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Title: Essays on the Implications of Firm Behaviors in Learning, Locating, and Advertising

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Rolf Färe

This dissertation addresses three topics on the implications of firm behaviors in creating and adopting knowledge of production, choosing international location for production and market access, and using informative advertising in a market competition with multidimensional product characteristics. The first study investigates the empirical evidence of local knowledge spillovers in Indonesian medium and large manufacturing industry. The second study looks at the link between the patterns of trade revealed comparative advantage and net inward foreign direct investment in five developed countries: France, Italy, Japan, the United Kingdom, and the United States. The third study seeks to determine the effects of informative advertising in a market with two-dimensional, vertically differentiated products.

The results of the first study show that the extent of knowledge spillovers depends on both geographical and technological proximities. In addition, the extent of knowledge spillovers seems to depend on sector-specific characteristics and the presence of foreign investment. The results of the second study reveal a significant role of comparative advantage in determining inflows of foreign direct investment in developed countries, especially in the services industry. Finally, the results of the third study show that with informative advertising, the firm with the 'better' product will charge a higher market, have a larger market share, and advertise more. In addition, even when advertising leads to higher market prices, the full-prices that the consumers must pay are still lower than in the case of no advertising.

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CONTRIBUTION OF AUTHORS

Dr. Bee-Yan Roberts contributed the basic idea for the first manuscript. Dr. Andreas Waldkirch was involved in the interpretation of the results of the second manuscript. Dr. Victor J. Tremblay provided ideas and suggestions for the third manuscript.

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Introduction

This dissertation addresses three topics on the implications of firm behaviors. Chapter 2 studies the effects of geographical and technological proximities as well as the role of foreign investment on the ability of firms to learn general production knowledge from other firms. Chapter 3 looks at the significance of factor abundance as a determinant of inward foreign direct investment (FDI) in developed countries. Finally, chapter 4 investigates the effects of informative advertising in a market with two dimensional, vertically differentiated products.

In chapter 2, we use Indonesian manufacturing data to study the extent of local knowledge spillovers in a developing country setting. In particular, we apply the "ring-model" idea to construct measures of external knowledge which vary by distance. Then, we use these measures to verify the effects of physical distance on the extent of knowledge spillovers. In addition, we also look at the variation of such spillovers across manufacturing sectors. Finally, we investigate the role of foreign investment as a potentially significant source of knowledge spillovers.

In chapter 3, we aim to extend the literature on the importance of factor abundance as a determinant of inward FDI in three important aspects. First, we examine the link between host countries' comparative advantage and their inward FDI in five developed countries. This allows us to better assess the generality of our findings than earlier studies which only looked at one or two countries. Second, we study such a link using three different measures of inward FDI: short-run, medium-run, and long-run. This allows us to better assess the robustness of our findings than earlier studies which only used the short-run measure of FDI. Finally, we use technology and trade data which are defined more uniformly across countries. This allows us to make more valid comparisons across the different countries we study.

In chapter 4, we extend the literature on the effects of informative advertising on prices by modeling informative advertising competition in a market with two-dimensional, vertically differentiated products. Specifically, we study the impact of informative advertising in a duopoly competition in two cases. In the first case, one of the firms has a higher quality in one dimension, but a lower quality in the other. In the last case, one of the firms dominates in both characteristics.

These chapters share topics on the implications of firm behaviors. They all consider what outcomes one may observe from such behaviors. The first essay focuses on the implication of firms' learning more from their closer neighbors than from the more distant ones. The second essay focuses on the implication of firms' motives in locating internationally. The last essay focuses on the implication firms' advertising expenditure on product prices. All of the topics covered in chapter 2, 3 and 4 are further linked by their use of microeconomics approach to explain such outcomes.

Chapter 2

Local Knowledge Spillovers in the Indonesian Manufacturing Industry

2.1 Introduction

In the economic growth literature, knowledge spillovers play an important role for sustaining long-run economic growth. A crucial assumption in Arrow's (1960) learning-by-doing model pertains to the ease with which new discoveries spill over to the entire economy. Similarly, early endogenous growth models such as Romer (1986) or a more recent one such as Grossman and Helpman (1991) also assume a relatively costless process of knowledge diffusion. In the first model, knowledge spillovers help sustain economic growth by minimizing the effect of diminishing returns on human capital investment. In the latter model, knowledge spillovers are necessary for sustaining economic growth in developing countries by allowing those countries to imitate new technologies invented in developed countries.

Given the important role of knowledge spillovers in the economic growth literature, economists have attempted to verify the existent of such spillovers (see for example Griliches, 1992). One important focus of these studies is the locality aspect of the knowledge diffusion process. The goal is to verify Marshall's (1920) hypothesis that geographical distance affects the extent of knowledge spillovers. Marshall (1920) basically argues that there should be some productivity effects from being able to observe and imitate what other local producers were doing. If this hypothesis is true, then the extent of knowledge spillovers from developed to developing countries, for example, might be more geographically bounded than the economic growth literature has assumed. In other words, the growth literature might need to pay more attention to the possible significance of geographical factors in its assumption of the underlying knowledge diffusion process.[1]

Marshall's (1920) hypothesis relies on the assumption of human interaction as an important vehicle for knowledge transfers. In particular, geographical proximity is an important determinant of knowledge diffusion process if it involves the diffusion of 'tacit knowledge' (Audretsch and Feldman, 1995). Tacit knowledge can be defined as the "know-how" and "know-who" knowledge of managerial skills, local regulations and customs, cheap supplier chains, and many more (Beuglesdijk and Cornet, 2001). This is in contrast to 'codified knowledge', which is defined as the "know-what" and "know-why" knowledge such as scientific facts published as books, articles, or blue prints. Unlike codified knowledge, tacit knowledge is rarely published and, therefore, requires more human interaction for its diffusion. On the other hand, codified knowledge can diffuse through the media it is published in without requiring much interaction. If the extent of human interaction is limited by geographical distance, then it is plausible for tacit knowledge to be geographically bounded as well.

Empirical studies based on United States (U.S.) data seem to find support for Marshall's (1920) local knowledge spillovers hypothesis. For example, Audretsch and Feldman (1996a) study innovative activity in the U.S. and find that the firms operating in the industries in which knowledge spillovers were thought to be more important

[1] Krugman (1991) provides other arguments for why economists in general should pay more attention to various geographical factors.

showed a higher tendency for clustering than those firms located in other industries. This finding implies that by clustering together the firms can benefit from a stronger knowledge spillover effect than by not clustering. Adams and Jaffe (1996) use a different set of U.S. plant level data and find more support for Marshall's (1920) geographical proximity hypothesis. In particular, they find that the benefits a subsidiary plant could receive from its headquarter are partially determined by the physical distance between the location of the plant and the headquarters. Finally, a study by Jaffe et al (1993) find the tendency for U.S. patents registrations and citations to occur from firms located in the same state. This indicates the possibility that the extent of innovation spillovers is stronger within state than outside of state, which supports the locality of knowledge diffusion hypothesis.

However, Winston (2001) notes that there is less evidence of knowledge spillovers when non-U.S. data are used. For example, Aitken and Harrison (1999) use Venezuelan plant level data and find that, contrary to theoretical prediction, Foreign Direct Investment (FDI) has negative spillover effects on domestic firms located in the same region. A different study based on data from Columbia, Mexico, and Morocco find little evidence of positive knowledge spillovers from exporting firms to non-exporting plants in the same location (Clerides et al, 1998).

Based on those observations, Winston (2001) argues that the lack of evidence in the developing country data might be a consequence of considering only specific sources of knowledge spillovers: FDI and exporting activity. For example, the study that focuses on knowledge spillovers coming from foreign invested producers might miss domestic producers as potential sources of external knowledge. Therefore, he proposes the use of Total Factor Productivity (TFP) as a proxy for general knowledge in order to measure the extent of spillovers regardless of the sources. His proposal is based on the idea that differences in TFP across firms may reflect differences in product design, processing technologies, organizational technologies, and/or managerial skills. If each of these differences can be interpreted as a part of the firm's collective knowledge, then it can also serve as a potential source of new knowledge for other firms.

Beugelsdijk and Cornet (2001) use the Nederland's firm level Research and Development (R&D) expenditure data and fail to find evidence of local knowledge spillovers even when they did not focus only on specific sources of knowledge spillovers. In this case, Winston's (2001) idea might still be useful in the sense that R&D expenditure may underestimate the extent of knowledge that can spill over to other local producers. In particular, R&D expenditure usually excludes the amount of resources spent on routine or non-research, knowledge-enhancing activities such as training workers to use new computer software (Aghion and Howitt, 1998, p. 8). In this case, any increase in worker productivity as a result of such training will be captured by a TFP measure.

There is one other possible reason why there is less evidence of local knowledge spillovers from non-US data. It is related to differences in institutional context and, therefore, the use of TFP may not improve the ability to capture the extent of knowledge spillovers. For example, Zucker and Darby (2001) explain that the lack of local spillovers from Japanese universities in their study might be due to institutional factors. More specifically, in Japan, top scientists conducted their research in specific top university's facilities. In the U.S., on the other hand, top scientists worked in the facilities of their own institutions. As a result, Japanese research outputs were more loosely connected to the locality of the institution where the researchers came from. This reduced the extent of local knowledge spillovers for firms located in the vicinity of a Japanese university.

In this essay, we apply Winston's (2001) idea on Indonesian manufacturing data in order to test for any local knowledge spillover in a developing country. In particular, we extend Winston (2001) in three important aspects. First, we include physical distance measures in our analysis. Such measures are missing from Winston's study due to lack of relevant information in the Taiwanese data set he used. More specifically, we apply Beuglesdijk and Cornet's (2001) "ring-model" idea in constructing our measure of external knowledge which varies by distance. Second, we look at how the extent of knowledge spillovers varies across manufacturing sectors. This sectoral comparison is missing from Winston (2001) since he only looked at the electronics sector of Taiwanese manufacturing industry. Finally, we compare the extent of knowledge spillovers from foreign investment plants to those from purely domestic plants.

The rest of this essay is structured as follows. Section 2 provides a short review of related studies. Section 3 describes the data and the measurement of knowledge. Section 4 reports and discusses the results. Section 5 concludes.

2.2 Theoretical and Empirical Framework

2.2.1 Theoretical Model

The theoretical model which underlies the empirical model specification explained in the next section is from Winston (2001), which is a modification of Hopenhayn's (1992) model of plant dynamics. The modified model is basically a model of knowledge creation which incorporates endogenous exit decision. In every period *t*, a representative plant *i* utilizes its current period stocks of internal (θ_{it}) and external ($\Theta_{it}^{S,L}$) knowledge to produce new ideas; where, *S* and *L* denote plant *i*'s industrial sector and location respectively.[2]

The quantity or quality of the new ideas as well as other exogenous firm characteristics (x_{it}) such as age or size determine a family of distributions $K(\theta_{it}, \Theta_{it}^{S,L}, x_{it})$ from which plant *i* can randomly draw its new knowledge (κ_{it}) for that period.[3] Since the transformation of new ideas into new knowledge is a time consuming process, we assume that κ_{it} can only be incorporated into plant *i*'s next period internal stock of knowledge. Furthermore, we assume that changes in market conditions and technology might require partial replacement or destruction of obsolete production knowledge. Mathematically, the whole process is summarized in equation (2.1)

$$\theta_{it+1} = (1-\delta)\,\theta_{it} + \kappa_{it} \tag{2.1}$$

[2] Thus, the full notation indicates that external knowledge depends on these two factors as will be explained later.

[3] The 'new-ness' of knowledge is with respect to plant *i* only. That is, plant *i*'s new knowledge might be considered old knowledge by other plants. In other words, there is no distinction between imitation or innovation in the model we consider here.

where δ denotes the proportion of the internal stock of knowledge destroyed in one period.

In every period, the representative plant *i* must form a rational expectation of all of its future knowledge and output and compute the present discounted value of future profits accordingly. If the expected lifetime profits exceed the firm's current scrap value, then the firm will stay in the market.

In this process, we assume the firm will use its own stock of internal knowledge to produce output (y_{it}) from a set of inputs which include labor (w_{it}), capital (c_{it}), and raw materials (m_{it}) according to a production technology $Y_{it}(\theta_{it}, w_{it}, c_{it}, m_{it})$. Therefore, by assumption, the sum of all future profits depends on the firm's current stock of internal and, by equation (2.1), external knowledge. More specifically, the firm's exit decision depends on a threshold level of knowledge $\underline{\theta}_{it}(z_{it}, \boldsymbol{\Theta}_{it}^{S,L})$. Mathematically, the plant exit decision rule is given by the following equation:

$$E_{it} = \begin{cases} 1 \text{ if } \theta_{it} \geq \underline{\theta}_{\mathrm{it}}(\mathrm{z}_{\mathrm{it}}, \boldsymbol{\Theta}_{\mathrm{it}}^{\mathrm{S,L}}) \\ 0 \text{ otherwise} \end{cases} \tag{2.2}$$

where $E_{it} = 1$ means that the plant chooses to continue production and z_{it} denotes exogenous firm characteristics which affect its exit decision such as age or size. Note that z_{it} and x_{it} may contain different variables. For example, the sunk cost explanation predicts that a larger firm will show fewer tendencies to exit than a smaller firm. Thus, size is a potential member of z_{it}. However, we have less significant theoretical prediction of the effect of firm size on its knowledge evolution. Therefore, size may not be included in x_{it}.

2.2.2 Empirical Specifications

The empirical model is specified as a reduced form system of equations based on equations (2.1) and (2.2) as follows

$$\begin{aligned} \theta_{it+1} &= \alpha_0 + \alpha_1 \theta_{it} + \mathbf{\Theta}_{it}^{S,L} \beta + x_{it} \gamma + \varepsilon_{it+1} \\ E_{it}^{*} &= \lambda_0 + \lambda_1 \theta_{it} + \mathbf{\Theta}_{it}^{S,L} \varphi + z_{it} \psi + \mu_{it} \\ E_{it} &= \begin{cases} 1 \text{ if } E_{it}^{*} > 0 \\ 0 \text{ otherwise} \end{cases} \end{aligned} \qquad (2.3)$$

where $\mathbf{\Theta}_{it}^{S,L}$ denotes a vector of external knowledge measures available for plant i in period t, while x_{it} and z_{it} denote exogenous vectors of plant characteristics as mentioned earlier.

We estimate the system of equations (2.3) using Heckman's sample selection maximum likelihood estimation method since it is quite possible for the unobservable error terms (ε_{it+1} and μ_{it}) to be correlated with each other. In particular, we assume ($\varepsilon_{it+1}, \mu_{it}$) to be jointly distributed as Bivariate Normal $[0, 0, \sigma, 1, \rho]$, where ρ denotes the correlation coefficient. In addition, following Winston (2001), we construct $\mathbf{\Theta}_{it}^{S,L}$ so that it satisfies two properties. First, the measure included in $\mathbf{\Theta}_{it}^{S,L}$ must reflect the distribution of internal knowledge of all other plants from which plant *i* may derive new knowledge. Second, it must include measures which reflect the extent of human interactions between plant *i* and its neighbors.

Consistent with the first property, we define $\Theta_{it}^{S,L}$ as the median of θ_{jt} for all firms $j \neq i$. In line with the second property, we define $F_{it}^{S,L}$ and $W_{it}^{S,L}$ as the total number of neighboring plants and the total number of workers in the neighboring plants.[4] In these measures of external knowledge, S and L capture the degree of technological and geographical proximity and, thus, allow us to test proximity hypotheses with regards to knowledge spillovers.

Depending on which measures of external knowledge are included in $\boldsymbol{\Theta}_{it}^{S,L}$ of equation (2.3), there are four different specifications that we estimate. These four specifications are summarized in table 2.1. The "+" and "$\downarrow(L)$" signs in the table are the expected signs of the coefficients in the knowledge-evolution equation (equation (2.1)).[5] More specifically, the "+" sign indicates positive knowledge spillovers. The "$\downarrow(L)$" sign indicates that the strength of the positive spillover effects decreases with the distance $L = 1,2,3$.

If there is any positive knowledge spillover, we expect $\Theta_{it}^{S,L}$ and $F_{it}^{S,L}$ or $W_{it}^{S,L}$ would have positive coefficients as determinants of plant i's future knowledge. All else equal, higher $\Theta_{it}^{S,L}$ implies better quality of external knowledge from which plant i can draw new ideas for generating better new knowledge, and, therefore, better future stock of internal knowledge. Similarly, all else equal, higher $F_{it}^{S,L}$ or $W_{it}^{S,L}$

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[4] We consider $W_{it}^{S,L}$ as an alternative proxy for human interaction because it is possible that having two neighboring plants with a combination of 500 employees might provide better chance for human interaction to facilitate knowledge diffusion than having 5 neighbors with a combination of 100 employees.

[5] Since we are not particularly interested in studying how or why external knowledge affects exit decision, we refrain from discussing in detail our expectation of the signs of the coefficients in the exit-rule equation (equation (2)).

means better chance for tapping other plants' internal knowledge and, thus, more ideas can be generated resulting in better knowledge for the future.

If geographical or technological proximity matters, then we expect such positive spillover effects to vary across sector and location in a systematic way. In particular, Marshall's (1920) hypothesis can be formulated as an inequality of the form $\Theta_{it}^{S,1} > \Theta_{it}^{S,2} > \Theta_{it}^{S,3}$, where each $L = 1, 2, 3$ represents locations in increasing distance away from plant *i*.[6] Similarly, the technological proximity hypothesis specifies that $\Theta_{it}^{s_i,L} > \Theta_{it}^{s_{-i},L}$, where s_i indicates plant i's sector and s_{-i} indicates all other sectors beside plant *i*'s. The same hypotheses can be expressed in similar inequalities using either $F_{it}^{S,L}$ or $W_{it}^{S,L}$.

Table 2.1 Empirical model specifications for knowledge evolution

External Knowledge	Model 1A	Model 1B	Model 2A	Model 2B
$\theta_{it}^{s,L}$	+, $\downarrow(L)$	+, $\downarrow(L)$		
$\theta_{it}^{s_i,L}$			+, $\downarrow(L)$	+, $\downarrow(L)$
$\theta_{it}^{s_{-i},L}$			?	?
$F_{it}^{s,L}$	+, $\downarrow(L)$			
$F_{it}^{s_i,L}$			+, $\downarrow(L)$	
$F_{it}^{s_{-i},L}$			?	
$W_{it}^{s,L}$		+, $\downarrow(L)$		
$W_{it}^{s_i,L}$				+, $\downarrow(L)$
$W_{it}^{s_{-i},L}$				?

[6] This three level location is explained in more detail in the next section.

Table 2.2 lists the exogenous variables included in the vectors of firm characteristics x_{it} and z_{it}. The "+" and "-" notations indicate our expectation of the signs of the coefficients. For example, if there is any vintage capital effect, then, all else equal, we expect the distribution of future knowledge for the older plants to have a lower average than that of the younger ones. Also, if larger firms are more willing to accept losses during a bad year, then the coefficients of c_{it} (the log value of the plant's total assets) should be positive.

Table 2.2 Exogenous variables

Variables	Knowledge-equation (x_{it})	Exit-equation (z_{it})
Log of age in years (a_{it})	-	+
New entrant dummy (N_{it})	-	-
Log of assets (c_{it})		+
Square of log of assets (c_{it}^2)		+
Year dummy (Yr_{it})	?	?
Island dummy (R_{it})	?	?
Sector dummy (Sd_{it})	?	?

Included in table 2.2 are a set of dummy variables: Yr_{it}, R_{it}, and Sd_{it}. These variables are intended to capture other factors which might affect the correlation between current external knowledge and future internal knowledge. More specifically, Yr_{it} consists of four year-dummy variables intended to capture any other contemporaneous shocks which may affect all plants in any year. R_{it} consists of four dummy variables defined according to whether or not the plant is located on any of

Indonesia's five major islands. Thus, R_{it} should capture any common regional effects specific to each major island. Finally, Sd_{it} is composed of eight sector-dummy variables according to 2-digit International Standard Industrial Classifications (ISIC). This should capture any common sector specific shock.[7]

2.3 Data and Measurement Methodology

2.3.1 Indonesian Manufacturing Plants

The data set we use for the empirical estimation is from the annual plant-level survey of all medium and large plants in Indonesia's manufacturing sector.[8] Our data set covers the period of 1990-1995, a period noted as the beginning of Indonesia's export oriented industrialization strategy. This annual data set contains detailed information on plant characteristics, expenditures on inputs, values of outputs and other revenues. Most important for our purpose, the data set allows us to track each individual plant performance across time so that we can estimate the exit-rule equation.

Overall, for 1990 and 1995, the raw data set contains 16030 and 21714 records of manufacturing plants, respectively. We take several pre-analysis data cleaning steps in order to ensure that our empirical analysis is consistent with fundamental theories of production. First, we drop all records with zero or negative value of outputs. Second, we eliminate records with zero or negative value of any factor input. Finally, we delete

[7] Note that we estimate the empirical model in equation (2.3) using data from the whole manufacturing industry and data from each manufacturing sector. For obvious reason, the sector-dummy variable, Sd_{it}, is not included in the estimation at the sectoral level.

[8] A medium or large plant is defined as a plant with at least 20 workers.

records which sold more than 75% of their outputs as industrial services to other plants. The last step ensures that we do not double count factor inputs, since those deleted records are most likely subcontractors with a majority of their factor inputs provided by the plants which purchase their services. As a result of these data cleaning steps, the total observation available for both years dropped to 7240 and 8596, respectively. Tables 2.3 and 2.4 provide the breakdown of the 1990-1994 average number of plants and average values of several plant characteristics by province and industrial sector.[9] In addition, figure 2.1 displays a map of the provincial distribution of manufacturing plants in 1992.

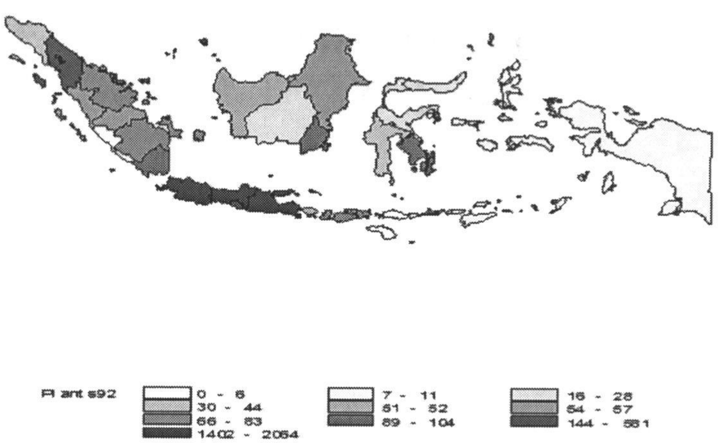

Figure 2.1 Distribution of Indonesian manufacturing plants in 1992.

[9] During the sample period, Indonesia consisted of 27 provinces including East Timor.

2.3.2 The Measure of Knowledge

The underlying assumption in our empirical model is that a plant's internal knowledge can be proxied by the value of its total factor productivity (TFP). The basic intuition of this assumption is that the variation in plant performances as measured by TFP values is mostly a reflection of the variation in plant general knowledge such as knowledge of production, business operations, marketing, and/or management.

One difficulty that may arise from using TFP as a measure of knowledge relates to the possibility for the measure to capture other aspects of technology that might not be considered as knowledge in general. For example, it is difficult to interpret returns to scale as a source of knowledge spillovers. However, other potential sources of performance variation which are not normally considered as knowledge, such as information about access to foreign markets, the skills of workers, customer and supplier relationships, and labor relations, are all potentially observable and useful to other plants. These sources will be accounted for by the TFP index but not by other more traditional measures of knowledge such as R&D expenditures or patents (Winston, 2001).

In addition, TFP would likely measure the combination of both tacit and codified knowledge. This might result in a downward bias on the estimate of the geographical proximity effects on knowledge spillovers since, as argued earlier, proximity matters more when the knowledge spillovers involve tacit rather than codified knowledge.

In order to measure plant TFP, we use the multilateral chained index of Good, Nadiri, and Sickles (1996). This method is an extension of Caves, Christensen, and Diewert (1982) and has been used in many empirical analyses such as Aw, Chung, and Roberts (1998). The method is expressed as a formula given in equation (2.4) below.

$$\begin{aligned} \ln TFP_{it} = & \left(\ln Y_{it} - \overline{\ln Y_t}\right) + \sum_{\tau=2}^{t}\left(\overline{\ln Y_\tau} - \overline{\ln Y_{t-1}}\right) - \\ & \sum_{f=1}^{n} \tfrac{1}{2}\left(a_{it}^{f} + \overline{a_{it}^{f}}\right)\left(\ln X_{it}^{f} - \overline{\ln X_{it}^{f}}\right) - \\ & \sum_{\tau=2}^{t} \sum_{f=1}^{n} \tfrac{1}{2}\left(\overline{a_\tau^{f}} + \overline{a_{\tau-1}^{f}}\right)\left(\overline{\ln X_\tau^{f}} - \overline{\ln X_{\tau-1}^{f}}\right) \end{aligned} \quad (2.4)$$

where X_{it}^{f} and a_{it}^{f} denote the value and cost share of factor input *f*.

The first term in the first line of the right hand side (RHS) of equation (2.4) measures plant *i*'s output relative to a hypothetical firm output.[10] The second term in the same line measures how much the value of output of the hypothetical firm has changed over time. The second and the third line have similar intuition, except that they are for each factor inputs rather than output.

To actually compute total factor productivity (TFP) as explained above, we define output (y_{it}) as the value of total output produced plus industrial services sold in period *t*. We define labor input (w_{it}) as the number of paid workers, capital input (c_{it}) as the value of total assets, and materials input (m_{it}) as the value of expenditures on raw materials, fuel, and electricity. In addition, we define other factor input (o_{it}) as

[10] The hypothetical firm is constructed as the average values of all firms in each sector.

the value of expenditure on industrial services.[11] All values are deflated with their appropriate price deflators.

2.3.2 Ring-Model of Geographical Proximity

In order to test the hypothesis that the extent of knowledge spillovers is affected by physical distance, we need to construct external knowledge measures which vary with distance. For this purpose, we follow Beuglesdijk and Cornet's (2001) approach by drawing rings around each plant *i* as shown in figure 2.2. These rings define regions which vary with distance. Thus, if we construct external knowledge measures for each separate region, we obtain the desired property.

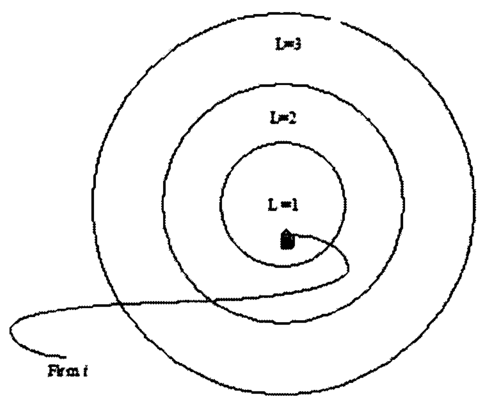

Figure 2.2 Ring-model of geographical proximity.[12]

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[11] The reason we include expenditure on industrial services as another factor input is because it usually represents payment for factor inputs in subcontracted-out production which cannot be broken down into any of the more traditional factor inputs.

[12] The ring-model of geographical proximity consists of three rings around a representative firm i. These rings define the firm's neighbors located in three different locations which are of increasing distance from the firm's location.

There are several possibilities of how the rings can be defined depending on the plant location information available. For example, Beuglesdijk and Cornet (2001) use Dutch zip codes since those are the only available data. Unfortunately, the use of zip codes may give inconsistencies in the resulting regions since zip code assignments are usually not based on economics consideration.

The ideal case would be to define rings according to equal-cost distance principle. That is, the resulting regions are defined consistently in terms how costly it is for plant *i* to interact with other plants in each region. Alternatively, we may define the rings simply as circles with predetermined diameters. For example, the closest region can be defined as the area within 0-10 miles of plant *i*'s location, and so on. In this case, regions are consistently defined in terms of actual physical distance.

For our paper, none of the above three alternatives is possible due to lack of relevant information. Instead, we define the rings according to Indonesia's administrative regional borders. During our sample period, Indonesia was divided into 27 provinces. Each province is divided into several *kabupaten*, and each kabupaten is further divided into *kecamatan.*[13] Therefore, we define $L = 1$ to be the *kecamatan* in which plant *i* is located, $L = 2$ to be the kabupaten plant i is located excluding plant *i*'s *kecamatan*, and $L = 3$ to be the province plant *i* is located excluding plant *i*'s kabupaten.

As discussed earlier, the use of administrative region to define the rings is not ideal in terms of region consistency across plants. However, we think it still reflects

[13] A *kecamatan* is approximately equivalent to a county in the United States. A *kabupaten*, therefore, can be thought of as consisting of several counties. In other empirical studies using Indonesian data, such as Sjoholm (1999), *kabupaten* is usually interpreted as "district".

the difficulty in interacting with plants located in other region. Moreover, we think it is better than the use of zip code. For example, different administrative regions usually have different rules and regulations which affect the costs of doing business in the region. Any information or knowledge that can be used to reduce such costs can be shared more usefully among neighboring plants in the same region than in other regions.

2.4 Empirical Results

2.4.1 The Effects of Geographical and Technological Proximity

Table 2.5 reports the estimation results of the four model specifications shown earlier. In any of the four specifications, current level of TFP is a significant determinant of future TFP. The value of the estimated coefficient ($\hat{\theta}_{it}$) implies that a 10% difference in the mean of current TFP distribution for plant i is positively associated with at least a 6.5% difference in the mean of the TFP distribution from which the plant can draw for the next period. In addition, the sign of the estimated coefficient for a_{it} indicates a statistically significant vintage capital effect, though economically the effect is relatively small. Surprisingly, only in model 1A do we find statistically significant evidence that newer plants are drawing from a TFP distribution with a lower mean than the incumbent plants are.

The more important results for our hypothesis come from the coefficient estimates of the external knowledge variables in the knowledge-equation: $\hat{\Theta}_{it}^{S,L}$ and $F_{it}^{S,L}$ or $W_{it}^{S,L}$. Model 1A and 1B show how much geographical proximity affects the extent of knowledge spillovers. Model 2A and 2B show how much technological proximity matters.

In both model 1A and 1B, there is a strong indication for the locality of knowledge spillovers when we look at the median TFP of the neighboring plants as a measure of external knowledge. The coefficient estimates for the closest region ($\hat{\Theta}_{it}^{s,1}$) are statistically significant in both models. Their small values relative to the values for internal knowledge indicate that the latter is a more important factor in the knowledge-evolution process. The estimated coefficients for the other two regions are decreasing monotonically with distance. That is $\hat{\Theta}_{it}^{s,1} > \hat{\Theta}_{it}^{s,2} > \hat{\Theta}_{it}^{s,3}$. Moreover, at a 5% significance level, we reject the null hypothesis that these coefficient estimates are all equal. Therefore, we have found significant evidence that knowledge spillovers in the whole manufacturing sector of Indonesia are geographically bounded.

The main difference between model 1A and 1B is in the included measure of human interaction. Model 1A uses the number of neighboring plants ($F_{it}^{S,L}$), while model 1B uses the number of workers in neighboring plants ($W_{it}^{S,L}$). Comparing columns 2 and 3 in table 2.5 show that the most notable difference between the two results is the coefficient estimates $\hat{F}_{it}^{s,1}$ and $\hat{W}_{it}^{s,1}$. While $\hat{F}_{it}^{s,1}$ is negative and insignificant, $\hat{W}_{it}^{s,1}$ is positive and statistically significant. Note that $\hat{W}_{it}^{s,2} > \hat{W}_{it}^{s,1} > \hat{W}_{it}^{s,3}$, which indicates the effect of distance is not as clear as in the case of median TFP. However, if we collapse location 1 and 2, we still find that the spillover effects as measured by the human interaction proxy decreases with distance.[14]

The specifications of model 2A and 2B allow us to see the effect of technological proximity. In this case we assume plants operating in the same 3-digit ISIC sector would have a more similar technology than plants operating in different sectors. For example, we expect cigarette manufacturers to use quite different technology from the one used by electronics manufacturer. As in model 1, we consider two different specifications depending on which human interaction proxy is included.

The results summarized in columns 4 and 5 of table 2.5 indicate positive effects from technological proximity. The estimated coefficients for the median TFP of neighboring plants operating in the same sector ($\Theta_{it}^{s_i,L}$) are consistently greater than of plants operating in different sectors ($\Theta_{it}^{s_{-i},L}$). In addition, all $\hat{\Theta}_{it}^{s_i,L}$ are positive and statistically significant, consistent with positive knowledge spillovers. However, $\Theta_{it}^{s_i,2} > \Theta_{it}^{s_i,1} > \Theta_{it}^{s_i,3}$, which means the geographical proximity effect is less clear than in the all sector case. Again, if we collapse region 1 and 2 into one region, we have a monotonic relationship between the spillover effects and the distance..

The estimated coefficients for the human interaction proxies in model 2A and 2B are more difficult to interpret. Neither the number of workers nor the number of plants provides any clear evidence in support of our theoretical expectations. Counter intuitively, at least for the two closest regions, they seem to indicate that there is a

[14] The 2-ring results are not reported but are available upon request.

better chance for interaction with people from different sectors is significantly more knowledge enhancing than with people from the same sector.

We think the above evidence seems to be more consistent with an explanation that the human interaction variables capture more local competition than local knowledge spillovers. For example, it is likely that local plants operating in the same sector are competing for similar factor inputs. If that is the case, then input prices may become higher in places where there are more plants. This implies negative effects on the measured TFP. If this is true, then the measure based on the number of neighboring plants should be able to capture more competitive effect than the one based on the number of workers, since such competition is usually found at plant level. As we can see from the last two columns of table 2.5, $\hat{F}_{it}^{s_i,1}$ (-0.014) is significantly more negative than $W_{it}^{s_i,1}$ (-0.002). In fact, the latter is not statistically significant.

Finally, we briefly comment on the estimation results for the exit equation reported in table 2.6. From the results we can see that new plants are more likely to exit. This is consistent with Hopenhayn's (1992) theoretical prediction, especially when sunk costs are small. In addition, there is limited evidence that larger plants, as measured by the value of assets, tend to have higher probability of staying. This is also consistent with the sunk costs explanation. Also, larger plants might be able to support themselves better during bad times.

2.4.2 Sectoral Variation

Table 2.7 reports the results of estimating model 1B using sub-samples constructed based on 2-digit ISIC.[15] If we look only at the coefficient estimates of median TFP ($\Theta_{it}^{S,L}$), there is evidence of positive local knowledge spillovers in sectors 31, 32, 34, 35, and 36. The other two sectors (33 and 38) exhibit little evidence, if any, of local knowledge spillovers. Moreover, for those sectors with significant spillovers, geographical proximity matters the most in sector 36 and 32.

If we look back at plant characteristics in table 2.4, we see that the sectors with significant knowledge spillovers have higher average age (15-18 years) than the two sectors in which knowledge spillovers may not be important (10-14 years). Thus, our results seem to contradict the industrial life cycle theory which predicts that knowledge spillovers involving tacit knowledge should be more important in the younger industry. However, our finding seems to be consistent with The World Bank's (2000, p. 3) argument that industries with fast changing technology would benefit more from diverse actors, while older industries would be more likely to benefit from localization economies.

The sectoral coefficient estimates for human interaction provide even less clear evidence than in all-sector estimation results. Nevertheless, there is one interesting result that we want to highlight. For sector 38, $F_{it}^{s,1}$ is positive and statistically significant. Furthermore, $\hat{W}_{it}^{s,1} > \hat{W}_{it}^{s,2} > \hat{W}_{it}^{s,3}$. This indicates that tacit knowledge

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[15] We decide to estimate model 1B instead of model 1A since we think the number of workers might serve as a better proxy than the number of plants.

spillovers might be relatively more important in this sector, outweighing any potential local competition effect.

Overall, the sectoral estimation results provide evidence that the extent of knowledge spillovers and how it is affected by geographical distance vary across sectors. Other studies such as Anselin, Varga, and Acs (2000) and Audretsch and Feldman (1996b) also found the importance of sectoral variation in knowledge spillovers.

2.4.3 The Role of Foreign Direct Investment

As our last analysis, we investigate whether or not foreign direct investment (FDI) serves as a more important source of knowledge spillovers than domestic plants. We do this by constructing a set of new measures distinguishing the two groups based on the share of foreign ownership. In particular, we define any plant i as FDI if it reports a positive share of foreign ownership. Then, we construct $\Theta_{it}^{FDI,L}$ ($\Theta_{it}^{DOM,L}$) as the median of TFP distribution of foreign (domestic) plants located in region L. Similarly, we construct $F_{it}^{FDI,L}$ ($F_{it}^{DOM,L}$) and $W_{it}^{FDI,L}$ ($W_{it}^{DOM,L}$) as the number of foreign (domestic) plants and the number of workers in foreign (domestic) plants located in region L. Furthermore, we only look at the extent of spillovers on domestic firms so that we restrict our samples for model estimation to plants with zero share of foreign ownership.

Table 2.8 reports the estimation results of model 3A and 3B which are specified similar to model 2A and 2B, except that we used ownership criteria rather than sector. From column 2 we can see that none of the $\hat{\Theta}_{it}^{FDI,L}$ is both positive and statistically significant. This indicates little knowledge spillovers as measured by the quality of local foreign firms. However, $\hat{F}_{it}^{FDI,1}$ is positive and statistically as well as economically significant. We can interpret this as evidence, though more limited than in our previous analyses, for positive knowledge spillovers. Furthermore, $\hat{F}_{it}^{FDI,1} > \hat{F}_{it}^{FDI,2} > \hat{F}_{it}^{FDI,3}$ indicates evidence for the negative effect from physical distance.

The third column of table 2.b summarizes the estimation results for the case of number of workers. First, the estimated coefficient of $\Theta_{it}^{DOM,1}$ indicates that domestic plants might serve as more important sources of knowledge spillovers. Furthermore, there is evidence that geographical proximity also matters. In terms of $W_{it}^{FDI,L}$, the evidence for knowledge spillovers is much weaker than in terms of $F_{it}^{FDI,L}$. This indicates that it is more important to have more foreign neighbors than to have larger foreign neighbors. One possible reason for this finding is that in Indonesia there are tendencies for large multinationals to be in resource extraction related industries with little connection to local industries. On the other hand, smaller multinationals tend to locate in specialized industrial zones which may have more connection to local producers in the surrounding area.

2.5 Conclusions

Knowledge spillovers have been thought as crucial for sustaining long-run economic growth by reducing the tendency for diminishing returns on investments in knowledge capital. Given its importance, knowledge spillovers have received great research attention. The goals of this line of research range from simply verifying the existence of such spillover to finding factors that could affect the extent of the externalities.

A particular strain of these research inquiries asks whether or not knowledge diffusion depends on geographical and technological proximity. There is evidence that knowledge spillovers, from firms to other firms or from research centers to firms, exist. Furthermore there is evidence that the extent of knowledge spillovers is geographically bounded. Most of this evidence however comes from studies using U.S. data. Other studies using other developed and developing country data sets did not find significant evidence for knowledge spillovers.

There are several reasons that can be proposed to explain this failure. The first one is institutional. A study using data from Japanese biotech industry explains that the lack of knowledge spillovers from local Japanese universities might be due to the centralization of important research activities. The second reason is the consideration of only a specific source of spillovers. For example, some of these studies look only at spillovers from foreign investment or exporting activities. Finally, it is because the use of a restrictive measure of knowledge, accumulated R&D expenditures. It can be argued that R&D expenditures ignore any non-research expenditure routinely spent by firms such as for training, conferences, or marketing-ideas or other brainstorming activities.

To tackle the last two reasons, we consider a more general measure of knowledge based on TFP recently proposed by Winston (2001). Specifically, we extend his work by incorporating measures of geographical distance and conducting sectoral comparisons. In addition, we also look for the possibility of foreign direct investment to serve as an important source of knowledge spillovers.

Our results indicate that knowledge spillovers in Indonesian manufacturing sector are important and depend on both geographical and technological distance. Furthermore, there is evidence for sectoral variations in technology diffusion and in the relationship between knowledge spillovers and geographical proximity. Finally, we find somewhat more limited evidence that FDI plants might serve as important sources of knowledge spillovers. In addition, unlike Sjoholm's (1999) study, our evidence indicates the importance of geographical proximity on the extent of FDI spillovers.

For the future, we would like to test the robustness of our results by using different measures of geographical distance. In particular, we are currently collecting data on global positioning coordinates of each firm regional location. In addition, one might want to look at the possibility of exporters as a source of knowledge spillovers. It should be noted that if such externalities were found, one should not immediately use them to justify an export-oriented policy since the evidence for learning effects from exporting are not clear (Aw et al, 1998 and 2001).

Table 2.3 Plant characteristics by province

Provinces	Plants	Age (years)	Labor (workers)	Capital (log)	TFP (log)
Aceh	36	13	193	12.9	0.044
North Sumatra	446	16	160	12.4	0.002
West Sumatra	45	15	112	11.7	0.122
Riau	72	9	416	14.0	0.057
Jambi	47	10	340	12.9	0.162
South Sumatra	82	6	155	12.4	-0.011
Bengkulu	2	14	437	12.5	0.108
Lampung	66	14	189	12.6	-0.037
Jakarta	604	14	196	13.1	0.090
West Java	2077	14	216	12.8	-0.022
Central Java	1414	20	107	11.2	-0.110
Yogyakarta	135	20	82	11.8	-0.097
East Java	1965	16	139	11.7	-0.098
Bali	159	11	75	11.7	-0.033
West Nusa Tenggara	63	12	55	10.8	0.019
East Nusa Tenggara	6	18	32	12.1	-0.221
East Timor	6	22	27	10.9	0.017
West Kalimantan	57	13	476	13.9	0.117
Central Kalimantan	30	10	237	13.3	0.160
South Kalimantan	83	11	280	12.9	0.096
East Kalimantan	51	13	523	14.1	0.128
North Sulawesi	21	9	131	11.9	0.056
Central Sulawesi	15	13	83	11.7	0.188
Southeast Sulawesi	109	14	95	11.7	-0.129
South Sulawesi	25	9	34	10.4	0.192
Maluku	8	10	678	14.3	0.108
Irian Jaya	12	9	367	14.1	-0.123
Total	7637	16	168	12.2	-0.042

All figures are rounded average across 1990-1994.

Table 2.4 Plant characteristics by industrial sector

Sector	Plants	Age (years)	Labor (workers)	Capital (log)	TFP (log)
31 Food, beverages, and tobacco	2491	18	102	11.5	-0.097
32 Textile, garments, and leathers	1463	15	236	12.1	0.043
33 Woods and wood products	951	10	246	12.6	0.033
34 Paper, printing and publishing	293	18	161	13.0	-0.010
35 Chemical, rubber and petroleum products	825	16	232	13.4	0.069
36 Nonmetallic mineral products	826	17	81	11.4	-0.156
37 Metals (iron, steel, nonferrous)	36	10	159	13.9	0.083
38 Fabricated metal products	617	14	179	13.0	0.032
39 Others	135	13	202	12.2	0.020
Total	7637	16	167	12.2	-0.042

All figures are rounded average across 1990-1994

Table 2.5 Estimates for the knowledge equation based on all sectors data

Regressors	Model 1A	Model 1B	Model 2A	Model 2B
N_{it}	-0.013** (0.006)	-0.009 (0.006)	-0.014 (0.008)	-0.010 (0.008)
a_{it}	-0.013***(0.002)	-0.012***(0.002)	-0.011*** (0.003)	-0.009*** (0.003)
θ_{it}	0.653***(0.004)	0.652***(0.004)	0.662*** (0.006)	0.663*** (0.006)
$\Theta_{it}^{s,1}$	0.079***(0.008)	0.076***(0.008)		
$\Theta_{it}^{s_i,1}$			0.037** (0.008)	0.040*** (0.008)
$\Theta_{it}^{s_{-i},1}$			0.004 (0.010)	-0.007 (0.010)
$\Theta_{it}^{s,2}$	0.056***(0.013)	0.040***(0.012)		
$\Theta_{it}^{s_i,2}$			0.057*** (0.010)	0.062*** (0.010)
$\Theta_{it}^{s_{-i},2}$			0.018 (0.016)	-0.002 (0.016)
$\Theta_{it}^{s,3}$	-0.068**(0.027)	-0.052**(0.025)		
$\Theta_{it}^{s_i,3}$			-0.016 (0.017)	-0.016 (0.017)
$\Theta_{it}^{s_{-i},3}$			-0.080** (0.034)	-0.062** (0.031)
$F_{it}^{s,1}$ or $W_{it}^{s,1}$	-0.002(0.002)	0.003***(0.001)		
$F_{it}^{s_i,1}$ or $W_{it}^{s_i,1}$			-0.014*** (0.002)	-0.002 (0.002)
$F_{it}^{s_{-i},1}$ or $W_{it}^{s_{-i},1}$			0.018*** (0.002)	0.012*** (0.002)
$F_{it}^{s,2}$ or $W_{it}^{s,2}$	0.005***(0.002)	0.008***(0.002)		
$F_{it}^{s_i,2}$ or $W_{it}^{s_i,2}$			0.002 (0.003)	0.002 (0.002)
$F_{it}^{s_{-i},2}$ or $W_{it}^{s_{-i},2}$			0.000 (0.003)	0.006*** (0.002)
$F_{it}^{s,3}$ or $W_{it}^{s,3}$	-0.009***(0.003)	-0.007*** (0.002)		
$F_{it}^{s_i,3}$ or $W_{it}^{s_i,3}$			0.005 (0.005)	0.001 (0.003)
$F_{it}^{s_{-i},3}$ or $W_{it}^{s_{-i},3}$			-0.015*** (0.005)	-0.013*** (0.004)
Const	0.073***(0.026)	0.005(0.034)	0.043 (0.037)	0.015 (0.048)
Observations	34347	34347	19637	19637

*, **, *** = significant at 10%, 5%, and 1% level.

() = standard errors

All regressions include year-, and region-dummy variables

Table 2.6 Estimates for the exit equation based on all sectors data

Regressors	Model 1A	Model 1B	Model 2A	Model 2B
N_{it}	-0.626*** (0.034)	-0.636*** (0.034)	-0.676*** (0.048)	-0.684*** (0.048)
a_{it}	0.134***(0.012)	0.133***(0.012)	0.129*** (0.016)	0.123*** (0.016)
c_{it}	0.095** (0.043)	0.100** (0.043)	0.086 (0.064)	0.080 (0.064)
c_{it}^2	0.001 (0.002)	0.001 (0.002)	0.002 (0.003)	0.002 (0.003)
θ_{it}	0.325***(0.028)	0.324***(0.028)	0.291*** (0.039)	0.275*** (0.039)
$\Theta_{it}^{s,1}$	-0.072 (0.048)	-0.098**(0.048)		
$\Theta_{it}^{s_i,1}$			-0.039 (0.049)	-0.086* (0.049)
$\Theta_{it}^{s_{-i},1}$			-0.065 (0.067)	-0.039 (0.067)
$\Theta_{it}^{s,2}$	-0.037 (0.072)	0.004 (0.073)		
$\Theta_{it}^{s_i,2}$			-0.093 (0.065)	-0.145*** (0.065)
$\Theta_{it}^{s_{-i},2}$			-0.091 (0.110)	0.006 (0.111)
$\Theta_{it}^{s,3}$	-2.368***(0.153)	-2.244***(0.143)		
$\Theta_{it}^{s_i,3}$			-0.136 (0.120)	-0.039 (0.120)
$\Theta_{it}^{s_{-i},3}$			-2.034*** (0.220)	-2.033*** (0.197)
$F_{it}^{s,1}$ or $W_{it}^{s,1}$	0.075***(0.009)	0.038***(0.007)		
$F_{it}^{s_i,1}$ or $W_{it}^{s_i,1}$			0.104*** (0.015)	0.048*** (0.011)
$F_{it}^{s_{-i},1}$ or $W_{it}^{s_{-i},1}$			-0.026* (0.015)	-0.021** (0.010)
$F_{it}^{s,2}$ or $W_{it}^{s,2}$	-0.039***(0.012)	-0.039***(0.009)		
$F_{it}^{s_i,2}$ or $W_{it}^{s_i,2}$			0.045*** (0.017)	0.019 (0.012)
$F_{it}^{s_{-i},2}$ or $W_{it}^{s_{-i},2}$			-0.041 (0.019)	-0.049*** (0.014)
$F_{it}^{s,3}$ or $W_{it}^{s,3}$	-0.029 (0.019)	0.019 (0.016)		
$F_{it}^{s_i,3}$ or $W_{it}^{s_i,3}$			-0.112*** (0.023)	-0.104*** (0.017)
$F_{it}^{s_{-i},3}$ or $W_{it}^{s_{-i},3}$			0.083*** (0.031)	0.078*** (0.026)
Const	0.986***(0.273)	1.121*** (0.339)	0.859* (0.464)	1.203** (0.507)
ρ	-0.214*** (0.025)			
Observations	34347	34347	19637	18017

*, **, *** = significant at 10%, 5%, and 1% level; () = standard errors

Table 2.7 Estimates for knowledge equation Model 1B, by sector.

Regressor	Sector							
	All	31	32	33	34	35	36	38
N_{it}	-0.009	-0.019*	-0.004	-0.007	0.001**	-0.012	-0.043*	-0.001
	(0.006)	(0.011)	(0.013)	(0.020)	(0.039)	(0.029)	(0.023)	(0.025)
a_{it}	-0.012***	-0.013***	-0.024***	0.010	-0.019*	-0.003	-0.019***	-0.002
	(0.002)	(0.003)	(0.004)	(0.007)	(0.011)	(0.008)	(0.007)	(0.008)
θ_{it}	0.652***	0.673***	0.637***	0.582***	0.771***	0.709***	0.438***	0.690***
	(0.004)	(0.008)	(0.010)	(0.016)	(0.022)	(0.014)	(0.017)	(0.016)
$\Theta_{it}^{s,1}$	0.076***	0.072***	0.055***	0.028	0.076***	0.022	0.086***	0.016
	(0.008)	(0.012)	(0.016)	(0.022)	(0.029)	(0.022)	(0.023)	(0.028)
$\Theta_{it}^{s,2}$	0.040***	0.085***	0.019	0.007	0.001	0.084***	-0.018	-0.005
	(0.012)	(0.017)	(0.024)	(0.028)	(0.057)	(0.033)	(0.030)	(0.037)
$\Theta_{it}^{s,3}$	-0.052**	-0.204***	0.035	-0.223***	0.150*	-0.112	-0.190**	0.020
	(0.025)	(0.057)	(0.045)	(0.057)	(0.084)	(0.071)	(0.090)	(0.080)
$W_{it}^{s,1}$	0.003***	-0.010***	0.001	0.005	-0.004	0.012**	-0.012***	0.011**
	(0.001)	(0.002)	(0.003)	(0.004)	(0.008)	(0.005)	(0.004)	(0.005)
$W_{it}^{s,2}$	0.008***	0.011***	0.007**	-0.002	0.001	-0.001	0.013**	0.008**
	(0.001)	(0.002)	(0.003)	(0.004)	(0.057)	(0.005)	(0.005)	(0.004)
$W_{it}^{s,3}$	-0.052**	-0.020***	0.001	-0.016*	-0.015	-0.010	0.032***	0.007
	(0.025)	(0.004)	(0.004)	(0.009)	(0.019)	(0.009)	(0.012)	(0.014)
Const	0.005	0.219***	-0.018	0.096	0.119	0.047	-0.303***	-0.193
	(0.034)	(0.035)	(0.045)	(0.095)	(0.193)	(0.106)	(0.114)	(0.157)
Observations	34347	10201	6153	3083	905	2805	2602	2194

*, **, *** = significant at 10%, 5%, and 1% level.

() = standard errors

All regressions include year-, and region-dummy variables

Table 2.8 Estimates for knowledge evolution, foreign and domestic

Regressor	Model 3A	Model 3B
N_{it}	-0.011 (0.015)	-0.010 (0.014)
a_{it}	-0.005 (0.004)	-0.007 (0.004)
θ_{it}	0.698*** (0.009)	0.699*** (0.009)
$\Theta_{it}^{FDI,1}$	-0.003 (0.013)	0.004 (0.012)
$\Theta_{it}^{DOM,1}$	0.041 (0.025)	0.044* (0.026)
$\Theta_{it}^{FDI,2}$	0.016 (0.021)	0.024 (0.021)
$\Theta_{it}^{DOM,2}$	-0.085* (0.047)	-0.056 (0.047)
$\Theta_{it}^{FDI,3}$	-0.093* (0.052)	-0.072 (0.052)
$\Theta_{it}^{DOM,3}$	-0.001 (0.105)	0.064 (0.098)
$F_{it}^{FDI,1}$ or $W_{it}^{FDI,1}$	0.016** (0.005)	0.002 (0.003)
$F_{it}^{DOM,1}$ or $W_{it}^{DOM,1}$	0.003 (0.005)	0.008** (0.004)
$F_{it}^{FDI,2}$ or $W_{it}^{FDI,2}$	0.004 (0.005)	0.007** (0.003)
$F_{it}^{DOM,2}$ or $W_{it}^{DOM,2}$	-0.006 (0.006)	-0.005 (0.005)
$F_{it}^{FDI,3}$ or $W_{it}^{FDI,3}$	-0.001 (0.008)	-0.010 (0.010)
$F_{it}^{DOM,3}$ or $W_{it}^{DOM,3}$	-0.009 (0.014)	0.013 (0.018)
Const	0.110 (0.097)	-0.099 (0.159)
Observations	7633	7633

*, **, *** = significant at 10%, 5%, and 1% level.

() = standard errors

All regressions include year-, region-, and sector-dummy variables

Chapter 3

Relative Factor Abundance and FDI Factor Intensity in Developed Countries

3.1 Introduction

In the last two decades, developed countries accounted for the bulk of world foreign direct investment (FDI) flows. In 1989, for example, they shared approximately 97% of global FDI outflows and 83% of inflows (United Nations, 1991). More recently, the share of developed countries is lower but still more than twice the share of developing countries. In 2001, developed countries accounted for around 94% of world FDI outflows and 68% of inflows (United Nations, 2002).

In addition to the above concentration of FDI flows in developed countries, Dunning (1993) observes a significant change in the pattern of foreign investment within developed countries themselves. In particular, he notes that foreign investors within these countries have shifted their location of interests from countries traditionally rich in resources, such as Canada and Australia, to top manufacturing countries such as the U.S. and Continental Europe.

Given the similarity of developed countries in terms of factor endowments such as labor and capital goods, these two observations appear to suggest the significance of motives other than those based on factor proportions theory in determining the global flows of FDI. More recent empirical works based on general-equilibrium theoretical models which categorize FDI as either vertical or horizontal seem to support such conclusions regarding the limitation of factor abundance as a determinant of FDI. For example, Markusen and Maskus' (2002) review of the literature finds that most of FDI is of the horizontal type, the type arising mainly from market access motive. In this case, FDI tends to flow among countries of similar relative endowments such as developed countries in response to high transportation costs or trade barriers.

On the other hand, much less evidence has been found in support of vertical FDI – which is motivated more by relative factor endowments.[1] For example, in a vertical FDI, the low-skilled intensive process of production is conducted by an affiliate plant located in the foreign country, which output is intended to be exported back to the home country. However, Brainard (1997) finds that less than 13 percent of US foreign affiliates' production is shipped back to the home country and that foreign affiliates located in the US sent no more than 2 percents of their outputs back to their home countries. This evidence is a strong indication against the underlying idea of vertical FDI.

As noted earlier, the stylized facts and supporting theoretical and empirical predictions seem to lead the literature to a conclusion that it is market access motivation, rather than comparative advantage, which acts as the primary determinant of FDI. However, Yeaple (2001) cautions that the literature might move to such conclusion a little too fast. He argues that the comparative advantage motivation for the international location of multinational production may still be important. In particular, he points out that studies which do not relate host country factor

[1] However, see Braconier, Norback, and Urban (2002) and Davies (2002) for recent findings which seem to provide support for vertical FDI.

endowment and the factor intensity of FDI might miss the importance of comparative advantage in the pattern of FDI.

Maskus and Webster (1995), one of the studies cited by Yeaple (2001) as providing evidence on the link between comparative advantage and FDI flows, is an empirical study designed to relate FDI factor intensity to the underlying factor abundance of the host country. Specifically, Maskus and Webster (1995) computes the factor contents of net inward FDI (inflows – outflows) for the United Kingdom (UK) and South Korea and the rank correlation of factor contents of FDI and factor contents of net exports (exports-imports). They find that for UK, there is a positive relationship between the patterns of revealed comparative advantage and inward FDI.

This paper is aimed at extending Maskus and Webster (1995) in order to assess the robustness of their findings. In particular, this paper contributes to the literature in three important aspects. First, it contributes to the robustness in terms of sample coverage by expanding the sample to five developed countries which are also known as members of the G7: France, Italy, Japan, the United Kingdom, and the United States.[2] Maskus and Webster's (1995) findings differ between the two countries they studied. Therefore, it is still an open question whether their results with the UK hold for other developed countries. Because of the heavy concentration of FDI in developed countries, we think that the investigation of other developed economies is necessary in order to fully understand the role of comparative advantage as a determinant of FDI flows.

[2] We exclude two other members of the G7, Canada and Germany, since we were not able to collect all the necessary data for our analysis.

The second contribution is in terms of the robustness of the empirical measures. Specifically, our second contribution comes from our use of three different measures of FDI depending on how the FDI values are measured: one-year flow of FDI, which is the only measure used by Maskus and Webster (1995), four-year accumulated flow of FDI, or FDI stock.[3] It has been shown that in the short-run, the flows of FDI may reflect fluctuation in the exchange rates (Blonigen, 1997). As a result, the use of a one-year flow data in order to relate the factor content of FDI and revealed factor endowment, which is a long-run measure derived from a long-run general equilibrium theory, may be inappropriate and misleading. That is, since short-run flows of FDI may arise from many different reasons, it is clear that the choice of year may affect the outcome of the analysis.[4] Moreover, as our findings seem to suggest, we cannot be sure of the direction of bias from the use of flow data rather than stock.

The last contribution of this paper is in terms of data robustness in both the quality of the data and the validity of the data for cross-country comparisons. This contribution comes from the use of technology and trade data which were defined more uniformly across countries. Thus, unlike Maskus and Webster (1995), we feel more confident in comparing the results from one country to another.

The rest of this paper is structured as follows. Section 3.2 reviews the related literature on determinants of FDI. It is then followed by a discussion of the empirical

[3] This is simply the stock data as reported by United Nations (1993).

[4] The years of 1999 and, more significantly, 2000 have been characterized as the years with exceptionally high cross-border Merger and Acquisition activities. The total value world FDI inflows in 2000, for example, is more than twice the value in 1998 or 2001 (United Nations, 2002).

framework in Section 3.3. Section 3.4 discusses the data and the relevant measures; whereas, section 3.5 reports and discusses the empirical finding. Finally, section 6 provides some concluding remarks.

3.2 Literature Review

Early theory of the firm approach to the determinants and motivations that lead to the establishments of multinational corporations (MNCs) through FDI has been synthesized by Dunning (1977, 1981) into his Ownership, Location, and Internalization (OLI) paradigm.[5] The idea is that in order to be able to compete in the foreign terrains, MNCs have to possess certain competitive advantages such as better production process, trademarks, or patents that national firms do not possess. In addition, there must be some location-advantages from operating in the foreign countries in order to supply their market directly rather than through exports. For example, a location advantage can be in the form of a lower production cost due to lower wage or costs of raw materials or avoidance of trade barriers. Finally, the establishment of foreign affiliates must be a reflection of the higher costs in alternative contractual arrangements including licensing or partnership relative to internalizing a foreign subsidiary.

Buckley and Casson (1976) and Caves (1982), as cited in Maskus and Webster (1995), for examples, argue that in order to exploit its advantages in technology, managerial techniques, or brand names, a firm will be more likely to choose FDI if other alternatives, such as licensing or exporting, for such exploitation are too costly.

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[5] Dunning (1993) provides a comprehensive review of the early literature on FDI.

Furthermore, Buckley and Casson (1976) also argued that firms would search for cost minimizing production locations according to comparative advantage. Therefore, in this case, there will be a positive correlation between the pattern of inward FDI and the underlying pattern of the host country comparative advantage.[6]

The more recent literature, in particular from the general-equilibrium approach, divides foreign direct investment into vertical and/or horizontal FDI. The vertical model of multinational firm originates from the work of Helpman (1984), while Markusen (1984) started the early horizontal model. Markusen (1997) unified the vertical and horizontal models into what has been referred to as the knowledge-capital (KK) model.[7]

In a vertical FDI, production processes are assumed to be separable into parts which can be located in different geographical locations. For example, developing countries abundant in low-skilled labor will be targeted as the location for low-skilled labor intensive activities to produce goods or intermediates to be shipped back to the parent firms located in high-wage countries abundant in high-skilled labor. In this case, factor abundance is an important determinant of inward FDI.

The horizontal FDI, on the other hand, would establish multiple plants producing the same products in different locations in order to service local markets directly rather than through exports. Usually, the reason is to avoid trade barriers or

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[6] Another alternative approach such as Mundell (1957) views that when there is significant barrier to trade based on the Hecksher-Ohlin-Vanek principle, FDI would arise. Thus, capitals would flow to the economy with the higher relative return. This implies that the relationship between comparative advantage and the location of FDI is the reverse of the firm-specific advantage argument.

[7] See Markusen and Maskus for a review.

high transportation costs. In other words, the main motivation of this type of FDI is usually for market access, rather than for finding low cost location.

Most recently, the horizontal and vertical models are combined into a unified approach in Markusen's (1997) knowledge-capital model (KCM). There are several important predictions from the KCM model which reinforce the conclusion of earlier vertical and horizontal model of FDI. First, vertical FDI arises between countries which are different in their relative factor abundance. Second, affiliate production of horizontal multinationals would be most important for countries with relatively similar factor abundance and size. Therefore, one may expect that FDI flows between developed countries to involve horizontal multinational corporations rather than the vertical ones and, thus, are guided more by market access than by comparative advantage motivation.

Carr et al (2001) provide empirical supports for the above predictions.[8] In particular, they find that U.S. affiliate productions in non-developed countries are complements to trade, which is consistent with vertical FDI. On the other hand, U.S. affiliate productions in developed countries are substitutes to trade, which is consistent with horizontal FDI.

3.3 Analytical Framework

We follow Maskus and Webster's (1995) analytical approach by relating a measure of which factors of production are the sources of comparative advantage and a measure of which factors of production are used relatively more intensively by FDI.

[8] However, see Blonigen, Davies, and Head (2003).

Both of these measures are constructed using the well established techniques of factor content analysis in the spirit of Heckscher-Ohlin-Vanek (HOV) theorem.

The HOV theorem starts with the following identity:

$$T_c = Q_c - C_c \tag{3.1}$$

where T_c, Q_c, and C_c are $n \times 1$ vectors of the amounts of net exports, output, and consumption, respectively, of a country *c;* whereas, *n* denotes the number of goods that are internationally freely mobile. Thus, the above identity simply states that a country *c* trades the part of its production that is not consumed.

Assume identical homothetic preferences and free and frictionless trade with perfectly competitive market for goods and services. Then, C_c can be defined as a constant fraction $s_c = (Y_c - B_c)/Y_w$ of world production (Q_w), where *Y* is the value of gross domestic product and B_c is the value of country *c*'s trade balance. That is,

$$C_c = s_c Q_w \tag{3.2}$$

Let *A* be an $m \times n$ input-output matrix of any country where *m* denotes the number of production factors that are internationally perfectly immobile. In other words, a_{mn}, an element of *A*, represents how much of a factor *m* is needed to produce one unit of output in sector *n*. Then, $F_c = A_c T_c$ is the vector of country *c*'s factor content of net trade which indicates how much skilled labor, unskilled labor, capital, and so forth the country's net exports contain.

Let V_c and V_w denote the $m \times 1$ vectors of factor endowment for country *c* and the world. Assume that every country uses identical constant returns to scale technology and factor prices are equalized across countries. Then, $A_c = A_{c'} = A$, and, by definition, $V_c = AQ_c$ and $V_w = AQ_w$. Therefore, pre-multiplying (3.1) and substituting (3.2) into the result yields a vector equation for country *c* with its *k*-th element given as

$$F_{kc} = V_{kc} - \left(\frac{Y_c - B_c}{Y_w}\right) V_{kw}. \tag{3.3}$$

Equation (3.3) is the essence of the HOV theorem. The left hand side is the trade revealed factor endowments predicted by the theorem. If it is positive then country *c* is revealed to be abundant in factor *k*. The right hand side is the true relative factor endowment. If it is positive, then country *c* is truly relatively abundant in factor *k*.

Following Corvers and Reininga (1998), a further manipulation of (3.3) yields the following inequality that has to be satisfied for country *c* to be revealed more abundant in factor *k* than in factor k', $\frac{F_{kc}}{V_{kw}} > \frac{F_{k'c}}{V_{k'w}}$.[9] Pre-multiplying (3.2) with *A*, incorporating the definitions of *V*, and substituting the result to the previous inequality yields

$$\frac{F_{kc}}{F_{kc}^C} > \frac{F_{k'c}}{F_{k'c}^C} \tag{3.4}$$

where F_{kc}^C is the contents of factor *k* in the domestic consumption.

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[9] Rearranging (3.4) yields $\frac{F_{kc}/V_{kw}}{y_c/y_w} - \frac{B_c}{y_c} = \frac{V_{kc}/V_{kw}}{y_c/y_w}$. The left-hand-side still measures the trade revealed factor abundance for country *c* in terms of factor *k* and provides the basis for the inequality condition for the relative abundance of factor k with respect to k'.

Intuitively, equation (3.4) states that if the ratio of the factor content of net trade to the factor content of domestic consumption for a production factor k is larger than the same ratio for production factor k', then, in country c, factor k is revealed to be more abundant than k'. In other words, the rank order of the factor content of ratios of net trade relative to consumption indicates the revealed relative factor abundance of the production factors within country c. The larger the ratio, the more abundant the factor is.

Similarly, we can assess the location of inward FDI using its factor content (Maskus and Webster, 1995). The basic idea is to measure where inward FDI is concentrated in terms of factor intensity. Are they more concentrated in industrial activities which are intensive in high-skilled labors and capitals, or are they more focused in activities intensive in low-skilled labors and natural resources? In other words, we want to measure the link between, on the one hand, the factor content of net exports (relative to consumption) which 'reveals' which factors are relatively abundant, and, on the other, the factor content of inward FDI which shows whether such investment is focused in industries intensive in the use of abundant factors. Because of the possibility of unaccounted intra-industry FDI patterns due to the use of highly aggregated FDI data, Maskus and Webster (1995) have suggested the use of net inward investment, inward – outward, in computing the factor contents of FDI as explained earlier. In addition, because some industries may have higher volumes of investment than the others, they also suggested scaling the computed factor contents of FDI with the factor contents of domestic investment in each sector.

Denote F_{kc}^{*} and F_{kc}^{I} as the total contents of factor k in net inward FDI and domestic investment, respectively. Then, factor k is used more intensively by inward FDI than factor k' if the following inequality holds:

$$\frac{F_{kc}^{*}}{F_{kc}^{I}} > \frac{F_{k'c}^{*}}{F_{k'c}^{I}} \tag{3.5}$$

3.4 Data

To compute the factor content of net exports for each country we use the *OECD Input-Output Database* which is part of the "*STructural ANalysis* "(STAN) project conducted by the Economics Analysis and Statistics Division of the OECD Directorate for Science, Technology, and Industry. This database provides 1990 input-output matrices as well as export, import, output, and consumption vectors for all of the five countries being studied.[10] The OECD STAN database also provides us with data on sectoral Gross Fixed Capital Formation.

The foreign direct investment flows and stock data for all countries were obtained from *World Investment Directory 1992, Volumes I, 1993: United Nations: New York.* This publication reports FDI statistics of the 1987-1990 period for Italy, Japan, and the United States, and of the 1986-1989 period for France and the United Kingdom.

Finally, the labor skill data were taken from *OECD Data On Skills: Employment By Industry and Occupation* another project of the OECD Directorate for

[10] Davis and Weinstein (2001) summarized the reasons for why we should use individual country's technology matrix rather than forcing the assumption of identical technology and explained some desirable properties of more uniformly defined data.

Science, Technology and Industry. This project provides occupation data disaggregated into four types: White-collar high-skill, White-collar low-skill, Blue-collar high-skill, and Blue-collar low skill. For France, Japan, and US the data period is 1990, for UK it is 1986, and for Italy it is 1991.

For more detailed explanation about the variables and data processing steps we refer the reader to Appendix A.

3.5 Results

This section discusses the results from applying equations (3.4) and (3.5) separately on each of the five developed countries in our sample. In the actual computation, we use three different measures of net inward FDI depending on how long the period of the FDI data is used: long-run FDI stock, four-year accumulation of FDI flows, and one year FDI flows.[11] Furthermore, we have three separate computations depending on which sector is used: all sector, agricultural and manufacturing sector, and services sector.

Given the potential inconsistency problems with the use of short-run FDI flows data as explained in the beginning of this paper, we focus more of our discussion in this section on the results based on the long-run and medium-run measures of FDI. In addition, it should be noted that, for the denominator in equation (3.5), the computation of accumulated values of gross fixed capital formation for each country may differ depending on data availability. For example, we use 4 and 11 years of

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[11] United Nations (1993) reported stock of net inward FDI for each country. The actual definition of the 'stock' data varies from country to country.

accumulation period to construct medium and long-term domestic capital stock whenever possible. For France, however, the available GFCF series at the aggregation level we desire only allows us to construct accumulation data using 3 year data (1987-1989).

3.5.1 France

Table 3.1 summarizes the computed values of factor content of France's net exports relative to the factor content of domestic consumption in 1990 (column 2), the factor contents of net stock of inward FDI in 1989 relative to the factor contents of accumulated gross fixed capital formation (column 3), the factor contents of net accumulated inflows of FDI in 1987-1989 relative to the factor contents of accumulated GFCF (column 4), and the factor content of net inflows of FDI relative to the factor contents of GFCF. All factor content values are provided separately for all sectors, agricultural and manufacturing sectors, and services sectors. In addition, the corresponding ranks are given in the parentheses.

As seen in table 3.1, there seems to be a strong positive relationship between comparative advantage and long-run net inward FDI for the whole economy. The all-sector results show that France is a net exporter of the services of agricultural-related factors and white collar labors and a net importer of all other factor services. Furthermore, France appears to be a net recipient of FDI that concentrates on the intensive use of white collar labor. In other words, the factor content of net exports shows that France is relatively abundant in factors related to agricultural resources and white collar labor and at the same time inward FDI tends to be concentrated in the use of the relatively abundant white collar labors. In addition, France is revealed to be relatively scarce in non-agricultural resources and basic capital goods. At the same time, net inward FDI is least concentrated in the use of these factors. Finally, the medium- and short-run FDI seem to exhibit ranking similar to the long-run measure, indicating similar fit between relative factor abundance and the shorter term FDI location.

However, the relationship between the factor content of net trade and the factor content of inward FDI is less clear when we exclude the service sector. The exclusion of services from the analysis shows that France is revealed to be abundant only in agricultural resources and no longer a net recipient of FDI in any factor. Though net inward FDI targeted for the use of agricultural services is still ranked high, it is not the highest. Non-basic physical capital such as non-electrical machinery and office and computing machinery are both revealed to be relatively scarcer than other factors. Yet, long-term net inward FDI is relatively more concentrated in activities highly intensive in the use of these factors.

Fontagne and Pajot (1997) found that French FDI outflows increased French exports of inputs and complementary final products to French affiliates in the foreign countries. At the same time, inflows of FDI in France were usually aimed at gaining an entry to the European market. The first observation implies a negative correlation between the factor contents of France's net inward FDI and net exports, while the second implies a possible positive correlation. The net result seems to be consistent with the low correlation we find for agriculture and manufacturing sector.

In contrast, the results of the service-sector show a stronger match between the pattern of net inward FDI and revealed comparative advantage. In the service sector, France is a net exporter of all factors and, in the long-run, a net recipient of FDI in all factors but basic metal.[12] In the service sectors, net inward FDI tends to be more focused in the activities which use agricultural resources and low-skilled blue-collar labors which are revealed to be abundant. Furthermore, net inward FDI is less focused on the intensive use of relatively scarce factors such as mining and quarrying and non-electrical machinery.

Table 3.2 provides the rank correlation coefficient between comparative advantage and net inward FDI. The correlation coefficients for all-sector and services are high (0.594 and 0.503, respectively) and statistically significant. However, the correlation coefficient for agriculture and manufacturing sector is small and insignificant. These confirm our earlier observation of a weaker match for the non-services sector and stronger match for the services sector. In addition, even for the all-sector result, the correlation coefficient between inward FDI and comparative advantage is still far from perfect, indicating that comparative advantage is not the only determinant of FDI. Finally, the coefficients vary across the three different measures of FDI, with those based on the one-year flow observation as the smallest of the three groups.

[12] Notice also that for the service sector, FDI is a net source of FDI in all but one sector, but is a net recipient of the single year FDI flow. This evidence reflects the effect of fluctuations in FDI flows and provides an indication of the possible inconsistencies in factor content analysis based on short-run data.

3.5.2 Italy

Table 3.3 summarizes the results of factor content computation of Italian net exports, net stock of inward FDI, net accumulated inflows of FDI, and net inflow FDI. The all-sector results indicate that Italy is a net exporter of the services of all factors except natural resources and blue-collar high-skilled labor. More importantly, both long-term and medium-term net inward FDI tend to avoid activities with intensive use of scarce factors and to be more concentrated in activities which uses more abundant factors such as capital more intensively. For example, four of the six measures of capitals (basic metal, fabricated metal, non-electrical machinery, office and computing machinery, and radio, TV and telecommunication equipment) receive high rankings in both relative abundance and relative intensity inward FDI. The factor services of which Italy is a net importer occupy the three lowest ranks in terms of the factor intensity of net inward FDI.

The exclusion of services from the analysis does not change much of the rankings of revealed factor abundance and factor intensity of net inward FDI. The exclusion of non-services, however, changes the ranking more significantly. For agriculture and manufacturing sector, capital is revealed to be most abundant and this is matched by high concentration of net inward FDI in utilizing these factors. For the service sector, low-skilled workers and natural resources are revealed to be abundant. Yet, activities intensive in the use of natural resources receive relatively less inward FDI. Thus, the relationship between factor endowment and the location of FDI seems to be stronger in the non-service industry than in the service industry.

Such conclusion is supported by the rank correlation coefficients reported in table 3.4. Based on the FDI stock data, the rank correlation coefficient for non-services is higher (0.587) and more significant than the coefficient for services (0.385). Furthermore, Italy seems to exhibit a stronger match between the pattern of factor abundance and the location of inward FDI than France. This is especially clear if we look at the coefficients based on the accumulated FDI data.

Like in the France case, if we compare the correlation coefficients across the three different measure of FDI, the measure based on one-year flow data exhibit the weakest link between FDI and comparative advantage. One possible explanation to the weak fit of the short term is that net exports in both countries are less sensitive to possible common sources of short-run fluctuation, such as exchange rate movements, which affect short-run FDI flow more strongly.

3.5.3 Japan

Table 3.5 reports the results of factor content computation of net exports and net inward FDI relative to domestic consumption and investment, respectively. One important difference between Japan and France or Italy or any other developed country is the fact that Japan is the largest net source of FDI outflows. This is shown by all negative signs in the factor content values of inward FDI indicating that there is instead a net outward FDI in all factors.

The all-sector results show that the relationship between factor endowment and inward FDI is much weaker than in the case of France or Italy. In particular, Japan is revealed to be abundant in non-basic capital such as radio, TV, and communication equipment and office and computing machinery, yet inward FDI is the among the least intensive in these factors. In other words, since Japan is a net source of FDI, Japanese outward FDI seems to follow the same comparative advantage exhibited by Japanese exports. This seems to be a better match to the 'market access' motivation for Japanese outward FDI.

Excluding services from the analysis of the factor contents indicates a similar poor fit between factor endowment and net inward FDI. In addition to the lack of concentration of net inward FDI in activities intensive in the abundant non-basic capitals, there is a tendency for concentration in activities intensive in scarce natural resources. This finding also supports the notion that Japanese FDI might seek market access for its manufacturing and other non-service products.

The rank correlation coefficients of factor content of net trade and net inward FDI are reported in table 3.6 and allow us to assess more objectively the strength of the relationship between comparative advantage and net inward FDI. The all-sector correlation is insignificant and negative for the case of short-run FDI. The non-service sector's correlation coefficient is also negative, indicating a possibly reversed link between factor abundance and net inward FDI. However, none of these negative correlations is statistically significant.

There is one possible explanation to the negative correlation in Japanese agriculture and manufacturing industry. Such a negative correlation can be interpreted as a positive correlation between Japanese net outward FDI and its comparative advantage. In other words, the negative correlation we find means Japanese outward FDI and exports move in the same direction. This finding seems to be consistent with existing evidence. Dunning (1986, pp. 103-118), for example, finds that Japanese manufacturing affiliates in British industry imported 58% of their supplies. Approximately 90% of these recurrent imports were imported from Japan. Such high import ratios were necessary due to the tendency of Japanese affiliates' product to be based on Japanese specifications and originally designed with the Japanese market in mind.[13] In addition, Caves (1993) notes that US trade restrictions boosted Japanese outward FDI to the US and certain East Asian Countries for building them as Japanese export platforms.

In contrast to the agriculture and manufacturing sector, the correlation coefficient for the service sector is consistently positive and statistically significant across the three different measures of FDI. So, in the services industry, comparative advantage is an important determinant of FDI location.

Finally, the correlation coefficient based on the one-year inflow data (the short-run FDI) seems to be higher than in the previous two countries. This is an indication that the difference between the role of comparative advantage in short-run and in long-run may not be straight forward. That is, the link between factor abundance and net inward FDI is not always weaker in the short run than in the long-run. One possible explanation to this finding is that there may be common sources of short-run fluctuations of Japanese net exports and net outward FDI such as exchange

[13] Bayoumi and Lipworth (1997) also argued that Japanese FDI outflows led to a short-run increase in Japanese exports since the new facilities in the foreign locations usually required Japanese capital goods.

rates. In fact, Dunning (1993) noted that Japan and Germany were two industrial countries with most improved outward/inward capital stakes resulting from the rapid appreciation of their currencies. In addition, Bayoumi and Lipworth (1997) found that since the early 1980s, Japanese outward FDI had exhibited significant cyclical pattern they attributed partly to the movements in Japanese currency.

3.5.4 United Kingdom

Table 3.7 summarizes the computed values and rankings of UK factor content of net exports in 1990, stock of net inward FDI in 1989, accumulated flows of net inward FDI in 1986-1989, and net inflow FDI in 1989. For the whole economy, the relationship between revealed factor abundance and each pattern of FDI is weaker than in the case of Italy or even France. Though there is a higher concentration of net inward FDI in activities intensive in the use of energy natural resources, which is revealed to be abundant, net inward FDI tend to be focused on non-basic capital (machineries and electrical apparatus) intensive activity which are revealed to be relatively scarce.

The exclusion of services from the analysis also shows a similarly weak match between revealed comparative advantage and inward FDI. However, the service sector alone seems to show stronger fit. For example, net inward FDI in services is focused on capital intensive activities which are revealed to be abundant by the factor contents of net exports in services. Furthermore, net inward FDI are less focused on activities intensive in the use of relatively scarce labor.

Table 3.8 reports the rank correlation coefficients of the factor contents summarized in the previous table. Overall, the relationship between net inward FDI and revealed comparative advantage is not statistically significant, except when we use the accumulated FDI-which is borderline significant at 10% level. Also, the service sector seems to indicate a stronger match than the non-service sector, though the correlation coefficient is not large enough to be statistically significant. Finally, as in the France and Italy, the one-year flow correlation is the smallest among the three measures of FDI perhaps reflecting less comparative advantage influence in the short-run FDI decision.

There is one important difference between our findings and those of Maskus and Webster (1995). They find significant positive correlations between revealed factor abundance of UK net exports and the factor intensity pattern of UK net inwards FDI. This is probably due to the fact that we use data from different years (1990 net exports data and 1989 FDI flow data) while they used data from the same (1989).[14] We note however that our results seem to be more consistent with Nachum, Dunning, and Jones (2000) which found significant positive correlation between UK outward FDI and its revealed comparative advantage.[15]

For example, for the service sector, Maskus and Webster (1995) find that UK is a net exporter of factor services in half of the factors they list. In contrast to their

[14] Unfortunately, the STAN database we use only provides UK technology and trade data for 1990, while the United Nations FDI statistics for UK only available for 1989.

[15] As noted earlier, a positive correlation of outward FDI and factor abundance is equivalent to a negative correlation in our analytical framework. Since Nachum, Dunning, and Jones (2000) use outward instead of net outward, it is plausible that the correlation they found will turn out to be smaller if net outward FDI were used.

finding, we find that UK is a net importer of all factors in agriculture and manufacturing sector and in services. This finding raises an important issue regarding the appropriateness of using a single year trade data in any factor content analysis, especially if trade pattern is sensitive with sources of short-term fluctuations such as exchange rate movement.

3.5.5 United States

Table 3.9 summarizes the values and rankings of US factor contents of net exports relative to domestic consumption, stock of net inward FDI relative to accumulated GFCF, accumulated net inflows of FDI relative to accumulated GFCF, and net inflow of FDI in relative to GFCF.

The all-sector results based on the long-run FDI data indicates a weak match between factor abundance and the focus of net inward FDI. For example, long-run net inward FDI tend to be more focused on, the relatively scarce, non-agricultural natural resources intensive activities and less focused on, the relatively more abundant, basic capital intensive activities and high-skilled labor. The short-run measure of FDI, however, shows much less intensity in the scarce factors and more intensity in the abundant factors.

However, the exclusion of the service sector from the computation of factor contents weakens the link between factor abundance and the location of FDI. Such a weak correlation seems to be consistent with a recent finding of Feliciano and Lipsey (2002). In particular, Feliciano and Lipsey (2002) that foreign acquisition and new establishment in US manufacturing industry tend to occur in the sectors in which the US has comparative disadvantage while the investing country has some comparative advantage in exporting. Furthermore, Lipsey (2000) also finds significant evidence that the manufacturing sectors in which US had comparative disadvantages, such as apparel and textiles and stone clay and glass products, tend to have higher shares of inward FDI production than outward FDI.

On the other hand, restricting only on services gives a stronger match between the two patterns, especially those based on the short-run FDI measures. Unfortunately, there is too little empirical research of FDI in the services industry for us to draw any meaningful comparison.

The rank correlation coefficients of the factor contents are reported in table 3.10. For the US, services exhibit a stronger link between comparative advantage and net inward FDI. In addition, similar to the case of Japan, short-run FDI seems to be more influenced by comparative advantage consideration than long-run FDI as shown by the stock data.

3.6 Conclusions

Traditional theories of multinational corporations look at FDI as a response to international differences in factor abundance. However, such a view seems to be against the recent stylized facts of FDI, such as the large concentration of FDI flows among developed countries similar in factor endowments. Furthermore, Markusen and

Maskus (2002) note that there is not a lot of empirical evidence that formally tests the idea that the pattern of FDI inflows vary according to factor endowments.[16]

This paper extends Maskus and Webster (1995) by studying four additional developed countries, constructing FDI measures which are more appropriate for long-run analysis, and using better data with more uniformly defined technological matrix and trade and production variables.

Our all-sector results suggest that comparative advantage is still an important determinant of FDI even for developed countries. In particular, the relationship between factor abundance and factor intensity of FDI seems to be much stronger in the service industry than in agriculture and manufacturing, though there are some country variations. Unfortunately, the bulk of empirical studies of FDI often only look at non-services sector so that it is difficult to assess the robustness of our finding.[17]

Except for Italy, we do not find any significant evidence that the factor contents of net exports and net inward FDI are positively correlated for the non-services sector. That is, FDI in the agriculture and manufacturing sector appears to be motivated by market access motives than low factor cost reasons. Furthermore, there is no clear pattern of how such relationship varies by the way the FDI measure is constructed. In particular, for Japan and the US there is a stronger match between revealed comparative advantage and short-run FDI measure. In the other three countries, the match is stronger when the long-run measure of FDI is used.

[16] They also note that Maskus and Webster (1995) is one simple exception.

[17] This is actually rather surprising and disappointing since around 60% of developed countries' FDI flows are in the services sector.

This study can be extended in two important directions. First, significant insights can be gain from conducting a more careful construction of revealed factor abundance and revealed location of FDI using bilateral data. This requires the computation of factor contents based on bilateral trade such as done in Davis and Weinstein (2001) or by Debaere (2003). In addition, it will also need the computation of factor contents of bilateral net inward FDI, paying careful attention to the use of correct technology matrix separately for outflow and for inflow. Finally, as indicated by the comparison of our findings with Maskus and Webster (1995), a potentially rewarding exercise should be done by constructing longer-term measures of trade flows similar to our accumulated FDI flows in order to get a more 'accurate' picture of revealed factor abundance in certain countries.

Table 3.1 Factor contents of net exports and net inward FDI - France

Factors of Production	Net Exports	FDI Stock	Acc. FDI	FDI Flows
A. All sectors				
Agricultural resources	0.015 (1)	-0.489 (7)	-0.511 (7)	-1.143 (10)
Mining and Quarrying	-0.146 (12)	-2.345 (12)	-1.021 (12)	-1.429 (11)
Basic metal	-0.034 (8)	-1.244 (11)	-0.952 (11)	-1.641 (12)
Fabricated metal	-0.040 (9)	-0.778 (10)	-0.675 (10)	-1.031 (9)
Machinery, non-electrical	-0.060 (11)	-0.707 (9)	-0.588 (8)	-0.847 (7)
Office and Computing Machinery	-0.055 (10)	0.158 (3)	-0.155 (1)	-0.135 (3)
Electrical apparatus	-0.024 (7)	-0.319 (6)	-0.442 (6)	-0.442 (6)
Radio, TV & Telecommunication	-0.006 (5)	-0.536 (8)	-0.637 (9)	-0.856 (8)
White collar, high-skilled	0.000 (3)	0.450 (2)	-0.205 (2)	0.035 (2)
White collar, low-skilled	0.006 (2)	0.503 (1)	-0.268 (5)	0.066 (1)
Blue collar, high-skilled	-0.001 (4)	-0.019 (5)	-0.250 (4)	-0.303 (5)
Blue collar, low-skilled	-0.024 (6)	0.102 (4)	-0.232 (3)	-0.226 (4)
B. Agriculture & Manufacturing				
Agricultural resources	0.014 (1)	-0.616 (3)	-0.585 (2)	-1.329 (3)
Mining and Quarrying	-0.197 (12)	-3.722 (12)	-1.439 (12)	-2.328 (12)
Basic metal	-0.046 (4)	-1.416 (10)	-1.046 (9)	-1.887 (11)
Fabricated metal	-0.054 (5)	-1.265 (8)	-0.978 (6)	-1.624 (8)
Machinery, non-electrical	-0.096 (10)	-1.096 (4)	-0.751 (4)	-1.311 (2)
Office and Computing Machinery	-0.116 (11)	-0.024 (1)	-0.616 (3)	-1.464 (5)
Electrical apparatus	-0.077 (8)	-1.534 (11)	-1.124 (11)	-1.824 (10)
Radio, TV & Telecommunication	-0.013 (2)	-1.282 (9)	-1.114 (10)	-1.738 (9)
White collar, high-skilled	-0.069 (7)	-1.260 (7)	-1.040 (8)	-1.580 (7)
White collar, low-skilled	-0.063 (6)	-1.161 (6)	-0.973 (5)	-1.538 (6)
Blue collar, high-skilled	-0.014 (3)	-0.543 (2)	-0.457 (1)	-0.822 (1)
Blue collar, low-skilled	-0.079 (9)	-1.117 (5)	-0.994 (7)	-1.433 (4)
C. Services				
Agricultural resources	0.039 (1)	0.621 (2)	0.097 (1)	0.163 (3)
Mining and Quarrying	0.011 (11)	0.021 (10)	-0.300 (10)	-0.071 (10)
Basic metal	0.023 (4)	-0.039 (12)	-0.335 (12)	-0.103 (12)
Fabricated metal	0.015 (8)	0.203 (7)	-0.121 (6)	0.033 (8)
Machinery, non-electrical	0.013 (10)	0.015 (11)	-0.314 (11)	-0.095 (11)
Office and Computing Machinery	0.019 (6)	0.187 (8)	-0.082 (4)	0.076 (7)
Electrical apparatus	0.009 (12)	0.078 (9)	-0.219 (9)	-0.016 (9)
Radio, TV & Telecommunication	0.025 (3)	0.232 (6)	-0.087 (5)	0.081 (6)
White collar, high-skilled	0.019 (7)	0.611 (3)	-0.128 (7)	0.166 (2)
White collar, low-skilled	0.019 (5)	0.633 (1)	-0.215 (8)	0.170 (1)
Blue collar, high-skilled	0.014 (9)	0.468 (5)	-0.070 (3)	0.091 (5)
Blue collar, low-skilled	0.028 (2)	0.560 (4)	0.021 (2)	0.150 (4)

( ): Rank

Acc. FDI = Accumulated FDI Flows

Table 3.2 Rank Correlation – France

	Rank Correlation Coefficient	t-stat
A. Net exports & stock of net inward FDI		
All Sectors	0.594	2.337
Agriculture and Manufacturing	0.091	0.289
Services	0.503	1.843
B. Net exports & accumulated inflows of FDI		
All Sectors	0.399	1.374
Agriculture and Manufacturing	0.266	0.872
Services	0.538	2.021
C. Net exports & inflow of FDI		
All Sectors	0.371	1.262
Agriculture and Manufacturing	0.147	0.470
Services	0.476	1.709

Table 3.3 Factor contents of net exports and net inward FDI – Italy

Factors of Production	Net Exports	FDI Stock	Acc. FDI	FDI Flows
A. All sectors				
Agricultural resources	-0.078 (12)	0.022 (3)	0.032 (3)	0.032 (2)
Mining and Quarrying	-0.021 (11)	0.004 (11)	0.003 (10)	-0.013 (6)
Basic metal	0.056 (3)	0.004 (9)	0.026 (4)	-0.070 (12)
Fabricated metal	0.032 (4)	0.020 (4)	0.025 (5)	-0.021 (10)
Machinery, non-electrical	0.072 (2)	0.039 (2)	0.036 (2)	0.012 (3)
Office and Computing Machinery	0.157 (1)	0.061 (1)	0.053 (1)	0.040 (1)
Electrical apparatus	0.006 (9)	0.013 (6)	0.007 (8)	-0.007 (5)
Radio, TV & Telecommunication	0.026 (5)	0.013 (5)	0.008 (7)	-0.020 (9)
White collar, high-skilled	0.012 (8)	0.004 (8)	-0.006 (12)	-0.016 (8)
White collar, low-skilled	0.020 (6)	0.004 (10)	-0.004 (11)	0.001 (4)
Blue collar, high-skilled	-0.019 (10)	0.001 (12)	0.011 (6)	-0.034 (11)
Blue collar, low-skilled	0.016 (7)	0.006 (7)	0.003 (9)	-0.015 (7)
B. Agriculture & Manufacturing				
Agricultural resources	-0.087 (12)	0.027 (6)	0.044 (6)	0.048 (3)
Mining and Quarrying	-0.043 (11)	0.006 (10)	0.013 (12)	-0.016 (5)
Basic metal	0.066 (3)	0.005 (11)	0.035 (8)	-0.101 (12)
Fabricated metal	0.046 (4)	0.039 (3)	0.060 (3)	-0.031 (7)
Machinery, non-electrical	0.100 (2)	0.077 (2)	0.081 (2)	0.050 (2)
Office and Computing Machinery	0.204 (1)	0.113 (1)	0.109 (1)	0.336 (1)
Electrical apparatus	0.007 (8)	0.028 (5)	0.028 (9)	0.007 (4)
Radio, TV & Telecommunication	0.041 (5)	0.030 (4)	0.039 (7)	-0.032 (8)
White collar, high-skilled	0.022 (6)	0.016 (7)	0.047 (4)	-0.060 (11)
White collar, low-skilled	0.007 (7)	0.012 (8)	0.046 (5)	-0.057 (10)
Blue collar, high-skilled	-0.029 (10)	0.000 (12)	0.025 (11)	-0.047 (9)
Blue collar, low-skilled	-0.012 (9)	0.011 (9)	0.027 (10)	-0.022 (6)
C. Services				
Agricultural resources	0.026 (3)	0.005 (1)	-0.011 (9)	-0.021 (12)
Mining and Quarrying	0.029 (2)	0.003 (10)	-0.002 (1)	-0.011 (2)
Basic metal	0.003 (12)	0.003 (12)	-0.009 (7)	-0.015 (7)
Fabricated metal	0.006 (8)	0.003 (9)	-0.010 (8)	-0.014 (6)
Machinery, non-electrical	0.017 (5)	0.003 (5)	-0.010 (6)	-0.017 (9)
Office and Computing Machinery	0.005 (11)	0.004 (3)	-0.014 (12)	-0.021 (11)
Electrical apparatus	0.005 (10)	0.003 (11)	-0.008 (4)	-0.014 (5)
Radio, TV & Telecommunication	0.006 (9)	0.004 (4)	-0.012 (11)	-0.018 (10)
White collar, high-skilled	0.010 (6)	0.003 (6)	-0.011 (10)	-0.013 (4)
White collar, low-skilled	0.023 (4)	0.003 (8)	-0.008 (3)	0.005 (1)
Blue collar, high-skilled	0.007 (7)	0.003 (7)	-0.009 (5)	-0.015 (8)
Blue collar, low-skilled	0.041 (1)	0.004 (2)	-0.006 (2)	-0.013 (3)

( ): Rank

Acc. FDI = Accumulated FDI Flows

Table 3.4 Rank Correlation – Italy

	Rank Correlation Coefficient	t-stat
A. Net exports & stock of net inward FDI		
All Sectors	0.490	1.775
Agriculture and Manufacturing	0.587	2.295
Services	0.385	1.318
B. Net exports & accumulated inflows of FDI		
All Sectors	0.476	1.709
Agriculture and Manufacturing	0.727	3.351
Services	0.559	2.134
C. Net exports & inflow of FDI		
All Sectors	0.021	0.066
Agriculture and Manufacturing	0.035	0.111
Services	0.406	1.403

Table 3.5 Factor contents of net exports and net inward FDI – Japan

Factors of Production	Net Exports	FDI Stock	Acc. FDI	FDI Flows
A. All sectors				
Agricultural resources	-0.098 (11)	-0.079 (6)	-0.129 (7)	-0.114 (7)
Mining and Quarrying	-0.108 (12)	-0.086 (7)	-0.083 (2)	-0.072 (2)
Basic metal	0.013 (5)	-0.067 (4)	-0.096 (6)	-0.082 (3)
Fabricated metal	-0.003 (6)	-0.065 (2)	-0.090 (4)	-0.084 (4)
Machinery, non-electrical	0.059 (4)	-0.069 (5)	-0.087 (3)	-0.090 (5)
Office and Computing Machinery	0.091 (3)	-0.040 (1)	-0.042 (1)	-0.058 (1)
Electrical apparatus	0.120 (2)	-0.149 (9)	-0.214 (9)	-0.243 (9)
Radio, TV & Telecommunication	0.137 (1)	-0.181 (10)	-0.269 (10)	-0.320 (11)
White collar, high-skilled	-0.024 (8)	-0.238 (12)	-0.319 (12)	-0.325 (12)
White collar, low-skilled	-0.019 (7)	-0.218 (11)	-0.269 (11)	-0.269 (10)
Blue collar, high-skilled	-0.064 (9)	-0.065 (3)	-0.095 (5)	-0.098 (6)
Blue collar, low-skilled	-0.068 (10)	-0.147 (8)	-0.179 (8)	-0.185 (8)
B. Agriculture & Manufacturing				
Agricultural resources	-0.113 (10)	-0.057 (4)	-0.099 (5)	-0.085 (4)
Mining and Quarrying	-0.153 (11)	-0.051 (3)	-0.048 (2)	-0.027 (1)
Basic metal	0.015 (5)	-0.070 (6)	-0.103 (6)	-0.088 (5)
Fabricated metal	-0.010 (6)	-0.094 (9)	-0.138 (10)	-0.140 (10)
Machinery, non-electrical	0.081 (4)	-0.049 (2)	-0.069 (3)	-0.082 (3)
Office and Computing Machinery	0.107 (3)	-0.020 (1)	-0.020 (1)	-0.045 (2)
Electrical apparatus	0.171 (1)	-0.194 (11)	-0.286 (11)	-0.349 (11)
Radio, TV & Telecommunication	0.155 (2)	-0.208 (12)	-0.313 (12)	-0.386 (12)
White collar, high-skilled	-0.055 (7)	-0.084 (7)	-0.115 (8)	-0.129 (8)
White collar, low-skilled	-0.061 (8)	-0.085 (8)	-0.115 (9)	-0.128 (7)
Blue collar, high-skilled	-0.086 (9)	-0.058 (5)	-0.087 (4)	-0.091 (6)
Blue collar, low-skilled	-0.159 (12)	-0.100 (10)	-0.110 (7)	-0.133 (9)
C. Services				
Agricultural resources	-0.004 (10)	-0.224 (10)	-0.289 (10)	-0.223 (10)
Mining and Quarrying	-0.001 (8)	-0.184 (9)	-0.171 (8)	-0.158 (8)
Basic metal	-0.004 (7)	-0.047 (1)	-0.052 (1)	-0.046 (1)
Fabricated metal	0.001 (6)	-0.047 (2)	-0.063 (2)	-0.055 (2)
Machinery, non-electrical	0.009 (2)	-0.109 (6)	-0.121 (4)	-0.105 (4)
Office and Computing Machinery	0.016 (1)	-0.119 (7)	-0.131 (6)	-0.108 (5)
Electrical apparatus	0.003 (4)	-0.082 (3)	-0.108 (3)	-0.095 (3)
Radio, TV & Telecommunication	0.008 (3)	-0.100 (5)	-0.133 (7)	-0.121 (7)
White collar, high-skilled	-0.012 (12)	-0.304 (12)	-0.392 (12)	-0.388 (12)
White collar, low-skilled	-0.004 (11)	-0.266 (11)	-0.319 (11)	-0.309 (11)
Blue collar, high-skilled	-0.001 (9)	-0.088 (4)	-0.122 (5)	-0.117 (6)
Blue collar, low-skilled	0.002 (5)	-0.174 (8)	-0.213 (9)	-0.207 (9)

( ): Rank

Acc. FDI = Accumulated FDI Flows

Table 3.6 Rank Correlation – Japan

	Rank Correlation Coefficient	t-stat
A. Net exports & stock of net inward FDI		
All Sectors	0.042	0.133
Agriculture and Manufacturing	-0.182	-0.585
Services	0.497	1.809
B. Net exports & accumulated inflows of FDI		
All Sectors	-0.077	-0.244
Agriculture and Manufacturing	-0.329	-1.101
Services	0.545	2.058
C. Net exports & inflow of FDI		
All Sectors	-0.105	-0.334
Agriculture and Manufacturing	-0.308	-1.023
Services	0.601	2.380

Table 3.7 Factor contents of net exports and net inward FDI – UK

Factors of Production	Net Exports	FDI Stock	Acc. FDI	FDI Flows
A. All sectors				
Agricultural resources	-0.123 (7)	-0.347 (12)	-0.469 (12)	-0.803 (12)
Mining and Quarrying, energy	-0.063 (2)	-0.080 (2)	-0.032 (1)	0.022 (3)
Basic metal	-0.153 (11)	-0.149 (8)	-0.182 (7)	-0.103 (8)
Fabricated metal	-0.124 (9)	-0.284 (11)	-0.299 (11)	-0.309 (11)
Machinery, non-electrical	-0.114 (4)	-0.134 (5)	-0.098 (3)	0.029 (2)
Office and Computing Machinery	-0.151 (10)	-0.090 (3)	-0.162 (6)	0.008 (4)
Electrical apparatus	-0.123 (8)	-0.077 (1)	-0.079 (2)	0.080 (1)
Radio, TV & Telecommunication	-0.177 (12)	-0.146 (7)	-0.195 (9)	-0.009 (5)
White collar, high-skilled	-0.069 (3)	-0.137 (6)	-0.141 (5)	-0.070 (7)
White collar, low-skilled	-0.060 (1)	-0.131 (4)	-0.135 (4)	-0.064 (6)
Blue collar, high-skilled	-0.119 (5)	-0.165 (9)	-0.188 (8)	-0.128 (9)
Blue collar, low-skilled	-0.122 (6)	-0.181 (10)	-0.198 (10)	-0.145 (10)
B. Agriculture & Manufacturing				
Agricultural resources	-0.144 (2)	-0.408 (12)	-0.591 (12)	-1.084 (12)
Mining and Quarrying, energy	-0.106 (1)	-0.138 (3)	-0.045 (1)	0.042 (3)
Basic metal	-0.182 (5)	-0.162 (5)	-0.217 (4)	-0.114 (6)
Fabricated metal	-0.185 (6)	-0.382 (11)	-0.454 (10)	-0.476 (11)
Machinery, non-electrical	-0.157 (3)	-0.150 (4)	-0.110 (2)	0.056 (2)
Office and Computing Machinery	-0.182 (4)	-0.115 (1)	-0.266 (5)	-0.004 (4)
Electrical apparatus	-0.206 (10)	-0.121 (2)	-0.187 (3)	0.246 (1)
Radio, TV & Telecommunication	-0.230 (12)	-0.287 (8)	-0.484 (11)	-0.048 (5)
White collar, high-skilled	-0.189 (7)	-0.293 (9)	-0.376 (8)	-0.195 (8)
White collar, low-skilled	-0.195 (8)	-0.330 (10)	-0.424 (9)	-0.292 (10)
Blue collar, high-skilled	-0.207 (11)	-0.219 (6)	-0.296 (6)	-0.195 (9)
Blue collar, low-skilled	-0.196 (9)	-0.250 (7)	-0.322 (7)	-0.188 (7)
C. Services				
Agricultural resources	-0.034 (8)	-0.126 (12)	-0.128 (12)	-0.062 (10)
Mining and Quarrying, energy	-0.011 (3)	-0.021 (1)	-0.021 (3)	-0.027 (4)
Basic metal	-0.009 (1)	-0.094 (6)	-0.056 (5)	-0.059 (9)
Fabricated metal	-0.013 (4)	-0.108 (7)	-0.075 (7)	-0.055 (6)
Machinery, non-electrical	-0.011 (2)	-0.078 (5)	-0.068 (6)	-0.058 (8)
Office and Computing Machinery	-0.030 (6)	-0.044 (3)	-0.020 (2)	0.025 (1)
Electrical apparatus	-0.031 (7)	-0.049 (4)	-0.029 (4)	-0.004 (3)
Radio, TV & Telecommunication	-0.036 (9)	-0.028 (2)	-0.010 (1)	0.017 (2)
White collar, high-skilled	-0.041 (11)	-0.114 (10)	-0.111 (10)	-0.055 (7)
White collar, low-skilled	-0.037 (10)	-0.112 (8)	-0.109 (9)	-0.044 (5)
Blue collar, high-skilled	-0.027 (5)	-0.113 (9)	-0.106 (8)	-0.077 (11)
Blue collar, low-skilled	-0.042 (12)	-0.123 (11)	-0.117 (11)	-0.116 (12)

( ): Rank

Acc. FDI = Accumulated FDI Flows

Table 3.8 Rank Correlation – UK

	Rank Correlation Coefficient	t-stat
A. Net exports & stock of net inward FDI		
All Sectors	0.259	0.847
Agriculture and Manufacturing	0.105	0.334
Services	0.469	1.677
B. Net exports & accumulated inflows of FDI		
All Sectors	0.490	1.775
Agriculture and Manufacturing	0.301	0.997
Services	0.448	1.583
C. Net exports & inflow of FDI		
All Sectors	0.126	0.401
Agriculture and Manufacturing	0.042	0.133
Services	0.035	0.111

Table 3.9 Factor contents of net exports and net inward FDI – US

Factors of Production	Net Exports	FDI Stock	Acc. FDI	FDI Flows
A. All sectors				
Agricultural resources	0.014 (2)	0.021 (4)	0.108 (5)	-0.070 (13)
Mining and Quarrying, non-energy	-0.044 (12)	0.051 (2)	0.132 (2)	-0.034 (11)
Mining and Quarrying, energy	-0.044 (11)	0.051 (1)	0.133 (1)	-0.038 (10)
Basic metal	-0.012 (7)	0.007 (8)	0.128 (3)	0.089 (1)
Fabricated metal	-0.015 (8)	0.004 (10)	0.105 (6)	0.007 (7)
Machinery, non-electrical	-0.025 (9)	-0.027 (11)	0.096 (8)	0.029 (5)
Office and Computing Machinery	-0.011 (6)	-0.061 (13)	0.107 (4)	-0.008 (9)
Electrical apparatus	-0.035 (10)	-0.030 (12)	0.073 (12)	-0.001 (8)
Radio, TV & Telecommunication	-0.071 (13)	0.005 (9)	0.083 (11)	-0.069 (12)
White collar, high-skilled	0.012 (3)	0.027 (3)	0.102 (7)	0.066 (2)
White collar, low-skilled	0.022 (1)	0.012 (7)	0.070 (13)	0.047 (3)
Blue collar, high-skilled	-0.000 (4)	0.018 (5)	0.090 (10)	0.039 (4)
Blue collar, low-skilled	-0.007 (5)	0.016 (6)	0.093 (9)	0.026 (6)
B. Agriculture & Manufacturing				
Agricultural resources	0.011 (1)	0.017 (3)	0.108 (11)	-0.096 (12)
Mining and Quarrying, non-energy	-0.069 (11)	0.067 (1)	0.185 (1)	-0.067 (11)
Mining and Quarrying, energy	-0.069 (10)	0.067 (2)	0.185 (2)	-0.067 (10)
Basic metal	-0.019 (2)	0.005 (5)	0.140 (6)	0.099 (1)
Fabricated metal	-0.043 (6)	-0.009 (10)	0.137 (7)	-0.008 (7)
Machinery, non-electrical	-0.052 (8)	-0.052 (11)	0.106 (12)	0.018 (2)
Office and Computing Machinery	-0.026 (3)	-0.099 (13)	0.157 (3)	-0.024 (9)
Electrical apparatus	-0.083 (12)	-0.062 (12)	0.088 (13)	-0.020 (8)
Radio, TV & Telecommunication	-0.118 (13)	-0.002 (7)	0.127 (9)	-0.132 (13)
White collar, high-skilled	-0.035 (4)	-0.006 (9)	0.136 (8)	-0.001 (5)
White collar, low-skilled	-0.040 (5)	-0.000 (6)	0.151 (5)	0.017 (3)
Blue collar, high-skilled	-0.057 (9)	-0.004 (8)	0.151 (4)	0.016 (4)
Blue collar, low-skilled	-0.046 (7)	0.006 (4)	0.124 (10)	-0.002 (6)
C. Services				
Agricultural resources	0.043 (1)	0.045 (1)	0.101 (1)	0.090 (1)
Mining and Quarrying, non-energy	0.005 (13)	0.015 (10)	0.041 (11)	0.015 (12)
Mining and Quarrying, energy	0.005 (12)	0.017 (9)	0.044 (10)	0.018 (10)
Basic metal	0.008 (11)	0.021 (8)	0.054 (8)	0.022 (9)
Fabricated metal	0.009 (10)	0.029 (4)	0.059 (7)	0.030 (7)
Machinery, non-electrical	0.017 (8)	0.033 (2)	0.075 (3)	0.052 (4)
Office and Computing Machinery	0.021 (5)	0.002 (13)	0.037 (12)	0.017 (11)
Electrical apparatus	0.015 (9)	0.024 (7)	0.052 (9)	0.028 (8)
Radio, TV & Telecommunication	0.020 (7)	0.015 (11)	0.034 (13)	0.008 (13)
White collar, high-skilled	0.021 (6)	0.033 (3)	0.096 (2)	0.077 (2)
White collar, low-skilled	0.031 (3)	0.013 (12)	0.063 (5)	0.050 (5)
Blue collar, high-skilled	0.021 (4)	0.028 (5)	0.064 (4)	0.049 (6)
Blue collar, low-skilled	0.039 (2)	0.026 (6)	0.063 (6)	0.056 (3)

( ): Rank

Acc. FDI = Accumulated FDI Flows

Table 3.10 Rank Correlation – US

	Rank Correlation Coefficient	t-stat
A. Net exports & stock of net inward FDI		
All Sectors	0.121	0.404
Agriculture and Manufacturing	-0.027	-0.091
Services	0.203	0.689
B. Net exports & accumulated inflows of FDI		
All Sectors	-0.247	-0.846
Agriculture and Manufacturing	0.000	0.000
Services	0.527	2.059
C. Net exports & inflow of FDI		
All Sectors	0.462	1.726
Agriculture and Manufacturing	0.335	1.180
Services	0.637	2.743

Chapter 4

Advertising in a Two-Dimensional Vertical Differentiation Model

4.1 Introduction

A set of similar goods are said to be vertically differentiated if when they are offered at the same price only one will be purchased, the highest ranked one. The most typical example for a vertical product characteristic is quality. That is, suppose all product attributes can be measured in terms of a single quality index. For example, most automobile consumers would agree that Volvo is preferable to KIA, or that Dell is preferable to *e*machines. Also, they would all buy the better quality product if both Volvo and KIA or Dell and *e*machines were offered at the same price.

However, when we can only summarize product characteristics down to two or more quality indices, it becomes less clear of how to rank each product. For example, a computer brand can be described in terms of its raw power, operating stability, user friendliness, and post-purchase services. Among different computer platforms, IBM-PC is usually regarded to be more powerful than Apple platform. On the contrary, Apple usually has a higher rating in terms of user-friendliness. Thus, it is not easy to conclude whether one platform is strictly better than the other. Therefore, in this case, consumer taste becomes a more important factor in the market performance of each product.

Advertising is an important element in most differentiated product market competition.[1] For example, one possible scenario in any differentiated product market is that consumers may have little knowledge of the different characteristics of each product. In this case, informative advertising can help in reducing the costs which must be incurred by each consumer in order to obtain information about product characteristics. Therefore, it is possible in this case for advertising to be welfare improving. It should be noted however that such welfare improvement is not guaranteed for any type of advertising in any setting. This lack of guarantee is what makes studying the effects of advertising in various market settings both interesting and useful.

The early literature on vertical product differentiation looks at the welfare implications of the firm's ability to differentiate its product in one dimension. Musa and Rosen (1978) pioneer this line of research by modeling a monopolist's choice of quality. Gabszewicz and Thisse (1979) and Shaked and Sutton (1982, 1983) extend the monopoly case to duopoly settings. For example, Shaked and Sutton (1982) show that under some conditions, firms in duopoly settings would attempt to relax price competition by choosing quality levels that exhibit maximal differentiation. In this case, one might expect that product differentiation would lead to higher prices.

The works mentioned above consider only one dimensional vertical differentiation. Vandenbosch and Weinberg (1995) analyze a duopoly competition in a two-dimensional vertical differentiation setting. They find that in such setting both

[1] In fact, Grossman and Shapiro (1984) argue that a study of the welfare effects of advertising in the framework of homogenous products might be inappropriate and misleading.

firms may not always exhibit maximum differentiation in the two dimensions. In particular, they find the tendency for the firms to choose the minimum level of differentiation in one dimension and the maximum level in the other dimension. They argue that this Max-Min position enables the firms to lower price competition while still maintaining "a sufficiently high quality level for the differentiating firm's products to appeal to a number of customers."

Grossman and Shapiro (1984) provide some of the early findings with regards to the effect of advertising in a differentiated market. They extend Butters (1977) and look at the effect of advertising in a horizontally differentiated setting. In their model, advertising provides potential consumers with accurate and truthful information about product location. In this case, they find that advertising levels can be excessive. In addition, they also find that a greater degree of horizontal differentiation may induce more advertising. They argue that the last finding is consistent with the observation that advertising is more important in a relatively concentrated industry. The intuition is that the marginal benefits from advertising increases with product diversity.

More recent works which extend Grossman and Shapiro's (1984) advertising model of horizontal product differentiation include Fehr and Stevik (1998) and Blich and Manceau (1999). The latter, for example, looks at the effects of persuasive advertising instead of informative advertising. One of their main findings is that advertising may be able to persuade consumer bunching around one of the products, intensifying price competition. In other words, the existence of persuasive advertising in a market with horizontally differentiated product may lead to lower prices.

Unfortunately, less work has been done with regards to the effects of advertising in a vertically differentiated product setting, especially in the case involving two vertical characteristics. Tremblay (2001) is one of the few who investigates the effects of informative and persuasive advertising using a single characteristic vertical differentiation model. One of his principal findings is that with one dimensional vertical product differentiation, the more dominant product would advertise more, charge a higher price, and command a larger market share. He also finds for the case of informative advertising the market price charged by the firms and the full price, defined as the product price plus any search cost incurred, paid by customers may not move in the same direction. This indicates the possibility of advertising to appear as having negative impacts on welfare if one only looks at the increase in the market prices and ignores the possibility for lower full prices.

This essay extends Tremblay (2001) into the case of two vertical characteristics by adding an informative advertising component into Vandenbosch and Weinberg's (1995) analytical framework. More specifically, we study the impact of informative advertising in two cases. First, one of the firms has higher quality in one dimension, but lower quality in the other. Second, one of the firms dominates in both characteristics. To our knowledge, this is the first formal attempt to characterize the impact of advertising in such setting.

The rest of this essay is structured as follows. Section 4.2 sets up the model. Section 4.3 derives and describes the subgame perfect Nash equilibrium of the game.

This is followed by a simulated comparative statics exercise in Section 4.4. Finally, section 4.5 provides some concluding remarks and some possible extensions.

4.2 Model

4.2.1 The Firms

There are two competing firms, each produces one product which is differentiated in two characteristics: X and Y. In particular, we assume that firm i's, $i = 1,2$ product can be defined as a pair of unit-less 'quality' indices (x_i, y_i) where $x_i \in [\underline{x}, \bar{x}]$ and $y_i \in [\underline{y}, \bar{y}]$. We can think of these quality indices as the products' rankings in the two vertical dimensions agreed upon by all consumers.

To simplify our analysis, we assume firm product position has been predetermined exogenously. In particular, we assume two possible cases: *asymmetric* and *fully-dominant*. In the asymmetric case, each firm has the advantage in one of the characteristics. Without loss of generality, we assume firm 1 to have a higher quality in the x-dimension. In the fully-dominant case, we assume firm 2 to be dominant in both x and y characteristics.

To simplify even further, we assume a max-max product differentiation in both of the above cases. That is, in the asymmetric case, firm 1's product can be defined as ($\bar{x}, \underline{y}$) and firm 2's product as ($\underline{x}, \bar{y}$). For the fully-dominant case, the products are defined as $(\underline{x}, \underline{y})$ for firm 1 and $\bar{x}, \bar{y}$ for firm 2. Finally, we only consider the case X-characteristic dominance in the sense that $|\underline{x} - \bar{x}| \geq |\underline{y} - \bar{y}|$. The last assumption can be interpreted as the consumers' putting more importance on the X - characteristic than on the other. Also for simplicity, we assume that each firm pays zero marginal and fixed costs.[2]

The firms are profit maximizers. Therefore, given the other firm's choices ($\hat{p}_j$ and $\hat{A}_j$), firm i chooses its price level (p_i) and advertising expenditure level (A_i) in order to maximize its profits:

$$\pi_i\left(p_i, \hat{p}_j, A_i, \hat{A}_j\right) = p_i D_i\left(p_i, \hat{p}_j, A_i, \hat{A}_j\right) - A_i \tag{4.1}$$

where $D_i(p_i, \hat{p}_j, A_i, \hat{A}_j)$ denotes total demand for product i.

4.2.2 Consumers

Consumers consider the product from each firm as a normal good. In addition, they put nonnegative valuation on each product characteristic and they prefer more of each characteristic to less. We also assume that each consumer can only buy one unit, either from firm 1 or from 2 and that each consumer has a reservation price R that is high enough to ensure a fully covered market.

4.2.2.1 Utility Function

Each consumer can only observe product characteristics after they pay a search cost for each product. For example, a consumer looking to purchase a particular product may need to spend time and energy to study consumer reports or other product

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[2] Vandenbosch and Weinberg (1995) discusses the implication of nonzero and different marginal cost for each firms. They ...

reviews or even to visit a place where product demonstration can be observed. To incorporate the notion that advertising is informative, we assume that firm advertising expenditures reduce the amount of search costs a potential consumer needs to incur. In particular, we define a representative consumer's valuation of product *i* as an additively separable function

$$U_i = R + \phi^x x_i + \phi^y y_i - s_i + \sqrt{A_i} - p_i \tag{4.2}$$

where ϕ^x and ϕ^y are consumer taste parameters with respect to each product characteristic, x_i and y_i represent *i*'s characteristics, s_i is the search cost that the consumer needs to incur to observe (x_i, y_i) and possibly p_i, A_i is the level of advertising expenditure of *i*, and p_i is the market price.

The taste parameters in equation 4.2 capture consumer heterogeneity in terms of how much each consumer values each of the product characteristics. We assume each of these parameters are independently and uniformly distributed in the $[0,1]$ interval.

As explained earlier, consumers can only observe product characteristics (x_i, y_i) after they pay some fixed search cost that is the same for every consumer. This implies that consumers have to consider the combination of the product's market price (p_i) and search cost (s_i) in making their purchasing decision. Because of this, the producer may want to expand the demand for its product by giving information which can lower consumer search costs. Denote $S_i(A_i) = s_i - \sqrt{A_i}$ as the effective search cost that each consumer has to pay in order to observe product *i*'s characteristics. We can then define the full-price of product *i* as $p_i^f = p_i + S_i(A_i)$.

4.2.2.2 The Indifference Line

The indifference line can be drawn on the consumer taste parameter space using the marginal consumer's valuation of y.

Proposition 4.1: The marginal consumer's valuation of characteristic y is given as

$$\phi_m^y(\phi^x) = \phi^x\left(\frac{x_1 - x_2}{y_2 - y_1}\right) + \frac{p_2^f - p_1^f}{y_2 - y_1} \tag{4.3}$$

where $p_i^f = p_i + s_i - \sqrt{A_i}$ denotes the 'full-price' of product *i*.

Proof: (see Appendix)

The slope of the indifference line provided in equation (4.3) above is equal to $\frac{x_1 - x_2}{y_2 - y_1}$. For the asymmetric case, $(x_1, y_1) \equiv (\bar{x}, \underline{y})$ and $(x_2, y_2) \equiv (\underline{x}, \bar{y})$, thus the slope is positive and greater than 1. For the fully-dominant case, the slope is negative since $(x_1, y_1) \equiv (\underline{x}, \underline{y})$ and $(x_2, y_2) \equiv (\bar{x}, \bar{y})$. Assuming $p_1^f < p_2^f$, the fully-dominant indifference line in the consumer taste parameter space is as shown in figure 4.1 below.[3]

In figure 4.1, firm 1's demand is represented by the area below the indifference line (the dashed line). Given firm 2's choices on price and advertising and the two

[3] The assumption is necessary for both firms to have positive demand, otherwise the market collapse into a monopoly competition.

product characteristics, the indifference line shifts up when firm 1 decreases its price or increases its advertising expenditure. Notice that since the slope is negative, then the angle α is greater than 90 degrees. More specifically, since

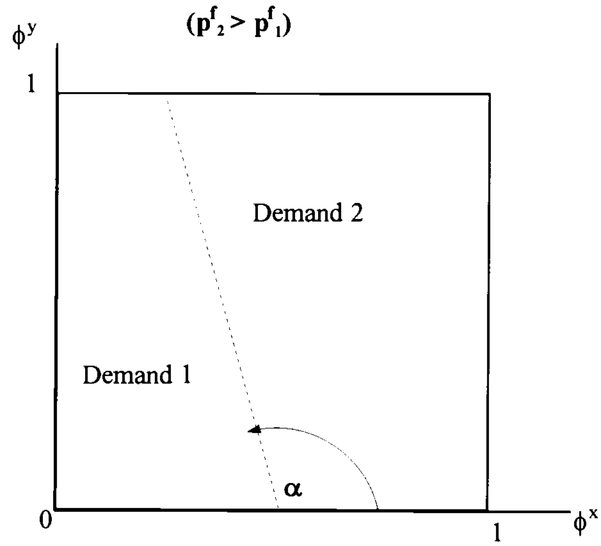

Figure 4.1 Consumer indifference line in the fully-dominant case.

$|\underline{x} - \overline{x}| > |\overline{y} - \underline{y}|$, then $90^\circ < \alpha < 135^\circ$.

4.3 The Non-cooperative Duopoly Game

The two firms play a two-stage game, taking their product locations as given. The sequencing of the game follows Tremblay (2001). In the first stage, both firms simultaneously choose the level of advertising expenditure. In the last stage, they simultaneously choose price. All the standard assumptions of non-cooperative game with perfect information such as players' rationality apply. Assuming its existence, we solve the game for a unique subgame perfect Nash equilibrium. We start by deriving the demand function for each possible demand region.

4.3.1 Demand Regions in the Fully-dominant Case[4]

To derive firm 1's demand function, we divide the consumer taste parameters space into three non-overlapping regions such as shown in figure 4.2 for the fully-dominant case.

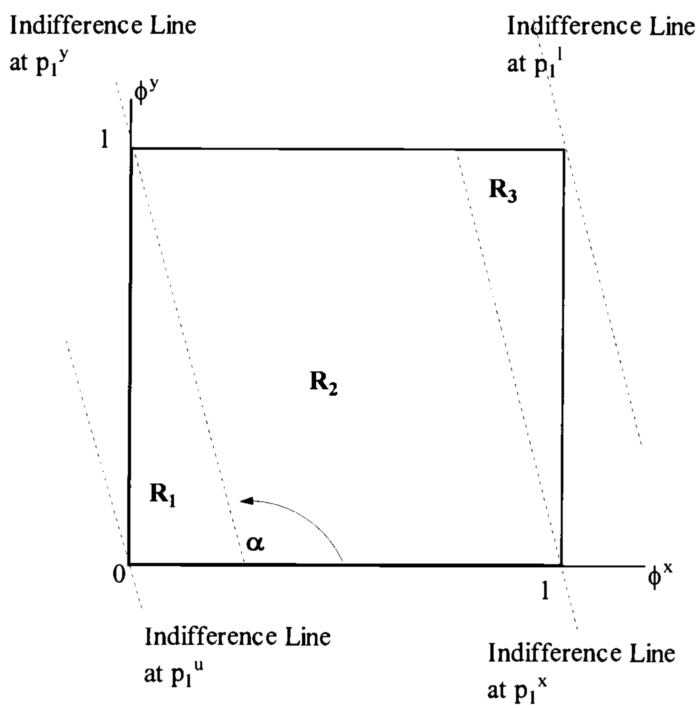

Figure 4.2: Price Boundaries for the fully-dominant case

Since the second stage of the game involves choosing prices simultaneously, we identify four price boundaries which define the three regions. In that figure, each

[4] The results for the asymmetric case are available upon request.

region represents firm 1's demand as a function of firm 2's price, and both firms' search costs and advertising expenditures.

Proposition 4.2: The price boundaries for firm 1 in the fully-dominant case are given as follow:

$$p_1^l = p_2 + s + \sqrt{A_1} - \sqrt{A_2} + x - y \quad (4.3)$$

$$p_1^y = p_2 + s + \sqrt{A_1} - \sqrt{A_2} - y \quad (4.4)$$

$$p_1^x = p_2 + s + \sqrt{A_1} - \sqrt{A_2} + x \quad (4.5)$$

$$p_1^u = p_2 + s + \sqrt{A_1} - \sqrt{A_2} \quad (4.6)$$

where $s \equiv s_2 - s_1$, $x \equiv \underline{x} - \overline{x}$, and $y \equiv \overline{y} - \underline{y}$.

Proof: (see Appendix)

The interpretation of these price boundaries is straight forward. For example, p_1^l is the lower bound for firm 1's price. At p_1^l, firm 1 has a full share of the market so that it would not make sense to charge a price level lower than that. On the other hand, p_1^u is the upper-bound for p_1. In order to get a non-zero market share, firm 1 has to set its price lower than p_1^u. Finally, p_1^x and p_1^y represent the price levels when the consumers care only about the x - and y -characteristic of the product, respectively. Therefore, the exact relationship of these four price boundaries depends on the relative degree of differentiation of the two characteristics. For example, if the degree of differentiation in terms of the x - characteristic is relatively more important, that is if

$\left|\frac{x-\bar{x}}{\bar{y}-\underline{y}}\right| > 1$, then $p_1^l < p_1^x < p_1^y < p_1^u$.[5] Otherwise, $p_1^l < p_1^y < p_1^x < p_1^u$.

4.3.2 Demand Functions in the Fully-dominant Case[6]

Proposition 4.3: For the fully-dominant case, firm 1's demand function corresponding to each demand region is given by equations (4.7) – (4.9) below,

$$D_1^1 = -\frac{1}{2xy}\left(p_2 - p_1 + s + \sqrt{A_1} - \sqrt{A_2}\right)^2 \tag{4.7}$$

$$D_1^2 = \frac{1}{2}\frac{y}{x} + \left(1 + \frac{p_2 - p_1 + s + \sqrt{A_1} - \sqrt{A_2} + x - y}{y - x}\right)\left(1 - \frac{y}{x}\right) \tag{4.8}$$

$$D_1^3 = 1 + \frac{1}{2}\frac{y}{x}\left(\left(\frac{p_2 - p_1 + s + \sqrt{A_1} - \sqrt{A_2} + x}{y}\right)^2 - 1\right) \tag{4.9}$$

where D_1^r denotes firm 1's demand function corresponding to region r, $r = 1,2,3$.

Proof: (see Appendix)

Note that by the covered market assumption, firm 2's demand is just the residual of firm 1's demand. That is, if D_1 represents the demand function for firm 1, then 1- D_1 would represent firm 2's demand function. Note also that in terms of prices and advertising, the intuition of equations (4.7) – (4.9) is straightforward. In particular, demand is decreasing in the firm's price and increasing in the rival's price. Adverting effects are the opposite. All else equal, a higher advertising expenditure leads to a

[5] This is exactly the assumption me made earlier.
[6] The results for the asymmetric case are available upon request.

higher demand. On the other hand, the intuition of the demand effects of a change in the values of product characteristics is less clear. The exception is demand in the first region where a greater degree of differentiation reduces the demand for the inferior products.

4.3.3 Equilibrium Prices for the Subgame

The best approach to derive equilibrium prices for the second-stage of the game is by considering each demand region, and thus each demand function, separately. As it turns out, there is a closed form solution for the subgame equilibrium prices only for region 2.[7] Therefore, all the following discussions will be based on firm choices in that specific region.

Proposition 4.4: The subgame equilibrium prices for the fully-dominant case are given in equations (4.10) and (4.11) below:

$$p_1 = \frac{-2x - y + 2s + 2\sqrt{A_1} - 2\sqrt{A_2}}{6} \tag{4.10}$$

$$p_2 = \frac{-4x + y - 2s - 2\sqrt{A_1} + 2\sqrt{A_2}}{6} \tag{4.11}$$

Proof: (See appendix)

[7] Vandenbosch and Weinberg (1995) find that the examination of the second region provides essentially the same conditions on product characteristic values implied by examining the first and the third region (see Proposition 4.5 below). Therefore, they conclude that it is enough for solving the production positioning competition stage in their model using the second region demand function.

We should note that the prices in equations (4.10) and (4.11) are subgame equilibrium only if they fall within region 2. That is, they must be bounded by corresponding boundary prices as shown below:

$$p_1 \in \lfloor p_1^x , p_1^y \rfloor \text{ and } p_2 \in \lfloor p_2^x , p_2^y \rfloor \tag{4.12}$$

Proposition 4.5: The restrictions on p_1 and p_2 in equation (4.12) hold if[8]

$$-x-3y>0 \tag{4.13}$$

Proof: (see Appendix)

Note that proposition 4.5 is important for selecting appropriate values of $\underline{x}$, $\bar{x}$, $\underline{y}$, and $\bar{y}$ in a simple comparative statics exercise discussed in section 4.4. The corresponding subgame equilibrium prices for the asymmetric case are given in proposition 4.6.

Proposition 4.6: The subgame equilibrium prices for the asymmetric case are as given in equation (4.14) and (4.15) below:

$$p_1 = \frac{-y+4x+2s+2\sqrt{A_1}-2\sqrt{A_2}}{6} \tag{4.14}$$

$$p_2 = \frac{y+2x-2s-2\sqrt{A_1}+2\sqrt{A_2}}{6} \tag{4.15}$$

Proof: (omitted)

[8] We remind the reader that by definition x is negative in the fully dominant case

As in the fully-dominant case, the above prices are the equilibrium for the subgame if they fall within the range of prices defined for region 2. Proposition 4.7 provides the condition in terms of the product characteristic values.

Proposition 4.7: The prices given in equations (4.14) and (4.15) constitute the subgame equilibrium provided that

$$x - y > 0 \tag{4.16}$$

Proof: (omitted)

4.3.4 Subgame-perfect Nash Equilibrium for the Fully-dominant Case[9]

Substituting the subgame equilibrium prices given by propositions 4.4 and 4.6 into the profit function in equation (4.1) yields the firms' objective function for the first stage of the game. Proposition 4.8 below provides the subgame perfect Nash equilibrium prices, advertising, demand, and profits for both firms as functions of product characteristics and consumer search costs for the fully-dominant case.

Proposition 4.8: The subgame perfect equilibrium prices, advertising expenditures, demand and profits are as given in equations (4.17)-(4.21).

$$p_1^* = -\frac{1}{2}x\frac{2-6s+6x+3y}{2+9x}, \quad p_2^* = -\frac{1}{2}x\frac{6s+12x-3y+2}{2+9x} \tag{4.17}$$

$$A_1^* = \frac{1}{36}\frac{(2-6s+6x+3y)^2}{(2+9x)^2}, \quad A_2^* = \frac{1}{36}\frac{(6s+12x-3y+2)}{(2+9x)^2} \tag{4.18}$$

[9] The results for the asymmetric case are available upon request.

$$D_1^* = \frac{1}{2}\frac{2-6s+6x+3y}{2+9x}, \quad D_2^* = \frac{1}{2}\frac{6s+12x-3y+2}{2+9x} \tag{4.19}$$

$$\begin{aligned} \pi_1^* &= -\frac{1}{36}(2-6s+6x+3y)^2\frac{1+9x}{(2+9x)^2} \\ \pi_2^* &= -\frac{1}{36}(6s+12x-3y+2)^2\frac{1+9x}{(2+9x)^2} \end{aligned} \tag{4.20}$$

Proof: (see Appendix)

4.4 Comparative Statics

Using equations (4.17) – (4.20), we conduct comparative statics analysis to compare the effects of advertising on demands, prices, and profits for both cases of asymmetric and fully-dominant product differentiation. For the first exercise, we set $\underline{x} = \underline{y} = 0$, $\bar{x} = 7$, and $\bar{y} = 2$. These values satisfy the conditions given in equations (4.13) and (4.16). Furthermore, we set the search costs for both products to be equal to the same value parameter α. For the second exercise, we reduce the level of absolute product differentiation in the x-dimension by lowering the value of $\bar{x}$ from 7 to 6.

Table 4.1 reports the results of the first exercise. We can see that allowing advertising increases the market price for the firm with better quality and decreases the price of the firm with lower quality. In the asymmetric dominant case, firm 1 has a 'relatively' better product and thus can charge a higher price when advertising is allowed.[10] In the fully-dominant case, firm 2 has a better quality in an absolute sense and is able to increase price at a higher rate than firm 1, which is only 'relatively' better in the asymmetric dominance case. Another important finding from the first exercise is the effects of advertising on the full-price levels. We find that informative advertising leads to lower full-price levels, a finding which is consistent with Tremblay's (2001) finding in the one-dimensional case. In other words, market price effects alone are not enough to determine any welfare implication of informative advertising in the vertical differentiation setting.

Table 4.2 reports the effects of a small reduction in the degree of product differentiation. In particular, we lower the value of $\bar{x}$ from 7 to 6 and examine how market equilibrium reacts to such a change. The results suggest that the effects of a lower differentiation depend on the specification of product characteristics. In the asymmetric dominance case, a lower degree of differentiation in the X-dimension hurts the firm which has the advantage in that dimension. In our particular example, the results indicate that firm 1 loses market share and finds less incentive to advertise. On the contrary, the same change benefits the better firm in the fully dominant case. That is, firm 2 advertises more and has a larger market share when the degree of differentiation in the X-dimension is reduced. Unfortunately, our simple framework does not allow us to see if such an increase in advertising as a response to the lower degree of differentiation is aimed at informing potential consumers about the characteristics in the Y-dimension which has gained in terms of relative importance.

[10]Firm 1 has a higher product quality in the X dimension, but a lower quality in the Y dimension. However, since the degree of product differentiation is higher in the first dimension, we can interpret firm 1 as producing a 'relatively' better product than firm 2.

Finally, the results summarized in table 4.2 also indicate some of the more common findings regarding the effects of a lower degree of product differentiation on prices and profits. In particular, we find that a lower differentiation leads to lower market price levels, which is consistent with the idea of intensified price competition. Consequently, profits also fall. Furthermore, note that the reduction in market prices seems to be large enough to lead to a reduction in the full-price levels.

4.5 Conclusions

This essay studies the impacts of informative advertising in duopoly competition with two-dimensional, vertically differentiated products. In particular, we extend Tremblay (2001) by incorporating advertising competition into a theoretical framework developed by Vandenbosch and Weinberg (1995).

Our results confirm one of Tremblay's (2001) important findings. More specifically, the presence of advertising has different effects on price levels depending on whether we are considering the market price alone or the full price. In particular, advertising leads to higher market prices but lower full prices. In addition, we also find that even when we allow advertising, a lower degree of differentiation still leads to a stiffer price competition resulting in lower market and full-prices as well as profits. Furthermore, the effects of such reduction in product differentiation on advertising levels seem to depend on which product characteristic is dominant. For example, in the asymmetric case, it leads to a lower advertising level of the 'relatively' better firm which has the advantage in the dimension with a reduced degree of differentiation.

The analysis in this essay is rather simple and quite limited, and, therefore, should be considered as an initial step toward more realistic and potentially fruitful research. A particularly interesting direct extension to this essay would be to look at the effects of persuasive advertising. In addition, a possibly more rewarding and definitely more challenging extension can be conducted by including an additional competition stage of product positioning.

Table 4.1 The effects of advertising

	Type of Dominance			
	Asymmetric*		Fully-Dominant**	
	No Adv.	With Adv.	No Adv.	With Adv.
p_1	4.333	4.361	2	1.951
p_2	2.667	2.639	5	5.049
p_1^f	4.333+α	4.153+α	2+α	1.858+α
p_2^f	2.667+α	2.514+α	5+α	4.809+α
A_1		0.043		0.009
A_2		0.016		0.058
D_1	0.619	0.623	0.286	0.279
D_2	0.381	0.377	0.714	0.721
π_1	2.683	2.673	0.571	0.535
π_2	1.016	0.979	3.572	3.584

'Adv.': advertising

*Firm 1 dominates firm 2 in the x-dimension and firm 2 dominates firm1 in the y-dimension. That is, $|x_1 - x_2| > |y_1 - y_2|$.

**Firm 2 fully dominates firm 1.

Table 4.2 The effects of a lower degree of product differentiation

	Type of Dominance			
	Asymmetric*		Fully-Dominant**	
	$\bar{x}=7$	$\bar{x}=6$	$\bar{x}=7$	$\bar{x}=6$
p_1	4.361	3.692	1.951	1.615
p_2	2.639	2.308	5.049	4.385
p_1^f	4.153+α	3.487+α	1.858+α	1.526+α
p_2^f	2.514+α	2.182+α	4.809+α	4.142+α
A_1	0.043	0.042	0.009	0.008
A_2	0.016	0.016	0.058	0.059
D_1	0.623	0.615	0.279	0.269
D_2	0.377	0.385	0.721	0.731
π_1	2.673	2.230	0.535	0.427
π_2	0.979	0.871	3.584	3.145

*Firm 1 dominates firm 2 in the x-dimension and firm 2 dominates firm1 in the y-dimension. That is, $|x_1 - x_2| > |y_1 - y_2|$.

**Firm 2 fully dominates firm 1.

Chapter 5

Concluding Remarks

The main objective of this dissertation is to analyze the implications of firm behaviors in accumulating general knowledge of production, choosing international location, and using informative advertising expenditure as a strategic action. Chapter 2 analyzes the role of geographical and technological proximities and foreign investment in the process of knowledge spillovers. Chapter 3 examines the empirical link between patterns of comparative advantage and net inward investment. Chapter 4 analyzes the strategic interactions between two firms when they can use informative advertising to attract potential consumers.

The results discussed in chapter 2 indicate that the extent of local knowledge spillovers in Indonesian manufacturing sector depends on both geographical and technological proximities. Furthermore, they also indicate variations across different sectors. Finally, though in a more limited sense, they suggest that plants receiving foreign investment are important sources of knowledge spillovers. In summary, the results in chapter 2 are consistent with a clustering firm behavior.

The results presented in chapter 3 suggest that comparative advantage is still an important determinant of inward FDI in developed countries, especially in the service sector. However, we find that that the relationship between factor abundance and factor intensity of FDI in the agriculture and manufacturing sector tends to be weaker than in the service sector. For example, except in Italy, we do not find any significant evidence that the factor contents of net exports and net inward FDI are positively correlated in the non-service sector. This seems to suggest that inward FDI in the agriculture and manufacturing sector is motivated by market access rather than factor abundance. In addition, we do not find any clear pattern of how the relationship between comparative advantage and the location of inward FDI varies across the different measures of FDI. For example, in Japan and the US, there is a stronger match between revealed comparative advantage and short-run FDI measure. On the contrary, in the rest of the countries the match is stronger when the long-run measure of FDI is used. In summary, the results in chapter 3 are consistent with firm behaviors based on both factor cost and market access motivation depending on the characteristics of the industry.

Finally, the results summarized in chapter 4 confirm one important finding from an earlier study. Specifically, the presence of advertising has different effects on price levels depending on whether we are considering the market price alone or the full price. In particular, advertising leads to higher market prices but lower full prices. In addition, our results also show that a lower degree of differentiation may lead to lower market and full prices. More interestingly, our results seem to suggest that the effects of a reduction in the degree of product differentiation on advertising levels depend on which product characteristic is dominant. For example, in the asymmetric case, the reduction leads to a lower advertising level of the 'relatively' better firm. In summary, the results in chapter 4 are consistent with firm behaviors of profit maximization through advertising.

There are various limitations to the studies presented in this dissertation. Further studies using different measures of geographical distance in the construction of the regional rings, for example, would provide more insights on the robustness of our results. In addition, one might want to extend our first essay by looking at the possibility of exporters as a potential source of knowledge spillovers. The second essay can be extended in several important directions as well. For example, one may gain important insights by using bilateral data to compute the factor contents of bilateral net trade and the factor contents of bilateral net inward FDI. Finally, the analysis in the third essay can be extended in a particularly interesting extension by incorporating the idea of persuasive advertising. In addition, a possibly more rewarding and definitely more challenging extension can be conducted by setting up the game so that in the first stage the firms compete in product positioning by choosing their optimum characteristics.

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APPENDICES

Appendix A

International Production, Trade, and FDI Data

The sample of developed countries was selected based on the availability of the required sets of data and it consists of France, Japan, Italy, the United Kingdom, and the United States. For all countries, the values of output, exports, imports, consumption (defined as output – exports + imports), and total (domestic + imported) intermediate matrix were measured in domestic currencies and taken from *OECD Input-Output Database*. The technology matrix is then constructed from total intermediate matrix by dividing the values in the matrix with the value of gross-output by industry. The matrix is disaggregated into 36 sectors according to the second revision of the International Standard Industrial Classification (ISIC, Rev 2). All of these data

Data on inward and outward FDI were taken from *World Investment Directory 1992, Volumes I and III, 1993, United Nations: New York*. Since the FDI data were more aggregated (21 sectors) than the technology matrix, the technology matrix was aggregated appropriately in the computation of the factor contents of net inward FDI.

Data on domestic gross fixed capital formation (GFCF) and capital stock (defined as a simple accumulation of the last 10 year GFCF) were obtained from *OECD Inter-Sectoral Database (ISDB)*. Since the data are more disaggregated than the technology matrix, we had to aggregate the GFCF data appropriately. The data periods were matched as close as possible to the availability of the FDI data.

Finally, the labor skill data were taken from *OECD Data On Skills: Emplyoment By Industry and Occupation,* an internal project of the OECD Directorate for Science, Technology and Industry. This dataset provides the number of employment in each industry categorized into four types: White-collar high-skill (legislators, senior officials and managers, professionals, technicians and associated professionals), White-collar low-skill (clerks, service workers, shops & sales workers), Blue-collar high-skill (skilled agricultural & fishery workers, craft & related trade workers), and Blue-collar low-skill (plant & machine operators and assemblers, elementary occupations). For France, Japan, and US the data period is 1990, for UK it is 1986, and for Italy it is 1991. The labor input requirements for each category were computed indirectly through the labor requirement per 1 unit currency of the intermediate input.

France

The available data on flow and stock of FDI are from the period of 1986-1989 and year of 1989, respectively. The accumulated flow of net inward FDI was constructed by accumulating net inflows of FDI in 1987-1989 to match the availability of GFCF data. More significantly, the OECD's GFCF data for mining and quarrying were missing and were substituted with investment in machinery and equipment data for the specific sector obtained from *OECD's Industrial Structure Statistics: Core Data, Vol. 1, 1998, p.101.*

Japan

There were no GFCF data for the whole economy in the OECD's ISDB database. As an alternative, we use consumption of fixed capital. However, the reported fixed capital consumption data is not disaggregated enough for important manufacturing sectors such as chemical, office machinery, electronics, motor vehicles, and hotel & restaurant. Fortunately, there was a detailed GFCF data set for the manufacturing industry published in OECD's *STAN Database for Industrial Analysis 1974-1993.* We then use STAN GFCF data to breakdown the more aggregated values of consumption of fixed capital.

For labor skills data, sectors such as pharmaceuticals, electronics, aircraft, retail trade, insurance, and international services were not disaggregated. Since there was no other alternative to break down the aggregated information, we aggregate the technology matrix in computing labor use related to the above sectors.

Finally, unlike in all other countries in the sample, Japanese FDI is reported in US$ as opposed to Japanese Yen. Since all other data were already in Yen, for convenience, we converted Japanese FDI into Yen using the corresponding exchange rates obtained from *Penn World Table Mark 6.1*.

Italy

FDI stocks data for certain sectors such as metals & mechanical equipment manufacturing and transport & storage were less disaggregated than in other countries.

As a result, we aggregate the input-output coefficients during the computation of factor content of FDI.

UK

While the input-output based data such as trade and factor requirement were from 1990, only the 1987 FDI stock data were available. However, since the flows data covered the period of 1986-1989, we updated the stock data by simply adding the 1987-1988 flow data into 1987 FDI stock. Furthermore, only the 1986 labor skills data were available.

US

The United States data are the most complete among the countries in the sample. In particular, only in the US FDI data that foreign investment in mining and quarrying was separately available for the energy and non-energy sub-sector.

Appendix B

Proofs of Propositions 4.1 – 4.8

Proof of Proposition 4.1:

First note that the marginal consumer is indifferent between product 1 and product 2 if $U_1 = U_2$. Substituting equation 4.2 yields:

$$R + \phi^x x_1 + \phi^y y_1 - p_1 - s_1 + \sqrt{A_1} = R + \phi^x x_2 + \phi^y y_2 - p_2 - s_2 + \sqrt{A_2}$$

Solve for ϕ^y and denote the result as $\phi_m^y(\phi^x)$:

$$\begin{aligned} \phi_m^y(\phi^x) &= \phi^x\left(\frac{x_1 - x_2}{y_2 - y_1}\right) + \frac{p_2 - s_2 - \sqrt{A_2} - p_1 - s_1 + \sqrt{A_1}}{y_2 - y_1} \\ &= \phi^x\left(\frac{x_1 - x_2}{y_2 - y_1}\right) + \frac{p_2^f - p_1^f}{y_2 - y_1} \end{aligned}$$

QED

Proof of Proposition 4.2:

The price boundaries can be obtained by substituting the taste-parameter coordinates passed by the indifference line (see figure 4.2) into equation (4.3) and solving for p_1. For example, to derive p_1^l, we look at the indifference line which passes through point $(\phi^x, \phi^y) = (1,1)$. Then, from equation (4.3), we have

$$1 = 1\frac{x}{y} + \frac{(p_2 - p_1) + s + (\sqrt{A_1} - \sqrt{A_2})}{y}$$

which can be solved for p_1 (denote the solution as p_1^l) easily.

QED

Proof of Proposition 4.3:

We show a complete proof for equation (4.7), noting that the other two equations (4.8 and 4.9) can be obtained using a similar approach. Figure 4.3 below illustrates firm 1's price choice (p_1) in the first demand region. That is, $p_1 \in \left[p_1^y, p_1^u\right]$. Let $z_1 \equiv \frac{p_1^u - p_1}{p_1^u - p_1^y}$ so that $p_1 = p_1^u \Rightarrow z_1 = 0$, and

$p_1 = p_1^y \Rightarrow z_1 = 1$, $z_1 \in [0,1]$.

In other words, for any price choice (p_1) , z_1 represents the height of the right triangles bordered by the solid lines shown in figure 4.3. Notice that the area of the triangle represents the demand for firm 1's product when it charges p_1.

Therefore, firm 1's demand function in the first region (D_1^1) is given by the area of the triangle.

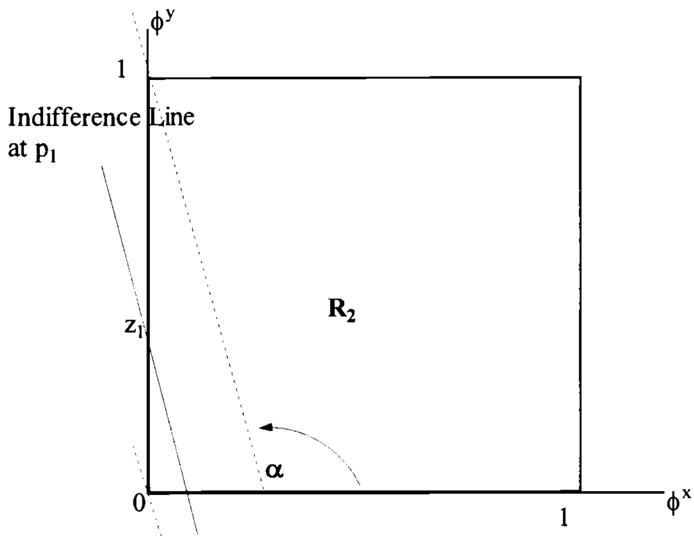

Figure B.1 Firm 1's price choice in demand region R1

To compute D_1^1, first substitute equations (4.4) and (4.6) into the definition of z_1. Noting that $D_1^1 = \frac{1}{2}\,\text{base} \times \text{height} = \frac{1}{2}\frac{\text{base}}{\text{height}} \times (\text{height})^2$ and that, from basic trigonometry, $\frac{base}{height} = \cot(180^\circ - \alpha) = -\frac{y}{x}$, we have

$$
\begin{aligned}
D_1^1 &= -\frac{1}{2}\frac{y}{x}\left(\frac{p_2 + s + \sqrt{A_1} - \sqrt{A_2} - p_1}{p_2 + s + \sqrt{A_1} - \sqrt{A_2} - (p_2 + s + \sqrt{A_1} - \sqrt{A_2} - y)}\right)^2 \\
&= -\frac{1}{2}\frac{y}{x}\left(p_2 - p_1 + s + \sqrt{A_1} - \sqrt{A_2}\right)
\end{aligned}
$$

where $\cot(180^\circ - \alpha)$ is obtained from observing product characteristic coordinates in the product space shown in figure 4.4 below.

QED

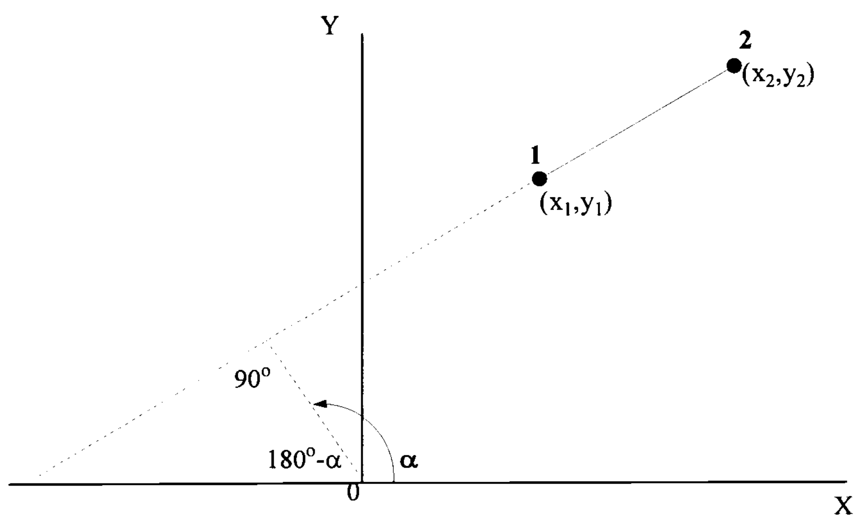

Figure B.2: Firm location in the product space for the fully-dominant case

Proof of Proposition 4.4:

We provide a sketch of the proof since the steps are just routine profit optimization steps. First, substitute the demand function for the second region (equation 4.8) into the profit function (equation 4.1). Then, for each firm, taking the other firm's choice variables as constant, solve the first order condition with respect to price. The resulting two equations need to be solved simultaneously to yield the two equilibrium prices in equations (4.10) and (4.11).

QED

Proof of Proposition 4.5:

We provide a sketch of the proof since it is quite straight forward. From the first part of equation (4.12), we have $p_1 \geq p_1^x$ and $p_1 \leq p_1^y$. Substituting equations (4.4), (4.5), (4.10) and (4.11) into the above inequalities yields equation (4.13).

QED

Proof of Proposition 4.8:

We provide a sketch of the proof since the steps are common in similar optimization procedure. Substitute (4.10) and (4.11) into (4.8), and substitute the resulting expressions into the profit function (4.1). Using the first-order conditions of the two firms' profit optimization problem, derive optimal levels of advertising. These can then be substituted back into the above equations to get the equilibrium level of prices, demands, and profits.

QED