Standardization versus Specialization in Outsourcing

Anu Kovarikova Arro*

Abstract

I study a general equilibrium model in which the industrial structure evolves into vertical integration or outsourcing to either specialized or standardized component producers. I show that outsourcing brings specialization efficiencies by reducing costs, whereas the degree of competition and the relative cost of customizing inputs determine whether specialized or standardized input suppliers survive in the equilibrium. Growth in the labor force or opening up to trade supports outsourcing to standardized input providers, since it generates the highest final good output at increasingly lower prices.

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* CERGE-EI, a joint workplace of the Center for Economic Research and Graduate Education, Charles University, and the Economics Institute of the Academy of Sciences of the Czech Republic, Politických vězňů 7, 111 21 Prague 1, Czech Republic. Tel: (+420 2) 2400 5187, fax: (+420 2) 2421 1374, e-mail: anu.arro@cerge-ei.cz.

3.1 Introduction

As Grossman and Helpman (2002b) note, "this is the age of outsourcing". Firms outsource an expanding range of activities, but particularly widespread is the current delegation of the production of intermediate inputs from in-house to outside producers in a variety of industries: aircraft, cars, computers, mobile phones, audio and video systems, and watches among others (Buehler and Haucap, 2006). An increase in the costs of production has specifically favored outsourcing since it has allowed final good firms to move from fixed to variable costs and by making variable costs more predictable.

This paper develops a general equilibrium framework so as to examine the decisions of final good firms to produce a necessary intermediate input in-house, outsource it to an 'ideal' intermediate producer, or outsource it to a standardized intermediate producer as an outcome of market interactions. A majority of the literature examining the global division of labor has been focused on the Dixit-Stiglitz-Ethier setup, which illustrates how the economy gains from the production of monopolistically competitive intermediate goods in an open economy setting. The main idea of this framework is that usage of a wider selection of intermediate goods allows lowering the price-index and increasing the output. The drawback of such a setup is that it does not allow analyzing situations in which a firm is not involved in the assembly of a large number of components, but instead requires a specific intermediate input to fit its specifications. Such a setup is, however, widely analyzed in the context of transaction cost analysis, whereby 'asset specificity' and incomplete contracts tend to make the organization of market transactions complicated due to 'hold-up' problems and 'double marginalization', thereby limiting the possibilities and benefits of arm's-length transactions.

My purpose is to revisit the situation in which a final good firm requires a specific input, but instead of envisioning that the only opportunity for this final good firm is either to produce the necessary input itself, thereby vertically integrating, or to outsource to a single monopolist, thereby facing a high marginal cost, it has the opportunity to meet two types of outsourcing firms on the market. One type has the technology to produce an exact match to the final good requirements; this type will be denoted the 'ideal' intermediate producer. The other type has the technology to produce a standard product and thereafter adapt it to the requirements of the final good producers; this type will be denoted the 'standardized' intermediate producer. Unlike the setup with a single monopolist intermediate good producer, it will be shown that in the market equilibrium, both types of intermediate good producers will accept the input price offered by the final good producer, which is identical to the price that equals their average cost. Therefore even though there is 'double marginalization', the markup is significantly diminished in the number of final good firms and as the number of firms grows large, the price for the intermediate good approaches its marginal cost, reducing the relevance of 'double marginalization' as the reason for vertical integration with complete contracts (Perry, 1989).

I will also show that even though vertical integration and outsourcing do not occur simultaneously due to differences in fixed costs, both types of outsourcing firms can operate in the same equilibrium if parameter restrictions are satisfied. In general, it is not the case that different types of input providers cannot simultaneously service the market.

The main objective is then to examine what happens in the open economy setup. The main outcome of free trade in final manufacturing goods is that final good manufacturing will be distributed in proportion to country size, hence the equilibrium is proportional. The increase of labor endowment or the possibility of trade yield four main predictions. First, both countries will experience an increase in real wages, though the smaller country will have a higher increase. Second, similarly to the Krugman-type setup the enlargement of the market results in an increase in final manufacturing good output and a decrease in its price. Third, market width (as expressed by the arc distance characterizing the set of consumers of a particular final good manufacturer) decreases, whereas market thickness (as defined by the number of final good firms) increases for intermediate producers. Finally, standardized outsourcing becomes more attractive as the market enlarges since it allows the highest final good output and the lowest prices.

When, instead, intermediate goods can be traded, the equilibrium is no longer proportional and the market width does not change, while market thickness again increases. Standardized outsourcing is again preferred, but the mechanism by which higher final good output and lower prices are generated is different. When the final goods are tradable, the market works through reducing the markups, whereas when the intermediate inputs are tradable, adaptation costs diminish instead.

The rest of the paper is structured as follows. Section 3.2 develops a three sector of production model and examines consumer and producer behavior. Section 3.3 examines different types of equilibria. Section 3.4 focuses on the growth and international trade outcomes and Section 3.5 offers concluding remarks. The Appendix C contains figures.

3.2 The Model

In this section I present the structure of the model. Let there be two types of goods available for consumption in the economy, a final manufacturing good and a constant returns *numéraire* good. The manufacturing good is produced in many varieties among which each consumer chooses their 'ideal' or preferred variety. The production of each manufacturing good requires a fixed cost and an intermediate good tailored to the final good specifications. This intermediate can be produced by the final good producer itself or it can be outsourced to independent firms. There is only one factor of production, labor. The model examines various possible equilibria based on available technologies for intermediate good production.

3.2.1. Consumers

Suppose a typical consumer consumes two types of goods, a preferred or 'ideal' manufactured commodity and a homogeneous good, which functions as a *numéraire*. Manufactured products in the economy are defined over a continuum of varieties such that there is a one-to-one correspondence between these varieties' characteristics and points on a circumference of a circle, with the circumference having a unit length.

Manufactured varieties can be differentiated by a single attribute. Each consumer hence has her most preferred manufactured good variety, defined as her 'ideal' variety, and it is ideal in the sense that given a choice between her ideal variety and another variety, the consumer would always prefer the ideal one (irrespective of units in which the quantities of the manufactured good is measured). Moreover, the further the available variety is from the consumer's 'ideal' variety, the less desirable it is.

To formalize these ideas, suppose that a consumer's utility function is represented by a Cobb-Douglas function with parameter $0 < \alpha < 1$ as a share of the 'ideal' manufactured product in consumption. The consumer maximizes her utility using a two-stage budgeting procedure. The first decision of the consumer concerns the variety of manufactured good that will be consumed. The consumer picks her preferred good among all produced varieties and takes into account the relative prices of varieties. The second decision of the consumer concerns the allocation of her budget between her 'ideal' manufactured good and the homogeneous good, given her budget constraint equaling to 1, since she supplies one unit of labor in the economy.

In order to solve the first-stage problem, it is necessary to represent consumer's preference ordering over the homogeneous commodity and all other types of manufactured goods, which are not her 'ideal' type. This is generally done by assuming the existence of Lancaster's compensation function $\upsilon(\delta)$, defined for $0 \leq \delta \leq 2r\pi = 1$, where $r = 1/2\pi$ is the radius of the circle. The Lancaster compensation function implies that the consumer is indifferent between q_m units of her 'ideal' variety and $\upsilon(\delta)q_m$ units of her less preferred variety, whose location on the circumference of the circle is at a distance δ (shortest arc distance) from the consumer's 'ideal' (Helpman, 1981). It is assumed that

$$\upsilon(0) = 1,\ \upsilon'(0) = 0,\ \upsilon(\delta) > 1,\ \upsilon'(\delta) > 0,\ \upsilon''(\delta) > 0 \text{ for } \delta > 0 \qquad (1)$$

It then follows that the further away a product is located from a consumer's 'ideal' product, the more of it is required to make a consumer indifferent. Moreover, marginal compensation is increasing in distance. Since it is assumed that the subutility function for all varieties is separable (Lancaster, 1980; Helpman and Krugman, 1985), the consumer chooses to purchase the variety that provides her with the lowest effective price of the 'ideal'. Note that such specification of preferences implies that a consumer chooses her variety independently of her income or intersectoral preferences (upper-tier Cobb-Douglas utility) as her choice depends only on the availability of actually produced varieties and their distance from her product with 'ideal' characteristics (Helpman and Krugman, 1985).

Given the variety chosen by the consumer, the second stage is the standard decision of budget allocation, which, given the specification, results in the consumer spending share α of her income on the particular variety of the manufactured good chosen and the rest on the homogeneous good.

It is also necessary to specify the properties of the whole population of consumers in the economy in order to be able to analyze aggregate demand. It is assumed here that there is a continuum of consumers with the same utility functions and the same income (they all supply their one unit of labor to the economy). Since consumers can consume different 'ideal' manufactured goods it is also assumed that preferences for a particular 'ideal' type are uniformly distributed on the circle. This implies that given a population of size L in the economy, the density of consumers whose 'ideal' variety is the same coincides with L (density is $L/2r\pi$) and the same density applies to every point on the circumference of the circle. The above assumptions assure symmetry in aggregate demand (Helpman, 1981).

In order to derive closed-form solutions for the model in later sections, I choose a specific functional form for Lancaster's compensation function satisfying restrictions required by (1). In particular, let

$$\upsilon(\delta) = 1 + \delta^2, \tag{2}$$

where δ is ½ of the shortest arc distance between the varieties available in the economy, determining the boundaries of a firm's demand.

3.2.2. Producers

The production of a homogeneous good in the economy utilizes the only factor of production, labor. As usual, the homogeneous product is produced if the price equals the marginal cost of production. Therefore the wage in the economy is also normalized to one.

The remainder of the section as well as the equilibrium analysis focuses on differentiated manufacturing good production. Suppose that the differentiated good production side can consist of two types of firms, one type comprised of final manufacturing good producers and another possible type comprised of intermediate good producers. The final good producers decide to outsource their production to intermediates if it helps them save on production costs, whereas in order to produce a unit of a final good, a unit of an intermediate tailored to the specific needs of a variety manufacturer is required.

The sequence of events on the production side is then as follows. First, final differentiated goods manufacturers decide to enter or not. If intermediate production is possible, intermediate firms choose their input specification given by a location on a circle occupied by final good firms (the same spot on a circle implies that an intermediate firm is able to produce an 'ideal' intermediate). Once intermediate firms have entered, final good firms make price offers on intermediate products and intermediate firms decide whether to produce or exit. Finally, final good firms maximize their profits by choosing the price of their product (true demand is known) by taking as given the price of the homogeneous good and the actions of other final good producers.

The production of each variety requires a fixed cost and a variable cost. Since labor is the only factor of production, let parameter λ denote the required fixed cost to set up the production of a final good variety.

In order to produce the final good variety, a firm requires a specific intermediate product that it can either produce itself or buy from an intermediate firm that specializes in producing this particular input. There are three possibilities: The final good firm can either choose to produce the input itself (in which case I classify this as in-house production or vertical integration), it can outsource the intermediate good production to a firm that has the technology to produce an 'ideal' (specialized) intermediate, or it can outsource the intermediate good production to a firm that has the technology to supply to two final good firms simultaneously by manufacturing a standard product (a standardized intermediate) and thereafter modifying it for both firms' needs given the specification.

In order to produce the specific intermediate required for final good production, there is a fixed cost to develop a prototype and thereafter a variable cost of production. If the final good firm decides to produce the intermediate product in-house, the fixed cost is θ_1 and the variable cost is γ_1. If instead the production of the intermediate is outsourced to a specialized firm, the fixed cost is θ_2 and the variable cost is γ_2. However, if the production of intermediate is outsourced to a standardized firm, the fixed cost is θ_3 and the variable cost is γ_3.

The described production applies to every variety represented by a point on the circumference of the circle.

3.2.3. Factor Markets

There is only one factor of production in the economy, labor. Depending on the production specificity as described above and as further examined below, in general equilibrium all labor available in the economy is fully employed and covers all resources needed for fixed and variable costs of production.

3.2.4. Firm Behavior

In this section I examine how final good manufacturers choose their output levels, the varieties they produce, and the prices they charge. Due to the economies of scale not all possible varieties are produced; in fact since the cost function is linear in output, it is known that only a finite number of varieties are supplied in the equilibrium.

Suppose a final good firm has entered production and a particular variety is produced with the characteristics defined by point d_i on the circle and sold for price p_{mi}. For the firm to attract any customers at all, it must be the case that the customers for whom the point d_i specification represents their 'ideal' product are the first to buy. This implies that the price p_{mi} charged cannot exceed the effective price charged by other variety producers, defined at points d_{i-1} and d_{i+1} on the circle. Then for a firm to operate at positive output levels it must be the case that $p_{mi} \leq \min(p_{mi-1}\upsilon(\delta_{i-1}), p_{mi+1}\upsilon(\delta_{i+1}))$, where δ_{i-1} is the arc distance between product characteristics defined by circle points d_{i-1} and d_i, and δ_{i+1} is the arc distance between d_i and d_{i+1}. This expression consequently determines the price at which the demand facing a firm is zero (Helpman, 1981).

Let the price that the firm charges for its variety be such that positive output levels are produced. The market width for the firm is then determined by the equality of effective prices for the product being at a certain arc distance from a consumer's 'ideal', such that the consumer is indifferent between the purchases of her 'ideal' and another (compensated) good. Consider among all consumers that have their 'ideal' commodity defined by characteristics between points d_i and d_{i-1} a subset of consumers whose 'ideal' is at the arc distance $\overline{\delta}$ from d_i. Then clearly a consumer whose 'ideal' characteristics of a product is at that particular point is indifferent between the products located (and characterized) at d_i and d_{i-1} if $p_{mi}\upsilon(\overline{\delta}) = p_{mi-1}\upsilon(\delta_{i-1} - \overline{\delta})$. By analogy, those consumers that are at the arc distance $\underline{\delta}$ from d_i between points d_i and d_{i+1} are indifferent between varieties if $p_{mi}\upsilon(\underline{\delta}) = p_{mi+1}\upsilon(\delta_{i+1} - \underline{\delta})$. It then ensues that if in the equilibrium the only varieties produced are at the points of the circle d_{i-1}, d_i and d_{i+1}, then all consumers whose 'ideal' product lies between the arc distance $\overline{\delta}$ and $\underline{\delta}$ from d_i will buy the output produced by the manufacturer with specifications defined by location d_i. The arc distances $\overline{\delta}$ and $\underline{\delta}$ are then the functions of prices and distances between produced varieties.

Since I am only interested in symmetric equilibria, it is assumed that the final good varieties that are produced in the equilibrium are equally spaced on the circumference of the circle. This implies that if there are N varieties produced and consumed, then the distance between any two varieties is $1/N$. The aggregate demand function facing the producer of variety d_i is then defined by

$$Q_{mi} = \frac{2\alpha L}{p_{mi}} \int_0^{1/2N} 1 d\delta = \frac{\alpha L}{p_{mi} N} \qquad (3)$$

The producer that knows the true demand function as presented in (3) will take the price of the homogeneous good and the actions of other final good producers as given to maximize profits. In this monopolistically competitive framework the producer then equates its marginal revenue to marginal cost. Given Lancaster's compensation function as defined by (2), the elasticity of demand can be shown to equal

$$\frac{\partial Q_{mi}}{\partial p_{mi}} \frac{p_{mi}}{Q_{mi}} = \varepsilon = -\left(\frac{5}{4} + N^2 \right) \qquad (4)$$

The degree of monopoly power of the producer hence declines in the number of varieties produced in the equilibrium. In the long run there is free entry into manufacturing production and as a result, profits are driven to zero. The degree of monopoly power then equals the degree of economies of scale. Since all firms that decide to enter are distributed equidistantly from each other on the circle and each variety is produced by only one firm, due to symmetry, each type of a manufactured variety produced will sell for the same price in the equilibrium. As a result, aggregate demand for each individual variety is also the same. In the next section the types of equilibria conditional on the decisions of final and intermediate good firms is analyzed.

3.3 Types of Equilibria

There are three types of possible outcomes. When there are no outside firms, then the final manufacturing good producer will have to produce the necessary intermediate itself. Since production takes place in-house, the firm pays no markup price for the required component. Suppose next that there are intermediate producers ready to enter the market with a technology allowing them to produce the 'ideal' intermediate. In this case I examine the outcome in which the final good producer only produces the final manufacturing good and outsources the production of the intermediate to the specialized producer. The third option is that there are intermediate producers with a technology allowing them to produce a standard intermediate, which they thereafter adapt to the requirements of the final good producer(s). This implies that they can produce any specification of the intermediate defined by a point on a circle not corresponding to the specification needed by the final good producer, but after the standard is produced, they modify it to match the particular requirements of the buyer. In this case again the final good producer only produces the final manufacturing good and outsources the production of the intermediate to the standardized producer.

3.3.1. Vertical Integration

Suppose that there is only one type of firm in the economy, the final manufacturing good producers. The final good producers that have entered the market pay the fixed cost λ (denominated in labor). In order to have the intermediate product necessary for the final good, they also have to invest a fixed cost θ_1, after which they produce the intermediate at the variable cost γ_1 per unit. Given this setup, the final good producers maximize their profits taking as given the price of the homogeneous good and the actions of other final good producers. It is straightforward to calculate from (4) that the markup charged for the final manufacturing good is always

$$m_m = \frac{4N^2 + 5}{4N^2 + 1} \tag{5}$$

Given that the markup for final goods is known, the clearing of the labor market implies that the equilibrium number of firms in the in-house production equilibrium can be found to equal

$$N^V\left(\frac{4(N^V)^2 + 5}{4}\right)(\lambda + \theta_1) = \alpha L \tag{6}$$

where superscript V denotes 'vertical integration' or in-house production.

Given the number of final good producers that enter the market and produce their intermediates in-house, in the long-run zero-profit equilibrium the quantity of the final good produced and the price charged to the consumers is then

$$Q_m^V = \frac{\lambda + \theta_1}{4\gamma_1}\left(4(N^V)^2 + 1\right) \tag{7}$$

and

$$p_m^V = \frac{4(N^V)^2 + 5}{4(N^V)^2 + 1}\gamma_1 \tag{8}$$

3.3.2. Specialized Intermediate Goods

Next suppose that the final manufacturing firms have already entered the market and have decided to produce. Their symmetric location on the circle defines the particular characteristics of the final good that they are going to supply to consumers. Let there be intermediate good firms that have the technology to produce an intermediate that suits exactly the final good at a particular location, the 'ideal' intermediate, and they have entered observing this location of the final good firm. There are no sunk costs and the intermediate firm will commit to the fixed cost of production only if production actually takes place.

The final good firm hence accounts for its own fixed cost of production λ as before, but now its variable cost is the price p^I per unit of a good paid to the intermediate firm for the 'ideal' intermediate good. The setup is such that each unit of the final good requires a unit of a specialized intermediate good for its production. Clearly, the number of intermediate good firms n^I that enter the market is equal to the number of final good firms N^I, where superscript I denotes an 'ideal' intermediate.

The final good firms maximize their profits and price the final good as a markup over their marginal cost. From labor market clearing one can then find the equilibrium number of final good firms active in the economy,

$$N^I\left(\frac{4(N^I)^2+5}{4}\right)\lambda = \alpha L \tag{9}$$

Given that the quantity of an 'ideal' intermediate good necessary for the production of the final good is known, the final manufacturing good firm can deduct the price it is willing to pay for the 'ideal' intermediate good given its own zero-profit condition and labor market clearing. Formally, the final good firm finds that

$$Q_m^I = \frac{\lambda}{4p^I}\left(4(N^I)^2+1\right) = \frac{4\lambda(N^I)^2+\lambda-4\theta_2}{4\gamma_2}, \tag{10}$$

where θ_2 is the fixed cost in the 'ideal' intermediate good sector and γ_2 is the variable cost. It is then straightforward to derive p^I, what the final manufacturing good firm is willing to offer the intermediate good firm for the purchase of the 'ideal' intermediate product. The relevant price is equal to

$$p^I = \frac{\lambda\gamma_2(4(N^I)^2+1)}{4\lambda(N^I)^2+\lambda-4\theta_2} \tag{11}$$

Given the price offer in (11), the 'ideal' intermediate good firm has to decide whether to produce the intermediate good or exit. Since the intermediate good producer maximizes its profits by equating its marginal revenue to marginal cost to be able to cover fixed costs, it is willing to accept a price offer allowing it to earn non-negative profits. Since the profit-maximizing price of an 'ideal' intermediate producer is exactly equal to the price equation derived in (11), the 'ideal' intermediate good firm accepts the price offer from the final manufacturing good firm and decides to produce. Note that the accepted price is equivalent to the pricing of the intermediate good at the average cost. Hence given the price in (11) the firm producing 'ideal' intermediates will have zero profits.

Lemma 1 *The 'ideal' intermediate good sector has zero profits in the equilibrium.*

Proof $\pi^I = \frac{\lambda}{4}\left(4(N^I)^2 + 1\right) - \theta_2 - \frac{4\lambda(N^I)^2 + \lambda - 4\theta_2}{4} = 0$. ■

Finally, the markup in the 'ideal' intermediate good can then be found to equal

$$m^I = \frac{\lambda(4(N^I)^2 + 1)}{4\lambda(N^I)^2 + \lambda - 4\theta_2} \tag{12}$$

3.3.3. Standardized Intermediate Goods

Now suppose that again the final manufacturing firms have already entered the market and have decided to produce, whereas the intermediate good firms have the technology to place themselves in-between two final good manufacturer's specifications. This means that they can produce a 'standard' intermediate good and thereafter adapt it to the particular specification of each of the two final good firms. In order to adapt an intermediate I assume that there is an adaptation function, which for simplicity is identical to the compensation function defined in (2), where $\delta = \frac{1}{2N}$. After the standard intermediate good is produced, the intermediate firm has to utilize $\upsilon(\delta)$ of labor per unit of an intermediate to fit the required final good specifications.

If there are technologies available to produce intermediate good specifications at any point on the circle, then it is straightforward to show that a setup where the intermediate producer can place in-between two final good producers is an equilibrium outcome. If a firm instead decides to produce its standard good closer to one variety (say, at an arc distance ξ), then the total cost of adaptation is larger (since the arc distance from another variety is now $\frac{1}{N} - \xi$) than a symmetric adaptation for two varieties. I therefore focus on the configuration where the intermediate good firm has the technology to produce its component in-between two final good specifications.

As with 'ideal' intermediate goods, the final good firm accounts for its own fixed cost of production λ and the variable cost that is now the price p^S per unit of a good paid to the intermediate firm for the 'adapted' intermediate good. The setup is again such that each unit of a final good requires a unit of a specialized intermediate good for its production. The number of intermediate good firms n^S that enter the market is then equal to $1/2$ the number of final good firms N^S.

The final good firms again maximize their profits and price the final good as a markup over their marginal cost. From labor market clearing the equilibrium number of final good firms active in the economy is then

$$N^S\left(\frac{4(N^S)^2+5}{4}\right)\lambda = \alpha L \tag{13}$$

Note that the equilibrium market clearing condition is exactly the same in both the 'ideal' and 'adapted' intermediate good context. Hence the number of final good firms is the same irrespective of outsourcing type. The number of final good firms is, however, smaller when no outsourcing is available and the intermediate good is produced in-house.

Again, given that the quantity of an 'adapted' intermediate good necessary for the production of the final good is known, the final manufacturing good firm finds a price it is willing to pay for the 'adapted' intermediate good. The final manufacturing good producer deducts that

$$Q_m^S = \frac{\lambda}{4p^S}\left(4(N^S)^2+1\right) = \frac{4\lambda(N^S)^2+\lambda-2\theta_3}{\gamma_3\left(4(N^S)^2+1\right)}\cdot(N^S)^2, \tag{14}$$

where the 'adaptation' function is known to the final good producer and where θ_3 is the fixed cost in the 'adapted' intermediate good sector and γ_3 is the variable cost. It is again straightforward to derive the price offered by the final manufacturing good producer to the 'adapted' intermediate good producer. This price is

$$p^S = \frac{\lambda\gamma_3(4(N^S)^2+1)^2}{4\lambda(N^S)^2+\lambda-2\theta_3}\cdot\frac{1}{4(N^S)^2} \tag{15}$$

Similar to the earlier case of outsourcing, the standardized intermediate good firm accepts the price offer from the final manufacturing good firm, since the price offered maximizes its profits and is simultaneously equivalent to pricing at the average cost. Again, given the price in (15), the profits in the 'adapted' intermediate good sector will be zero.

Lemma 2 *The 'adapted' intermediate good sector has zero profits in the equilibrium.*

Proof $\pi^S = \frac{\lambda}{2}\left(4(N^S)^2 + 1\right) - \theta_3 - \frac{4\lambda(N^I)^2 + \lambda - 2\theta_3}{2} = 0$. ■

The markup for the 'adapted' intermediate good can then be found to equal

$$m^S = \frac{\lambda(4(N^S)^2 + 1)}{4\lambda(N^S)^2 + \lambda - 2\theta_3} \tag{16}$$

The markups as found in (5) for the final manufacturing good, (12) for the 'ideal' intermediate good and (16) for the 'adapted' intermediate good, are presented in Figure 1 for different parameter values of fixed costs in both final and intermediate good sectors. Additional specifications are depicted in Figure C1 in Appendix C.

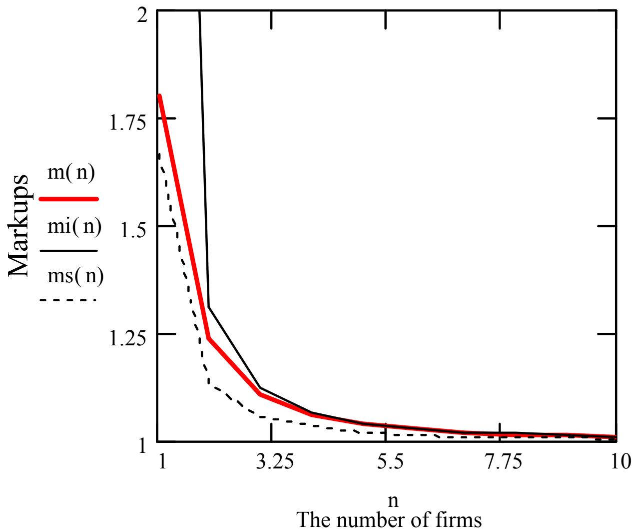


Figure 1. Final good, 'ideal' intermediate good and 'standard' intermediate good markups depending on the number of final good firms (all parameters=1)

The figure shows that markups are high only when the number of firms in the final good production is very small, which is of no concern in this setup of monopolistic competition. However, this explains why, when the number of firms is small, the 'double marginalization' problem is particularly severe. It also reveals that in the monopolistically competitive framework the ‘double marginalization’ problem becomes negligible as the number of firms becomes large. In addition, even though due to fixed cost there is always a markup charged by both the intermediate and final good firms, they both operate in a zero-profit equilibrium in the long run with free entry.

Figure C2 in Appendix C also depicts the equilibrium values for the final manufacturing good quantities and prices for certain parameter values. Clearly, if parameter values are all the same, a vertically integrated economy would have the highest final good outputs, whereas outsourcing outputs would be (almost) the same irrespective of the outsourcing mode. Final good prices, on the other hand, would be very close to each other with prices in the integrated equilibrium slightly lower. Hence the efficiency drawn from outsourcing relies on both lower fixed and variable costs in comparison to costs in vertically integrated firms, and the magnitude of the cost differences determines the exact equilibrium outcomes. If parameter values differ such that the ‘adapted’ intermediate good sector is the most cost effective, it will provide the highest output levels at the same number of firms. If, however, we take into consideration that outsourcing equilibrium has more firms, then even when costs are the same, the outsourcing equilibrium can have larger output. Final good prices are highly dependent on variable costs and if the variable cost to produce the intermediate in-house is sufficiently high, final good prices when firms are vertically integrated can exceed those prices that could be reached under outsourcing.

To conclude, a higher fixed cost of entry for the final good firm would shift all output curves to the left (would increase output), whereas a higher fixed cost in intermediate production would shift the output curve to the left for in-house production, but right under outsourcing (would decrease output). A higher variable cost would shift all output curves to the right. A higher fixed cost of entry for the final good firm would shift the equilibrium prices when intermediate production is outsourced down (would decrease prices), whereas a higher variable cost would shift them up (would increase prices given that the number of firms is large enough to have positive prices). Finally, a higher fixed cost in intermediate production would shift the price curves up (would increase prices).

3.3.4. Mixed Equilibrium

Given the outcomes of the previous sections I now show whether any of the equilibria can exist simultaneously. It has already been established that as long as there are additional fixed costs to produce an intermediate good in-house, the number of firms under vertical integration will be smaller than under either of the two types of outsourcing. Therefore the market clearing equilibrium conditions also differ and vertical integration and outsourcing cannot be used simultaneously by different firms in the industry. Nevertheless, two types of outsourcing can occur simultaneously in special cases. A comparison of the total cost that the final manufacturing good firm spends on its outsourced intermediate input reveals no difference and the labor market clears identically. Hence the outcome where two types of outsourcing can be utilized in the same equilibrium depends on parameter values.

Proposition 1 *In general, no industry has simultaneous vertical integration, 'ideal' outsourcing, and 'standardized' outsourcing. In the special case where parameter values are* $\theta_3 = 2\theta_2$ *and* $\gamma_2 = \gamma_3 \upsilon(\delta)$*, however, both types of outsourcing firms can co-exist in the same equilibrium.*

Proof Substitute to the full employment condition and take into account that $n^I + 2n^S = N$, where n^I is the number of 'ideal' intermediate producers, n^S is the number of standardized intermediate producers, and N is the total number of final good firms, to reach (10). Note that the exact values of n^I and n^S are indeterminate. ■

3.4 Growth and Trade

Suppose next that there are two countries with different endowments of labor that open up to trade, whereas technologies and tastes are the same. In this section I concentrate on the situation in which trade is not costly and aim to analyze how the opportunity for exchange influences the main variables and henceforth the outcomes of the model. For tractability, when analyzing possible trade in the intermediate inputs and homogeneous good, I assume that the countries are symmetric. I first begin, however, by examining comparative statics in a closed economy setting.

3.4.1. Effects of Country Size

When there are no trade costs and the two traded goods are produced in both countries, the effects of trade (exchange of goods) and market enlargement (increase in factor endowments) are often equivalent when there is just one factor of production. As will be shown below, this is not always the case in the given model due to the complex setup of intermediate goods production. Nevertheless, the analysis of comparative statics helps to understand the mechanism by which the change in factor endowments affects the elasticity of demand, which in turn influences the equilibrium number of firms and as a consequence all other equilibrium variables.

As a benchmark I focus on the market clearing in outsourcing, since the outcome when production is vertically integrated is then straightforward. Note that in outsourcing labor market equilibrium one can rewrite (9) or (13) as $N\lambda|\varepsilon| = \alpha L$, where $|\varepsilon|$ is the absolute value of the price elasticity of demand. Next, expressing the number of firms as a function of labor endowment, the price elasticity and parameters, and substituting back to the elasticity expression allows to write $|\varepsilon|^2 \lambda^2 (4|\varepsilon| - 5) = 4\alpha^2 L^2$. Implicit derivation then implies the following expression, $\frac{\partial|\varepsilon|}{\partial L} \cdot \frac{L}{|\varepsilon|} = \frac{4\alpha^2 L^2}{\lambda^2 |\varepsilon|^2 (6|\varepsilon| - 5)}$, which after substitution yields the result

$$\frac{\partial|\varepsilon|}{\partial L} \cdot \frac{L}{|\varepsilon|} = \frac{4|\varepsilon| - 5}{6|\varepsilon| - 5} = \frac{8N^2}{12N^2 + 5} \tag{17}$$

The resulting expression is strictly positive and strictly less than one, meaning that the price elasticity of demand is increasing in population density, but at a less-than-proportional rate. To see why, one needs to utilize the concept of market width of a produced variety, determined by arc distances $\overline{\delta}$ and $\underline{\delta}$ from a specification at location d_i, as discussed in section 2.4. The market width of a particular variety then encompasses all consumers who become customers of the producer producing at d_i. The extreme values of the market width in this Lancaster-type model are zero and one, where zero reflects perfect competition and one monopoly. An increase in population density as expressed by an increase in L has two effects. On the one hand it enhances the purchasing power of consumers on each interval on the circle and increases the firm's earning power. On the other hand, it makes entry more attractive. Therefore in the new zero-profit equilibrium the market width for each produced final good reduces. As more firms enter and the distance between the 'ideal' varieties decreases, consumers become more sensitive to the variation in price (Hummels and Lugovskyy, 2009).

Clearly, the equilibrium quantity of the supplied final good variety increases, whereas the price decreases in all model configurations. As the entry of firms increases, increasing the elasticity of demand, the markups must be reduced in order to compete.

At lower prices firms must sell higher quantities to break even and satisfy demand. The number of varieties therefore increases less than proportionally with population growth since increased elasticity of demand dampens the attractiveness of entry. Also note that the equilibrium condition with additional fixed cost as given by (6) in the vertical integration equilibrium does not change the above outcomes, as increased fixed cost has no impact on how the elasticity of demand reacts to the increase in population density.

Another interesting outcome is that an increase in labor endowment increases the real wage in the economy, because real income is proportional to the nominal income deflated by the cost-of-living index, $(p_m)^{\alpha}$. Since the population increase lowers the price of the final good in all configurations, a larger country always has a higher real wage in autarky.

3.4.2. Free Trade in Final Manufacturing Goods and Homogeneous Good

Suppose next that two countries can exchange final manufacturing goods with each other as well as trade the homogeneous good. At zero transportation cost, possible trade in the homogeneous good ensures that the wage rates in the two countries equalize, implying the equality of prices for the final manufacturing goods. Similar to what happens when a population grows in a closed economy, exchange in final manufacturing goods ensures that the scale of production of final goods increases, whereas the markups fall. However, the equilibrium is not the same since domestic labor market clearing has to hold, even though the effect on the price elasticity of demand is the same. Domestic labor market clearing then ensures that

$$N^H\left(\frac{4(N^H+N^F)^2+5}{4}\right)\lambda=\alpha L^H, \tag{18}$$

where superscript H denotes 'Home' and superscript F denotes 'Foreign'. An analogous expression holds for the foreign country with foreign variables. Therefore in the equilibrium where final goods and the homogeneous good can be traded, final manufacturing good production is distributed proportionally to country size, or formally

$$\frac{N^H}{N^F}=\frac{L^H}{L^F} \tag{19}$$

This, however, implies that the homogeneous good is not traded in the equilibrium since trade in the final manufactured goods is balanced (the share of home country number of firms is equal to its world income share).

The variable solutions for vertical integration and specialized 'ideal' intermediate good equilibrium therefore take into account both the number of firms at home and abroad, as they would if the labor endowment had increased in a closed economy, but the difference stems from the type of outsourcing used. In particular, the final manufacturing good output in the 'ideal' intermediate equilibrium as expressed by (10) changes to

$$Q_m^I = \frac{4\lambda(N^H + N^F)^2 + \lambda - 4\theta_2}{4\gamma_2} \tag{20}$$

and the price charged for the final good becomes

$$p_m^I = \frac{\lambda\gamma_2(4(N^H + N^F)^2 + 5)}{4\lambda(N^H + N^F)^2 + \lambda - 4\theta_2} \tag{21}$$

Hence the variable solutions when the 'ideal' intermediate is used is equivalent to a closed economy outcome when the domestic labor endowment would have increased in the exact same amount as stipulated by the increase brought about in the foreign number of firms. The outcome is, however, different if the equilibrium is such that intermediates are outsourced to the standardized intermediate producers. Since intermediates are not traded, the 'adaptation' cost used to adapt the standard intermediate to the final good specifications can only account for the number of firms in the local market. Even though the labor market clearing condition is the same as given by (18), the 'adaptation' cost stays unchanged and the final manufacturing good output in the 'adapted' intermediate equilibrium becomes

$$Q_m^S = \frac{4\lambda(N^H + N^F)^2 + \lambda - 2\theta_3}{\gamma_3\left(4(N^H)^2 + 1\right)} \cdot (N^H)^2, \tag{22}$$

whereas the price charged for the final good solves for

$$p_m^S = \frac{\lambda\gamma_3 \cdot (4(N^H + N^F)^2 + 5)}{4\lambda(N^H + N^F)^2 + \lambda - 2\theta_3} \cdot \frac{(4(N^H)^2 + 1)}{4(N^H)^2} \tag{23}$$

These outcomes are further depicted in Figure C3 in Appendix C and show that the larger the trading partner, the more the final good outputs increase and prices decrease.

Also note that since only one intermediate good is required to produce each final good, the outcome differs significantly from the Krugman-type models where a non-traded intermediate good in such a setup would imply agglomeration of final good production in only one country (Helpman and Krugman, 1985).

3.4.3. Free Trade in Intermediate Goods and Homogeneous Good

Suppose instead that final manufacturing goods now cannot be traded, implying that domestic expenditure on domestic final manufacturing goods stays intact, as does the price elasticity of demand (likewise in a foreign country). Instead let the two countries now be able to exchange the intermediate goods as well as have an opportunity to trade the homogeneous good. As before, zero transportation costs imply that the wage rates in the two countries equalize. Even though there is the possibility of trade, the labor endowment of a foreign country is unable to influence the domestic elasticity of demand. Since labor market clearing conditions stay intact, this implies that in the equilibrium final manufacturing good production is no longer distributed proportionally to country size; instead

$$\frac{N^H\left(4(N^H)^2+5\right)}{N^F\left(4(N^F)^2+5\right)}=\frac{L^H}{L^F} \tag{24}$$

For tractability, let the two countries be symmetric. In this case there is no trade in the equilibrium when an 'ideal' intermediate is used and each country operates as if in autarky; consequently, the final manufacturing good output and price are unchanged from their autarky values. This is not so, however, when standardized intermediates can be used, since the 'adaptation' cost can take into account the number of final good firms in both countries. As a result, the final manufacturing good output in the 'adapted' intermediate equilibrium becomes

$$Q_m^S=\frac{4\lambda(N^H)^2+\lambda-2\theta_3}{\gamma_3\left(4(N^H+N^F)^2+1\right)}\cdot(N^H+N^F)^2, \tag{25}$$

whereas the price charged for the final good solves for

$$p_m^S=\frac{\lambda\gamma_3\cdot(4(N^H)^2+5)}{4\lambda(N^H)^2+\lambda-2\theta_3}\cdot\frac{(4(N^H+N^F)^2+1)}{4(N^H+N^F)^2} \tag{26}$$

The outcomes in this subsection are further depicted in Figure C4 in Appendix C. Proposition 2 summarizes the results of this section (proof in the text and figures).

Proposition 2 *In the model developed above when trade is free, growth in labor endowment or trade in this economy:*

(1) increases real wages in both countries,

(2) increases final manufacturing good output and decreases final good prices and

(3) makes standardized outsourcing more attractive

Note that a larger country has higher real wages in autarky, so opening up to trade leads to the smaller country gaining relatively more. In fact, when final goods are traded in proportion, the larger is the foreign trade partner, the more final good prices fall and consequently, the more a small country can gain from the increase in real wages. Standardized outsourcing, on the other hand, becomes more attractive since the increase in final manufacturing good output and the decrease in its price is the most pronounced. The most relevant outcome in this regard is that when the final manufacturing goods are tradable, then the market width is reduced and market thickness (the number of firms) expanded, consequently lowering the markups. On the other hand, when intermediate goods are tradable, an analogous outcome is reached through lowering the 'adaptation' costs.

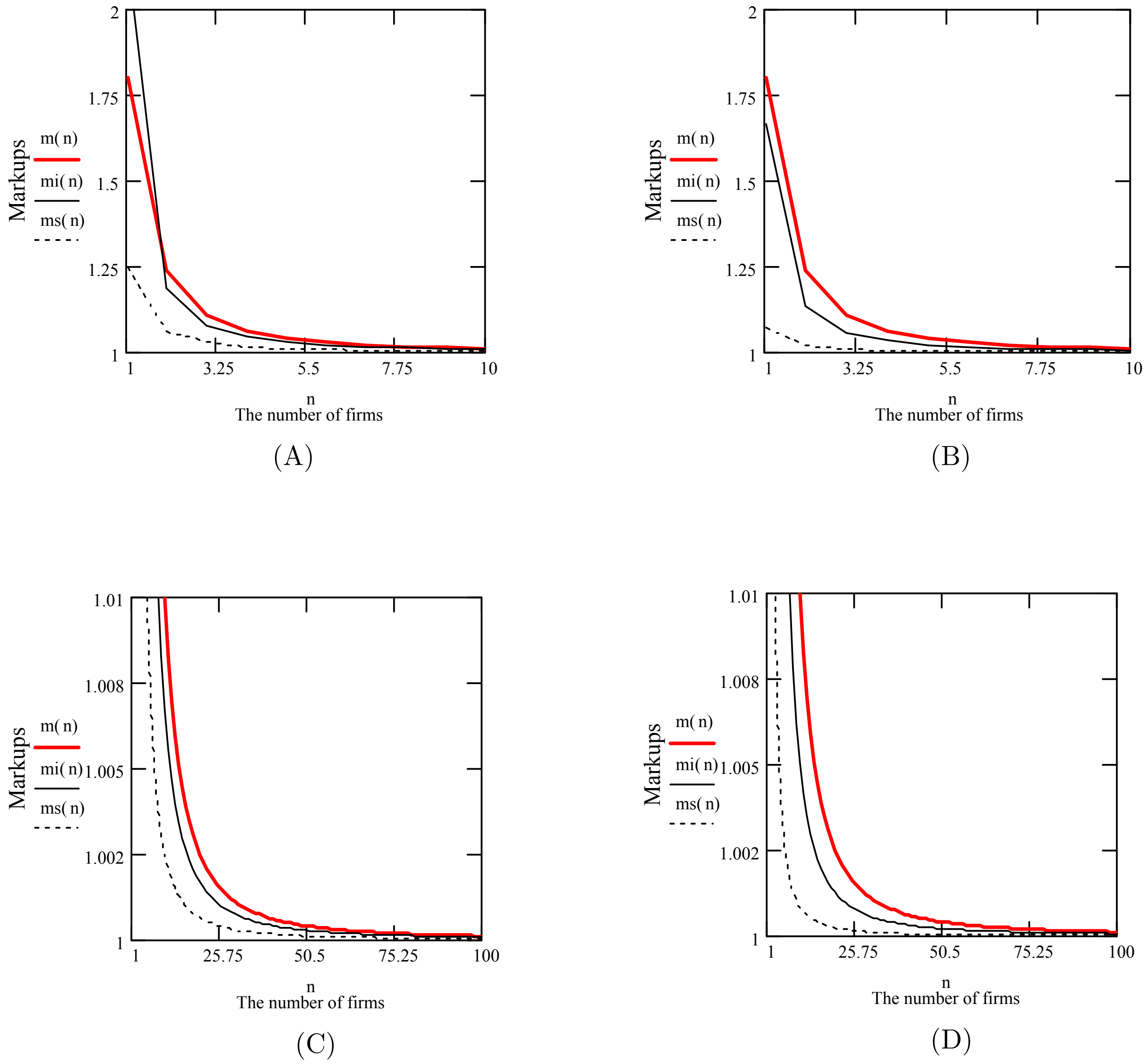
3.5 Conclusions

This paper developed a general equilibrium framework by which to examine the decisions of final good firms to produce a necessary intermediate input in-house, to outsource it to an 'ideal' intermediate producer, or to outsource it to a 'standardized' intermediate producer as an outcome of market interactions. It then expanded the setup to analyze which industrial structure is preferred when countries gained resources or opened up to trade. Such a framework differs from the popular Krugman-type models of monopolistic competition (in the final good sector) where opening up to trade in a one-factor world would imply indeterminacy given the integrated equilibrium. It also differs from the Dixit-Stiglitz-Ethier intermediate good setup that emphasizes gains from international specialization, since here every final good producer just needs one particular intermediate. The framework also differs from a transactional economics setup, which focuses on how the 'asset specificity' creates bilateral monopoly and its resulting deadweight losses, and from other works that examine the intermediate good provider being a monopoly.

The spatial framework utilized in this paper instead emphasized how monopolistically competitive final good producers require a specific intermediate good to produce its output, with its specifications being defined by a location on a circle. The final good firms can produce the necessary inputs themselves or can outsource the production of intermediates to either specialized or standardized input providers. It was shown that the final good firms offer such input price to the intermediate producers that in the equilibrium every firm earns zero profits. Hence contrary to what has been utilized in the literature, it is not necessary to assume contestable markets or place any other restrictions on intermediate production, since long-run input pricing at the average cost is the equilibrium outcome. It was also shown that in general vertical integration and outsourcing cannot simultaneously occur, whereas both types of outsourcing outcomes may exist in the same equilibrium.

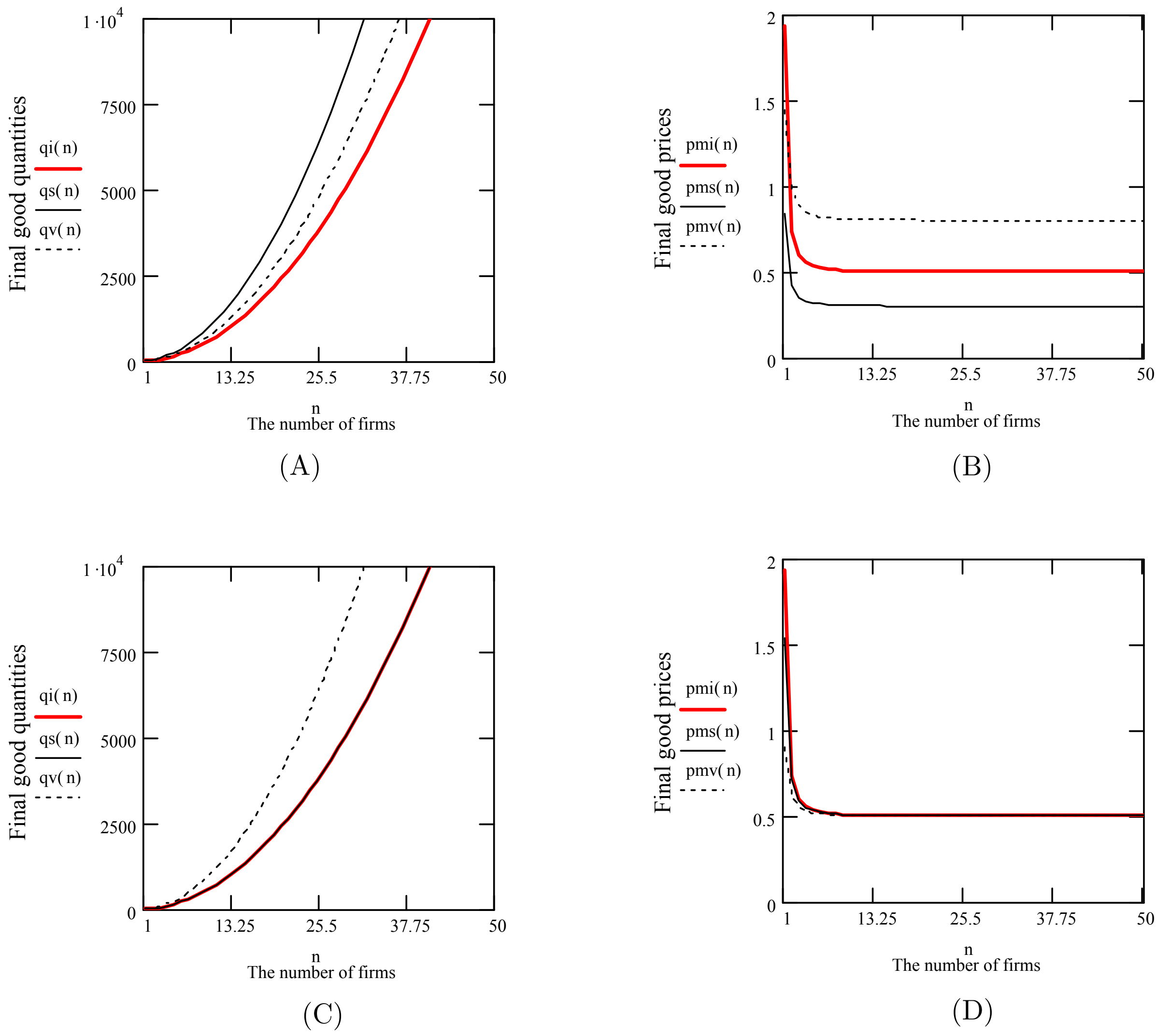
An increase in market size through either endowment growth or trade was shown to increase final manufacturing good output and decrease final good prices due to lower markups. These results are known given the spatial framework, but have not been previously quantified based on the dependence on the chosen type of intermediate good provider. It was further shown that in an open economy, market width of the final good producer decreases and market thickness for intermediate good suppliers increases. Therefore standardized outsourcing becomes more attractive, as it generates the highest outputs at increasingly lower prices.

3.6 Appendix C



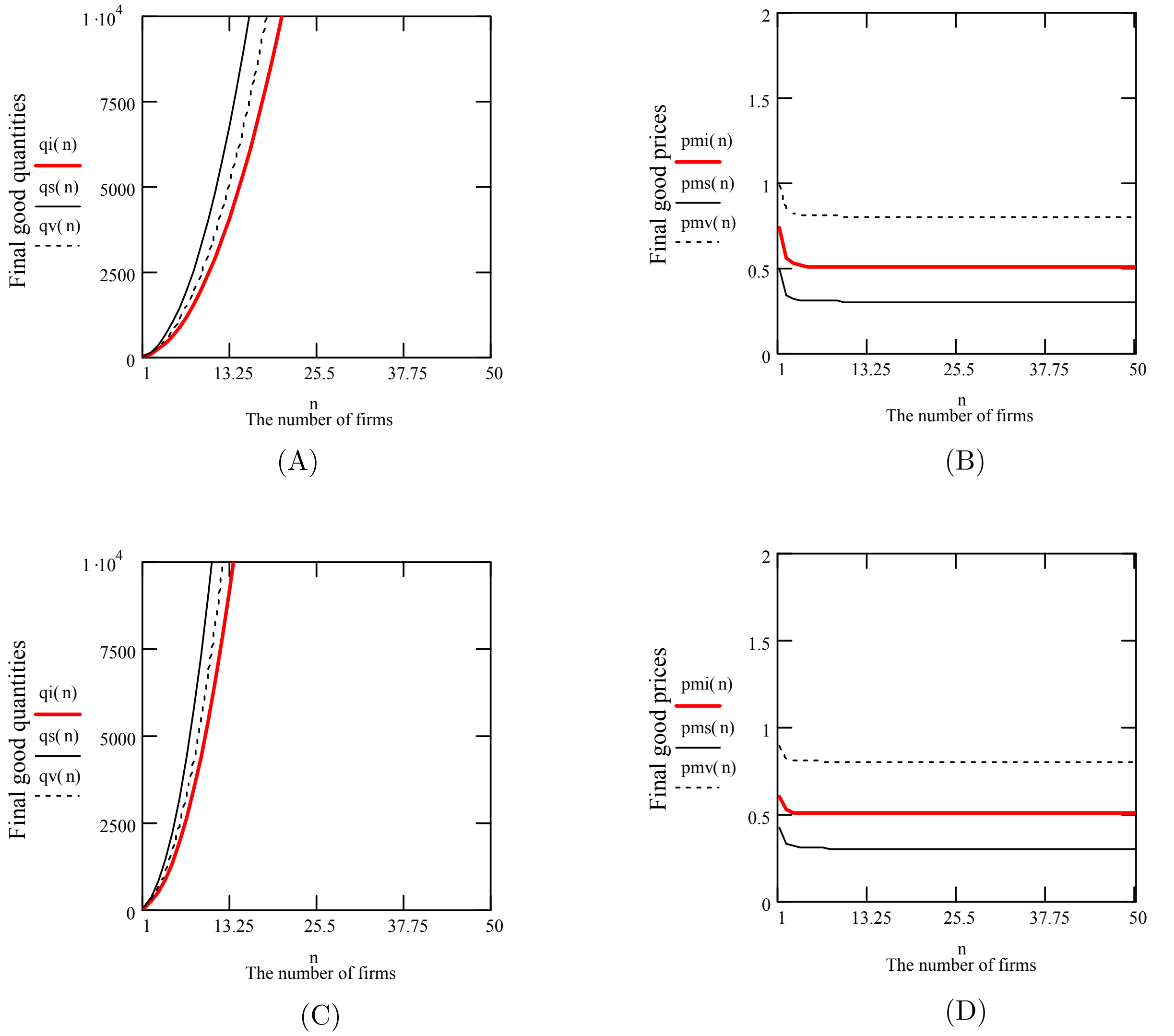
The parameter values in the above figure are as follows: in panel (A) and (C) fixed cost (denominated in labor) in the final good sector $\lambda = 3$, fixed cost in the 'ideal' intermediate good sector $\theta_2 = 2$ and fixed cost in the 'standardized' intermediate good sector $\theta_3 = 1.5$; in panel (B) and (D) $\lambda = 3$, $\theta_2 = 1.5$ and $\theta_3 = 0.5$. 'The number of firms' denotes the number of final manufacturing good firms producing in the equilibrium. As can be seen from the figure, the markups are negligible when the number of firms is sufficiently large.

Figure C1. Variable markups, depending on the number of final good firms



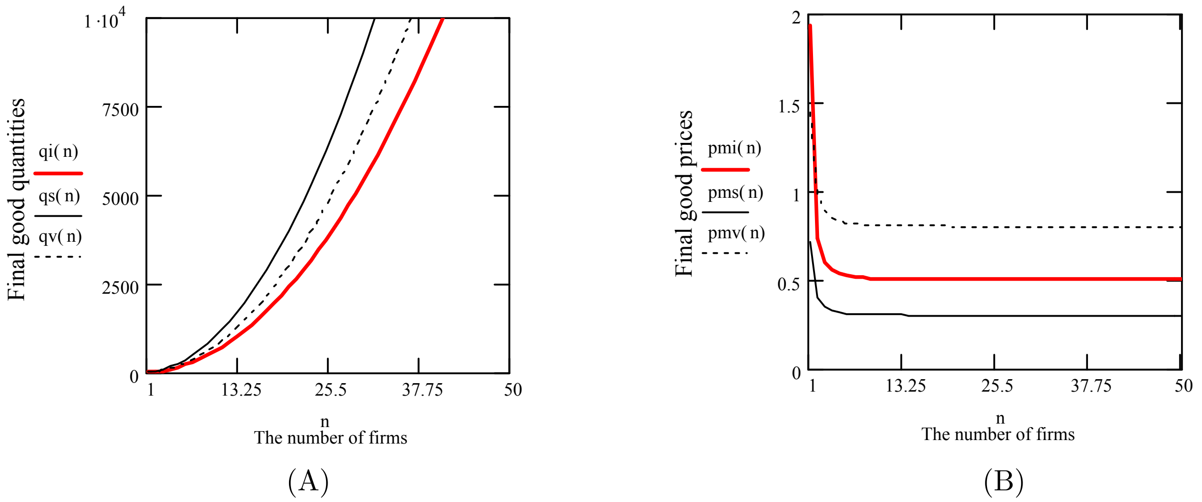
The parameter values in the above figure in panels (A) and (B) are as follows: fixed cost (denominated in labor) in the final good sector $\lambda = 3$, additional fixed cost if intermediate is produced in-house $\theta_1 = 3$, fixed cost in the 'ideal' intermediate good sector $\theta_2 = 2$ and fixed cost in the 'standardized' intermediate good sector $\theta_3 = 1.5$; variable cost if production is vertically integrated $\gamma_1 = 0.8$, variable cost in the 'ideal' intermediate good sector $\gamma_2 = 0.5$ and variable cost in the 'standardized' intermediate good sector $\gamma_3 = 0.3$. 'The number of firms' denotes the number of final manufacturing good firms producing in the equilibrium. In panel (C) and (D) all parameter values are equal to the 'ideal' intermediates' parameter values.

Figure C2. Final good quantities and prices in a closed economy, depending on the number of final good firms



The parameter values in the above figure are as follows: fixed cost (denominated in labor) in the final good sector $\lambda = 3$, additional fixed cost if intermediate is produced in-house $\theta_1 = 3$, fixed cost in the 'ideal' intermediate good sector $\theta_2 = 2$ and fixed cost in the 'standardized' intermediate good sector $\theta_3 = 1.5$; variable cost if production is vertically integrated $\gamma_1 = 0.8$, variable cost in the 'ideal' intermediate good sector $\gamma_2 = 0.5$ and variable cost in the 'standardized' intermediate good sector $\gamma_3 = 0.3$. 'The number of firms' denotes the number of final manufacturing good firms producing in the equilibrium. In panels (A) and (B) the foreign country has the same number of firms, whereas in panels (C) and (D) the foreign country has twice as many firms as the home country.

Figure C3. Final good quantities and prices in an open economy, depending on the number of final good firms when final goods are traded



The parameter values in the above figure are as follows: fixed cost (denominated in labor) in the final good sector $\lambda = 3$, additional fixed cost if intermediate is produced in-house $\theta_1 = 3$, fixed cost in the 'ideal' intermediate good sector $\theta_2 = 2$ and fixed cost in the 'standardized' intermediate good sector $\theta_3 = 1.5$; variable cost if production is vertically integrated $\gamma_1 = 0.8$, variable cost in the 'ideal' intermediate good sector $\gamma_2 = 0.5$ and variable cost in the 'standardized' intermediate good sector $\gamma_3 = 0.3$. 'The number of firms' denotes the number of final manufacturing good firms producing in the equilibrium.

Figure C4. Final good quantities and prices in an open economy, depending on the number of final good firms when intermediate goods are traded

3.7 References

ANTRAS, P. and E. HELPMAN (2004). “Global sourcing”, *Journal of Political Economy,* 112, 552-580.

BATRA, R.N. and F. CASAS (1973). “Intermediate products and the pure theory of international trade: A neo-Heckscher-Ohlin framework”, *American Economic Review*, 63, 297-311.

BUEHLER, S. and J. HAUCAP (2006). “Strategic outsourcing revisited”, *Journal of Economic Behavior & Organization*, 61, 325-338.

DEARDORFF, A. (2001). “Fragmentation in simple trade models”, *North American Journal of Economics and Finance*, 12, 121-137.

DIXIT, A. (1983). “Vertical integration in a monopolistically competitive industry”, *International Journal of Industrial Organization*, 1, 63-78.

EATON, C. and N. SCHMITT (1994). “Flexible manufacturing and market structure”, *American Economic Review*, 84, 875-888.

FEENSTRA, R. (1998). “Integration of trade and disintegration of production in the global economy”, *Journal of Economic Perspectives*, 12, 31-50.

FEENSTRA, R. and G. HANSON (1996). ”Globalization, outsourcing, and wage inequality”, *American Economic Review*, 86, 240-245.

FRANCOIS, J. and D. NELSON (1998). “A geometry of specialization”, Centre for International Economic Studies, University of Adelaide, Seminar Paper 98-01.

GROSSMAN, G. and E. HELPMAN (2002a). “Integration versus outsourcing in industry equilibrium”, *Quarterly Journal of Economics*, 117, 85-120.

GROSSMAN, G. and E. HELPMAN (2005). “Outsourcing in a global economy”, *Review of Economic Studies*, 72, 135-159.

GROSSMAN, G. and E. HELPMAN (2002b). “Outsourcing versus FDI in industry equilibrium”, *Journal of the European Economic Association*, 1, 317-327.

HELPMAN, E. (1981). “International trade in the presence of product differentiation, economies of scale and monopolistic competition”, *Journal of International Economics*, 11, 305-340.

HELPMAN, E. (2006). “Trade, FDI, and the organization of firms”, *Journal of Economic Literature*, 44, 589-630.

HELPMAN, E. and P. KRUGMAN (1985). *Market structure and foreign trade: Increasing returns, imperfect competition, and the international economy* (MIT Press).

HUMMELS, D. and V. LUGOVSKYY (2009). “International pricing in a generalized model of ideal variety”, *Journal of Money, Credit and Banking*, forthcoming.

LORZ, O. and M. WREDE (2008). “Standardization of intermediate goods and international trade”, *Canadian Journal of Economics*, 41, 517-536.

KRUGMAN, P. (1980). “Scale economies, product differentiation, and the pattern of trade”, *American Economic Review*, 70, 950-959.

PERRY, M. (1989). “Vertical integration: determinants and effects”, Chapter 4 in Schmalensee, R. and Willig, R. (eds.) *Handbook of Industrial Organization* (North-Holland).

SCHWARTZ, G. and A. van ASSCHE (2006). “Input specificity and global sourcing”, CIRANO Working Paper.

VAN ASSCHE, A. (2008). “Modularity and the organization of international production”, *Japan and the World Economy*, 20, 353-368.

VENABLES, A. (1996). “Equilibrium locations of vertically linked industries”, *International Economic Review*, 37, 341-359.