 107
2.2 Production . . . 108
2.3 Ownership Structure . . . 110

3 Firms' Optimisation **111**
3.1 Vertical Integration . . . 111
3.2 Outsourcing . . . 113
3.3 Vertical Integration vs Outsourcing . . . 115
3.3.1 Quality . . . 115
3.3.2 Price . . . 116
3.3.3 Quantity . . . 117
3.3.4 Revenue . . . 117
3.3.5 Profits . . . 118

4 Industrial Equilibrium **119**
4.1 Properties of the Profit Functions . . . 119
4.1.1 Slopes of the Profit Functions . . . 119
4.1.2 Properties of M . . . 120

4.2 Pervasive Outsourcing Equilibrium 121
4.3 Pervasive Vertical Integration Equilibrium 122
4.4 Equilibrium with Both Ownership Structures 123
4.5 Free Entry and Industry Equilibrium 125

5 Determinants of Ownership Structures 125

5.1 Nash Bargaining Share (ϕ) 125
5.2 Intensity of Preference for Quality (δ) 126

6 Productivity Lowers Fixed Cost instead of Marginal Cost 127

6.1 Gradients of the Profit functions 127
6.2 Productivity Cutoff and Productivity Threshold 128

7 Conclusion 129

8 Appendix 131

8.1 Proof for $\frac{dM}{d\delta} < 0$ 131
8.2 Conditions for Positive $\frac{dM}{d\phi}$ 131

V Conclusion 133

Bibliography 137

List of Figures

1 Human Capital Isoquants 20
2 Submodular Production in $\underline{h}$ Space 25
3 Chinese Prefectures 34
4 Average Monthly Income of Employees (2005) 35
5 Low and High Educational Attainment Across China (2005) 35
6 Geographic Dispersion of Unit Labour Costs: General Machinery 38
7 Simulation Fit 48
8 Chinese Educational Attainment (2005) 48
9 Productivity: Unit Labour Costs vs Total Employment (General Machinery) 56
10 Local Isoquants for Share of Workers Hired 60
11 Distribution of Foreign Ownership Shares in Thailand 65
12 Marginal Effect of Capital Intensity on Ownership Share 69
13 Marginal Effect of Skill Intensity on Ownership Share 69
14 Effects of Capital and Skill Intensity on Ownership across Low and High Elasticity Groups 70
15 Production Timeline 74
16 Predictions Across Low to High Substitutability 79
17 Decision-making in U.S. Based Multinationals 82
18 Distribution of Exporting Firms' Export Share 85
19 Distribution of Importing Firms' Import Share 86
20 Division of Foreign Owned Firms into Three Quantiles by Their Export Share 89
21 Coefficient Plot: First Prediction 92
22 Coefficient Plot: Second Prediction 95
23 Pervasive Outsourcing 121
24 Pervasive Vertical Integration 122
25 Equilibrium with Both Ownership Structures 123

List of Tables

1 First Stage Results: General Machinery . . . 37
2 Model Primitive Estimates . . . 38
3 Second Stage Estimates . . . 39
4 Intra-industry Unit Labour Cost and Productivity Ratios . . . 40
5 Determinants of Regional (Log) Value Added per Capita . . . 41
6 Second Stage Estimates vs Homogeneous Labour Estimates . . . 42
7 Explaining Survival with Productivity . . . 43
8 Simulation details . . . 47
9 Simulation Results . . . 47
10 Educational and Wage Distribution by Province (2005) . . . 49
11 Descriptive Statistics by Province (2005) . . . 50
12 Manufacturing Survey Descriptive Statistics (2005) . . . 51
13 Census Wages as a Predictor of Reported Firm Wages . . . 52
14 First Stage Estimates I . . . 53
15 First Stage Estimates II . . . 54
16 Model Primitive Estimates . . . 55
17 Explaining Growth with Productivity . . . 56
18 Explaining Propensity to Export with Productivity . . . 57
19 Firm-level Variable Description . . . 83
20 The Characteristics of the Top Twenty Investor Countries . . . 88
21 The Characteristics of Firms in the Three Integration Groups . . . 89
22 Main Regression Results: First Prediction . . . 91
23 Main Regression Results: Second Prediction . . . 94
24 Results When Stricter Definitions of Vertical Integration are Used . . . 96
25 Results for Section 6.1.2 and 6.1.3 . . . 97
26 Regression Results When Exporting Foreign Affiliates are Divided into Four Quantiles 99
27 Separate Elasticity of Substitution into Three Groups; Low, Medium and High . . . 100
28 Results When Weighted Average Elasticities are Not Used . . . 102
29 Correlation Matrix . . . 103

30 Additional Characteristics of the Top Twenty Investor Countries 104
31 Marginal and Fixed Costs for Input Production 109

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Part I

Introduction

This thesis consists of three chapters. Their common denominator is the study of how firms organise their production, with a focus on the skill mix of employees (the first chapter) and on ownership decisions (the second and third chapters). In the first chapter, firms choose to locate in a region where they can obtain the optimal skill mix, given their production technology, at the lowest costs and this maximizes their productivity. If this is true, firms' optimal production decisions should depend on local labour market characteristics. A multi-region, multi-industry general equilibrium model, where industries vary in production technology is proposed to analyse the hypothesis and measure how significant this is in comparison to existing mo dels where skill mix and and local labour market conditions are not taken into account when estimating firm productivity. Each region is endowed with a different distribution of skill types and wages across workers. Firms freely locate and hire a team of workers by choosing the optimal combination of skill levels given local conditions. Since firms take regional characteristics as given, each firm chooses an optimal labour force conditional on industry technology and locality. It follows that the comparative suitability of regions varies by industry. Firms thus locate in proportion to the cost advantages available in each region.

The model allows the authors to test the hypothesis empirically by estimating structural model parameters which relies on a two stage OLS procedure. The first stage estimates local market conditions using firm employment and regional data, while the second incorporates regional costs into production function estimation. Viability of the estimator is illustrated by simulating the underlying production model and accurately recovering the model parameters. The method is applied to Chinese manufacturing, population census and geographic data to estimate local market costs and production technologies. In line with the model, we find that labour markets which provide cost advantages explain substantial differences in firm productivity. Furthermore, regions which have lower optimal hiring costs attract more firms per capita. The results indicate that differences in local markets are quantitatively important and support the hypothesis that modeling a firm's local environment may yield substantial insights into production patterns.

The first chapter focuses on firms' optimal decisions on hiring and production location whereas the second and third chapters analyse firms' decisions on their ownership structure. The second chapter investigates how existing results in property-rights theories change if the degree of integration (i.e. fraction of a subsidiary owned by its parent firm) becomes a continuous choice variable. Existing papers in property-right literature, especially papers which examine the determinants of intra-firm trade, mostly treat the degree of integration as an exogenous and discrete variable. A property-right model where ownership share is endogenous and continuous is proposed and it gives two testable predictions for firm behaviour under vertical integration. Firstly, foreign ownership shares should increase with the significance of foreign investors' investment. Secondly, the effect of investors' investment on ownership increases with the elasticity of substitution across product varieties. Both predictions find considerable support in firm-level data from Thailand. This chapter provides the first piece of evidence suggesting that switching from exogenous and discrete degree of ownership to a continuous choice variable generates significantly different results.

The aim of the third chapter is to explain how the desired level of input quality affects firms' decision on their ownership structure. The chapter presents a partial equilibrium model with product quality differentiation where heterogeneous firms choose whether to vertically integrate their foreign suppliers or outsource input production. Quality is non-verifiable by a third party which causes the well-known hold-up problem. The severity of the problem increases with product quality. The model yields a closed form expression for the productivity threshold that assigns firms into different ownership structures. The impact of quality related parameters on the threshold is analysed in detail. This chapter provides the first framework where both product quality and firm boundaries are jointly determined and this is a good basis for future empirical work on the issue.

Even if both chapter two and three provides insights into the theory of the firm, they focus on different aspects and based on different strands of ownership literature. The setting in the second chapter is based on property-rights theory while the third chapter is based on transaction cost theory. This is because the extra complexity that comes with the property-rights theory does not provide additional insight into analysing the effect of product quality on ownership. By opting for transactional cost theory, much richer findings are generated and closed form solutions can be found.

This thesis generates several new insights into how firms organise their production. Those new insights include how firms hire their heterogeneous workers and choose their locations, how existing results about firm ownership change when the degree of ownership becomes a continuous choice variable and how product quality affects firms' decisions on their ownership structure.

Part II

Productivity As If Space Mattered: An Application to Factor Markets Across China

1 Introduction

A number of studies document large and persistent differences in productivity across both countries and firms.[1] However, these differences remain largely 'some sort of measure of our ignorance' (Abramovitz, 1956). This chapter enquires to what extent the supply characteristics of regional input markets might help explain such systematic productivity dispersion across firms. It would be surprising if disparate factor markets result in similar outcomes, when clearly the prices and quality of inputs available vary considerably over space. Modeling firm adaptation to different factor markets provides deeper insights and testable predictions about how firms produce and where they choose to locate.

Differences between factor markets, especially for labour, are likely to be especially stark in developing economies undergoing urbanisation (Lewis, 1954), or when government policies increase relocation costs beyond those normally present. Institutional mobility constraints, such as the *hukou* system in China, further exacerbate differences in the composition of labour markets. Even the US labour market, which is considered relatively fluid, exhibits high migration costs as measured by the wage differential required to drive relocation (Kennan and Walker, 2011). Thus, free movement of factors does not mean frictionless movement, and recent work has indicated imperfect factor mobility has sizable economic effects (Topalova, 2010). Rather than considering the forces which cause workers to locate across space, this chapter instead takes a different turn to enquire what existing differences in regional input markets imply for firm input use, location and productivity.

To better understand these issues, we propose a multi-region, multi-industry general equilibrium model. Industries vary in team technology, i.e. their ability to substitute between different types of labour (e.g. Bowles, 1970). Each region is endowed with a different distribution of skill types and wages across workers. Firms freely locate and hire a team of workers by choosing the optimal combination of skill levels given local conditions. Since firms take regional characteristics as given,

[1] See Syverson (2011) for a review.

each firm chooses an optimal labour force conditional on industry technology and locality. It follows that the comparative suitability of regions varies by industry. Firms thus locate in proportion to the cost advantages available in each region.

In the model, firm hiring depends on the local distribution of worker types and wages. Since labour demand depends on model parameters and regional labour market conditions, this implies real labour costs vary by region and industry. These labour costs help explain differences in productivity.[2] However, it is not immediately clear that such productivity differences are of an economically large magnitude. To quantify real world supply conditions, we develop an estimation strategy for the key structural parameters. A simple relationship obtains between the firm-level shares of worker types hired and regional observables, which can be estimated by OLS as a first stage. The first stage identifies the labour technology parameters and allows computation of regional labour costs by industry, linking regional markets to productivity. Furthermore, the model relaxes the often imposed restriction that production be supermodular, a restriction that would otherwise often bind in our sample. The second stage incorporates regional costs into production function estimation, either by OLS or other commonly used methods. This strategy is straightforward to implement, and simulation of the underlying production model shows little accuracy is lost in comparison to full structural estimation.

The procedure just outlined is applied to manufacturing and population census data spread over three hundred prefectures in China. The manufacturing survey reports the distribution of workers across skills for each firm, while the population census provides regional distributions of wages and worker skill types. By revealing how firm demand for skills varies with local conditions, this information allows recovery of the unit costs for labour across China. Our estimates imply an interquartile difference in labour costs for each industry of 30 to 80 percent. As predicted by the model, labour costs are negatively related to the value added per capita across regions. This indicates that economic activity locates where regional costs are lowest.

A second stage estimates production function parameters, explicitly accounting for regional cost differences. Since firms are capable of substituting out of labour inputs when they are relatively expensive, this fact alters estimation of the relative share of labour in production. Once this effect is accounted for, labour cost differences result in firm productivity differences for each industry of 3 to 17 percent. The estimates show that favourable labour market conditions explain substantial

[2] Effective labour costs are driven by the complementarity of regional endowments with industry technology, and this chapter refers to these additional real production possibilities as ‘productivity’.

differences in firm productivity. Once local market costs are controlled for, 'residual' productivity is a stronger predictor of firm performance characteristics such as survival and growth. This suggests that the unobservables which make firms more competitive are often conflated with advantageous input markets.

Related work. The importance of local market characteristics, especially in developing countries, has recently been emphasised by Karadi and Koren (2012). These authors calibrate a spatial firm model to sector level data in developing countries to better account for the role of firm location in measured productivity. Moretti (2011) reviews work on local labour markets and agglomeration economies, explicitly modeling spatial equilibrium across labour markets. Distinct from this literature, we take the outcome of spatial labour markets as given and focus on the trade offs firms face and the consequences of regional markets in productivity measurement and firm location.

Several papers have explored how different aspects of labour affect firm-level productivity. There is substantial work on the effect of worker skills on productivity (Abowd Kramarz and Margolis (1999, 2005), Fox and Smeets (2011)). Other labour characteristics that drive productivity include managerial talent and practices (Bloom and Reenen, 2007), social connections among workers (Bandiera, Barankay, and Rasul, 2009), organisational form (Garicano and Heaton, 2010) and incentive pay (Lazear, 2000). Other determinants of firm productivity include market structure (Syverson (2004)), product market rivalry and technology spillovers (Bloom, Schankerman, and Van Reenen (2007)) and vertical integration (Hortaçsu and Syverson (2007), Atalay, Hortacsu, and Syverson (2012)). In contrast, this chapter considers the role of differences in input markets across regions.

Within the trade literature, a few studies propose that different industries perform optimally under different degrees of skill diversity. Based on this idea, Grossman and Maggi (2000) build a theoretical model explaining how differences in skill dispersion across countries could determine comparative advantage and global trade patterns. Building on this work, Morrow (2010) proposes a multi-industry model of firms which allows for technology choice and general skill distributions to estimate the model across developing countries, finding that skill diversity is significant in explaining productivity and export differences.

Although we are unaware of other studies estimating model primitives as a function of local market characteristics, reduced form empirical work is consonant with the theoretical implications. Iranzo, Schivardi, and Tosetti (2008) find that higher skill dispersion is associated with higher TFP in Italy. Similarly, Parrotta, Pozzoli, and Pytlikova (2011) find that diversity in education leads to higher productivity in Denmark. Martins (2008) finds that firm wage dispersion affects firm performance in Portugal. Bombardini, Gallipoli, and Pupato (2011) use literacy scores to show that countries with more dispersed skills specialise in industries characterised by lower skill complementarity. In contrast, this chapter combines firm and population census data to explicitly model regional differences in input markets, leading to micro founded identification and estimates. The method used is novel, and results of this chapter highlight the degree to which firm behaviour are influenced by economic geography through the availability of inputs.[3]

Clearly this study also contributes to the empirical literature on Chinese productivity. Ma, Tang, and Zhang (2011) show that exporting is positively correlated with TFP and that firms self select into exporting which, ex post, further increases TFP. Brandt, Van Biesebroeck, and Zhang (2012) estimate Chinese firm TFP, showing that new entry accounts for two thirds of TFP growth and that TFP growth dominates input accumulation as a source of output growth. Hsieh and Klenow (2009) posit that India and China have lower productivity relative to the US due to resource misallocation and compute how manufacturing TFP in India and China would increase if resource allocation was similar to that of the US. This chapter uncovers local factors that determine productivity. How this interacts with the above mechanisms is a potential area for further work.[4]

The rest of the chapter continues by laying out a model that incorporates a rich view of the labour hiring process. The model explains how firms internalise local labour market conditions to maximise profits, resulting in an industry specific unit cost of labour by region. Section 3 places these firms in a general equilibrium, monopolistic competition framework, in particular addressing where firms locate. Section 4 explains how the model can be estimated with a simple nested OLS approach, and is illustrated using a simulated dataset generated by the model. Section 5 discusses details of the data, while Section 6 presents our model estimates and uses them to explain the effect of different regional input markets on firm behaviour. Section 7 concludes and the appendix is in Section 8.

2 The Role of Skill Mix in Production

The primary goal of this section is to develop a model of firm hiring which takes into account both the wages and quantity of locally available worker types. Recently, both Borjas (2009) and Ottaviano

[3] The importance of backward linkages for firm behaviour are a recurring theme in both the development and economic geography literature, see Hirschman (1958) and recently Overman and Puga (2010).

[4] Such regional differences might help explain the Chinese export facts of Manova and Zhang (2012) and the different impact of liberalisation across trade regimes found by Bas and Strauss-Kahn (2012).

and Peri (2010) have emphasised the importance of more complete model frameworks to estimate substitution between worker types. However, in distinction to most of the labour literature, our primary interest is firm behaviour and accordingly we develop a model that predicts hiring by firms rather than wages to estimate substitution patterns.

The model specifies a theory of the firm which begins with a neoclassical production function combining homogeneous inputs (materials, capital) and differentiated inputs (types of labour). While homogeneous inputs are perfectly mobile within industries, labour is perfectly mobile within regions. Industries are assumed to have different technologies available for combining types of labour into teams. Since workers are imperfectly substitutable, they potentially induce spillovers within firms, a distinct possibility allowed for by our model, and consequently are not paid their marginal product.[5] We proceed with a detailed specification of the labour hiring process, solving for firms' optimal responses to prevailing labour market supply conditions. This provides a characterisation of the unit cost for labour by region which depends on local conditions and firm technology. This induces comparative advantage across regions for any given technology, and thereby helps explain productivity differences in terms of local input markets.

2.1 Firm Production

Firm j within an industry T faces a neoclassical production technology $F_j^T(M,K,L)$ which combines materials M, capital K and labour L[6] to produce output. While M and K are composed of homogeneous units measured by value, labour is composed of a heterogeneous team of workers who provide an aggregate vector of human capital H. An industry specific capital stock K^T is mobile across regions but immobile across industries, and in equilibrium is available at rental rate r_K^T. Similarly, an industry specific stock of materials M^T is also mobile within each industry and available at a price r_M^T.

Labour is intersectorally mobile but interregionally immobile, and consists of $\mathbb{S}$ skill types of workers, indexed $i \in \{1,\ldots,\mathbb{S}\}$, who are combined to provide effective labour L. The amount of L employed by the firm depends on the composition of a team through a technological parameter θ^T in

[5] Such spillovers are internalised by firms in the model. The extent to which spillovers might also occur across industries is beyond the scope of this study, however see Moretti (2004) for evidence in the US context.

[6] These variables are at firm level, however the firm subscript j is dropped in order to simplify notation.

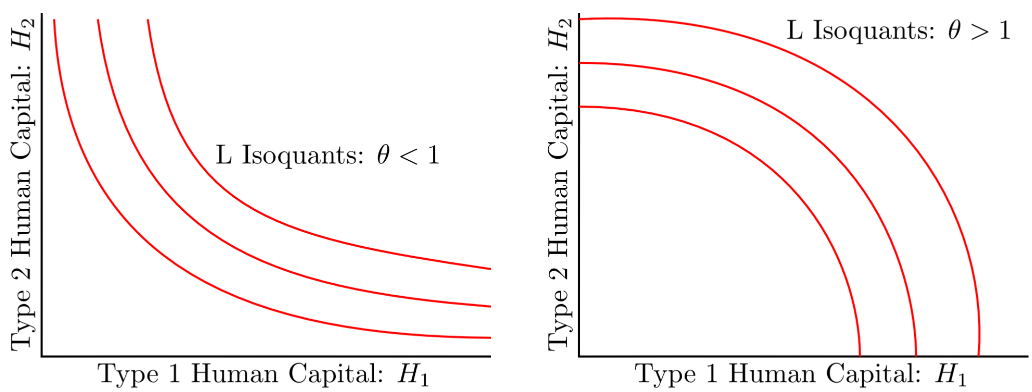
the following way:

$$L \equiv \left(H_1^{\theta^T} + H_2^{\theta^T} + \ldots + H_{\mathbb{S}}^{\theta^T}\right)^{1/\theta^T}. \tag{2.1}$$

Notice that in the case of $\theta^T = 1$, this specification collapses to a model where L is the total level of human capital $H_{\text{TOT}} = \sum_i H_i$[7]. More generally, the Marginal Rate of Technical Substitution of type i for type i' is $(H_i/H_{i'})^{\theta^T - 1}$. $\theta^T < 1$ implies worker types are complementary, so that the firm's ideal workforce tends to represent a mix of all types (Figure 1a). In contrast, for $\theta^T > 1$, firms are more dependent on singular sources of human capital as L becomes submodular, i.e. convex in the input of each single type (Figure 1b).[8] We will specify a hiring process so that despite the convexity inherent in Figure 1b, once firms choose the quality of their workers through hiring standards $\underline{h}$, the labour isoquants resume their typical shapes as in Figure 2. This avoids the possibility that some worker types are never hired, in line with expectations about real world data patterns.

Figure 1: Human Capital Isoquants

(a) Supermodular Production in H Space (b) Submodular Production in H Space



Rewriting Equation (2.1) in terms of human capital shares within the firm shows the labour provided per unit of human capital is

$$L/H_{\text{TOT}} = \left((H_1/H_{\text{TOT}})^{\theta^T} + (H_2/H_{\text{TOT}})^{\theta^T} + \ldots + (H_{\mathbb{S}}/H_{\text{TOT}})^{\theta^T}\right)^{1/\theta^T}.$$

Writing the shares of human capital across types of workers as $\tilde{H} \equiv (H_1/H_{\text{TOT}}, \ldots, H_{\mathbb{S}}/H_{\text{TOT}})$, effec-

[7] The variable H_i is at firm level, however the firm subscript j is dropped in order to simplify notation.
[8] See Morrow (2010) for a more detailed interpretation of super- and sub-modularity and implications.

tive labour can be written

$$\underbrace{L}_{\text{Effective Labour}} = \underbrace{\phi\left(\tilde{H},\theta^{T}\right)}_{\text{Team Productivity Effect}} \cdot \underbrace{H_{\text{TOT}}}_{\text{Total Human Capital}}$$

where $\phi\left(x,\theta^{T}\right) \equiv \left(\sum_i x_i^{\theta^T}\right)^{1/\theta^T}$ so that the output is given by $F_T\left(M,K,\phi\left(\tilde{H},\theta^T\right)\cdot H_{\text{TOT}}\right)$.

Although the technology θ^T is the same for all firms in an industry, firms do not all face the same regional factor markets. Explicitly modeling these disparate markets emphasises the role of regional heterogeneity in supplying human capital inputs to the firm in terms of both price and quality. This provides not only differences in productivity across regions by technology, but since industries differ in technology, local market conditions are more or less amenable to particular industries. We now detail the hiring process, introducing different markets and deriving firms' optimal hiring to best accommodate these differences.

2.2 Optimal Hiring by Region and Technology

In each region R, workers command region specific wages for each type of labour $w_R = (w_{R,1},\ldots,w_{R,\mathbb{S}})$ and have type-industry specific human capital $\underline{m}^T = \left(\underline{m}_1^T,\ldots,\underline{m}_{\mathbb{S}}^T\right)$. In order to hire workers, a firm must pay a fixed search cost of f effective labour units, at which point a distribution of worker types with regional frequencies $a_R = (a_{R,1},\ldots,a_{R,\mathbb{S}})$ are available from the search process.[9] Each worker has a firm specific match quality $h \sim \Psi$ which is observed during search and the firm hires on the basis of match quality. Consequently, the firm chooses a minimum threshold of match quality for each type they will retain, $\underline{h} = (\underline{h}_1,\ldots,\underline{h}_{\mathbb{S}})$.[10] Upon keeping a preferred set of workers, the firm may repeat this process N times until achieving their desired workforce. At the end of hiring, the amount of human capital produced by each type i is given by[11]

$$H_i \equiv N \cdot a_{R,i}\underline{m}_i^T \int_{\underline{h}_i}^{\infty} h d\Psi. \tag{2.2}$$

[9] The weights a_R can capture both the frequencies of available workers in addition to the possibility that certain types of workers may be more difficult to hire for a particular task.

[10] This assumption is familiar from labour search models. We do not explicitly model equilibrium unemployment due to the lack of a simple form for cross regional empirical work (see Helpman, Itskhoki, and Redding (2010)). Unlike Helpman, et al., differences in hiring patterns across firms within the same industry are determined by regional market conditions, rather than a productivity draw.

[11] Variables $\underline{h}_i$, $\underline{h}$, N, and H_i are at firm level, however the firm subscript j is dropped in order to simplify notation.

From a firm's perspective, the threshold of worker match quality $\underline{h}$ is a means to choose an optimal level of H, holding N fixed. However, as a firm lowers its quality threshold, it faces an increasing average cost of each type of human capital H_i . These increasing average costs induce the firm to maintain a positive match quality threshold and to search repeatedly for suitable workers.

The total costs of hiring labour depend on the regional wage rates w_R, the availability of workers a_R, and the unit cost of labour in region R using technology T, labelled c_R^T. Since the total number of each type i hired is $Na_{R,i}\left(1-\Psi\left(\underline{h}_i\right)\right)$, the total hiring bill is

$$\text{Total Hiring Costs}: \quad N\left[\sum_i w_{R,i}a_{R,i}\left(1-\Psi\left(\underline{h}_i\right)\right)+fc_R^T\right]. \tag{2.3}$$

Clearly, the firm faces a trade-off between the quantity and quality of workers hired. For instance, the firm might hire a large number of workers and "cherry pick" the best matches by choosing high values for $\underline{h}$ or save on interviewing costs f by choosing a low number of prospectives N and permissively low values for $\underline{h}$. This trade off and its dependence on the regional labour supply characteristics a_R and w_R is made explicit by considering the technology and region specific cost function $C_T\left(H|a_R,w_R\right)$, defined by

$$C_T \equiv \min_{N,\underline{h}} N\left[\sum_i a_{R,i}w_{R,i}\left(1-\Psi\left(\underline{h}_i\right)\right)+fc_R^T\right] \text{ where } H_i \leq Na_{R,i}\underline{m}_i^T\int_{\underline{h}_i}^{\infty} hd\Psi. \tag{2.4}$$

Letting μ_i denote the Lagrange multiplier for each of the $\mathbb{S}$ cost minimisation constraints, the first order conditions for $\{\underline{h}_i\}$ imply $\mu_i = w_{R,i}/\underline{m}_i^T\,\underline{h}_i$, while the condition for N implies

$$C_T\left(H|a_R,w_R\right)=\sum_i \mu_i H_i=\sum w_{R,i}H_i/\underline{m}_i^T\,\underline{h}_i. \tag{2.5}$$

Equation (2.5) shows that the multipliers μ_i are the marginal cost contribution (per skill unit) to H_i of the last type i worker hired.

The trade off between being more selective (high $\underline{h}$) and avoiding search costs (fc_R^T) is clearly illustrated by combining Equations (2.3) and (2.5), which shows:

$$\sum_i a_{R,i}w_{R,i}\int_{\underline{h}_i}^{\infty}\left(h-\underline{h}_i\right)/\underline{h}_i d\Psi = fc_R^T. \tag{2.6}$$

The LHS of Equation (2.6) decreases in $\underline{h}$, so when a firm faces lower interviewing costs it can afford to be more selective by increasing $\underline{h}$. Conversely, in the presence of high interviewing costs, the firm optimally "lowers their standards" $\underline{h}$ to increase the size of their workforce without interviewing additional workers.

2.3 Cost Minimisation

For a firm j to produce Q_j units of output at minimal cost, inputs are chosen to solve

$$\min_{K,M,H} C_T(H|a_R,w_R) + r_K^T K + r_M^T M \text{ subject to } F_j^T\left(M,K,\phi\left(\tilde{H},\theta^T\right)\cdot H_{\text{TOT}}\right) \geq Q_j. \tag{2.7}$$

The first order conditions for H_{TOT} and H_i immediately imply that

$$\left(w_{R,i}H_i/\underline{m}_i^T\underline{h}_i\right)/C_T(H|a_R,w_R) = d\ln L/d\ln H_i = \left(\tilde{H}_i + d\ln\phi\left(\tilde{H},\theta^T\right)/d\ln H_i\right). \tag{2.8}$$

This fixes a key relationship about the *wage premium*, defined as the share of wages paid to a type beyond the share of human capital contributed. From (2.8), let

$$\widetilde{w}_{R,i}^T \equiv \left(w_{R,i}H_i/\underline{m}_i^T\underline{h}_i\right)/C_T(H|a_R,w_R)$$

denote the share of wages attributable to workers of type i. Then from (2.8) we have:

$$\text{Wage Premium}: \quad \underbrace{\widetilde{w}_{R,i}^T - \tilde{H}_i}_{\text{Share of Cost } - \text{ Share of Human Capital}} = \underbrace{d\ln\phi\left(\tilde{H},\theta^T\right)/d\ln H_i}_{\text{Productivity Elasticity}}. \tag{2.9}$$

Explicitly, $d\ln\phi\left(\tilde{H},\theta^T\right)/d\ln H_i = \tilde{H}_i^{\theta^T}/\sum_z \tilde{H}_z^{\theta^T} - \tilde{H}_i$, so that $\widetilde{w}_{R,i}^T = \tilde{H}_i^{\theta^T}/\sum_j \tilde{H}_j^{\theta^T}$. Notably, when labour types are perfectly substitutable ($\theta^T = 1$), $\phi\left(\tilde{H},\theta^T\right)$ is identically 1 so the wage premium is zero for all types.

2.4 Unit Labour Costs under Pareto Match Quality

The above reasoning shows the relationship between technology and the optimal choice of worker types. To make this model more concrete, we assume that firm specific match quality follows a Pareto distribution $\Psi(h) \equiv 1 - h^{-k}$. Here k is the shape parameter[12] and 1 is the minimum value h can take. Under a Pareto distribution, a sufficient condition for a firm to optimally hire every type of worker is

[12] κ varies across industry but its its superscript T is dropped to simplify notation.

that

$$\beta^T \equiv \theta^T + k - k\theta^T > 0.$$

We now prove this result, stated as

Proposition 1. *If $\beta^T > 0$ then it is optimal for a firm to hire all types of workers.*

Proof. Let c_R^T denote a firm's unit labour cost when all worker types are hired, and $\check{c}_R^T$ the unit labour cost if a subset of types $\mathbb{T} \subset \{1, \ldots \mathbb{S}\}$ is hired. For the result, we require that $c_R^T \leq \check{c}_R^T$ for all $\mathbb{T}$. Considering a firm's cost minimisation problem when $\mathbb{T}$ are the only types available shows with Equation (2.10) that

$$\check{c}_R^T = \left[\sum_{i \in \mathbb{T}} \left[a_{R,i} \left(\underline{m}_i^T \right)^k w_{R,i}^{1-k} / f(k-1) \right]^{\theta^T/\beta^T} \right]^{\left(\beta^T/\theta^T\right)/(1-k)}.$$

Considering then that

$$c_R^T / \check{c}_R^T = \left[1 + \left(\sum_{i \notin \mathbb{T}} \left[a_{R,i} \left(\underline{m}_i^T \right)^k w_{R,i}^{1-k} \right]^{\theta^T/\beta^T} / \sum_{i \in \mathbb{T}} \left[a_{R,i} \left(\underline{m}_i^T \right)^k w_{R,i}^{1-k} \right]^{\theta^T/\beta^T} \right) \right]^{\left(\beta^T/\theta^T\right)/(1-k)},$$

clearly $c_R^T \leq \check{c}_R^T$ so long as $\beta^T/\theta^T(1-k) \leq 0$, which holds for $\beta^T > 0$ since $k > 1$. □

A positive β^T is guaranteed by a supermodular labour technology ($\theta^T < 1$). For submodular production ($\theta^T > 1$), a positive β^T is a requirement that the Pareto shape parameter k be sufficiently close to 1. This guarantees the tail of the match quality distribution is thick enough to justify hiring at least a few workers of each type. This induces the isoquants depicted in Figure 2, which illustrates a more standard trade off between different types of workers, so long as the coordinates are transformed to the space of hiring standards $\underline{h}$.

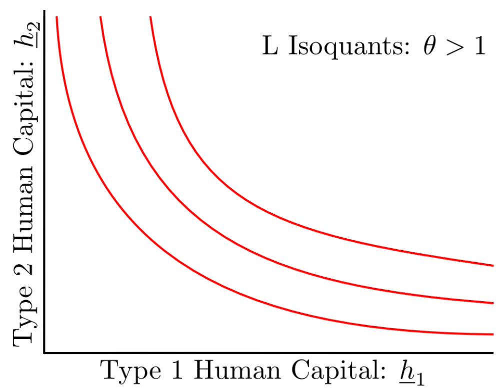


Figure 2: Submodular Production in $\underline{h}$ Space

The general cost function derived implies the unit labour cost of L in region R is

$$\text{Unit Labour Cost Problem}: \quad c_R^T \equiv \min_H C_T\left(H|a_R, w_R\right) \text{ subject to } L = \phi\left(\tilde{H}, \theta^T\right) \cdot H_{\text{TOT}} = 1.$$

From Equations (2.5) and (2.9) the unit labour cost function may be solved as

$$\text{Unit Labour Costs}: \quad c_R^T = \left[\sum_i \left[a_{R,i}\left(\underline{m}_i^T\right)^k w_{R,i}^{1-k}/f(k-1)\right]^{\theta^T/\beta^T}\right]^{\left(\beta^T/\theta^T\right)/(1-k)}. \tag{2.10}$$

Notably, the number of times a firm goes to hire workers, N, can be solved as $N = 1/fk$. Thus, N is decreasing in both the cost of hiring and k, as increases in k imply a thinner right tail of match quality, so that repeatedly screening workers has lower returns. Finally, $\widetilde{w}_{R,i}^T$, the share of wages attributable to workers of type i becomes

$$\widetilde{w}_{R,i}^T = \left(a_{R,i}\left(\underline{m}_i^T\right)^k w_{R,i}^{1-k}\right)^{\theta^T/\beta^T} / \sum_j \left(a_{R,j}\left(\underline{m}_j^T\right)^k w_{R,j}^{1-k}\right)^{\theta^T/\beta^T}.$$

Equation (2.10) summarises the cost of one unit of labour L in terms of the Pareto shape parameter k, the technology θ^T and regional characteristics a_R and w_R. Such differences in regional unit labour costs translate directly into measured productivity differences across firms. In order to solve for total unit costs (which include non-labour costs), we assume each production function F_j^T is defined by the following Cobb-Douglas form:

$$F_j^T(M,K,L) = \eta_j^{-1} \cdot M^{\alpha_M^T} K^{\alpha_K^T} L^{\alpha_L^T}. \tag{2.11}$$

Here η_j is a Hicks neutral cost shifter which varies across firms, and we assume constant returns to scale. It is then straightforward to derive total unit costs from (2.7) and (2.10) as

$$\text{Total Unit Costs}: \quad u_{Rj}^T = u_R^T \eta_j = \left(r_M^T/\alpha_M^T\right)^{\alpha_M^T} \left(r_K^T/\alpha_K^T\right)^{\alpha_K^T} \left(c_R^T/\alpha_L^T\right)^{\alpha_L^T} \cdot \eta_j, \tag{2.12}$$

where u_R^T represents the regional component of unit costs not idiosyncratic to firms.

Section 3 presents a two stage OLS procedure which can recover the differences in unit labour costs $c_R^T(a_R, w_R)/c_{R'}^T(a_{R'}, w_{R'})$ between any two regions R and R', but first we resolve firm behaviour in general equilibrium.

3 Firm Production under Monopolistic Competition

This section combines the insights into firm behaviour just developed into a general equilibrium model of monopolistic competition. Firms, who are ex ante identical, choose among regions to locate. Key to a firm's location decision are the expected profits of entry. These profits depend on 1) the distribution of worker types and wages and 2) the competition present from other firms who enter the region. We determine equilibrium production and location choices conditional on wages, which relates regional costs to firm density. We also show an equilibrium wage vector exists which supports these choices by firms.

3.1 Model Setting

Each region R is endowed with a population $\mathbb{P}_R$ of workers composed of $\mathbb{S}$ types. We take the well known approach of Melitz (2003) to model firms who face fixed entry costs F_e, receive a random cost draw $\eta_j \sim G$ and face a fixed production cost f_e.[13] Akin to Bernard, Redding, and Schott (2007), firms combine different types of inputs to produce. Distinct from both of these models, firms ex ante may freely enter any region R which will determine the cost structure they face. Each firm j produces a distinct variety, and in equilibrium a mass of firms $\mathbb{M}_R^T$ enter and entrants with cost draws less than a prohibitively high cost level $\overline{\eta}_R^T$ produce. $\mathbb{M}_R^T$ and $\overline{\eta}_R^T$ together determine the set of varieties available to consumers.

[13] G is assumed to be absolutely continuous with finite mean.

3.2 Aggregate Income, Demand and Budget Shares

Consumption is determined by the aggregate level of income I_{Agg}, and since labour is supplied inelastically, this is necessarily

$$I_{\text{Agg}} = \sum_R \sum_i \underbrace{w_{R,i} a_{R,i} \mathbb{P}_R}_{\text{Total Wages of Type i in R}} + \sum_T \underbrace{r_M^T M^T + r_K^T K^T}_{\text{Non-Labour Income}} . \tag{3.1}$$

Consumer preferences over varieties j and quantities $\left\{Q_{Rj}^T\right\}$ take the Dixit-Stiglitz form

$$U_R^T \equiv U\left(\mathbb{M}_R^T, \overline{\eta}_R^T, Q_R^T\right) = \mathbb{M}_R^T \int_0^{\overline{\eta}_R^T} \left(Q_{Rj}^T\right)^\rho dG(j)$$

in each region and industry, with total utility $U(\mathbb{M}, \overline{\eta}, Q) \equiv \Pi_T \Pi_R \left(U_R^T\right)^{\sigma_R^T}$, where σ_R^T are relative weights put on final goods normalised so that $\sum_{T,R} \sigma_R^T = 1$.

Firms are the sole sellers of their variety, and thus are monopolists who provide their variety at a price P_{Rj}^T. Consumers, in turn, face a vector of prices $\left\{P_{Rj}^T\right\}$, and a particular consumer with income I has the following demand curve for each variety:

$$Q_{Rj}^T = I \cdot \left(P_{Rj}^T U_R^T / \sigma_R^T\right)^{\frac{1}{\rho-1}} / \sum_{t,r} \left(\sigma_r^t\right)^{\frac{1}{\rho-1}} \mathbb{M}_r^t \int_0^{\overline{\eta}_r^t} \left(\left(P_{r,z}^t\right)^\rho U_r^t\right)^{\frac{1}{\rho-1}} dG(z) . \tag{3.2}$$

Clearly, even if consumers have different incomes, aggregate demand for variety j corresponds to that of a representative consumer with income equal to aggregate income, I_{Agg}.

After paying an entry cost of F_e output units, firms know their cost draw, which paired with regional input markets determine their total unit cost u_{Rj}^T. Firms maximise profits

$$\pi_{Rj}^T\left(P_{Rj}^T\right) = \left(P_{Rj}^T - u_{Rj}^T\right) Q_{Rj}^T - u_R^T f_e$$

by choosing an optimal price $P_{Rj}^T = u_{Rj}^T / \rho$, resulting in a markup of $1/\rho$ over costs. Firms who cannot make a positive profit do not produce to avoid paying the fixed cost of f_e output units. Since profits decrease in costs, there is a unique cutoff cost draw $\overline{\eta}_R^T$ which implies zero profits, while firms with $\eta_j < \overline{\eta}_R^T$ produce. As there are no barriers to entry besides the entry cost F_e, firms enter in every region until expected profits are zero. This yields the

$$\text{Spatial Zero Profit Condition :} \quad \mathrm{E}\left[\pi_{Rj}^{T}\right] = F_e, \quad \forall R, T.$$

The expressions which fix the cutoff cost draw $\overline{\eta}_R^T$ and mass of entry $\mathbb{M}_R^T$ can be neatly summarised by defining the mass of entrants who produce, $\widetilde{\mathbb{M}}_R^T$, and the (locally weighted) average cost draw in each region, $\widetilde{\eta}_R^T$:

$$\widetilde{\mathbb{M}}_R^T \equiv \mathbb{M}_R^T G\left(\overline{\eta}_R^T\right), \qquad \widetilde{\eta}_R^T \equiv \int_0^{\overline{\eta}_R^T} \left(\eta_{Rz}^T u_R^T \left(U_R^T\right)^{1/\rho}\right)^{\rho/(\rho-1)} dG(z) / G\left(\overline{\eta}_R^T\right).$$

It is shown in Appendix 8.5.1 that $\overline{\eta}_R^T$ depends only on f_e, F_e, and G, so there is a unique cutoff cost $\overline{\eta} = \overline{\eta}_R^T$ across all regions and industries. The appendix also shows that the free entry and zero profit conditions imply that the share of income spent on goods from each region and technology pair (R, T) is given by

$$\text{Consumer Budget Share for R, T :} \quad \mathbb{M}_R^T u_R^T / \sum_{t,r} \mathbb{M}_r^t u_t^t = \sigma_R^T / \sum_{t,r} \sigma_r^t = \sigma_R^T.$$

Having determined firm behaviour in the product market, we now examine input markets.

3.3 Regional Factor Market Clearing

The only remaining equilibrium conditions are that input prices guarantee firm input demand exhausts material and capital stocks, in addition to each regional pool of workers. A final assumption on the budget shares $\left\{\sigma_R^T\right\}$ ensures that two regions which have identical skill distributions have the same wage schedule. Within an industry, each σ_R^T is proportional to $\mathbb{P}_R$, so that $\sigma_R^T = \sigma^T \mathbb{P}_R$ for some σ^T. Since production is Cobb-Douglas, the share of total costs (equal to I_{Agg}) which go to each factor is the factor output elasticity, so full resource utilisation of materials and capital requires

$$M^T = \alpha_M^T \sigma^T I_{\text{Agg}} \mathbb{P} / r_M^T, \qquad K^T = \alpha_K^T \sigma^T I_{\text{Agg}} \mathbb{P} / r_K^T. \tag{3.3}$$

where $\mathbb{P} \equiv \sum_R \mathbb{P}_R$ is the total population. These two equations capture the allocation of technology specific resources across regions.

In contrast, labour is immobile outside of a region, and effective labour of L_R^T is produced by each technology in each region. Since the wage bill $L_R^T c_R^T$ must receive a share α_L^T of total revenues,

$$\text{Aggregate Labour Demand}: \quad L_R^T = \alpha_L^T \sigma^T I_{\text{Agg}} \mathbb{P}_R / c_R^T. \tag{3.4}$$

Embedded in each L_R^T is the set of workers hired by firms attendant to regional market conditions. The number of workers of type i employed with technology T in region R is labelled $e_{R,i}^T$. The Pareto match assumption and firm hiring conditions imply $e_{R,i}^T$ takes the form[14]

$$e_{R,i}^T = a_{R,i}^{\theta^T/\beta^T} \left(\underline{m}_i^T\right)^{k\theta^T/\beta^T} w_{R,i}^{-k/\beta^T} L_R^T \left(c_R^T\right)^{k/\beta^T} \left(f\left(k-1\right)\right)^{-\theta^T/\beta^T}. \tag{3.5}$$

The total demand for employees of each type in a region R, $\sum_T e_{R,i}^T$, must equal the supply of $a_{R,i}\mathbb{P}_R$, yielding the regional resource clearing conditions. Wages are determined by

$$a_{R,i} = \sum_T e_{R,i}^T / \mathbb{P}_R = w_{R,i}^{-1} \sum_t \sigma^t \alpha_L^t \widetilde{w}_{R,i}^t I_{\text{Agg}}, \quad \forall R, i. \tag{3.6}$$

Equation (3.6) affords a interpretation of equilibrium wages. A type i's contribution to mean wages, $a_{R,i}w_{R,i}$, is an average of the income spent on labour in an industry, times the wages attributable to each type:

$$a_{R,i}w_{R,i} = \sum_t \underbrace{\sigma^t}_{\text{Industry Share Per Capita}} \cdot \underbrace{\alpha_L^t}_{\text{Labour Share}} \cdot \underbrace{\widetilde{w}_{R,i}^t}_{\text{Type Share}} \cdot I_{\text{Agg}}$$

Solving Equation (3.6) requires finding a wage for each worker type in each region that fully employs all workers. Accordingly, showing that an equilibrium wage vector exists is slightly tricky. In order to do so, first note that the resource clearing conditions determine wages, provided an exogenous vector of unit labour costs $\left\{c_R^T\right\}$, as proved in Appendix 8.1.2:

Lemma. *There is a wage function $\mathbb{W}$ that uniquely solves (3.6) given unit labour costs.*

Of course, unit labour costs are not exogenous as in the Lemma, but rather depend on endogenous wages $\{w_{R,i}\}$. However, the lemma does show that the following mapping:

$$\{w_{R,i}\} \underset{\text{Equation 2.10}}{\mapsto} \left\{c_R^T\left(\{w_{R,i}\}\right)\right\} \underset{\text{Lemma}}{\mapsto} \mathbb{W}\left(\left\{c_R^T\left(\{w_{R,i}\}\right)\right\}\right),$$

[14] See Supplemental Appendix.

which starts at one wage vector $\{w_{R,i}\}$ and ends at another wage vector $\mathbb{W}$ is well defined. This mapping is shown in Appendix 8.1.2 to have a fixed point, which yields[15]

Proposition 2. *An equilibrium wage vector exists which clears each regional labour market.*

3.4 Relative Concentration of Firms

Of course, differences in input costs will influence the relative concentration of firms across regions. Since regions may vary substantially in population size $\mathbb{P}$, the most relevant metric is the number of firms per capita in a region, $\widetilde{\mathbb{M}}_R^T/\mathbb{P}_R$. The number of firms per capita vary by both regional costs and the budget shares spent on goods from each industry. The impact of different regional costs can be clearly seen by fixing an industry T and considering the ratio of firms per capita in region R versus R' as in Equation (3.7):

$$\text{Firms per Capita, R to R}': \quad \left(\widetilde{\mathbb{M}}_R^T/\mathbb{P}_R\right)/\left(\widetilde{\mathbb{M}}_{R'}^T/\mathbb{P}_{R'}\right) = u_{R'}^T/u_R^T = \left(c_{R'}^T/c_R^T\right)^{\alpha_L^T} \tag{3.7}$$

Equation (3.7) shows that areas with lower unit labour costs have more firms per capita. Additionally, the larger the share of labour in production, α_L^T, the more important are differences between regions. This relationship is summarised as

Proposition 3. *Within an industry, regions with lower labour costs have more firms per capita.*

The next section lays out a strategy to structurally estimate model parameters.

4 Estimation Strategy

This section lays out a simple two stage estimator to recover the underlying structural model parameters above. The estimator involves two regressions, with an intervening computation which can be done easily in most statistical software. The first stage equation determines firm labour demand and, unlike many approaches, is based on the firm-level shares of workers hired across regions, rather than wages. The second stage equation uses regional unit labour costs fixed by the model and first stage to estimate the remaining parameters of the production function. To illustrate feasibility, we simulate a

[15] Factor price equalisation does not generally hold across labour types since trade in goods is not a substitute for trade in factors. See Appendix 8.1.1 for some limited ways in which equalisation does hold.

dataset consistent with the firm production problem above and show our estimation method recovers model primitives accurately.

4.1 First Stage Estimation

The employment expression (3.5) determines the share of each type of workers hired in each region R and industry T. Since this does not vary by firm for fixed R and T, it follows that the share of workers of type i hired by firm j in R and T, $s^T_{R,ij}$, satisfies

$$\ln s^T_{R,ij} = -\frac{k}{\beta^T}\ln w_{R,i} + \frac{\theta^T}{\beta^T}\ln a_{R,i} + \frac{\theta^T}{\beta^T}k\ln \underline{m}^T_i + \frac{\theta^T}{\beta^T}\ln\frac{\left(\tilde{c}^T_R\right)^k}{f(k-1)} + \varepsilon_{ij}, \tag{4.1}$$

where ε_{ij} denotes a firm-type level error term and $\tilde{c}^T_R$ denotes the unit labour cost function at wages $\left\{w^{k/(k-1)\theta^T}_{R,i}\right\}$[16]. To estimate this equation we use a combination of type and region dummies.[17] To further explain how regional variation identifies the model we discuss equilibrium hiring predicted by Equation (4.1) in Appendix 8.5.2.

In order to control for firm characteristics which might influence hiring patterns across worker types, $\underline{m}^T_i$ is allowed to vary with firm observables labelled Controls_j:

$$\underline{m}^T_{ij} \equiv \underline{m}^T_i \cdot \exp\left\{\text{Controls}_j \gamma^T_i\right\}, \tag{4.2}$$

where γ^T_i is a type-industry specific estimate of characteristics which might influence the value of each worker type in an industry. The inclusion of Controls_j makes type specific human capital vary by firm, and accordingly we denote unit labour costs as c^T_{Rj}. We now discuss how the first stage estimates are used to estimate production function parameters in a second stage.

4.2 Second Stage Estimation

From above we can estimate $\theta^T, k, \left\{\underline{m}^T_i/\underline{m}^T_{\mathbb{S}}\right\}, \left\{\gamma^T_i\right\}$ and therefore can estimate regional differences in unit labour cost functions, $\Delta\ln c^T_R \equiv \mathrm{E}\left[\ln c^T_{Rj}|R,T,\text{Controls}_j\right] - \mathrm{E}\left[\ln c^T_{Rj}|T\right]$. From above, revenues

[16] Formally $\tilde{c}^T_R \equiv \min_H C_T\left(H|a_R, \left\{w^{-k/\theta^T(1-k)}_{R,i}\right\}\right)$ subject to $L = \phi\left(\tilde{H}, \theta^T\right)\cdot H_{\text{TOT}} = 1$.

[17] We suggest the convention of creating of type and region fixed effects, omitting the highest type fixed effect. The remaining type coefficients then correspond to the estimates of $\left(\theta^T/\beta^T\right)k\ln \underline{m}^T_i/\underline{m}^T_{\mathbb{S}}$.

$P_{Rj}^T Q_{Rj}^T$ for a firm j satisfy

$$\ln P_{Rj}^T Q_{Rj}^T = \alpha_M^T \ln M_j + \alpha_K^T \ln K_j + \alpha_L^T \ln L_j - \ln \rho \eta_j. \tag{4.3}$$

As firm expenditure on labour $L \cdot c_{Rj}^T$ equals the share α_L^T of revenues $P_{Rj}^T Q_{Rj}^T$, we have $L_j c_{Rj}^T = \alpha_L^T P_{Rj}^T Q_{Rj}^T$ and taking differences with the population mean gives

$$\Delta \ln L_j = \Delta \ln P_{Rj}^T Q_{Rj}^T - \Delta \ln c_{Rj}^T. \tag{4.4}$$

Taking differences of Equation (4.3) with the population mean and using (4.4) yields

$$\Delta \ln P_{Rj}^T Q_{Rj}^T = \alpha_M^T \Delta \ln M_j + \alpha_K^T \Delta \ln K_j + \alpha_L^T \Delta \ln P_{Rj}^T Q_{Rj}^T - \alpha_L^T \Delta \ln c_{Rj}^T - \Delta \ln \eta_j.$$

So reduction gives the estimating equation

$$\Delta \ln P_{Rj}^T Q_{Rj}^T = \frac{\alpha_M^T}{1-\alpha_L^T} \Delta \ln M_j + \frac{\alpha_K^T}{1-\alpha_L^T} \Delta \ln K_j - \frac{\alpha_L^T}{1-\alpha_L^T} \Delta \ln c_{Rj}^T - \frac{1}{1-\alpha_L^T} \Delta \ln \eta_j. \tag{4.5}$$

The entire estimation procedure is now briefly recapped.

4.3 Estimation Procedure Summary

1. Using $s_{R,ij}^T$, the share of workers of type i hired in region R and industry T, estimate Equation (4.1), using type and region dummies.
2. Recover $\widehat{\theta^T}$, $\widehat{k}$, $\left\{\widehat{\underline{m}_i^T / \underline{m}_{\mathbb{S}}^T}\right\}$ and $\left\{\widehat{\gamma_i^T}\right\}$. Bootstrap standard errors or use the delta method.
3. Use Equation (2.10) to calculate estimates $\widehat{\Delta \ln c_{Rj}^T}$ by region and industry using the regional data $\{a_R\}$, $\{w_R\}$ and estimated $\widehat{\theta^T}$, $\widehat{k}$, $\left\{\widehat{\underline{m}_i^T / \underline{m}_{\mathbb{S}}^T}\right\}$ and $\left\{\widehat{\gamma_i^T}\right\}$ from Step 1.
4. Estimate Equation (4.5) using $\widehat{\Delta \ln c_{Rj}^T}$.

This specification is structural, but obviously does not compute every element of the model, and therefore efficiency of the estimator might suffer. In Appendix 8.2, we both illustrate the estimator and evaluate efficiency loss by simulating firms which obey the production model specified above and apply these steps. In the simulation, the first stage can explain 99% of the variation in firm hiring of the full model and the second stage explains 97% of the variation in firm output, suggesting that the time savings of this specification likely outweigh any gain in estimation accuracy within the context of the model.

Having laid out both a production model detailing the interaction of firm technologies with local market conditions and specifying an estimation strategy, we now move on to applying the method to China using manufacturing and population census data. The next section discusses this data in detail while the sequel presents our results.

5 Data

This section discusses the data, in particular regional educational attainment and wages.

5.1 Data Overview

Our firm level data comes from the 2004 Survey of Industrial Firms conducted by the Chinese National Bureau of Statistics. It includes all enterprises with sales over 5 million RMB. The data includes firm's ownership, location, industry, financial variables, profit and cash flow statements. Firms report their number of employees by education level, in addition to output, value added sales and export value. For detailed summary statistics regarding these firms and industrial characteristics see Appendix 8.3.3. From the Survey, a subsample was constructed of manufacturing firms who report positive net fixed assets, material inputs, output, value added and wages. Firms with fewer than 8 employees were excluded as they fall in a different legal regime. The final sample includes 141,464 firms in 284 prefectures and 19 industries at the two digit level.

Firm capital stock is reported fixed capital, less reported depreciation. Worker composition is measured by the share of workers across education bins. Regional wage distributions are calculated from the 0.5% sample of the 2005 China Population Census. The census contains information on education level by prefecture of residence, occupation, industry code, monthly income and weekly hours of work. We restrict the sample to employees age 15 to 65 who report positive wages and hours of work. The regional wage distribution is recovered from the average annual income of employees by education using census data.[18] Since our firm data is from 2004 and our census data is from 2005, one potential concern is any discrepancy that might be caused by the lag between when these datasets were collected. Fortunately, the assumption that firm skill mix is stable over time is reasonable based

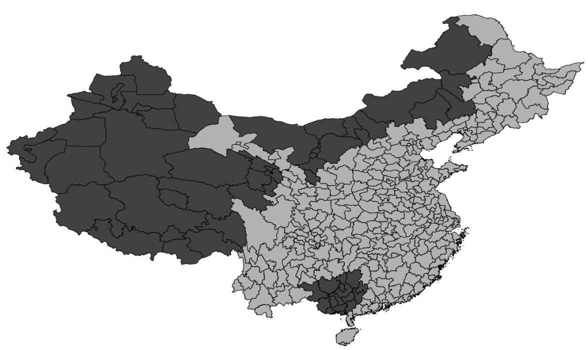
[18] The census data is highly representative of the firm wage data, as discussed in Appendix 8.4.1.

on existing studies.[19]

In addition, we use geographic data. One source is GIS data for the year 2005 to locate firms at the county and prefecture level, available from the China Data Center at the University of Michigan. This also provides sea port locations. This is supplemented by inland port data from The World Port Index

Since regions in China are quite heterogeneous, the first consideration is to restrict the data to qualitatively comparable regions. Figure 3 illustrates the prefectures of China, which we take as our definition of a region from the perspective of the model above. Prefectures illustrated by a darker shade in Figure 3 are excluded from the analysis, as they operate under substantially different government policies and objectives. These regions typically have large minority populations or historically distinct conditions, with the majority being declared autonomous regions. Autonomous regions have their own regulations development and educational policies (see the Information Office of the State Council of the People's Republic of China document cited). We restrict attention to the lighter shaded regions of Figure 3, preserving 284 prefectures displaying distinct labour market conditions.

Figure 3: Chinese Prefectures



- 33 Provinces, excluding:
  - 5 Autonomous
  - 1 Non-Autonomous
- 345 Prefectures, excluding:
  - 53 Autonomous
  - 8 Non-Autonomous

5.2 Regional Variation

Key to our analysis is regional variation in skill distribution and wages. Here we briefly discuss both. Further discussion may be found in Appendix 8.3. Monthly incomes vary substantially across China as illustrated in Figure 4. This is due to both the composition of skills (proxied by education) across regions as well as the rates paid to these skills.

[19] Ilmakunnas and Ilmakunnas (2011) find the standard deviation of plant-level education years is very stable from 1995-2004 in Finland. Parrotta, Pozzoli, and Pytlikova (2011) find that a firm-level education diversity index was roughly constant over a decade in Denmark.

Figure 4: Average Monthly Income of Employees (2005)

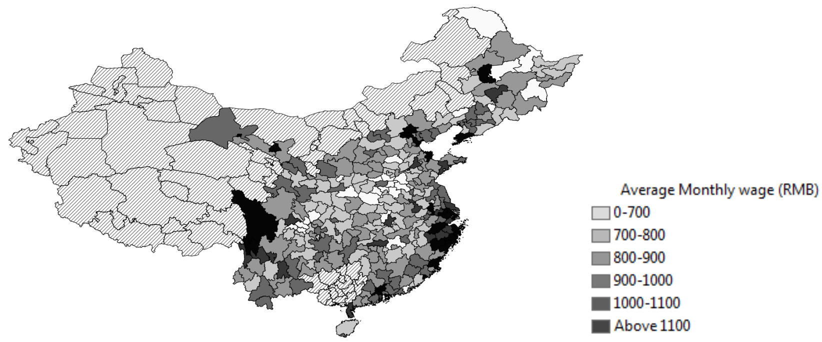
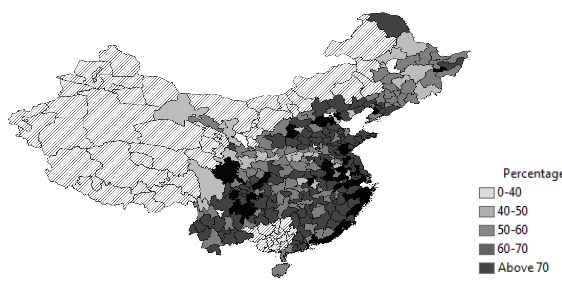


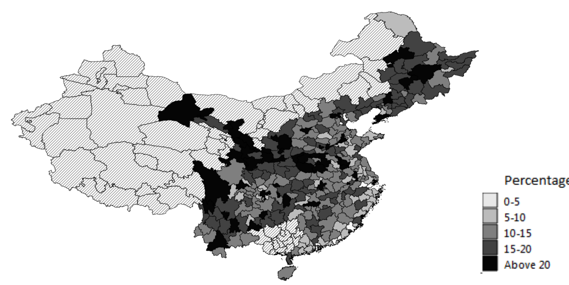
Figure 5 contrasts educational distributions of the labour force. Figure 5(a) shows those with a Junior High School education (the mandated level in China), while Figure 5(b) displays those with a Junior College or higher level of attainment. A more detailed breakdown of the distribution of wages and educational attainment is presented in Appendix 8.3.

Figure 5: Low and High Educational Attainment Across China (2005)

(a) % Labour Force with $\leq$ Junior High School



(b) % Labour Force with $\geq$ Junior College



While this study focuses on the differing composition of input markets across China as they exist in 2004-2005, some brief remarks are in order about the origins of these substantial differences.[20] These differences stem from many factors, including the dynamic nature of China's rapidly growing economy, targeted economic policies and geographic agglomeration of industries across China. Faber (2012) finds that expansion of China's National Trunk Highway System displaced economic activity from counties peripheral to the System. Similarly, Baum-Snow, Brandt, Henderson, Turner, and Zhang (2012) show that mass transit systems in China have increased the population density in city centers, while radial highways around cities have dispersed population and industrial activity. An overview of important Chinese economic policies is also provided by Defever and Riano (2012), who quantify

[20]We consider regional price variation at a fixed point in time. Reallocation certainly occurs and is very important in explaining dynamics (e.g. Borjas (2003)) but are outside the scope of this chapter.

their impact on firms.

Of particular interest for labour markets are substantial variation in wages and the attendant migration this induces. The extent to which labour market migration has been stymied by the *hukou* system of internal passports is not well studied, although its impact has likely lessened since 2000.[21] Given that rural to urban migration typifies the pattern of structural transformation currently underway in China, we control for rural and urban effects for each type of worker below. Nonetheless, it remains unclear to what degree the hukou system alters labour flows under the present system. In particular, high income and highly educated workers can more easily move among urban regions as local governments are likely to approve their migration applications (Chan, Liu, and Yang, 1999). It therefore seems likely that the size of labour markets accessible to workers is extremely heterogeneous. Given what little is known about the actual determinants of migration in China, modeling firm decisions when faced with dynamically changing input markets is an interesting avenue for further work.

5.3 Worker Types

Our definition of distinct, imperfectly substitutable worker types is based primarily on formal schooling attained. Census data from 2005 shows that the average years of schooling for workers in China ranges from 8.5 to 11.8 years across provinces, with sparse postgraduate education. The most common level of formal education is at the Junior High School level or below. Reflecting substantial wage differences by gender within that group, we define Type 1 workers as Junior High School or Below: Female and Type 2 workers as Junior High School or Below: Male. Explicit differentiation in the role of gender for low skill labour is especially important in developing countries, where a variety of influences result in imperfect substitutability across gender.[22] Completion of Senior High School defines Type 3 and completion of Junior College or higher education defines Type 4.

Having discussed the data, we now apply the estimation procedure developed above.

[21] The Hukou system and its reform in the late 1990s are well explained in Chan and Buckingham (2008). The persistence of such a stratified system has engendered deep set social attitudes which likely affect economic interactions between Hukou groups, see Afridi, Li, and Ren (2012).

[22] Bernhofen and Brown (2011) distinguish between skilled male labour, unskilled male labour and female labour and find that the factor prices across these three types of labour differ substantially.

6 Estimation Results

This section reports our estimation results, then turns to a discussion of the quantitative labour cost and productivity differences accounted for by local market conditions in China. The section continues by testing the firm location implications of the model, finding broad support that economic activity locates where estimated unit labour costs are lower. Finally, we compare estimation results of our unit cost based method with one approach common in the literature, which assumes that labour types are perfectly substitutable.

6.1 Estimates of Market Conditions and Production Technologies

The full first stage regression results for several manufacturing industries in China are presented in Tables 14 and 15 of Appendix 8.4.2. A representative set of estimates for the General Machinery industry are presented in Table 1. The first box in Table 1, labelled Primary Variables, are consistent with the model. Though values for the coefficients $\left(\theta^T/\beta^T\right)\ln \underline{m}_i/\underline{m}_4$ are not specified by the model, their estimated values do increase in type in Table 1, which is consonant with formal education increasing worker output.

Table 1: First Stage Results: General Machinery

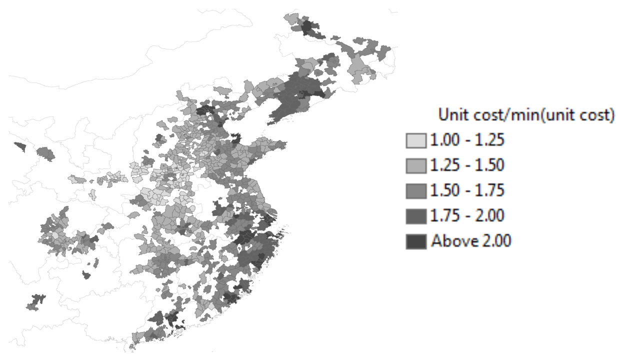
Primary Variables	$\ln(\%\text{ Hired})$	Firm Controls	
$\ln(w_{R,i})$	-2.687***	$\underline{m}_1 *$ Urban Dummy	-1.384***
$\ln(a_{R,i})$	1.794***	$\underline{m}_2 *$ Urban Dummy	-0.980***
$\underline{m}_1$ ($\leq$Junior HS: Female)	-10.170***	$\underline{m}_3 *$ Urban Dummy	0.427***
$\underline{m}_2$ ($\leq$Junior HS: Male)	-6.171***	$\underline{m}_4 *$ Urban Dummy	2.336***
$\underline{m}_3$ (Senior High School)	-3.180***	$\underline{m}_1 *$% Foreign Equity	-2.448***
		$\underline{m}_2 *$% Foreign Equity	-1.864***
		$\underline{m}_3 *$% Foreign Equity	0.311***
Regional Controls		$\underline{m}_4 *$% Foreign Equity	3.847***
$\underline{m}_1 *$% Non-Ag Hukou	-5.957***	$\underline{m}_1 * \ln(\text{Firm Age})$	0.934***
$\underline{m}_2 *$% Non-Ag Hukou	-3.072***	$\underline{m}_2 * \ln(\text{Firm Age})$	0.403***
$\underline{m}_3 *$% Non-Ag Hukou	-3.218***	$\underline{m}_3 * \ln(\text{Firm Age})$	0.143***
$\underline{m}_4 *$% Non-Ag Hukou	-7.026***	$\underline{m}_4 * \ln(\text{Firm Age})$	0.351***
Observations: 62,908. R^2 : 0.139		Includes Regional Fixed Effects	

Standard errors in parentheses. Significance: *** p<.01, ** p<.05, * p<.1.

The remaining two boxes include regional controls from the Census and firm level controls from the manufacturing survey. The regional controls are by prefecture, and include the percentage of each type with a non-agricultural Hukou. The firm level controls include the share of foreign equity, the age of the firm, and whether the firm is in an urban area. Inclusion of controls for average worker age, which control for accumulated skill or vintage human capital, do not appreciably alter the results. Other controls which did not appreciably alter the results include State Ownership and the percentage of migrants in a region.

These first stage estimates are interesting in themselves, as the model above allows us to use these estimates to construct the unit cost function for labour by region. We will quantify this shortly, but to continue with the example of the General Purpose Machine industry, the implied dispersion of unit labour costs are depicted in Figure 6.

Figure 6: Geographic Dispersion of Unit Labour Costs: General Machinery



The model primitives of our two stage estimation procedure across industries are summarised in Tables 2 and 3. Standard errors are calculated using a bootstrap procedure stratified on industry and region, presented in Appendix 8.4.3. Table 2 displays the estimated model primitives, showing a range of significantly different technologies θ^T and match quality distributions through k. Table 3 shows the second stage estimation results when the regional unit labour costs are calculated using regional data and the first stage estimates.

Table 2: Model Primitive Estimates

Industry	k	θ	β	Industry	k	θ	β
Beverages	2.12	1.24	0.75	Paper	6.25	0.73	2.48
Electrical Equipment	2.60	1.22	0.65	Plastic	3.51	1.08	0.81
Food Manufacturing	1.59	1.28	0.86	Printing	3.93	1.04	0.89
General Machinery	2.50	1.22	0.68	Radio TV PC & Comm	2.21	1.41	0.51
Iron and Steel	3.21	1.00	1.02	Rubber	1.63	1.15	0.93
Leather & Fur	2.15	0.76	1.24	Specific Machinery	1.63	1.43	0.74
Med, Prec Equip, Clocks	2.34	1.43	0.43	Textile	3.73	0.95	1.15
Metal Products	3.20	1.10	0.77	Transport Equipment	1.26	1.38	0.92
Non-ferrous Metal	2.89	1.15	0.72	Wood	1.52	1.62	0.71
Non-metallic Products	2.02	1.25	0.75				

Table 3: Second Stage Estimates

Industry	α_L	α_K	α_M	Industry	α_L	α_K	α_M
Beverages	0.13	0.10	0.70	Paper	0.18	0.14	0.53
Electrical Equipment	0.25	0.14	0.47	Plastic	0.27	0.14	0.41
Food Manufacturing	0.14	0.09	0.70	Printing	0.09	0.22	0.55
General Machinery	0.17	0.12	0.60	Radio TV PC & Comm	0.16	0.21	0.43
Iron and Steel	0.40	0.07	0.48	Rubber	0.06	0.13	0.63
Leather & Fur	0.10	0.13	0.59	Specific Machinery	0.10	0.16	0.55
Med, Prec Equip, Clocks	0.20	0.16	0.43	Textile	0.12	0.11	0.61
Metal Products	0.24	0.14	0.46	Transport Equipment	0.04	0.15	0.65
Non-ferrous Metal	0.40	0.08	0.43	Wood	0.22	0.10	0.56
Non-metallic Products	0.20	0.07	0.61				

While the capital coefficients may seem low, they are not out of line with other estimates which specifically account for material inputs (e.g. Javorcik (2004)). For the specific case of China, there are few studies estimating production coefficients.[23] The most comparable study is Fleisher and Wang (2004) who find microeconomic estimates for α_K in the range of .40 to .50 (which does not differentiate between capital and materials) and these estimates compare favourably with the combined estimates of $\alpha_K + \alpha_M$ in Table 3.

6.2 Implied Productivity Differences Across Firms

Table 4 quantifies the implied differences in unit labour costs and productivity across regions implied by Table 2. The c_R^T column of Table 4 displays the interquartile (75%/25%) unit labour cost ratios by industry, where unit labour costs have been calculated according to the model. The u_R^T column of Table 4 contains the differences in productivity implied by unit labour cost differences, taking into account second stage production parameter estimates. Specifically, if firms 1 and 2 face unit labour costs of c_{RT}^1 and c_{RT}^2 and have the same wage bill W, they will employ labour of $L^1 = W/c_{RT}^1$ and $L^2 = W/c_{RT}^2$. Thus if these firms hire the same capital and material inputs (K,M), then the ratio of their output is

$$Y^1/Y^2 = \left(M^{\alpha_M^T} K^{\alpha_K^T} L_1^{\alpha_L^T}\right) / \left(M^{\alpha_M^T} K^{\alpha_K^T} L_2^{\alpha_L^T}\right) = (L_1/L_2)^{\alpha_L^T} = \left(c_{RT}^2/c_{RT}^1\right)^{\alpha_L^T}.$$

For example, contrast two firms in General Machinery at the 25th and 75th unit labour cost percentile. If both firms have the same wage bill, the labour (L) available to the lower cost firm is 1.41 times

[23] Though not directly comparable, macroeconomic level estimates include Chow (1993) and Ozyurt (2009) who find much higher capital coefficients. These studies do not account for materials.

greater than the higher cost firm. From Table 3 above, the estimated share of wages in production is $\alpha_L^T = 0.17$, so the lower cost firm will produce $1.41^{0.17} = 1.06$ times as much output as the higher cost firm, holding all else constant.

Table 4: Intra-industry Unit Labour Cost and Productivity Ratios

Industry	c_R^T 75/25	u_R^T 75/25	Industry	c_R^T 75/25	u_R^T 75/25
Beverages	1.51	1.06	Paper	1.66	1.07
Electrical Equipment	1.38	1.08	Plastic	1.35	1.09
Food Manufacturing	1.81	1.09	Printing	1.37	1.03
General Machinery	1.41	1.06	Radio TV PC & Comm	1.44	1.06
Iron and Steel	1.34	1.13	Rubber	2.16	1.04
Leather & Fur	1.92	1.04	Specific Machinery	1.99	1.08
Med, Prec Equip, Clocks	1.80	1.13	Textile	1.37	1.04
Metal Products	1.33	1.07	Transport Equipment	4.01	1.04
Non-ferrous Metal	1.45	1.17	Wood	1.47	1.10
Non-metallic Products	1.42	1.08			

Table 4 indicates that the range of total unit costs faced by firms within the same industry are indeed substantial, even after explicitly taking into account the technology θ^T and the ability to substitute across several types of workers. However, the second stage estimates indicate these differences are attenuated by substitution into capital and materials. Thus, while differences in regional markets indicate an interquartile range of 30-80% in unit cost differences, substitution into other factors reduces this range to between 3-17%. These rather substantial differences reiterate an important issue raised by Kugler and Verhoogen (2011): since TFP is often the 'primary measure of [...] performance', accounting for local factor markets might substantially alter estimates of policy effects.

Since firms locate freely, the model predicts that these substantial cost differences drive economic activity towards more advantageous locations, which we now examine.

6.3 Firm Location

Per capita volumes of economic activity across regions are determined by Equation (3.7), which states that relatively lower industry labour costs should attract relatively more firms to a region. Table 7 summarises estimates of this relationship, controlling for regional distance to the nearest port (weighted by the share of value added in a region). Whenever the relationship between value added and labour costs is statistically significant, the relationship is negative, in line with the model.[24]

[24]These results are robust if distance is unweighted, and to the inclusion of Economic Zone status.

Table 5: Determinants of Regional (Log) Value Added per Capita

Industry	$\ln\left(c_R^T\right)$	Std Err	100 km to Port	Std Err	Const	Std Err	Obs	R^2
Beverages	-0.696^b	(.274)	-0.122	(.200)	18.96^a	(3.36)	155	.03
Electrical Equipment	-0.057	(.403)	-1.567^a	(.259)	11.98^b	(4.80)	166	.22
Food Manufacturing	-0.553^b	(.229)	-0.397^b	(.179)	15.49^a	(2.15)	171	.04
General Machinery	-0.705^c	(.400)	-1.314^a	(.340)	19.68^a	(4.86)	195	.11
Iron and Steel	-1.245^b	(.565)	-0.576^a	(.194)	16.30^a	(2.22)	160	.06
Leather & Fur	-1.255^a	(.249)	-1.028^b	(.421)	25.81^a	(3.05)	89	.27
Med, Prec Equip & Clocks	-0.267	(.300)	-1.135^b	(.432)	13.13^a	(3.39)	68	.07
Metal Products	-0.236	(.463)	-1.239^a	(.260)	13.24^a	(4.86)	157	.14
Non-ferrous Metal	-1.977^a	(.544)	-0.468^c	(.275)	27.29^a	(4.57)	139	.10
Non-metallic Products	-0.827^a	(.290)	-0.910^a	(.155)	20.89^a	(3.38)	259	.11
Paper	-0.911^a	(.197)	-0.320	(.246)	20.04^a	(2.08)	159	.12
Plastic	-0.556	(.352)	-1.406^a	(.221)	16.86^a	(3.99)	159	.22
Printing	0.103	(.655)	-0.123	(.257)	8.54	(7.12)	98	.01
Radio TV PC & Comm	-0.212	(.366)	-0.741^b	(.333)	13.92^a	(4.60)	90	.04
Rubber	-0.424^c	(.219)	-0.470	(.398)	14.06^a	(2.07)	79	.06
Specific Machinery	-0.316^c	(.184)	-0.680^a	(.194)	14.74^a	(2.28)	167	.07
Textile	-0.934^a	(.273)	-1.168^a	(.153)	19.70^a	(2.44)	186	.18
Transport Equipment	-0.105	(.099)	-1.119^a	(.253)	12.69^a	(1.30)	168	.10
Wood	-2.234^a	(.338)	-1.038^a	(.267)	47.02^a	(5.63)	133	.20

Note: a, b and c denote 1, 5 and 10% significance level respectively.

In contrast to the present setting, most firm models used in production function estimation assume perfect labour substitutability. One implication of perfect substitutability is that, conditional on wages, the local composition of the workforce is irrelevant for hiring patterns. We have just seen that our approach, which is more sensitive to local factor market characteristics, helps explain firm location. We now compare our approach with others.

6.4 Comparison with Conventional Labour Measures

The estimates above reflect a procedure using regional variation to recover the unit cost of labour. Often, such information is not incorporated into production estimation. Instead, the number of employees or total wage bill are used to capture the effective labour available to a firm. The estimation results using these labour measures are contrasted with our method in Table 6. The production coefficients using the total wage bill or total employment are very similar, reflecting the high correlation of these variables. However, both measures mask regional differences in factor markets. Once local substitution patterns are taken into account explicitly, substantial differences emerge.[25]

Table 6: Second Stage Estimates vs Homogeneous Labour Estimates

	Unit Labour Cost			Total Wage Bill			Total Employment		
Industry	α_L	α_K	α_M	α_L	α_K	α_M	α_L	α_K	α_M
Beverages	0.13	0.10	0.70	0.23	0.06	0.71	0.22	0.07	0.73
Electrical Equipment	0.25	0.14	0.47	0.34	0.12	0.47	0.32	0.12	0.51
Food Manufacturing	0.14	0.09	0.70	0.16	0.06	0.73	0.17	0.06	0.75
General Machinery	0.17	0.12	0.60	0.25	0.09	0.61	0.23	0.09	0.64
Iron and Steel	0.40	0.07	0.48	0.25	0.07	0.68	0.29	0.05	0.70
Leather & Fur	0.10	0.13	0.59	0.27	0.09	0.55	0.30	0.09	0.56
Med, Prec Equip, Clocks	0.20	0.16	0.43	0.44	0.08	0.38	0.36	0.10	0.44
Metal Products	0.24	0.14	0.46	0.30	0.12	0.48	0.30	0.12	0.51
Non-ferrous Metal	0.40	0.08	0.43	0.17	0.10	0.65	0.22	0.08	0.65
Non-metallic Products	0.20	0.07	0.61	0.20	0.06	0.67	0.18	0.06	0.70
Paper	0.18	0.14	0.53	0.28	0.11	0.52	0.31	0.10	0.54
Plastic	0.27	0.14	0.41	0.31	0.13	0.43	0.32	0.13	0.45
Printing	0.09	0.22	0.55	0.40	0.14	0.44	0.34	0.17	0.49
Radio TV PC & Comm	0.16	0.21	0.43	0.48	0.14	0.35	0.40	0.16	0.41
Rubber	0.06	0.13	0.63	0.31	0.07	0.55	0.32	0.06	0.56
Specific Machinery	0.10	0.16	0.55	0.31	0.10	0.48	0.26	0.11	0.52
Textile	0.12	0.11	0.61	0.29	0.07	0.56	0.29	0.06	0.58
Transport Equipment	0.04	0.15	0.65	0.31	0.09	0.53	0.27	0.09	0.57
Wood	0.22	0.10	0.56	0.23	0.08	0.62	0.26	0.07	0.63
Average	0.18	0.13	0.55	0.29	0.09	0.54	0.28	0.09	0.58

Pushing this comparison further, Table 7 predicts the three year survival rate of firms by residual firm productivity. The first column shows the results under our unit cost method. The second and third columns show the results when labour is measured as perfectly substitutable (either by employment or wages). Note that in all cases, regional and industry effects are controlled for. The Table illustrates that productivity estimates which account for regional factor markets are almost twice as important in predicting firm survival as the other measures. Section 8.4.5 of the Appendix shows that similar results hold when examining sales growth and propensity to export: productivity under the unit cost approach is more important in predicting firm performance, suggesting the other measures conflate the role of advantageous factor markets with productivity.

[25]The residuals remaining after the second estimation step, which are often interpreted as idiosyncratic firm productivity, are compared across methods in Appendix 8.4.4.

Table 7: Explaining Survival with Productivity

	Survival Rate (2005-7)		
Productivity under Unit Cost method	0.019***		
	(0.003)		
Productivity under L =Employment		0.010***	
		(0.002)	
Productivity under L =Wage Bill			0.010***
			(0.002)
Prefecture and Industry FE	Yes	Yes	Yes
Observations	141,409	141,409	141,409
R-squared	0.023	0.022	0.022

Standard errors in parentheses. Significance: *** p<.01, ** p<.05, * p<.1.

7 Conclusion

This chapter examines the importance of local supply characteristics in determining firm input usage and productivity. To do so, a theory and empirical method are developed to identify firm input demand across industries and heterogeneous labour markets. The model derives labour demand as driven by the local distribution of wages and available skills. Firm behaviour in general equilibrium is derived, and determines firm location as a function of regional costs. This results in estimating equations which can be easily implemented in two steps. The first step exploits differences in firm hiring patterns across distinct regional factor markets to recover firm labour demand by type. The second step uses the estimates of the first stage to introduce local labour costs into production function estimation. Both steps characterise the impact of local market conditions on firm behaviour through recovery of model primitives. This is of particular interest when explaining the relative productivity or location of firms, especially in settings where local characteristics are known to be highly dissimilar.

Our empirical strategy combines information from the Chinese manufacturing, population census, and geographic data from the mid-2000s. The estimates provide a quantitative linkage from local market conditions to productivity. The results suggest that team technologies combined with favourable factor market conditions explain substantial differences in firm productivity. Other methods which do not model worker substitution or factor markets yield relatively skewed productivity estimates in China. This supports the thesis that modeling a firm's local environment may yield substantial insights into production patterns. Our results indicate that differences in local markets are quantitatively important.

The importance of local factor markets for understanding firm behaviour suggests new dimensions for policy analysis. For instance, regions with labour markets which generate lower unit labour costs tend to attract higher levels of firm activity within an industry. As unit labour costs depend not only on the level of wages, but rather the distribution of wages and worker types that represent substitution options, this yields a more varied view of how educational policy or flows of different worker types could impact firms.

This chapter also colours the interpretation of heterogeneous productivity at the firm level, since a component of differences across firms is due to the influence of local supply conditions. Productivity estimates which result from our model are more important in predicting firm performance than models based on perfectly substitutable worker types. This suggests that if firm productivity is a measure of ‘competitiveness’ leading to dynamic advantages such as innovation or exporting, then regional factor markets should be controlled for. Taken as a whole, our results show that policy changes which influence the composition of regional labour markets, such as the construction of Special Economic Zones or liberalisation of the Hukou system, will have sizable effects on firm behaviour, productivity and location.

Finally, nothing precludes the application of this chapter’s approach beyond China, and it is suitable for analysing regions which exhibit a high degree of labour market heterogeneity. As the model affords the interpretation of trade between countries which have high barriers to immigration but low barriers to capital and input flows, it is also suitable for analysing firm behaviour across national borders. Further work could leverage or extend the approach of combining firm, census and geographic data to better understand the role of local factor markets in hiring, input usage and firm dynamics.

8 Appendix

8.1 Further Model Discussion and Proofs

8.1.1 Relative Prices and Limited Factor Price Equalisation

The formula for unit labour costs shows that regions with different skill distributions, say region R and R', typically cannot have both $c_R^T = c_{R'}^T$ and $w_R = w_{R'}$. However, factor price equalisation for labour holds in a limited fashion in two ways. First, Equation (3.4) a limited form of factor price equalisation holds within each industry: the industry wage bill *per capita* is equalised, formally

$$c_R^T L_R^T/\mathbb{P}_R = c_{R'}^T L_{R'}^T/\mathbb{P}_{R'} \text{ for all region pairs } \left(R,R'\right).$$

Second, since $\sum_i \widetilde{w}_{R,i}^T = 1$, (3.6) implies

$$\text{Average Wages}: \quad \sum_i a_{R,i} w_{R,i} = \sum_t \alpha_L^t \sigma^t I_{\text{Agg}},$$

i.e. that average wages are constant across regions, despite differences in unit labour costs.

8.1.2 Existence of Regional Wages to Clear Input Markets

What is required is to exhibit a wage vector $\{w_{R,i}\}$ that ensures Equation (3.6) holds. Since all prices are nominal, WLOG we normalise $I_{\text{Agg}} = 1$ in the following.

Lemma. *There is a wage function that uniquely solves (3.6) given unit labour costs.*

Proof. Formally, we need to exhibit $\mathbb{W}$ such that

$$a_{R,i} = \mathbb{W}_{R,i}\left(\left\{c_{R'}^{T'}\right\}\right)^{-1} \sum_t \alpha_L^t \sigma^t \left(c_R^t\right)^{k/\beta^t - 1} \left(\frac{\mathbb{W}_{R,i}\left(\left\{c_{R'}^{T'}\right\}\right)^{1-k} a_{R,i}\left(\underline{m}_i^t\right)^k}{f\left(k-1\right)}\right)^{\theta^t/\beta^t} \quad \forall R,i.$$

Fix $\left\{c_{R'}^{T'}\right\}$ and define $h_{R,i}(x) \equiv \sum_t \alpha_L^t \sigma^t \left(c_R^t\right)^{k/\beta^t-1}\left(x^{1-k} a_{R,i}\left(\underline{m}_i^t\right)^k / f\left(k-1\right)\right)^{\theta^t/\beta^t}$, $g_{R,i}(x) \equiv a_{R,i}x$. For the result we require a unique x s.t. $g_{R,i}(x) = h_{R,i}(x)$. $g_{R,i}$ is strictly increasing and ranges from 0 to ∞, while $h_{R,i}(x)$ is strictly decreasing, and ranges from ∞ to 0, so x exists and is unique. □

Lemma. *The function $\left\{c_R^T \circ \mathbb{W}\left(\left\{c_R^T\right\}\right)\right\}$, where c_R^T is the unit cost function of Equation (2.10), has a fixed point $\left\{\widehat{c}_R^T\right\}$ and so $\mathbb{W}\left(\left\{\widehat{c}_R^T\right\}\right)$ is a solution to Equation (3.6).*

Proof. We first show that any equilibrium wage vector must lie in a compact set $\times_{R,i}\left[\underline{w}_{R,i}, \overline{w}_{R,i}\right]$ which contains strictly positive values. From (3.6), $\widetilde{w}_{R,i}^T \in [0,1]$ so $w_{R,i} \le \overline{w}_{R,i} \equiv \sum_t \alpha_L^t \sigma^t / a_{R,i}$. Now let

$$\underline{b}_R \equiv \min_i \sum_t \alpha_L^t \sigma^t \left(a_{R,i}\left(\underline{m}_i^t\right)^k\right)^{\theta^t/\beta^t} / \sum_i \left[a_{R,i}\left(\underline{m}_i^t\right)^k\right]^{\theta^t/\beta^t} a_{R,i},$$

and we will show that a lower bound for equilibrium wages is $\underline{w}_R \equiv \begin{bmatrix} \underline{b}_R, & \dots, & \underline{b}_R \end{bmatrix}$ for each R.

Consider that for $\mathbb{W}$ evaluated at $\left\{c_R^T\left(\underline{w}_R\right)\right\}$,

$$\mathbb{W}_{R,i}=\sum_t \alpha_L^t \sigma^t \left(a_{R,i}\left(\underline{m}_i^t\right)^k\left(\mathbb{W}_{R,i}/\underline{w}_R\right)^{1-k}\right)^{\theta^t/\beta^t} / \sum_i \left[a_{R,i}\left(\underline{m}_i^t\right)^k\right]^{\theta^t/\beta^t} a_{R,i}. \tag{8.1}$$

Evaluating Equation (8.1), if $\mathbb{W}_{R,i}\leq\underline{w}_R$ then $\mathbb{W}_{R,i}\geq\underline{w}_R$, and otherwise, $\mathbb{W}_{R,i}\geq\underline{w}_R$ so $\{\underline{w}_R\}$ is a lower bound for $\mathbb{W}\left(\left\{c_R^T\left(\underline{w}_R\right)\right\}\right)$. Since necessarily $\mathbb{W}\left(\left\{c_R^T\left(\hat{w}_R\right)\right\}\right)=\{\hat{w}_R\}$, $\mathbb{W}$ is increasing in $\left\{c_R^T\right\}$, and $c_R^T\left(w_R\right)$ is increasing in w_R, we have $\{\hat{w}_R\}=\mathbb{W}\left(\left\{c_R^T\left(\hat{w}_R\right)\right\}\right)\geq\mathbb{W}\left(\left\{c_R^T\left(\underline{w}_R\right)\right\}\right)\geq\{\underline{w}_R\}$. In conclusion, all equilibrium wages must lie in $\times_{R,i}\left[\underline{w}_{R,i},\overline{w}_{R,i}\right]$.

Now define a strictly positive, compact domain for $\left\{c_R^T\right\}$, $\times_R\left[\underline{c}_R^T,\overline{c}_R^T\right]$, by

$$\underline{c}_R^T\equiv\inf_{\times_i\left[\underline{w}_{R,i},\overline{w}_{R,i}\right]} c_R^T\left(w_R\right)=c_R^T\left(\underline{w}_R\right),\qquad \overline{c}_R^T\equiv\sup_{\times_i\left[\underline{w}_{R,i},\overline{w}_{R,i}\right]} c_R^T\left(w_R\right)=c_R^T\left(\overline{w}_R\right).$$

Now consider the mapping $\mathbb{C}\left(\left\{c_R^T\right\}\right)\equiv\left\{c_R^T\circ\mathbb{W}\left(\left\{c_R^T\right\}\right)\right\}$ on $\times_R\left[\underline{c}_R^T,\overline{c}_R^T\right]$, which is continuous on this domain. By above, $\mathbb{W}_{R,i}\left(\left\{c_R^T\right\}\right)\leq\overline{w}_{R,i}$ for each R,i so $\mathbb{C}\left(\left\{c_R^T\right\}\right)\leq\left\{\overline{c}_R^T\right\}$. Also by above, $\mathbb{C}\left(\left\{c_R^T\right\}\right)\geq\left\{c_R^T\circ\mathbb{W}\left(\left\{c_R^T\left(\underline{w}_R\right)\right\}\right)\right\}\geq\left\{c_R^T\left(\left\{\underline{w}_R\right\}\right)\right\}=\left\{\underline{c}_R^T\right\}$. Thus $\mathbb{C}$ maps $\times_R\left[\underline{c}_R^T,\overline{c}_R^T\right]$ into itself and by Brouwer's fixed point theorem, there exists a fixed point $\left\{\hat{c}_R^T\right\}$, which implies $\mathbb{W}\left(\left\{\hat{c}_R^T\right\}\right)$ is an equilibrium wage vector. □

8.2 Model Simulation and Estimator Viability

A model simulation was constructed using parameters given in Table 8. In the simulation, firms maximise profits conditional on local market conditions, and applying the procedure above produces Tables 9a and 9b. The estimation results are given in the Estimate column while the model analytical values are reported in the Predicted column. The results are quite satisfactory, insofar as the estimates are not only consistent but also close to the predicted values. Figure 7 further confirms this by plotting the simulated and predicted differences in the share of workers hired. For ease of comparison across panels, Figure 7 plots regional frequencies along the horizontal axis and (linearly) normalised wages for each worker type. As suggested by the Figure, the adjusted R^2 in both cases are quite high: .99 for the first stage and .97 for the second stage.

Table 8: Simulation details

Variable	**Description**	**Value**
θ^T	Technological parameter.	2
k	Pareto shape parameter.	1.5
$\{\underline{m}_i\}$	Human capital shifters.	$\{4, 8, 12, 16, 20\}$
$\{w_{R,i}\}$	Regional wages by type.	$\sim$LogNormal $\mu = (12, 24, 36, 48, 60)$, $\sigma = 1/3$.
$\{a_{R,i}\}$	Regional type frequencies.	$\sim$LogNormal $\mu = (.4, .3, .15, .1, .05)$, $\sigma = 1/3$, scaled so that frequencies sum to one.
K, M	Firm capital and materials.	$\sim$LogNormal $\mu = 1$, $\sigma = 1$.
L	Level of L employed by firm.	Profit maximising given K, M and region.
$\alpha_M, \alpha_K, \alpha_L$	Production Parameters.	$\alpha_M = 1/6$, $\alpha_K = 1/3$, $\alpha_L = 1/2$.
Control	Misc variable for output.	$\sim$LogNormal $\mu = 0$, $\sigma = 1$.
Coeff	Exponent on Control.	Control Coeff$= \pi$.
$\{\omega_j\}$	Firm idiosyncratic wage costs.	$\sim$LogNormal $\mu = 0$, $\sigma = .1$.

Sample: 200 regions with 20 firms per region, with errors $\sim$LogNormal($\mu = 0$, $\sigma = 1/2$).

Table 9: Simulation Results

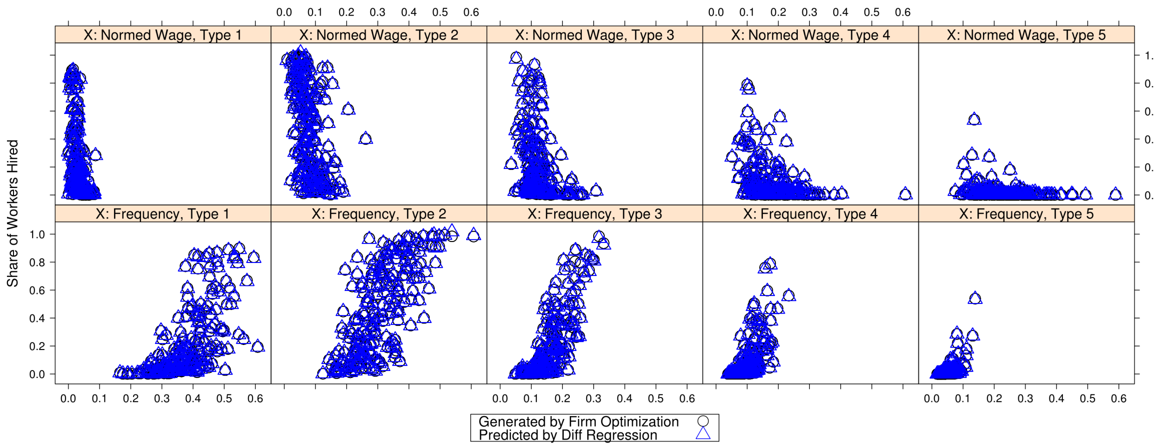
(a) Simulation First Stage Estimates: Technology and Human Capital

Variable	**Parameter**	**Estimate**	**Std Err**	**Predicted**
$\{\ln a_{R,i}\}$	(θ^T/β^T)	3.912	.0019	4
$\{\ln w_{R,i}\}$	$(-k/\beta^T)$	-2.922	.0021	-3
Dummy (Type = 1)	$(\theta^T/\beta^T)\,k\,(\ln \underline{m}_1/\underline{m}_5)$	-9.376	.0057	-9.657
Dummy (Type = 2)	$(\theta^T/\beta^T)\,k\,(\ln \underline{m}_2/\underline{m}_5)$	-5.295	.0045	-5.498
Dummy (Type = 3)	$(\theta^T/\beta^T)\,k\,(\ln \underline{m}_3/\underline{m}_5)$	-2.950	.0031	-3.065
Dummy (Type = 4)	$(\theta^T/\beta^T)\,k\,(\ln \underline{m}_4/\underline{m}_5)$	-1.274	.0024	-1.339

(b) Simulation Second Stage Estimates: Production Parameters

Variable	**Parameter**	**Estimate**	**Std Err**	**Predicted**
$\ln M$	$\alpha_M/(1-\alpha_L)$	.3298	.0079	.3333
$\ln K$	$\alpha_K/(1-\alpha_L)$	.6680	.0080	.6667
$\ln c_{RT}$	$-\alpha_L/(1-\alpha_L)$	-.9303	.0748	-1
Control	Control Coeff	3.148	.0079	3.141

Figure 7: Simulation Fit



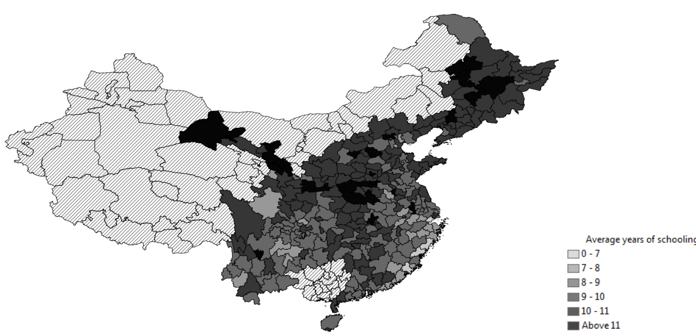
8.3 Further Details on Regional Variation In China

8.3.1 Educational Summary Statistics

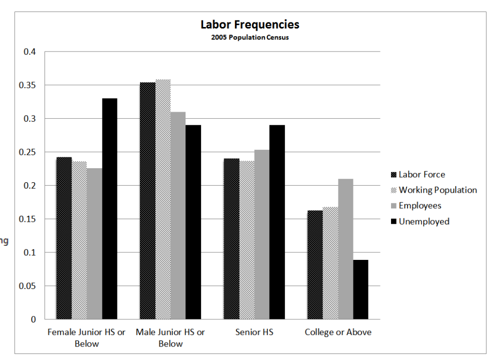
Figures 8a and 8b reveal more details about regional variation across China. Figure 8a illustrates the average years of schooling for the Chinese labour force.

Figure 8: Chinese Educational Attainment (2005)

(a) Labour Force Schooling (2005)



(b) Distribution of Attainment (2005)



UNICEF suggests that the typical Chinese primary school entrance age is 7.[26] Compulsory education lasts nine years (primary and secondary school) and ends around age sixteen. Figure 8b illustrates the distribution of education by classification of (potential) workers. In the Figure, the labour Force includes both workers and the unemployed. Workers are those of age 15 to 65 who work outside the agricultural sector. Employees is the subset of workers who are not employers, self-employed, or in

[26]Source: childinfo.org

a family business. Figure 8b illustrates that the frequency of each type of worker under each of these definitions of labour. The measures are quite similar, with the exception that unemployment is more prevalent among the less skilled.

Table 10: Educational and Wage Distribution by Province (2005)

Province	Fraction of Labour Force by Education				Avg Monthly Wage by Education			
	≤Junior HS (Female)	≤Junior HS (Male)	Senior HS	College or Above	≤Junior HS (Female)	≤Junior HS (Male)	Senior HS	College or Above
Anhui	0.296	0.485	0.155	0.063	581	862	866	1210
Beijing	0.140	0.284	0.299	0.277	796	1059	1314	2866
Chongqing	0.272	0.408	0.227	0.093	582	820	872	1379
Fujian	0.348	0.453	0.146	0.052	695	942	1103	1855
Gansu	0.216	0.399	0.271	0.114	507	738	869	1135
Guangdong	0.327	0.362	0.231	0.080	748	967	1281	2719
Guizhou	0.292	0.478	0.162	0.069	572	758	925	1189
Hainan	0.328	0.334	0.259	0.080	532	694	894	1527
Hebei	0.230	0.515	0.190	0.066	515	793	832	1233
Heilongjiang	0.217	0.393	0.285	0.104	515	740	797	1096
Henan	0.229	0.428	0.234	0.109	487	675	714	1079
Hubei	0.271	0.384	0.264	0.081	541	757	809	1262
Hunan	0.263	0.444	0.229	0.063	634	828	889	1267
Jiangsu	0.314	0.400	0.210	0.076	758	994	1086	1773
Jiangxi	0.291	0.456	0.196	0.056	525	783	794	1240
Jilin	0.204	0.382	0.307	0.107	522	745	809	1163
Liaoning	0.250	0.410	0.219	0.120	576	822	848	1366
Shaanxi	0.203	0.406	0.277	0.114	497	731	805	1149
Shandong	0.288	0.441	0.203	0.068	602	823	863	1398
Shanghai	0.221	0.321	0.272	0.186	891	1155	1450	3085
Shanxi	0.169	0.520	0.221	0.089	502	872	857	1113
Sichuan	0.277	0.480	0.162	0.081	541	737	829	1477
Tianjin	0.258	0.321	0.285	0.136	995	1019	1074	1617
Yunnan	0.275	0.495	0.160	0.070	504	697	896	1542
Zhejiang	0.357	0.469	0.129	0.045	817	1097	1299	2333

8.3.2 Provincial Summary Statistics

Table 11: Descriptive Statistics by Province (2005)

	Manufacturing		Population Census			
Province	Firm Count	Avg Workers	# of Regions	# Region-Industries	Monthly Wage	Avg Yrs School
Anhui	2,296	208	17	822	832	8.925
Beijing	3,676	145	2	128	1665	11.542
Chongqing	1,574	287	3	184	862	9.606
Fujian	7,534	212	9	504	945	8.170
Gansu	461	274	14	658	805	9.728
Guangdong	21,575	275	21	1269	1137	9.607
Guizhou	812	246	9	464	805	8.565
Hainan	126	149	3	151	830	9.772
Hebei	5,104	231	11	623	781	9.527
Heilongjiang	921	256	13	622	774	10.197
Henan	5,849	228	17	798	720	10.053
Hubei	2,685	247	14	742	789	9.731
Hunan	3,500	195	14	751	843	9.588
Jiangsu	22,197	170	13	756	1013	9.431
Jiangxi	1,501	245	11	556	766	9.208
Jilin	927	274	9	477	796	10.340
Liaoning	5,141	170	14	770	865	10.152
Shaanxi	1,207	368	10	548	787	10.068
Shandong	12,958	216	17	947	825	9.596
Shanghai	9,857	147	2	119	1577	10.569
Shanxi	1,118	386	11	619	847	9.895
Sichuan	3,209	238	21	887	800	9.149
Tianjin	2,671	195	2	128	1119	10.243
Yunnan	733	240	16	695	794	8.675
Zhejiang	27,639	144	11	629	1098	8.201

8.3.3 Industrial Summary Statistics

Table 12 presents the distribution of firms by industry and other descriptive statistics.

Table 12: Manufacturing Survey Descriptive Statistics (2005)

				Share of				
Industry	# of firms	# of Regions	Avg # of workers	Female	White Collar	Export	State Equity	Foreign Equity
Beverages	2,225	155	219.20	0.281	0.114	0.150	0.107	0.121
Electrical Equipment	12,241	166	201.58	0.289	0.106	0.351	0.030	0.195
Food Manufacturing	3,807	171	193.98	0.321	0.091	0.266	0.060	0.202
General Machinery	15,727	195	152.68	0.205	0.117	0.262	0.047	0.115
Iron and Steel	4,676	160	227.40	0.148	0.088	0.101	0.032	0.056
Leather & Fur	4,852	89	320.70	0.362	0.036	0.682	0.005	0.335
Med, Prec Equip, Clocks	2,702	68	214.89	0.296	0.180	0.457	0.063	0.299
Metal Products	10,686	157	146.93	0.233	0.086	0.332	0.028	0.161
Non-ferrous Metal	3,607	139	157.75	0.186	0.093	0.180	0.035	0.093
Non-metallic Products	15,347	259	195.57	0.207	0.090	0.169	0.059	0.088
Paper	5,698	159	151.05	0.269	0.061	0.127	0.026	0.131
Plastic	9,235	159	140.47	0.298	0.065	0.327	0.019	0.235
Printing	3,382	98	133.01	0.303	0.084	0.118	0.150	0.109
Radio TV PC & Comm	6,699	90	402.04	0.342	0.120	0.571	0.038	0.459
Rubber	2,212	79	226.25	0.294	0.067	0.377	0.027	0.218
Specific Machinery	7,816	167	176.76	0.197	0.154	0.244	0.072	0.166
Textile	18,292	186	222.43	0.390	0.044	0.406	0.018	0.168
Transport Equipment	8,632	168	252.01	0.228	0.120	0.240	0.088	0.138
Wood	3,629	133	137.04	0.288	0.050	0.290	0.025	0.137

8.4 Estimates Referenced in Main Text

8.4.1 Verisimilitude of Census and Firm Wages

One of the main concerns about combining census data with manufacturing data is the representativeness of regional labour market conditions in determining actual wages within firms. It turns out they are remarkably good predictors of a firm's labour expenses. We construct a predictor of firm wages based on Census data and test it as follows: First, compute the average wages per prefecture. Second, make an estimate CensusWage by multiplying each firm's distribution of workers by the average wages of each type from the population census. Third, regress actual firm wages on CensusWage. The results are presented in Table 13 of Appendix 8.4.1. Not only is the R^2 of this predictor very high for each industry, but the coefficient on CensusWage is close to one in all cases, showing that one-for-one the census based averages are excellent at explaining the variation in the wage bill across firms.

Table 13: Census Wages as a Predictor of Reported Firm Wages

Industry	Dependent Variable: ln (Firm Wage)					
	ln (Census Wage)	Std Dev	Constant	Std Dev	Obs	R^2
Beverages	1.052***	(0.0147)	-0.904***	(0.204)	2223	0.85
Electrical Equipment	1.018***	(0.0103)	-0.370***	(0.138)	12213	0.86
Food Manufacturing	1.032***	(0.0104)	-0.602***	(0.144)	3766	0.83
General Machinery	1.020***	(0.0063)	-0.365***	(0.091)	15711	0.84
Iron and Steel	1.049***	(0.0082)	-0.777***	(0.116)	4663	0.87
Leather & Fur	0.982***	(0.0112)	0.116	(0.165)	4851	0.87
Med, Prec Equip, Clocks	1.018***	(0.0221)	-0.332	(0.308)	2689	0.83
Metal Products	1.012***	(0.0094)	-0.286**	(0.130)	10654	0.83
Non-ferrous Metal	1.054***	(0.0092)	-0.833***	(0.127)	3588	0.88
Non-metallic Products	0.981***	(0.0085)	0.16	(0.122)	15329	0.80
Paper	1.012***	(0.0086)	-0.335***	(0.120)	5695	0.82
Plastic	1.015***	(0.0129)	-0.340**	(0.170)	9214	0.85
Printing	1.055***	(0.0135)	-0.839***	(0.189)	3377	0.83
Radio TV PC & Comm	1.021***	(0.0172)	-0.354	(0.224)	6685	0.86
Rubber	1.000***	(0.0132)	-0.133	(0.182)	2195	0.87
Specific Machinery	1.036***	(0.0105)	-0.580***	(0.139)	7780	0.83
Textile	0.981***	(0.0060)	0.132	(0.084)	18281	0.86
Transport Equipment	1.050***	(0.0071)	-0.755***	(0.099)	8618	0.86
Wood	0.965***	(0.0136)	0.309	(0.197)	3619	0.78

Standard errors in parentheses. Significance: *** p<0.01, ** p<0.05, * p<0.1.

8.4.2 First Stage Results By Industry

Table 14: First Stage Estimates I

Industry	Beverages	Electrical Equip	Food Manuf	General Machinery	Iron & Steel	Leather & Fur	Med, Clocks Prec Equip	Metal Products	Non-ferrous Metal
					Dependent Variable: $\ln(\%\text{type})$				
$\ln(w_{R,i})$	-1.808^a	-2.977^a	-0.870	-2.687^a	-2.150^a	-0.708^c	-4.517^a	-3.174^a	-3.096^a
$\ln(a_{R,i})$	1.673^a	1.878^a	1.489^a	1.794^a	1.018^a	0.636^a	3.358^a	1.439^a	1.627^a
m_1 (≤Junior HS: Fem)	-8.447^a	-9.491^a	-3.186	-10.170^a	7.190^a	-2.052	-13.450^a	-5.800^a	-1.189
m_2 (≤Junior HS: Male)	-5.947^c	-7.181^a	-1.504	-6.171^a	12.370^a	-1.089	-11.160^a	-2.176^c	3.768^c
m_3 (Senior High School)	-2.470	-4.475^a	1.123	-3.180^a	14.210^a	-2.058^c	-4.100^b	-0.758	6.119^a
m_1*% Non-Ag Hukou	0.837	-7.619^a	-2.341^b	-5.957^a	-2.373^c	-4.544^a	-7.142^a	-6.038^a	-4.591^a
m_2*% Non-Ag Hukou	0.306	-3.272^a	-1.880	-3.072^a	-1.355	-2.882^c	-3.957^c	-1.805^b	-0.370
m_3*% Non-Ag Hukou	-1.102	-0.593	-0.837	-3.218^a	-2.394^a	-1.606^b	0.315	-1.104^b	-0.903
m_4*% Non-Ag Hukou	-3.913	-4.572^a	-0.426	-7.026^a	10.130^a	-8.496^a	1.793	-2.491^b	3.403
$\underline{m}_1 *$ Urban Dummy	-0.271	-1.379^a	-1.462^a	-1.384^a	-1.393^a	-0.0822	-1.032^a	-1.408^a	-1.188^a
$\underline{m}_2 *$ Urban Dummy	-0.007	-0.991^a	-1.085^a	-0.980^a	-0.585^a	-0.128	-1.176^a	-0.533^a	-0.601^a
$\underline{m}_3 *$ Urban Dummy	0.286^c	0.139^b	0.175	0.427^a	0.503^a	0.220^c	-0.249	0.247^a	0.108
$\underline{m}_4 *$ Urban Dummy	2.212^a	1.513^a	1.743^a	2.336^a	3.275^a	0.683^a	1.053^a	2.147^a	1.791^a
m_1*% Foreign Equity	0.531^a	1.030^a	0.841^a	0.934^a	0.751^a	-0.107	1.952^a	0.876^a	1.366^a
m_2*% Foreign Equity	0.422^a	0.678^a	0.661^a	0.403^a	0.354^a	-0.0680	1.840^a	0.335^a	0.432^a
m_3*% Foreign Equity	0.106	0.259^a	0.197^b	0.143^a	0.083	0.257^a	0.574^a	0.145^a	0.093
m_4*% Foreign Equity	-0.005	0.232^a	0.015	0.351^a	-0.069	0.249	0.033	-0.150	0.589^a
$m_1 * \ln(\text{Firm Age})$	-2.803^a	-0.215	-0.983^a	-2.448^a	-2.160^a	0.113	0.727^b	-0.627^a	-2.156^a
$m_2 * \ln(\text{Firm Age})$	-2.290^a	-0.547^a	-0.494^c	-1.864^a	-1.662^a	-0.190^b	0.319	-0.788^a	-1.838^a
$m_3 * \ln(\text{Firm Age})$	0.714^a	-0.114	0.016	0.311^a	0.862^a	0.198	-0.510^b	0.417^a	0.695^a
$m_4 * \ln(\text{Firm Age})$	2.840^a	1.621^a	2.301^a	3.847^a	5.656^a	3.133^a	0.279	3.488^a	4.413^a
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,900	48,960	15,228	62,908	18,704	19,408	10,808	42,744	14,428
R-squared	0.124	0.117	0.098	0.139	0.168	0.208	0.246	0.124	0.145

Note: a, b and c denote 1, 5 and 10% significance level respectively.

Table 15: First Stage Estimates II

Industry	Other Non-metallic	Paper	Plastic	Printing	Radio, TV, PC, Comm	Rubber	Specific Machinery	Textile	Transport Equip	Wood
					Dependent Variable: $\ln(\%\text{type})$					
$\ln(w_{R,i})$	-1.693[a]	-1.542[a]	-3.324[a]	-3.491[a]	-3.371[a]	-0.854	-1.260[a]	-2.230[a]	-0.372	-1.220[b]
$\ln(a_{R,i})$	1.664[a]	0.332[b]	1.321[a]	1.212[a]	2.785[a]	1.267[a]	1.961[a]	0.830[a]	1.477[a]	2.286[a]
m_1 (≤Junior HS: Fem)	-7.246[a]	-3.469[c]	-7.881[a]	-5.515[b]	-13.770[a]	-1.997	-10.130[a]	1.588	-6.326[a]	-10.890[a]
m_2 (≤Junior HS: Male)	-3.128[a]	-0.645	-4.596[a]	-2.913	-11.970[a]	0.188	-4.811[a]	2.703[b]	-3.359[b]	-9.086[a]
m_3 (Senior High School)	-0.808	0.076	-2.657[b]	-1.849	-7.325[a]	2.347	-1.515	3.468[a]	-1.290	-6.106[b]
m_1∗% Non-Ag Hukou	-2.750[a]	-6.210[a]	-6.682[a]	-5.979[a]	-7.176[a]	-5.162[a]	-4.763[a]	-6.271[a]	-5.279[a]	-0.301
m_2∗% Non-Ag Hukou	-1.750[a]	-6.148[a]	-4.710[a]	-4.386[a]	-5.210[a]	-2.819[c]	-4.295[a]	-5.555[a]	-3.153[a]	-0.308
m_3∗% Non-Ag Hukou	-2.198[a]	-3.251[a]	-2.685[a]	-1.835[b]	0.597	-3.361[a]	-1.463[a]	-3.264[a]	-1.039[b]	-2.549[a]
m_4∗% Non-Ag Hukou	-3.926[a]	-7.690[a]	-7.074[a]	-4.440[c]	-3.291[a]	-2.211	-2.447	-4.025[a]	-3.450[b]	-13.060[a]
$\underline{m}_1 *$ Urban Dummy	-1.333[a]	-0.691[a]	-1.057[a]	-1.711[a]	-1.881[a]	-0.819[a]	-1.597[a]	-0.650[a]	-1.130[a]	-1.630[a]
$\underline{m}_2 *$ Urban Dummy	-0.834[a]	-0.338[b]	-0.590[a]	-1.170[a]	-1.619[a]	-0.603[a]	-1.234[a]	-0.421[a]	-0.714[a]	-0.720[a]
$\underline{m}_3 *$ Urban Dummy	0.250[a]	0.350[a]	0.272[a]	0.198	-0.512[a]	-0.035	0.216[b]	0.285[a]	0.233[a]	0.129
$\underline{m}_4 *$ Urban Dummy	2.570[a]	2.644[a]	2.413[a]	2.251[a]	0.902[a]	2.211[a]	1.924[a]	2.709[a]	1.381[a]	3.331[a]
m_1∗% Foreign Equity	0.834[a]	0.407[a]	0.877[a]	0.193	1.340[a]	0.620[a]	1.588[a]	0.214[a]	1.023[a]	0.415[a]
m_2∗% Foreign Equity	0.244[a]	0.153[c]	0.361[a]	-0.029	1.072[a]	0.234[c]	0.750[a]	0.202[a]	0.547[a]	0.176
m_3∗% Foreign Equity	0.028	0.039	0.048	0.242[a]	0.294[a]	0.002	0.169[a]	0.137[a]	0.129[a]	-0.142
m_4∗% Foreign Equity	-0.310[a]	-0.012	0.000	0.176	-0.160[b]	-0.191	0.097	0.442[a]	0.168[b]	0.197
$m_1 * \ln(\text{Firm Age})$	-1.016[a]	-1.899[a]	-0.857[a]	-0.247	0.310	-0.576	-1.601[a]	-0.384[a]	-1.266[a]	-0.423
$m_2 * \ln(\text{Firm Age})$	-0.768[a]	-0.819[a]	-0.773[a]	-0.402	0.223	-0.242	-1.675[a]	-0.058	-1.171[a]	0.066
$m_3 * \ln(\text{Firm Age})$	0.105	0.457[a]	0.398[a]	-0.023	-0.049	0.319	0.100	0.445[a]	0.588[a]	-0.468
$m_4 * \ln(\text{Firm Age})$	3.429[a]	4.850[a]	3.776[a]	3.143[a]	0.321[a]	2.577[a]	1.629[a]	4.391[a]	2.298[a]	3.850[a]
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	61,388	22,792	36,940	13,528	26,796	8,848	31,264	73,168	34,528	14,516
R-squared	0.150	0.164	0.130	0.107	0.188	0.120	0.177	0.221	0.129	0.245

Note: a, b and c denote 1, 5 and 10% significance level respectively.

8.4.3 First and Second Stage Models Parameter Estimates

Table 16: Model Primitive Estimates

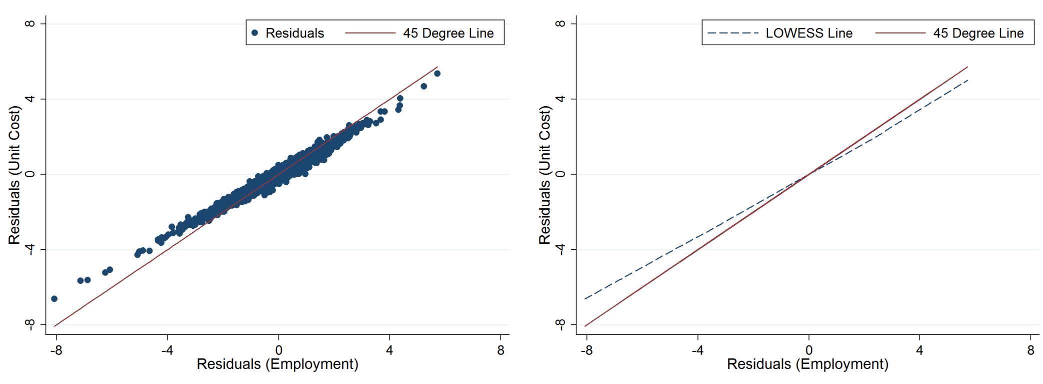
Industry	k	Std Err	θ	Std Err	β	Std Err	α_L	Std Err	α_K	Std Err	α_M	Std Err
Beverages	2.12	(0.38)	1.24	(0.08)	0.75	(0.08)	0.13	(.05)	0.10	(.007)	0.70	(.04)
Electrical Equipment	2.60	(0.15)	1.22	(0.02)	0.65	(0.03)	0.25	(.01)	0.14	(.001)	0.47	(.00)
Food Manufacturing	1.59	(0.36)	1.28	(0.13)	0.86	(0.10)	0.14	(.08)	0.09	(.009)	0.70	(.06)
General Machinery	2.50	(0.14)	1.22	(0.03)	0.68	(0.03)	0.17	(.02)	0.12	(.003)	0.60	(.01)
Iron and Steel	3.21	(0.56)	1.00	(0.06)	1.02	(0.15)	0.40	(.06)	0.07	(.010)	0.48	(.05)
Leather & Fur	2.15	(0.70)	0.76	(0.14)	1.24	(0.24)	0.10	(.11)	0.13	(.017)	0.59	(.07)
Med, Prec Equip, Clocks	2.34	(0.18)	1.43	(0.05)	0.43	(0.03)	0.20	(.01)	0.16	(.003)	0.43	(.01)
Metal Products	3.20	(0.24)	1.10	(0.03)	0.77	(0.05)	0.24	(.01)	0.14	(.001)	0.46	(.00)
Non-ferrous Metal	2.89	(0.38)	1.15	(0.05)	0.72	(0.08)	0.40	(.03)	0.08	(.005)	0.43	(.02)
Non-metallic Products	2.02	(0.16)	1.25	(0.04)	0.75	(0.03)	0.20	(.02)	0.07	(.002)	0.61	(.02)
Paper	6.25	(3.82)	0.73	(0.11)	2.48	(2.08)	0.18	(.36)	0.14	(.026)	0.53	(.28)
Plastic	3.51	(0.29)	1.08	(0.03)	0.81	(0.06)	0.27	(.04)	0.14	(.008)	0.41	(.02)
Printing	3.93	(0.60)	1.04	(0.04)	0.89	(0.12)	0.09	(.06)	0.22	(.014)	0.55	(.03)
Radio TV PC & Comm	2.21	(0.14)	1.41	(0.04)	0.51	(0.03)	0.16	(.01)	0.21	(.003)	0.43	(.01)
Rubber	1.63	(0.61)	1.15	(0.19)	0.93	(0.17)	0.06	(.15)	0.13	(.021)	0.63	(.10)
Specific Machinery	1.63	(0.18)	1.43	(0.07)	0.74	(0.05)	0.10	(.03)	0.16	(.005)	0.55	(.02)
Textile	3.73	(0.36)	0.95	(0.03)	1.15	(0.09)	0.12	(.05)	0.11	(.007)	0.61	(.03)
Transport Equipment	1.26	(0.24)	1.38	(0.13)	0.92	(0.09)	0.04	(.03)	0.15	(.006)	0.65	(.02)
Wood	1.52	(0.22)	1.62	(0.17)	0.71	(0.09)	0.22	(.11)	0.10	(.017)	0.56	(.08)

8.4.4 Residual Comparison: Unit Labour Costs vs Substitutable Labour

Of particular interest for work on productivity are the residuals remaining after the second estimation step, which are often interpreted as idiosyncratic firm productivity. Figure 9 contrasts the results of our method with the result when total employment is used as a measure of labour. Examining the

45 degree line also plotted in the Figure, a general pattern emerges: above average firms under the employment measure are slightly less productive under the unit cost approach, while below average firms are more productive. This suggests that a more detailed analysis of the role of local factor markets may substantially alter interpretation of differences in firm productivity.

Figure 9: Productivity: Unit Labour Costs vs Total Employment (General Machinery)



8.4.5 Firm Performance Characteristics and Productivity

Table 17: Explaining Growth with Productivity

	Sales Growth Rate (2005-7)		
Productivity under Unit Cost method	-0.074**		
	(0.030)		
Productivity under L =Employment		-0.052**	
		(0.021)	
Productivity under L =Wage Bill			-0.054**
			(0.022)
Prefecture and Industry FE	Yes	Yes	Yes
Observations	119,159	119,159	119,159
R-squared	0.027	0.027	0.027

Standard errors in parentheses. Significance: *** p<.01, ** p<.05, * p<.1.

Table 18: Explaining Propensity to Export with Productivity

	Export Dummy (2005)		
Productivity under Unit Cost method	0.024***		
	(0.007)		
Productivity under L =Employment		0.015***	
		(0.004)	
Productivity under L =Wage Bill			0.017***
			(0.004)
Prefecture and Industry FE	Yes	Yes	Yes
Observations	141,409	141,409	141,409
R-squared	0.202	0.202	0.202

Standard errors in parentheses. Significance: *** p<.01, ** p<.05, * p<.1.

8.5 Supplemental Appendix

8.5.1 Derivation of Region-Techonology Budget Shares

Using the profit maximising price P_{Rj}^{T} and combining Equations (2.12), (3.1) and (3.2) then yields the equilibrium quantity produced,

$$Q_{Rj}^{T}=\rho I_{\text{Agg}}\left(u_{R}^{T}\eta_{j}\left(U_{R}^{T}/\sigma_{R}^{T}\right)^{1/\rho}\right)^{\rho/(\rho-1)}/u_{Rj}^{T}\sum_{t,r}\left(\sigma_{r}^{t}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{r}^{t}\widetilde{\eta}_{r}^{t}. \tag{8.2}$$

Aggregating revenues using Equation (8.2) shows that each consumer's budget share allocated to region R and industry T is

$$\text{Consumer Budget Share for R,T}: \quad \left(\sigma_{R}^{T}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{R}^{T}\widetilde{\eta}_{R}^{T}/\sum_{t,r}\left(\sigma_{r}^{t}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{r}^{t}\widetilde{\eta}_{r}^{t}. \tag{8.3}$$

Consequently, since free entry implies expected profits must equal expected fixed costs, the mass of entrants $\mathbb{M}_{R}^{T}$ solves the implicit form[27]

$$\frac{1-\rho}{\rho}I_{\text{Agg}}\left(\left(\sigma_{R}^{T}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{R}^{T}\widetilde{\eta}_{R}^{T}/\sum_{t,r}\left(\sigma_{r}^{t}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{r}^{t}\widetilde{\eta}_{r}^{t}\right)=\mathbb{M}_{R}^{T}u_{R}^{T}\left(f_{e}G\left(\overline{\eta}_{R}^{T}\right)+F_{e}\right), \tag{8.4}$$

[27] To see a solution exists, note that for fixed prices, $\{\widetilde{\eta}_{R}^{T}\}$, and $\{\overline{\eta}_{R}^{T}\}$, necessarily $\mathbb{M}_{R}^{T}\in A_{R}^{T}\equiv\left[0,(1-\rho)I_{\text{Agg}}/\rho u_{R}^{T}F_{e}\right]$. Existence follows from the Brouwer fixed point theorem on the domain $\times_{R,T}A_{R}^{T}$ for $H\left(\left\{\widetilde{\mathbb{M}}_{R}^{T}\right\}\right)\equiv(1-\rho)I_{\text{Agg}}\left(\left(\sigma_{R}^{T}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{R}^{T}\widetilde{\eta}_{R}^{T}/\sum_{t,r}\left(\sigma_{r}^{t}\right)^{1/(1-\rho)}\widetilde{\mathbb{M}}_{r}^{t}\widetilde{\eta}_{r}^{t}\right)/\rho u_{R}^{T}\left(f_{e}G\left(\overline{\eta}_{R}^{T}\right)+F_{e}\right)$.

while the equilibrium cost cutoffs $\overline{\eta}_R^T$ solve the zero profit condition[28]

$$\frac{1-\rho}{\rho} I_{\text{Agg}} \left(\sigma_R^T\right)^{1/(1-\rho)} \left(u_R^T \overline{\eta}_R^T \left(U_R^T\right)^{1/\rho}\right)^{\rho/(\rho-1)} = u_R^T f_e \sum_{t,r} \left(\sigma_r^t\right)^{1/(1-\rho)} \widetilde{\mathbb{M}}_r^t \widetilde{\eta}_r^t. \tag{8.5}$$

Equations (8.4) and (8.5) fix $\overline{\eta}_R^T$ since combining them shows

$$\int_0^{\overline{\eta}_R^T} \left(\eta_{Rz}^T / \overline{\eta}_R^T\right)^{\rho/(\rho-1)} dG(z) / G\left(\overline{\eta}_R^T\right) = 1 + F_e / f_e G\left(\overline{\eta}_R^T\right).$$

In particular, $\overline{\eta}_R^T$ does not vary by region or technology. Thus, Equation (8.5) shows that

$$U_R^T u_R^T / \sigma_R^T = \left[(1-\rho) I_{\text{Agg}} / \rho f_e \sum_{t,r} \left(\sigma_r^t\right)^{1/(1-\rho)} \widetilde{\mathbb{M}}_r^t \widetilde{\eta}_r^t\right]^{1-\rho} / \left(\overline{\eta}_R^T\right)^{\rho}. \tag{8.6}$$

where the RHS does not vary by region or technology. Combining this equation with (3.2) shows $Q_{Rj}^T = Q_{R'j}^{T'}$ for all (T,R) and (T',R'), so that $\mathbb{M}_R^T u_R^T / \sigma_R^T = \mathbb{M}_{R'}^{T'} u_{R'}^{T'} / \sigma_{R'}^{T'}$. At the same time, using Equation (8.6) reduces (8.3) to

$$\text{Consumer Budget Share for R,T:} \quad \mathbb{M}_R^T u_R^T / \sum_{t,r} \mathbb{M}_r^t u_t^t = \sigma_R^T / \sum_{t,r} \sigma_r^t = \sigma_R^T.$$

Since $\sum_{t,r} \sigma_r^t = 1$, each region and industry receive a share σ_R^T of consumer expenditure.

8.5.2 Regional Variation in Input Use

Equation (4.1) specifies the relative shares of each type of worker hired. Since input markets are competitive, firms and workers take regional labour market characteristics as given. As characteristics such as wages worker availability and human capital vary, the share of each labour type hired differs across regions. These differences can be broken up into direct and indirect effects. Direct effects ignore substitution by holding the unit labour cost $\widetilde{c}_{RT}$ constant, while indirect effects measure how regional differences give rise to substitution. The direct effects are easy to read off of Equation (4.1),

[28] To see a solution exists, note that for fixed prices, $\left\{\mathbb{M}_{R'}^{T'}\right\}$ and $\left\{U_R^T\right\}$, the LHS ranges from 0 to ∞ as $\overline{\eta}_R^T$ varies, while the RHS is bounded away from 0 and ∞ when $\min\left\{\widetilde{\eta}_r^t G\left(\overline{\eta}_r^t\right)\right\} > 0$. $\widetilde{\eta}_R^T G\left(\overline{\eta}_R^T\right) > 0$ follows from inada type conditions on goods from each T and R.

showing:

$$\text{Direct Effects}: \quad d\ln s_{R,T,i}/d\ln w_{R,i}|_{\widetilde{c}_{RT}\text{ constant}} = -k/\beta^T \quad < 0, \tag{8.7}$$

$$d\ln s_{R,T,i}/d\ln a_{R,i}|_{\widetilde{c}_{RT}\text{ constant}} = \theta^T/\beta^T \quad > 0, \tag{8.8}$$

$$d\ln s_{R,T,i}/d\ln \underline{m}_i^T|_{\widetilde{c}_{RT}\text{ constant}} = k\theta^T/\beta^T > 0. \tag{8.9}$$

These direct effects have the obvious signs: higher wages ($w_{R,i} \uparrow$) discourage hiring a particular type while greater availability ($a_{R,i} \uparrow$) and higher human capital ($m_{T,i} \uparrow$) encourage hiring that type. The indirect effects of substitution through $\widetilde{c}_{RT}$ are less obvious as seen by

$$d\ln\widetilde{c}_{RT}^k/d\ln w_{R,i} = \left(k/\theta^T\right)\left[a_{R,i}\left(\underline{m}_i^T\right)^k w_{R,i}^{1-k-\beta^T/\theta^T}\right]^{\theta^T/\beta^T}\widetilde{c}_{RT}^{k\left(\theta^T/\beta^T\right)} > 0, \tag{8.10}$$

$$d\ln\widetilde{c}_{RT}^k/d\ln a_{R,i} = -\left[a_{R,i}\left(\underline{m}_i^T\right)^k w_{R,i}^{1-k-\beta^T/\theta^T}\right]^{\theta^T/\beta^T}\widetilde{c}_{RT}^{k\left(\theta^T/\beta^T\right)} < 0, \tag{8.11}$$

$$d\ln\widetilde{c}_{RT}^k/d\ln\underline{m}_i^T = -k\left[a_{R,i}\left(\underline{m}_i^T\right)^k w_{R,i}^{1-k-\beta^T/\theta^T}\right]^{\theta^T/\beta^T}\widetilde{c}_{RT}^{k\left(\theta^T/\beta^T\right)} < 0. \tag{8.12}$$

Thus, the indirect effects counteract the direct effects through substitution. To see the total of the direct and indirect effects, define the Type-Region-Technology coefficients $\chi_{i,R,T}$:

$$\chi_{i,R,T} \equiv 1 - \left[a_{R,i}\left(\underline{m}_i^T\right)^k w_{R,i}^{1-k-\beta^T/\theta^T}\right]^{\theta^T/\beta^T}\widetilde{c}_{RT}^{k\left(\theta^T/\beta^T\right)}.$$

Investigation shows that each $\chi_{i,R,T}$ is between zero and one. Combining Equations (8.7-8.9) and Equations (8.10-8.12) shows that the direct effect dominates since

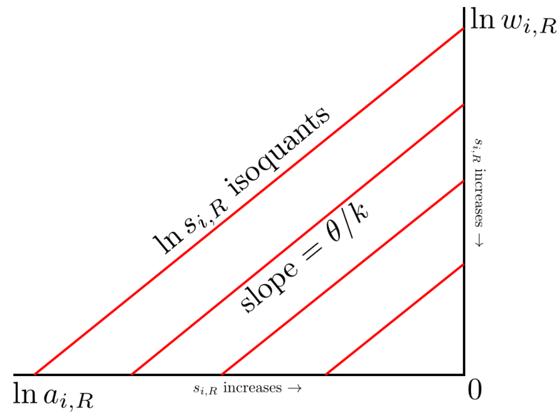
$$\text{Total Effects}: \quad d\ln s_{R,T,i}/d\ln w_{R,i} = \left[-k/\beta^T\right]\chi_{i,R,T} \quad < 0, \tag{8.13}$$

$$d\ln s_{R,T,i}/d\ln a_{R,i} = \left[\theta^T/\beta^T\right]\chi_{i,R,T} \quad > 0, \tag{8.14}$$

$$d\ln s_{R,T,i}/d\ln\underline{m}_i^T = \left[k\theta^T/\beta^T\right]\chi_{i,R,T} > 0. \tag{8.15}$$

Equations (8.13-8.15) summarise the relationship between regions and labour market characteristics in a parsimonious way. For small changes in labour market characteristics, the log share of a type hired in linear in log characteristics with a slope determined by model parameters and a regional shifter $\chi_{i,R,T}$. These (local) isoquants for the share of type i workers hired in region R are depicted in Figure 10.

Figure 10: Local Isoquants for Share of Workers Hired



8.5.3 Regional Variation in Theory: Isoquants

Equations (8.13-8.15) also characterise local isoquants of hiring the same share of a type across regions. It is immediate that for small changes in market characteristics, $\begin{pmatrix} \Delta_w, & \Delta_a, & \Delta_m \end{pmatrix}$, the share of a type hired is constant so long as

$$-\left(k/\theta^T\right)\Delta_w/w_{R,i}+\Delta_a/a_{R,i}+k\Delta_m/\underline{m}_i^T=0.$$

For instance, firms in regions R and R' will hire the same fraction of type i workers for small differences in characteristics (Δ_w,Δ_a) so long as

$$\Delta_w/\Delta_a=\left(\theta^T/k\right)w_{R,i}/a_{R,i}. \tag{8.16}$$

By itself, an increase in type i wages Δ_w would cause firms to hire a lower share of type i workers as indicated by the direct effect. However, Equation (8.16) shows that firms would keep the same share of type i workers if the availability Δ_a increases concurrently so that Equation (8.16) holds.

8.5.4 Derivation of Unit Labour Costs

Unit labour costs by definition solve

$$\text{Unit Labour Costs}: \quad c_R^T\equiv\min_H C_T\left(H|a_R,w_R\right)\text{ subject to }L=\phi\left(\tilde{H},\theta^T\right)\cdot H_{\text{TOT}}=1.$$

Under the parameterisation $\Psi(h) = 1 - h^{-k}$, Equations (2.2) become

$$H_i = a_{R,i}k/(k-1)\cdot \underline{m}_i^T \underline{h}_i^{1-k}\cdot N. \tag{8.17}$$

From above, $w_{R,i}H_i/\underline{m}_i^T \underline{h}_i C_T(H|a_R, w_R) = H_i^{\theta^T}/\sum_j H_j^{\theta^T}$, and $L = 1 = \left(\sum_j H_j^{\theta^T}\right)^{1/\theta^T}$ so

$$\underline{h}_i = w_{R,i}H_i^{1-\theta^T}/\underline{m}_i^T C_T(H|a_R, w_R). \tag{8.18}$$

Substitution now yields

$$H_i = a_{R,i}k/(k-1)\cdot \underline{m}_i^T \left(w_{R,i}H_i^{1-\theta^T}/\underline{m}_i^T C_T(H|a_R, w_R)\right)^{1-k}\cdot N. \tag{8.19}$$

Further reduction and the definition of β^T shows that

$$H_i^{\beta^T} = H_i^{\theta^T+k-k\theta^T} = a_{R,i}k/(k-1)\cdot \left(\underline{m}_i^T\right)^k w_{R,i}^{1-k} C_T(H|a_R, w_R)^{k-1} N. \tag{8.20}$$

Again using $\left(\sum_j H_j^{\theta^T}\right)^{1/\theta^T} = 1$ then shows

$$1 = \sum_i \left[a_{R,i}k/(k-1)\cdot \underline{m}_i^{Tk} w_{R,i}^{1-k}\left(c_R^T\right)^{k-1} N\right]^{\theta^T/\beta^T}. \tag{8.21}$$

From the definition of the cost function we have

$$c_R^T = N\left[\sum_i a_{R,i}w_{R,i}\underline{h}_i^{-k} + f c_R^T\right] = \sum_i w_{R,i}\left((k-1)/k\right)H_i/\underline{m}_i^T \underline{h}_i + N f c_R^T.$$

Therefore from $w_{R,i}H_i/\underline{m}_i^T \underline{h}_i C_T(H|a_R, w_R) = H_i^{\theta^T}$ it follows

$$1 = \sum_i (k-1)/k\cdot H_i^{\theta^T} + Nf = (k-1)/k + Nf,$$

and therefore $N = 1/fk$. Now from Equation (8.21) c_R^T is seen to be Equation (2.10).

8.5.5 Derivation of Employment Shares

Combining Equations (8.18), (8.20) and $N = 1/fk$ shows

$$\underline{h}_i = a_{R,i}^{\left(1-\theta^T\right)/\beta^T} \left(\underline{m}_i^T\right)^{-\theta^T/\beta^T} w_{R,i}^{1/\beta^T} \left(c_R^T\right)^{-1/\beta^T} / \left(f\left(k-1\right)\right)^{\left(1-\theta^T\right)/\beta^T}. \tag{8.22}$$

Let $A_{R,i}^T$ be the number of type i workers hired to make $L = 1$, exclusive of fixed search costs. By definition, $A_{R,i}^T = N|_{L=1}\, a_{R,i} \left(1 - \Psi\left(\underline{h}_i\right)\right) = a_{R,i}\underline{h}_i^{-k}/fk$. Using Equation (8.22),

$$A_{R,i}^T = k^{-1}\left(k-1\right) a_{R,i}^{\theta^T/\beta^T} \left(\underline{m}_i^T\right)^{k\theta^T/\beta^T} w_{R,i}^{-k/\beta^T} \left(c_R^T\right)^{k/\beta^T} \left(k-1\right)^{-\theta^T/\beta^T} f^{-1}.$$

Labour is also consumed by the fixed search costs which consist of $N|_{L=1} \cdot f = 1/k$ labour units. Therefore, if $\widetilde{A}_{R,i}^T$ denotes the total number of type i workers hired to make $L = 1$, necessarily $\widetilde{A}_{R,i}^T = A_{R,i}^T + \widetilde{A}_{R,i}^T/k$ so $\widetilde{A}_{R,i}^T = k\left(k-1\right)^{-1} A_{R,i}^T$, and the total number of type i workers hired in region R using technology T is $L_R^T \widetilde{A}_{R,i}^T$. The total number of employees in R, T is $\sum_i L_R^T \widetilde{A}_{R,i}^T = L_R^T \left(c_R^T\right)^{k/\beta^T} \left(\widetilde{c}_R^T\right)^{-k\theta^T/\beta^T}$, where $\widetilde{c}_R^T$ denotes the unit labour cost function at wages $\left\{w_{R,i}^{k/(k-1)\theta^T}\right\}$[29].

[29] Formally $\tilde{c}_R^T \equiv \min_H C_T\left(H|a_R, \left\{w_{R,i}^{-k/\theta^T(1-k)}\right\}\right)$ subject to $L = \phi\left(\tilde{H}, \theta^T\right) \cdot H_{\mathrm{TOT}} = 1$.

Part III

Foreign Ownership Share and Property Rights: Evidence from Thai Manufacturing Firms

1 Introduction

The theories proposed to explain firm boundaries have been highly influential and significantly developed in the past century. The literature was started by Coase (1937) who explains the existence and size of firms through transaction costs. Then Williamson (1971,1973,1979) adds some content to this idea by including the fact that transactions with an agent outside the firm involve incomplete contracts and relationship-specific investments that result in the well-known hold-up problem. This problem vanishes when transactions are done within the firm. This is the core of transaction cost economics. There is also another approach to the theory of the firm that is due to Grossman and Hart (1986) and this leads to property-rights theories.

The theories of property rights feature incompleteness of contracts, relationship-specific investment and the hold-up problem like the ones in the transaction-cost literature but they also exist within the boundaries of the firms.[30] It is impossible to list all possible contingencies in a contract. Hence, among parties inside a firm, the owner of the firm has the right to decide what to do in situations which are not foreseen in the contract. In other words, the owner has residual rights of control. If there are two vertically integrated entities, the one with ownership and, hence, residual rights will be able to affect ex-post division of surplus. This in turn affects each party's decision on the level of relationship-specific investments and the degree of the hold-up problem. Optimally, the ownership should be given to the party whose investment is more important to production. Property-rights theories have been supported by many empirical studies, which include Baker and Hubbard (2004) where property-rights theories explain truck ownership and Acemoglu, Aghion, Griffith, and Zilibotti (2010) which shows that a UK producer is more likely to own its supplier if the producer's R&D intensity at industry level is high relative to its supplier's.[31]

[30]See Whinston (2001) for a thorough comparison between transaction-cost and property-rights theories.

[31]See Aghion and Holden (2011), Antràs (2011) and Hart and Moore (2007) for a complete summary of property-rights literature.

The property rights approach to theory of the firm has been extended to explain many important economic issues. Antràs (2003) proposes a property-rights model to answer why trade in capital intensive goods has a greater tendency to be traded within the boundaries of the firm. Antràs (2005) uses similar model to explain how product cycles lead to changes in ownership structures over time. Besley and Ghatak (2001) extend Grossman and Hart's model to analyse how public good ownership affects its provision. Aghion, Griffith, and Howitt (2006) investigate the effect of competition on ownership structure. Acemoglu, Antras, and Helpman (2007) analyse how incompleteness of contracts leads to the adoption of less advanced technologies. These are examples of numerous studies based on the property rights approach.

Nearly all the papers in the literature, including all aforementioned papers, treat ownership as binary. In other words, a firm can either wholly own its supplier or let the supplier be independent. Nonetheless, a majority of firms partially own their affiliates. In my dataset, among all Thai manufacturing firms with some foreign ownership, only around 30% of them are 100% owned by foreign firms. The rest have foreign ownership shares ranging from 1% to 99% as you can see from Figure 11. Hence treating ownership as continuous matches with firms' integration choice in reality. When firms decide to integrate with their suppliers, they have to choose the optimal amount of supplier's equity that they should acquire and this can be anything from 0 to 100 percent of the total equity.

There are two peaks in the distribution of foreign ownership shares and one of them is around 50%. One may think that there must be a restriction on foreign ownership shares. Out of 125 industries, there are only 22 industries where the maximum foreign ownership share is less than fifty percent. A case where these industries are dropped is done as a robustness check and the main results of this chapter do not change.

Furthermore, the empirical literature on intra-firm trade is based on different ownership thresholds. For example, U.S. Census Bureau classifies a trade transaction to be intra-firm if one party owns at least 6% of the other[32] while the ownership threshold used by the Bureau of Economic Analysis (BEA) is 10%.[33] The threshold is higher outside the U.S.; for instance, the ownership threshold is 50% in French trade data.[34] The subjectivity in ownership thresholds can have a significant impact on the empirical tests of firm boundaries. When ownership is treated as continuous, this problem is

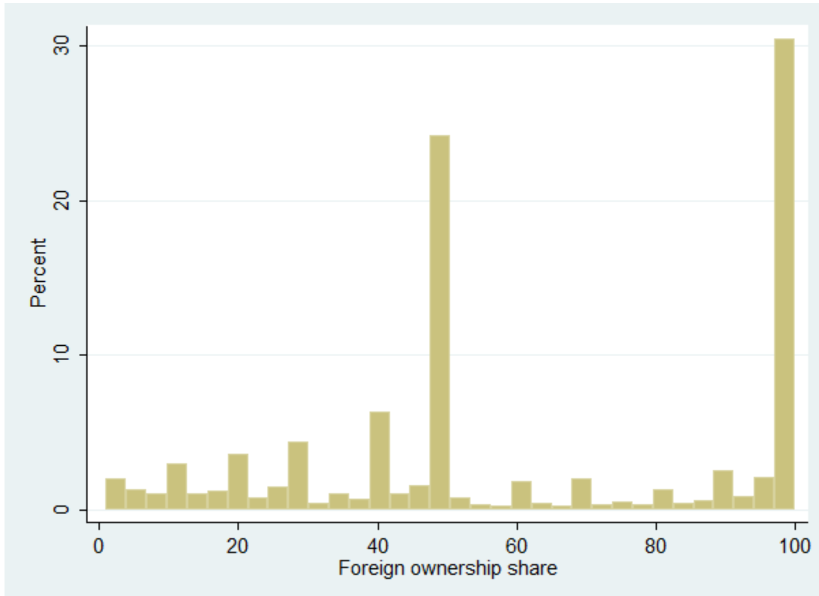
[32]The empirical papers based on this set of data includes Bernard, Jensen, Redding, and Schott (2010) and Nunn and Trefler (2008).

[33]The empirical part in Antràs (2003) is based on this dataset.

[34]For more details about the data, see Corcos, Irac, Mion, and Verdier (2012) and Defever and Toubal (2007).

circumvented.

Figure 11: Distribution of Foreign Ownership Shares in Thailand



Several papers also highlight that moving away from treating ownership as binary is non-trivial. Hart and Moore (1990) proposed a property-rights model where there is a discrete number of assets in a production process and conclude that all assets that are complementary should be under common ownership. Maskin and Tirole (1999) show in a similar framework that joint ownership can be more efficient. Consistent with Maskin and Tirole's (1999) prediction, Fehr, Kremhelmer, and Schmidt's (2008) experiments[35] suggest that 100% ownership is not optimal and they observed that a majority of experiment participants optimally choose joint ownership (50-50) over sole ownership. It is clear that firms can choose different degree of integration and I believe that an insight into a firm's decision making on optimal ownership share will broaden our understanding of firm boundaries.

The aim of this chapter is to test whether the property rights approach to the theory of the firm can explain firms' optimal degree of integration both theoretically and empirically. I propose a property-rights model where the degree of integration is continuous and becomes a choice variable. Then, I use the Thai manufacturing Census to test the model's predictions. To the best of my knowledge, this is the first time that property-rights theories have been used to explain the optimal degree of integration theoretically and empirically because existing papers generally treat ownership as binary or discrete.

[35] In the experiments, players bargain over ownership rights on a firm (joint ownership or wholly owned entity) and then make relationship-specific investments. The ownership pattern that minimises the under-investment by both parties is regarded to be more optimal.

Ferreira, Ornelas, and Turner (2011) use a mechanism design approach to characterise the optimal restructuring mechanism. Their model also has continuous ownership but the authors aim to explain the optimal allocation of corporate ownership and control, whereas I follow Grossman and Hart (1986) and assume that there is no separation between ownership and control.

The property-rights model proposed here has a similar setting to the theoretical models in Antràs (2003) and Antras and Helpman (2004). There are many differentiated varieties in each industry and the demand is of CES form. Each final good producer needs to match with a supplier to produce a commodity. Once matched, the final good producer chooses the optimal amount of supplier's equity that they should acquire (this will be called ownership share from this point onwards) which can be anything between 0 and 100%.[36] At the same time, the side payments are agreed and paid. Input production involves capital investment from the final good producers and labour from suppliers as in Antràs (2003). These investments in capital and labour are relationship specific and their quality are not verifiable by third parties. Therefore, it is futile to write any ex ante contracts and both parties will Nash bargain over the surplus after the investments have been made. Then the final good producer costlessly transforms the inputs into final goods and the revenue will be split according to the Nash bargaining result.

Ownership share affects the Nash bargaining result in two ways. Firstly, it determines the final good producer's outside option. The higher the ownership share is, the more of the inputs that the final good producer can seize when the negotiation breaks down. The seized inputs can be transformed into final goods at negligible costs. This leads to a higher outside option for the final good producer. Supplier's outside option is always zero as he does not have the technology to convert remaining inputs into final goods when the negotiation breaks down.[37] Secondly, the quasi rent (total surplus less the values of both parties' outside options) will be split according to the ownership share. In Antràs (2003) and Antras and Helpman (2004), the Nash bargaining share is exogenous and fixed but it is endogenous here. Letting the ownership share be the Nash bargaining share is logical. If your ownership share is large, you should get a big fraction of the quasi rent. Hence, higher ownership share increases both the outside option and the fraction of quasi rent obtained by the final good producer. The Nash

[36]Zero ownership share means that the supplier is independent from the final good producer. 100% ownership means that the final good producer own all the supplier's assets.

[37]The assumption of suppliers' zero outside option is a modeling trick which allows authors to avoid introducing complicated matching process into the model. This assumption is common in the property rights literature which includes, for instance, Antràs (2003) and Antras and Helpman (2004). The assumption is only dropped in the papers where the effect of some elements of the matching process on ownership is the focal point of the studies (i.e. McLaren (2000) and Grossman and Helpman (2002)), however this is outside the scope of this chapter.

bargaining result is that each party gets a fraction of the quasi rent and its outside option. Therefore, higher ownership share will lower the return received by the supplier and, hence, its investment. Final good producers have to consider this trade off when choosing the optimal ownership share.

Backward induction yields two testable predictions. Firstly, the degree of integration is expected to be high when the relative importance of final good producer's investment which is proxied by capital intensity[38] is high. On the other hand, when the supplier's contribution which is proxied by skill intensity is large, final good producers optimally choose lower ownership share. The intuition is that the parent firm is willing to increase the ownership which raises the degree of underinvestment by its supplier only when the supplier's investment is not significant relative to its own investment.

The second prediction from the model states that the marginal effects of capital and skill intensities on ownership should be higher when the elasticity of substitution across varieties is high. Final good producers increase ownership in order to be able to seize a bigger share of inputs when negotiation breaks down resulting in a higher outside option. When the elasticity is low which implies that the market is not competitive, equilibrium price is steep. In this case, seizing a small amount of inputs can still generate high outside option without increasing the ownership. Hence ownership is less sensitive to the importance of headquarter's investment under low elasticity. The opposite is true when the elasticity is high.

Thai manufacturing census 2007 is used to test the above predictions. Each firm must report the foreign ownership share along with the nationality of the top three investors. They must also report their export share and main export destination. Given the dataset, the universe of foreign affiliates in Thailand can be divided into groups by their purpose of integration. By definition, horizontally integrated firms duplicates its parent's production with the main purpose of serving the host economy alone in order to avoid relevant trade costs. If a foreign affiliate sells most of its production in Thailand, it is more likely to be under horizontal integration.[39] On the other hand, if it exports a lot, it is likely to be a part of a global production chain and hence under vertical integration.[40] For the main analysis, I divide foreign owned firms into three groups (horizontal, mixed and vertical integration) according to their export share in order to test the predictions which only apply to vertically integrated firms. The

[38]See section 3.1 for the explanation on the choice of the proxies.

[39]Atalay, Hortacsu, and Syverson (2012) and Ramondo, Rappoport, and Ruhl (2011) both found that the domestic flows between establishments owned by the same corporation are very rare and small. Hence most of the affiliate's local sales are mainly to unrelated parties in the host countries.

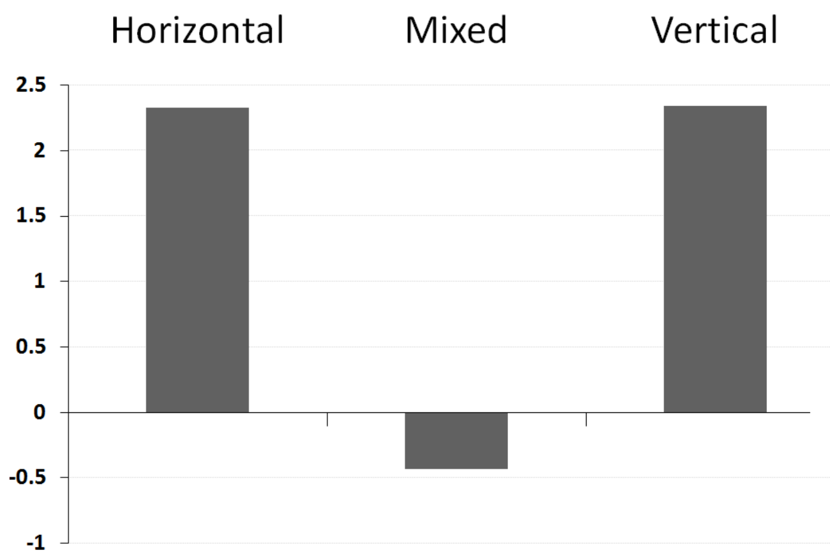
[40]It is possible for these firms to be Thai multinationals with some foreign shareholders and they are clearly not under vertical integration. Nonetheless, this is unlikely because there are only a few Thai multinationals. As a robustness check, firm size is included as a control and that does not alter the main results.

results under other definitions of vertical integration are shown in the robustness check section.

One may think that there must be a restriction on foreign ownership shares in Thailand which may explain why there are two peaks in Figure 11; one of them is around 50% and another one is at 100% foreign ownership share. Nevertheless, there are hardly any restrictions to foreign ownership in Thai manufacturing sector. Of course, foreigners are not freely allowed to operate in some manufacturing industries which are related to weapons, alcohol and tobacco like in any other countries. However, out of 125 industries, there are only 22 industries, which includes the aforementioned industries, where the maximum foreign ownership share is less than 50 percent. Moreover, 90 industries have maximum foreign ownership higher than 90 percent. This shows that the restrictions on foreign ownership are minimal. One of the robustness checks shows that dropping those 22 industries with low maximum foreign ownership share does not change the empirical results.

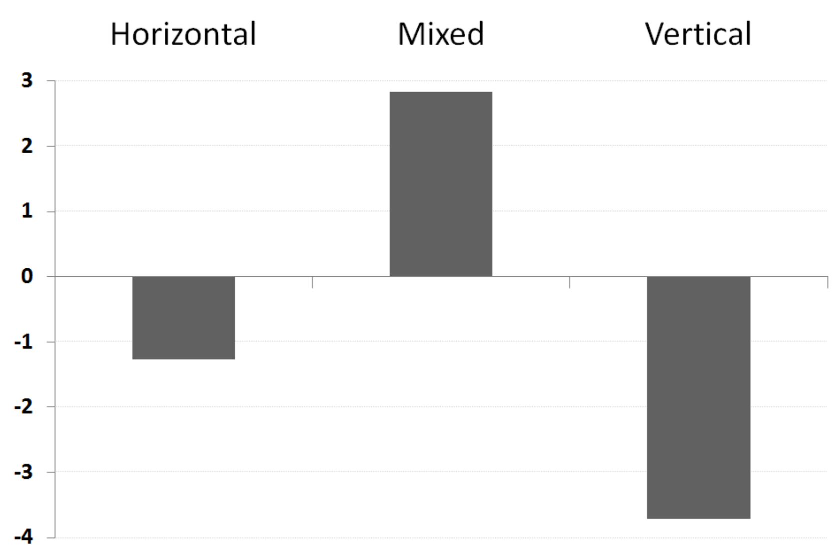
The first prediction is confirmed by the data as the empirical results suggest that the effects of capital and skill intensities on ownership share are positive and negative respectively for vertically integrated firms. The results are highly robust as they survive stricter definitions of vertical integration, division of foreign firms into four groups instead of three, controlling for firm size and dropping land costs from capital expenditure. Furthermore, they reveal that the effects of factor intensities on ownership are heterogeneous across integration types as summarised in Figures 12 and 13, which show the effects of capital and skill intensities on ownership respectively. The figures show that the effects of those factor intensities on ownership are similar for firms under vertical and horizontal integration (capital and skill intensities have positive and negative effects on ownership respectively under both integration types) while the effects are reversed under mixed integration. This emphasises that it is important to only include vertically integrated firms in the sample when testing property-rights theories which only apply to those firms.

Figure 12: Marginal Effect of Capital Intensity on Ownership Share



Note: the Y-axis measures the estimated value of the marginal effect of capital intensity on ownership share.

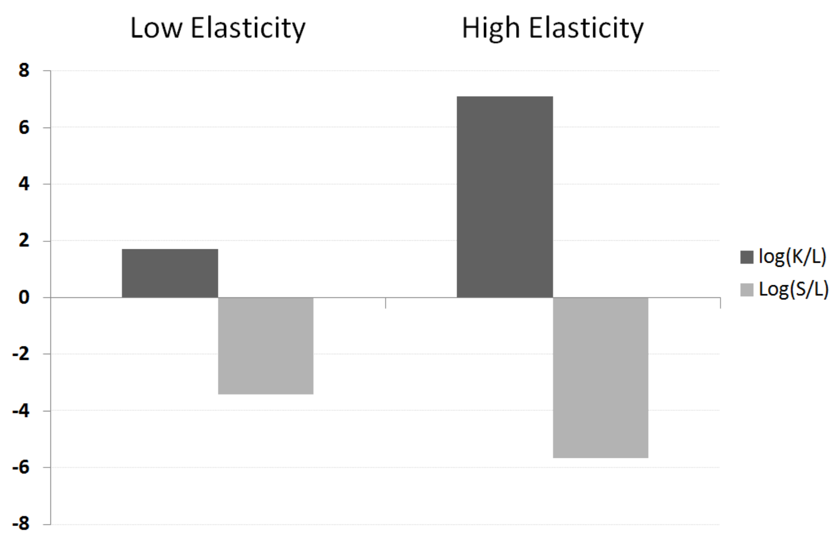
Figure 13: Marginal Effect of Skill Intensity on Ownership Share



Note: the Y-axis measures the estimated value of the marginal effect of skill intensity on ownership share.

The empirical results also support the second prediction. When foreign owned exporting firms are divided into two groups according to their elasticity of substitution across varieties, the effects of factor intensities on ownership are magnified when they face higher elasticity. The result is summarised in Figure 14. The darker columns represent the marginal effect of capital intensity on ownership. Both columns are positive but the effect is larger for firms with high elasticity. The effect of skill intensity on ownership is also magnified with higher elasticity.

Figure 14: Effects of Capital and Skill Intensity on Ownership across Low and High Elasticity Groups



Note: the Y-axis measures the estimated value of the marginal effect of capital and skill intensity on ownership share.

The remainder of the chapter is organised as follows. Section 2 describes the theoretical model and its predictions. The estimation strategy is explained in Section 3 while Section 4 is devoted to describing the data used in the chapter. Section 5 and 6 show the empirical results from the main regressions and robustness checks, respectively. Finally, Section 7 summarises this chapter and the appendix of this chapter is in Section 8.

2 The Model

The following model is an extension to the model in Antràs (2003) and Antras and Helpman (2004) with three main modifications. Firstly, the ownership choice is binary in Antràs (2003) and Antras and Helpman (2004) while it is continuous in this model, which means that the foreign multinationals can choose the optimal degree of integration. Secondly, the quasi rent share is no longer fixed and exogenous but endogenously determined in the model. This is a crucial extension if one wants to study the optimal ownership share. This is because higher ownership share should correspond to higher quasi rent share. Lastly, the fraction of inputs that the parent firm can seize when negotiation breaks down is also endogenous. When parent firms are allowed to choose different degree of integration, it is important to let the fraction of inputs that the parent firm can seize when negotiation breaks down vary with the degree of integration.

Consider a world with two countries, North and South where the North is more developed than the South. There are two factors of production: capital and labour. Let the cost of capital in both countries be the same and normalised to 1. Wages are determined outside this model but the wage in the South is assumed to be low enough to force all final good producers in the North to have their intermediate inputs produced in the South. This assumption is made to match the aim of this chapter which is to analyse the degree of integration not the location of input production. The following sub-sections explain the model and its equilibrium in detail.

2.1 Demand

The world is populated by a unit measure of consumers with identical preferences represented by

$$U = y_0 + \frac{1}{\mu}\Sigma_{j=1}^{J} Y_j^{\mu}, 0 < \mu < 1,$$

where y_0 is consumption of the homogeneous good and Y_j is aggregate consumption in sector j expressed by the following expression; $Y_j = \left[\int y_j(i)^{\alpha_j} di\right]^{1/\alpha_j}$ where $0 < \alpha_j < 1$ and α_j varies across industries. There are J non-homogeneous sectors and i indexes varieties. Assume that goods are more substitutable within the same industry which translates into $\alpha_j > \mu$. This yields the following inverse demand function

$$y_j(i) = Y_j^{-(\alpha_j-\mu)/(1-\alpha_j)} p_j(i)^{-1/(1-\alpha_j)} \tag{2.1}$$

where $y_j(i)$ represents the demand received by a final good producer producing variety i which belongs to industry j.

2.2 Production

Final good producers (F) are in the North while suppliers (S) are in the South. There are a large number of suppliers and they are ex-ante identical. This implies that all suppliers are expected to get zero profit in the equilibrium. In order to produce an output, F needs to match with a supplier in the South and choose the fraction of S that F wants to acquire. Let this fraction be denoted by $\gamma \in [0,1]$. Then S makes a side payment to F. This side payment can be negative which would mean that F makes a payment to S. The side payment is introduced to the model as a mechanism to allow suppliers' expected profit to be zero.[41] F and S contribute capital ($k_j(i)$) and labour ($l_j(i)$) respectively into the input production. The input production function has the following form.

$$x_j(i) = \left[\frac{k_j(i)}{\eta(i)}\right]^{\eta(i)} \left[\frac{l_j(i)}{1-\eta(i)}\right]^{1-\eta(i)}, 0 < \eta(i) < 1, \tag{2.2}$$

where $x_j(i)$ is the quantity of manufactured intermediate input for the production of variety i in industry j. The variety index i is also firm index as each variety is produced by one firm in the equilibrium. The parameter $\eta(i)$ measures the importance of capital investment relative to investment in labour. Here I follow Defever and Toubal (2007) and let the parameter be firm specific.

The production of final good is done by F. Only F has the technology to convert the intermediate inputs into outputs. For simplicity, it is assumed that F can transform 1 unit of intermediate input into 1 unit of output costlessly. In other words, the final good production function has the following form.

$$y_j(i) = x_j(i) \tag{2.3}$$

2.3 Incompleteness of Contracts

F's investment in capital $k_j(i)$ and S's investment in $l_j(i)$ are non-verifiable to a third party. They are also relationship-specific which means that the investments are useless outside this relationship. The parties cannot commit not to renegotiate an initial contract (if one is written) and the precise nature of the required input is revealed only ex-post and is not verifiable by a third party. As renegotiation will take place if a contract is written anyway, there is no point in signing an ex-ante contract. Hence F and S bargain over the surplus only after the investments have been made.

It is also assumed that the amount of intermediate inputs can not be verified by a third party. Otherwise, the investments are indirectly contractible through signing a contract specifying the value of intermediate inputs produced. Nevertheless, the ownership share (γ) and the side payment are contractible ex ante.[42]

The ex-post bargaining follows a generalised Nash bargaining game. F and S get the fraction γ and $(1-\gamma)$ of the ex-post gains (quasi rent) respectively. In the case of a negotiation break down, F

[41] This modeling trick is common in the literature. For an example, please see Antràs (2003). A more detailed explanation can be found in the last paragraph of Section 2.3.

[42] This follows an assumption in Grossman and Hart (1986).

can seize the fraction δ of $x_j(i)$ and S is left with $(1-\delta)x_j(i)$. The remaining intermediate inputs has no value to S because it does not have the technology to convert them into output. In other words, suppliers have zero outside option. On the other hand, F can turn the seized inputs into outputs and this gives rise to F's outside option of $\delta^{\alpha_j}R_j(i)$. The whole production process is summarised in the next subsection.

The assumption of suppliers' zero outside option is a modeling trick which allows authors to avoid introducing complicated matching process into the model. This assumption is common in the property rights literature which includes, for instance, Antràs (2003) and Antras and Helpman (2004). Nonetheless, the assumption is dropped in the papers where the effect of some elements of the matching process on ownership is the focal point of the studies (i.e. McLaren (2000) and Grossman and Helpman (2002)). In these papers, the suppliers investments can also be used by other final good producers (getting a new match) which give some outside options to the suppliers when negotiation breaks down. This issue is outside the scope of this chapter and I follow the literature by assuming that suppliers have zero outside option. The case where suppliers face positive outside option is a potential area for further work.

2.4 Production Timeline

This section provides a summary of all production stages starting from the matching between final good producers and suppliers until the division of surplus from selling final products. The graphical illustration of the timeline is shown in Figure 15.

1. A final good producer (F) in the North matches with a supplier (S) in the South where there are many ex ante identical suppliers.

2. F chooses γ which is the fraction of S that F wants to acquire and S observes it.

3. Side payment from S to F. This side payment can be negative (F pays S).

4. F and S invest in capital (k) and labour (l) respectively into the input production.

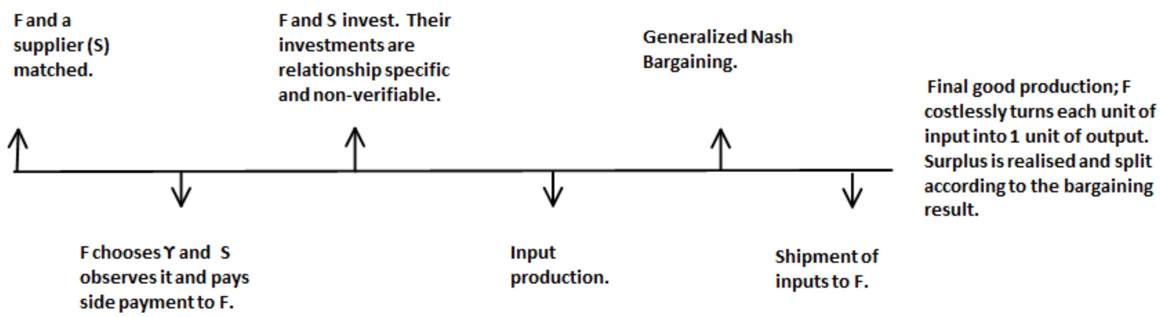
5. Input $x_j(i)$ is produced.

6. Nash bargaining over the produced inputs.

7. F turns the inputs into outputs costlessly, $y_j(i) = x_j(i)$.

8. Surplus $R_j(i)$ is realised and split according to the bargaining result.

Figure 15: Production Timeline



2.5 Subgame Perfect Equilibrium

The equilibrium values can be calculated from backward induction. The surplus or revenue from output sale has the following form.

$$\begin{aligned} R_j(i) &= p_j(i)y_j(i) \\ &= Y_j^{\mu-\alpha_j} x_j(i)^{\alpha_j} \\ R_j(i) &= Y_j^{\mu-\alpha_j}\left[\frac{k_j(i)}{\eta(i)}\right]^{\alpha_j\eta(i)}\left[\frac{l_j(i)}{1-\eta(i)}\right]^{\alpha_j[1-\eta(i)]} \end{aligned} \tag{2.4}$$

If negotiation breaks down, F seizes the fraction δ of $x_j(i)$. This generates a surplus of $\delta^{\alpha_j}R_j(i)$. Hence, F earns its outside option plus a fraction γ of the quasi rents. As a result, F earns

$$\delta^{\alpha_j}R_j(i) + \gamma(1-\delta^{\alpha_j})R_j(i) \tag{2.5}$$

while S receives

$$(1-\gamma)(1-\delta^{\alpha_j})R_j(i). \tag{2.6}$$

As $k_j(i)$ and $l_j(i)$ are non-contractible ex-ante, F and S invest non-cooperatively. As mentioned at the beginning of the model, the cost of capital in both countries is assumed to be the same and normalised to 1. Capital is assumed to be mobile across countries so its rental rate should be the same across countries. F's investment decision becomes

$$\max_{k_j(i)} \delta^{\alpha_j} R_j(i) + \gamma(1-\delta^{\alpha_j}) R_j(i) - k_j(i)$$
$$= \max_{k_j(i)} \phi Y_j^{\mu-\alpha_j} \left[\frac{l_j(i)}{1-\eta(i)}\right]^{\alpha_j[1-\eta(i)]} \left[\frac{1}{\eta(i)}\right]^{\alpha_j \eta(i)} k_j(i)^{\alpha_j \eta(i)} - k_j(i)$$

where $\phi = [\delta^{\alpha_j} + \gamma(1-\delta^{\alpha_j})]$. The first order condition yields

$$k_j(i) = \phi Y_j^{\mu-\alpha_j} \left[\frac{l_j(i)}{1-\eta(i)}\right]^{\alpha_j[1-\eta(i)]} \left[\frac{k_j(i)}{\eta(i)}\right]^{\alpha_j \eta(i)} \alpha_j \eta(i) \tag{2.7}$$

$$k_j(i) = \alpha_j \eta(i) \phi R_j(i). \tag{2.8}$$

This first order condition implies that the marginal cost of capital investment must be optimally equal to its marginal return. It is clear that F wants to invest more if its investment is more important to the production of the input (i.e. higher $\eta(i)$). S also chooses the level of labour investment to maximise its profit. S's optimisation problem has the following form.

$$\max_{l_j(i)} (1-\gamma)(1-\delta^{\alpha_j}) R_j(i) - l_j(i)$$

The optimal level of labour investment becomes

$$l_j(i) = \alpha_j [1-\eta(i)] (1-\phi) Y_j^{\mu-\alpha_j} \left[\frac{k_j(i)}{\eta(i)}\right]^{\alpha_j \eta(i)} \left[\frac{l_j(i)}{1-\eta(i)}\right]^{\alpha_j[1-\eta(i)]} \tag{2.9}$$

$$l_j(i) = \alpha_j [1-\eta(i)] (1-\phi) R_j(i). \tag{2.10}$$

Similar to the previous first order condition, this first order condition implies that the marginal cost of labour investment must be optimally equal to its marginal return. It is clear that S wants to invest more if its investment is more important to the production of the input (i.e. lower $\eta(i)$). Combine Equation (2.8) and (2.10) and we get the relationship between the optimal levels of investment in capital and labour

$$k_j(i) = \frac{\eta(i)}{[1-\eta(i)]} \frac{\phi}{[1-\phi]} l_j(i). \tag{2.11}$$

The capital-labour ratio is increasing in $\eta(i)$ and ϕ. Clearly, F would like to invest more if its share of the revenue (ϕ) is higher or its investment is more important in the production of inputs relative to labour (higher $\eta(i)$).[43] The optimal level of capital and labour as functions of parameters $\eta(i)$ and ϕ can be obtained from substituting Equation (2.11) into Equation (2.7) and (2.9) respectively. Their expressions are shown below.

$$k_j(i) = \phi^{\frac{1}{1-\alpha_j}} \left[\frac{1-\phi}{\phi}\right]^{\frac{\alpha_j - \alpha_j \eta(i)}{1-\alpha_j}} Y_j^{\frac{\mu-\alpha_j}{1-\alpha_j}} \alpha_j^{\frac{1}{1-\alpha_j}} \eta(i) \tag{2.12}$$

$$l_j(i) = (1-\phi)^{\frac{1}{1-\alpha_j}} \left[\frac{\phi}{(1-\phi)}\right]^{\frac{\alpha_j \eta(i)}{1-\alpha_j}} Y_j^{\frac{\mu-\alpha_j}{1-\alpha_j}} \alpha_j^{\frac{1}{1-\alpha_j}} [1-\eta(i)] \tag{2.13}$$

The equilibrium price can be calculated from the demand function (Equation (2.1)), input production function (Equation (2.2)) and the optimal values of capital and labour investment derived above. This yields the following function for the equilibrium price.

$$p_j(i) = \left\{\alpha_j \left[\phi^{\eta(i)} [1-\phi]^{1-\eta(i)}\right]\right\}^{-1} \tag{2.14}$$

The equilibrium side payment T must be just enough to make S's participation constraint bind. In other words, the side payment should have the value that drives S's profit to zero. The equilibrium side payment is

$$T = (1-\phi) R_j(i) - l_j(i). \tag{2.15}$$

Finally, the last step of the backward induction is to find the optimal γ. F chooses γ to maximise its profits inclusive of the side payment. Its profit maximisation problem becomes

$$\max_{\gamma} R_j(i) - k_j(i) - l_j(i).$$

This problem can be solved by inputting the values of capital and labour from Equation (2.8) and

[43] With higher $\eta(i)$, F finds that a small increase in its investment can boost the size of the total revenue a lot and this makes a rise in capital investment more worthwhile.

(2.10) respectively. This optimisation problem becomes

$$\max_{\gamma} \left\{1-\alpha_j\left\{\eta\left(i\right)\phi+\left[1-\eta\left(i\right)\right]\left[1-\phi\right]\right\}\right\} Y_j^{\frac{\mu-\alpha_j}{1-\alpha_j}} \left[\alpha_j\phi^{\eta(i)}\left[1-\phi\right]^{1-\eta(i)}\right]^{\frac{\alpha_j}{1-\alpha_j}}.$$

where $\phi = [\delta^{\alpha_j} + \gamma(1-\delta^{\alpha_j})]$. As mentioned at the beginning of the model, when parent firms are allowed to choose different degree of integration, it is important to let the fraction of inputs that the parent firm can seize when negotiation breaks down (δ) to vary with the degree of integration (γ). The fraction δ is assumed to have the same value as γ. This assumption brings the model closer to reality. For example, a shareholder with half of the total number of equity shares of a firm is entitled to own half of all the firm's assets including all intermediate inputs. In other words, if $\gamma = 0.5$, the final good producer must also be able to recoup half of all the assets which include the inputs produced. Given the assumption, ϕ becomes $\gamma^{\alpha_j} + \gamma(1-\gamma^{\alpha_j})$. Some derivation yields the following expression which pins down the equilibrium γ as a function of $\eta\left(i\right)$ and α_j.

$$\gamma^{\alpha_j} + \gamma(1-\gamma^{\alpha_j}) = \frac{\eta\left(i\right)\left[\alpha_j\eta\left(i\right)+1-\alpha_j\right] - \sqrt{\eta\left(i\right)\left[1-\eta\left(i\right)\right]\left[1-\alpha_j\eta\left(i\right)\right]\left[\alpha_j\eta\left(i\right)+1-\alpha_j\right]}}{2\eta\left(i\right)-1} \quad (2.16)$$

The first result from this expression is that the optimal degree of integration (γ) is increasing with F's relative importance of its investment $(\eta\left(i\right))$. The right-hand-side is similar to the one in Antras and Helpman (2004) and they are both increasing with $\eta\left(i\right)$. The left-hand-side is increasing with γ because γ is a fraction with value less than one.[44] Hence higher $\eta\left(i\right)$ leads to larger optimal degree of integration γ as depicted by the lower simulation lines in Figure 16 where γ and $\eta\left(i\right)$ are on the vertical and horizontal axis respectively. The first graph on the left has $\alpha = 0.25$ which translates into low elasticity while the value of α in the second and third graphs are 0.5 and 0.75 respectively. The simulations also show that the positive relationship takes place regardless of the value of α_j. The intuition for this result is simple. Final good producers optimally choose higher degree of integration when the importance of its investment relative to the supplier's investment is higher taking into account the hold-up problem (S's underinvestment is worse when it receives a lower share of the surplus).

Another novel prediction from Equation (2.16) is that the magnitude of the impact of $\eta\left(i\right)$ on γ is crucially dependent on the elasticity of substitution across varieties in that industry. This is not the case

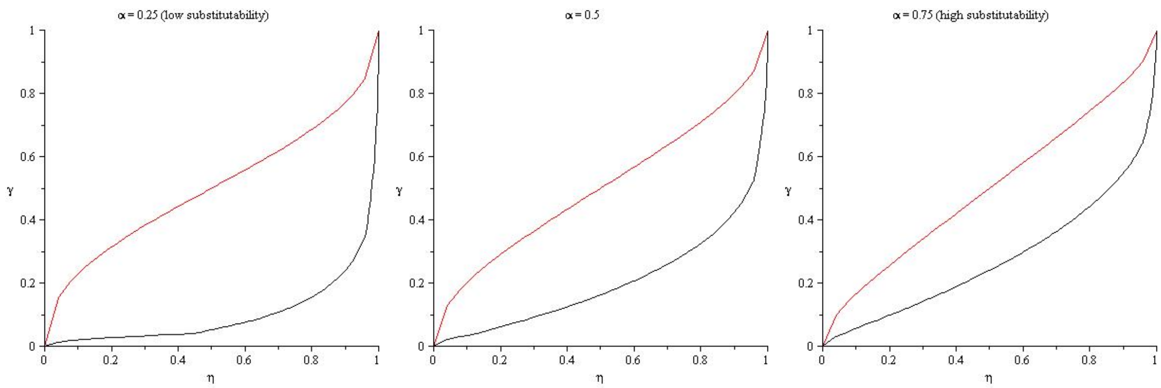
[44] $\frac{d\left(\gamma^{\alpha_j}+\gamma\left(1-\gamma^{\alpha_j}\right)\right)}{d\gamma} = (\alpha_j\gamma^{\alpha_j-1} - \alpha_j\gamma^{\alpha_j}) + (1-\gamma)$ and both terms are positive as long as $0 < \gamma < 1$

under the settings in Antràs (2003) and Antras and Helpman (2004) where the Nash bargaining share and the fraction of inputs that can be seized are exogenous. The differences are shown in Figure 16. The three graphs have different values of α_j and α_j is increasing from the left graph to the right graph. The elasticity of substitution across varieties is increasing with α_j,[45] so the elasticity of substitution is also increasing from left to right. Each graph contains two simulation lines. The simulation lines, which are based on Antràs (2003) and Antras and Helpman (2004), are always higher than the lines from this model. This is because an increase in γ under the setting in those papers only increases the outside option while it also raises the Nash bargaining share in this model. Hence parent firms do not have to raise γ as much when $\eta(i)$ is high and this explains why the simulation lines based on this model are lower.

Furthermore, it is clear from the graphs that under the settings in Antràs (2003) and Antras and Helpman (2004), the elasticity of substitution hardly affects the optimal ownership lines. On the contrary, it affects the optimal ownership lines under this model significantly. When the elasticity is low (left graph), an increase in $\eta(i)$ hardly changes γ while γ rises faster with a change in $\eta(i)$ in the graph on the right. In other words, the impact of $\eta(i)$ on γ is higher when the elasticity of substitution is high. When α_j is low, varieties are less substitutable. Constant Elasticity of Substitution (CES) demand and the monopolistic nature of this model dictate that optimal price will be higher while quantity will be lower. If negotiation breaks down, seizing a small amount of inputs will yield a large revenue due to the high output price. This means that the outside option is quite high even when γ is low anyway. So optimal γ increases slowly with η under low α_j. The opposite is true under high elasticity of substitution.

[45] The elasticity of substitution is equal to $\frac{1}{1-\alpha_j}$.

Figure 16: Predictions Across Low to High Substitutability



Note: The y-axis measures the optimal ownership share (γ) while the x-axis shows how important F's investment is relative to S's (η). The elasticity of substitution of the final good (α) is increasing from the left graph to the right ones.

3 Estimation Strategy

The model yields two testable predictions for firms under vertical integration. The setup of the property-rights model explained in the previous section is such that the production of the input is done in the South by the supplier while the final goods are produced in the North. Hence, the predictions from the model only apply to vertically integrated firms. Antràs (2003) and Antras and Helpman (2004) have a similar setup and their predictions are only applied to firms under vertical integration as well. The first testable prediction is that the optimal degree of integration is increasing with the importance of final good producer's investment relative to supplier's investment. Another testable prediction is that the impact of the importance of final good producer's investment on the optimal degree of integration is increasing with the elasticity of substitution. This section explains how these predictions can be tested on vertically integrated firms.

3.1 Estimation Strategy to Test the First Prediction

The first testable prediction is that final good producers should optimally choose a higher degree of integration when the importance of its investment relative to supplier's investment is higher under vertical integration. The theoretical result is similar to the ones in Antràs (2003) and Antras and Helpman (2004) but their ownership is binary. Moreover, the Nash bargaining share and the fraction of inputs that can be seized are fixed and exogenous in those papers. Because the result is only applicable to vertically integrated firms, the definition of different types of integration and the method to identify them will be explained in the following paragraphs. Discussions about other types of integration are not required when Antras' model is tested with trade data because the authors assume that all intra-firm trade transactions are done under vertical integration which is not always true.

By definition, a foreign affiliate is horizontally integrated when it duplicates its parent's production with the main purpose of serving the host economy alone in order to avoid relevant trade costs. Nonetheless, in this chapter, a foreign affiliate has horizontal relationship with its parent if its production is mainly for consumption in the host country alone. This is because I do not observe the information about parent company production. It would be more precise if that information is available but a dataset with such information, ownership shares and domestic sales is not available anywhere. The best available data that can pin down whether an affiliate is horizontally or vertically integration with its parent is the highly confidential U.S. multinationals data from the Bureau of Economic Analysis (BEA) used by Ramondo, Rappoport, and Ruhl (2011). Their paper has the best dataset to study U.S. multinationals, [46] but even that dataset is not appropriate to use here as it has no information about ownership shares which is the core of this chapter and their samples only include U.S. affiliates with ownership more than 50% .

There are some supporting pieces of evidence that the definition of horizontal integration in this chapter is not far from the strictest definition. Firstly, Ramondo, Rappoport, and Ruhl (2011) also interpret the high level of affiliate's sale to parties in the host country as an evidence of horizontal integration. Secondly, one may think that an affiliate with large domestic sales might be selling to another affiliate in the same host country and this should be interpreted as vertical instead of horizontal integration. In contrast to that belief, Atalay, Hortacsu, and Syverson (2012) and Ramondo, Rappoport, and Ruhl (2011) both found that the domestic flows between establishments owned by the same corporation are very rare and small. Hence most of the affiliate's local sales are mainly to unrelated parties in the host countries.

A parent firm is vertically integrated with its supplier if the production done at the supplier's plant is a part of a production chain. Therefore, strictly speaking, a foreign affiliate in the South is under vertical integration if it produces inputs and exports them to the foreign headquarter for final good production. With the data that I have, it is not possible to check whether the foreign affiliate's

[46] The dataset has information about parent's and affiliate's sales to both related and unrelated parties. Hence, parent's product codes can be compared to affiliate's one. With the available information on affiliate's local sales, it is straight forward to pinpoint which firms have horizontal relationship with their parents.

products are used as inputs for the final production or not. Hence, a less strict description of vertical integration is used here. If a foreign affiliate exports a lot of its products to a foreign country, it is more likely to be under vertical integration. Nonetheless, a stricter definition of vertical integration will be used in the robustness check section. With the stricter definition, a foreign affiliate is vertically integrated if it exports a lot and export to the country where its parent company locates.

In the main regression, foreign owned firms will be divided into three groups; vertical, horizontal and mixed integration. Firms under mixed integration are foreign affiliates and they export enough to the point where their aim is to serve both local and foreign markets. Clearly these firms should neither be classified as vertically nor horizontally integrated. The division of foreign firms into three groups has two advantages. Firstly, the thresholds happen to yield a pure horizontally integrated group as all of the firms in this group do not export. Therefore, this group can be treated as pure horizontal integration because their production is purely for domestic consumption. Another advantage of having three groups is the ease of interpretation. If there are more than three groups, it is hard to classify the groups in the middle. If there are just two groups, the firms around the threshold are very similar while they are divided into different groups making the distinction between two groups unclear. When there are three groups, the distinction between horizontal and vertical integration is stark and the classification of the group in the middle (mixed integration) is more definite. Nonetheless, the case where those firms are divided into four groups is also analysed in this chapter as a robustness check.

In order to test the first prediction, I follow Antràs (2003) and assume that capital intensity is a good proxy for the importance of parent company's investment. Antras uses Figure 17 to show that the decision on capital investment is done mainly by the parent company. Hence, capital intensity should be a good proxy for the importance of parent company's contribution. As the importance of parent company's investment is always relative to supplier's, I propose skill intensity as a proxy for the importance of supplier's investment. There are two pieces of evidence to support this. Firstly, the shares of British affiliates in which parent firms have strong influence on the recruitment of executives and senior managers are very low as shown in Figure 17. This means that affiliates are the ones who make decision about hiring skilled workers. Another piece of evidence is from the same article that Antras took the table from. Young, Hood, and Hamill (1985) asked the same set of affiliates about who makes decisions on training and 90 percent reported that the decision is made by affiliates not the parent company. It is quite clear that one important contribution from affiliates is recruiting and training skilled workers. Hence, skill intensity should be a good proxy for the importance of supplier's investment.

Figure 17: Decision-making in U.S. Based Multinationals

% of British affiliates in which parent influence on decision is strong or decisive			
Financial decisions		Employment/personnel decisions	
Setting of financial targets	51	Union recognition	4
Preparation of yearly budget	20	Collective bargaining	1
Acquisition of funds for working capital	44	Wage increases	8
Choice of capital investment projects	33	Numbers employed	13
Financing of investment projects	46	Lay-offs/redundancies	10
Target rate of return on investment	68	Hiring of workers	10
Sale of fixed assets	30	Recruitment of executives	16
Dividend policy	82	Recruitment of senior managers	13
Royalty payments to parent company	82		

Source: Dunning (1993, p. 227). Originally from Young, Hood and Hamill (1985).

The first testable prediction suggests that the degree of integration or ownership share ($fshare$) should be positively correlated with capital intensity $[log(K/L)]$ while it has negative relationship with skill intensity $[log(S/L)]$ under vertical integration. In order to test the prediction, integration types dummies (Hor, Mix and Ver) are created as explained in Table 19. The main regression equation is

$$\begin{aligned} fshare_{ijc} =& \beta_0 + \beta_1 log(K/L)_i + \beta_2 log(S/L)_i + \beta_3 Mix_i + \beta_4 Ver_i \\ &+ \beta_5 Mix_i * log(K/L)_i + \beta_6 Mix_i * log(S/L)_i \\ &+ \beta_7 Ver_i * log(K/L)_i + \beta_8 Ver_i * log(S/L)_i \\ &+ parentcountryFE_c + industryFE_j + firmcontrols_i + \varepsilon_{ijc} \end{aligned} \tag{3.1}$$

where i, j and c are firm, industry and parent country index respectively. Under this regression, the model predicts that the effects of $log(K/L)$ and $log(S/L)$ on $fshare$ are positive and negative respectively under vertical integration which implies that $(\beta_1 + \beta_7)$ should be positive while $(\beta_2 + \beta_8)$ should be negative. Similarly, $(\beta_1 + \beta_5)$ and $(\beta_2 + \beta_6)$ captures the effect of $log(K/L)$ and $log(S/L)$ on $fshare$ respectively under mixed integration. The dummy for horizontal integration (Hor) is not included in the main regression in order to prevent perfect colinearity. Hence, β_1 and β_2 captures the effect of $log(K/L)$ and $log(S/L)$ on $fshare$ under horizontal integration. The model neither makes a prediction about the estimates under mixed nor horizontal integration but they will be documented and compared against the results under vertical integration in this chapter. If the results vary across integration types then it is crucial to take the integration type of each observation (i.e. each intra-firm trade pair) into account.

Table 19: Firm-level Variable Description

Variable	Description
$fshare_{ijc}$	Foreign ownership share
Hor_i	Dummy for Horizontal integration
Mix_i	Dummy for Mixed integration
Ver_i	Dummy for Vertical integration
$backtohq_{ic}$	This dummy is 1 when the firm exports to the parent country
	Export share
$highelasticity_j$	This dummy is 1 when the elasticity of substitution is high.

Parent country fixed effects are necessarily included in the regression. Desai, Foley, and Hines (2004) report that there are some policies in the U.S. which encourage U.S. parent firms to acquire more shares of their affiliates. Moreover, it is possible that investors from different cultures have different preferences on optimal ownership shares. The parent country fixed effects will capture these effects.

Other controls include industry fixed effects and firm-level controls. Any industry-level factors that can affect ownership shares (i.e. some industries are associated with high possibility of greenfield investments which normally come with full ownership) are taken care of by the industry fixed effects. The main firm-level controls are R&D intensity and firm size. Existing papers in the literature normally include R&D intensity as a control because parent firms might also contribute some technology for R&D at the affiliates and this can affect the optimal ownership share. I also control for the possibility that ownership decision can be affected by the size of the affiliate as firm size is usually associated with higher scale economies or the likelihood of being a stock exchange listed company. This chapter follows the existing literature and uses log(sale) and total employment as proxies for firm size.

3.2 Estimation Strategy to Test the Second Prediction

Another testable prediction from the model is that the impact of the importance of the parent's investment on optimal ownership share is higher when the elasticity of substitution is high under vertical integration. In contrast to the previous section, the sample will be restricted to firms under vertical integration only in this section. Then firms are divided into two groups (low and high elasticity) in the main specification. A dummy "highelasticity" is created and it is 1 when relevant elasticity of substitution falls in to high elasticity group.[47] The main regression becomes

$$\begin{aligned} fshare_{ijc} =& \beta_0 + \beta_1 log(K/L)_i + \beta_2 log(S/L)_i + \beta_3 highelasticity_j \\ & + \beta_4 highelasticity_j * log(K/L)_i + \beta_5 highelasticity_j * log(S/L)_i \\ & + parentcountryFE_c + firmcontrols_i + \varepsilon_{ijc}. \end{aligned} \tag{3.2}$$

The model predicts that the effects of $log(K/L)$ and $log(S/L)$ on $fshare$ are larger when firms are in high elasticity group. In other words, β_4 and β_5 are predicted to be positive and negative respectively. The explanations for the inclusion of parent country fixed effects and firm-level controls are the same as explained earlier. Nonetheless, industry fixed effects are not included here as elasticity of substitution only varies across industries.

4 Data

This section discusses the Thai manufacturing census, foreign ownership shares, characteristics of firms under different integration types and the data on elasticity of substitution.

4.1 Data Overview

Data used in this study comes from the 2007 industrial census, compiled by the National Statistics Office (NSO) of Thailand every 10 years. The establishments under the scope of this census were those engaged primarily in manufacturing industry (category D International Standard Industrial Classification of All Economic Activities; ISIC: Revision 3). The 2007 industrial census covered all establishments with 10 employees or more in all regions throughout the nation.

The census used a Stratified Systematic Sampling methodology. Regions and provinces or cities were constituted strata while type of industrial activities and groups of industrial establishment were constituted sub-stratum. The sampling units were establishments. An interview method was employed in the data collection (the National Statistical Office of Thailand, 2010).

The variables available in the dataset are categorised into six parts: (i) general information on establishments, (ii) persons engaged and remuneration, (iii) cost of production and expenditure of establishments, (iv) production and receipts of establishments, (v) fixed assets of establishments, and

[47] The case where firms are divided into 3 groups according to their elasticity is also tested as a robustness check.

(vi) research and development and laboratory spending and activities.

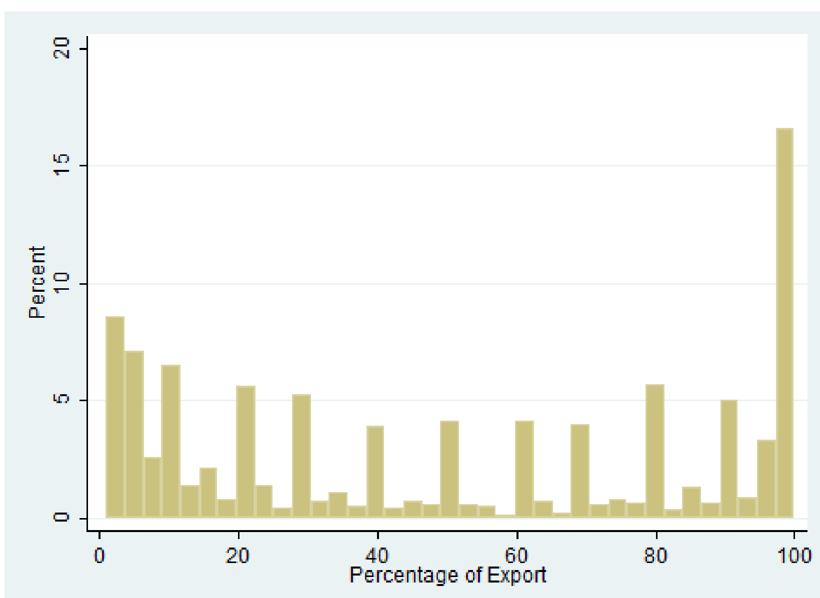
The total number of enterprises surveyed is 73,931. NSO provides weight for each firm and the weights are used in all regressions. Out of 73,931 firms, 6,825 firms (9.23%) export. There are 2,753 foreign-owned enterprises which is around 3.7% of the total number of firms surveyed. Approximately, 2.5% of all firms are both exporting and foreign-owned.

Each establishment is assigned with a four-digit industry code. The industry codes used in the data are ISIC revision 3 and there are 125 industries at the 4-digit level. All firms reported detailed descriptions of their main products and then NSO officials assigned the most appropriate industry code to each firm.

4.2 Firm-level Trade

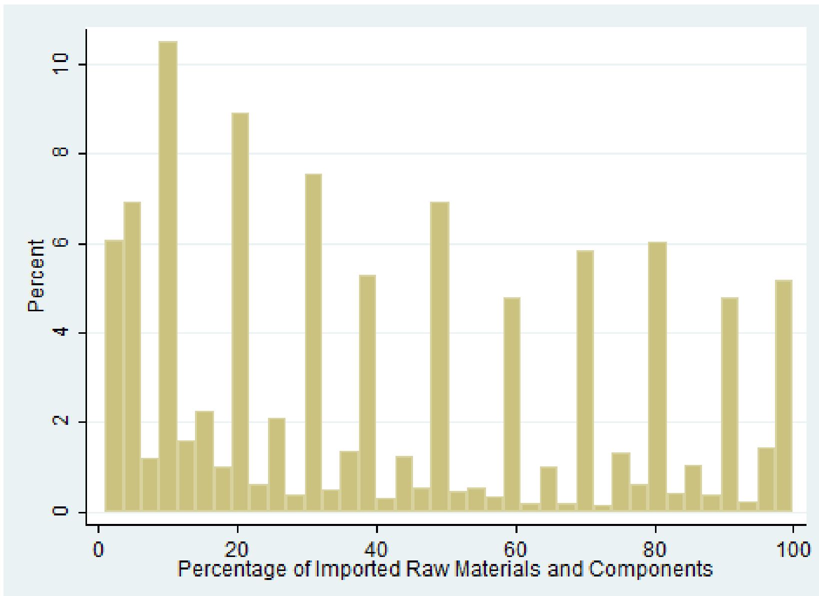
Each firm is obliged to report its export share which is the annual value of exports divided by the total value of sale. The dataset also provides the sale revenue and this allows me to calculate the value of firm-level exports. All exporting firms must also declare their top exporting destination country. Figure 18 shows the distribution of exporting firms' export share. Around 17% of all exporting firms export all of their production while the rest of the distribution is close to uniform distribution with a spike at the lower end of the distribution.

Figure 18: Distribution of Exporting Firms' Export Share



The dataset also includes the import share which is the value of imported inputs divided by the total expenditure on inputs. Therefore the value of imported inputs is calculated from the product of import share and the total input expenditure. The sourcing countries of the imports are not reported. Out of 73,931 firms, 6,624 firms (9%) import some inputs. Figure 19 shows the distribution of importing firms' import share. The distribution is quite uniform with a peak near the lower end of the distribution.

Figure 19: Distribution of Importing Firms' Import Share



4.3 Capital, Skill and R&D Intensity

Capital input (K) is measured as the average of the beginning and the end of year total asset values. Another definition of capital input is the value of total assets less cost of land, which I use as a robustness check. labour input (L) is the total number of workers in the enterprise, including owner, unpaid workers and production workers. R&D input is the sum of all expenditures related to R&D. Following the trade literature, the number of skilled workers (S) is proxied by the number of non-production workers.

Following the intra-firm trade literature, capital intensity is defined to be the ratio between capital input and labour input (K/L). Similarly, skill intensity and R&D intensity are S/L and RD/L respectively. Table 29 in the appendix shows the correlation matrix of these factor intensities and export dummy.

4.4 Foreign Ownership Share and Characteristics of the Foreign Investors

The unique feature of this dataset is that firm-level foreign equity shares are reported along with the nationalities of the top three foreign investors. The distribution of foreign ownership shares among foreign owned firms is shown in Figure 11. There are clearly two peaks: one in the middle and another one at the far end of the distribution. With a closer look, the middle peak is exactly at 49% foreign ownership share which is nearly three times larger than the frequency at 50%. At the far end of the distribution, around 31% of the foreign owned firms are fully owned by foreign investors. Other levels of ownership share have significantly lower frequency than these two peaks but they are also significantly higher than zero.

The main benefit of using the Thai manufacturing census is that the investors' nationalities are reported. Investors' nationalities have to be taken into account when foreign ownership share is analysed because many countries use the tax system which rewards firms who choose the government's preferred level of foreign equity. For instance, Desai, Foley, and Hines (2004) mention that U.S. multinationals face lower tax if they own their foreign affiliates by more than 50%. Also, different cultures may have different preferences on the optimal level of ownership share. As I can control for the foreign investors' nationalities, my analysis is free from these caveats.

Another advantage of the Thai data is that there are hardly any restrictions to foreign ownership in Thai manufacturing sector. Of course, foreigners are not freely allowed to operate in some manufacturing industries which are related to weapons, alcohol and tobacco like in any other countries. Nonetheless, out of 125 industries, there are only 22 industries where the maximum foreign ownership share is less than 50 percent. Moreover, 90 industries have maximum foreign ownership higher than 90 percent. This shows that the restrictions on foreign ownership are minimal. One of the robustness checks shows that dropping those 22 industries with low maximum foreign ownership share does not change the empirical results.

The characteristics of the top twenty investor countries, in terms of number of affiliates, are shown in Table 20. Additional characteristics of affiliates belonging to these countries can be found in Table 30 in the appendix. The country characteristics are taken from Hall and Jones (1999) and Penn World Table version 7.0 [Heston, Summers, and Aten (2011)].

Table 20: The Characteristics of the Top Twenty Investor Countries

Country	# of affiliates	Avg fshare	Avg # of workers	Relative log GDP/Pop	Relative log Human cap/Pop	Relative log Capital/Pop	Avg % export	distance (km)
Australia	28	56.11	201.21	1.20	1.69	1.28	40.9	7489
Belgium	13	68.85	256.92	1.20	1.58	1.26	59.7	9262
China	202	36.90	197.13	0.89	1.14	0.93	20.9	3301
France	53	53.08	157.79	1.19	1.23	1.27	38.5	9455
Germany	53	48.00	228.75	1.19	1.51	1.28	38.7	9074
Hong Kong	52	52.96	783.12	1.16	1.38	1.15	54.6	1725
India	32	43.56	239.28	0.93	0.63	0.92	47.6	2925
Italy	22	50.55	93.45	1.19	1.19	1.27	22.6	8840
Japan	1206	66.66	425.33	1.15	1.51	1.24	35.5	4613
Malaysia	112	59.64	151.03	1.06	1.04	1.13	27.8	1185
Myanmar	27	44.70	7.63	0.80	0.42	0.79	3.0	576
Netherlands	40	73.83	380.63	1.19	1.52	1.26	44.4	9184
South Korea	125	74.72	200.73	1.10	1.43	1.13	25.5	3727
Singapore	297	74.76	210.66	1.16	0.92	1.23	25.1	1436
Sweden	13	44.54	222.85	1.19	1.61	1.26	65.7	8278
Switzerland	51	67.29	468.61	1.20	1.57	1.30	63.1	9132
Taiwan	457	53.83	159.60	1.12	1.30	1.14	28.4	2531
UK	44	64.07	503.93	1.18	1.53	1.21	53.2	9542
USA	164	62.55	368.28	1.22	1.86	1.28	50.2	14169

4.5 Integration Types

Foreign-owned establishments can be divided into groups by their purpose of integration. If a foreign affiliate sells most of its output in Thailand, it is more likely to be under horizontal integration.[48] On the other hand, if it exports a lot, it is likely to be a part of a global production chain[49]and, hence, vertically integrated. In the main specification, foreign owned firms are divided into three quantiles by their export shares. In other words, all the foreign owned firms with export share below the thirty-third percentile are under horizontal integration (Hor) while firms with export share above the sixty-sixth percentile are under vertical integration (Ver). The firms with export share between the two thresholds are classified as "mixed integration" (Mix). The thirty-third and sixty-sixth percentiles of export share turn out to be 0 and 60 respectively. This division into 3 groups are shown in Figure 20. The reasons for dividing foreign firms into three groups are explained in the estimation strategy. Summary statistics for the three groups are displayed in Table 21.

[48] Atalay, Hortacsu, and Syverson (2012) and Ramondo, Rappoport, and Ruhl (2011) both found that the domestic flows between establishments owned by the same corporation are very rare and small. Hence most of the affiliate's local sales are mainly to unrelated parties in the host countries.

[49] It is possible for these firms to be Thai multinationals with some foreign shareholders and they are clearly not under vertical integration. Nonetheless, this is unlikely because there are only a few Thai multinationals. Moreover, firm size is included as a control and this should partly take into account of the existence of these few multinationals which are huge in size.

Figure 20: Division of Foreign Owned Firms into Three Quantiles by Their Export Share

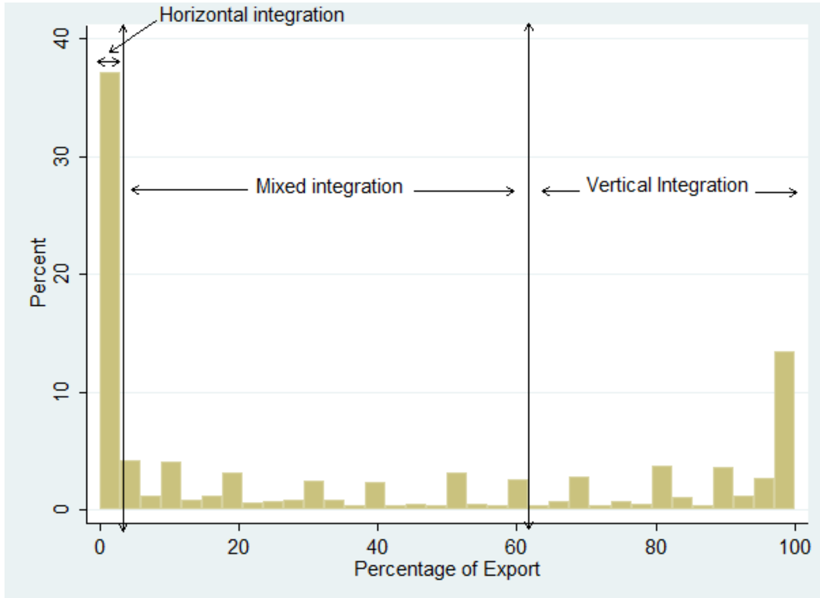


Table 21: The Characteristics of Firms in the Three Integration Groups

Group	# of affiliates	Avg fshare	Avg K/L	Avg S/L	Avg RD/L	Avg # of workers
Horizontal	910	52.51	1038828	0.24	4780491	180.35
Mixed	954	62.36	1704384	0.22	6758509	317.97
Vertical	882	70.10	1709997	0.16	6813344	566.47

Group	Avg % export	backtohq	Avg log GDP/Pop of parent countries	Avg distance of parent countries
Horizontal	0	n/a	9.63	4447
Mixed	24	0.42	9.81	4873
Vertical	90	0.54	9.82	5309

4.6 Elasticity of Substitution

The estimates of elasticity of substitution are taken from Broda, Greenfield, and Weinstein (2006). The authors used 6-digit HS import data (1992 classification system) from the COMTRADE database from 1994 - 2003 to estimate import demand elasticities for 73 countries in the world. The estimation strategy section describes that the required demand elasticities should be taken from the final market. Therefore import demand elasticities of the countries that import Thai products available in their paper exactly meet the requirement. The data provides an estimate for each HS3 code-country pair. As the industry code used in the Thai database is ISIC revision 3, I use a concordance table from United Nations Statistics Division website to assign the elasticities to each ISIC-country pair.

Ideally, there should be such elasticity estimates for all Thai trading partners, however the estimates are not available for many industry - country pairs. This drops more than half of all observations. Therefore, the average of the elasticities weighted by export shares to different destinations is used instead. In other words, for each ISIC code, I calculate the average of the elasticities across all the countries available in the data weighted by the share of Thai exports to those destinations. Nonetheless, the case where industry-country pair elasticities are used is also analysed as a robustness check even though the sample size is much smaller.

5 Empirical Results

5.1 Empirical Results on the First Prediction

Before discussing the main results, columns (1) and (2) in Table 22 give two interesting messages. Column (1) shows the result from regressing the foreign owned dummy on three factor intensities. The regression in column (2) is similar except that the dependent variable is now foreign ownership share which is continuous. Similar to the empirical results in existing papers where ownership is binary, the estimates in (1) are significant and the coefficients of capital and R&D intensity are positive. This shows that the same pattern is also observed in Thai data when ownership is binary. Another important message is that switching to continuous ownership is not trivial. In column (2), none of the estimates are significant and the point estimate on R&D intensity is even negative and these are very different from the results in column (1) which is based on binary ownership.

Section 3.1 explains the method to test the first theoretical prediction. It suggests that the degree of integration or ownership share ($fshare$) should be positively correlated with capital intensity $[log(K/L)]$ while it has a negative relationship with skill intensity $[log(S/L)]$ for firms under vertical integration. From Equation (3.1), the model predicts that the effects of $log(K/L)$ and $log(S/L)$ on $fshare$ are positive and negative respectively under vertical integration which implies that $(\beta_1 + \beta_7)$ should be positive while $(\beta_2 + \beta_8)$ should be negative.

Column (3) in Table 22 confirms that $(\beta_1 + \beta_7)$ and $(\beta_2 + \beta_8)$ are positive and negative respectively. In other words, capital intensity is positively correlated with foreign ownership while skill intensity is negatively correlated with it for vertically integrated firms. The industry and parent country fixed effects are included so the results are true when comparing two foreign firms with investors from the same country that operate in the same industry.

Proxies for firm size which are log revenue and employment are added to the regression and the result is shown in column (4). Large firms are more likely to be listed on the stock exchange and involved with other factors that can influence the relationship between factor intensities and foreign ownership share. The coefficients on these proxies are statistically zero and the result from column (3) remains valid. Hence, the results are robust even when firm size is included as a control.

Table 22: Main Regression Results: First Prediction

	(1)	(2)	(3)	(4)
Dependent variable:	Foreign owned dummy	fshare	fshare	fshare
ln (K/L)	0.136*	1.255	2.330**	2.180**
	(0.075)	(1.045)	(0.897)	(0.904)
ln (S/L)	-0.368***	-0.893	-1.270	-1.153
	(0.027)	(1.026)	(0.915)	(0.905)
ln (RD/L)	0.012***	-0.086	0.170	0.164
	(0.003)	(0.091)	(0.177)	(0.179)
Mix (dummy)			52.350**	51.960**
			(20.410)	(20.750)
Ver (dummy)			8.315	6.722
			(19.340)	(18.940)
ln (K/L)*Mix			-2.765*	-2.765*
			(1.441)	(1.451)
ln (S/L)*Mix			4.107**	4.079**
			(1.571)	(1.594)
ln (RD/L)*Mix			-0.538**	-0.538**
			(0.224)	(0.227)
ln (K/L)*Ver			0.009	0.092
			(1.371)	(1.348)
ln (S/L)*Ver			-2.440**	-2.427**
			(1.225)	(1.211)
ln (RD/L)*Ver			-0.301	-0.302
			(0.224)	(0.225)
ln (sale)				0.274
				(0.300)
L				0.0003
				(0.001)
Constant	-4.804***	1.174	-11.300	-13.910
	(0.932)	(12.190)	(9.483)	(9.767)
Estimation	Probit	OLS	OLS	OLS
Sector fixed effect	Yes	Yes	Yes	Yes
Parent country fixed effect	No	Yes	Yes	Yes
Observations	72,302	2,746	2,746	2,746
Sample	All firms	Foreign owned firms		
R-squared	N/A	0.260	0.306	0.307

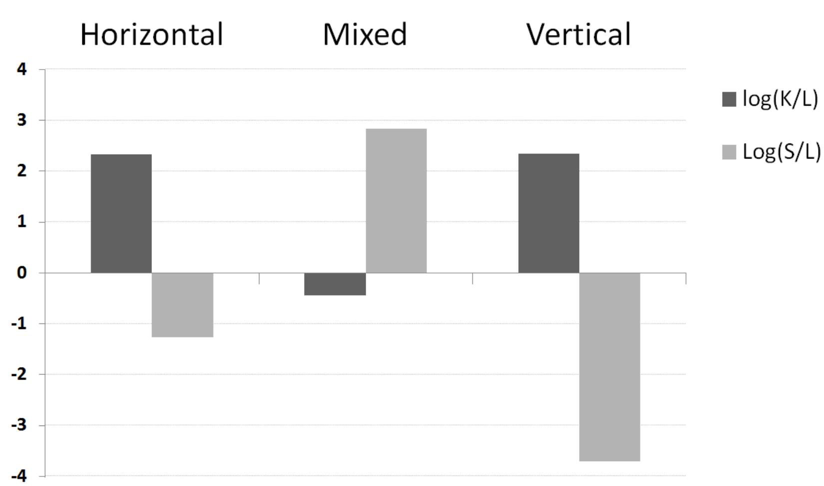
*** p<0.01, ** p<0.05, * p<0.1 and all standard errors are clustered by industry.

Another interesting result from these regressions is that the marginal effects of factor intensities on foreign ownership share vary across integration types. The point estimates of relevant coefficients under different integration types are plotted in Figure 21. The marginal effects of capital and skill intensities on foreign ownership under horizontal integration are similar to the ones under vertical integration whereas the opposite effects are observed under mixed integration.

This result suggests that the normal rational behind the property rights model might be sufficient to explain the degree of ownership under horizontal integration while extra elements are needed in order to explain the opposite results under mixed integration. An extension to my model and further empirical tests on this surprising result are outside the scope of this chapter and left to further work.

Moreover, the heterogeneous effects across integration types also signal that the composition of firms is crucial in studying the determinants of ownership or boundaries of the firm. For example, each intra-firm trade data consists of a combination of firms under mixed and vertical integration. If a particular dataset has a big share of firms under vertical integration, the overall effects of skill intensity can be negative like the empirical results in Antràs (2003). Some other papers which include Nunn and Trefler (2008) and Bernard, Jensen, Redding, and Schott (2010) might be based on a dataset where the share of mixed integration is large as their regression results suggest that ownership is positively related to skill intensity.

Figure 21: Coefficient Plot: First Prediction



Note: the Y-axis measures the estimated value of the marginal effect of capital and skill intensity on ownership share.

5.2 Empirical Results on the Second Prediction

The second testable prediction states that the impact of the importance of parent's investment on optimal ownership share is higher when the elasticity of substitution is high for firms under vertical integration. In other words, the model predicts that the effects of $log(K/L)$ and $log(S/L)$ on $fshare$ are larger when firms are in a higher elasticity group. The estimation strategy to test this statement is explained in Section 3.2. From regression Equation (3.2), β_4 and β_5 are predicted to be positive and negative respectively.

In this section, the focus is on vertically integrated firms, the horizontally integrated firms are dropped. Two definitions of vertical integration are employed here. The results in column (1)-(3) are based on all foreign owned firms that export and can be matched with one of the weighted average estimate of the elasticity of substitution from Broda, Greenfield, and Weinstein (2006). Clearly that is a weak definition of vertical integration, hence the sample used in regression (4)-(5) only includes foreign owned firms that export more than 60 percent of its production which is the same definition used in previous sections.

The results in Table 23 show that the sign of β_4 and β_5 are positive and negative respectively for both definitions of vertical integration. The coefficient on the interaction between log capital intensity and elasticity dummy is positive and significant which implies that the effect of capital intensity on ownership share is higher when elasticity of substitution is higher. The coefficient of the interaction between log skill intensity and elasticity dummy is negative as predicted, however it is not statistically significant.

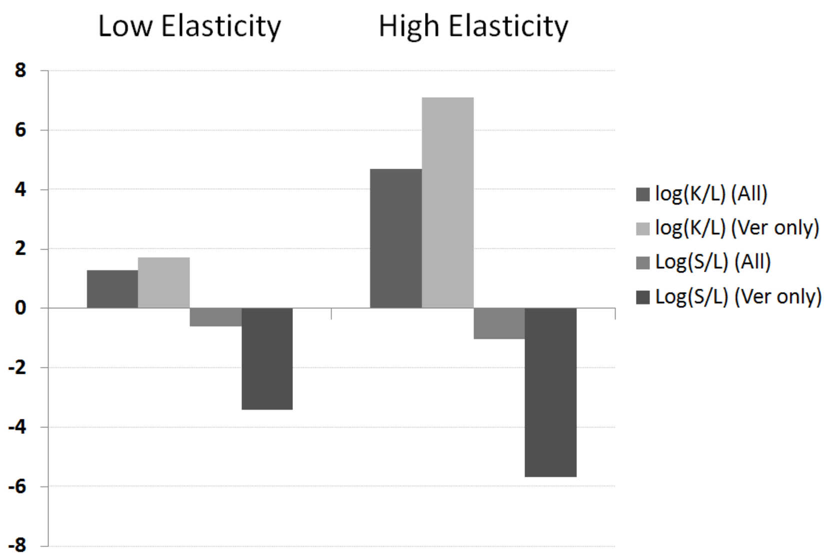
Table 23: Main Regression Results: Second Prediction

Dependent variable:fshare	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All exporting foreign owned			Ver only (export share > 60)		
ln (K/L)	0.008	1.277	2.212*	0.274	1.719	1.212
	(0.808)	(0.957)	(1.201)	(1.060)	(1.092)	(1.343)
ln (S/L)	-0.480	-0.610	-0.145	-3.044**	-3.426*	-3.239*
	(1.082)	(1.382)	(1.298)	(1.287)	(1.862)	(1.808)
ln (RD/L)	-0.305***	-0.250	-0.263	-0.400***	-0.319*	-0.312*
	(0.109)	(0.168)	(0.170)	(0.129)	(0.167)	(0.167)
highelasticity (dummy)		-46.680***	-52.420***		-80.750***	-77.870***
		(15.990)	(17.350)		(20.680)	(20.93)
ln (K/L)*highelasticity		3.436***	3.842***		5.390***	5.179***
		(1.203)	(1.280)		(1.523)	(1.536)
ln (S/L)*highelasticity		-0.432	-0.698		-2.248	-2.217
		(2.053)	(2.014)		(2.469)	(2.456)
ln (RD/L)*highelasticity		-0.125	-0.158		-0.102	-0.091
		(0.225)	(0.218)		(0.241)	(0.242)
ln (sale)			1.230			-0.650
			(0.921)			(1.102)
L			0.002			0.000
			(0.001)			(0.002)
Constant	55.340***	73.11***	62.730***	44.650***	72.770***	78.000***
	(14.63)	(15.53)	(19.630)	(13.910)	(15.110)	(17.950)
Estimation	OLS	OLS	OLS	OLS	OLS	OLS
Parent country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1765	1765	1765	809	809	809
R-squared	0.109	0.116	0.124	0.197	0.220	0.220

*** p<0.01, ** p<0.05, * p<0.1 and all standard errors are clustered by industry.

The coefficient plot in Figure 22 summarises the effects of factor intensities on ownership share across low and high elasticity groups. It shows two important trends. Firstly, the effects of factor intensities are magnified when the elasticity of substitution is higher as predicted by the model. Another result is that the effects are also larger when the stricter definition of vertical integration is used. The second result is not surprising because from the previous section we know that the effects are reversed under mixed integration. Moving from “all exporting foreign owned firms” to “vertical integration only” will definitely strengthen the effects.

Figure 22: Coefficient Plot: Second Prediction



Note: the Y-axis measures the estimated value of the marginal effect of capital and skill intensity on ownership share.

6 Robustness Checks

6.1 Robustness Checks on the Results from the First Prediction

6.1.1 Stricter Definitions of Vertical Integration

Up to this point, vertically integrated firms are defined to be foreign owned firms that export more then 60 percent of their output. This section explores whether the empirical results on the first prediction are robust to stricter definitions of vertical integration. Two sets of definitions are proposed here. One set of definitions involves with raising the exporting threshold. The other set of definitions involves with both increasing exporting threshold and a dummy which is one if a firm exports to the country where its headquarter locates.

A foreign owned firm is more likely to be vertically integrated if it exports majority of its output. For instance, if a foreign owned firm exports all of its output, the firm surely can not be under horizontal integration and it is highly likely to be a part of a production chain, hence vertically integrated. Columns (1)-(4) in Table 24 show the marginal effects of factor intensities on ownership share across different export thresholds. All firms with export share less than the export threshold are not considered to be vertically integrated and excluded from the sample. The thresholds are increasing from

70 percent in column (1) to 100 percent in column (4). The results confirm that the marginal effects of capital and skill intensities are still positive and negative respectively as predicted by the model. Moreover, the marginal effect of capital on ownership share is increasing when firms in the sample are more likely to be vertically integrated. On the contrary, the marginal effect of skill intensity on ownership share gets smaller with a higher export threshold.

Traditional definition of vertical integration suggests that vertically integrated affiliates are supposed to produce intermediate inputs and ship them to their parent firms abroad. The dataset allows me to check whether a foreign owned firm exports back to its parent country or not and this is captured by "backtohq" dummy. Similar to columns (1) to (4), the export threshold is also increasing from columns (5) to (8). The regressions confirm that the marginal effect of capital and skill intensities are still positive and negative respectively. Therefore the empirical results on the first prediction are highly robust across other definitions of vertical integration. The effect of capital intensity increases with the exporting threshold like in columns (1)-(4). Nonetheless, the effects are larger for those firms which do not export back to parent country.

Table 24: Results When Stricter Definitions of Vertical Integration are Used

Dependent variable:fshare	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample: Foreign owned with	%exp>70	%exp>80	%exp>90	%exp=100	%exp>70	%exp>80	%exp>90	%exp=100
ln (K/L)	2.628**	3.103**	3.410**	4.137*	5.964***	6.692***	5.088**	6.056**
	(1.171)	(1.383)	(1.496)	(2.359)	(1.540)	(1.817)	(2.207)	(2.818)
ln (S/L)	-3.191***	-2.849**	-2.516*	-2.492	-2.088*	-1.966*	-0.558	0.109
	(0.882)	(1.110)	(1.268)	(1.885)	(1.145)	(1.150)	(1.788)	(2.148)
ln (RD/L)	-0.095	-0.168	0.084	-0.163	0.103	0.082	0.367	-0.201
	(0.190)	(0.188)	(0.190)	(0.169)	(0.226)	(0.236)	(0.236)	(0.376)
backtohq					69.370***	72.130***	26.560	26.220
					(16.630)	(19.990)	(26.990)	(46.250)
ln(K/L)*backtohq					-5.294***	-5.383***	-2.283	-2.526
					(1.308)	(1.597)	(2.459)	(4.084)
ln(S/L)*backtohq					-2.167	-2.015	-3.697	-4.500*
					(1.715)	(1.967)	(2.464)	(2.376)
ln(R&D/L)*backtohq					-0.332	-0.385	-0.473	0.071
					(0.317)	(0.324)	(0.376)	(0.530)
Constant	12.890	-17.510	6.696	-2.204	-19.970	-70.200**	-5.878	-17.340
	(13.720)	(18.530)	(17.640)	(27.490)	(16.770)	(28.010)	(23.780)	(31.520)
Sector fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Parent country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	769	628	482	287	769	628	482	287
R-squared	0.361	0.357	0.387	0.463	0.382	0.381	0.402	0.475

*** p<0.01, ** p<0.05, * p<0.1 and all standard errors are clustered by industry.

6.1.2 Exclusion of Industries with Low Maximum Foreign Ownership Share

As explained in Section 3, there are hardly any restrictions on foreign ownership in Thai manufacturing sector. There are only 22 out of 125 industries where maximum ownership shares are less than fifty percent. This might be because there are actually some government controls in these industries (i.e.

weapon, alcohol and tobacco production) or the foreign investors are not interested in investing in them (i.e. carpentry and cassette tape production). Irrespective of the reason, columns (1)-(3) in Table 25 display the empirical results for the first prediction when all firms in those 22 industries are excluded. The regressions are exactly the same as the ones in columns (2)-(4) in Table 22, but with restricted sample. The results here are very similar to those in Table 22. This is not surprising as only 43 out of 2,746 foreign owned firms are dropped here which implies that there are not many foreign owned firms in those potentially problematic industries anyway.

Table 25: Results for Section 6.1.2 and 6.1.3

Dependent variable:fshare	(1)	(2)	(3)	(4)	(5)	(6)
Sample	No industries with max(fshare)<50			All foreign owned but K excludes Land		
ln (K/L)	1.277	2.355**	2.205**	1.712*	2.668***	2.575***
	(1.048)	(0.907)	(0.915)	(0.952)	(0.863)	(0.866)
ln (S/L)	-0.908	-1.278	-1.160	-0.903	-1.301	-1.222
	(1.031)	(0.924)	(0.914)	(1.047)	(0.914)	(0.901)
ln (RD/L)	-0.088	0.171	0.165	-0.086	0.175	0.171
	(0.091)	(0.177)	(0.179)	(0.092)	(0.184)	(0.185)
Mix (dummy)		53.000**	52.600**		48.640**	48.460**
		(20.310)	(20.650)		(20.630)	(21.000)
Ver (dummy)		8.550	6.945		11.430	10.450
		(19.670)	(19.250)		(18.710)	(18.310)
ln (K/L)*Mix		-2.807*	-2.806*		-2.513*	-2.518*
		(1.435)	(1.445)		(1.465)	(1.478)
ln (S/L)*Mix		4.105**	4.075**		4.233**	4.220**
		(1.582)	(1.604)		(1.627)	(1.646)
ln (RD/L)*Mix		-0.542**	-0.541**		-0.540**	-0.540**
		(0.225)	(0.227)		(0.232)	(0.233)
ln (K/L)*Ver		0.000	0.085		-0.255	-0.205
		(1.394)	(1.370)		(1.342)	(1.319)
ln (S/L)*Ver		-2.461**	-2.450**		-2.410*	-2.386*
		(1.239)	(1.225)		(1.221)	(1.208)
ln (RD/L)*Ver		-0.309	-0.309		-0.302	-0.303
		(0.225)	(0.225)		(0.227)	(0.227)
ln (sale)			0.272			0.163
			(0.301)			(0.295)
L			0.000			0.000
			(0.001)			(0.001)
Constant	0.861	-11.590	-14.160	-1.925	-12.490	-14.190
	(12.240)	(9.600)	(9.882)	(10.850)	(9.083)	(9.434)
Sector fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Parent country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,703	2,703	2,703	2,741	2,741	2,741
R-squared	0.248	0.296	0.297	0.262	0.307	0.307

*** p<0.01, ** p<0.05, * p<0.1 and all standard errors are clustered by industry.

6.1.3 Capital is Total Value of Fixed Assets Less Cost of Land

Land ownership by foreigners in Thailand was not fully allowed during the time when the data was collected. Therefore, this section analyses whether removing land costs from capital will change the main results. Similar to previous section, columns (4)-(6) in Table 25 are based on the same regression used in columns (2)-(4) in Table 22, but with a new definition of capital.[50] Again, the marginal effects of capital and skill intensities are still positive and negative respectively as predicted. Nonetheless, the coefficient of the interaction between capital intensity and Ver dummy is negative here. It is statistically insignificant and relatively small though.

6.1.4 Division of Exporting Foreign Affiliates into Four Quantiles

The division of foreign owned firms into three groups can be seen as highly subjective. Therefore, as a robustness check, all foreign owned exporters are divided into four groups here. The dummies for the the four quantiles are exp1, exp2, exp3 and exp4. The last quantile has the highest export share. Notice that the lowest quantile (exp1) is under mixed integration not horizontal integration.[51] The results are similar to the main results in Section 5. The correlation between capital intensity and fshare is positive for firms in a higher quantile (vertical integration) while the correlation is negative for firms in a lower quantile (mixed integration). This strengthens the validity of the main results.

[50] The number of observations falls by five because those firms now have values of capital less than ten baht (less than a pound) which is the capital threshold used in this chapter to exclude outliers.

[51] It is not possible to include non-exporting firms here because they must always be in the same quantile. That would give a much bigger weight to horizontally integrated group which would bias the results

Table 26: Regression Results When Exporting Foreign Affiliates are Divided into Four Quantiles

Dependent variable:fshare	(1)	(2)
ln (K/L)	-1.902	-2.688*
ln (S/L)	1.833	2.087
ln (RD/L)	-0.389**	-0.407**
exp2	-58.360*	-64.360**
exp3	-64.690*	-69.920**
exp4	-55.130*	-61.500**
ln (K/L)*exp2	4.335**	4.769**
ln (S/L)*exp2	0.447	0.394
ln (RD/L)*exp2	0.135	0.127
ln (K/L)*exp3	4.240*	4.622**
ln (S/L)*exp3	-5.802**	-5.802**
ln (RD/L)*exp3	0.106	0.113
ln (K/L)*exp4	4.315**	4.758**
ln (S/L)*exp4	-4.696**	-4.714**
ln (RD/L)*exp4	0.410*	0.409*
Log (sale)		1.144
L		0.000
Constant	20.890	5.234
Sector fixed effect	Yes	Yes
Investor fixed effect	Yes	Yes
Observations	1814	1814
R-squared	0.308	0.310

*** p<0.01, ** p<0.05, * p<0.1, SE is clustered by industry

6.2 Robustness Checks on the Results From the Second Prediction

6.2.1 Division of Firms into Three Groups

Firms were divided into two groups with equal size by the value of their elasticity of substitution in Section 5.2. In this section, firms are separated into three quantiles according to weighted average elasticity assigned to each of them. The regressions in Table 23 are reproduced here with three groups of firms instead of two. The results in Table 27 reassure that the empirical results on the second prediction is robust against different methods used to divide firms into groups.

The coefficients on the interaction terms between capital intensity and medium or high elasticity dummy are all positive. Actually, the results here are even more stark than before as the size of those coefficients are increasing with the elasticity. In other words, it confirms that firms with a higher elasticity face bigger marginal effect of capital intensity on foreign ownership as predicted by the model and the effect is even larger when elasticity increases. The coefficients on the interaction terms between skill intensity and medium or high elasticity dummy are negative only when the sample consists of firms under vertical integration. This further strengthens the validity of the second prediction. Nonetheless, the estimates are not statistically significant and its marginal effect on ownership does not seem to increase from medium to high elasticity group.

Table 27: Separate Elasticity of Substitution into Three Groups; Low, Medium and High

Dependent variable:fshare	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All exporting foreign owned			Ver only (export share > 60)		
ln (K/L)	0.00833	0.547	1.556	0.274	2.378**	2.147
	(0.808)	(0.953)	(1.192)	(1.060)	(1.174)	(1.563)
ln (S/L)	-0.480	-0.0310	0.701	-3.044**	-3.190	-3.074
	(1.082)	(1.451)	(1.402)	(1.287)	(2.012)	(1.956)
ln (RD/L)	-0.305***	-0.305	-0.328*	-0.400***	-0.430**	-0.428**
	(0.109)	(0.189)	(0.191)	(0.129)	(0.193)	(0.192)
medium elasticity (dummy)		-38.44**	-46.12**		-65.03**	-64.38**
		(18.81)	(19.87)		(29.54)	(30.32)
high elasticity (dummy)		-29.86*	-35.29*		-101.4***	-99.52***
		(16.73)	(18.10)		(21.60)	(22.96)
ln (K/L)*mediumelasticity		1.766	2.330		3.753*	3.712*
		(1.421)	(1.479)		(2.139)	(2.180)
ln (S/L)*mediumelasticity		-4.214***	-4.465***		-3.299	-3.222
		(1.602)	(1.614)		(2.965)	(2.948)
ln (RD/L)*mediumelasticity		0.240	0.228		0.421	0.430
		(0.241)	(0.233)		(0.285)	(0.286)
ln (K/L)*highelasticity		2.390*	2.780**		7.530***	7.389***
		(1.306)	(1.377)		(1.456)	(1.530)
ln (S/L)*highelasticity		1.734	1.515		-0.0983	-0.0928
		(2.283)	(2.229)		(2.541)	(2.541)
ln (RD/L)*highelasticity		-0.227	-0.236		-0.148	-0.142
		(0.252)	(0.251)		(0.370)	(0.371)
lsale			1.252			-0.283
			(0.918)			(1.135)
L			0.00130			-0.000385
			(0.00123)			(0.00214)
Constant	55.34***	64.08***	54.30***	44.65***	83.23***	85.32***
	(14.63)	(15.73)	(19.62)	(13.91)	(17.68)	(18.40)
Parent country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1765	1765	1765	809	809	809
R-squared	0.109	0.129	0.137	0.197	0.244	0.244

*** p<0.01, ** p<0.05, * p<0.1 and all standard errors are clustered by industry.

6.2.2 Deviation From Weighted Average Elasticities

According to the model, each foreign owned firm should be assigned with the elasticity of substitution belonging to the final destination country of its product. However, the data only allows me to observe the main exporting destination not the whole production chain. Hence, it is not possible to identify the final market for each firm. Even if the final market can be identified, available elasticity estimates from Broda, Greenfield, and Weinstein (2006) and current concordance table would fail to assign the elasticity to more than half of all foreign owned firms that export anyway as explained in Section 4.6.

This leads to the use of weighted average elasticity of substitution.

In order to show that the results in Section 5.2 are not driven by the choice of elasticity, two other sets of elasticities are used here. The results in columns (1)-(3) in Table 28 are based on the elasticity estimates for the U.S. As Broda and Weinstein are equipped with data that can accurately estimate the elasticity of substitution in the U.S., their elasticity estimates for the U.S. industries may be more credible than the estimates for other countries. The results are very similar to the ones in columns (1)-(3) in Table 23. The coefficients on the interaction term between capital intensity and high elasticity dummy are positive and significant. Moreover, the interaction term between skill intensity and high elasticity dummy is negative, however it is not statistically significant.

The estimates in columns (4)-(5) in Table 28 are based on the actual industry-country pair elasticity. In other words, each firm is assigned with the elasticity of substitution belonging to the industry of its product in the export destination country. As explained earlier, not all industry-country pairs are available and this drops more than half of all the observations. Nonetheless, the results are reported in columns (4)-(5). The coefficients on the interaction term between capital intensity and high elasticity dummy are positive but only significant when firm size is not controlled. This partly confirms the main empirical results on the second prediction. On the contrary, the coefficients on the interaction term between skill intensity and high elasticity dummy are positive, but neither of them are statistically significant. It is clear here that this empirical test can be improved by getting another set of elasticity estimates and concordance table that is capable of assigning the actual industry-country pair elasticity without dropping more than half of all observations. Another route for improvement is to add appropriate industry-level controls to these regressions.

Table 28: Results When Weighted Average Elasticities are Not Used

Dependent variable:fshare	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All obs that can be matched using USA elasticity			All obs that have exact industry-country match		
ln (K/L)	0.413	0.917	1.281	4.220***	2.286*	1.338
	(1.124)	(1.284)	(1.168)	(1.283)	(1.366)	(1.684)
ln (S/L)	-0.544	-0.481	-0.185	-0.149	-0.824	-0.177
	(1.203)	(1.668)	(1.518)	(1.386)	(1.576)	(1.540)
ln (RD/L)	-0.269**	-0.210	-0.214	0.030	0.129	0.046
	(0.110)	(0.132)	(0.131)	(0.177)	(0.282)	(0.257)
highelasticity (dummy)		-62.880**	-64.550**		-53.290*	-41.750
		(29.560)	(29.840)		(27.880)	(31.860)
ln (K/L)*highelasticity		3.996**	4.076**		4.561**	3.893
		(1.824)	(1.847)		(2.121)	(2.429)
ln (S/L)*highelasticity		-0.290	-0.387		1.175	1.826
		(2.260)	(2.264)		(2.788)	(2.672)
ln (RD/L)*highelasticity		-0.181	-0.188		-0.226	-0.264
		(0.200)	(0.194)		(0.356)	(0.337)
ln (sale)			0.696			3.245***
			(1.135)			(0.945)
L			0.000			0.000
			(0.001)			(0.001)
Constant	14.870	54.020**	44.150	10.720	32.660*	-16.510
	(17.460)	(25.590)	(35.220)	(15.730)	(18.090)	(26.170)
Parent country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1440	1440	1440	664	664	664
R-squared	0.257	0.264	0.265	0.021	0.029	0.061

*** p<0.01, ** p<0.05, * p<0.1 and all standard errors are clustered by industry.

7 Conclusion

This chapter provides an insight into the determinants of ownership share under property-rights theories theoretically and empirically. I propose a property-rights model where the degree of integration is continuous and becomes a choice variable. Due to incompleteness of contracts and investment specificity, higher ownership share leads to a bigger incentive for parent firm to invest but decreases its supplier's contribution. The model yields two main predictions for firms under vertical integration. Firstly, the degree of integration is expected to be high when the relative importance of headquarter's investment which is proxied by capital intensity is high. When supplier's contribution which is proxied by skill intensity is large, parent firms optimally choose lower ownership share. Thai manufacturing census allows me to divide the universe of foreign owned affiliates into three groups; horizontal, vertical and mixed integration. Empirical results confirm the first prediction of the model. The results are highly robust against many checks. Furthermore, they reveal that the effects of factor intensities on ownership are heterogeneous across integration types as summarised in Figure 21. This emphasises that it is important to only include vertically integrated firms in the sample when testing property-rights theories which are only applied to those firms.

The second prediction from the model states that the marginal effects of capital and skill intensities on ownership should be higher when the elasticity of substitution across varieties is high. Final good producers increase ownership in order to be able to seize a bigger share of inputs when negotiation breaks down resulting in a higher outside option. When the elasticity is low, which implies that the market is not competitive, equilibrium price is steep. In this case, seizing a small amount of inputs can still generate high outside option without increasing the ownership. Hence ownership is less sensitive to the importance of headquarter's invest under low elasticity. The empirical results along with their robustness checks confirm the prediction. This strengthens the validity of the property-rights model in this chapter which is based on continuous and endogenous degree of integration.

8 Appendix

8.1 Correlation Matrix

Table 29: Correlation Matrix

	ln(K/L)	ln(S/L)	ln(RD/L)	Export
ln(K/L)	1			
ln(S/L)	-0.041***	1		
ln(RD/L)	0.116***	0.096***	1	
Export	0.215***	-0.277***	0.131***	1

Significance: *** p<0.01 ** p<0.05 * p<0.1.

8.2 Additional Parent Country Characteristics

Table 30 shows some additional characteristics of affiliates belonging to the top twenty parent countries. The variable descriptions can be found in Table 19.

Table 30: Additional Characteristics of the Top Twenty Investor Countries

Country	# of affiliates	Avg K/L	Avg S/L	Avg R&D/L	backtohq	Share of affiliates under		
						Hor	Mixed	Ver
Australia	28	2814723	0.308	5357059	0.353	0.393	0.179	0.429
Belgium	13	937703	0.091	2309356	0.100	0.231	0.154	0.615
China	202	725630	0.254	6487039	0.133	0.619	0.193	0.188
France	53	815653	0.176	797932	0.469	0.415	0.245	0.340
Germany	53	3747060	0.257	4109435	0.529	0.358	0.321	0.321
Hong Kong	52	723192	0.172	14982074	0.128	0.269	0.212	0.519
India	32	693529	0.431	392871	0.316	0.406	0.094	0.500
Italy	22	508974	0.265	808056	0.500	0.727	0.091	0.182
Japan	1206	1968073	0.173	6686360	0.666	0.325	0.387	0.288
Malaysia	112	2639905	0.199	1597495	0.569	0.500	0.259	0.241
Myanmar	27	208982	0.255	0	0.000	0.963	0.000	0.037
Netherlands	40	1524504	0.338	9265085	0.226	0.225	0.400	0.375
South Korea	125	618592	0.129	2957708	0.141	0.552	0.216	0.232
Singapore	297	531776	0.330	1302517	0.705	0.162	0.653	0.185
Sweden	13	534353	0.063	0	0.600	0.231	0.077	0.692
Switzerland	51	2390224	0.188	2112962	0.304	0.098	0.314	0.588
Taiwan	457	695000	0.150	5265778	0.268	0.527	0.230	0.243
UK	44	2552842	0.190	26061589	0.333	0.205	0.273	0.523
USA	164	1650720	0.197	6617809	0.568	0.293	0.250	0.457

Part IV

Product Quality and Intra-firm Trade

1 Introduction

The intra-firm trade literature has been highly influential and significantly developed in the past decade. Many prominent papers have discovered several determinants of ownership structure which directly affect the level of intra-firm trade relative to arm's length trade. Antràs (2003) proposed a property-rights model to answer why trade in capital intensive goods has a greater tendency to be traded within the boundaries of the firms. Antras and Helpman (2004) extend the model in Antràs (2003) to show that firm productivity is also an important determinant of ownership structure. Antras and Helpman (2007) further extend the model to show that judicial quality in the sourcing countries play an important role in determining the boundaries of the firm. Grossman and Helpman (2002) propose a model where matching costs under arm's length trade influence headquarter decisions on ownership structure.

Both Antràs (2003) and Grossman and Helpman (2002) assume that input quality is non-verifiable to a third party, which gives rise to the incompleteness of contracts and the hold-up problem. Clearly, the hold-up problem is more severe when the desired level of input quality is higher. Nonetheless, input quality in these papers are binary; either high or zero quality. Inputs are useless when their quality is zero. Also, there is no link from input quality to product quality in these papers.

Several papers empirically document that higher input quality is required to produce high quality output. Kugler and Verhoogen (2012) use the Colombian manufacturing census to explore the empirical relationships between input and output prices. They find that large plants use more expensive inputs and charge more for their outputs. Verhoogen (2008) also documents that upgrading the quality of the factors of production is important in producing a better-quality good for export.

The aim of this chapter is to explain how the desired level of input quality affects firms' decision on their ownership structure. This chapter presents a heterogeneous-firm model with product-quality differentiation where firms choose whether to produce relevant inputs in-house or outsource input production. Product quality is increasing with input quality and quality is continuous. Quality is non-verifiable by a third party, hence it is futile to write an ex ante contract specifying quality because renogotiation will take place after relationship-specific inputs are produced. Hence both parties negotiate only after the inputs have been made.

The quality aspect in this model follows the setting in Hallak and Sivadasan (2011). Product quality enters the constant elasticity of substitution (CES) utility function as a demand shifter. Firms face higher marginal and fixed costs when they increase the quality of their products. The incompleteness of contracts environment in this chapter is similar to the one in Grossman and Helpman (2002) where the hold-up problem does not occur under vertical integration while it leads to sub-optimal level of investments for firms under outsourcing.

The model in this chapter is based on transaction cost theory while the model in the previous chapter is based on property-rights theory. The hold-up problem exists even under vertical integration in the previous chapter while vertically integrated firms in this chapter face no under-investment problem. Both models are built to identify determinants of ownership, however the model in this chapter is chosen to be based on transactional cost theory. This is because the extra complexity that comes with the property-rights theory does not provide additional insight into analysing the effect of product quality on ownership. By opting for transactional cost theory, much richer findings are generated and closed form solutions can be found.

Under arm's length relationship, suppliers realise that their investment on input quality can not be contracted upon and it will be sunk at the negotiation. This leads to a sub-optimal level of investment on input quality. The under-investment problem becomes worse when input quality is higher because it involves with higher level of investment which is not contractible.

Vertically integrated firms do not face the under-investment problem because they wholly own their suppliers. When firms produce relevant inputs themselves, there is nothing to negotiate and, therefore, they do not face the hold-up problem. Nonetheless, firms under vertical integration face higher fixed costs relative to outsoucing pairs because final good producers have to oversee both input and output production. The increase in managerial tasks is reflected in the higher fixed costs.

Firms are heterogeneous in their productivity. More productive firms face lower marginal costs. Firms face a trade-off between a sub-optimal quality (under outsourcing) and a higher fixed cost (under vertical integration). Their ownership decisions depend on their productivity and the values of several important parameters, such as intensity of preference for quality and the degree of the hold-up problem. There are three possible equilibria and the existence of each equilibrium depends on parameter values. The model provides closed form solutions for all variables across all equilibria.

In general, when the hold-up problem - which leads to sub-optimal product quality - becomes less severe and quality does not matter much, then outsourcing is preferred. Conversely, when quality matters a lot, firms are willing to pay a higher fixed cost and opt for vertical integration in order to avoid the hold-up problem. Also, more productive firms are more likely to choose vertical integration when quality matters because they are more capable of covering the higher fixed costs. The effects of the hold-up problem and the intensity of preference-for-quality on the productivity threshold are larger when productivity lowers the endogenous part of fixed costs instead of marginal costs. This is because profits are less sensitive to a change in productivity when productivity only affects fixed costs.

The rest of this chapter continues by detailing the demand and production setting of the model. The firm's optimisation problem is discussed in Section 3. Section 4 explores all possible industrial equilibria. The determinants of ownership structures under two different assumptions on productivity are explained in Section 5 and 6. Section 7 concludes. The appendix of this chapter is in Section 8.

2 The model

This section describes the basic setup of the model. The environment of the model is similar to the one in Hallak and Sivadasan (2011) and Grossman and Helpman (2002) combined. The latter provides an incompleteness of contract setting while the former gives a framework with vertical product differentiation. Consider a world with two countries: the North and the South. There is only one factor of production, labour. Assume that the wage in the South is low enough to attract all final goods producers to produce their inputs in the South. Final goods are only consumed in the North, hence the South only acts as the base for input production. Final good production is done in the North. The partial equilibrium model assumes monopolistic competition among the final good producers in the North. This section continues with describing the demand structure in the North, production function, ownership structures and the incompleteness of contracts.

2.1 Demand

A representative consumer has constant elasticity of substitution (CES) demand. The utility system is augmented to account for product quality variation across varieties. Utility is given by

$$U = \left(\int_{j\in\Omega} \left(\lambda_j^{\delta} q_j\right)^{\frac{\sigma-1}{\sigma}} dj\right)^{\frac{\sigma}{\sigma-1}}$$

where j is the variety index. σ captures the elasticity of substitution across varieties in a given industry and it is greater than one $(\sigma > 1)$. λ_j and q_j are the quality and quantity of variety j respectively, while Ω is the set of all varieties available in the industry.

The quality term in the demand function acts as a demand shifter and it captures all attributes of a product that consumers value other than price.[52] δ is the intensity of preference for quality and it is higher than zero $(\delta > 0)$. This parameter should varies across industries and countries. For instance, if people in the North become richer, this can be interpreted as an increase in δ. Moreover, it can also vary across industries because product markets' scope for quality differentiation varies across industries as suggested by Khandelwal (2010).

Utility maximisation yields the following optimal demand for variety j:

$$q_j = p_j^{-\sigma} \lambda_j^{\delta(\sigma-1)} \frac{E}{P} \tag{2.1}$$

where E is the total expenditure on all varieties in this industry and P is the price index which is defined as $P = \int p_j^{-\sigma} \lambda_j^{\delta(\sigma-1)} dj$.

2.2 Production

Potential final good producers in the North (only firms in the North have the technology to produce final goods) pay a fixed entry cost, f_e, and take a productivity draw, ψ_j, from a known distribution $G(\psi)$ with the support $(0,\infty)$. Then, they decide whether to begin a production or leave the market. If they decide to start a production, each of them has to choose whether to integrate a supplier in the South (vertical integration) or outsource input production to a supplier (outsourcing) instead. The matching process does not involve with any costs. All potential suppliers in the South are ex-ante identical and the supply of these firms is infinitely elastic. The differences between the two choices are described in the next section.

There are two production stages; Input production stage and Final good production stage. Product quality is increasing with input quality and they are assumed to be equal in this model and both denoted by λ_j. The production functions for the input production are the same across ownership structures except the exogenous fixed cost which is higher under vertical integration. Both fixed and marginal costs across ownership structures are summarised in Table 31.

[52] Many other papers also include quality as a demand shifter. Those papers include Kugler and Verhoogen (2012) and Hallak and Schott (2011).

Table 31: Marginal and Fixed Costs for Input Production

	Vertical Integration	Outsourcing
Marginal Cost $c(\lambda, \psi)$	$\frac{1}{\psi}\lambda^{\beta}$	$\frac{1}{\psi}\lambda^{\beta}$
Fixed Cost $F(\lambda, \zeta)$	$F_v + \frac{1}{\zeta}\lambda^{\alpha}$	$F_o + \frac{1}{\zeta}\lambda^{\alpha}$

Both marginal and fixed costs for the input production are increasing with quality (λ). Both costs are in terms of wages paid to their workers. Marginal costs are identical across ownership structures and they rise with quality, but decrease with productivity. The assumption that marginal costs are increasing with quality is common in the product quality literature. For instance, firms need workers with higher human capital (higher wage) to produce higher quality input. β captures how fast marginal cost increases with quality. It is assumed to be lower than 1 in order to ensure concavity of the profit function. Hence, we have $0 < \beta < 1$ which means that the costs do not increase with quality excessively fast. Marginal costs are lower when the final good producer is more productive. For example, a more productive final good producer may help its supplier design its production line such that fewer skilled workers are needed to produce one unit of input for a given level of quality.

The fixed cost has two components. The first component is exogenous to quality level and it is higher for firms under vertical integration $(F_v > F_o)$. The assumption is common in intra-firm trade literature.[53] Following the work by Shaked and Sutton (1983) and Sutton (2007), the second component of the fixed cost is increasing with quality. α captures how fast fixed costs rise with quality and it is assumed to be positive $(\alpha > 0)$. In the main model, ζ is treated as a constant. It is included here for latter section which analyses the case where productivity lowers fixed costs instead of marginal costs.

In order to assure the concavity of the profit function, it requires the following two assumptions.

Assumption 1. $\kappa = \alpha - (\sigma - 1)(\delta - \beta) > 0$

If assumption 1 does not hold, the profit function becomes convex and first order conditions give the values that generates the smallest profits. In that case, the optimal quality would be infinity as costs of quality are small and its return is large. This condition implies that the cost of quality should be increasing fast enough with the benefit from additional quality. This gives an upper boundary of δ which is $\frac{\alpha}{\sigma-1} + \beta > \delta$. When δ is above this value, quality is so important to the demand relative to the costs of quality and this leads to a non-concave profit function and a corner solution where all firms choose quality to be infinity.

[53] For example, see Antras and Helpman (2004), Grossman and Helpman (2002) and Defever and Toubal (2007).

Assumption 2. $\delta > \beta$

This assumption is made to make sure that the marginal benefit of quality is higher than the marginal cost of quality. It is only when this inequality holds that firm choose positive quality.

Once inputs have been produced in the South, they are shipped to the North for final good production and sale. Shipping the inputs to the North does not involve with any trade costs. The final good producers can costlessly transform each unit of input into one unit of output with quality λ and this is summarised in Equation (2.2) and (2.3).

$$\lambda_{Final\,Good} = \lambda_{Input} = \lambda \tag{2.2}$$

$$q_{Final\,Good} = q_{Input} = q \tag{2.3}$$

2.3 Ownership Structure

There are two types of ownership structure;Vertical integration and Outsourcing. Each final good producer under vertical integration, denoted by subscript v, acquires a supplier in the South and control both output and input production. Therefore, they make decisions on input quality and quantity. They pay for all the costs of input production. It is assumed that the hold-up problem does not happen under vertical integration. Nonetheless, the exogenous fixed cost faced by vertically integrated firms (F_v) is assumed to be higher than the fixed costs under outsourcing (F_o) .This is because these firms have to control both input and output production and this generates extra costs.

Under outsourcing, each final good producer (denoted by subscript o)[54] outsources the production of input to a supplier in the South. There are a large number of suppliers in the South and they are ex-ante identical. This implies that all suppliers are expected to get zero profit in the equilibrium. A final good producer matches with a supplier, then the supplier makes a side payment to the final good producer. This side payment can be negative which would mean that the final good producer makes a payment to the supplier. The side payment is introduced to the model as a mechanism to allow suppliers' expected profit to be zero. In other words, final good producers under outsourcing always set side payment, T, such that their suppliers earn zero profit. The assumption of suppliers' zero outside option is a modeling trick which allows authors to avoid introducing complicated matching

[54] Because subscript v and o will be used through out this chapter, the variety index j under productivity, price, quantity and quality variables is dropped in order to save some notation and reduce confusion.

process into the model. This assumption is common in the intra-firm trade literature which includes, for instance, Antràs (2003) and Antras and Helpman (2004). Nonetheless, the assumption is dropped in the papers where the effect of some elements of the matching process on ownership is the focal point of the studies (i.e. McLaren (2000) and Grossman and Helpman (2002)). In these papers, the suppliers investments can also be used by other final good producers (getting a new match) which give some outside options to the suppliers when negotiation breaks down. This issue is outside the scope of this chapter and I follow the literature by assuming that suppliers have zero outside option. The case where suppliers face positive outside option is a potential area for further work.

Each final good producer only has the control over output production while the input production is under the control of its supplier. In other words, final good producer chooses optimal output price and quality while its supplier chooses the quality and quantity of inputs and bears all input production costs. Because there is a separate control over intermediate and final production lines (leaner organisation), the exogenous part of fixed costs faced by the final good producer is less than the ones faced by a vertically integrated firm $(F_o < F_v)$.

Arm's length relationship is subject to the hold-up problem. Product and input quality are not verifiable in the court of law but observable to all firms and consumers. Therefore, any ex-ante contracts specifying a fixed price for each unit of input will never be agreed by final good producers because suppliers will always choose zero input quality under such contracts. As a result, final good producers are only willing to negotiate when inputs have already been produced and their quality observed. Moreover, inputs are relationship-specific and they have no values outside the relationship. Suppliers foresee that their investment on input quality will be sunk at the negotiation and they carry out sub-optimal investment in input quality and quantity.

3 Firms' Optimisation

3.1 Vertical Integration

Final good producers under vertical integration have the control over input production. Hence they will choose product quality and quantity to maximise their profits. As vertically integrated firms produce input in-house, the hold-up problem does not occur under vertical integration. Hence, they will not face under-investment. Nonetheless, the exogenous part of fixed costs faced by vertically integrated firms is higher than the one under outsourcing. Profit maximisation yields the following optimal values for price, quality and quantity.

$$\lambda_v = \left[\frac{(\delta-\beta)}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\psi^{\sigma-1}\zeta\frac{E}{P}\right]^{1/\kappa} \tag{3.1}$$

$$\begin{aligned} p_v &= \left(\frac{\sigma}{\sigma-1}\right)\frac{1}{\psi}\lambda_v^{\beta} \\ &= \left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha-\beta-(\sigma-1)\delta}{\kappa}}(\psi)^{\frac{(\sigma-1)\beta}{\kappa}-1}\left[\frac{(\delta-\beta)}{\alpha}\zeta\frac{E}{P}\right]^{\beta/\kappa} \end{aligned} \tag{3.2}$$

$$q_v = p_v^{-\sigma}\lambda_v^{\delta(\sigma-1)}\frac{E}{P} \tag{3.3}$$

where $\kappa = \alpha-(\sigma-1)(\delta-\beta)$ and it is assumed to be greater than zero as explained in Assumption 1.

The optimal quality level is shown in Equation (3.1). As κ is positive and $\sigma > 1$, more productive firms choose higher quality level because it is relatively cheaper for them to produce high quality products. λ_v is increasing with δ which captures how important quality is to consumers. It is decreasing with α and β as they capture the costs of raising quality.

Equation (3.2) shows that the optimal price is equal to the product of mark-up and marginal costs. The price is increasing with quality which directly affects the marginal costs. The overall effect of productivity on price is ambiguous. A more productive firm has higher ψ which directly reduces marginal costs and, hence, price. However, higher productivity allows the firm to choose higher quality which increases the price. Price is increasing with productivity only when quality is highly responsive to an increase in ψ and that happens when the elasticity of substitution (σ) is high and marginal costs are sensitive to an increase in λ (β is high). In other words, that happens when $\frac{(\sigma-1)\beta}{\kappa} > 1$ which can be reduced to $\delta > \frac{\alpha}{\sigma-1}$.

The expression of the optimal quantity is shown in Equation (3.3). The effect of ψ on optimal quantity is ambiguous due to the ambiguity of the effect of productivity on price. Given all these optimal values, the expressions for revenue and profit can be derived and they are shown below.

$$r_v = H(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}}[\zeta]^{\frac{\alpha-\kappa}{\kappa}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}} \tag{3.4}$$

$$\pi_v = J(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}} [\zeta]^{\frac{\alpha-\kappa}{\kappa}} \left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}} - F_v \tag{3.5}$$

where $H = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma-\kappa}{\kappa}} \left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha-\kappa}{\kappa}}$ and $J = \left[\frac{\kappa}{\alpha-\kappa}\right] \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\kappa}} \left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha}{\kappa}}$.

Eventhough the effects of productivity on price and quantity are ambiguous, higher ψ leads to higher revenue and profit as shown in Equation (3.4) and (3.17). This is simply because quality matters in this setting and higher productivity leads to a lower cost and higher quality which increases demand. Also, the revenue from the case where productivity increases price and lowers quantity should be similar to the revenue under the case where productivity lowers price and increases quantity. Hence, quality which is always increasing with productivity dominates.

3.2 Outsourcing

Final good producers under outsourcing simply buy relationship-specific inputs from their suppliers in the South. Suppliers are ex-ante identical, hence final good producers are indifferent in matching with any suppliers. Once the matching has taken place, suppliers have to pay side payment, T, which can be negative, to their partners.

Each supplier carries out input production, so they choose input quality and input quantity. They also bear all the costs of input production. Each final good producer obtains inputs from its supplier and transforms each unit of input into one unit of output costlessly. Hence, final good producers choose output quantity and price.

When contracts are incomplete, input quality are not verifiable in the court of law but observable by both parties. As a result, final good producers will never accept any ex-ante contracts specifying a number of inputs at a fixed price. Otherwise, their suppliers will simply choose to produce the lowest possible input quality $(\lambda = 0)$. Final good producers and their suppliers only negotiate after inputs have been produced and their quality observed. Suppliers no longer have the incentive to choose the lowest possible input quality because that will yield low revenue and their share of the surplus will be low. Nonetheless, suppliers realise that all the input production costs will be sunk when they negotiate and this gives them a low bargaining power. This leads to sub-optimal investment in quality. This setting has one-sided hold-up problem because the only person who invests is the supplier which is different from previous chapter where both final good producer and supplier invest.

The bargaining process follows Generalised Nash Bargaining. Both parties have zero outside option because the inputs are specific to their intended user and can not be used by other firms. After the bargaining process, each supplier under outsourcing receives a fraction ϕ of the total revenue. It is a share so its value is bounded by zero and one; $0 < \phi < 1$. ϕ is exogenous in this model, and it represents the supplier's bargaining power.[55]

Given the Nash bargaining share of ϕ and side payment T, supplier's profit maximisation problem becomes

$$max_{q,\lambda}\pi_{Supplier} = (\phi p - c(\lambda,\psi))q - F(\lambda,\psi) - T.$$

It can be proven that final good producers will always use up all the inputs provided by their partners. The intuition is that final good producers do not pay marginal costs while the marginal benefit is split between them and their suppliers. As a result, the output quantity will optimally be equal to input quantity. Suppliers realise this fact and take into account of the effect of their decision on the number of units produced on price which is captured in the demand expressed in Equation (2.1). This results in the following optimal values for quality, price and quantity.

$$\lambda_o = \left[\phi^\sigma \frac{(\delta-\beta)}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)^\sigma \psi^{\sigma-1}\zeta\frac{E}{P}\right]^{1/\kappa} \tag{3.6}$$

$$\begin{aligned} p_o &= \frac{1}{\phi}\left(\frac{\sigma}{\sigma-1}\right)\frac{1}{\psi}\lambda_o^\beta \\ &= \phi^{\frac{\sigma\beta-\kappa}{\kappa}}\left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha-\beta-(\sigma-1)\delta}{\kappa}}(\psi)^{\frac{(\sigma-1)\beta}{\kappa}-1}\left[\frac{(\delta-\beta)}{\alpha}\zeta\frac{E}{P}\right]^{\beta/\kappa} \end{aligned} \tag{3.7}$$

$$q_o = p_o^{-\sigma}\lambda_o^{\delta(\sigma-1)}\frac{E}{P} \tag{3.8}$$

The intuition behind the effects of productivity and other parameters on these values is the same as in the vertical integration case. Nonetheless, the expressions are different and they will be compared in the next section.

[55] An increase in ϕ can be interpreted as an improvement in judicial quality in the South which will increase the supplier's bargaining power.

Given the optimal quality, quantity and price, final good producers choose the side payment T such that $\pi_{Supplier} = 0$. The side payment has the following expression.

$$T = (\phi p_o - \frac{1}{\psi}\lambda_o^{\beta})q_o - F_o - \frac{1}{\zeta}\lambda_o^{\alpha} \tag{3.9}$$

Under outsourcing, final good producers face the following profit function.

$$\pi_o = (1-\phi)p_o q_o + T$$

Substituting in all relevant values, the optimal revenue and profit under outsourcing are shown below.

$$r_o = \phi^{[\sigma\alpha-\kappa]/\kappa} H\left(\psi\right)^{\frac{\alpha(\sigma-1)}{\kappa}}\left[\zeta\right]^{\frac{\alpha-\kappa}{\kappa}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}} \tag{3.10}$$

$$\pi_o = \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa} - 1\right]\phi^{\frac{\sigma\alpha}{\kappa}} J\left(\psi\right)^{\frac{\alpha(\sigma-1)}{\kappa}}\left[\zeta\right]^{\frac{\alpha-\kappa}{\kappa}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}} - F_v \tag{3.11}$$

where $H = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma-\kappa}{\kappa}}\left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha-\kappa}{\kappa}}$ and $J = \left[\frac{\kappa}{\alpha-\kappa}\right]\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\kappa}}\left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha}{\kappa}}$. Again, the intuition behind the effects of productivity and other parameters on profit and revenue is the same as in the vertical integration case.

3.3 Vertical Integration vs Outsourcing

This section compares the equilibrium values of quality, price, quantity and profit across ownership structures.

3.3.1 Quality

Vertical integration case;

$$\lambda_v = \left[\frac{(\delta-\beta)}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\psi^{\sigma-1}\zeta\frac{E}{P}\right]^{1/\kappa}.$$

Outsourcing case;

$$\lambda_o = \left[\phi^{\sigma}\frac{(\delta-\beta)}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)^{\sigma}\psi^{\sigma-1}\zeta\frac{E}{P}\right]^{1/\kappa}.$$

In other words, we have

$$\lambda_o = \phi^{\sigma/\kappa}\lambda_v. \tag{3.12}$$

$\phi^{\sigma/\kappa}$ is positive and less than one. This implies that, given a productivity level, firms under outsourcing always produces lower product quality. This is a result of the hold-up problem and arm's length suppliers make sub-optimal investment on quality. As $\kappa = \alpha - (\sigma-1)(\delta-\beta)$, κ is decreasing with δ. When quality matters more (an increase in δ), the quality gap becomes larger and the hold-up problem becomes more severe.

3.3.2 Price

Vertical integration case;

$$p_v = \left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha-\beta-(\sigma-1)\delta}{\kappa}} (\psi)^{\frac{(\sigma-1)\beta}{\kappa}-1} \left[\frac{(\delta-\beta)}{\alpha}\zeta\frac{E}{P}\right]^{\beta/\kappa}.$$

Outsourcing case;

$$p_o = \phi^{\frac{\sigma\beta-\kappa}{\kappa}} \left(\frac{\sigma}{\sigma-1}\right)^{\frac{\alpha-\beta-(\sigma-1)\delta}{\kappa}} (\psi)^{\frac{(\sigma-1)\beta}{\kappa}-1} \left[\frac{(\delta-\beta)}{\alpha}\zeta\frac{E}{P}\right]^{\beta/\kappa}.$$

In other words, we have

$$p_o = \phi^{\frac{\sigma\beta-\kappa}{\kappa}} p_v. \tag{3.13}$$

Which price is higher depends on the value of relevant parameters. Firms under outsourcing charge lower price when $\frac{\sigma\beta-\kappa}{\kappa} > 1$. This is because the hold-up problem lowers product quality under outsourcing and that decreases the price whereas potential under-investment in input quantity will increase the price. If the hold-up problem affects product quality more, price under outsourcing will be lower. This happens when $\frac{\sigma\beta-\kappa}{\kappa} > 1$ which reduces to

$$\delta > \frac{\alpha-\beta}{\sigma-1}. \tag{3.14}$$

This is intuitive. The previous section concludes that the quality gap rises when quality matters more (δ is high). In other words, the under-investment in quality is severe enough to make $p_o < p_v$ when δ is higher than $\frac{\alpha-\beta}{\sigma-1}$. Moreover the gap is increasing with δ when the inequality holds and this is simply because the quality gap widens.

3.3.3 Quantity

Vertical integration case;

$$q_v = p_v^{-\sigma} \lambda_v^{\delta(\sigma-1)} \frac{E}{P}.$$

Outsourcing case;

$$q_o = p_o^{-\sigma} \lambda_o^{\delta(\sigma-1)} \frac{E}{P}.$$

After substituting in relevant values, we have

$$q_o = \phi^{\frac{\sigma(\alpha-\beta)}{\kappa}} q_v. \tag{3.15}$$

The quantity supplied by firms under outsourcing is lower for a given productivity level when $\alpha > \beta$. Optimal quantity depends on price and quality. Higher quality raises demand while higher price lowers it. The hold-up problem affects both price and quality. The effect of lower quality on demand dominates when $\alpha > \beta$. To reconcile this with the difference in prices, p_o is lower than p_v when the under-investment in quantity is small. This section suggests that there is no under-investment in quantity when $\beta > \alpha$. Under this condition, p_o must be lower than p_v. This is confirmed because the inequality in (3.14) holds when $\beta > \alpha$ because δ is greater than zero.

3.3.4 Revenue

Vertical integration case:

$$r_v = H(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}} [\zeta]^{\frac{\alpha-\kappa}{\kappa}} \left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}$$

Outsourcing case:

$$r_o = \phi^{[\sigma\alpha-\kappa]/\kappa} H(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}} [\zeta]^{\frac{\alpha-\kappa}{\kappa}} \left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}$$

where $H = \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma-\kappa}{\kappa}} \left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha-\kappa}{\kappa}}$. This implies that we have

$$r_o = \phi^{[\sigma\alpha-\kappa]/\kappa} r_v. \tag{3.16}$$

From Assumption 1 ($\kappa > 0$) and 2 ($\delta > \beta$), the expression for κ $[\kappa = \alpha - (\sigma-1)(\delta-\beta)]$ implies that $\alpha > \kappa$ as $(\sigma-1)(\delta-\beta)$ is positive. Therefore, $\sigma\alpha$ must be higher than κ and the revenue under outsourcing is lower than firms under vertical integration controlling for productivity level. This holds for all δ within the range specified in Assumption 1 regardless of the ranking of price or quantity across ownership structures. The intuition is simple. For a given λ, there are two possible scenarios; higher quantity leads to a lower price and lower quantity leads to a higher price. Both cases roughly generates the same level of revenue for a given level of λ. Therefore, the main determinant of the revenue is λ and it is lower under outsourcing. This explains why firms under outsourcing always get a lower revenue controlling for productivity level regardless of the uncertainty about which scenario the industry is in. Of course, this does not mean that vertical integration is always better because looking at revenue alone ignores production costs. Costs are taken into account only when profits are compared across ownership structures in the next section.

3.3.5 Profits

Vertical integration case;

$$\pi_v = J(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}} [\zeta]^{\frac{\alpha-\kappa}{\kappa}} \left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}} - F_v. \tag{3.17}$$

Outsourcing case;

$$\pi_o = J\left[\phi^{-1}\frac{\alpha}{\alpha-\kappa} - 1\right] \phi^{\frac{\sigma\alpha}{\kappa}} (\psi)^{\frac{\alpha(\sigma-1)}{\kappa}} [\zeta]^{\frac{\alpha-\kappa}{\kappa}} \left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}} - F_o \tag{3.18}$$

where $J = \left[\frac{\kappa}{\alpha-\kappa}\right] \left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\kappa}} \left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha}{\kappa}}$. The comparison between the two profit functions will be made in the next section which describes industrial equilibrium. These equations pin down productivity cutoff and productivity threshold which sorts firms according to their productivity into different ownership structures.

4 Industrial Equilibrium

This section describes all possible industrial equilibria under this model. The equilibria include pervasive outsourcing, pervasive vertical integration and the equilibrium where both ownership structures coexist. This section starts by discussing the properties of profit functions derived in the previous section as they determine the conditions required for each equilibrium. Then, the conditions for those three equilibria will be discussed.

4.1 Properties of the Profit Functions

4.1.1 Slopes of the Profit Functions

Differentiating the profit functions in Equations (3.17) and (3.18) with respect to productivity yields the following expressions for the gradients of those profit curves.

Vertical integration case;

$$\frac{d\pi_v}{d\psi} = \left[\frac{\alpha(\sigma-1)}{\kappa}\psi^{\frac{\alpha(\sigma-1)-\kappa}{\kappa}} J\zeta^{\frac{\alpha-\kappa}{\kappa}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}\right]. \tag{4.1}$$

Outsourcing case;

$$\frac{d\pi_o}{d\psi} = \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1\right]\phi^{\frac{\sigma\alpha}{\kappa}}\left[\frac{\alpha(\sigma-1)}{\kappa}\psi^{\frac{\alpha(\sigma-1)-\kappa}{\kappa}} J\zeta^{\frac{\alpha-\kappa}{\kappa}}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}\right] \tag{4.2}$$

where $J = \left[\frac{\kappa}{\alpha-\kappa}\right]\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\kappa}}\left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha}{\kappa}}$.

Equation (4.1) shows that the gradient of π_v is strictly positive. The gradient of the profit function under outsourcing is also positive because $\phi^{-1}\frac{\alpha}{\alpha-\kappa} > 1$.[56] The equations below compare the two gradients.

$$\begin{aligned} \frac{d\pi_o}{d\psi} &= \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1\right]\phi^{\frac{\sigma\alpha}{\kappa}}\frac{d\pi_v}{d\psi} \\ \frac{d\pi_o}{d\psi} &= M\frac{d\pi_v}{d\psi}. \end{aligned} \tag{4.3}$$

where $M = \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1\right]\phi^{\frac{\sigma\alpha}{\kappa}}$. M determines which profit curve is steeper. When M is less than 1, the profit curve under vertical integration is steeper ($\frac{d\pi_v}{d\psi} > \frac{d\pi_o}{d\psi}$). As both profit functions are strictly

[56] This is because $0 < \phi < 1$ which means that $\phi^{-1} > 1$. Also Assumption 1 dictates that $\alpha > \kappa$ and this leads to $\frac{\alpha}{\alpha-\kappa} > 1$.

increasing with productivity, this variable M which captures the relative gradient between the two profit curves will play an important role in analysing each equilibrium later. Therefore, next section is devoted to describe the properties of M.

4.1.2 Properties of M

M captures the effect of the hold-up problem on revenue ($\phi^{\frac{\sigma\alpha}{\kappa}-1}\frac{\alpha}{\alpha-\kappa}$) and fixed costs $\left(\phi^{\frac{\sigma\alpha}{\kappa}}\right)$. The former is always higher than the later but their relative values determine which profit curve has a higher gradient. When the effect of the hold-up problem on revenue is not severe relative to the its effect on the fixed cost ($\phi^{\frac{\sigma\alpha}{\kappa}-1}\frac{\alpha}{\alpha-\kappa}$ is much larger than $\phi^{\frac{\sigma\alpha}{\kappa}}$) then $M > 1$ and the profit curve under outsourcing is steeper than the one under vertical integration. Some properties of M are discussed below.

Firstly, M is positive. As explained in the previous section that $\phi^{-1}\frac{\alpha}{\alpha-\kappa} > 1$. This implies that $M = \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa} - 1\right]\phi^{\frac{\sigma\alpha}{\kappa}}$ is strictly positive because $\phi^{\frac{\sigma\alpha}{\kappa}}$ is positive.

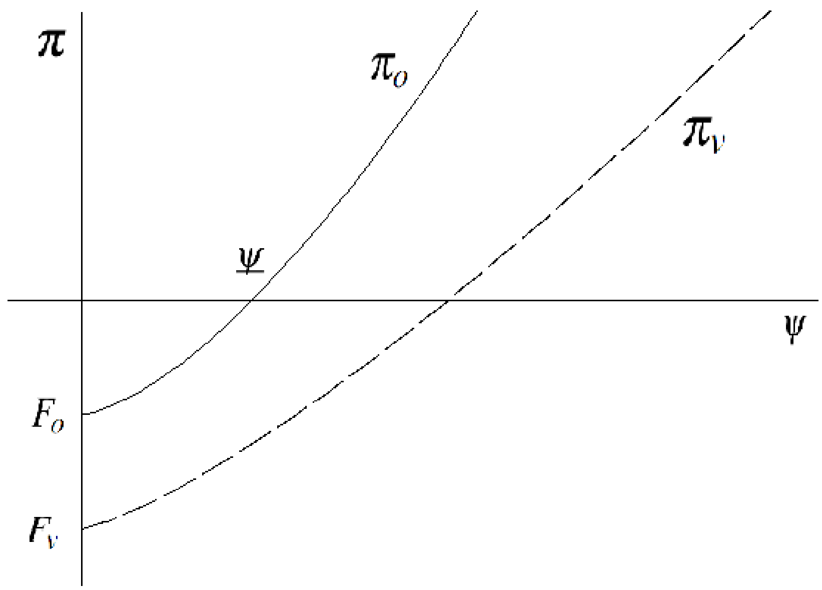
Secondly, $\frac{dM}{d\delta} < 0$ for any values of parameters restricted by Assumption 1. The proof of this condition is shown in Section 8.1 in the Appendix. This means that when quality matters more, the gradient of the profit curve under vertical integration will be steeper relative to the one under outsourcing.

Lastly, $\frac{dM}{d\phi} > 0$ for any values of parameters restricted by Assumption 1. This result holds under an additional assumption that the elasticity of substitution across varieties (σ) and the Nash bargaining share (ϕ) are large enough to allow quality to matter under outsourcing case $(\phi\sigma > 1)$. Section 8.2 in the appendix shows that when the assumption holds, M is increasing with ϕ. When the elasticity of substitution is very low or close to 1, varieties are not substitutes and consumers have to consume all varieties with equal amount regardless of their quality. In other words, quality does not matter. As this chapter is interested in the case where quality matters, it makes sense to assume a reasonably high σ. Also, when ϕ is too low, the hold-up problem is severe and the under-investment in quality is large. Under this situation, suppliers will choose low quality even when quality matters significantly. Hence the assumption that $\phi\sigma > 1$ implies that quality also matters for firms under outsourcing. If this is the case, an increase in ϕ, which lowers the hold-up problem, allows firms under outsourcing to produce higher quality products and increase their revenues. This is why M increases when ϕ is higher.

4.2 Pervasive Outsourcing Equilibrium

This equilibrium occurs when outsourcing yields higher profit for all productivity levels. In other words, this happens when π_o curve lies above π_v curve in profit-productivity space. This requires two conditions; the exogenous fixed cost under vertical integration is strictly higher and π_o curve is steeper than π_v curve for all level of productivity. These conditions are shown in Figure 23.

Figure 23: Pervasive Outsourcing



By assumption, the fixed cost must be higher under vertical integration. Therefore, the equilibrium takes place when $\frac{d\pi_v}{d\psi} < \frac{d\pi_o}{d\psi}$ for all values of ψ. Equation (4.3) suggests that this happens when $M > 1$. Previous section shows that M is increasing with ϕ while decreasing with δ. This suggests that this equilibrium occur when ϕ is high and δ is low. The intuition is that when the Nash bargaining share (ϕ) is high, the hold-up problem becomes less severe which makes outsourcing more attractive. Also when quality matters less (low δ) , sub-optimal quality caused by the hold-up problem does not affect the revenue much.

Firms with productivity lower than the productivity cutoff $(\underline{\psi})$ leaves the market before matching with a supplier. In this case, the productivity cutoff $(\underline{\psi})$ is the productivity level where π_o curve crosses the x-axis. In other words, $\pi_o(\underline{\psi}) = 0$. This yields an expression for the productivity cutoff as shown below.

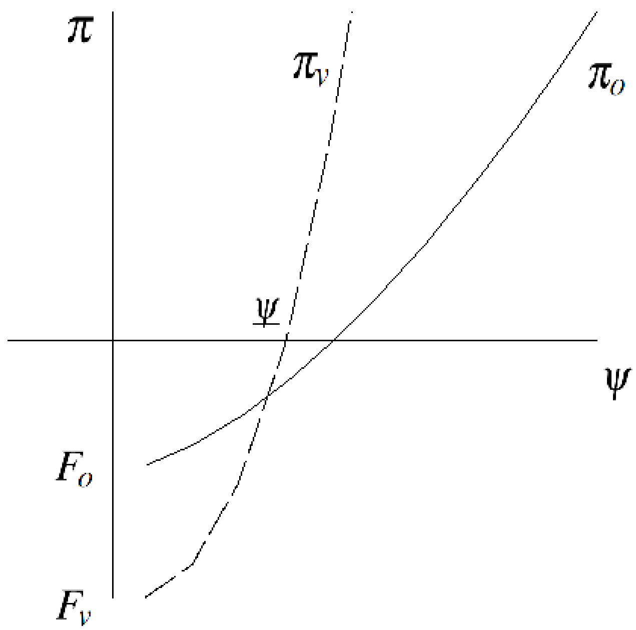
$$\underline{\psi} = M^{\frac{-\kappa}{\alpha(\sigma-1)}} \zeta^{\frac{-\alpha+\kappa}{\alpha(\sigma-1)}} \left(\frac{E}{P}\right)^{\frac{-1}{\sigma-1}} \left(\frac{F_o}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}} \tag{4.4}$$

Pervasive outsourcing equilibrium suggests that all suppliers are independent from final good producers. Hence, there is no intra-firm trade in this equilibrium. All transactions are done at arm's length.

4.3 Pervasive Vertical Integration Equilibrium

This equilibrium occurs when π_v curve lies above π_o curve and both curves are above the x-axis (both profits are positive). This requires two conditions; π_v curve is steeper than π_o curve $(M < 1)$ for all level of productivity and both curves cross below the horizontal axis. These conditions are shown in Figure 24.

Figure 24: Pervasive Vertical Integration



This condition is achieved when the productivity cutoff from $\pi_v(\underline{\psi}) = 0$ makes $\pi_o < 0$. The productivity cutoff has the following expression.

$$\underline{\psi} = \zeta^{\frac{-\alpha+\kappa}{\alpha(\sigma-1)}} \left(\frac{E}{P}\right)^{\frac{-1}{\sigma-1}} \left(\frac{F_v}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}} \tag{4.5}$$

Substituting this into π_o, and $\pi_o(\underline{\psi}) < 0$ yields the condition where this equilibrium will take place.

The inequality can be reduced to the inequality below.

$$F_v M < F_o$$

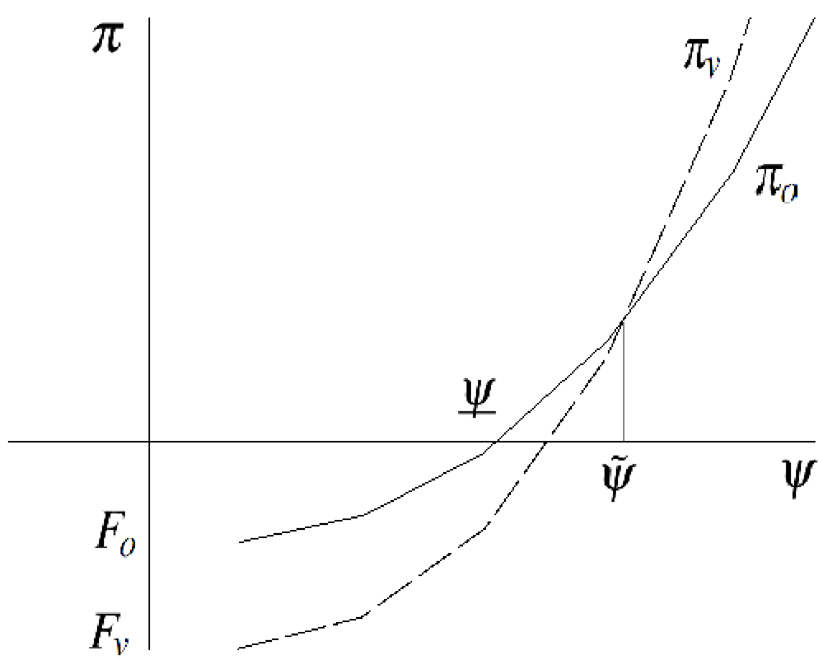
This suggests that the equilibrium exists when M is low and F_o is high relative to F_v. The only problem with vertical integration is that it has higher exogenous fixed cost. If it is lower, vertical integration is more attractive because it does not involve with the hold-up problem. M is low when ϕ is low and δ is high. When the Nash bargaining share is low, the hold-up problem under outsourcing is severe. Also when δ is high, quality matters a lot which means that under-investment caused by the hold-up problem will lower profit significantly. Both conditions make vertical integration more attractive and increase the likelihood of this equilibrium.

Pervasive vertical integration equilibrium implies that all suppliers are vertically integrated. As a result, all shipments of the inputs to the North are intra-firm.

4.4 Equilibrium with Both Ownership Structures

Some firms are under vertical integration and the rest are under outsourcing in this equilibrium. This requires two conditions; π_v curve is steeper than π_o curve $(M < 1)$ for all level of productivity and both curves cross above the horizontal axis. These conditions are shown in Figure 25.

Figure 25: Equilibrium with Both Ownership Structures



Apart from $M < 1$, this equilibrium requires that π_v is above π_o at the productivity threshold. In other words, $\pi_v(\underline{\psi}) > 0$. This condition reduces to

$$F_v M > F_o.$$

Both conditions imply that M must be lower than one but it must not be too low. Also, the exogenous fixed cost must be higher relative to the one under outsourcing.

This industry equilibrium is captured by both productivity cutoff $(\underline{\psi})$ and productivity threshold $(\tilde{\psi})$. The productivity cutoff is where the least productive firm under outsourcing operates. In other words, it can be calculated from $\pi_o(\underline{\psi}) = 0$. The productivity cutoff has the same closed form expression as in Equation (4.4).

The productivity threshold $(\tilde{\psi})$ divides surviving firms into the two ownership structures. Firms with productivity higher than the threshold choose vertical integration while the rest of the surviving firms operate under outsourcing. The firm with $\psi = \tilde{\psi}$ is indifferent between the two ownership structures. In other words, the threshold can be derived from $\pi_v(\tilde{\psi}) = \pi_o(\tilde{\psi})$ and its expression is shown below.

$$\tilde{\psi} = [1-M]^{-\frac{\kappa}{\alpha(\sigma-1)}} \left(\frac{F_v - F_o}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}} \zeta^{\frac{-(\alpha-\kappa)}{\alpha(\sigma-1)}} \left(\frac{E}{P}\right)^{\frac{-1}{(\sigma-1)}} \tag{4.6}$$

Sections 4.2, 4.3 and 4.4 have described the conditions where each of the equilibria can occur. Empirically, these conditions tend to vary across industries which is why some industries are biased towards pervasive outsourcing while some are closer to pervasive vertical integration. Nonetheless, it is more common to observe indusries with both types of integration. The equilibrium is also the most interesting one as we can easily analyse firms' decision making process between vertical integration and outsourcing.

This equilibrium is the main focus of this chapter. When a change in the value of a parameter shifts either or both productivity cutoff and productivity threshold, the parameter basically is a determinant of intra-firm trade share. Such parameters are explored in the next main section.

4.5 Free Entry and Industry Equilibrium

Free entry ensures that, in equilibrium, the expected operating profits of a potential entrant equal the fixed cost of entry (f_e). The productivity cutoff under different equilibrium have been calculated above and those firms with productivity higher than the cutoff operate and choose the ownership structure $z \in \{v, o\}$ that maximise their profits. Therefore the free entry condition becomes

$$\int_{\underline{\psi}(P)}^{\infty} \pi_z(P)\, dG(\psi) = f_e.$$

This condition provides a closed form solution for P. Once P is known, all other equilibrium variables can be written as closed form expressions.

5 Determinants of Ownership Structures

This section discusses the effect of a change in some parameters on the productivity cutoff and productivity threshold in the industry equilibrium where vertical integration and outsourcing coexist. The movement of these thresholds explains how those parameters affect optimal ownership structure and intra-firm trade.

5.1 Nash Bargaining Share (ϕ)

An increase in ϕ can occur when suppliers have higher bargaining power relative to final good producers'. For example, if some aspects of the inputs become verified in the court of law in the South due to an improvement in judicial quality, suppliers have higher outside option and they should obtain higher surplus share from the bargaining process. Another possible scenario is that ϕ is likely to be higher in the industries where suppliers' investment is highly important. Clearly, final good producers will be more willing to offer higher surplus share to their suppliers to mimic the hold-up problem.[57]

The effects of a change in ϕ on $\underline{\psi}$ and $\tilde{\psi}$ will shed light on how the degree of the hold-up problem affect the optimal ownership structure. In other words, the signs of $\frac{d\underline{\Psi}}{d\phi}$ and $\frac{d\tilde{\psi}}{d\psi}$ will tell how the fraction of firms under vertical integration (i.e. intra-firm trade share) change after an increase in ψ.

[57] Endogenising the bargaining process will be an important improvement of this model

$\frac{d\Psi}{d\phi}$ and $\frac{d\tilde{\psi}}{d\psi}$ have the following expressions.

$$\frac{d\Psi}{d\phi} = -\frac{dM}{d\phi}\{M\}^{-\frac{\kappa}{\alpha(\sigma-1)}-1}\left(\frac{\kappa}{\alpha(\sigma-1)}\right)\left(\frac{F_o}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}}\zeta^{\frac{-\alpha+\kappa}{\alpha(\sigma-1)}}\left(\frac{E}{P}\right)^{\frac{-1}{\sigma-1}} \tag{5.1}$$

$$\frac{d\tilde{\psi}}{d\phi} = \frac{dM}{d\phi}\frac{\kappa}{\alpha(\sigma-1)}[1-M]^{-\frac{\kappa}{\alpha(\sigma-1)}-1}\left(\frac{F_v-F_o}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}}\zeta^{\frac{-\alpha+\kappa}{\alpha(\sigma-1)}}\left(\frac{E}{P}\right)^{\frac{-1}{\sigma-1}} \tag{5.2}$$

Equations (5.1) and (5.2) show that $\frac{d\Psi}{d\phi}$ has the opposite sign from $\frac{dM}{d\phi}$ while $\frac{d\tilde{\psi}}{d\phi}$ has the same sign as $\frac{dM}{d\phi}$. From Section 4.1.2, we know that $\frac{dM}{d\phi} > 0$. This implies that $\frac{d\Psi}{d\phi} < 0$ and $\frac{d\tilde{\psi}}{d\phi} > 0$. Hence, the productivity cutoff falls whereas the productivity threshold rises when suppliers' Nash bargaining share rises. In other words, there are more firms under outsourcing and fewer firms under vertical integration, leading to a fall in intra-firm trade share. The intuition is simple. When ϕ increases, the hold-up problem is less severe which improves the revenue under outsourcing. Some of the firms with productivity lower than the previous cutoff now find that production under outsourcing is profitable and join the market and this lowers the productivity threshold. As outsourcing provides higher return, more existing firms switch to outsourcing which increases the productivity threshold. Hence, there are fewer firms under vertical integration.

5.2 Intensity of Preference for Quality (δ)

This section explores the effect of an increase in δ on the fraction of firms under vertical integration. In the model, δ belong to the consumer in the North. Empirically, it varies across countries and industries. For instance, if we instead look at another country pair where the North is richer, this can be interpreted as an increase in δ. Moreover, it can also vary across industries because product markets' scope for quality differentiation varies across industries as suggested by Khandelwal (2010).

δ enters in the expressions for $\underline{\psi}$ and $\tilde{\psi}$ through κ, J and M. Hence, differentiating them with δ does not provide a useful analysis without making further assumptions on the values of some parameters. Hence, I opt for a more intuitive route and check the impact of δ on the relative gradient of the two profit curves.

Equation (4.3) ($\frac{d\pi_o}{d\psi} = M\frac{d\pi_v}{d\psi}$) implies that the gradient of π_o curve relative to the gradient of π_v is M. From Section 4.1.2, we know that $\frac{dM}{d\delta} < 0$. This means that π_v will be steeper relative to π_o when δ rises. This might be because π_v tilts upwards more than π_o or π_o might actually tilts downwards.

Regardless of what actually happen to each curve, it is curtain that the productivity threshold must be lower. This implies that an increase in the intensity of preference for quality lowers the number of firms under vertical integration. The intuition is that when quality is more important, under-investment in quality due to the hold-up problem under outsourcing decreases firms' profit more. Therefore firms switch to vertical integration to avoid the hold-up problem. This increases the number of intra-firm trade transactions.

6 Productivity Lowers Fixed Cost instead of Marginal Cost

This section explores how the aforementioned results change when productivity lowers the endogenous part of fixed costs instead of marginal costs. So far, I have assumed that productive firms have the ability to produce extra unit at a lower cost. This can happen, for example, when productive firms do not have to hire many skilled workers to produce a unit of input because it has better technology. It is also possible that firms with higher productivity can build sophisticated factory or machine at a lower cost. These costs constitute the fixed costs of production. The likelihood of each situation probably varies across industries. The analysis below shows how this change affects the results in previous sections.

The results of this case can be obtained from defining ζ in the Table 31 to be productivity instead of ψ. Clearly, the expressions for quality, price, quantity, revenue and profit under both ownership structures are the same as in Section 3.3. Nonetheless, the gradients of the profit functions, productivity threshold and productivity cutoff are different.

6.1 Gradients of the Profit functions

The gradients of the profit functions $\left(\frac{d\pi_v}{d\zeta} \text{ and } \frac{d\pi_o}{d\zeta}\right)$ under the new productivity have the following expressions.

$$\frac{d\pi_v}{d\zeta} = \left[\frac{\alpha-\kappa}{\kappa}[\zeta]^{\frac{\alpha-2\kappa}{\kappa}-1} J\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}\right]$$

$$\frac{d\pi_o}{d\zeta} = M\left[\frac{\alpha-\kappa}{\kappa}[\zeta]^{\frac{\alpha-\kappa}{\kappa}-1} J\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}\right]$$

where $J=\left[\frac{\kappa}{\alpha-\kappa}\right]\left(\frac{\sigma-1}{\sigma}\right)^{\frac{\alpha\sigma}{\kappa}}\left(\frac{\delta-\beta}{\alpha}\right)^{\frac{\alpha}{\kappa}}$.

It is logical to compare these expressions with the ones under the old productivity. In order to make them comparable, I assume that ψ is one when ζ is the productivity term and vice versa. The gradients under the previous definition of productivity are shown below.

$$\frac{d\pi_v}{d\psi}=\left[\frac{\alpha(\sigma-1)}{\kappa}(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}-1}\frac{J}{c}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}\right]$$
$$\frac{d\pi_o}{d\psi}=M\left[\frac{\alpha(\sigma-1)}{\kappa}(\psi)^{\frac{\alpha(\sigma-1)}{\kappa}-1}\frac{J}{c}\left(\frac{E}{P}\right)^{\frac{\alpha}{\kappa}}\right]$$

When these gradients are compared controlling that ψ have the same value as ζ, their relative values depend on whether $\frac{\alpha-\kappa}{\kappa}$ is higher or lower than $\frac{\alpha(\sigma-1)}{\kappa}$. It turns out that $\frac{\alpha-\kappa}{\kappa}>\frac{\alpha(\sigma-1)}{\kappa}$ holds , which is when ζ has more marginal impact on profit functions than ψ, only when $\delta>\alpha+\beta$. Nonetheless, the value of δ under the inequality violates Assumption 1 which says that the profits functions are concave only when $\frac{\alpha}{\sigma-1}+\beta>\delta$. Therefore, we know for certain that $\frac{\alpha-\kappa}{\kappa}<\frac{\alpha(\sigma-1)}{\kappa}$ holds and the marginal impact of ψ on profit functions is larger relative to ζ's. The intuition is that marginal costs affect price directly and indirectly through quality while fixed costs only affect price indirectly through quality. In the situation where quality matters but not too excessively to the point where Assumption 1 is violated, the case where productivity lowers marginal costs must therefore have larger impact on profits.

6.2 Productivity Cutoff and Productivity Threshold

The productivity cutoff and productivity threshold under the case where productivity lowers fixed costs are shown below.

$$\underline{\zeta}=M^{-\frac{\kappa}{\alpha-\kappa}}\left(\frac{E}{P}\right)^{\frac{-\alpha}{\alpha-\kappa}}\left(\frac{F_o}{J}\right)^{\frac{\kappa}{\alpha-\kappa}}$$

$$\tilde{\zeta}=[1-M]^{-\frac{\kappa}{\alpha-\kappa}}\left(\frac{F_v-F_o}{J}\right)^{\frac{\kappa}{\alpha-\kappa}}\left(\frac{E}{P}\right)^{\frac{-\alpha}{\alpha-\kappa}}.$$

The productivity cutoff and productivity threshold under the case where productivity lowers marginal cost are shown below.

$$\underline{\psi} = M^{\frac{-\kappa}{\alpha(\sigma-1)}} \left(\frac{E}{P}\right)^{\frac{-1}{\sigma-1}} \left(\frac{F_o}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}}$$

$$\tilde{\psi} = [1-M]^{-\frac{\kappa}{\alpha(\sigma-1)}} \left(\frac{F_v - F_o}{J}\right)^{\frac{\kappa}{\alpha(\sigma-1)}} \left(\frac{E}{P}\right)^{\frac{-1}{(\sigma-1)}}$$

From these expressions, it is clear that the signs of the effect of ϕ or δ on these thresholds are the same. Nonetheless, the magnitudes are different. For example, the effect of ϕ and δ on these thresholds are larger under the case where productivity lowers fixed costs instead of marginal costs.

$$\left(\frac{d\underline{\zeta}}{d\phi}\right) / \left(\frac{d\underline{\psi}}{d\phi}\right) = M^{-\frac{\kappa}{\alpha-\kappa}+\frac{\kappa}{\alpha(\sigma-1)}} \left[\left(\frac{\kappa}{\alpha-\kappa}\right) / \left(\frac{\kappa}{\alpha(\sigma-1)}\right)\right] \left(\frac{E}{P}\right)^{\frac{-\alpha}{\alpha-\kappa}+\frac{1}{\sigma-1}} \left(\frac{F_o}{J}\right)^{\frac{\kappa}{\alpha-\kappa}-\frac{\kappa}{\alpha(\sigma-1)}} \tag{6.1}$$

Equation (6.1) shows that the right hand side tends to be larger than one because $\frac{\alpha-\kappa}{\kappa} < \frac{\alpha(\sigma-1)}{\kappa}$.[58] Similarly, $\left(\frac{d\tilde{\zeta}}{d\phi}\right) / \left(\frac{d\tilde{\psi}}{d\phi}\right)$ tends to be higher than one as well. This means that an increase in ϕ will lower productivity cutoff and raise productivity threshold more when the productivity term lowers fixed costs instead of marginal costs. The intuition is simple. From Section 6.1, it is clear that productivity under the case where it affects fixed costs has smaller impact on profits because fixed costs only affect revenue indirectly through the choice of optimal λ while it affects the revenue both directly though price and indirectly through quality when productivity lowers marginal cost. Therefore, the productivity threshold and productivity cutoff change more when productivity only affects the fixed cost because profit is less sensitive to the change of productivity in this case. As a result, an increase in ϕ decreases intra-firm trade share more when productivity lowers fixed costs instead of marginal costs.

7 Conclusion

This chapter shows how product quality affects firms' decision on their ownership structure through a heterogeneous-firm model with product-quality differentiation where firms choose whether to produce relevant inputs in-house or outsource input production. Firms face a trade-off between a sub-optimal

[58] $M^{-\frac{\kappa}{\alpha-\kappa}+\frac{\kappa}{\alpha(\sigma-1)}} > 1$because $M < 1$in this case and the power is negative.

quality (under outsourcing) and a higher fixed cost (under vertical integration). Their decisions depend on the values of several important parameters and different sets of parameter values lead to different equilibrium. The model provides closed form solutions for all variables across all equilibria.

In general, when the hold-up problem - which leads to sub-optimal product quality - becomes less severe and quality does not matter much, outsourcing is preferred. Conversely, when quality matters a lot, firms are willing to pay a higher fixed cost and opt for vertical integration in order to avoid the hold-up problem. Also, more productive firms are more likely to choose vertical integration when quality matters because they are more capable of covering the higher fixed costs. The effects of the hold-up problem and the intensity of preference-for-quality on the productivity threshold are larger when productivity lowers the endogenous part of fixed costs instead of marginal costs. This is because profits are less sensitive to a change in productivity when productivity only affects fixed costs.

The area of future research includes the empirical test of the predictions. The test requires three main elements: a good measure of product quality, firm-level productivity and the importance of quality in each industry. There are several of good candidates for the latter element which include the estimates of quality ladders in Khandelwal (2010). A detailed intra-firm trade data can provide a measure for product quality. Using unit price as a measure of quality is not accurate unless product code is disaggregated enough up to the point where different product codes really represent different products (i.e. HS8 or HS10). Once the data is obtained, unit price will be the measure of product quality. With firm-level productivity, empirical exercises can be set up to test the predictions.

8 Appendix

8.1 Proof for $\frac{dM}{d\delta} < 0$

$$
\begin{aligned}
M &= \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1\right]\phi^{\frac{\sigma\alpha}{\kappa}} \\
M &= \left[\phi^{\frac{\sigma\alpha}{\kappa}-1}\frac{\alpha}{\alpha-\kappa}-\phi^{\frac{\sigma\alpha}{\kappa}}\right] \\
\frac{dM}{d\delta} &= \left[\phi^{\frac{\sigma\alpha}{\kappa}-1}ln(\phi)\frac{d\left(\frac{\sigma\alpha}{\kappa}-1\right)}{d\kappa}\frac{d\kappa}{d\delta}\frac{\alpha}{\alpha-\kappa}+\phi^{\frac{\sigma\alpha}{\kappa}-1}(-1)\alpha(\alpha-\kappa)^{-2}(-1)\frac{d\kappa}{d\delta}\right]-\left[ln(\phi)\phi^{\frac{\sigma\alpha}{\kappa}}\frac{d(\sigma\alpha/\kappa)}{d\kappa}\frac{d\kappa}{d\delta}\right] \\
&= \left[\phi^{\frac{\sigma\alpha}{\kappa}-1}ln(\phi)\sigma\alpha\kappa^{-2}(\sigma-1)\frac{\alpha}{\alpha-\kappa}-\phi^{\frac{\sigma\alpha}{\kappa}-1}\alpha(\alpha-\kappa)^{-2}(\sigma-1)\right]+\left[ln(\phi)\phi^{\frac{\sigma\alpha}{\kappa}}(\sigma\alpha)(-1)\kappa^{-2}(\sigma-1)\right] \\
&= \left[\phi^{\frac{\sigma\alpha}{\kappa}-1}ln(\phi)\sigma\alpha\kappa^{-2}(\sigma-1)\frac{\alpha}{\alpha-\kappa}-ln(\phi)\phi^{\frac{\sigma\alpha}{\kappa}}\sigma\alpha\kappa^{-2}(\sigma-1)\right]-\phi^{\frac{\sigma\alpha}{\kappa}-1}\alpha(\alpha-\kappa)^{-2}(\sigma-1) \\
&= \left[\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1\right]\phi^{\frac{\sigma\alpha}{\kappa}}ln(\phi)\sigma\alpha\kappa^{-2}(\sigma-1)-\phi^{\frac{\sigma\alpha}{\kappa}-1}\alpha(\alpha-\kappa)^{-2}(\sigma-1) \\
&= \{\left[\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1\right]ln(\phi)\sigma\kappa^{-2}-\phi^{-1}(\alpha-\kappa)^{-2}\}\phi^{\frac{\sigma\alpha}{\kappa}}\alpha(\sigma-1)
\end{aligned}
$$

As $ln(\phi) < 0$ and $\phi^{-1}\frac{\alpha}{\alpha-\kappa}-1 > 0$, it must be the case that $\frac{dM}{d\delta} < 0$. So when δ is high, it is likely that $M < 1$ will hold. In other words, it is more likely that π_v curve will be steeper than $\pi_o$when quality matters more.

8.2 Conditions for Positive $\frac{dM}{d\phi}$

$$
\begin{aligned}
\frac{dM}{d\phi} &= \frac{d\{\phi^{-1+\frac{\sigma\alpha}{\kappa}}\frac{\alpha}{\alpha-\kappa}-\phi^{\frac{\sigma\alpha}{\kappa}}\}}{d\phi} \\
&= \frac{\sigma\alpha-\kappa}{\kappa}\phi^{\frac{\sigma\alpha-2\kappa}{\kappa}}\frac{\alpha}{\alpha-\kappa}-\frac{\sigma\alpha}{\kappa}\phi^{\frac{\sigma\alpha-\kappa}{\kappa}} \\
&= \left[\frac{\sigma\alpha-\kappa}{\kappa}\phi^{-1}\frac{\alpha}{\alpha-\kappa}-\frac{\sigma\alpha}{\kappa}\right]\phi^{\frac{\sigma\alpha-\kappa}{\kappa}}
\end{aligned}
$$

$\frac{dM}{d\phi} < 0$ only when

$$\frac{\alpha(\sigma\alpha-\kappa)}{\alpha-\kappa}\phi^{-1} < \sigma\alpha$$
$$\frac{\sigma\alpha-\kappa}{\alpha-\kappa} < \phi\sigma$$
$$\sigma\alpha-\kappa < \alpha\phi\sigma-\kappa\phi\sigma$$
$$(1-\phi)\sigma\alpha < (1-\phi\sigma)\kappa$$
$$(1-\phi)\sigma\alpha < -(\phi\sigma-1)\kappa$$
$$\frac{(1-\phi)}{(1-\phi\sigma)}\sigma\alpha > \kappa$$
$$\frac{(1-\phi)}{(1-\phi\sigma)}\sigma\alpha > \alpha-(\sigma-1)(\delta-\beta)$$
$$(\sigma-1)(\delta-\beta) > \left[\frac{1-\phi\sigma-(1-\phi)\sigma}{(1-\phi\sigma)}\right]\alpha$$
$$(\sigma-1)(\delta-\beta) > \left[\frac{1-\sigma}{(1-\phi\sigma)}\right]\alpha$$
$$\delta > \frac{\alpha}{(\phi\sigma-1)}+\beta$$

The derivation above is based on the assumption that σ is high enough so that $\phi\sigma-1>0$. When the elasticity of substitution is very low or close to one, varieties are not substitutes and consumers have to consume all varieties with equal amount regardless of their quality. In other words, quality does not matter. Hence it makes sense to assume a reasonably high σ which is greater than one with no upper bound while ϕ a fraction which has a value between zero and one. Then we have $\frac{dM}{d\phi} < 0$ only when $\delta > \frac{\alpha}{(\phi\sigma-1)}+\beta$ holds. Nonetheless, Assumption 1 which restricts these parameters so that the concavity of the profit functions holds dictates that δ must not be higher than $\frac{\alpha}{\sigma-1}+\beta$. This means that the inequality $\delta > \frac{\alpha}{(\phi\sigma-1)}+\beta$ will never hold. This is because $\frac{\alpha}{(\phi\sigma-1)}+\beta > \frac{\alpha}{\sigma-1}+\beta$. Hence it is certain that $\frac{dM}{d\phi} > 0$ during the range of parameters that makes the profit functions concave.

Part V

Conclusion

This thesis provides several new insights into how firms organise their production with a focus on the skill mix of employees (the first chapter) and on ownership decisions (the second and third chapters). The model in the first chapter derives labour demand as driven by the local distribution of wages and available skills. Firm behaviour in general equilibrium is derived, and determines firm location as a function of regional costs. This results in estimating equations which can be easily implemented in two steps. The first step exploits differences in firm hiring patterns across distinct regional factor markets to recover firm labour demand by type. The second step uses the estimates of the first stage to introduce local labour costs into production function estimation. Both steps characterise the impact of local market conditions on firm behaviour through recovery of model primitives. This is of particular interest when explaining the relative productivity or location of firms, especially in settings where local characteristics are known to be highly dissimilar.

The results from the first chapter suggest that team technologies combined with favourable factor market conditions explain substantial differences in firm productivity. Other methods which do not model worker substitution or factor markets yield relatively skewed productivity estimates in China. This supports the thesis that modeling a firm's local environment may yield substantial insights into production patterns.

The importance of local factor markets for understanding firm behaviour suggests new dimensions for policy analysis. For instance, regions with labour markets which generate lower unit labour costs tend to attract higher levels of firm activity within an industry. As unit labour costs depend not only on the level of wages, but rather the distribution of wages and worker types that represent substitution options, this yields a more varied view of how educational policy or flows of different worker types could impact firms.

This chapter also colours the interpretation of heterogeneous productivity at the firm level, since a component of differences across firms is due to the influence of local supply conditions. Productivity estimates which result from our model are more important in predicting firm performance than models based on perfectly substitutable worker types. This suggests that if firm productivity is a measure of 'competitiveness' leading to dynamic advantages such as innovation or exporting, then regional factor markets should be controlled for. Taken as a whole, our results show that policy changes which influence the composition of regional labour markets, such as the construction of Special Economic Zones or liberalisation of the Hukou system, will have sizable effects on firm behaviour, productivity and location.

Moreover, nothing precludes the application of this chapter's approach beyond China, and it is suitable for analysing regions which exhibit a high degree of labour market heterogeneity. As the model affords the interpretation of trade between countries which have high barriers to immigration but low barriers to capital and input flows, it is also suitable for analysing firm behaviour across national borders. Further work could leverage or extend the approach of combining firm, census and geographic data to better understand the role of local factor markets in hiring, input usage and firm dynamics.

In the second chapter, I propose a property-rights model where the degree of integration is continuous and becomes a choice variable. Due to incompleteness of contracts and investment specificity, higher ownership share leads to a bigger incentive for parent firm to invest but decreases its supplier's contribution.

The model yields two main predictions for firms under vertical integration. Firstly, the degree of integration is expected to be high when the relative importance of headquarter's investment which is proxied by capital intensity is high. When supplier's contribution which is proxied by skill intensity is large, parent firms optimally choose lower ownership share. Thai manufacturing census allows me to divide the universe of foreign owned affiliates into three groups; horizontal, vertical and mixed integration. Empirical results confirm the first prediction of the model. The results are highly robust against many checks. Furthermore, they reveal that the effects of factor intensities on ownership are heterogeneous across integration types. This emphasises that it is important to only include vertically integrated firms in the sample when testing property-rights theories which are only applied to those firms.

The empirical results on the first prediction also suggests that the normal rational behind the property rights model might be sufficient to explain the degree of ownership under horizontal integration while extra elements are needed in order to explain the opposite results under mixed integration. An extension to my model and further empirical tests on this surprising result are possible venues for further work.

The second prediction from the model states that the marginal effects of capital and skill intensities on ownership should be higher when the elasticity of substitution across varieties is high. Final good producers increase ownership in order to be able to seize a bigger share of inputs when negotiation breaks down resulting in a higher outside option. When the elasticity is low, which implies that the market is not competitive, equilibrium price is steep. In this case, seizing a small amount of inputs can still generate high outside option without increasing the ownership. Hence ownership is less sensitive to the importance of headquarter's investment under low elasticity. The empirical results along with their robustness checks confirm the prediction. This strengthens the validity of the property-rights model in this chapter which is based on continuous and endogenous degree of integration. A possible further work is to check whether the predictions are still valid under datasets from other countries.

The third chapter shows how product quality affects firms' decision on their ownership structure through a heterogeneous-firm model with product-quality differentiation where firms choose whether to produce relevant inputs in-house or outsource input production. Firms face a trade-off between a sub-optimal quality (under outsourcing) and a higher fixed cost (under vertical integration). Their decisions depend on the values of several important parameters and different sets of values lead to different equilibrium. The model provides closed form solutions for all variables across all equilibria.

In general, when the hold-up problem - which leads to sub-optimal product quality - becomes less severe and quality does not matter much, then outsourcing is preferred. Conversely, when quality matters a lot, firms are willing to pay a higher fixed cost and opt for vertical integration in order to avoid the hold-up problem. Also, more productive firms are more likely to choose vertical integration when quality matters because they are more capable of covering the higher fixed costs. The effects of the hold-up problem and the intensity of preference-for-quality on the productivity threshold are larger when productivity lowers the endogenous part of fixed costs instead of marginal costs. This is because profits are less sensitive to a change in productivity when productivity only affects fixed costs.

The area of future research includes the empirical test of the predictions. The test requires three main elements: a good measure of product quality, firm-level productivity and the importance of quality in each industry. There are several of good candidates for the latter element which include the estimates of quality ladders in Khandelwal (2010). A detailed intra-firm trade data can provide a measure for product quality. Using unit price as a measure of quality is not accurate unless product code is disaggregated enough up to the point where different product codes really represent different products (i.e. HS8 or HS10). Once the data is obtained, unit price will be the measure of product quality. With firm-level productivity, empirical exercises can be set up to test the predictions. Another possible future work is to endogenise the matching process.

This thesis generates several new insights into how firms organise their production. Those new insights include how firms hire their heterogeneous workers and choose their locations, how existing results about firm ownership change when the degree of ownership becomes a continuous choice variable and how product quality affects firms' decisions on their ownership structure. Several policies implications can be taken from these three chapters and this thesis also extends the boundaries of related literature by providing many future research possibilities.

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