The Influence of Markets on the Division of Labor

by

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DEDICATION

To my academic advisor, Brian Wu

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"A teacher affects eternity; he can never tell where his influence stops."

-Henry Adams (1918)

This dissertation on the division of labor has as many fathers and mothers as the teachers I had. The author's "we" throughout the manuscript is a constant reference to their help.

Among my teachers, I am especially indebted to Brian, my academic advisor. My dissertation is dedicated to him, whose teachings I will follow when teaching to my own students.

I am grateful to Jagadeesh, Minyuan, Gautam, and Ying, who serve on my committee, and to the scholars I encountered during my stay in Michigan. I owe gratitude to my parents, who are my first teachers, and to my younger siblings, who are my first students. I am thankful to my wife, to whom I dedicate my future, and to the teachers I never met but cite in my work. In the seminars I attend in my imagination, I raise my hand to ask them if they see what I see. Sometimes, I try to see a little further.

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ABSTRACT

Understanding the workings of the division of labor is a critical research goal for economists and strategy scholars alike. For economists, the division of labor is a distinguishing feature of capitalism and a primary driver of productivity gains in the economic system. For strategy scholars, who study heterogeneity in firm performance, the division of labor among firms is inherently intertwined with the identification of factors determining why some firms outperform others.

Within this topical research stream, this dissertation comprises two studies examining how the division of labor is influenced by the supply side and the demand side of markets. In the first study, we examine the supply side. Using a formal model, we identify the firm resources that are precursory to integration, to taper integration, and to the division of labor.

In the second study, we examine the demand side. We argue that demand characteristics such as market size and the heterogeneity of consumers' valuations impact the costs and benefits of the division of labor. We find empirical support for the theory from large-scale longitudinal data covering the real estate industry in Southeast Michigan.

CHAPTER 1: INTRODUCTION

"The fundamental social phenomenon is the division of labor and its counterpart human cooperation. Experience teaches man that cooperative action is more efficient and productive than isolated action ..."

- Ludwig von Mises (1949)

The division of labor is a classical topic of intellectual debate. For Plato, cooperation through the division of labor is the historical foundation of sociality and, ultimately, of the state. For Rousseau, the division of labor increases the dependence among self-interested individuals, who may employ insincerity and opportunistic behavior to game the system to their own advantage (Evers 1980).

This dichotomy between competition and cooperation plays a critical role in the formulation of the theory of the division of labor among firms – i.e., the theory examining the extent to which different firms co-specialize in distinct activities necessary to produce products and services. Economists, in particular, emphasize opportunism as one of the main constraints to the division of labor (Grossman and Hart 1986; North 1991; Williamson 1975).

In contrast to opportunism-based explanations, the students of the resource-based view draw on Ricardian ideas about resource heterogeneity as the source of gains from the division of labor (e.g. Argyres 1996; Conner & Prahalad, 1996; Madhok, 2002). The intuitive argument advanced by this literature is that firms should allocate their resources to the value-adding activities they perform better or at a lower cost than their suppliers (Argyres 1996; Barney 1999; Fabrizio 2012). If the opposite holds true, gains from the division of labor are available and outsourcing may take place (Jacobides and Hitt 2005; Jacobides and Winter 2005).

In this dissertation, we join the debate within the resource-based view and enrich the scholarly conversation with a more holistic approach, extending the resource-based logic to the influence of markets on the division of labor. Markets are conceptualized as unique intercepts of supply and demand characteristics delineating the environments in which firms operate. Supply characteristics include the types of heterogeneous resources that firms may allocate along the value chain. Demand characteristics include market size and the heterogeneity of consumers' valuations.[1]

We investigate this research topic with two studies. In the first study, coauthored with Brian Wu[2] and Deepak Somaya,[3] we analyze the supply side. Using a formal model, we identify the attributes of the resources employed in the processes of production that are precursory to the division of labor, to integration, and to taper integration. Taper integration, specifically, is defined as the extent to which firms concurrently produce and outsource a given input. In the second study, the emphasis is on the demand side. We argue that demand characteristics such as market size and the heterogeneity of consumers' valuations impact the costs and benefits of the division of labor.

[1] In Chapter 3, the heterogeneity of consumers' valuations is defined as the extent to which some customers in the market are more valuable to firms than other customers.
[2] Assistant professor of Strategy at the University of Michigan.
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In the following section of this chapter, we motivate the study of the influence of markets on the division of labor. Subsequently, we propose a synopsis of the methodology employed in each study.

1.1 MOTIVATION

The conception that supply characteristics may impact the division of labor is rooted in the resource-based tradition. To our knowledge, this literature can be summarized in one key prediction: *ceteris paribus*, firms will internalize the value-adding activities in which they are more capable than their suppliers (Amit and Schoemaker 1993; Argyres 1996; Demsetz 1988; Jacobides 2008; Jacobides and Hitt 2005; Jacobides and Winter 2005; Kaul 2013; Kogut and Zander 1992; Langlois 1992; Madhok 2002; Mayer and Salomon 2006; Teece 1988).

The hypothesis that the most productive firms will integrate is based on the assumption that firms can easily scale up their operations and simultaneously operate multiple value adding activities. Here, however, we challenge this assumption and, in doing so, we turn the canonical resource-based prediction on its head, uncovering a set of instances in which the most productive firms may prefer the division of labor to integration.

In the first chapter, we borrow insights from recent developments in the literature on diversification, identifying scalability – i.e., the extent to which resources may be employed in multiple uses concurrently (Levinthal and Wu 2010) - as an important resource attribute precursory to integration, to taper integration, and to the division of labor. We show that a productivity advantage of a firm with respect to its suppliers has little impact on its integration strategies and propose a mechanism by which integration occurs when firms have similar resource endowments.

In the second study, the emphasis is on the demand-side of markets and its influence on the division of labor in service settings. The notion that demand perturbations may affect the division of labor is one of the oldest in economic history, dating back to the pre-industrial period. In *The Wealth of Nations* (1776), Adam Smith writes in a famous pass (1776: I.3.2): "There are some sorts of industry, even of the lowest kind, which can be carried on nowhere but in a great town. A porter, for example, can find employment and subsistence in no other place. A village is by much too narrow a sphere for him…" The Smithean conjecture that the division of labor is limited by the extent of the market (Smith 1776; Stigler 1951) conforms to empirical observations and it has been validated by multiple historical accounts (Macher and Mowery 2004). Yet, existing theories do not account for its occurrence, suggesting that this topic deserves further development.

In the resource-based view, in particular, the division of labor is fully determined by inter-firm productivity differentials. Therefore, market characteristics are inconsequential. This happens because of the assumption that firms are not resource constrained, which implies that firms should perform any activity in which they possess a productivity advantage independently of market characteristics. While this assumption may be true in capital intensive industries, where firms enjoy economies of scale, it loses its theoretical bite in human-capital intensive settings, such as service industries, where firms are on average smaller (Choi and Spletzer 2012; Garicano and Hubbard 2009) and may be resource constrained because of their limited ability to acquire and manage human capital (Barney 1986; Penrose 1959). When firms are resource constrained, the division of labor increases productivity because it allows firms to focus their resources on a subset of the activities necessary to bring products and services to markets. However, when firms divide labor, they also divide value, incurring the costs of sharing the "pie" they contribute to create. Resource constrained firms must then choose between dividing labor with other firms to capture of portion of the “pie” for a larger number of customers and integrating to capture the whole pie for a smaller number of customers. This allocation of human assets to complementary activities is likely to depend on the returns these assets generate in alternative allocations (Levinthal and Wu 2010; Sakhartov and Folta 2013) and these, in turn, are determined by demand characteristics. Therefore, in settings where firms are resource constrained, such as service industries, demand characteristics are likely to be a key determinant of the costs and benefits of the division of labor.

1.2 RESEARCH DESIGN

Methodologically, the thesis advanced in Chapter 2 is analyzed through a *biform game* (Brandenburger and Stuart 2007). *Biform games* are formal models consisting of a noncooperative stage and a cooperative stage. *Biform games* are elected as one of the methodological drivers of this dissertation because their structure closely mirrors the competition-cooperation dichotomy inherent in the division of labor.

In Chapter 3, we find support for the theory using large-scale longitudinal data. At the time of their writing Adam Smith drew insights from butchers, bakers and brewers in the Highlands of Scotland (1776), and George Stigler from the Lancashire textile industry (1951); nowadays the productive system in developed economies is mainly devoted to the tertiary sector. Moving with the times, we gather evidence from a service industry, namely, the residential real estate brokerage industry in Southeast Michigan. Chapter 3 includes a detailed description of the data sources, variables, and model specifications.

CHAPTER 2: RESOURCE ATTRIBUTES AND THE DIVISION OF LABOR[4]

2.1 INTRODUCTION

"[I]t is easy to forget that outsourcing is simply one manifestation of the division of labor."

- Arora, Vogt, and Yoon (2009)

Value chains consist of complementary activities that represent different phases of a process of production (Balakrishnan and Wernerfelt 1986; Richardson 1972; Teece 1986). The question of which activities should be conducted inside the firm and which ones should be outsourced to other firms has long been of interest to the students of the resource-based view. The canonical answer to this question resides in the concept of firm heterogeneity, according to which some firms are more productive than others at some activities. Firm heterogeneity is posited to imply that firms should perform the value-adding activities in which they have a productivity advantage with respect to the other firms in the industry. This allocation of firms to activities increases the value created by the value chain and the firms' potential for earning higher Ricardian rents from their resources (Argyres 1996; Barney 1999; Fabrizio 2012; Jacobides and Hitt 2005; Kaul 2013; Langlois 1992; Madhok 2002).

In this chapter, we argue that this logic is incomplete. While prior work treats firms as heterogeneous, assuming they have different productivities, it overlooks resource heterogeneity within firms – i.e., the extent to which firms use different resources to attain a given productivity

[4] This chapter is coauthored with Brian Wu, assistant professor of Strategy at the University of Michigan, and Deepak Somaya, associate professor of Strategy & Entrepreneurship at the University of Illinois.

level. Using a formal model that casts the vertical integration problem as a *biform game* (Brandenburger & Stuart, 2007), we decompose resource heterogeneity into two resource attributes previously examined in the context of diversification strategies: (i) fungibility, defined as the extent to which resources may have multiple uses along the value chain; and (ii) scalability, defined as the extent to which fungible resources may be employed in multiple uses concurrently or in a single use at the time.

Our analysis of the impact of resource attributes, individually and in combination, on vertical scope provides multiple insights. First, we show that non-scalable resources are likely to be conductive to specialization. Firms endowed with non-scalable resources may in fact prefer to focus their resources on a smaller subset of value-adding activities rather than spread too thin along the value chain. Second, we provide a different interpretation of the phenomenon of vertical integration. In contrast to the canonical resource-based prediction, we find that a productivity advantage (relative to other firms) is neither necessary nor sufficient for a firm to integrate into a particular activity. In our model, in fact, integration arises when firms have similar resource endowments. Finally, we find a novel precursor to taper integration (Jacobides and Hitt 2005; Puranam, Gulati, and Bhattacharya 2013). Taper integration is defined as the extent to which firms concurrently produce and outsource an input required in the process of production. We show that an excess of non-scalable, fungible resources is a necessary and sufficient condition for taper integration. Firms with deep stocks of non-scalable resources in relation to their suppliers are more likely to operate along multiple value adding stages, preferring taper integration to full integration.

These findings contribute to the resource-based view by shedding new light on the impact of resources on the vertical strategies of firms. Our analysis negates the canonical prediction that firms should internalize the production of complementary activities in which they have a productivity advantage (Argyres 1996; Barney 1999; Fabrizio 2012; Jacobides and Hitt 2005; Kaul 2013; Langlois 1992; Madhok 2002).

2.2 LITERATURE REVIEW

The view that resources and capabilities may impact the division of labor along the value chain has numerous proponents. In a seminal paper applying Penrose's *The Theory of Growth of the Firm* (1959) to the division of labor, Richardson (1972) argues that the relationship among specialized firms along the value chain is akin to cooperation. Cooperation is the result of technical specialization and of the complementarities among different phases of the processes of production. Firms tend to specialize and perform technically related activities. However, because the activities along the value chain may require distinct technical competences, the cooperation of multiple specialized firms may be necessary to bring products to markets.

Demsetz (1988) stresses that the different capabilities of firms in the value chain are due to the role of the management. Conner and Prahalad (1996) advance this notion and formulate a resource-based theory of the firm. Capabilities arise from the entrepreneur's knowledge and disseminate within the organization through the employment contract, which requires employees to apply the knowledge of the entrepreneur to tasks. The capabilities of firms, however, may accumulate and persist even after changes in management because firms are social communities that share and transfer knowledge from the individual members into the organizing principles of cooperation within the firm (Kogut and Zander 1996).

The theoretical speculations on the role played by knowledge and capabilities on the type of activities conducted inside the firm have spurred investigations by multiple scholars (Amit and Schoemaker 1993; Argyres 1996; Jacobides 2008; Jacobides and Hitt 2005; Jacobides and

Winter 2005; Kaul 2013; Kogut and Zander 1992; Langlois 1992; Madhok 2002; Mayer and Salomon 2006; Teece 1988). These studies summarize the role played by the firm's capabilities and resources on vertical scope with the following prediction: *ceteris paribus*, firms will internalize the activities in which they possess a productivity advantage with respect to their suppliers/buyers. For instance, according to Jacobides (2005: 1212):

"To make headway in a theory of capability-based analysis of vertical scope, we must further refine the concept of capability. An important distinction we introduce in this paper is the distinction of productive capabilities of a firm (productive efficiency or 'zero-order capabilities'—see Winter, 2003) in each of the vertically related stages, vs. the capabilities of governance, the ability of a particular firm to use integration or the market to create value by linking these stages. To be precise about this distinction, we introduce some notation. Consider a firm that performs an upstream activity (e.g., production) and is considering whether to insource or outsource a downstream activity (e.g., sales). Let the efficiency of the downstream activity for the focal firm (i) be represented by p_i, and the bureaucratic cost of integrating both activities internally, including the cost of muted incentives, as B_i. Similarly, let the productivity of a potential outside vendor (j) be represented by p_j and the transactions cost for firm i procuring product from that vendor j through the market be represented by TC_{ij}. In this framework, the vertical integration decision depends on the comparison of whether $p_i - B_i > p_j - TC_{ij}$."

The logic behind this argument is intuitive. If firms have different capabilities that cannot be traded in the strategic factor market (Barney 1986; Dierickx and Cool 1989), they should internalize the activities in the value chain in which they have a productivity advantage. This positive assortative matching of firms to activities may increase the value created by the value chain, increasing the pie from which vertically related firms extract their rents.

Recent developments in the literature on horizontal scope, however, argue that much of the previous resource-based work is based on the implicit assumption that capabilities have a scale-free property (Levinthal and Wu 2010; Sakhartov and Folta 2013). In other words, capabilities are assumed to display "some of the characteristics of a public good in that it may be used in many different non-competing applications without [their] value in any one application being substantially impaired (Teece 1980: p. 226)." This may be true for some knowledge artifacts underpinning the productivity of firms, such as patents, brands, and reputation, which may be used by firms in multiple competing applications. Yet, other resources, such as managers and employees, who are the embodiment and depositaries of the capabilities of firms, may be non-scalable – i.e., they may be deployed only in one activity at the time (Anand and Singh 1997; Capron 1999; Helfat and Eisenhardt 2004; Mitchell and Shaver 2003; Puranam and Srikanth 2007; Teece 1980; Zollo and Singh 2004). Compared to the public good nature of scale-free resources, non-scale free resources are fixed in their supply at any point in time and their accumulation is often costly and lengthy (Atalay, Hortaçsu, and Syverson 2014; Dierickx and Cool 1989; Helfat 1997; Penrose 1959; Teece, Pisano, and Shuen 1997). These fixities in non-scalable resources are such that the allocation of resources to activities is subject to an opportunity-cost logic, which we examine in the model delineated in the next paragraph.

This opportunity cost logic is somewhat related to the notion of comparative advantage in international trade (Richardson 1972). Because it is unclear whether and how the fundamental logic (the opportunity costs of using resources) that drives comparative advantage at the country level extends to firms, the model in the next section formally examines the different resource attributes (fungibility and scaleability) that the recent literature has introduced to study the constraints firms face when expanding their resource base.

2.3 THE MODEL

2.3.1 The economy

In this section, we present a model examining the incentives of firms to either specialize or integrate in response to their resource endowments. Our approach follows the form of two-stage biform games (Brandenburger & Stuart, 2007), consisting of a noncooperative stage solved using the concept of *Nash equilibrium*, and a cooperative stage solved using the concept of *core*.

The economy in the model has a value chain where 2 firms –1 and 2 - may allocate their resources either upstream, downstream, or both. We follow the traditional practice in the literature on the division of labor and on vertical specialization (Ames and Rosenberg 1965; Balakrishnan and Wernerfelt 1986; Becker and Murphy 1992; Bikard, Murray, and Gans 2015; Dixit and Grossman 1982; Jacobides 2008; Rosen 1978, 1982; Stigler 1951) and assume a fixed-proportion Leontief production function such that one unit of the final good requires one unit of the downstream input and one unit of the upstream intermediate input. This type of function is the theoretical analogous to a range of empirical production processes. For instance, in industries such as the automotive industry, the computer industry, and the mobile-phone industry, the number of inputs provided by suppliers to final assemblers (e.g., wheels, motherboards, operating systems) is proportional to the number of final goods sold (e.g., cars, desktops, smartphones). Formally:

$$Q = \min\left\{\sum_{i\in\{1,2\}} S_i\,;\ \sum_{i\in\{1,2\}} B_i\right\}, \tag{1}$$

where $S_i \in \mathbb{R}^+$ and $B_i \in \mathbb{R}^+$ are the intermediate downstream and the upstream inputs, respectively, and $Q \in \mathbb{R}^+$ is the final good. The final good is sold in a market characterized by a perfectly elastic demand, where consumers' willingness to pay is normalized to 1.

The production of the intermediate inputs follows a stage specific production function such that:

$$S_i = g_i \varepsilon_{is} \tau_i, \quad (2)$$

$$B_i = g_i \varepsilon_{ib} (1 - \tau_i). \quad (3)$$

The parameter $\tau_i \in [0,1]$ indicates the percentage of firm *i*'s non-scalable resources allocated in upstream production. Similarly, the expression $(1 - \tau_i)$ indicates the percentage of firm *i*'s non-scalable resources allocated downstream. Non-scalable resources consist of a fungible and of a non-fungible component. The fungible component is represented by g_i, which indicates the extent to which the productivity of the non-scalable resources is constant across stages of production. The non-fungible component is represented by the parameter ε_{ij}, which indicates the stage-specific productivity of the non-scalable resources.

Note that firms can allocate any portion $\tau_i \in [0,1]$ of their non-scalable resources either upstream or downstream. When $\tau_i = 0$, firm *i* specializes as a buyer; when $\tau_i = 1$, firm *i* specializes as a supplier; when τ_i is set such that $S_i = B_i$ – i.e., $\tau_i = \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}$ - firm *i* is a vertically integrated company; for any other value of τ_i we observe taper integration (see Figure 1 for a graphical representation).

[Insert Figure 1 approximately here]

2.3.2 The game

The *Game* analyzed in our model is a *biform game* consisting of 2 stages. In the first stage, firms decide the production quantities of S_i and B_i based on the realizations of the parameters of the model. In the second stage, the value crated by the economy is split among its constituents in accordance with a payoff profile contained in the *core*. The *core* is the solution concept for coalitional games with transferrable payoffs. A coalitional game is identified by the duple $\langle N, v(\cdot)\rangle$, where N is the set of players, and $v(\cdot)$ is a function that associates with every nonempty subset S of N (a coalition) a real number $v(S)$. In our model, the set of players is given by the two firms, 1 and 2, and the value function is given by the following:

$$\mathrm{v}(S) = \min\left\{\sum_{i\in S} S_i\, ; \sum_{i\in S} B_i\right\}. \tag{4}$$

The value function of the *Game* has the following properties. First, the value generated by a non-cooperating firm equals its production as an integrated entity, e.g., $v(S = \{1\}) = \min\{S_1; B_1\}$. Second, the value generated by both firms when cooperating can be equal (i) to the summation of the value they generate as integrated entities, e.g., $v(N = \{1,2\}) = \min\{S_1; B_1\} + \min\{S_2; B_2\}$, (ii) to the value they generate as specialized entities, e.g., $v(N = \{1,2\}) = \min\{S_1 + 0; B_2 + 0\}$, and (iii) to the value they generate when opting for a taper integration set up, e.g., $v(N = \{1,2\}) = \min\{S_1 + S_2; B_1 + B_2\}$ with $S_1 \neq B_1$ and $S_2 \neq B_2$.

2.3.3 The Cooperative Stage

Because the *Game* is an extensive game with perfect information, it is solved by backward induction, starting from the final coalitional stage. The following lemma characterizes the *core* of the coalitional stage.

Proposition 1*: Let* $\alpha \in [0,1]$. *The core of the coalitional stage of the Game coincides with the collection of payoff profiles* $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ *assigning the payoff:*

a. $\pi_1(\alpha) = \begin{cases} \min\{S_1; B_1\} + \alpha \times \min\{S_1 - B_1; B_2 - S_2\} \ if \ S_1 \geq B_1 \ and \ B_2 \geq S_2, \\ \min\{S_1; B_1\} + \alpha \times \min\{B_1 - S_1; S_2 - B_2\} \ if \ S_2 > B_2 \ and \ B_1 > S_1, \end{cases}$

to firm 1 and the payoff:

b. $\pi_2(\alpha) = \begin{cases} \min\{S_2; B_2\} + (1-\alpha) \times \min\{S_2 - B_2; B_1 - S_1\} \ if \ S_2 \geq B_2 \ and \ B_1 \geq S_1, \\ \min\{S_2; B_2\} + (1-\alpha) \times \min\{B_2 - S_2; S_1 - B_1\} \ if \ S_1 > B_1 \ and \ B_2 > S_2, \end{cases}$

to firm 2.

Proof. The collection of payoff profiles $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ is feasible because $\pi_1(\alpha) + \pi_2(\alpha) = v(\{1,2\})$. Furthermore, the collection of payoff profiles $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ is in the core because firms are better off by joining the grand coalition. If they do not join the grand coalition, their payoff is at most $\min\{S_i; B_i\}$, which is no better than the payoff $\pi_i(\alpha)$. Therefore, $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ is in the core.

To prove $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ coincides with the core, assume the core contains a payoff profile $(y_i)_{i\in\{1,2\}}$ which is not an element of $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$. Because $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ is a convex set in $\alpha \in [0,1]$, $(y_i)_{i\in\{1,2\}}$ does not belong to $\left(\pi_i(\alpha)\right)_{i\in\{1,2\}}$ if at least one of the following is true:

1. $y_1 < \min\{S_1; B_1\}$
2. $y_1 > \min\{S_1, B_1\} + \alpha \min\{|S_1 - B_1|, |B_2 - S_2|\}$
3. $y_2 < \min\{S_2; B_2\}$
4. $y_2 > \min\{S_2, B_2\} + (1-\alpha) \min\{|S_1 - B_1|, |B_2 - S_2|\}$.

But if point 1 or 3 are true, then $(y_i)_{i\in\{1,2\}}$ is not in the core. If either point 3 and 4 are true, $(y_i)_{i\in\{1,2\}}$ is not feasible. Q.E.D.

In the remaining of the paper, we set α equal to ½. This means that when firms specialize, they share the value created equally. From a modelling standpoint, the choice of setting α equal to ½ can be compared to the equilibrium outcome of a bargaining game. From an analytical standpoint, this choice is in line with the objectives of the model. Because the main focus of this study is to analyze vertical strategies in the spirit of the resource-based literature, which abstracts from haggling and opportunistic behaviors (Conner and Prahalad 1996; Kogut and Zander 1996), it is intuitively appealing to allocate the surplus generated by the value chain equally between the buyer and the supplier.

2.3.4 The Noncooperative Stage

The solution of the cooperative stage characterizes firm 1 and firm 2's objective functions, whose analysis allows for the identification of the optimal strategies of the *Nash equilibrium* of the non-cooperative stage. Firm 1 may find itself in three situations. In the first situation, firm 2 may opt for an integration strategy such that $S_2 = B_2$. In the second one, firm 2 may opt for a strategy entailing $S_2 > B_2$, meaning that firm 2 has allocated the majority of its resources upstream and it has partly or totally specialized as a supplier. In the third one, firm 2 may opt for a strategy entailing $B_2 > S_2$, meaning that firm 2 has allocated the majority of its resources downstream and it has partly or totally specialized as a buyer. When $S_2 = B_2$, firm 1 must integrate as well. If one of the two firms opts for an integration strategy, the other firm must also integrate because there is either no "buyer" or "supplier" in the market for intermediate inputs.

When $S_2 > B_2$, firm 2 produces an excess supply of the intermediate upstream good to be sold in the intermediate good market. For firm 1, any optimal strategy leads to an outcome such that $B_1 \geq S_1$. Firm 1 is best either by integrating or by injecting in the intermediate good market an excess supply of the downstream good. Any strategy entailing $B_1 < S_1$ can be excluded because there is no buyer in the market (both firms become suppliers) and at least one firm has incentives to deviate and reduce the unsold excess supply of the intermediate upstream good. Therefore, firm 1's maximization problem is given by:

$$\max_{t_1} \quad g_1\varepsilon_{1s}\tau_1 + \frac{1}{2}[g_1\varepsilon_{1b}(1-\tau_1) - g_1\varepsilon_{1s}\tau_1] \tag{5}$$

Subject to

$$g_1\varepsilon_{1b}(1-\tau_1) - g_1\varepsilon_{1s}\tau_1 \leq S_2 - B_2 \tag{6}$$

The maximization problem presented in (5) can be described as follows. The quantity of the final good produced in-house is $g_1\varepsilon_{1s}\tau_1$, which is less than or equal to $g_1\varepsilon_{1b}(1-\tau_1)$ because $B_1 \geq S_1$. The quantity of the downstream input produced is given by $g_1\varepsilon_{1b}(1-\tau_1) - g_1\varepsilon_{1s}\tau_1$. The ½ preceding the expression in the square brackets accounts for the fact that firm 1 receives only half of the price of the final good for every unity of the downstream input produced. The inequality in (6) is a simple market clearing constraint that must hold in equilibrium.

After some simple algebra, firm 1's unconstrained best response function when $S_2 > B_2$ is given by the following expression:

$$\tau_1^* = 0 \; if \, \frac{\varepsilon_{1s}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}, else \; \tau_1^* = \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}. \tag{7}$$

When $B_2 > S_2$, firm 2 produces an excess supply of the intermediate downstream good. For firm 1, any optimal strategy leads to an outcome such that $S_1 \geq B_1$. Any strategy entailing $S_1 < B_1$ can be excluded because the market does not clear. Firm 1's maximization problem is therefore given by the following:

$$\max_{t_1} \quad g_1\varepsilon_{1b}(1-\tau_1) + \frac{1}{2}[g_1\varepsilon_{1s}\tau_1 - g_1\varepsilon_{1b}(1-\tau_1)] \tag{8}$$

Subject to

$$g_1\varepsilon_{1s}\tau_1 - g_1\varepsilon_{1b}(1-\tau_1) \le B_2 - S_2 \tag{9}$$

The maximization problem presented in (8) can be described as follows. From firm 1 perspective, the quantity of the final good produced in-house is $g_1\varepsilon_{1b}(1-\tau_1)$, which is less than or equal to $g_1\varepsilon_{1s}\tau_1$ because $S_1 \ge B_1$. The quantity of the upstream input produced is given by $g_1\varepsilon_{1b}(1-\tau_1) - g_1\varepsilon_{1s}\tau_1$. Also in this case, the ½ preceding the expression in the square brackets accounts for the fact that firm 1 receives only half of the price of the final good for every unity of the upstream input produced. The inequality in (9) is the market clearing constraint.

After some simple algebra, firm 1's unconstrained best response function when $S_2 > B_2$ is given by the following expression:

$$\tau_1^* = 1 \; if \; \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}, else \; \tau_1^* = \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}. \tag{10}$$

Firm 2's strategies are a mirror image to firm 1's, meaning that equations (7) and (10) are a good approximation of the equilibrium behavior of firm 2. The equilibrium outcomes of *The Game* are graphically represented in Figure 2 and fully characterized by the following proposition:

Proposition 2: The unique equilibrium of *the Game* consists of an action profile $\tau^* = (\tau_1^*, \tau_2^*)$ such that:

1. If $\frac{\varepsilon_{1s}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}$ and $\frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}} < \frac{1}{2}$, then $\tau_1^* < \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}$ and $\tau_2^* > \frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}}$. If $g_1\varepsilon_{1b} = g_2\varepsilon_{2s}$, then $\tau_1^* = 0$ or $\tau_2^* = 1$ so that firm 1 and firm 2 specialize as a buyer and as a

supplier, respectively. If $g_1\varepsilon_{1b} > g_2\varepsilon_{2s}$, then $0 < \tau_1^* < \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}$ and $\tau_2^* = 1$, with firm 1 adopting a taper integration set up and with firm 2 specializing as a supplier. If $g_1\varepsilon_{1b} < g_2\varepsilon_{2s}$, then $\tau_1^* = 0$ and $1 > \tau_2^* > \frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}}$, with firm 1 specializing as a buyer and firm 2 adopting a taper integration set up.

2. If $\frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}$ and $\frac{\varepsilon_{2s}}{\varepsilon_{2s}+\varepsilon_{2b}} < \frac{1}{2}$, then $\tau_1^* > \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}$ and $\tau_2^* < \frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}}$ If $g_1\varepsilon_{1s} = g_2\varepsilon_{2b}$, then $\tau_1^* = 1$ or $\tau_2^* = 0$ so that firm 1 and firm 2 specialize as a supplier and as a buyer, respectively. If $g_1\varepsilon_{1s} > g_2\varepsilon_{2b}$, then $1 > \tau_1^* > \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}$ and $\tau_2^* = 0$, with firm 1 adopting a taper integration set up and with firm 2 specializing as a supplier. If $g_1\varepsilon_{1s} < g_2\varepsilon_{2b}$, then $\tau_1^* = 1$ and $0 < \tau_2^* < \frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}}$, with firm 1 specializing upstream and firm 2 adopting a taper integration set up.
3. If $\frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}$ and $\frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}} < \frac{1}{2}$ or if $\frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}} > \frac{1}{2}$ and $\frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}} > \frac{1}{2}$, then $\tau_1^* = \frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}}$ and $\tau_2^* = \frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}}$ so that both firms integrate.

Sketch of the proof. From (8) and (11), it can be deduced that the division of labor outcome of point 1) and 2) arises if and only if $\frac{\varepsilon_{1s}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}$ and $\frac{\varepsilon_{2b}}{\varepsilon_{2s}+\varepsilon_{2b}} < \frac{1}{2}$ or $\frac{\varepsilon_{1b}}{\varepsilon_{1s}+\varepsilon_{1b}} < \frac{1}{2}$ and $\frac{\varepsilon_{2s}}{\varepsilon_{2s}+\varepsilon_{2b}} < \frac{1}{2}$. Taper integration arises if and only if the full specialization outcome is constrained by the market clearing constraints (6) and (9). If the division of labor outcomes cannot be achieved, then both firms have no other option but integrating as in point 3).

Proposition 2 suggests the following. When firms' productivity is driven by similar types of resources, such that both firms have an “internal” preference for the same value-adding activity, we observe integration. When firms are similar, there are no gains from the division of labor and integration is their last resort. Alternatively, when the division of labor dominates, firms try to allocate as much of their resources to the value adding stage they perform internally best. However, they are constrained by the productivity of their own trading partner. These constraints lead to taper integration. If one of the trading partners is resource constrained, the partner with excess resources fills up the gap and provides the intermediate value-adding activities that cannot be performed by the constrained firm.

Interestingly, while our results are determined by the same opportunity cost logic of the models of comparative advantage, the firms in our model do not specialize in accordance with their comparative advantage, but in accordance with their "internal advantage". Specifically, firms specialize in what they do "internally" best, with the comparison being made with respect to the firms' own capabilities, not with respect to the capabilities of the other firms in the industry.

[Insert Figure 2 approximately here]

2.4 COMPUTATIONAL EXAMPLE

To expand on the analysis, we propose a computational simulation as follows. We assume that the fungible component of firms' resources is represented by the random variable $g_i \sim |\mathrm{N}(1,1)|$.[5] Similarly, the non-fungible component is also a random variable $\varepsilon_{ij} \sim |\mathrm{N}(1,1)|$.[6] We run the simulation 100 times. At every round, we generate new realizations of the parameters g_1, g_2, ε_{1s}, ε_{1b}, ε_{2s}, ε_{2b} according to the distributions specified above and compute (i) the percentage of firms that integrate, (ii) the percentage of firms that opt for taper integration, (iii) the percentage of superior firms that integrate, and (iv) the percentage of integrating firms that are superior. If the percentage of superior firms that integrate - point (iii) – is equal to 100% then being superior

[5] g_i is a random variable distributed according to a folded normal distribution with mean 1 and standard deviation 1.
[6] ε_{ij} is a random variable distributed according to a folded normal distribution with mean 1 and standard deviation 1.

is a necessary condition for integration. In addition, if 100% of the firms that integrate are superior – point (iv) - then being superior is also a sufficient condition for integration.

2.4.1 Integration vs. division of labor

In 49% of the simulations, firms prefer not to fully integrate upstream and downstream. The high frequency of cases in which firms prefer not to integrate is due to the productivity advantages arising from activity specialization when firms operate mainly with non-scale free resources. When firms operate with non-scale-free resources, they face the opportunity cost of allocating their resources either upstream or downstream. If they operate in both stages, they have to spread their resources along both activities, reducing their overall productivity. Firms, in fact, can increase production by concentrating their non-scale-free resources on specific value-adding activities, thus generating "gains from the division of labor".

To see why specialization is advantageous in our model, consider a scenario where, for a given amount of capital, firm 1 can produce 3 units of S_1 if it specializes upstream (τ_1=1), 2 units of B_1 if it specializes downstream($\tau_1 = 0$), or 1.2 units of the final good if it integrates ($\tau_1 = \frac{2}{3+2}$ such that $S_1 = \tau_1 \times 3 = B_1 = (1 - \tau_1) \times 2 = 1.2$) . For $\alpha = \frac{1}{2}$, firm 1 prefers to specialize upstream rather than to integrate ($\alpha \times \pi_1(\tau_1 = 1) = 1.5 > \pi_1\left(\tau_1 = \frac{2}{3+2}\right) = 1.2$). If firm 2 can produce 1 units of S_2 if it specializes upstream (τ_2=1), 3 units of B_2 if it specializes downstream (τ_2=0), or 0.75 units of the final good if it integrates ($\tau_2 = \frac{3}{1+3}$ such that $S_2 = \tau_2 \times 1 = B_2 = (1 - \tau_2) \times 3 = 0.75$). For $\alpha = \frac{1}{2}$, firm 2 prefers to specialize downstream rather than to integrate ($(1 - \alpha) \times \pi_2(\tau_2 = 0) = 1.5 > \pi_2\left(\tau_2 = \frac{3}{1+3}\right) = 0.75$). In the example, both firm 1 and firm 2 prefer to specialize upstream and downstream, respectively, allocating their non-scalable resources to the activities they perform comparatively better. Note that if both firms specialize, the value chain will produce 3 units of the final good. This is much more than 1.95 (i.e., 1.2 + 0.75) units it will produce if both firms integrate.

In 51% of the simulations, the firms in our model opted for an integration strategy. Only 69% of the firms that are superior to their trading partner both upstream and downstream opted for an integration strategy. Similarly, only 71% of the firms that integrate are superior to their trading partners. From these results, we can deduce that firm superiority is neither a necessary nor sufficient condition for integration.

Looking at the simulation data, we notice that integration occurs if both firms are better at the same activity – i.e., firm 1 and firm 2 are concurrently more productive upstream or concurrently more productive downstream - independently of the absolute productivity level of firms. This finding corroborates Proposition 2. This condition is both necessary and sufficient. In 100% of the cases in which both firms are better at the same activity, we observe integration. Similarly, in all the runs in which we observe integration, both firms are more productive at the same activity. Therefore, in our model, integration is not triggered by firm heterogeneity, but by the lack thereof. Firms integrate when they are similar and there are no gains from the division of labor.

To see why integration may not be an equilibrium outcome in such cases, consider the following economy. Similarly to the previous example, firm 1 can produce 3 units of S_1 if it specializes upstream (τ_1=1), 1 unit of B_1 if it specializes downstream ($\tau_1 = 0$), or 0.75 units of the final good if it integrates ($\tau_1 = \frac{1}{3+1}$ such that $S_1 = \tau_1 \times 3 = B_1 = (1 - \tau_1) \times 1 = 0.75$). Firm 2 can produce 2.5 units of S_2 if it specializes upstream (τ_2=1), 2 units of B_2 if it specializes downstream (τ_2=0), or 1.1 units of the final good if it integrates ($\tau_2 = \frac{2}{2+2.5}$ such that $S_2 = \tau_2 \times$

$2.5 = B_2 = (1 - \tau_2) \times 2 = 1.1$). For $\alpha = \frac{1}{2}$, both firms prefer to specialize upstream, where they are internally most productive. As both firms have a preference for upstream specialization, coordination and cooperation cannot be achieved as there are no gains from the division of labor.

2.4.2 Taper integration

Taper integration occurs 47% of the times, with only one firm out of the pair operating both upstream and downstream and with one firm specializing. Taper integration occurs when both firms in the economy have incentives to specialize and, conditional on specialization, the supplier can produce more intermediate inputs that the buyer can possibly process or, vice versa, the buyer can process more inputs than the supplier can possible produce. For example, assume that firm 1 can produce 3 units of S_1 if it specializes upstream (τ_1=1), 2 units of B_1 if it specializes downstream ($\tau_1 = 0$), or 1.2 units of the final good if it integrates ($\tau_1 = \frac{2}{3+2}$ such that $S_1 = \tau_1 \times 3 = B_1 = (1 - \tau_1) \times 2 = 1.2$) . Additionally, assume firm 2 can produce 1 units of S_2 if it specializes upstream (τ_2=1), 1.5 units of B_2 if it specializes downstream (τ_2=0), or 0.6 units of the final good if it integrates ($\tau_2 = \frac{1.5}{1+1.5}$ such that $S_2 = \tau_2 \times 1 = B_2 = (1 - \tau_2) \times 1.5 = 0.6$). For $\alpha = \frac{1}{2}$, firm 2 prefers to specialize downstream ($\tau_2 = 0 \rightarrow \pi_2 = (1 - \alpha) \times (1 - \tau_2) \times B_2 = \frac{1}{2} \times 1.5 = 0.75 > 0.6$). For similar reasons, firm 1 prefers to specialize upstream ($\tau_1 = 1 \rightarrow \pi_1 = \alpha \times \tau_1 \times S_1 = \frac{1}{2} \times 3 = 1.5 > 1.2$) but if it does so it outproduces firm 2, the buyer, by 1.5 units. By opting for a taper integration set up, however, firm 1 can sell 1.5 unit of the intermediate good to firm 2 and use the resources not used to sell to intermediate inputs to produce final goods in-house. This can be obtained by allocating 70% of its non-scale free resources upstream and 30% of its non-scale free resources downstream, so that firm 1 produces

2.1 units of S_1 ($S_1 = 0.7 \times 3 = 2.1$) and 0.6 units of B_1 ($B_1 = 0.3 \times 2 = 1.2$). Of the 2.1 units of S_1, 1.5 are sold to firm 2, the buyer, which can process at most 1.5 units of the intermediate upstream input, and the remaining 0.6 units of S_1s are matched to the internally produced B_1s. As the example shows, taper integration in our model is triggered by an excess of non-scale free resources. Interestingly, this excess of resources does not lead to full integration.

2.5 CONCLUSION

This chapter examines the impact of resource attributes on the division of labor. We argue that the existing RBV logic is fundamentally incomplete, because it treats firms' resources as perfectly scalable and fungible. We address this limitation by analyzing the impact of resources imperfections on the division of labor, looking at this important research question through the lenses of a *biform game*. In our model, resource characteristics drive the occurrence of integration, taper integration, and division of labor. The rival nature of non-scalable resources impairs the productivity of firms when these resources are stretched too thin along the value chain. Therefore, non-scalable resources are likely to induce the division of labor. In our model, integration is not driven by a productivity advantage of a firm relative to other firms, but by the lack of heterogeneity among potential trading partners. When the firms in the industry have similar resource endowments, there are no gains from the division of labor and integration becomes firms' last resort.

Overall, these findings shed new light on the impact of resources on the vertical strategies of firms because they negate negates the canonical prediction that firms should internalize the production of complementary activities in which they have a productivity advantage (Argyres 1996; Barney 1999; Fabrizio 2012; Jacobides and Hitt 2005; Kaul 2013; Langlois 1992; Madhok 2002).

In this chapter, we also underline the tradeoff inherent in the division of labor. On one hand, the division of labor may be beneficial for all firms along the productivity spectrum because it allows firms to focus their limited resources on a subset of complementary activities, increasing productivity. This implies that productivity differentials may be less relevant in the prediction of integration outcomes because both highly productive firms and less productive firms stand to gain from cooperation. On the other hand, the division of labor comes at a cost. When firms divide labor, they also divide the value they contribute to create. In this chapter, we show that if the cost of sharing value is higher than the opportunity cost firms face when deploying their resources along the whole value chain, integration will occur.

Before proceeding to the next chapter, it must be noted that our results are based on the concept of opportunity cost that can be also found in the comparative advantage model of international trade, according to which countries with different technologies face the opportunity cost of allocating their factor endowments to the production of distinct products (Jacobides and Hitt 2005).

Having noted that both models employ the notion of opportunity cost, we believe that the similarities end here. In the international trade model, countries (and the firms within) trade through perfect markets. In our model, firms trade through imperfect markets. Imperfect markets arise from the complementarities between firms operating in the value chain context, which make room for bilateral bargaining, a market imperfection resulting from the minimal assumptions of the cooperative stage of the game. With bilateral bargaining, firms obtain more than their marginal cost of production for the sale of intermediate inputs. This unique feature of value chain settings distinguishes our model from models of international trade, having deep implications. While in the international trade theory, countries always find it optimal to specialize in accordance with their comparative advantage, firms in our model may optimally integrate in some circumstances preferring not to “trade” when the opportunity cost of sharing value is too high compared to the opportunity cost of doing activities in-house. Additionally, our model does not exhibit specialization patterns conforming to the comparative advantage logic. If firms do specialize, they don’t specialize in what they do relatively best, but simply in what they do “internally” best. Here, the comparison is being made with respect to the firms’ own capabilities, not with respect to the capabilities of the other firms in the industry.

CHAPTER 3: THE DIVISION OF LABOR IN SERVICE SETTINGS

3.1 INTRODUCTION

"Historically, the division of labor originates in two facts of nature: the inequality of human abilities and the variety of the external conditions of human life on the earth. These two facts are really one: the diversity of Nature, which does not repeat itself but creates the universe in infinite, inexhaustible variety…"

- Ludwig von Mises, quoted from Evers (1980: 46)

In the resource-based view of the firm, value creation arises from a combination of complementary activities that jointly contribute to the provision of products and services to final customers (Balakrishnan and Wernerfelt 1986; Richardson 1972; Teece 1986). According to this literature, the division of labor – i.e., the extent to which different firms co-specialize in disjoint subsets of complementary activities - is the outcome of the heterogeneity across firms (Argyres 1996; Barney 1999). Specifically, firms divide labor when some firms are better at a subset of complementary activities and other firms are more productive at the complementary subset (Jacobides 2008; Jacobides and Hitt 2005). Conversely, if one firm is more productive than its complementors, there are no gains from the division of labor and the most productive firm can create more value by integrating (Langlois 1992; Madhok 2002).

Implicit in this theory is the assumption that firms are not resource constrained and, therefore, they should perform any activity in which they possess a productivity advantage. While this assumption may hold in capital intensive industries, where firms enjoy economies of scale, it is less likely to hold in human-capital intensive settings, such as service industries, where firms are on average smaller (Choi and Spletzer 2012; Garicano and Hubbard 2009) and may be resource constrained because of their limited ability to acquire and to manage human capital (Barney 1986; Penrose 1959). When firms are resource constrained, the division of labor increases productivity because it allows firms to focus their resources on a subset of the activities necessary to bring services to the market. However, when firms divide labor, they also divide value, incurring the costs of sharing the pie they contribute to create. Therefore, resource constrained firms must choose between allocating their scarce resources to a smaller subset of activities, dividing labor with other firms to capture of portion of the pie for a larger number of customers, and allocating their limited human capital to multiple complementary activities, integrating to capture the whole pie for a smaller number of customers. This allocation of human assets to complementary activities depends on the returns these assets generate in alternative allocations (Levinthal and Wu 2010; Sakhartov and Folta 2013). These, in turn, are determined by demand characteristics.

We therefore argue demand characteristics are a key determinant of the costs and benefits of the division of labor in service settings. The benefits of the productivity gains associated with the division of labor are likely to be more salient in bigger, more munificent markets, which can better absorb the excess supply due to the division of labor. On the contrary, the costs of dividing the value created by complementary activities may increase with the heterogeneity of consumers' valuations – i.e., the extent to which some customers are more valuable than others. When the heterogeneity of consumers' valuations is high, the productivity gains due to the division of labor may expand the production of services towards the least valuable customers, increasing the opportunity cost of using resources to serve those customers rather than to capture the whole pie for the most valuable ones. Once demand characteristics are accounted for, the most productive firms may be those more likely to specialize in bigger markets and to integrate when the heterogeneity of consumers' valuation is high. In fact, the most productive firms may be more sensitive to demand characteristics because they may gain more from resource redeployment than their less productive counterparts.

We test the empirical implications of the theory using fine-grained proprietary data from the residential real estate brokerage industry in Southeast Michigan. Specifically, we examine the brokerages' choices to allocate their resources between two sets of complementary activities: one set associated with serving home buyers, and one set associated with serving home sellers. In residential real estate, value is created when home buyers are matched to home sellers and it is generally equal to 6% of the selling price of the house being sold. In some real estate transactions, a house sale requires cooperation between two different types of firms: (i) seller's brokers, i.e., the firms assisting house sellers, and (ii) buyer's brokers, i.e., the firms assisting house buyers. When a sellers' broker and a buyers' broker divide labor over a house sale, they split the 6% commission by half, with each firm collecting 3% of the price of the house being sold. Some real estate transactions, however, occur under dual agency, meaning that the same firm performs both the selling side and the buying side of the same transaction, capturing the whole 6% commission.

The empirical findings of this study show that firms are (i) more likely to specialize in geographic markets with high transaction volumes, and (ii) more likely to perform dual agency (i.e., bundling selling and buying services) in markets where the heterogeneity of the value created by selling services and buying services is high. These demand-side effects persist after the inclusion of statistical measures controlling for house matching probabilities, house characteristics, individual agents' specialization, and market entry. Additional findings show that the influence of markets on the division of labor among real estate brokerages is stronger for the most productive firms, which are more likely to specialize in bigger markets and to integrate when the heterogeneity of the value created by selling services and buying services is high.

Taken together, these findings enrich the scholarly understanding of the influence of demand characteristics on the division of labor among firms. Prior work suggests that firms should internalize the production of complementary activities in which they have a productivity advantage (Argyres 1996; Barney 1999; Jacobides and Hitt 2005). According to the extant logic, dividing labor may not be beneficial for the most productive firms because they can create more value by internalizing the whole set of complementary activities. In this paper, however, we argue that this conception is incomplete because it does not consider the influence of demand characteristics. Once demand characteristics are accounted for, the most productive firms may be those for which the productivity gains associated with the division of labor outweigh the costs of sharing the value created by complementary activities, inducing the division of labor rather than integration in bigger markets.

More broadly, this study contributes to the historical debate on the influence of markets on the division of labor among firms. Advancing a rationale put forward by Adam Smith (1776) in *The Wealth of Nations*, Stigler (1951) argues that in vertical integration settings[7] demand growth may be positively related to the division of labor along the value chain. According to Stigler, demand growth triggers entry in the intermediate input markets because it allows intermediate good producers to sell enough quantities to recover sunk investments in scale economies. Therefore, in

[7]In vertical integration settings, successive stages of production are complementary activities by definition (Balakrishnan and Wernerfelt 1986; Richardson 1972). If stage 2 generates value only after stage 1 has been performed, and if the value of stage 1 is realized only after stage 2 has been performed, then stage 1 and 2 are complementary – i.e., they are jointly need to create value to the final customers.

Stigler's theory, the division of labor is caused by market entry and the effect of demand growth on the division of labor may not persist once entry is controlled for. Although Stigler's conjecture conforms to anecdotal evidence in some industries (Macher and Mowery 2004; Rosenberg 1994), his prediction has been refuted in other settings, most notably in Chandler's historical accounts on the evolution of Corporate America (Chandler 1962, 1977). In this study, we provide a mechanism accounting for the influence of demand characteristics on the division of labor in service settings that persists after controlling for market entry and that can explain why demand growth *per se* may not be sufficient to explain the division of labor. If demand growth is correlated with an increase in the heterogeneity of consumers' valuations, integration may be more likely than the division of labor.

The remaining sections of this paper are organized as follows. In the next section, we provide a theoretical background and formulate the hypotheses. We then conduct the empirical analysis, discuss the implications and limitations of the study, and draw conclusions.

3.2 THEORY AND HYPOTHESES

In this study, the decision of firms to operate in different complementary activities is looked at through the lenses of the resource-based view of the firm (Conner and Prahalad 1996; Wernerfelt 1984).[8] The starting assumption of the resource-based view of the firm is that the existence of organizations is driven by individual-level heterogeneity (Conner and Prahalad 1996; Rosen 1978). Some individuals but not all may have the capabilities necessary to become entrepreneurs (Nguyen-Chyung 2013; Wu and Knott 2006). Once an entrepreneur generates a novel value-

[8]This choice is driven by analytical parsimony. I selected the theory that more synthetically focuses on the theoretical constructs of interest. It is our belief that the theoretical underpinnings of resource-based view of the firm closely mirror many of fundamental constructs employed in other theories of the firm, such transaction cost economics (Williamson 1975).

creating idea, its implementation may require the performance of multiple activities and labor in excess of that the entrepreneur can provide herself (Jacobides and Winter 2007).

In capital-intensive industries, the entrepreneur may scale up her firm's operations by substituting labor with capital. In the service sector, capital cannot substitute for labor. As a consequence, the choice of an entrepreneur facing the option of scaling up her business is constrained to hiring labor or hiring contractors. The underlying difference between an employee and a contractor is that the employee willingly accepts the entrepreneur's guidelines when performing activities, while the contractor autonomously decides according to her judgment and she is subject to the entrepreneur's control only as to the end product (Conner and Prahalad 1996; Simon 1951).[9] The employee accepts the entrepreneur's authority because she may recognize the entrepreneur's superior knowledge (Conner and Prahalad 1996). Therefore, the entrepreneur may prefer employees to contractors when her knowledge about the performance of a value adding activity are superior to the contractor's (Jacobides and Winter 2005).

However, the ability of firms to accumulate human capital is highly constrained (Dierickx and Cool 1989; Penrose 1959). Firms may hire more workers and managers, but these need to be trained by the firms' current workers and managers, who may withdraw their human capital from operational activities and devote it to the firms' expansion. Redirecting resources from operations to expansion is costly because it may induce a negative short-term toll on productivity and, consequently, on profitability. The costs of scaling firms' human capital become higher as the level of tacitness and complexity characterizing the job description increases (Szulanski

[9]Black's Law Dictionary (2004) defines an employee as "a person in the service of another under any contract of hire […] where the employer has the power or right to control and direct the employee in the material details of how the work is to be performed. An independent contractor is defined as one who, "in the exercise of an independent employment, contracts to do a piece of work according to his own methods and is subject to his employer's control only as to the end product or final result of his work". This definition is used under the US Federal Law (Muhl 2002).

1996; Winter and Szulanski 2001). Nevertheless, these costs could be relatively high even for lower level jobs. For instance, in the residential real estate brokerage industry, it takes agents at least one year to become established (Dizik 2014),

Because the accumulation of human capital is costly, the human capital stock of firms may be regarded as fixed in the short run (Penrose 1959; Stigler 1939). Therefore, human-capital constrained firms must determine the ideal allocation of their limited resources to different activities. This decision is likely to depend on the productivity of human capital, which may vary in alternative allocations. This happens because different value-adding activities can be technologically distinct and require different skills and capabilities (Nelson and Winter 1982).

Assuming that the monetary value of the output resulting from any given activity is the same, a firm has incentives to allocate its human capital to the activity its employees produce at the highest rate. As a consequence, in a system of complementary activities, firms are better off if they specialize in what they do "internally" best, with the comparison being with respect to the firm's own productivities, not in reference to the productivity of other firms.

Imagine a hypothetical economy in which firm A can produce two perfectly complementary services - 1 and 2. The value of a bundle of service 1 and 2 is V, while the value created by service 1 is zero without the performance of service 2, and vice versa. If firm A specializes in the production of service 1, the revenues accruing to A are likely to be a portion of the joint value created by the two complementary activities. Assuming that firm A operates under fair dealing with the industry complementors, it may be natural to envision instances in which firm A opts to share equally the value created by the two complementary services, capturing $\frac{V}{2}$ for each unit of service 1 or 2 it produces. This assumption is without loss of generality (see Appendix A).[10] Firm A, which employs three workers, can produce three units of service 1 if it allocates its employees to activity 1 and six units of service 2 if it allocates its employees to activity 2. Because the employees of firm A underwent the same training and they are under the oversight of the same entrepreneur, their productivities at different activities are the same. Specifically, each worker has a productivity of one units of service 1 per amount of time and two units of service 2 per amount of time.

If firm A produces activities 1 and 2 by itself, it can produce at most two bundles of services 1 and 2 by allocating two workers to activity 1 and one worker to activity 2. Any other allocation generates an excess supply of either service 1 or service 2 whose value is zero if there is no cooperation with the industry complementors. Under integration, firm A captures value $4 \times \frac{V}{2} = 2V$. If firm A divides labor, it can produce six units of service 2, for which it collects half of the value created, i.e., $6 \times \frac{V}{2} = 3V$. Under these conditions, firm A can increase the productivity of its resources by dividing labor, preferring to collect half of the value produced by six units of service 2 rather than capturing the whole value produced by two bundles of service 1 and 2 (see Figure 3 for a graphical representation of the arguments in the example).

[Insert Figure 3 approximately here]

3.2.1 The influence of demand characteristics

The benefits of the productivity gains associated with the division of labor arise from the parsimonious allocation of resources to activities. By leveraging the resources of the industry

[10] Appendix A formalizes the arguments of the examples described in the remaining sections of the paper. In Appendix A, it is showed that the hypotheses do not depend on the parameter α, which measures the percentage of value captured by the focal firm.

complementors, specialized firms can cache the resources they would have used in complementary activities and expand their produce in the subset of activities they are "internally" best at.

In smaller markets, however, the benefits of saving resources for expansion are muted because firms face few opportunities to fully exhaust their resources under a division of labor set up. Specialized firms may end up with more capacity than the one needed to close the available transactions and find it profitable to redeploy their excess resources from one set of value adding activities to the complementary set (Levinthal and Wu 2010; Sakhartov and Folta 2013). On the contrary, in bigger markets, the benefits of the productivity gains due to the division of labor are likely to be more salient because bigger markets can more easily absorb the excess supply associated with the division of labor.

Following the previous example, if the residual demand faced by firm A is bigger than four customers (e.g., six customers), firm A can do better by specializing in the production of service 2 than by integrating. If it integrates, it collects value 2V. If it specializes, it collects more (e.g., $6 \times \frac{\mathrm{V}}{2} = 3\mathrm{V}$). However, if the residual demand is less than four customers (e.g. three customers), the revenues from the division of labor are less than $2V$ (e.g. $3 \times \frac{V}{2} = 1.5V$), where $2V$ is the value captured under integration. Consequently, if the residual demand faced by firm A is small enough, firm A prefers integration to the division of labor (see Figure 4 for a graphical representation and Appendix A for a formal treatment of the arguments in the example). Therefore, we hypothesize the following:

Hypothesis 1: Ceteris paribus, market size is negatively related to the integration of complementary services.

Thus far, the theorizing has proceeded under the assumption that the value created by bundles of complementary services is constant. However, in multiple industries, value is likely to vary across customers (Adner and Zemsky 2006; Makadok and Ross 2013). In these settings, the costs of sharing value are likely to outweigh the productivity gains due to the division of labor: The productivity gains due to the division of labor may induce firms to provide specialized services to the least valuable customers, increasing the opportunity cost of using the firm's resources to serve those customers rather than to capture the whole pie for the most valuable ones.

Going back to the hypothetical economy, imagine now that the residual demand for bundles of complementary services consists of six customers with heterogeneous valuations: one customer is willing to pay $32V$ for a bundle of services 1 and 2; one customer is willing to pay $16V$, one customer is willing to pay $8V$, and so on, up to the least valuable customer with willingness to pay equal to V. Firm A can allocate two workers to service 1 and one worker to service 2, integrating services 1 and 2 to the customers worth $32V$ and $16V$, capturing 48V in total. Alternatively, firm A can divide labor, specializing in service 2, producing 6 units of service 2, and capturing value $32 \times \frac{V}{2} + 16 \times \frac{V}{2} + \cdots + \frac{V}{2} = 31.5\,V$. Under these circumstances, firm A prefers integration to the division of labor (see Figure 5 for a graphical representation and Appendix A for a formal treatment of the arguments in the example). Consequently, we hypothesize the following:

Hypotheses 2: Ceteris paribus, the heterogeneity of consumers' valuation is positively related to the integration of complementary services.

[Insert Figure 4 approximately here]

[Insert Figure 5 approximately here]

3.2.2 The influence of resource characteristics

Because firms' are heterogeneous (Nelson and Winter 1982; Wernerfelt 1984), they may exhibit heterogeneous responses to demand characteristics. If demand characteristics change over time, resource allocations that may be optimal at time *t* may become suboptimal at time *t+1*. If redeploying resources were costless, any firm would respond to market changes by reallocating its resources in response to demand perturbations. However, redeploying resources from one activity to the other does not occur without a cost. Sakhartov and Folta (2013) argue that the cost of redeploying resources may be a function of the relatedness between the activity of origin and the activity of destination. Therefore, redeployment costs may not vary across firms in the same industry because these firms perform the same set of activities. While these costs may be similar, the benefits of resource redeployment are likely to be higher for the most productive firms.

Now assume the existence of another firm, A', identical to firm A with the exception that firm A' is half as productive as firm A. Specifically, firm A' employs three employees who can produce one and one half units (instead of three) of service 1 if allocated to activity 1 and three units (instead of six) of service 2 if allocated to activity 2. If firm A' integrates when the value created by the complementary activities is constant and equal to V, it produces one bundle of service 1 and 2 collecting value V, which is less than the value created when dividing labor –i.e., $\frac{3}{2}V$ (half value from three bundles). Conversely, firm A, which is twice as productive, captures value $2V$ when integrating and value $3V$ when dividing labor. If both firms experience a demand perturbation such that market size increases, firm A' gains $\frac{1}{2}V$ if it moves from integration to a division of labor set up and firm A gains V.

Because the reallocation of resources involves the redeployment of two employees for both firms, they are likely to face similar redeployment costs. If both firms weigh the benefits of redeploying resources versus redeployment costs, the most productive firm, A, may be more likely to adopt a division of labor set up in response to an increase in market size because it gains more while facing similar redeployment costs (see Figure 6 for a graphical representation and Appendix A for a formal treatment of the arguments in the example). Therefore, we hypothesize the following:

Hypotheses 3: Ceteris paribus, the effect of market size on integration is more negative for the most productive firms.

Now assume that both firms experience a demand perturbation such that the heterogeneity of customers' valuations increases. Under these circumstances, one bundle of complementary activities is worth $32V$, one bundle is worth $16V$, etc. If firm A' divides labor, it creates value $(32+16+8)\times\frac{V}{2}=28V$. If it integrates, however, it creates value $32V$. By responding to the increase in the heterogeneity of consumers' valuations, moving from the division of labor to integration, firm A' gains value $4V$. Conversely, firm A generates value $31.5V$ under the division of labor and value $48V$ under integration. If firm A responds to an increase in the heterogeneity of consumers' valuations by integrating, it gains value $16.5V$, a much larger amount than the value firm A' gains, that is $4V$.

Also in this case, the reallocation of resources involves the redeployment of two employees, implying that both firms are likely to face similar redeployment costs. Similarly to the previous example, the most productive firm, A, stands to gain more from resource redeployment and it is therefore more likely to adopt an integration strategy in response to an increase in the heterogeneity of consumers' valuations (see Figure 7 for a graphical representation and Appendix A for a formal treatment of the arguments in the example). Therefore, we hypothesize the following:

Hypotheses 4: Ceteris paribus, the effect of the heterogeneity of consumers' valuations on integration is more positive for the most productive firms.

[Insert Figure 6 approximately here]

[Insert Figure 7 approximately here]

3.3 METHODS

3.3.1 Setting

The empirical setting of this study is the residential real estate brokerage industry in Southeast Michigan, in the United States. Americans often view homeownership as an inalienable right and the great American dream. The residential real estate brokerage industry is not only part of the collective imaginary, but it is also of great importance to the US economy. In 2005, brokerage commissions exceeded USD 60 billion (Federal Trade Commission 2007).

In this industry, firms act as brokers in the buying and selling of residential properties. Value is created when home buyers are matched to home sellers and it is equal to the commission on the selling price of the house being sold (generally 6% of the selling price). Approximately two thirds (64%) of the residential real estate transactions are conducted through the collaboration of two separate brokerage firms: (i) a seller's broker, i.e., the firm assisting house sellers, and (ii) a buyer's broker, i.e., the firm assisting the house buyer (see Figure 6 for a summary of the activities performed by the buyer's broker and the seller's broker). The 6% commission is paid to the seller's broker by the house seller and it is split among the parties involved in the brokerage of the transaction. According to a widespread custom in the industry, the 6% commission is equally divided among the seller's broker and the buyer's broker (see Figure 7). The remaining third (34%) of the transactions in real estate occur under dual agency, meaning that the same firm performed both the selling side and the buying side of the same transaction, capturing the whole 6% commission.[11]

The typical brokerage firm employs real estate agents and brokers (Nguyen-Chyung 2013). Real estate agents are licensed professionals. Their license can be obtained without prior experience in the real estate industry (Dizik 2014). Without a broker license, a real estate agent cannot own her own brokerage and must work as an apprentice for an established broker. The broker is generally the manager and the owner of the brokerage. She is a licensed real estate professional with years of experience in real estate transactions (Nguyen-Chyung 2013).[12] The broker's managerial duties include training the real estate agents, distributing leads and referrals to the agents, assigning mentors to the agents, allocating office hours, monitoring agents' productivity, and firing agents if productivity goals are not met (Abelson, Kacmar, and Jackofsky 1990). Agents are remunerated on a commission basis, obtaining a percentage of the value of the real estate transactions they help to close. For example, 50% of the 3% commission collected by a buyer's brokerage goes to the broker and the remaining 50% goes to the agent who closed the transaction. The broker can purposefully assign different percentages to different types of transactions. The broker may provide a higher percentage to the transactions occurring under dual agency. Beyond the leads provided by the broker, agents have autonomy in finding and

[11] Some states distinguish between "dual agency" and "designated agency". In those states, dual agency occurs when the same real estate agent represents both the buyer and the seller in the same transaction, while designated agency occurs when two agents working for the same broker cover the same transaction. In the latter case, one agent represents the seller and the other represents the buyer. In this paper, I will refer to both dual agency and designated agency as dual agency.

[12] There could be multiple licensed brokers within a firm, some of whom may not have managerial responsibilities.

serving their own clients. In these instances, the broker may oversee the closing of the transactions because she is legally responsible for potential breaches of contract (Burke 2007).

From a legal standpoint, the relationship between brokers and agents is governed by an industry-specific federal statute (26 U.S.C. §3508). For year 2014, the majority of real estate agents are regarded as independent contractors for tax purposes, but as employees for other purposes (Burke 2007). For instance, if an agent fails to meet its fiduciary duties to her clients while working for a broker, the broker is responsible for possible breaches of contracts. The classification of real estate agents as independent contractors for tax purposes has clear advantages for the broker in terms of reduced labor costs. However, this classification is currently being disputed in court. In 2013, multiple class actions and litigations were initiated to challenge the current classification for tax purposes, arguing that the relationship between brokers and agents should be regarded as an employee relationship in accordance with the broader federal labor laws (Brambila 2014; Hunt 2014; Vetstein 2013). The federal law defines employees as individuals for whom the employer has a right to direct and control what work is accomplished and how the work is done, through instructions, training, or other means. In real estate, the broker exerts considerable control over the way agents perform their daily activities. The broker not only hires and trains agents in accordance with her business model, she also exercises authority on how transactions are assigned to agents and on how these transactions are performed. Additionally, the broker determines the incentives for conducting transactions under dual agency. Therefore, for the purpose of this study, real estate agents are regarded as employees.

Because the majority of real estate transactions involve the cooperation between two firms, the division of labor is a predominant feature of the real estate brokerage industry (see Figure 8).

The emergence of the existing collaborative business model dates to the late 1950s. In principle, US brokerages operated autonomously (National Association of Realtors 2007). Things changed with the introduction of Multiple Listing Services (MLS), i.e., institutions that accumulate and disseminate information about house listings and commissions. The MLS allows different brokers to cooperate to complete transactions. The economic rationale for these collaborations resides in the fact that some firms may have an excess of buyers or sellers in their portfolio of clients. Cooperation permits firms to match their excess inventory with other brokerages. The prevalence of collaboration can be attributed to the institutional background conductive to the division of labor (North 1991; Williamson 1975). For example, haggling between cooperating parties, which could inhibit inter-firm collaborations in other settings (Williamson 1975), is prevented by the custom to share commissions by half. Search costs, which could hinder the ability of firms to find complementors (Williamson 1975), are minimal because the MLS accumulates and disseminates information about house listings. Opportunistic behavior between cooperating firms, which could reduce the value created under cooperation (Williamson 1975), is monitored and sanctioned by the NAR, the largest trade association and one of the most powerful lobbying groups in North America.

3.3.2 Data

The data for this study were obtained from the MLS network in Southeast Michigan. The sample covers 705,369 transactions for nonrental residential properties from 1995 to 2012. The data include property characteristics such as address and zip code, square footage, lot size, closing date, and price. Each entry also contains the name of the seller’s agent, the name of the buyer’s agent, their MLS identification code, the MLS identification code of the office in which each agent is employed, and the MLS identification code of the firm in which each agent is employed. The data also record commissions obtained by the seller's brokerage and the buyer's brokerage.

To test the hypotheses, we constructed an unbalanced panel consisting of 95,445 observations and 1340 firms (see Table 1 for list of the top-25 firms by size and Table 2 for a list of the top-25 growing firms during the observation period). Each observation represents a brokerage-year-zip code triple over the period 1995-2012. We address brokerage's ownership changes, name changes, mergers, acquisitions, and dissolutions by manual verification of firm information from sources including firms' websites, by interviews with practitioners, and by tracking the name changes associated with offices' and brokers' multiple listing IDs. Only firms with more than one entrepreneur/employee and with more than five transactions during the observation period are included in the study. Firms with one entrepreneur/employee are excluded because the focus of this study is on firm-level strategies and multiple empirical construct of interested cannot be computed for firms with less than two employees. The exclusion of firms with small transaction volumes is due to the impossibility to retrieve the corporate history of smaller firms.

Zip codes are used as an approximation for geographic markets (see Table 3 for a list of the top-25 counties by number of markets). Markets are limited by the ability of real estate agents to serve extended geographic areas by car. A zip code is an administrative unit established by the United States Postal Service for the most efficient delivery of mail, fitting the definition of a geographic area easily served by car (Krieger, Waterman, Chen, Soobader, Subramanian, and Carson 2002).

[Insert Table 1 approximately here]

[Insert Table 2 approximately here]

[Insert Table 3 approximately here]

[Insert Figure 8 approximately here]

[Insert Figure 9 approximately here]

[Insert Figure 10 approximately here]

3.3.3 Main variables

Dual agency

Dual agency is the dependent variable of this study. It indicates the percentage of transactions performed under dual agency by a brokerage firm in a given year in a given zip code. When firms do not perform as dual agents, they collaborate with other firms to close a transaction. Therefore, *dual agency* is a direct measurement of the firm decision *not to* divide labor and, consequently, to integrate buying and selling activities for the same transaction. Because the focus of the analysis is the firm's decision to divide labor or to integrate, only the transactions performed by the same firm but by different real estate agents are counted as dual agency.

Market size

Market size is an independent variable in this study. It is measured as the number of transactions performed by all the firms active in a given year in a given zip code. This measure identifies market size as the equilibrium outcome resulting from the interception of the demand curve with the supply curve in the housing market (see Figure 9 for a graphical representation of variation in market sizes in Southeast Michigan aggregated at the county level). The distribution of the variable *market size* is skewed to the right and it resembles a log-normal distribution. Therefore, we log-transform this variable to generate accurate estimates under the normality assumptions typical in regression models.

Heterogeneity of consumers' valuations

Heterogeneity of consumers' valuations is an independent variable in this study. To compute this empirical construct, we proceed as follows. For each transaction, we calculate the sum of the buyer's broker's commission and of the seller's broker's commission. Then, we estimate the variance of this sum across all the transactions occurring in a given year in a given zip code. This market-level measure is regarded as a good proxy for the heterogeneity of the consumers' valuations because it directly measures the extent to which some consumers' transactions may be more valuable than others. Similarly to the measure *market size*, the distribution of the variable *heterogeneity of consumers' valuations* resembles a log-normal distribution. Also in this case, we log-transform the variable to generate accurate estimates.

Productivity percentile

Productivity percentile is an independent variable ranking firms from the least productive to the most productive. To estimate this variable, we compute the *buying side productivity* and the *selling side productivity* of firms using a total-factor-productivity (TFP) approach (Atalay et al. 2014) (see Appendix B for the estimation procedures and results). After estimating the *buying side productivity* and the *selling side productivity* of firms, we associate each productivity measure to a percentile of their respective productivity distributions, assigning higher percentiles to higher productivity values. The variable *productivity percentile* is then defined as the minimum percentile between the percentile of the *buying side productivity* distribution and the percentile of the *selling side productivity* distribution.

[Insert Figure 11 approximately here]

3.3.4 Control variables

Random matching

The decision of firms to operate in complementary activities could be a result of a diversification decision due to excess resources, to market opportunities, or to the necessity to supply complementary activities short on supply (Levinthal and Wu 2010; Stigler 1951). Firms may operate in complementary activities without the specific purpose of bundling complementary services to the final customer (Atalay et al. 2014). In fact, it is common for brokerages to operate on both the buying side of the market and on the selling side of the market without necessarily performing dual agency. Because the main purpose of brokerages is to match house buyers and house sellers, dual agency may occur only when the ideal match between buyers and sellers happens to reside among the clients in the firms' portfolios. In these instances, firms with large market shares on the buying side and on the selling side may be more likely to perform dual agency only because the probability that an ideal match between a buyer and a seller may reside within the firm's portfolio is higher for more active firms.

To control for this possibility, we constructed the variable *random matching*. we first calculate the probability that an ideal match for a house seller may be among the brokerage's buyers. This probability is equal to the number of buyers served by the brokerage divided by the number of buyers in the market. The probability thus obtained is then multiplied by the probability that an ideal match for a house buyer may be among the brokerage's sellers. The latter probability is equal to the number of sellers served by the brokerage divided by the number of sellers in the market. In other words, the variable random matching computes the joint probability that a house seller may randomly choose a brokerage and that the brokerage is serving the ideal match on the buying side. The statistical construct random matching should therefore account for the occurrence of dual agency as a manifestation of the decision of firms to diversify on the buying side and on the selling side of the market.

Agent specialization

Because real estate agents enjoy a certain degree of autonomy, it is important to verify that the influence of demand characteristics on the division of labor among firms persists after controlling for agents' specialization. Given an individual agent, the *individual agent specialization* is equal to the following:

$$Individual\ agent\ specialization = \left|1 - \frac{2 \times sellers\ served}{sellers\ served + buyers\ served}\right|.$$

This variable takes values between zero and one. A value of zero corresponds to an agent that serves an equal number of sellers and buyers in a given year in a given zip code. A value of one corresponds to an agent that serves only buyers or only sellers. *Agent specialization* is a firm level variable computed as the average of *the individual agent specialization* across the agents working for a given firm in a given year in a given zip code.

House characteristics

To fulfill their fiduciary duties towards their clients, seller's brokerages and buyer's brokerages must collect relevant information about house characteristics to obtain the highest possible price for the seller and the lowest possible price for the buyer, respectively. The price of certain types of properties may be hard to assess. For instance, the appraisal of bigger properties with multiple amenities may be more complex because it may require the simultaneous evaluation of multiple features. In these cases, dual agency may be an efficient vehicle for information sharing among agents working for the same firm. Brokerages may prefer to perform transactions in-house under dual agency because information sharing may be easier within the firm rather than across firms for certain types of transactions (Arrow 1975). To control for this possibility, we include a vector containing 30 different types of house characteristics. Each element of the vector is a firm-level average of a specific house characteristic computed across the properties served by the brokerage in a given year in a given zip code. These house characteristics include the property lot size, the square footage of the habitation, the house style (e.g., whether the house is a one-story house, two-story, an apartment, a loft, historic, a bi-level unit), the number of bathrooms, the number of bedrooms, whether the house has a garage, whether the house has a basement, whether the house has a fireplace, and whether the house has a swimming pool.

Other controls

Beyond controlling for *random matching*, *agent specialization*, and *house characteristics,* we also control for *year effects, firm age*, for the *average age* of firms in a given year in a given zip code, for *firm size*, for the *average size* of the firms in a given year in a given zip code, their *average buying side* and *selling side productivities*, and for the *number of firms* in a given year in a given zip code*s*. With the exception of *year effects, firm age* and *average age,* these control variables account for the supply-side characteristics of the market in which the focal firm is active. Because the value created by firms in this industry depends on the supply of complementary activities, firms may operate on the buying side and on the selling side of the market when one complementary activity is in short supply. For example, if a brokerage specializes as a seller's agency and the other agencies are not able to inject enough buyers to the market, the seller's agency may end up with unsold inventory. This could happen because there may be not enough firms in the market, or because these firms may be capacity constrained or unproductive. Then, the seller's agency may reduce the amount of resources allocated to the selling side of its operations and increase the amount allocated to the buying side, augmenting its level of integration. In this case, dual agency is no longer a decision not to share the value created by the system of complementary activities, but a response to the negative externality engendered by the insufficient supply of complementary activities. This mechanism conforms to Stigler's (1951) original argument on the influence of markets on the division of labor in vertical settings. According to Stigler, market growth leads to market entry in the intermediate input markets, which, in turn, allows for the division of labor. In the absence of market entry, firms have no choice but to produce intermediate inputs by themselves. Table 4 summarizes the main variables and Table 5 reports the summary statistics.

[Insert Table 4 approximately here]

[Insert Table 5 approximately here]

3.3.5. Econometric methods

To test the hypotheses, we use an estimation method for panel data with two-sided censoring. The dependent variable, *dual agency*, measures the percentage of transactions performed by the firm under dual agency, taking values between 0 and 1. The lower and upper bounds of the dependent variable can be interpreted as corner solutions to a value maximization strategy. Two-limit Tobit models which censor the dependent variable at 0 and 1 are ideal for this type of estimation. Tobit models not only have the desirable property of predicting values in the same range of the dependent variable, but also are minimally affected by the incidental parameter problem (Greene 2004a, b).

In the context of this study, it is important to account for firms' selection into markets and for firms' unobserved heterogeneity. While this can be done by including the interaction between firm dummies and market dummies in the model – i.e., by accounting for fixed effects – the sheer number of panel units in the large sample of this study makes this approach computationally infeasible. In linear models, it would be possible to solve this issue by demeaning the dependent variable and the independent variables to account for fixed effects at the market and firm level. In nonlinear models, like the Tobit specification elected in this study, fixed effect differencing cannot be applied because it would not remove the individual effects (Chamberlain 1982).

Until recently, there was no estimator that could handle a fixed effect specification in the presence of two-sided censoring. However, a new semi-parametric estimator developed by Alan et al. (2014) allows the application of a fixed effects estimator to the firm's decision to perform dual agency. Relative to the correlated random effects Tobit, this method sidesteps the unrealistic assumption that the panel unit effects may be orthogonal to the independent variables of interests (Greene 2004a, b).

The structural equation of the Tobit model is:

$$Dual\ agency^{*} = \beta_0 + \beta_1 X_{imt} + \beta_2 Y_{im} + a_{im} + u_{imt},$$

where *dual agency** is a latent variable observed for values between 0 and 1 and censored otherwise. *Dual agency** is a linear function of X_{ijm}, a vector of main variables, Y_{ijm}, a vector of control variables, a_{im}, the market-firm-level fixed effect, and u_{imt}, a random disturbance. Formally, the observed *dual agency* is characterized by the following equation:

$$Dual\ agency = \begin{cases} dual\ agency^{*} & if\ 0 < dual\ agency^{*} < 1 \\ 0 & if\ dual\ agency^{*} < 0 \\ 1 & if\ dual\ agency^{*} > 1 \end{cases}$$

The main strength of the resulting estimator is that it produces consistent estimates of a fixed effect Tobit model. A disadvantage of this technique is that it cannot be used to compute the marginal effects in the censored regressions. Therefore, the tables and results in this study are based on the estimates of the coefficients on the latent variable rather than on marginal effects on the observed variable.

3.4 RESULTS

Table 2 shows the results of the fixed-effect models. Model 2-1 contains the control variables. Model 2-2 adds the main effects of the variables *market size*, *heterogeneity of consumers' valuations,* and *productivity percentile*. Consistent with Hypotheses 1 and 2, the effects of *market size* and *heterogeneity of consumers' valuations* in model 2-2 are negative and positive, respectively. The main effect of the variable *productivity percentile* is positive and significant. This effect is consistent with the canonical resource-based prediction that the most productive firms may integrate complementary activities (Argyres 1996; Barney 1999).

Model 2-3 adds the interaction between *market size* and *productivity percentile* and the interaction between *heterogeneity of consumers' valuations* and *productivity percentile.* Consistent with Hypothesis 3, the interaction between *market size* and *productivity percentile* is negative and significant, suggesting the most productive firms are more likely to specialize as market size increases. Consistent with Hypothesis 4, the interaction between *heterogeneity of consumers' valuations* and *productivity percentile* is positive and significant, suggesting that the most productive firms are more likely to integrate complementary activities as *heterogeneity of consumers' valuations* increases.

It must be noted that the main effect of the variable *productivity percentile* becomes negative in model 2-3, losing its statistical significance (for $\alpha < 0.01$). Similarly, the main effects of the variable *market size* and *heterogeneity of consumers' valuations* also lose their statistical significance (for $\alpha < 0.01$). A comparison between the results of model 2-2 and model 2-3 suggests that the division of labor is driven by the interaction between productivity and market characteristics, not by their main effects.

The economic magnitudes of the results of model 2-3 can be interpreted as follows. For a firm located in the 10th percentile of the distribution of the variable *productivity percentile* (i.e., *productivity percentile* equal to 0.06), one standard deviation increase in market size (185 transactions) over the mean (272 transactions) is associated with a 3% decrease in the percentage of transactions performed under *dual agency* ($= 0.05 \times [\log(185+272) - \log(272)] + 0.04 \times 0.06 \times [\log(185+272) - \log(272)]$). For a firm located in the 90th percentile of the distribution of the variable *productivity percentile* (i.e., *productivity percentile* equal to 0.82), the same increase corresponds to a 5% decrease in the percentage of transactions performed under *dual agen*cy ($= 0.05 \times [\log(185+272) - \log(272)] + 0.04 \times 0.82 \times [\log(185+272) - \log(272)]$). For a firm located in the 10th percentile of the distribution of the variable *productivity percentile* (i.e., *productivity percentile* equal to 0.06), one standard deviation increase in *heterogeneity of consumers' valuations* (USD 4.8 thousands) over the mean (USD 4.8 thousands) is associated with a 2% increase in in the percentage of transactions performed under *dual agency* ($= 0.02 \times [\log(4{,}800+4{,}800) - \log(4{,}800)] + 0.12 \times 0.06[\log(4{,}800) - \log(4{,}800)]$). For a firm located in the 90th percentile of the distribution of the variable *productivity percentile* (i.e., *productivity percentile* equal to 0.82), the same increase in *heterogeneity of consumers' valuations* corresponds to a 8% increase in the percentage of transactions performed under *dual agency* ($= 0.02 \times [\log(4{,}800+4{,}800) - \log(4{,}800)] + 0.12 \times 0.82[\log(4{,}800) - \log(4{,}800)]$). Considering that the average value of the variable *dual agency* is 16%, it can be concluded that these effects exert a significance influence on the firms' decision to integrate complementary activities.

The results of several control variables are worth noting. The coefficient of *random matching* is positive and significant, showing the relevance of controlling for this variable. *Agents' specialization* has a positive impact on *dual agency*. This positive coefficient suggests that firms may substitute the division of labor across firms with the division of labor within firms when *dual agency* is perceived to be superior to inter-firm collaborations, achieving some of the productivity gains associated with the division of labor *within* the firm without resorting to the division of labor *across* firms. As for the vector of *house characteristics*, six dimensions out of thirty are statistically significant, suggesting that the firm's positioning in the housing market has an important impact on *dual agency*. Additionally, we find that market entry is associated with a reduction in dual agency by the focal firm. This result conforms to Stigler's (1951) conjecture that entry in the intermediate input market facilitates the division of labor among firms.

[Insert Table 6 approximately here]

3.5 DISCUSSION AND CONCLUSION

In this paper, we examine the costs and benefits of the division of labor among firms in service industries. When firms operate in complementary activities, strategic interactions are cooperative in nature rather than competitive (Jacobides and Winter 2005; Richardson 1972). The division of labor among firms may be advantageous because it allows firms to focus their scarce resources on a subset of complementary activities, increasing productivity (Huckman and Zinner 2008; KC and Terwiesch 2011). In the service industry, in particular, the benefits of the division of labor may be more salient because firms are resource constrained to the extent they cannot easily scale up their human-capital stock. Although generally beneficial, in some circumstances the division of labor may come at a cost. When firms divide labor, they also divide the value created by the complementary activities, forgoing a portion of the pie they help to create.

We argue that demand characteristics are key determinants of the costs and benefits of the division of labor. Because specialized service firms can produce more services than their integrated counterparts, the division of labor may be economically viable when the volume of transactions in the market can absorb the excess supply due to the division of labor. Conversely, dividing labor – and value - may be less profitable than capturing the whole pie when the heterogeneity of consumers' valuations is high. The productivity gains from the division of labor may expand the production of services towards the least valuable customers, increasing the opportunity cost of not using the firm's resources to capture the whole pie for most valuable customers. We find support for these arguments using a proprietary dataset on real estate transactions in Southeast Michigan. Specifically, the empirical findings corroborate the hypotheses that firms are (i) more likely to specialize in geographic markets with high transaction volumes, and (ii) more likely to bundle complementary services in markets where the heterogeneity of commissions is high. Additional findings suggest that the influence of markets on the division of labor among real estate brokerages is stronger for the most productive firms. The most productive firms are more sensitive to demand characteristics because they may gain more from resource redeployment.

Before discussing contributions and implications, it is important to recognize the limitations of this study. First, the present paper focuses on a specific industry and its findings may not generalize to other empirical settings. The theory holds primarily in human-capital intensive industries, where firms cannot easily create synergies by investing in "scale-free" resources that may increase the returns from performing multiple activities simultaneously (Levinthal and Wu 2010; Sakhartov and Folta 2013). Second, this paper does not account for the strategic intents of firms to accumulate resources and capabilities. Firms may differ not only in terms of their productivity, but also in terms of their ability to accumulate resources (Helfat and Peteraf 2003). Future research could explicitly model the costs and benefits faced by expanding firms, which may have the option to extend their boundaries with the intent to acquire capabilities and resources that may be valuable in the long-term (Argyres 1996). Finally, this study looks at the division of labor among firms, without accounting for the division of labor within firms (Rosen 1978). Examining the emergence of the division of labor within firms could be a fruitful research avenue for understanding how the capabilities and the routines that allow cooperation among multiple individuals within firms come into existence.

Despite these caveats, this paper makes its primary contributions to the resource-based literature. Specifically, we show the importance of demand factors as drivers of the division of labor among firms. Although the resource-based view recognizes demand as a defining aspect of value creation (Barney 1991; Peteraf 1993), the impact of demand characteristics on firms' strategies is elusive (Barney 2001; Priem and Butler 2001). Perhaps for this reason, the extant research examines how inter-firm heterogeneity drives the division of labor, overlooking the influence of demand characteristics. According to the existing logic, the division of labor takes place when some firms are better at performing a subset of complementary activities and other firms are more effective at performing the complementary subset (Argyres 1996; Barney 1999). The reverse of the medal is that firms integrate when they are more productive than the industry complementors. However, this study shows that, when market characteristics are factored in, the most productive firms are more likely to divide labor in bigger markets than to integrate.

This study also participates in the classical conversation on the influence of markets on the division of labor among firms. Initiated by Adam Smith (1776) and subsequently advanced by George Stigler (1951), this literature argues that in vertical integration settings demand growth may be positively related to the division of labor. Stigler's conjecture has been the subject of much scholarly scrutiny. Anecdotal evidence in some industries confirms his prediction (Rosenberg 1994). However, other case studies refute its occurrence (Macher and Mowery 2004). The most notable accounts of the failure of Stigler's conjecture can be attributed to Alfred Chandler's depictions of the evolution of Corporate America (Chandler 1962, 1977). For Chandler, advances in communications and transportations lead to the emergence of large national markets, which are considered the preconditions of the integrated corporations. In this study, we provide a mechanism that may reconcile this apparent chasm. we posit that scholars may need to consider the distribution of the value created by value-adding activities to different customers. In fact, demand growth *per se* may be insufficient to explain the division of labor. If demand growth is correlated with an increase in the heterogeneity of consumers' valuations, integration may be a more likely outcome than the division of labor.

This paper also provides compelling guidance to managerial practice. Our theory prompts managers to account for demand characteristics when formulating corporate strategies. The assessment of which activities should be performed "in-house" and which ones should be left to complementors may hinge upon the potential alternative uses and returns that resources have when not employed in the provision of complementary products and services. If the portfolio of opportunities faced by the firm is narrow, it may be beneficial for firms to extend their scope over complementary activities rather than share value with the industry complementors. If the environment is munificent, managers may consider collaborations and partnerships, focusing the firm's limited resources in what the firm does best. Furthermore, there may be a fit between the firm positioning strategy and its optimal scope (Porter 1985; Porter 1996). In accordance with the prediction of our theory, managers are advised to divide labor with partners if pursuing a cost leadership strategy targeting mass markets and to use a more integrated structure if pursuing a product differentiation strategy targeting niche markets.

CHAPTER 4: CONCLUSION

According to the opportunism-based theories of the division of labor among firms (Grossman and Hart 1986; North 1991; Williamson 1975), the division of labor can be costly because of transaction costs, i.e., the costs of using the market.

In this dissertation, however, we look at the division of labor from a different angle. We attempt to emphasize the benefits associated with the division of labor. We argue that the division of labor is beneficial because it entails productivity gains arising from the parsimonious allocation of resources to activities. By leveraging the resources of the other firms in the industry, specialized firms can cache the resources they would have used in complementary activities and expand their produce in the subset of activities they are "internally" best at.

However, when firms divide labor, they divide value. Therefore, firms face the following tradeoff. They can allocate their limited resources to multiple complementary activities, integrating to capture the whole "pie" for some customers, or allocate their scarce resources to a smaller subset of activities, dividing labor to capture a portion of the "pie" for a bigger number of customers.

In Chapter 2, we analyze the resource underpinnings and the productivity implications of the division of labor through a simple model. In Chapter 3, we test the implications of our theory in the residential real estate brokerage industry in Southeast Michigan.

4.1 THEORETICAL CONTRIBUTIONS

This dissertation advances the resource-based view as a theory of the division of labor. Borrowing insights from recent developments in the literature on diversification, we argue that prior work has implicitly assumed that firms can easily scale up their operations, thus predicting that they will internalize the stages of production in which they have a productivity advantage. By challenging this assumption, we turn the canonical resource-based prediction on its head, uncovering a set of instances in which the most productive firms may prefer the division of labor to integration.

In Chapter 2, we show that non-scalable resources are likely to be conductive to specialization because firms endowed with non-scalable resources may prefer focusing their resources on a smaller subset of value-adding activities rather than spreading too thin along the value chain. We show that a productivity advantage does not imply integration. When firms are endowed with non-scalable resources, the division of labor is advantageous both for highly productive firms and for less productive firms, nullifying the impact of productivity advantages on integration. Additionally, we explain taper integration as an excess of non-scalable resources. Firms with deep stocks of non-scalable resources may be more likely to operate along multiple value adding stages, preferring taper integration to full integration.

In Chapter 3, we counter the predicaments of the resource-based view, which has often been elusive about the impact of demand characteristics on firms' strategies (Barney 2001; Priem and Butler 2001), and demonstrate the importance of demand factors as drivers of the division of labor among firms. We show that firm heterogeneity does not impact the integration strategies of firms in a static way, as previously hypothesized, but in a dynamic way. According to the existing logic, inter-firm heterogeneity affects the division of labor to the extent that firms integrate when they are more productive than the industry complementors. However, this study shows that the most productive firms are not more likely to integrate, but more likely to respond to changes in demand characteristics. The most productive firms are those for which a suboptimal allocation of resources to tasks may have a bigger impact on profitability. When market characteristics are factored in, the most productive firms are more likely to divide labor in bigger markets than to integrate.

We also contribute the classical conversation on the influence of markets on the division of labor among firms. Initiated by Adam Smith (1776) and subsequently advanced by George Stigler (1951), this literature posits that demand growth is positively related to the division of labor. This conjecture on “the extent of the market” has attracted much scholarly scrutiny, but the empirical evidence on the matter is mixed (Macher and Mowery 2004). This dissertation provides a mechanism that may explain these unreconciled results. We posit that scholars may need to consider the distribution of the value created by value-adding activities to different customers to explain the influence of demand characteristics on the division of labor. Demand growth *per se* may be insufficient: If demand growth is correlated with an increase in the heterogeneity of consumers’ valuations, integration may be more likely than the division of labor.

4.2 MANAGERIAL IMPLICATIONS

From a managerial standpoint, this dissertation has significant implications for firms operating in settings where opportunism-based explanations of the division of labor are less salient. Opportunism-based theories of the firm describe a mechanism accounting for the vertical structure of the industrial organizations of 60s and 70s. However, as often observed by the popular press, we are witnessing greater specialization and outsourcing by firms in many industries - e.g., biotechnologies, consumer electronics, semiconductors, etc. Arguably, this is the result of a reduction in transaction costs due to (i) the diffusion of information technology, which eases the access to intermediate inputs; and to (ii) the constant development of legal institutions, which reduce the uncertainty concerning legal resolutions over suppliers' opportunistic behaviors. When opportunism-based logics lose their explanatory power, managers are advised to turn to the predictions of our theory. Specifically, we suggest managers weigh the costs and benefits of a division of labor, examining the instances in which the productivity gains associated with inter-firm cooperation offset the cost of sharing the pie with other firms, and vice versa.

Demand characteristics, in particular, may shift the costs and benefits of cooperation. Before committing to an integration strategy, managers may need to assess how demand influences the potential alternative uses of resources. If the resources have a low outside option, managers may extent the vertical scope of firms over complementary activities rather than share value with the other firms in the industry. However, if the opportunities for growth abound, managers may consider collaborations and partnerships, sharing the rents arising from munificent environments.

4.3 AVENUES FOR FUTURE RESEARCH

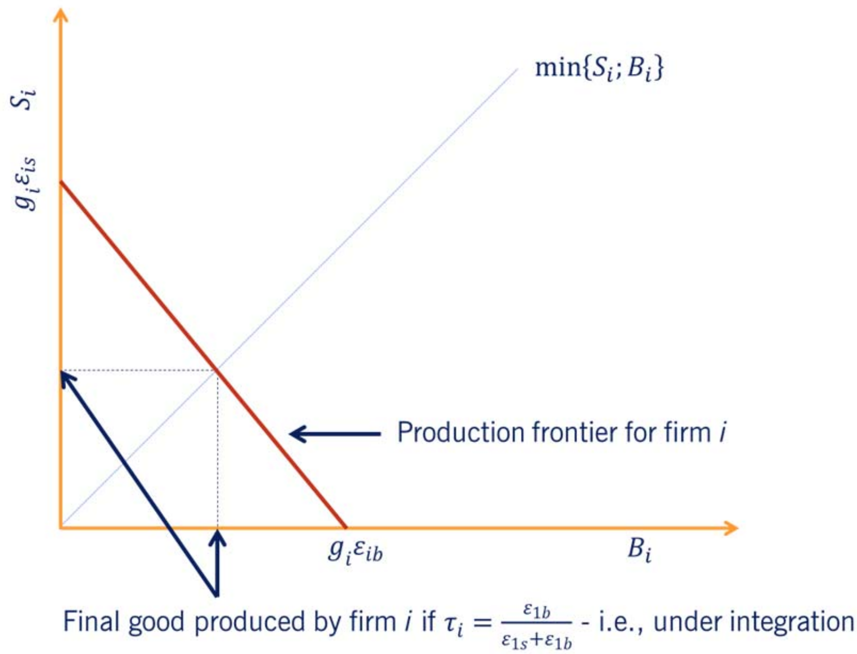
Our division of labor perspective offers multiple directions for future work. First, having examined the division of labor among firms, we could extend our theory to the mechanisms leading to the division of labor within firms (Rosen 1972, 1978, 1982). Understanding the comparative costs and benefits of different forms of the division of labor could be a fruitful research avenue to explain how the capabilities and the routines that allow cooperation among multiple individuals come into existence.

Second, having looked at the incentives of firms to cooperate given their resource stocks, the division of labor perspective could encompass dynamic scenarios covering the strategic intents of firms accumulating resources and capabilities over time. Firms may differ not only in terms of their productivity, but also in terms of their ability to strategically accumulate resources (Helfat 1997; Teece et al. 1997). The costs and benefits faced by expanding firms, which must acquire resources from the strategic factor markets, are inherently connected to the concepts of synergies and complementarities (Barney 1986). These may be the result the forward looking behavior of growing firms which have the option to extend their boundaries with the intent to acquire capabilities and resources that may be valuable in the long-term (Argyres 1996).

Finally, our division of labor perspective opens the door to a new interpretation of the phenomenon of entrepreneurship. The existing evidence suggests that many firms are born to provide services to established, integrated companies and that these new firms are founded by former employees of the incumbents (Elfenbein, Hamilton, and Zenger 2010; Klepper 2007). These firms may come into existence to ease the incumbents' resource constraints and to facilitate the emergence of gains from the division of labor, creating a win-win situation where both incumbents and entrants are better off by cooperating along the value chain. Therefore, the division of labor perspective may provide an alternative pathway to the process of creative construction hypothesized by strategy scholars (Agarwal, Audretsch, and Sarkar 2007), according to which entry may not always be a threat to incumbents, but a strategic variable that can be managed to increase the value created by the industry. By allowing entry, incumbents could facilitate the emergence of industry architectures in which they capture a smaller portion of a much bigger pie.

FIGURES

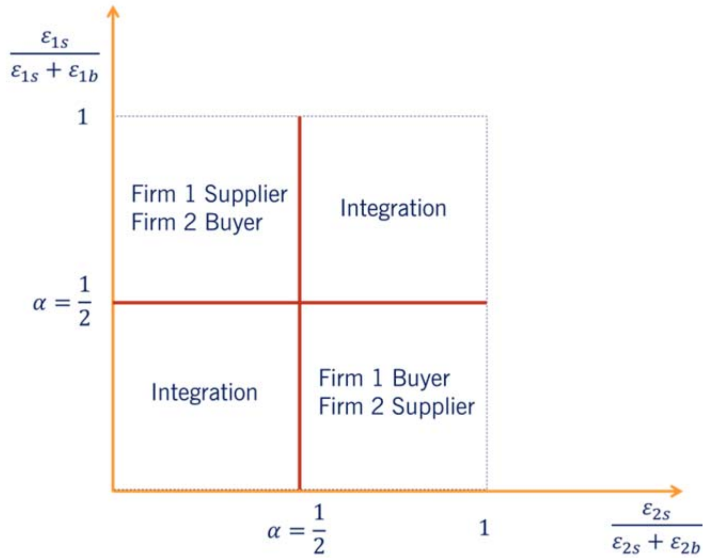
Figure 1. Graphical Representation of the Resource Allocation Trade-off



Notes:

Firm i can either allocate all of its resources upstream, producing a quantity $g_i\varepsilon_{is}$ of S_i, or downstream, producing a quantity $g_i\varepsilon_{ib}$ of B_i. Any other allocation of τ_i that is different from zero or one corresponds to a point on the production frontier line. Integration occurs when τ_i is chosen such that $S_i = B_i$. The quantity of the final good produced is given by either coordinate of the point where the production frontier line intersects the 45° line.

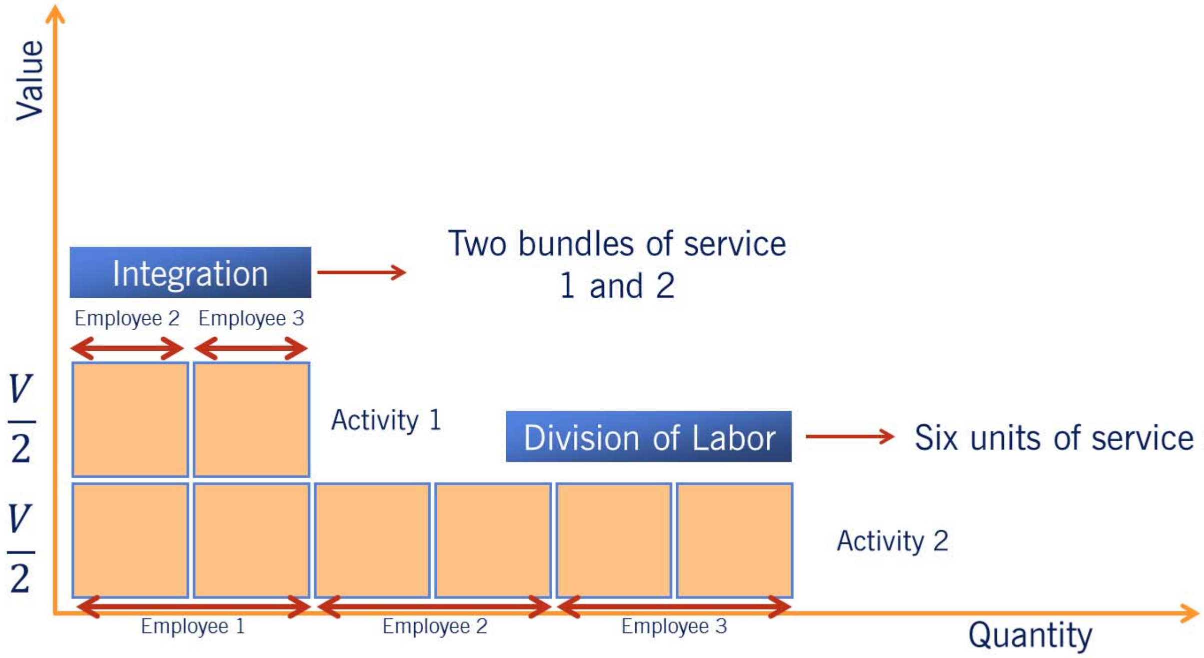
Figure 2. Graphical Representation of the Equilibrium Behavior of Firms.



Notes:

This figure shows that the division of labor is an outcome due to the non-scalable non-fungible resources of firms. When both firms have the same "internal" preference for one type of activity (both prefer buying or supplying), there are no gains from the division of labor, and we observe integration. If the two firms have different internal preferences, the division of labor is the outcome of the model. Note that the absolute level of productivity of firms is irrelevant in the determining the model outcome.

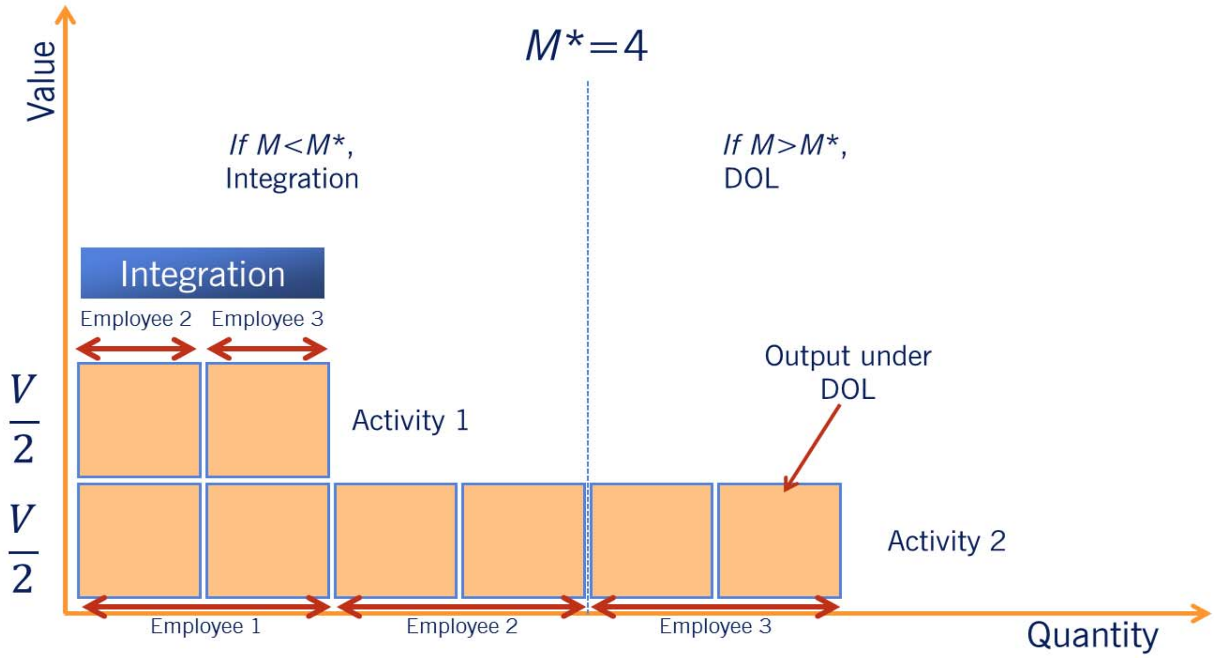
Figure 3. Resource Allocation with Infinite Market Size and Uniform Consumers' Valuations.



Notes:

Firm A employs three workers and can produce three units of service 1 if it allocates its employees to activity 1 (one unit per employee) and six units of service 2 if it allocates its employees to activity 2 (two units per employee). If firm A produces activities 1 and 2 under an integration set up, it can produce at most two bundles of services 1 and 2 by allocating two workers to activity 1 and one worker to activity 2. Under these conditions, firm A can increase the productivity of its resources by dividing labor, preferring to collect half of the value produced by six units of service 2 rather than capturing the whole value produced by two bundles of services 1 and 2.

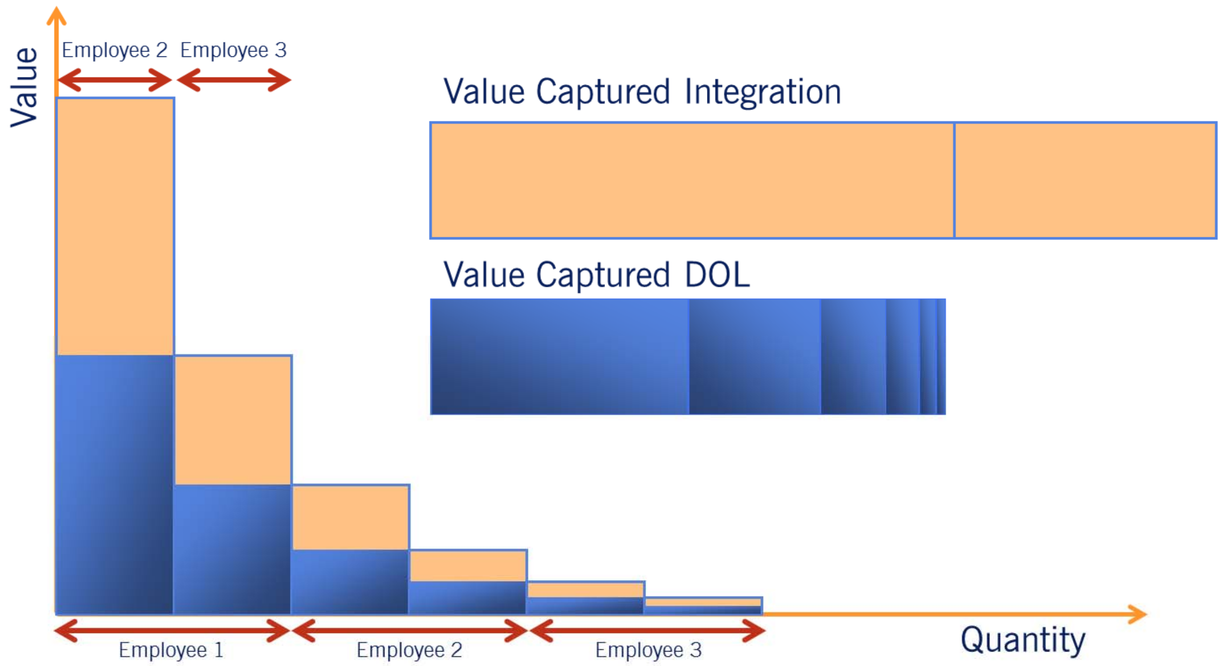
Figure 4. Resource Allocation with Finate Market Size and Uniform Consumers' Valuations.



Notes:

If the residual demand faced by firm A is bigger than four customers (e.g., six customers), firm A is better off specializing in the production of service 2, for which it collects more than 2V (e.g., $6 \times \frac{V}{2} = 3V$), where 2V is the value collected under integration. However, if the residual demand is less than four customers (e.g. three customers), the revenues from the division of labor are less than 2V (e.g. $3 \times \frac{V}{2} = 1.5V$) and firm A is better off integrating.

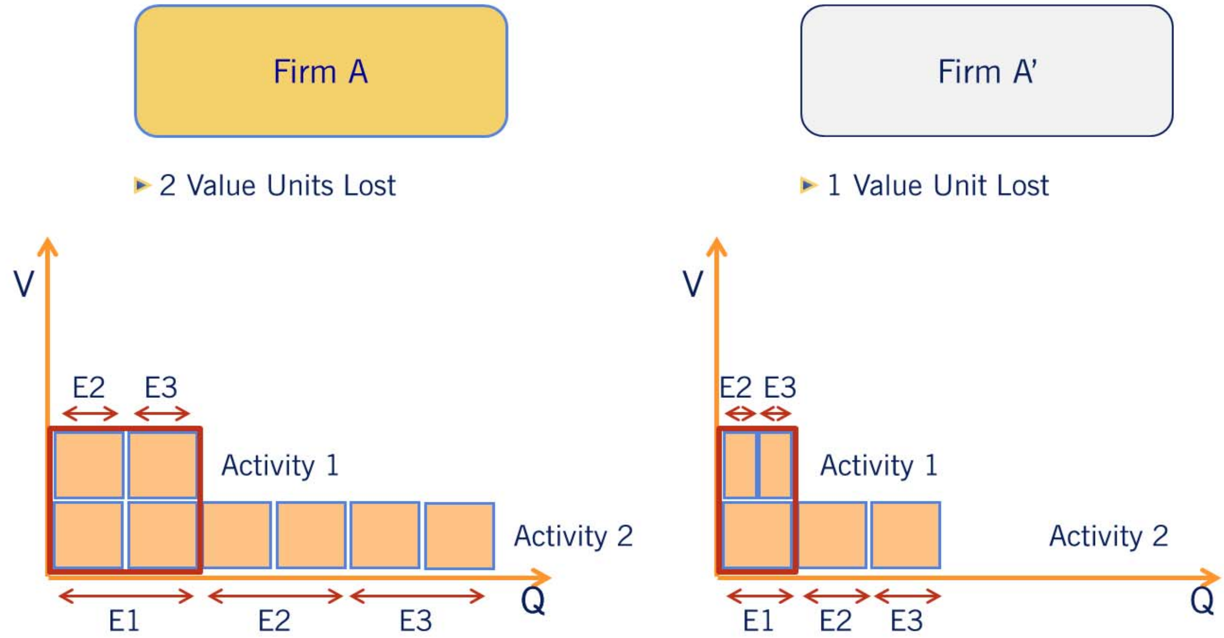
Figure 5. Resource Allocation with Infinite Market Size and Heterogeneity of Consumers' Valuations.



Notes:

If the residual demand for bundles of complementary services exhibits heterogeneity of consumers' valuations, firm A can allocate two workers to service 1 and one worker to service 2, integrating services 1 and 2 to the customers worth 32V and 16V, capturing 48V in total. Alternatively, firm A can divide labor, specializing in service 2, producing 6 units of service 2, and creating value $32 \times \frac{V}{2} + 16 \times \frac{V}{2} + \cdots + \frac{V}{2} = 31.5\,V$. But then firm A prefers integration.

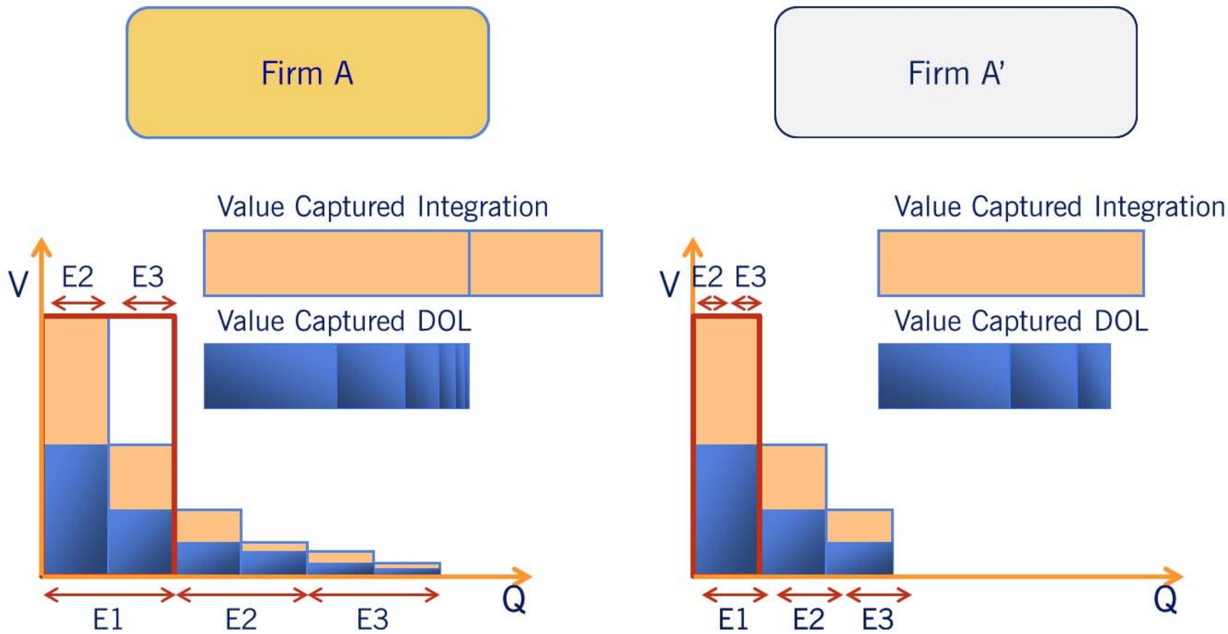
Figure 6. Resource Allocation with Shifts in Market Size and Firm Heterogeneity.



Notes:

If market size increases, both firms may benefit from resource redeployment. The reallocation of resources involves the redeployment of two employees for both firms, implying that they are likely to face similar redeployment costs. However, the most productive firm, A, stands to gain more. If market size increases, firm A' gains $\frac{1}{2}$V if it moves from integration to a division of labor set up. Firm A, which is twice as productive, gains V.

Figure 7. Resource Allocation with Shifts in Heterogeneity of Consumers' Valuations and Firm Heterogeneity.



Notes:

If the heterogeneity of consumers' valuations increases, both firms may benefit from resource redeployment. The reallocation of resources involves the redeployment of two employees for both firms, implying that they are likely to face similar redeployment costs. However, the most productive firm, A, stands to gain more. If firm A responds to an increase in the heterogeneity of consumers' valuations by integrating, it gains value 16.5V, a much larger amount than the value firm A' gains, that is 4V.

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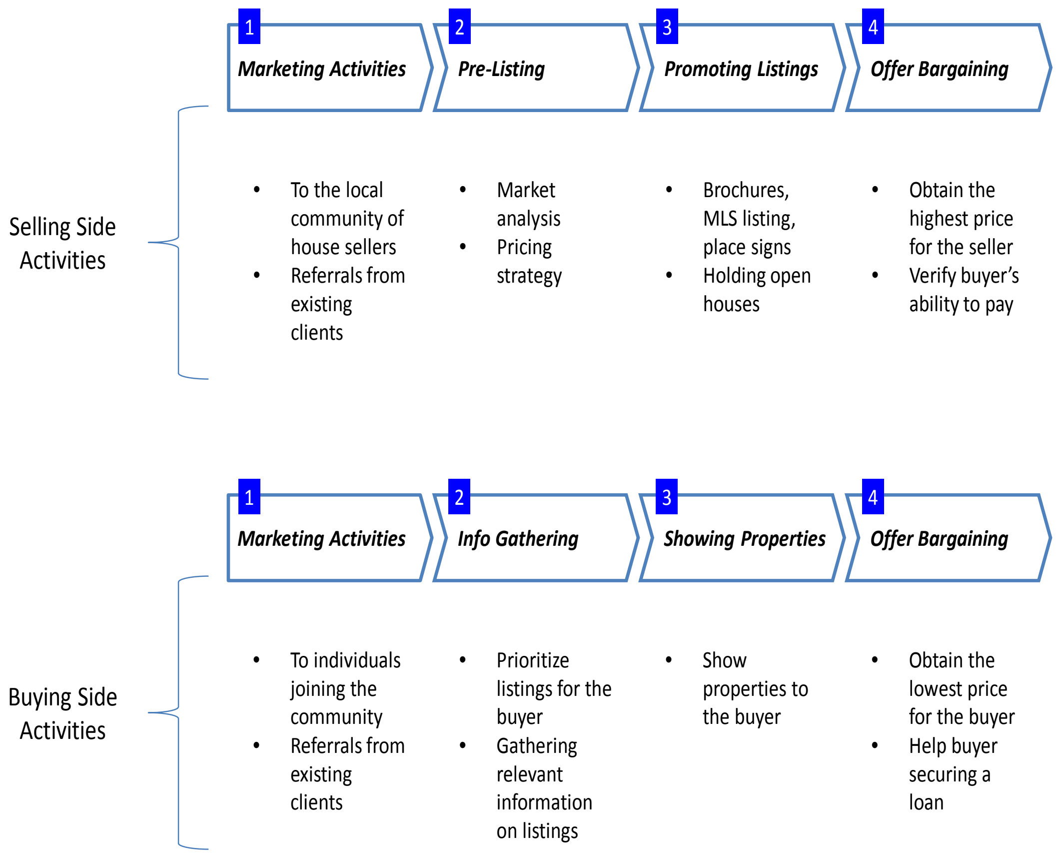
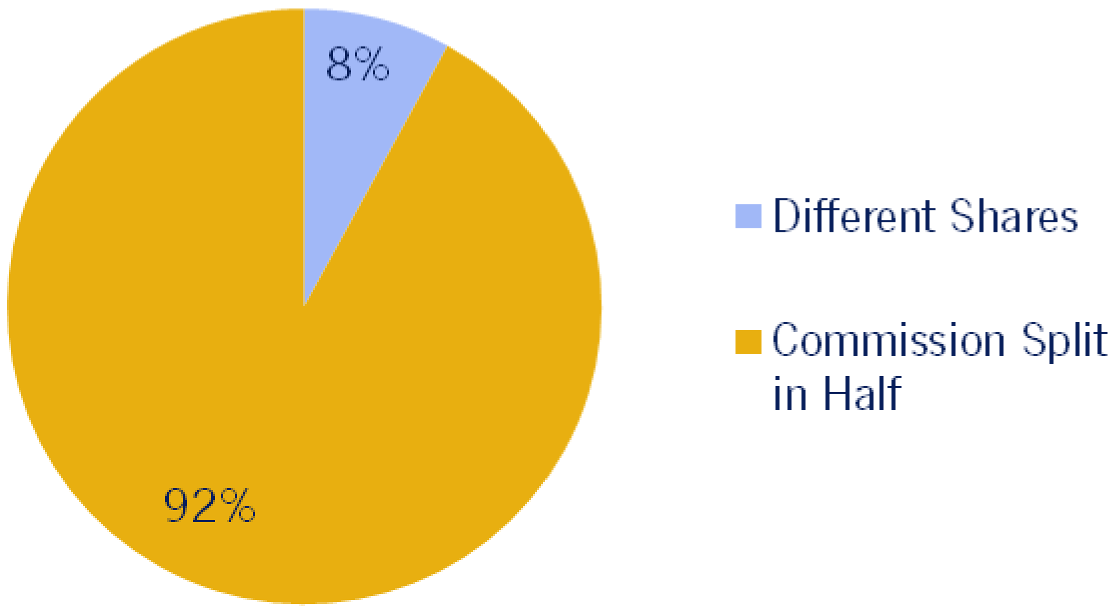
Figure 8. Selling Side and Buying Side of the Real Estate Brokerage Market.



Notes:

This figure lists the different activities in which firms engage when serving sellers and buyers.

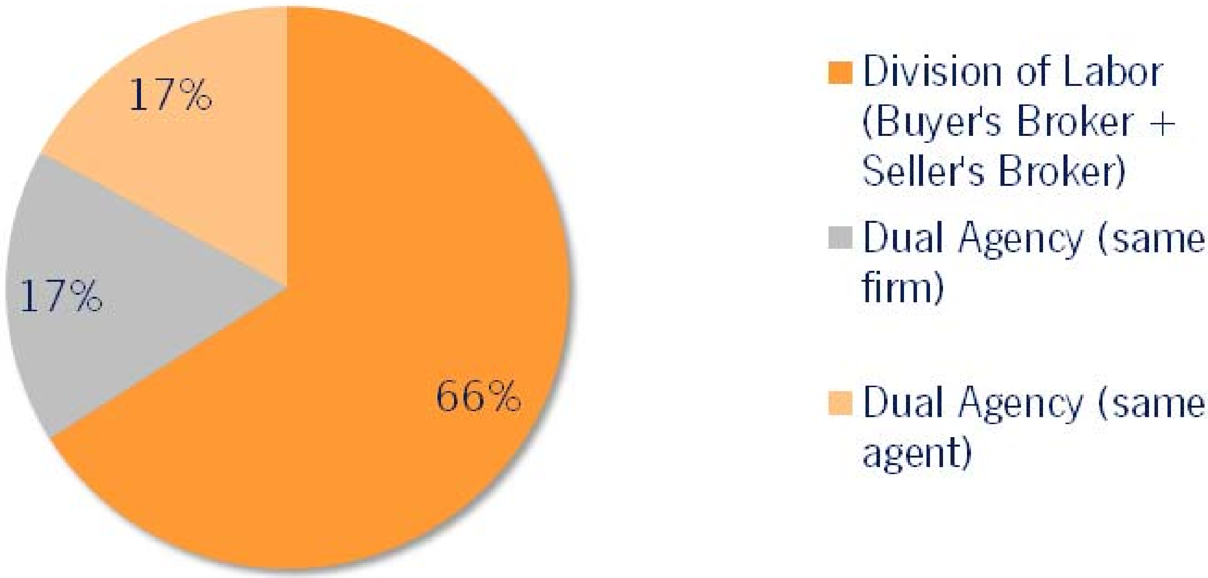
Figure 9. Commissions Splits in the Real Estate Industry in Southeast Michigan.



Notes:

The pie chart documents the custom of splitting commissions in half between buyers' brokerages and sellers' brokerages. In 92% of the transactions occurring under the division of labor, commissions were split in half between co-specialized firms.

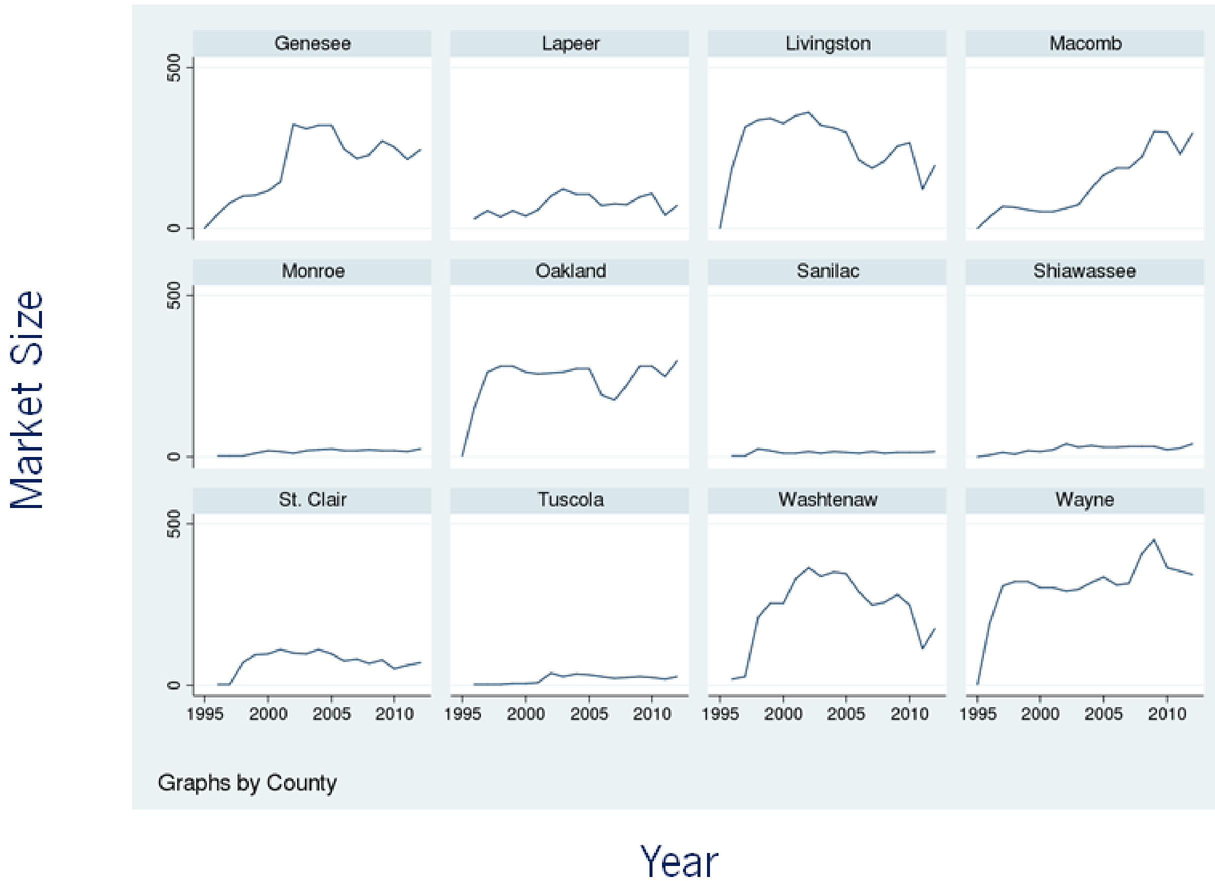
Figure 10. Division of Labor in the Real Estate Industry in Southeast Michigan.



Notes:

In 66% of the transactions in this study, two different firms cooperated over a house sale, with one firm performing the buying side and one firm performing the selling side of the same transaction. 34% of the transactions occurred under dual agency. In 17% of the total transactions (i.e., half of the transactions occurring under dual agency), the same agent performed both the selling side and the buying side of the same transaction.

Figure 11. Variation in Market Size in Southeast Michigan by County.



Notes:

The graph reports the time trend of the variable market size, aggregated at the county level. The vertical axis measures the number of transactions occurring in a given county in a given year and the horizontal axis indexes the year in which the observations are collected.

TABLES

Table 1. Top-25 Firms by Average Size.

Firm	County	Average Size 1995-2012
REAL ESTATE ONE	Oakland	1,859.7
CENTURY 21 TOWN & COUNTRY	Oakland	1,372.9
REAL ESTATE ONE	Wayne	1,291.1
KELLER WILLIAMS	Wayne	1,057.4
KELLER WILLIAMS	Oakland	1,041.6
COLDWELL BANKER SCHWEITZER	Oakland	751.5
MAX BROOCK	Oakland	690.5
CENTURY 21 CURRAN & CHRISTIE	Wayne	647.6
COLDWELL BANKER WEIR MANUEL	Oakland	587.8
CENTURY 21 TOWN & COUNTRY	Macomb	582.6
KELLER WILLIAMS	Macomb	582.0
CENTURY 21 ASSOCIATES	Oakland	558.0
CENTURY 21 TODAY	Oakland	552.1
REMERICA HOMETOWN	Wayne	488.6
COLDWELL BANKER SCHWEITZER	Wayne	434.4
CENTURY 21 TOWN & COUNTRY	Wayne	434.1
REAL ESTATE ONE	Macomb	421.2
REAL ESTATE ONE	Washtenaw	418.2
PRUDENTIAL CHAMBERLAIN STIEHL	Oakland	414.2
CHARLES REINHART CO	Washtenaw	397.2
COLDWELL BANKER PREFERRED	Wayne	362.7
CRANBROOK ASSOCIATES	Oakland	356.1
CENTURY 21 TODAY	Wayne	351.7
RE/MAX CLASSIC	Wayne	340.6
RE/MAX LEADING EDGE	Wayne	333.6

Table 2. Top-25 Growing Firms (Growth in Number of Employees).

Firm	County	Average Growth	Starting Size	Final Size	Years	
CENTURY 21 ASSOCIATES	Oakland	117.2	12	1067	1995	2004
CENTURY 21 TOWN & COUNTRY	Oakland	94.9	520	2133	1995	2012
REAL ESTATE ONE	Oakland	82.3	1089	2488	1995	2012
COLDWELL BANKER SCHWEITZER	Oakland	75.2	24	1303	1995	2012
PRUDENTIAL CHAMBERLAIN STIEHL	Oakland	55.5	47	991	1995	2012
REAL ESTATE ONE	Wayne	48.5	772	1596	1995	2012
COLDWELL BANKER SCHWEITZER	Wayne	40.1	17	699	1995	2012
MAX BROOCK	Oakland	33.5	437	1007	1995	2012
RE/MAX 100	Oakland	28.8	131	505	1995	2008
AMERICAN REALTY GROUP	Wayne	28.7	1	202	2005	2012
RE/MAX ADVANTAGE 1 INC	Macomb	26	2	366	1998	2012
CENTURY 21 TODAY	Oakland	23.6	362	764	1995	2012
CENTURY 21 HARTFORD	Wayne	22.1	49	425	1995	2012
CENTURY 21 TODAY	Wayne	20.1	182	524	1995	2012
THE MICHIGAN GROUP INC	Oakland	19.9	98	436	1995	2012
CENTURY 21 ASSOCIATES	Wayne	19.2	1	174	1995	2004
CENTURY 21 VAL-U-WAY	Oakland	17.5	42	235	1995	2006
REALTY EXECUTIVES WEST	Wayne	14	8	106	1995	2002
JACK CHRISTENSON	Oakland	13.8	116	351	1995	2012
RE/MAX IN THE HILLS	Oakland	12.6	137	351	1995	2012
ERA NETWORK	Oakland	11.5	65	261	1995	2012
CENTURY 21 WOODLAND REALTY	Genesee	11.4	1	161	1998	2012
COLDWELL BANKER PROFESSIONALS	Oakland	11.3	1	193	1995	2012
PROFESSIONAL REALTY TEAM LLC	Oakland	4.9	2	36	2005	2012
TEAM ONE TOWN & COUNTRY	Lapeer	4.7	11	39	2006	2012

Table 3. Top-25 Counties by Number of Markets.

County	# Markets (Zip Codes)
Wayne	91
Oakland	87
Macomb	41
Genesee	31
Ingham	27
St. Clair	23
Saginaw	22
Washtenaw	19
Jackson	18
Monroe	17
Sanilac	17
Tuscola	17
Lenawee	16
Huron	14
Kent	14
Livingston	13
Shiawassee	13
Gratiot	11
Hillsdale	11
Lapeer	11
Berrien	10
Alcona	9
Calhoun	9
Eaton	9
Clinton	8

Table 4. Main Variables.

Variable	Description
Dual agency	Percentage of transactions performed under dual agency by the firm
Market size	Number of transactions performed by all the firms in the market
Heterogeneity of consumers' valuations	Market variance of the sum of the buyer's commission and of the seller's commission for each transaction
Productivity percentile	Firm's percentile of belonging in the productivity distribution
Random matching	Number of buyers served by the firm divided by the number of buyers in the market times the number of sellers served by the firm divided by the number of sellers in the market
Agent specialization	Firm-level average of the formula $\left\lvert 1 - \frac{2 \times sellers\ served}{sellers\ served + buyers\ served} \right\rvert$ for each agent.
House characteristics	Vector containing 30 different types of house characteristics
Year effects	Year dummies (1996-2012)
Firm age	Observation year minus year of founding
Average age	Average age (as computed above) of the firms in the market
Firm size	Number of employees working for the firm
Average size	Average size (as computed above) of the firm in the market
Average buying side productivity	Average buying-side TFP of firms in the market
Average selling side productivity	Average selling-side TFP of firms in the market

Table 5. Summary Statistics.

	Variable	Mean	S. D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	*Dual agency*	0.16	0.28	1												
2	*Market size*	272	185	-0.16	1											
3	*Heterogeneity of consumers' valuations*	4825	4831	-0.06	-0.08	1										
4	*Productivity percentile*	0.47	0.30	-0.01	-0.09	0.34	1									
5	*Random matching*	0.01	0.06	0.23	-0.15	-0.04	0.04	1								
6	*Agent specialization*	0.83	0.21	0.06	-0.03	0.03	-0.37	-0.04	1							
7	*Firm size*	6.66	9.29	0.03	0.14	0.10	0.10	0.06	-0.08	1						
8	*Firm age*	7.46	4.59	-0.08	0.00	0.04	-0.08	-0.04	0.06	0.08	1					
9	*Average size*	3.56	1.30	-0.19	0.50	0.28	0.27	-0.10	-0.02	0.25	-0.27	1				
10	*Average age*	6.47	2.81	-0.02	-0.03	0.05	-0.14	-0.04	0.07	-0.06	0.73	-0.37	1			
11	*Average selling side productivity*	2.64	0.38	-0.10	-0.08	0.58	0.58	0.01	0.00	0.14	-0.18	0.53	-0.23	1		
12	*Average buying side productivity*	4.46	0.30	-0.09	-0.07	0.57	0.58	0.00	0.01	0.12	-0.12	0.41	-0.16	0.91	1	
13	*Number of firms*	79.5	41.9	-0.17	0.79	-0.18	-0.23	-0.20	0.02	0.05	0.20	0.08	0.21	-0.36	-0.28	1

Table 6. Dependent Variable Dual Agency: Semi-parametric Fixed-Effect Tobit.

VARIABLES	(2-1)	(2-2)	(2-3)
Market size		-0.06***	-0.05**
		(0.02)	(0.02)
Heterogeneity of consumers' valuations		0.03***	0.02*
		(0.01)	(0.01)
Productivity percentile		0.05***	-0.01
		(0.01)	(0.01)
Market size × productivity percentile			-0.04***
			(0.01)
Heterogeneity of consumers' valuations × productivity percentile			0.12***
			(0.01)
Random matching	0.62***	0.45***	0.48***
	(0.11)	(0.10)	(0.10)
Agent specialization	0.52***	0.73***	0.74***
	(0.02)	(0.02)	(0.02)
Firm size	0.26***	0.28***	0.28***
	(0.01)	(0.01)	(0.01)
Firm age	-0.12***	-0.14***	-0.14***
	(0.02)	(0.02)	(0.02)
Average size	-0.40***	-0.27***	-0.23***
	(0.03)	(0.05)	(0.05)
Average age	-0.07*	-0.04	-0.03
	(0.04)	(0.04)	(0.04)
Average selling side productivity	-0.04	-0.03	-0.03
	(0.03)	(0.03)	(0.03)
Average buying side productivity	0.10***	0.01	-0.01
	(0.02)	(0.02)	(0.02)
Number of firms	-0.31***	-0.24***	-0.21***
	(0.01)	(0.03)	(0.03)
House characteristics	Yes (4***, 3**, 3*)	Yes (4***, 1**)	Yes (4***, 1**, 1*)
Year dummies	Yes (9***, 6**, 1*)	Yes (4**, 8*)	Yes (1*, 4**)
Fixed Effects	Yes	Yes	Yes
Observations	95,455	95,455	95,455

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Cobb-Douglas Specification Fixed-Effects Estimation with Clustered Errors.

VARIABLES	Dependent Variable Output Selling	Dependent Variable Output Buying
Number of seller's agents	1.43***	0.096***
	(0.01)	(0.01)
Number of buyer's agents	0.05***	1.60***
	(0.01)	(0.01)
Cash Stock	-0.01***	-0.00
	(0.00)	(0.00)
Number of offices	-0.06***	-0.16***
	(0.01)	(0.01)
Constant	0.78***	0.64***
	(0.01)	(0.01)
Observations	95,455	95,455
Fixed Effects	Yes	Yes
R-squared	0.65	0.59

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDICES

Appendix A: Formalization Hypotheses Chapter 3

In this appendix, we formalize the arguments leading to the hypotheses by depicting a simple model that mirrors the assumptions in the theory section of the paper. The first two hypotheses of the paper are derived from the basic set up without redeployment costs. The last two hypotheses come from the model extension with redeployment costs.

The economy consists of a value chain where a firm may allocate its resources either to the production of complementary service 1, to the production of complementary service 2, or both. Each complementary service can be used solely in conjunction with one unit of the remaining complementary service, creating value 0 otherwise. The production of each complementary service by firm i follows a service-specific production function such that:

$$Q_{i1} = \rho_{i1} g_i \tau_i, \tag{11}$$

$$Q_{i2} = \rho_{i2} g_i (1 - \tau_i). \tag{12}$$

The parameters $\tau_i \in [0,1]$ indicate the percentage of the firm's employees allocated in the provision of service 1. The term $g_i \in \mathbb{R}^+$measure the general productivity of firm i, while the term ρ_{is}, with $s \in \{1,2\}$, accounts for service-specific productivities.

The demand faced by firm i consists of a mass M of consumers. Each consumer j attaches a privately known value to the bundle of services 1 and 2, denoted by θ_j, distributed across the population according to a uniform distribution on $[\underline{\theta}, \overline{\theta}]$. Given the set of firms in the market $C \equiv \{1,2, \dots, n\}$ and the set of their of their general productivities $G \equiv \{g_1, g_2, \dots, g_n\}$, the portion of the demand faced by firm i is given by the proportion $\frac{g_i}{\sum g_{c \in C}}$. We further assume that (i) firm i bundles any pair of service 1 and service 2 it produces in house, and (ii) that the supply of complementary services in the market is unconstrained, such that consumers can purchase the complementary service from some other firm for any unbundled service sold by the firm i. Consequently, the overall quantity of bundles the firm injects in the market is given by the maximum between $Q_1$and Q_2. Given the assumptions, the equilibrium price for bundles of services 1 and 2 is given by the following:

$$P = \frac{\sqrt{\sigma^2}}{M \frac{g_i}{\sum g_j}} \left(\frac{\hat{\theta}}{\sigma} M \frac{g_i}{\sum g_j} - \max\{Q_1, Q_2\} \right), \tag{13}$$

where $\hat{\theta} = \frac{1}{\sqrt{12}} \bar{\theta}$ and σ^2 is the heterogeneity of consumers' valuations.

If firm i captures value $\alpha \in [0,1]$ for each unbundled service 1 sold in the market and $(1-\alpha)$ for each unbundled service 2 sold in the market, the profit maximization problem faced by the firm is the following:

$$\max_{\tau_i} \pi_i = P(\tau_i)[\alpha Q_1(\tau_i) + (1-\alpha) Q_2(\tau_i)], \tag{14}$$

The solution of the first order conditions is given by the following:

$$\begin{cases} \tau_i^* = \frac{1}{2}\left(\frac{\hat{\theta}}{\sqrt{\sigma^2}}\frac{M}{\rho_{i1}\sum g_j} - \frac{(1-\alpha)\rho_{i2}}{\alpha\rho_{i1}-(1-\alpha)\rho_{i2}}\right) \text{ if } \alpha \geq \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}; \\ \tau_i^* = \frac{1}{2}\left(1 + \frac{(1-\alpha)\rho_{i2}}{(1-\alpha)\rho_{i2}-\alpha\rho_{i1}} - \frac{\hat{\theta}}{\sqrt{\sigma^2}}\frac{M}{\rho_{i2}\sum g_j}\right) \text{if } \alpha < \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}. \end{cases} \tag{15}$$

The following proposition fully characterizes the equilibrium behavior of firm i:

Proposition 3: The unique equilibrium strategy of firm i consists of an action profile τ_i^* such that:

4. If $\alpha \geq \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, then $\tau_1^* \geq \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$ and $\frac{\partial \tau_1^*}{\partial M} > 0$, $\frac{\partial \tau_1^*}{\partial \sigma^2} < 0$. Firm i produces a higher quantity of service 1 than service 2 and its degree of specialization increases as market size increases and it decreases as the heterogeneity of consumers' valuation increases.
5. If $\alpha < \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, then $\tau_1^* < \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$ and $\frac{\partial \tau_1^*}{\partial M} < 0$, $\frac{\partial \tau_1^*}{\partial \sigma^2} > 0$. Firm i produces a higher quantity of service 2 than service 1 and its degree of specialization increases as market size increases and it decreases as the heterogeneity of consumers' valuation increases.

Proof. If the conditions of point 1 are met, the reader can easily verify from (5) that the first order derivative of τ_1^* is increasing in M and decreasing in σ^2, meaning that a firm that produces more of service 1 will allocate more resources to that complementary service as market size increases and as the heterogeneity of consumers' valuations decreases. If the conditions of point 2 are met, from (5) the reader can deduce that a firm that produces less of service 1 will allocate fewer resources to that complementary service as market size increases and as the heterogeneity of consumers' valuations decreases, therefore increasing the supply of service 2 as market size increases and as the heterogeneity of consumers' valuations decreases. Note that α influences only the direction of specialization of firm i, but that hypotheses 1 and 2 are both confirmed independently of α. Q.E.D.

Model extension: Two-period game with redeployment costs

In this model extension, firm i maximizes over two periods. In the second period, the market consist of a mass of consumers M', with heterogeneity of consumers' valuations $\sigma^{2\prime}$. The firm faces a discount factor equal to 1 so that it values future revenues as much as current revenues. Given the firm resource allocation strategy in the second period, indicated by τ_1', the firm incurs a cost $r \in \mathbb{R}^+$ associated with resource redeployment such that the firm maximizes the following expression with respect to τ_i and $\tau_i{}'$:

$$P(M,\sigma^2,\tau_i)[\alpha Q_1(\tau_i) + (1-\alpha)Q_2(\tau_i)] + P(M',\sigma^{2\prime},\tau_i{}')[\alpha Q_1{}'(\tau_i{}') + (1-\alpha)Q_2{}'(\tau_i{}') - r(\tau_i{}' - \tau_i)]. \tag{16}$$

The solution of the first order conditions is given by the following:

$$\begin{cases} \tau_i^* = \frac{1}{2}\left(\frac{\hat{\theta}}{\sqrt{\sigma^2}}\frac{M}{\rho_{i1}\sum g_j} - \frac{(1-\alpha)\rho_{i2}}{\alpha\rho_{i1}-(1-\alpha)\rho_{i2}} + \frac{\sqrt{\sigma^2}}{M}\frac{\sum g_j}{\rho_{i1}}\frac{1}{g_i}\frac{r}{\alpha\rho_{i1}-(1-\alpha)\rho_{i2}}\right) \text{ if } \alpha \geq \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}; \\ \tau_i^* = \frac{1}{2}\left(1 + \frac{(1-\alpha)\rho_{i2}}{(1-\alpha)\rho_{i2}-\alpha\rho_{i1}} - \frac{\hat{\theta}}{\sqrt{\sigma^2}}\frac{M}{\rho_{i2}\sum g_j} - \frac{\sqrt{\sigma^2}}{M}\frac{\sum g_j}{\rho_{i1}}\frac{1}{g_i}\frac{r}{(1-\alpha)\rho_{i2}-\alpha\rho_{i1}}\right) \text{ if } \alpha < \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}; \\ \tau_i'^* = \frac{1}{2}\left(\frac{\hat{\theta}}{\sqrt{\sigma^{2\prime}}}\frac{M'}{\rho_{i1}\sum g_j} - \frac{(1-\alpha)\rho_{i2}}{\alpha\rho_{i1}-(1-\alpha)\rho_{i2}} - \frac{\sqrt{\sigma^{2\prime}}}{M'}\frac{\sum g_j}{\rho_{i1}}\frac{1}{g_i}\frac{r}{\alpha\rho_{i1}-(1-\alpha)\rho_{i2}}\right) \text{ if } \alpha \geq \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}; \\ \tau_i'^* = \frac{1}{2}\left(1 + \frac{(1-\alpha)\rho_{i2}}{(1-\alpha)\rho_{i2}-\alpha\rho_{i1}} - \frac{\hat{\theta}}{\sqrt{\sigma^{2\prime}}}\frac{M}{\rho_{i2}\sum g_j} + \frac{\sigma'}{M'}\frac{\sum g_j}{\rho_{i1}}\frac{1}{g_i}\frac{r}{(1-\alpha)\rho_{i2}-\alpha\rho_{i1}}\right) \text{ if } \alpha < \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}. \end{cases} \tag{17}$$

If $\alpha \geq \frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, the difference in the resource allocations between period 2 and period 1 is therefore given by the following expression:

$$\tau_i'^{*}-\tau_i^{*}=\frac{1}{2}\left[\frac{\hat{\theta}}{\rho_{i1}\sum g_j}\left(\frac{M'}{\sqrt{\sigma^{2'}}}-\frac{M}{\sqrt{\sigma^2}}\right)-\frac{\sum g_j}{\rho_{i1}}\frac{1}{g_i}\frac{r}{\alpha\rho_{i1}-(1-\alpha)\rho_{i2}}\left(\frac{\sqrt{\sigma^{2'}}}{M'}+\frac{\sqrt{\sigma^2}}{M}\right)\right]. \qquad (18)$$

If $\alpha<\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, the difference in the resource allocations between period 2 and period 1 is therefore given by the following expression:

$$\tau_i'^{*}-\tau_i^{*}=\frac{1}{2}\left[-\frac{\hat{\theta}}{\rho_{i1}\sum g_j}\left(\frac{M'}{\sqrt{\sigma^{2'}}}+\frac{M}{\sqrt{\sigma^2}}\right)+\frac{\sum g_j}{\rho_{i1}}\frac{1}{g_i}\frac{r}{(1-\alpha)\rho_{i2}-\alpha\rho_{i1}}\left(\frac{\sqrt{\sigma^{2'}}}{M'}+\frac{\sqrt{\sigma^2}}{M}\right)\right]. \qquad (19)$$

The following proposition fully describes the interaction between the general productivity level g_i and demand characteristics in the two-period game with redeployment costs.

Proposition 4: The unique equilibrium strategy of firm *i* consists of an action profile $(\tau_i'^{*},\tau_i^{*})$ such that:

6. If $\alpha\geq\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, then $\tau_1^{*}\geq\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, $\tau_i'^{*}\geq\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, and $\frac{\partial\tau_i'^{*}-\tau_i^{*}}{\partial M'\partial g_i}>0$, and $\frac{\partial\tau_i'^{*}-\tau_i^{*}}{\partial\,\sigma^{2'}\partial g_i}<0$. Firm i produces a higher quantity of service 1 than service 2. The positive effect of market size on specialization increases as the general productivity increases and negative effect of the heterogeneity of consumers' valuations on specialization becomes more negative as the general productivity increases.

7. If $\alpha<\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, then $\tau_1^{*}<\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, $\tau_i'^{*}<\frac{\rho_{i2}}{\rho_{i1}+\rho_{i2}}$, and $\frac{\partial\tau_i'^{*}-\tau_i^{*}}{\partial M'\partial g_i}<0$, and $\frac{\partial\tau_i'^{*}-\tau_i^{*}}{\partial\,\sigma^{2'}\partial g_i}>0$. Firm i produces a higher quantity of service 2 than service 1. Also in this case, the positive effect of market size on specialization increases as the general productivity increases and negative effect of the heterogeneity of consumers' valuations on specialization becomes more negative as the general productivity increases.

Proof. Point 3 can be deduced by taking the derivatives of (18) with respect to the parameters of interest. Point 4 can be deduced by taking the derivatives of (19) with respect to the parameters of interest. Note that also in this case α influences only the direction of specialization of firm i, but that hypotheses 3 and 4 are both confirmed independently of α. Q.E.D.

Appendix B: TFP Estimation Chapter 3

Buying side productivity and *selling side productivity* are two empirical constructs used to compute the independent variable *productivity percentile.* To estimate these activity-specific productivities, We assume that the output of firms follows a Cobb-Douglas functional form. Given an output y_{ijzt}, produced by firm *i* in market *j* when performing activity *z* in year *t*, and a series of productive inputs x_{qijzt}, where *q* indexes one of the *n* inputs used by firm *i*, production follows the functional form:

$$y_{ijzt} = (\alpha_{ijz} \times \varepsilon_{ijzt}) \times \prod_{q=1}^{n} x_{qijzt}{}^{\beta_q}\ .$$

In this functional form, α_{ijzt} is the time invariant productivity of firm *i* in market *j* when performing activity *z* (i.e., fixed effect), ε_{ijzt} is the year-specific productivity of firm *i* in market *j* in year *t* when performing activity *z*, $\prod_{q=1}^{n} x_{qijzt}{}^{\beta_q}$ is the product of the *n* inputs entering production with output elasticity β_q. To estimate this Cobb-Douglas specification, we take the natural logarithm on the right-hand side and on the left-hand side, obtaining the following specification:

$$log(y_{ijzt}) = log(\alpha_{izt}) + log(\varepsilon_{ijzt}) + \sum_{q=1}^{n} \beta_q\, log(x_{qijzt}).$$

When z indexes buying activities, y_{ijzt} is the number of buyers served by the brokerage in a given postal code in a given year. When z indexes selling activities, y_{ijzt} is the number of sellers served by a brokerage in a given postal code in a given year. The set of inputs x_{qijzt} is the same for both types of activities. Following this procedure, we am able to control for potential synergies/diseconomies of scope arising from the simultaneous activity of firms on the buyers' side and on the sellers' side. The inputs considered are the *number of seller's agents*, the *number of buyer's agents*, the *cash stock* accumulated by firms, and the *number of offices* operated by firms. *Number of seller's agents* is measured as the number of agents who have performed transactions with the focal firm in the observational year times the average share of transactions these agents perform as seller's agents. *Number of buyer's agents* is measured as the number of agents who have performed transactions for the focal firm in the observational year, times the average share of transactions these agents perform as buyer's agents. *Cash stock* is measured as the discounted sum of the commissions collected by the firm in a given market. It is computed recursively as follows: $Cash\ stock_{ijt} = sum\ commissions_{ijt-1} + 0.85 \times Cash\ stock_{ijt-1}$. *Number of offices* counts the number of offices in the focal firm whose agents are active in the focal market. *Number of offices* and *cash stock* are included in the analysis as proxies for non-human capital. Results from these estimations are presented in Table B1. In summary, *buying side productivity* coincides with $log(\alpha_{izt}) + log(\varepsilon_{ijzt})$ when *z* indexes buying activities (i.e., the time invariant productivity of firm *i* in market *j* when performing activity *z* plus the year-specific productivity of firm *i* in market *j* in year *t* when performing activity *z*), while *selling side productivity* coincides with $log(\alpha_{izt}) + log(\varepsilon_{ijzt})$ when *z* indexes selling activities.

[Insert Table 7 approximately here]

REFERENCES

Abelson, M.A., M.K. Kacmar, E.F. Jackofsky. 1990. Factors influencing real estate brokerage sales staff performance. *Journal of Real Estate Research* 5(2) 265-275.

Adams, H. 1918. *The Education of Henry Adams*. The Massachusetts Historical Society, Boston.

Adner, R., P. Zemsky. 2006. A demand-based perspective on sustainable competitive advantage. *Strategic Management Journal* 27(3) 215-239.

Agarwal, R., D. Audretsch, M.B. Sarkar. 2007. The process of creative construction: Knowledge spillovers, entrepreneurship, and economic growth. *Strategic Entrepreneurship Journal* 1(2) 263-286.

Alan, S., B.E. Honoré, L. Hu, S. Leth-Petersen. 2014. Estimation of panel data regression models with two-sided censoring or truncation. *Journal of Econometric Methods* 3(1) 1-20.

Ames, E., N. Rosenberg. 1965. The progressive division and specialization of industries. *Journal of Development Studies* 1(4) 363-383.

Amit, R., P.J.H. Schoemaker. 1993. Strategic assets and organizational rent. *Strategic Management Journal* 14(1) 33-46.

Anand, J., H. Singh. 1997. Asset redeployment, acquisitions and corporate strategy in declining industries. *Strategic Management Journal* 18(Special Issue Supplement) 99-118.

Argyres, N.S. 1996. Evidence on the role of firm capabilities in vertical integration decisions. *Strategic Management Journal* 17(2) 129-150.

Arora, A., W.B. Vogt, J.W. Yoon. 2009. Is the division of labor limited by the extent of the market? Evidence from the chemical industry. *Industrial and Corporate Change* 18(5) 785-806.

Arrow, K.J. 1975. Vertical integration and communication. *Bell Journal of Economics* 6(1) 173-183.

Atalay, E., A. Hortaçsu, C. Syverson. 2014. Vertical integration and input flows. *American Economic Review* 104(4) 1120-1148.

Balakrishnan, S., B. Wernerfelt. 1986. Technical change, competition, and vertical integration. *Strategic Management Journal* 7(4) 347-359.

Barney, J.B. 1986. Strategic factor markets: Expectations, luck, and business strategy. *Management Science* 32(10) 1231-1241.

Barney, J.B. 1991. Firm resources and sustained competitive advantage. *Journal of Management* 17(1) 99-120.

Barney, J.B. 1999. How a firm's capabilities affect boundary decisions. *Sloan Management Review* 40(3) 137-145.

Barney, J.B. 2001. Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review* 26(1) 41-56.

Becker, G.S., K.M. Murphy. 1992. The division of labor, coordination costs, and knowledge. *Quarterly Journal of Economics* 107(4) 1137-1160.

Bikard, M., F. Murray, J.S. Gans. 2015. Exploring trade-offs in the organization of scientific work: Collaboration and scientific reward. *Management Science* Articles in Advance(Forthcoming) 1–23.Black, H.C. 2004. *Black's Law Dictionary*. West Publishing Company, St. Paul, Minnesota:.

Brambila, A.V. 2014. Redfin accused of misclassifying employees as independent contractors. Inman News, Emeryville, CA.

Brandenburger, A., H. Stuart. 2007. Biform games. *Management Science* 53(4) 537-549.

Burke, B. 2007. *Law of Real Estate Brokers*. Wolters Kluwer Law & Business, Austin, TX.

Capron, L. 1999. The long-term performance of horizontal acquisitions. *Strategic Management Journal* 20(11) 987-1018.

Chamberlain, G. 1982. Multivariate regression models for panel data. *Journal of Econometrics* 18(1) 5-46.

Chandler, A.D.J. 1962. *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. MIT Press, Cambridge, MA.

Chandler, A.D.J. 1977. *The Visible Hand: The Managerial Revolution in American Business*. Belknap Press, Cambridge, MA.

Choi, E.J., J.R. Spletzer. 2012. Declining average size of establishments: The evidence and explanations. *Monthly Labor Review* 135 50-65.

Conner, K.R., C.K. Prahalad. 1996. A resource-based theory of the firm: Knowledge versus opportunism. *Organization science* 7(5) 477-501.

Demsetz, H. 1988. The theory of the firm revisited. *Journal of Law, Economics, & Organization* 4(1) 141-162.

Dierickx, I., K. Cool. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science* 35(12) 1504-1512.

Dixit, A.K., G.M. Grossman. 1982. Trade and Protection With Multistage Production. *The Review of Economic Studies* 49(4) 583-594.

Dizik, A. 2014. Can selling real estate make you rich? *The Wall Street Journal*. Dow Jones & Company, New York.

Elfenbein, D.W., B.H. Hamilton, T.R. Zenger. 2010. The small firm effect and the entrepreneurial spawning of scientists and engineers. *Management Science* 56(4) 659-681.

Evers, W.M. 1980. Specialization and the division of labor in the social thought of Plato and Rousseau. *Journal of Libertarian Studies* 4(1) 45-64.

Fabrizio, K.R. 2012. Institutions, capabilities, and contracts: Make or buy in the electric utility industry. *Organization Science* 23(5) 1264-1281.

Federal Trade Commission. 2007. Competition in the real estate brokerage industry. Federal Trade Commission, Washington, DC.

Garicano, L., T.N. Hubbard. 2009. Specialization, firms, and markets: The division of labor within and between law firms. *Journal of Law, Economics, and Organization* 25(2) 339-371.

Greene, W. 2004a. The behaviour of the maximum likelihood estimator of limited dependent variable models in the presence of fixed effects. *Econometrics Journal* 7(1) 98-119.

Greene, W. 2004b. Fixed effects and bias due to the incidental parameters problem in the Tobit model. *Econometric Reviews* 23(2) 125-147.

Grossman, S.J., O.D. Hart. 1986. The costs and benefits of ownership: A theory of vertical and lateral integration. *Journal of Political Economy* 94(4) 691-719.

Helfat, C.E. 1997. Know-how and asset complementarity and dynamic capability accumulation: The case of R&D. *Strategic Management Journal* 18(5) 339-360.

Helfat, C.E., K.M. Eisenhardt. 2004. Inter-temporal economies of scope, organizational modularity, and the dynamics of diversification. *Strategic Management Journal* 25(13) 1217-1232.

Helfat, C.E., M.A. Peteraf. 2003. The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal* 24(10) 997-1010.

Huckman, R.S., D.E. Zinner. 2008. Does focus improve operational performance? Lessons from the management of clinical trials. *Strategic Management Journal* 29(2) 173-193.

Hunt, R. 2014. California lawsuit challenges independent contractor status for real estate agents. RealtyTimes, Ft. Worth, TX.

Jacobides, M.G. 2008. How capability differences, transaction costs, and learning curves interact to shape vertical scope. *Organization Science* 19(2) 306-326.

Jacobides, M.G., L.M. Hitt. 2005. Losing sight of the forest for the trees? Productive capabilities and gains from trade as drivers of vertical scope. *Strategic Management Journal* 26(13) 1209-1227.

Jacobides, M.G., S.G. Winter. 2005. The co-evolution of capabilities and transaction costs: explaining the institutional structure of production. *Strategic Management Journal* 26(5) 395-413.

Jacobides, M.G., S.G. Winter. 2007. Entrepreneurship and firm boundaries: the theory of a firm. *The Journal of Management Studies* 44(7) 1213-1241.

Kaul, A. 2013. Entrepreneurial action, unique assets, and appropriation risk: Firms as a means of appropriating profit from capability creation. *Organization Science* 24(6) 1765-1781.

KC, D.S., C. Terwiesch. 2011. The effects of focus on performance: Evidence from California hospitals. *Management Science* 57(11) 1897-1912.

Klepper, S. 2007. Disagreements, spinoffs, and the evolution of Detroit as the capital of the U.S. automobile industry. *Management Science* 53(4) 616-631.

Kogut, B., U. Zander. 1992. Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science* 3(3) 383-397.

Kogut, B., U. Zander. 1996. What firms do? Coordination, identity, and learning. *Organization Science* 7(5) 502-518.

Krieger, N., P. Waterman, J.T. Chen, M.-J. Soobader, S. Subramanian, R. Carson. 2002. Zip code caveat: bias due to spatiotemporal mismatches between zip codes and US census-defined geographic areas - the Public Health Disparities Geocoding Project. *American Journal of Public Health* 92(7) 1100-1102.

Langlois, R.N. 1992. Transaction cost economics in real time. *Industrial and Corporate Change* 1(1) 99-127.

Levinthal, D.A., B. Wu. 2010. Opportunity costs and non-scale free capabilities: Profit maximization, corporate scope, and profit margins. *Strategic Management Journal* 31(7) 780-801.

Macher, J.T., D.C. Mowery. 2004. Vertical specialization and industry structure in high technology industries. *Advances in Strategic Management* 21 317-355.

Madhok, A. 2002. Reassessing the fundamentals and beyond: Ronald Coase, the transaction cost and resource-based theories of the firm and the institutional structure of production. *Strategic Management Journal* 23(6) 535-550.

Makadok, R., D.G. Ross. 2013. Taking industry structuring seriously: A strategic perspective on product differentiation. *Strategic Management Journal* 34(5) 509-532.

Mayer, K.J., R.M. Salomon. 2006. Capabilities, contractual hazards, and governance: Integrating resource-based and transaction cost perspectives. *Academy of Management Journal* 49(5) 942-959.

Mitchell, W., J.M. Shaver. 2003. Who buys what? How integration capability affects acquisition incidence and target choice. *Strategic Organization* 1(2) 171-201.

Muhl, C.J. 2002. What is an employee? The answer depends on the federal law. *Monthly Labor Review* 125 3.

National Association of Realtors. 2007. Multiple listing service (MLS): what is it? National Association of REALTORS®.

Nelson, R., S. Winter. 1982. *An Evolutionary Theory of Economic Change*. Belknap Press, Cambridge, MA.

Nguyen-Chyung, A. 2013. How entrepreneurial do you choose to be? Talent, risk attitudes, overconfidence and self-selection into entrepreneurship. *Working Paper*.

North, D.C. 1991. Institutions. *Journal of Economic Perspectives* 5(1) 97-112.

Penrose, E.T. 1959. *The Theory of the Growth of the Firm*. Blackwell Publishers, Oxford.

Peteraf, M.A. 1993. The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal* 14(3) 179-191.

Porter, M.E. 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*. Collier Macmillan, New York, London.

Porter, M.E. 1996. What is strategy? *Harvard Business Review* 74(6) 61-&.

Priem, R.L., J.E. Butler. 2001. Tautology in the resource-based view and the implications of externally determined resource value: Further comments. *Academy of Management Review* 26(1) 57-66.

Puranam, P., R. Gulati, S. Bhattacharya. 2013. How much to make and how much to buy? An analysis of optimal plural sourcing strategies. *Strategic Management Journal* 34(10) 1145-1161.

Puranam, P., K. Srikanth. 2007. What they know vs. what they do: How acquirers leverage technology acquisitions. *Strategic Management Journal* 28(8) 805-825.

Richardson, G.B. 1972. The organisation of industry. *Economic Journal* 82(327) 883-896.

Rosen, S. 1972. Learning by experience as joint production. *Quarterly Journal of Economics* 86(3) 366-382.

Rosen, S. 1978. Substitution and division of labour. *Economica* 45(179) 235-250.

Rosen, S. 1982. Authority, control, and the distribution of earnings. *Bell Journal of Economics* 13(2) 311-323.

Rosenberg, N. 1994. *Exploring the Black Box: Technology, Economics, and History*. Cambridge University Press.

Sakhartov, A.V., T.B. Folta. 2013. Resource relatedness, redeployability, and firm value. *Strategic Management Journal* 35(12) 1781-1797.

Simon, H.A. 1951. A formal theory of the employment relationship. *Econometrica: Journal of the Econometric Society* 19(3) 293-305.

Smith, A. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. William Strahan, London.

Stigler, G. 1939. Production and distribution in the short run. *Journal of Political Economy* 47(3) 305-327.

Stigler, G.J. 1951. The division of labor is limited by the extent of the market. *Journal of Political Economy* 59(3) 185-193.

Szulanski, G. 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal* 17(Winter) 27-43.

Teece, D.J. 1980. Economies of scope and the scope of the enterprise. *Journal of Economic Behavior and Organization* 1(3) 223-247.

Teece, D.J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy* 15(6) 285-305.

Teece, D.J. 1988. Technological Change and the Nature of the Firm. G. Dosi, ed. *Technical change and economic theory*. Pinter Publishers, London ; New York, x, 646.

Teece, D.J., G. Pisano, A. Shuen. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* 18(7) 509-533.

Vetstein, R. 2013. Are mass. real estate agents independent contractors or employees? Crucial issue heads to appeals court. Vetstein Law Group, P.C., Framingham, MA.

Von Mises, L. 1949. *Human Action: A Treatise on Economics*. Yale University Press, New Haven.

Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal* 5(2) 171-180.

Williamson, O.E. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. Macmillan, New York.

Winter, S.G., G. Szulanski. 2001. Replication as strategy. *Organization Science* 12(6) 730-743.

Wu, B., A.M. Knott. 2006. Entrepreneurial risk and market entry. *Management Science* 52(9) 1315-1330.

Zollo, M., H. Singh. 2004. Deliberate learning in corporate acquisitions: Post-acquisition strategies and integration capability in US bank mergers. *Strategic Management Journal* 25(13) 1233-1256.