Department of Economics

Multinational Firms, Technology and Location

Pehr-Johan Norbäck

DISSERTATIONS IN ECONOMICS 1998:2

Multinational Firms, Technology and Location

Pehr-Johan Norbäck

Department of Economics
Stockholm University

Abstract

This thesis consists of four essays. Its main theme is the location of production in multinational firms.

Subsidizing away exports? - A note on strategic trade policy, investigates how strategic trade policy arguments for R&D subsidies are altered when firms are multinational rather than national. Using a standard model, where a home firm and a foreign firm compete in exports on an international market, it is shown that cost-reducing R&D subsidies by the home government to the home firm indeed increase this firm's market share. However, the subsidy can also eliminate export production in the home country, as production is shifted abroad.

Strategic R&D policy, domestic unionization and multinational firms, extends the model in the first essay to include labor market effects. Labor is unionized in the home firm and wage and employment are derived using the efficient Nash-Bargaining solution. In this environment, R&D subsidies will also improve the firm's bargaining position against the union, as the improved technology can be used abroad in the case of a break-down of negotiations, when production is shifted abroad. Whether this effect increases the firm's market share and domestic welfare depends on union preferences.

Multinational firms, technology and location generalizes the above model into a full three-stage game where both firms choose (i) their respective technology, by deciding on a level of R&D, (ii) whether this technology is to be used in a domestic or a in local plant and (iii) the quantity produced and sold on the market. If technology transfer costs are fixed, "high-tech" firms tend to produce abroad, but if such costs are associated with the level of R&D, high-tech firms tend to export. An empirical analysis using a data set of Swedish multinational firms, confirms the latter prediction.

Cumulative effects of labor market distortions in a developing country considers a small open economy where an input-output industrial structure, scale economies and imperfect competition, create vertical linkages and multiple equilibria. In this environment, an imperfect labor market is introduced by assuming unionized labor. It is shown that if the vertical linkages are sufficiently strong, a deregulation of the labor market may trigger a large, discontinuous expansion of industrial output, as reduced wage-costs start a circular, cumulative process in which the expansions of the up-and downstream industries promote each other.

ISBN 91-7153-838-0

Akademitryck AB, Edsbruk 1998

To Ann and Sara

Contents

List of Figures

List of Tables

Preface

Its not without surprise that I find myself writing this preface. A long journey is actually reaching its end, and it is time to express my gratitude to a number of people without whom this would not have been possible.

First, I would like to thank my thesis advisors, Harry Flam and Mats Persson at the Institute for International Economic Studies in Stockholm (IIES). Mats Persson encouraged me to enroll in the graduate program, and his enthusiasm convinced me to complete the dissertation. In the later stage of my graduate studies, I became interested in international trade, and I was very fortunate to have Harry Flam as my supervisor. With his profound knowledge of international trade, Harry guided me through the essay-producing stage, making sure to put me on the right track when I went astray. I would also like to thank Lars Persson and Johan Stennek for valuable comments, and, of course, Christina Lönnblad for her patient and thorough work correcting my English.

At the Department of Economics, Stockholm University, where I have spent the major part of my graduate life, a number people made my stay there enjoyable as well as fruitful: I have benefitted from many discussions with Xiang Lin, Sten Nyberg, Mahmood Arai, Sven-Olof Fridolfsson, Jonas Häckner and Hans Lindblad. Besides being a nice room-mate and a good drummer, Peter Skogman explained Heckman's Lambda. Roger Vilhelmsson teached me how to survive at the white-board and, finally, Lars Vahtrik provided valuable help on computer problems.

At the Stockholm School of Economics, Ari Kokko always took the time to read various drafts of the essays in this thesis, for which I am very grateful. Björn Segendorff explained some of the subtleties of game theory, and provided proofs that were beyond my understanding.

I spent my last year at the Research Institute of Industrial Economics (IUI), where chapter four was written, and I am forever indebted to Pontus Braunerhjelm and Ulf Jakobsson for letting me in. Without prior experience in empirical economics, I was helped through the hardships of empirical work by the staff at IUI. Comments and assistance were given by Karolina Ekholm, Pontus Braunerhjelm, Jörgen Nilson, Per Thulin, Erik Mellander, Petter Lundvik, Mattias Ganslandt, Helen Jakobsson and Per Skedinger. Roger Svensson and Karl-Markus Modén deserve special mentioning: Roger closely monitored the empirical work and prevented fatal errors in my usage of the IUI data base. Karl-Markus generously shared his expertice on Scientific Workplace and LaTeX, and made sure that this thesis was put into printable form.

Finally my thoughts go to Ann and Sara. Completing this thesis has meant long working days, with too little time for the fun things in life. Thank you for your patience! I dedicate this thesis to you.

Stockholm, October 1998

Pehr-Johan Norbäck

1

Introduction

This thesis consists of four essays, which can all be characterized as writings in the *new trade theory*. In this introductory chapter, I try to put them into this perspective and show the reader how they contribute to this vast literature. The chapter also contains a summary of the findings of each essay.

1.1 New trade theory

The word "new", in itself, presupposes the existence of something old or traditional. Within trade theory, the latter category contains the Heckscher-Ohlin/Ricardo type of model, relating trade flows to comparative advantage.[1] While these traditional models could easily deal with numerous issues within trade theory, there were trade patterns which could not be explained within this framework. The most important of these patterns was intra-industry trade, where countries trade with each other in similar types of goods. Scale economies, which characterize many industries with considerable international activities, was another such pattern.

Since the Heckscher-Ohlin/Ricardo type of models built on assumptions of constant returns to scale and perfect competition, trade theorists were obliged to turn to other fields of economic theory to find the tools required for dealing with these patterns. Such tools were found in the industrial organization (IO) literature, which could provide imperfect competition, product differentiation, increasing returns to scale and strategic interaction. At the risk of oversimplifying, it could be argued that the new trade theory was created by taking models from the IO field and distributing the firms in those models into separate countries.

This strategy had a great impact on trade theory, however, as seminal papers by Krugman (1980), Lancaster (1979) and Dixit and Norman (1980) showed. Scale economies were now given a role equal to that of comparative advantage for generating trade and gains from trade. In fact, as was shown by Helpman and Krugman (1985), these could even be synthesized in formal models, thus generating comparative advantage-driven inter-industry trade (countries specializing in different goods), while scale economies generated intra-industry trade (trade in similar goods).

---

[1] I have put the word "new" within quotes, since the Heckscher-Ohlin theory used to be called "the modern theory of trade".

1.1.1 Strategic trade policy

While the new trade theory showed its strength by giving new, robust and coherent insights into why trade takes place, the normative side - designing the appropriate trade policy - did not show the same progress.

In traditional, perfect competition trade models, the general rule prescribed free trade - with the exception of the argument for an optimal tariff for a large country.[2] With the use of imperfect competition and oligopoly models, however, the door was open to government interventions and the normative side soon expanded into a considerable body of literature, referred to as the strategic trade policy literature.[3] Seminal contributions included a series of papers by Brander and Spencer, e.g. Brander and Spencer (1983, 1985).

As the strategic trade policy literature has matured, it has been subject to a great deal of criticism, however. Due to its origins in the Industrial Organization literature, critics remark upon the absence of universal policy rules. The diversity of models, with competing assumptions, such as Bertrand or Cournot interaction, implies that the desirable government actions must be defined on a case-by-case basis. This raises questions about the practical use of strategic trade policy, as the information requirement on government officials is excessive.[4]

Another problem is what type of agents receive the government's assistance. A government is supposed to support its domestic national champions on rent-yielding international markets against the national champions of other countries, which assumes the existence of clearly defined national firms. However, when observing the firms in the relevant, international industries, these firms are multinational rather than national - that is, they perform production activities in more than one country.

The question is then how the policy conclusions emerging from this literature are changed, when the assumption of national firms is excluded. Some previous work deals with this issue; the impact of foreign ownership on domestic production has been investigated by Dick (1993). Horstmann and Markusen (1992) show that the firms' ability to change plant configurations limits the extent to which tariff policy can applied. Mezetti and Dinopuolos (1991) discuss unionized labor and multinational firms.[5]

In chapters two and three, *Subsidizing away exports? - A note on strategic trade policy* and *Strategic R&D policy, domestic unionization and multinational firms*, I attempt to include the effects of strategic technology policies

[2] See, for example, Markusen et al. (1995).

[3] Brander (1996) provides an overview of this literature.

[4] Other issues, which have also received attention in the literature are, general equilibrium effects, the question of whether the government can really commit to actions when firms cannot, and the risk for trade wars between governments. See, for example, Helpman and Krugman (1989), Laussel and Montet (1994) and Leahy and Neary (1996).

[5] The model in Mezetti and Dinopoulos (1991) is discussed in chapter three.

in this literature. These two chapters investigate how mobile production affects the government's incentive to support domestic firms through R&D subsidies.

1.1.2 Multinational firms

Earlier literature on multinational firms has been synthesized into a common framework by Dunning (1977, 1981), known as the OLI-framework, dividing the advantages of a multinational firm versus other types of firms into three categories: (i) Ownership advantages, (ii) location advantages and (iii) internalization advantages[6].

As these advantages play an essential part in three of the essays, I will review them more closely.

- *Ownership advantages* refer to ownership of assets, which enables these firms to sell on a foreign market. This could be a blue-print, a production process or a trade-mark, for example. The distinguishing features of such assets are that (i) they are firm-specific, thus giving the firm a competitive edge against other firms, but (ii) they also act as joint inputs within the firm. The second property is of great importance, for it implies that the services of these assets can be put to use in additional plants at zero or low costs.

- *Location advantages* explain why these firms can separate their production into plants located in different countries. The obvious reasons for the location advantages are transportation costs, tariffs and differences in production costs across countries.

- Finally, the *Internalization advantages* of the firms relate to factors explaining why these firms choose to exploit their firm-specific assets internally, when a foreign market is penetrated, and not by licensing or selling the assets. Examples of such factors are the non-excludability of the knowledge embedded in these assets, and asymmetric information between the buyer and the seller of such assets.[7]

The OLI-framework has been integrated into the imperfect competition models used within the new trade theory. The main contributions include Markusen (1984), Helpman (1984, 1985), Brainard (1993), Horstmann and Markusen (1992) who incorporate ownership advantages and location advantages, and Ethier (1986) and Ethier and Markusen (1996) who - in

[6] For an overview of the earlier literature, see Ekholm (1995) and Caves (1996).

[7] A firm wishing to license a production process, say, must convince a potential licensee of the merits connected to this process, since only the licensor knows its true value. But this might lead to the knowledge embedded in the process being dissipated to the licensee. For such reasons, the market for knowledge is prone to failures.

addition to ownership and location advantages - also investigate motives for internalization.

Chapter 3, *Multinational firms, technology and location,* examines a model combining ownership advantages and location advantages. The question asked is how a firm's choice between supplying a foreign market through exports or local production interacts with the development of its technology. That is, I try to model how a firm's ownership advantages interact with location advantages. I also provide empirical tests of the predictions of the theoretical analysis, by using data on Swedish multinationals provided by the Research Institute of Industrial Economics (IUI) in Sweden.

1.1.3 Agglomeration economies

The latest branch of the new trade theory is what could broadly be perceived as the literature of trade and geography. Even though some of the ideas are quite old, this line of research was initiated by Krugman (1991). The use of this type of models has then expanded into a wide range of fields in economics.[8]

A central concept used in this literature is complementarities. In the words of Matsuyama (1993), complementarities arise when the actions of two activities reinforce each other. When introduced into economic systems, pecuniary externalities (the type of complementarity studied here) may create circular, cumulative agglomeration processes, which, in turn, might give rise to multiple equilibria. In the models used within the new trade theory, such agglomeration phenomena are likely to occur due to the interaction of trade costs and scale economies.

The multiplicity of equilibria makes this type of model particularly advantageous, when issues of under-development are investigated. In the final chapter, *Cumulative effects of labor market distortions in a developing country,* I investigate a model where pecuniary externalities, created by vertical linkages between an upstream and a downstream industry, interact with labor market distortions. The question in this essay is whether labor market distortions can contribute to keeping the economy in a low-level equilibrium and, if so, how government policy may be used to shift the economy to the high-level, industrialized equilibrium.

[8] For example, the concept of cumulative causation and its impact on growth and development builds on previous ideas in Development Economics, such as Myrdal (1957) and Rosenstein-Rodan (1943). The new models provide a way of formalizing and analyzing these issues.

1.2 Summary of the main findings

In chapter two, *Subsidizing away exports? - A note on strategic trade policy,* I use the work-horse of the strategic trade policy literature, that is, the Brander-Spencer (1983, 1985) model, where two firms - a home-based firm and a foreign-based firm - compete in exports on a third country's market. This model is then expanded to allow for direct investment, by assuming that the home firm does not only have the export alternative, but also the alternative to produce locally, by incurring an extra fixed cost. The purpose of this exercise is to see how the arguments for R&D subsidies are altered, when the assumption of an exogenous production structure is removed.

The standard result in the Brander-Spencer model shows that by reducing the home firm's costs through productivity-improving R&D subsidies, the home government enables the home firm to credibly commit to a larger production volume, thereby reducing the output of its foreign competitor.

In comparison, chapter two shows that R&D subsidies indeed work towards increasing the market share of the home firm, while decreasing the market share of the foreign firm - as predicted. However, these subsidies may have the surprising side-effect that the home firm also decides to shift from export production to local production.

This result arises because local production always exceeds export production, due to a transport cost which can be avoided by direct investment. As the firm's technology is applicable to both export production and local production, however, a subsidy-induced decrease in the home firm's marginal cost favors direct investment on the margin, for (i) the cost-reduction affects more units in local production, and (ii) the price increase associated with the cut-back of the foreign firm's export production also affects more units, if local production is chosen. Hence, even though the R&D subsidy increases the market-share for the home firm - exports may drop to zero!

In chapter three, *Strategic technology policy in a model with international competition, domestic unionization and multinational firms*, I use the same direct investment-augmented Brander-Spencer model dealt with in chapter two, with the difference that labor can now respond to the threat of a shift from export production to production abroad. This approach is based on Mezetti and Dinopoulos (1991).

It assumed that labor and capital share the rents captured on the market, and that the division of these rents is accomplished by efficient bargaining between the management and a labor union. If a conflict develops, the home firm has the capacity to shift from domestic export production to local production.

It now turns out that R&D subsidies, which increase productivity, give the home firm a two-fold benefit: (i) Higher productivity enables the home firm to commit to higher export production, thereby reducing the foreign firm's exports - once more, this is the *standard* rent-shifting effect at work. (ii) The home firm's position on the labor market is also strengthened.

The latter effect is due to the firm's ownership advantage of its technology: As the technology is also applicable to local production, the home firm's threat-point (or its profit during a conflict) in the bargaining with the union also increases.

When assessing the welfare effects of an R&D subsidy to the home firm, the following emerges: If the union emphasizes wages rather than employment, the home firm's exports, market share and domestic welfare unambiguously increase. On the other hand, if the union emphasizes employment rather than wages, the effects on exports, the market share or welfare, cannot be signed.

These different results depend on the way in which the firm uses its improved bargaining position: In the former case, it is used with a bias towards reducing the union wage, which tends to further increase output. In the latter case, it is used with a bias towards reducing employment and, hence, production. Part of the commitment effect of the subsidy is then lost, as foreign exports increase in response to the decrease in home exports. Accordingly, the argument for using strategic R&D subsidies hinges critically on the shape of the union's preferences.

In chapter three, *Multinational firms, technology and location,* the normative issues are excluded. Instead, the model encountered in the first two chapters is generalized into a full three-stage game where both firms choose (i) their respective technology, by deciding a level of R&D, (ii) whether this technology is to be used in a domestic or a local plant and, finally, (iii) the quantity produced and sold on the market.[9]

The purpose here is to first model how a firm's technology choice interacts with the way in which a foreign market is served, and then to test the predictions emerging from this theoretical exercise empirically. This will give valuable insights into the interaction of ownership advantages and location advantages.

The theoretical results show that the relationship between technology and location hinges critically on how the costs of transferring technology from domestic R&D labs to affiliates are defined.

On the one hand, if such transfer cost are truly fixed, in the sense that they are independent of the R&D efforts, "high-tech" firms prefer direct investment and produce abroad. The mechanism driving this result is that savings on trade costs generate an additional incentive to increase R&D efforts, as sales increase. This, in turn, increases the wedge in unit costs between export and affiliate production.

On the other hand, if transfer costs of technology are dependent on the degree of sophistication of the firm's technology, and accordingly, the in-

[9]This paper builds on Leahy and Neary (1996), who include stages (i) and (iii), but not stage (ii). In contrast to the present paper, the market structure is, accordingly, not endogenous. Leahy and Neary provide a computational innovation, which considerably simplifies the solution to this type of model.

crease in R&D efforts, the prediction is reversed and the "high-tech firms" tend to choose export production rather than affiliate production. The intuition for this reversal is simply that when transfer costs are related to R&D, increasing the level of R&D is, in itself, a reason for maintaining production in the home country.

The empirical part of the paper shows that within a sample of Swedish multinational firms for which data have been collected by the Research Institute of Industrial Economics (IUI), the estimation results seem consistent with the latter view.[10] Using a two-stage estimation procedure, the empirical analysis produces a persistent negative correlation between R&D intensity and both the affiliate share of foreign sales (the sum of exports and affiliate sales) and the probability that any affiliate sales are recorded. These results also seem consistent with findings in US industrial data (see e.g. Lall, 1980 and, to some extent, Brainard, 1997).

While the first three chapters in this dissertation all build on models of international oligopolies, the final chapter, *Cumulative effects of labor market distortions in a developing country,* is based on a somewhat different theoretical framework. The paper, which originates in Venables (1996), discusses how labor market distortions may have such strong effects that they act as an impediment to development. This is done by using a model where agglomeration economies arise.

A small open economy is considered, where an input-output industrial structure, scale economies and imperfect competition, create vertical linkages and multiple equilibria. In this environment, I introduce an imperfect labor market by assuming labor in the downstream industry to be unionized.

It is then shown that if the vertical linkages are sufficiently strong, a reform of the labor market, which weakens the unions, may trigger a large, discontinuous expansion of industrial output. This process works through the "positive feedbacks" inherent in this type of economy. As the final good producers increase production in response to decreased wage costs, upstream producers benefit through a stronger demand for inputs. This permits the entry of additional upstream firms, and further reduces production costs for final good producers, through a more efficient use of intermediate inputs.

While it is shown that a deregulation may have considerable effects on industrial production, there are also circumstances when flexible labor markets are not sufficient, and not even necessary, for industrial take-off. What seems to be important is that a number of factors jointly push the economy over the edge to industrialization. Constituting such a force, flexible labor markets can then be of importance.

[10] For a description of the IUI database, see Braunerhjelm and Ekholm (1998) .

1.3 REFERENCES

Brainard, S.L. A simple theory of multinational corporations and trade with a trade-off between proximity and concentration. NBER Working Paper No. 4269, 1993.

Brainard, S.L. "An empirical assessment of the proximity-concentration trade-off between multinational sales and trade". *American Economic Review*, 87:520–544, 1997.

Brander, J.A. Strategic trade policy. NBER Working Paper No. 5020, 1995.

Brander, J.A. and B.J. Spencer. "International R&D rivalry and industrial strategy". *Review of Economic Studies*, 50:707–722, 1983.

Brander, J.A. and B.J. Spencer. "Export subsidies and market share rivalry". *Journal of International Economics*, 18:83–100, 1985.

Braunerhjelm, P. and K. Ekholm, editors. *The Geography of Multinational Firms*. Boston: Kluwer Academic Publishers, 1998.

Caves, R.E. *Multinational Enterprise and Economic Analysis*. Cambridge and New York: Cambridge University Press, 2nd edition, 1996.

Dick, A. "Strategic trade policy and welfare: The empirical consequences of cross-ownership". *Journal of International Economics*, 35:227–249, 1993.

Dixit, A.K. and V. Norman. *Theory of International Trade*. Cambridge: Cambridge University Press, 1980.

Dunning, J.H. "Trade, location of economic activities and the MNE: A search for an eclectic approach". In P.-O. Hesselborn, B. Ohlin and P.-M. Wijkman, editors, *The International Allocation of Economic Activity*, pages 395–418. London: MacMillan, 1977.

Dunning, J.H. *International Production and the Multinational Enterprise*. London: George Allen and Unwin, 1981.

Ekholm, K. *Multinational Production and Trade in Technological Knowledge*. PhD thesis, University of Lund, 1995. Lund Economic Studies No. 58.

Ethier, W.J. "The multinational firm". *Quarterly Journal of Economics*, 101:806–33, 1986.

Ethier, W.J. and J.R. Markusen. "Multinational firms, technology diffusion, and trade". *Journal of International Economics*, 41:1–28, 1996.

Helpman, E. "A simple theory of international trade with multinational corporations". *Journal of Political Economy*, 92:451–471, 1984.

Helpman, E. "Multinational corporations and trade structure". *Review of Economic Studies*, 52:443–57, 1985.

Helpman, E. and P.R. Krugman. *Market Structure and Foreign Trade.* Cambridge, MA: MIT Press, 1985.

Helpman, E. and P.R. Krugman. *Trade Policy and Market Structure.* Cambridge, MA: MIT Press, 1989.

Horstmann, I. and J.R. Markusen. "Endogenous market structures in international trade (*natura facit saltum*)". *Journal of International Economics*, 32:109–129, 1992.

Krugman, P.R. "Scale economies, product differentiation and the pattern of trade". *American Economic Review*, 70:950–59, 1980.

Krugman, P.R. *Geography and Trade.* Cambridge, MA and Leuven: MIT and Leuven University Press, 1991.

Lall, S. "Monopolistic advantages and foreign involvement by U.S. manufacturing industry". *Oxford Economic Papers*, 32:105–122, 1980.

Lancaster, K. *"Variety, Equity, and Efficiency".* Columbia University Press, New York, 1979.

Laussel, D. and C. Montet. "Strategic trade policies". In Greenaway, D. and A. Winters, editors, *Surveys in International Trade*, pages 177–206. Blackwell Publishers, Oxford UK and Cambridge USA, 1994.

Leahy, D. and P. Neary. "International R&D rivalry and industrial strategy without government commitment". *Review of International Economics*, 4:322–338, 1996.

Markusen, J. R., J. R. Melvin, W. H. Kaempfer and K. E. Maskus. *International Trade Theory and Evidence.* McGraw-Hill, Inc, 1995.

Markusen, J.R. "Multinationals, multi-plant economies, and the gains from trade". *Journal of International Economics*, 16:205–26, 1984.

Markusen, J.R. and A.J. Venables. "Multinational firms and the new trade theory". *Journal of International Economics*, 1998. Forthcoming.

Matsuyama, K. Modelling complementarity in monopolistic competition. IIES Seminar Paper No. 534, Institute for International Economic Studies, Stockholm, 1993.

Mezetti, C. and E. Dinopoulos. "Domestic unionization and imperfect competition". *International Journal of Economics*, 31:79–100, 1991.

Myrdal, G. *Economic Theory and Underdeveloped Regions.* London: Methuen, 1957.

Rosenstein-Rodan. "Problems of industrialization of Eastern Europe and South-Eastern Europe". *Economic Journal*, 53:202–211, 1943.

Venables, A. "Trade policy, cumulative causation and industrial development". *Journal of Development Economics*, 49:179–197, 1996.

2

Subsidizing away exports: A note on strategic trade policy

2.1 Introduction

In recent years, there has been much debate over so-called strategic trade policy. The basic insight emerging from this literature, is that the strategic interaction between firms in international oligopolistic markets, can be modified by governments. As a result, the economic rents captured by domestic firms are increased, at the expense of foreign firms.

Brander and Spencer (1983) formally show how R&D subsidies can be used for such purposes. In their model, two firms - a domestic firm and a foreign firm - are engaged in Cournot-competition on a third country's market. The domestic and the foreign firm produce for exports only and the third country exclusively imports the good. By granting subsidies to R&D in the domestic firm, thereby lowering its marginal cost, this firm can credibly commit to acting more aggressively in the export game which, in turn, induces the foreign firm to decrease its exports.

However, as has been pointed out by Markusen (1995), the above Brander-Spencer argument simply assumes an exogenous production structure - export production is always attached to a domestic plant. Assuming that the market structure is not exogenous, I will show that R&D subsidies can, in fact, induce the domestic firm to locate all production in a local factory on the third market. A subsidy may then have the completely opposite effect; *exports may decrease, not increase.*

In the model, the domestic firm is assumed to face the discrete choice of either building a domestic plant and export, or to direct invest and supply the market from an affiliate. Both alternatives incur a constant marginal cost in production c, whereas exports incur an additional transport cost t per unit. Thus, variable profits must always be higher in affiliate production than in export production. This bias towards using the affiliate is assumed to be counterbalanced by a higher fixed cost.

It can now be shown that an R&D subsidy may tip the balance in favor of affiliate production, since technology has the character of a joint input or a public good within the firm. Hence, R&D subsidies have the interesting effect of improving the firm's production technology, irrespective of the plant location, thereby lowering the marginal cost in both alternatives.[1] However, affiliate production benefits more from improvements in technology than export production, for; (i) affiliate production outweighs export production due to transport costs, and cost savings thus affect a larger number of units; and (ii) at a lower marginal cost, the home firm can credibly commit to producing a larger output, thus inducing the foreign firm to reduce its exports. As this contraction leads to a higher market price, the price increase benefits a larger production volume in affiliate production.

This conclusion is based on some strong assumptions: Only the home firm chooses its location, the foreign firm always exports. The firms' technologies are exogenously fixed; it is simply assumed that the home government can affect the home firm's technology through the R&D subsidy. The foreign government is a passive observer of events. Moreover, the shape of the demand function may introduce ambiguities. If the demand function is linear, or approximately linear, the results hold. For a strong non-linear demand, the direct effect still works toward affiliate production, whereas the strategic effect cannot be signed.

Nevertheless, this does not invalidate the point made in this paper, that is, the fact that I provide an example where the effects of strategic trade policy arguments for R&D subsidies may be the opposite to what is anticipated. Accordingly, this paper contributes to examining the robustness of the arguments behind the use of strategic trade policy. Dick (1993), investigating the consequences of foreign ownership, Horstmann and Markusen (1992) and Smith (1987) examining tariffs and Flam (1994), studying voluntary export restraints, are other papers with similar aims.

The paper is organized as follows. Section 2.2 outlines the model and section 2.3 investigates how a domestic R&D subsidy affects the equilibrium. Section 2.4 summarizes and concludes.

2.2 The model

Consider an international industry with two firms producing a homogeneous good. Firm 1 is a home-country firm, firm 2 originates from a second country which we will refer to as "foreign". The two firms compete on a third country's market, where all demand is located.

The sequence of events is as follows. In the first period, the home government can issue a subsidy to the home firm, which enables this firm to lower its marginal cost.[2] In the second period, the home firm implements

[1] Ownership advantages, that is, know-how of a production process or a trade mark, for example, is one of the three pillars of the so-called OLI-framework, synthesizing the advantages of multinational firms. See Dunning (1977), Caves (1996) and Markusen (1995).

[2] Even though R&D is here modeled as "process R&D", this framework may still be

its technology either in export production from a domestic factory (henceforth denoted N), or it direct invests and produces in an affiliate in the third country (henceforth denoted M). The foreign firm is assumed not to have this choice. Finally, we assume that firms act as Cournot competitors when market interaction occurs at the end of period two.

The notation is as follows; q_h^i is the output choice of firm h in market structure i, for $h = \{1, 2\}$ and $i = \{N, M\}$. For example, q_1^N is then the home firm's export quantity, and q_1^M the production quantity of the home firm's affiliate. q_2^N and q_2^M are the foreign firm's export choices under these two regimes.

Turning to production costs, it will be assumed that establishing production or implementing the firm's technology in the third country is more expensive than taking the same measures for export production in a domestic plant. This might be due to a technology transfer cost, or to the fact that pre-existing domestic production facilities can more easily be modified for new production. Hence, $G^M > G^N$.

Furthermore, the marginal cost in production for each firm in market structure i, are given in (2.1) and (2.2):

$$c_1^M = c(\phi) \qquad c_1^N = c(\phi) + t \qquad c'(\phi) < 0 \tag{2.1}$$
$$c_2^N = c + t \tag{2.2}$$

Several factors affect production costs. Export production is subject to a transport cost or a tariff barrier, t, which can be avoided by direct investment. In (2.1), the marginal cost can be affected by the government through an R&D subsidy, which improves the domestic firm's technology (through an increased ϕ), and reduces its marginal cost. Note that such a subsidy reduces the home firm's marginal cost, irrespective of the plant location.

For market structure i, total profits in each firm are given in (2.3) and (2.4):

$$\Pi_1^i(q_1^i, q_2^i) = \left[P(q_1^i + q_2^i) - c_1^i\right] q_1^i - G^i \tag{2.3}$$
$$\Pi_2^i(q_1^i, q_2^i) = \left[P(q_1^i + q_2^i) - c_2^i\right] q_2^i - G^N \tag{2.4}$$

where Π_j^i for $j = \{1, 2\}$ indicates the home (foreign) firm's total profits, marginal cost are given by (2.1) and (2.2), and a concave demand, $P'(q_1^i + q_2^i) < 0$ and $P''(q_1^i + q_2^i) \leq 0$, is assumed.

The first-order conditions in the output game are:

$$\Pi_{1,1}^i = P(q_1^i + q_2^i) + P'(q_1^i + q_2^i)q_1^i - c_1^i = 0 \tag{2.5}$$
$$\Pi_{2,2}^i = P(q_1^i + q_2^i) + P'(q_1^i + q_2^i)q_2^i - c_2^i = 0 \tag{2.6}$$

valid for "product R&D", if one considers products as delivering services to consumers. If the development of new goods makes such services less costly, this has the same effect as a pure cost-reduction in production. See Spence (1984) for a formal argument.

where $\Pi^i_{1,1} = \frac{\partial \Pi^i_1}{\partial q^i_1}$ and $\Pi^i_{2,2} = \frac{\partial \Pi^i_2}{\partial q^i_2}$ is an abbreviation of first-order derivatives. It will be convenient to calculate the effect on outputs q^i_h from a subsidy-induced improvement in the home firm's technology, ϕ. Following Brander (1995) and thus, totally differentiating the above system of first-order conditions, we can write:

$$\Pi^i_{1,11} dq^i_1 + \Pi^i_{1,12} dq^i_2 + \Pi^i_{1,1\phi} d\phi = 0 \tag{2.7}$$

$$\Pi^i_{2,21} dq^i_1 + \Pi^i_{2,22} dq^i_2 + \Pi^i_{2,2\phi} d\phi = 0 \tag{2.8}$$

where $\Pi^i_{j,hh}$ for $h = \{1,2\}$ is an abbreviation of second-order derivatives. For example, $\Pi^N_{1,11}$ is the change in the domestic firm's marginal profits $\Pi^N_{1,1}$, due to a small increase in its export sales. From the first-order conditions, it is obvious that $\Pi^i_{2,2\phi} = 0$, since only a domestic R&D subsidy is investigated. Using this information, we can solve for $\frac{dq^i_1}{d\phi}$ and $\frac{dq^i_2}{d\phi}$. These are:

$$\frac{dq^i_1}{d\phi} = -\frac{\Pi^i_{1,1\phi}\Pi^i_{2,22}}{D^i} > 0 \tag{2.9}$$

$$\frac{dq^i_2}{d\phi} = \frac{\Pi^i_{1,1\phi}\Pi^i_{2,21}}{D^i} < 0 \tag{2.10}$$

where $\Pi^i_{1,1\phi} = -c'_1(\phi) > 0$, $\Pi^i_{2,22} = 2P' + P'' q^i_2$, $\Pi^i_{2,21} = P' + P'' q^i_2$ and the determinant D^i can be written:

$$\begin{aligned} D^i &= \Pi^i_{1,11}\Pi^i_{2,22} - \Pi^i_{1,12}\Pi^i_{2,21} \\ &= P' \left\{3P' + P'' \left[q^i_1 + q^i_2\right]\right\} > 0 \end{aligned}$$

2.3 Implementing the subsidy

To determine the effect of an R&D subsidy on the home firm's location decision in period two, it suffices to compare total profits in the available alternatives and then see how a slight decrease in the home firm's marginal cost affects these profits.

For this purpose, we define the value function $\Delta\Pi(q^i_1(\phi), q^i_2(\phi), \phi)$ as the difference between total profits in affiliate and export production:

$$\Delta\Pi(q^i_1(\phi), q^i_2(\phi), \phi) = \Pi^M_1(q^M_1(\phi), q^M_2(\phi), \phi) - \Pi^N_1(q^N_1(\phi), q^N_2(\phi), \phi) \tag{2.11}$$

The total derivative of this function, with respect to ϕ, yields (2.12):

$$\frac{d\,\Delta\,\Pi}{d\phi} = \left[\Pi^M_{1,1}\frac{dq^M_1}{d\phi} - \Pi^N_{1,1}\frac{dq^N_1}{d\phi}\right] + \left[\Pi^M_{1,2}\frac{dq^M_2}{d\phi} - \Pi^N_{1,2}\frac{dq^N_2}{d\phi}\right] + \left[\Pi^M_{1,\phi} - \Pi^N_{1,\phi}\right] \tag{2.12}$$

There are three distinct terms in (2.12); the indirect effect, the strategic effect and the direct effect of the subsidy.[3] Note that due to the envelope theorem, the first term (the indirect effect), cancels. What can then be said about the sign of (2.12)? There are two cases; linear and non-linear demand.

2.3.1 Linear demand

In this case, we have the following proposition and its corollary.

Proposition 1 *If the demand is linear, then an R&D subsidy that improves the home firm's technology by lowering its marginal cost, tends to induce the home firm to choose affiliate production rather than export production.*

Proof. In this case, we have $P''(\cdot) = 0$. Using (2.3), (2.5) and (2.10), (2.12) simplifies to (2.13):

$$\frac{d \triangle \Pi}{d\phi} = -\frac{c'(\phi)}{3P'} P' \left[q_1^M - q_1^N\right] - c'(\phi) \left[q_1^M - q_1^N\right] > 0 \qquad (2.13)$$

remembering that $c'(\phi) < 0$. ■

Corollary 2 *Assume that $\triangle\Pi < 0$ holds initially, so that export production is chosen. Then introduce the R&D subsidy. This may induce the firm to choose affiliate production.*

Proof. Let $\triangle\Pi < 0$ be small (in absolute value). This will be the case when the larger variable profits in affiliate production do not suffice to cover the larger fixed cost in this alternative. Then, by proposition 1, the subsidy may reverse the sign of $\triangle\Pi$. ■

Proposition 1 and Corollary 2 then show that R&D subsidies may induce the home firm to abandon domestic production and locate all production in the third country.

What is the intuition? *First*, affiliate production must exceed export production, due to the transport cost ($q_1^M > q_1^N$). Even though the marginal cost is reduced by the same amount for a unit of exports as for a unit of affiliate production, the cost reduction ($c'(\phi) < 0$) affects a larger number of units in the latter case. Thus, the last term in (2.13), that is, the direct effect, must be positive. *Second*, when the home firm's marginal cost decreases, it can credibly commit to a higher production volume. As indicated by the term $-\frac{c'(\phi)}{3P'} < 0$, the foreign firm's response is to reduce its production in order to prevent a fall in the market price. But contracting foreign

[3] See Tirole (1988).

exports increases the market price, and this price effect, $-\frac{c'(\phi)}{3P'}P' > 0$, involves a larger production volume, if affiliate production is chosen. Hence, also the first term in (2.13), or the strategic effect, must be positive.

2.3.2 Non-linear demand

In this case, once more using (2.3), (2.5) and (2.10), and introducing the elasticities $\varepsilon_2^i = \frac{P''(q_1^i+q_2^i)}{P'(q_1^i+q_2^i)}q_2^i$ and $\varepsilon_q^i = \frac{P''(q_1^i+q_2^i)}{P'(q_1^i+q_2^i)}\left[q_1^i + q_2^i\right]$ as a measure of the curvature of the inverse demand function $P(\cdot)$, we can rewrite (2.12) as:

$$\frac{d\triangle\Pi}{d\phi} = -c'(\phi)\left[q_1^M\frac{1+\varepsilon_2^M}{3+2\varepsilon_q^M} - q_1^N\frac{1+\varepsilon_2^N}{3+2\varepsilon_q^N}\right] - c'(\phi)\left[q_1^M - q_1^N\right] \quad (2.14)$$

The direct effect is not affected by the shape of the inverse demand function - a lower marginal cost on a larger volume still benefits affiliate production more, so that the second term is, again, positive. The strategic effect is more complicated in this case, however. If $P(\cdot)$ is not too concave, in the sense that the elasticities are small, $\frac{d\triangle\Pi}{d\phi} > 0$ still holds. But if $P(\cdot)$ has a strong curvature, we cannot tell which case - affiliate or export production - will yield the strongest effect of the contraction of the foreign firm's exports.[4] This is due to the fact that the elasticities in (2.14) should be evaluated on different parts of the inverse demand curve $P(\cdot)$, as the total amount sold on the market is discretely dependent on the market regime i. Since the strategic effect cannot be signed, the total effect is ambiguous.[5]

2.4 Conclusions and discussion

Using an international Cournot model, this short paper has given an example where industrial policies with rent-shifting motives generate a somewhat surprising result. While increasing the home firm's market share at the expense of foreign competitors, R&D subsidies may transfer production from the home country to an affiliate in the host country.

[4] The intuition seems to be the following: It is still the case that a given price increase affects more units if affiliate production is chosen (that is, $q_1^M > q_1^N$). However, it is hard to establish in which case the foreign firm decreases its output the most, and, in turn, in which case the market price increases the most (that is, $-c'(\phi)\frac{1+\varepsilon_2^N}{3+2\varepsilon_q^N} \lessgtr -c'(\phi)\frac{1+\varepsilon_2^M}{3+2\varepsilon_q^M}$).

[5] This problem indeed exists in most models involving multinational firms. Since discrete changes are encountered, simulation practices are often used. For a class of such models, including general equilibrium effects, see Markusen and Venables (1998).

What policy conclusions can then be drawn from this exercise? If the home firm's profit is used as a welfare measure, which is the normal case in this literature, moving production abroad increases profits, and hence, welfare. If pure rents are our metric, the fact that production is moved abroad should be of no concern.[6]

Several remarks could, however, be made on this assessment. First, as suggested by the new growth theory, the production of certain goods may have its own value if external economies or spillovers are associated with such production. This feature has been used as an argument in favor of strategic trade policy (see Brander, 1995). Clearly, the loss of such production may then have negative effects.

Another issue is whether the rents captured on foreign markets are repatriated in the same way as if export production was chosen. If this is not the case, lower tax-revenues may increase the costs of the subsidy policy in addition to the actual subsidies.

If employment is scarce, maintaining production may be important, at least in a political sense. Furthermore, as shown in Norbäck (1998), even if production, in equilibrium, remains in the home country, the political economy context can be altered[7]. The possibility that production may be located abroad extends the effects of the subsidy policy beyond the product market to also include the labor market, by shifting the relative bargaining positions of the domestic firm and its unionized labor in favor of the firm.[8]

In these respects, it is interesting to give the example of Sweden, where a generous public policy towards R&D - in subsides or tax deductions - has mainly benefitted Sweden's large multinational firms, which dominate the Swedish industry (Davis and Henrekson, 1997). Observers are now beginning to take a more sceptical view of government policies targeting these large international firms (Kokko and Blomström, 1995). This change of views has taken place while both Swedish unemployment and Swedish MNCs overseas operations have been increasing rapidly.

2.5 References

Blomström, B and A. Kokko. "Foreign direct investment and politics: The Swedish model". Working Paper No. 66, Stockholm School of Economics, 1995.

Brander, J.A. Strategic trade policy. NBER Working Paper No. 5020, 1995.

[6]In addition, the loss of exports of final goods may, to some extent, be compensated for by exports of input goods.

[7]See chapter three.

[8]When the improved technology can be used abroad, the profits associated with such production increase. In turn, the firm would then recieve a higher pay-off during a conflict.

Brander, J.A. and B.J. Spencer. "International R&D rivalry and industrial strategy". *Review of Economic Studies*, 50:707–722, 1983.

Caves, R.E. *Multinational Enterprise and Economic Analysis.* Cambridge and New York: Cambridge University Press, 2nd edition, 1996.

Davis, S and M. Henrekson. "Industrial policy, employer size and economic performance in Sweden: An exploratory empirical analysis". In Topel R. Freeman, R. B and B. Swedenborg, editors, *The Welfare State in Transition Reforming the Swedish Model*, pages 353–398. Chicago: University of Chicago Press, Chicago and London, 1997.

Dick, A. "Strategic trade policy and welfare: The empirical consequences of cross-ownership". *Journal of International Economics*, 35:227–249, 1993.

Dunning, J.H. "Trade, location of economic activities and the MNE: A search for an eclectic approach". In P.-O. Hesselborn, B. Ohlin and P.-M. Wijkman, editors, *The International Allocation of Economic Activity*, pages 395–418. London: MacMillan, 1977.

Flam, H. "EC members fighting about surplus: VERs, FDI and Japanese cars". *Journal of International Economics*, 36:117–131, 1994.

Horstmann, I. and J.R. Markusen. "Endogenous market structures in international trade (*natura facit saltum*)". *Journal of International Economics*, 32:109–129, 1992.

Markusen, J.R. "The boundaries of multinational enterprises and the theory of international trade". *Journal of Economic Perspectives*, 9:169–89, 1995.

Markusen, J.R. and A.J. Venables. "Multinational firms and the new trade theory". *Journal of International Economics*, 1998. Forthcoming.

Smith, A. "Strategic investment, multinational corporations and trade policy". *European Economic Review*, 31:89–96, 1987.

Spence, A.M. "Cost reductions, competition, and industry performance". *Econometrica*, 52, 1984.

Tirole, J. *The Theory of Industrial Organization.* Cambridge, MA: MIT Press, 1988.

3

Strategic R&D policy, domestic unionization and multinational firms

3.1 Introduction

During the last two decades, trade theorists have been incorporating imperfect competition and strategic interaction into trade theory. The presence of international oligopolistic markets have affected the normative conclusions of the new trade theory, so that these differ a great deal from the free-trade prescription of the traditional, perfect competition framework. The reason for this is that the government can alter the strategic interaction in favor of its domestic firms and - in the process - seize a larger part of the rents on these markets. This is valid, regardless of the size of a country and has proved to be of great interest to governments. From a purely domestic perspective, labor, capital and the government have a common interest and can share the proceeds of such activist policies.

These conclusions have also been subject to strong criticism, however. Determining the specific kind of market interaction between firms is crucial for choosing the appropriate type of policy.[1] A possible retaliation from other governments might, moreover, lead to trade wars.

This paper will focus on how a firm is defined in this literature. As has been pointed out by Markusen (1995), a firm is assumed to be synonymous with a plant producing in the home country, which obviously rules out multinational firms. In reality, however, most international firms - the national champions in the above framework - produce in multiple countries and in certain countries, Sweden for instance, the activities of these firms abroad may, by far, exceed their domestic activities. Therefore, it is very important to examine how the policy conclusions from strategic trade policy are altered, when the assumption of an exogenous production structure

[1] Hence, the practical use of strategic trade policy requires that a great deal of information is gathered by the government and much of the criticism has been directed towards this point. Helpman and Krugman (1989) give an exhaustive description of the limitations of activist policies.

is removed.

The effects of productivity-improving R&D subsidies in a model where the domestic firm may choose where to implement its technology, will be examined. As suggested in the literature on multinational firms, the services of a firm's technology are then considered to be available to all production facilities within a firm - both in the home country and abroad.[2] Since production can also be located abroad, the effects of the subsidy policy are extended beyond the product market to include the labor market, by shifting the relative bargaining positions of the domestic firm and its unionized labor in favor of this firm.

More specifically, two firms - a home firm and a foreign firm - are engaged in export competition to a third country, which exclusively imports the good. To simplify, only the domestic government contemplates granting R&D subsidies, and the labor market interaction is restricted to the home country, where the firm and a union, representing the employees, bargain over wages and employment. The following results arise.

If the union is wage-oriented, that is, if it puts more weight on wages than on employment, an R&D subsidy increases the market share of the home firm; a higher productivity enables the firm to commit to higher export production. This is the standard rent-shifting effect, as shown by Brander and Spencer (1983). But the subsidy also improves the home firm's bargaining position versus the union, as the improved technology also increases its profits, if local production is used. This, in turn, tends to decrease the union's wage demands and increases the home firm's production and market share even further. In this case, domestic welfare, unambiguously, increases. The intuition is simply that the pre-subsidy level of exports is too low from a domestic welfare perspective, since the wage-oriented union will, ex ante, use its bargaining power with a bias toward excess wages.

If the union is employment-oriented, that is, if it puts more weight on employment than on wages, the commitment effect again increases the market share of the home firm. But - in contrast to the previous case - the union will force the home firm to act more aggressively in the export game, which leads to a situation with excessive exports, as compared to a competitive labor market. The home firm will then use its improved bargaining power towards lowering production, which, in turn, has an ambiguous effect on domestic welfare: On the one hand, reducing export towards the point where marginal revenue equals marginal cost, increases welfare. On the other hand, reduced home exports incur increased foreign exports. Hence, by weakening the union, the firm acts less aggressively in the output game, which, in turn, tends to limit the commitment effect of the subsidy. Accordingly, if the union is employment-oriented, the total effect of the subsidy on welfare is ambiguous.

---

[2] See Caves (1996) and Markusen (1995).

In the literature, a few papers have introduced unionized labor in a strategic trade policy framework. For example, Brander and Spencer (1988) show that a decrease in bargaining power for the union increases exports and welfare, whereas Fung (1995) discusses how rent-sharing can have the same effect. Neither of these papers, however, make any references to multinational production.

The set-up in this paper builds on Mezetti and Dinopoulos (1991), who extend the above type of model by using an efficient bargaining process (McDonald and Solow, 1981), thereby showing that the comparative statics results are crucially dependent on union preferences. Mezetti and Dinopoulos also discuss the effects of introducing a credible threat to move production abroad, i.e. they allow for multinational production. In their setting of import competition, the home firm can credibly shift to producing abroad during a strike, and Mezetti and Dinopoulos demonstrate how a tariff on imports then deteriorates the firm's bargaining position with the union.[3]

The present paper describes a similar mechanism. It permits government policy through R&D subsidies to affect and, in fact, reinforce the threat of a shift of production abroad. The contribution is then to demonstrate this effect of R&D subsidies, and the possible consequences in a strategic trade policy context involving labor unions.

The paper is organized as follows: Section 3.2 describes the model and derives the effects of the R&D subsidy on domestic and foreign exports and domestic wages. These results are discussed in section 3.3. Section 3.4 concludes. To make the presentation clearer, most calculations and detailed discussions are provided in appendices.

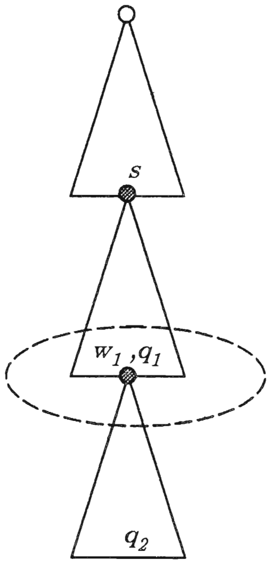
3.2 The model

3.2.1 Structure

This is a version of a so called third-market model.[4] That is, two firms - a home firm and a foreign firm - compete in exports on the market of a third country. No domestic consumption is considered. A special feature of the case considered here is that labor is unionized in the home firm and demands a share of the firm's profits. Furthermore, the home firm is assumed to have access to production facilities in both the home country and the third country, that is, it is a multinational firm. For simplicity, only the home firm has these characteristics; the foreign firm always exports and the labor markets in the foreign country and the third country are both

[3] A tariff will make it more costly for the home firm to supply the home market from abroad, which, in turn, decreases the home firm's threat-point.

[4] For a survey of the different types of models used in the strategic trade policy literature, see Brander (1995).



Stage 1:

Domestic government sets a subsidy s, which is observed by both firms and the union.

Stage 2:

Taking the foreign export as given, the home firm and the union bargain over wage and employment (exports).

Taking the exports of the home firm as given, the foreign firm chooses its exports.

FIGURE 3.1. The structure of the model

competitive.

The game is shown in its "extensive form" in figure 3.1. In the first stage, the domestic government grants an R&D subsidy to the domestic firm, thus improving its productivity. The level of the subsidy is observed, and taken as given, by both firms and the union. In the second stage, the domestic firm and the union bargain over wage and employment, for a given level of foreign exports. With labor as the only factor of production, these negotiations also implicitly determine the domestic firm's exports. In the negotiations, the threat-point of the domestic firm consists of the profit it would make if the third market were supplied from a local plant, i.e. if the bargaining with the union were to break down. Simultaneously, the foreign firm sets its level of exports for a given level of the domestic firm's exports and wages.

"Backward induction" is used for studying the effects of domestic R&D subsidies in this context; we first solve the wage and output game. Then, we let the government increase its subsidy to domestic R&D and infer the effects on output, wages and welfare.

Before going into details, the following convention will be used for notations. Subscripts indicate firm identity. When required, a superscript M will also be used for indicating local production. The absence of superscripts indicates export production. Table 3.1 describes the included variables.

TABLE 3.1. Description of variables

Variable name	*Description*
w_1	wage in the home country paid to union members
$\overline{w}_3$	wage in the third country
$\overline{w}_2$	wage in the foreign country
$\bar{w}_1$	competitive wage in the rest of the home country
q_2	foreign export production to the third country when the home firm exports the good
q_1	domestic export production to the third country
q_1^M	production in the third country by the domestic firm, that is, multinational production
q_2^M	foreign export production to the third country when the domestic firm produces in the third country
k	constant defined in terms of a and γ
a_1	constant defined in terms of a and γ
a_2	constant defined in terms of a and θ
ϕ_1	home firm's productivity
ϕ_2	foreign firm's productivity
θ	excess wage elasticity of the union's utility
γ	employment elasticity of the union's utility
a	measure of the union's bargaining power
s	subsidy to R&D in the domestic firm by the home government
W	measure of domestic welfare. The sum of the home firm's profit and the aggregate wage of all employed union members
$\Psi(\phi_1)$	home firm's "threat-point". Defined as the home firm's reduced-form profit function emerging from multinational production
$P(q_1 + q_2)$	inverse demand for the homogeneous good in the third country

Technology

Both firms use a CRS-technology, with labor as the single input. For the home firm, we have:

$$q_1 = \phi_1 L_1 \tag{3.1}$$

where q_1 is the home firm's export choice, L_1 is the amount of labor employed and $\frac{1}{\phi_1}$ indicates the productivity of labor. Using (3.1), the home firm's cost function is given by (3.2):[5]

$$C_1(w_1, q_1, \phi_1) = \frac{w_1 q_1}{\phi_1} \tag{3.2}$$

Analogously, the cost function for the foreign firm is given by (3.3):

$$C_2(\overline{w}_2, q_2, \phi_2) = \frac{\overline{w}_2 q_2}{\phi_2} \tag{3.3}$$

where q_2 is the export choice of the foreign firm, $\overline{w}_2$ is the exogenous foreign wage and ϕ_2 is the productivity parameter in the foreign firm.

The union

The union is supposed to have preferences over excess wage $(w_1 - \bar{w}_1)$ and unionized employment L_1 of the Stone-Geary type:[6]

$$U(w_1 - \bar{w}_1, L_1) = (w_1 - \bar{w}_1)^{\theta} (L_1)^{\gamma} \tag{3.4}$$

where $\bar{w}_1$ is the outside wage interpreted as the competitive wage paid for employment in the rest of the domestic economy, and where θ and γ are the excess wage and employment elasticities of the utility function. $\theta > 0$ and $\gamma > 0$ then measure the relative importance of excess wages and employment. Below, the union is employment-oriented (Mezetti and Dinopoulos, 1991), if $\theta < \gamma$ and wage-oriented if $\theta > \gamma$. Note that since the home firm uses the CRS-technology (3.1), the union can, in fact, have preferences over excess wages and export production:

$$U(w_1 - \bar{w}_1, q_1) = (w_1 - \bar{w}_1)^{\theta} \left(\frac{q_1}{\phi_1}\right)^{\gamma} \tag{3.5}$$

[5] To simplify, fixed costs and transport costs will be ignored. While such costs are easily included, they are not necessary for the results in this paper.

[6] See McDonald and Solow (1981), and Mezetti and Dinopoulos (1991). Pemberton (1988) derives $U(\cdot)$ as the maximand of a "managerial union", with a leadership interested in size (employment) and union members (i.e the median worker) interested in excess wages. Parameters θ and γ then correspond to the bargaining power of workers and leadership, respectively.

Collective bargaining

Domestic wages and exports are derived, using the generalized Nash bargaining solution (Nash, 1950, 1953). For a given level of the foreign firm's export q_2 and the subsidy s, the outcome of the wage and export (i.e. employment) bargaining can be derived by maximizing the Nash-bargaining product $\mathcal{G}$ in (3.6), with respect to w_1 and q_1.

$$\begin{aligned} \mathcal{G} &= \max_{\{w_1,q_1\}} \left[\Pi_1 - \Pi_1^M\right]^{1-a} \left[U_1 - U_1^M\right]^a \qquad (3.6) \\ s.t &: \Pi_1 = P(q_1 + q_1)q_1 - C_1^N(w_1, q_1, \phi_1) \\ &: \Pi_1^M = \Psi(\phi_1) \\ &: U_1 = U(w_1 - \bar{w}_1, q_1) \qquad U_1^M = 0 \end{aligned}$$

Examining the different terms in the Nash-Bargaining product $\mathcal{G}$ more closely, $a \in [0,1]$ is a measure of the union's relative bargaining power, where $a = 0$ implies a union without bargaining power. Π_1 is the home firm's profit when the market is supplied by exports, where $C_1^N(\cdot)$ is given by (3.2) and $P(\cdot)$ is the inverse demand for the homogeneous good. Π_2^M is the profit of the home firm when production is shifted abroad during a break-down of negotiations, and this is then the domestic firm's threat-point or reservation pay-off. Further comments on this term will be made in the next section. Finally, note that the union's pay-off is given by (3.5), and that the union's threat-point is zero; if outsourcing occurs, no export production takes place and zero union members are employed.

3.2.2 Stage 2 - output and wages

Now turn to stage 2 in figure 3.1. Inserting (3.2) and (3.5) into (3.6), the Nash-Bargaining product can be rewritten as:[7]

$$\mathcal{G} = \left[\left(P(q_1 + q_2) - \frac{w_1}{\phi_1}\right) q_1 - \Psi\right]^{1-a} \left[(w_1 - \bar{w}_1)^\theta \left(\frac{q_1}{\phi_1}\right)^\gamma\right]^a \qquad (3.7)$$

[7]The generalized Nash-Bargaining solution can be derived from a few reasonable axioms but can also be given a microeconomic foundation. Binmore et al. (1986) show that the generalized Nash-Bargaining solution can be obtained as the limit solution of a non-cooperative sequential offer game, when the length of each bargaining round approaches zero.

Following Segendorff (1998) and Binmore et al. (1986), we can then rationalize the use of these reservations pay-offs as follows: The domestic firm and the union know or believe that there exists an exogeneous probability that the negotiations will break down. In that case, outsourcing will occur and the reservation pay-offs will be received. The driving force inducing a settlement is then the parties' fear for a breakdown, which would prevent the exploitation of the gains of co-operation.

The conditions for which this problem is well-posed are discussed in appendices 3.D and 3.E. In the following, we shall assume this to be the case.

Differentiating (3.7) in w_1 and q_1, the first-order conditions are:

$$\frac{a\theta}{w_1 - \bar{w}_1} = \frac{(1-a)\,q_1}{\phi_1\left[\left(P - \frac{w_1}{\phi_1}\right)q_1 - \Psi\right]} \tag{3.8}$$

$$\frac{a\gamma}{q_1} = \frac{(1-a))\left(\frac{w_1}{\phi_1} - P - P'q_1\right)}{\left(P - \frac{w_1}{\phi_1}\right)q_1 - \Psi} \tag{3.9}$$

Dividing and rearranging these expressions result in the contract curve (CC). It shows the locus of all points in the w_1, q_1-space, where the domestic firm's isoprofit curves and the union's indifference curves are tangent to each other:

$$\frac{\gamma}{\theta}\left(w_1 - \bar{w}_1\right) = w_1 - \phi_1\left(P + P'q_1\right) \tag{3.10}$$

Rearranging (3.9) yields the Nash-bargaining curve (NBC):

$$w_1 = \phi_1\left[P + (1-k)\,P'q_1 - \frac{k\Psi}{q_1}\right] \tag{3.11}$$

where the constant k is defined as $k = \frac{a\gamma}{1-a+a\gamma}$ and $k \in [0,1]$, since $a \in [0,1]$. Then, the CC (3.10) and the NBC (3.11) will give the outcome of bargaining over domestic export production, q_1, and domestic wage w_1 for a given level of foreign exports q_2, the R&D subsidy s and the firm's threat-point Ψ. Figures 3.D.2 and 3.D.3 in appendix 3.D illustrate the bargaining outcomes for the two cases of a wage-oriented union and an employment-oriented union.

We can incorporate an equation for q_2, by noting that the foreign firm simultaneously solves:

$$\Pi_2 = \max_{\{q_2\}} \Pi_2 = P(q_1 + q_2)q_2 - C_2(\overline{w}_2, q_2, \phi_2)$$

that is, the foreign firm chooses its exports optimally, *given* its belief in the outcome of the wage and employment (exports) negotiations in the home country. Using (3.3), the first-order condition is:

$$P + P'q_2 = \frac{\overline{w}_2}{\phi_2} \tag{3.12}$$

Then, expressions (3.10), (3.11) and (3.12) define the solutions for q_1, q_2 and w_1 in terms of the parameters of the model, that is, they define the outcome of the game in stage two. We can now proceed to infer the effects of an active domestic industrial policy on these variables, by analyzing an increase in the R&D subsidy to the home firm. In the next section, we thus turn to the decision of the home government in stage 1.

3.2.3 Stage 1 - R&D subsidies to the home firm

Productivity improvements are introduced in the following way. The home firm can produce quantity q_1, according to the constant returns to scale technology $q_1 = \phi_1 L_1$. We assume that a government can increase the firm's productivity ϕ_1, through an R&D subsidy s:

$$\frac{d\phi_1(s)}{ds} > 0 \tag{3.13}$$

This increase in productivity has an interesting effect in this model. Note that since the services of the firm's technology asset are available across the firm's production facilities, the home firm's reservation pay-off in (3.7) can, in fact, be defined as a function of the firm's productivity parameter ϕ_1, $\Pi_1^M = \Psi(\phi_1)$. It is easily shown that this function is also increasing in ϕ_1, $\frac{d\Psi}{d\phi_1} > 0$, which is done in appendix 3.A.

$$\Psi'(\phi_1)\frac{d\phi_1}{ds} > 0 \tag{3.14}$$

Hence, an R&D subsidy will increase the firm's profit when it supplies the market by local production, which means that the firm's threat-point or reservation pay-off is increased.

To derive the effects of an increase in the R&D subsidy to the home firm, we differentiate (3.10), (3.11) and (3.12) in q_1, q_2, w_1 and ϕ_1, taking into account that the government can affect the home firm's productivity ϕ_1 through the subsidy s, as shown in (3.13) and (3.14). A linear inverse demand will be assumed. Then, as is shown in appendix 3.B, we can derive (3.15):

$$\begin{aligned}
\frac{dq_1}{d\phi_1} &= \frac{-\frac{2}{P'}\frac{1}{\phi_1^2}\left\{\frac{\gamma}{\theta}\bar{w}_1 - \left(\frac{\gamma-\theta}{\theta}\right)\frac{\phi_1^2 k\Psi'(\phi_1)}{q_1}\right\}}{D} \\
\frac{dq_2}{d\phi_1} &= \frac{\frac{1}{P'}\frac{1}{\phi_1^2}\left\{\frac{\gamma}{\theta}\bar{w}_1 - \left(\frac{\gamma-\theta}{\theta}\right)\frac{\phi_1^2 k\Psi'(\phi_1)}{q_1}\right\}}{D} \\
\frac{dw_1}{d\phi_1} &= \frac{\frac{A}{\phi_1}\left\{w_1\left(\frac{3-A}{A}\right) + \frac{\gamma}{\theta}\left(w_1 - \bar{w}_1\right)\right\} - \frac{3\phi_1 k\Psi'(\phi_1)}{q_1}}{D}
\end{aligned} \tag{3.15}$$

where $D = 3 + \left(\frac{\gamma}{\theta} - 1\right)A$ and $A = 3 - 2k + \frac{2k\Psi}{P' q_1^2}$. The next task is to interpret these changes.

3.3 Results

First, I will discuss the effects of the R&D subsidy on output and the union wage. Second, I will analyze welfare effects. Both issues will be discussed in terms of the following propositions.

3.3.1 *Domestic exports and wages, foreign exports*

Proposition 3 *When the union has no bargaining power, the effect of an R&D subsidy conforms to the standard strategic trade policy prediction.*

Proof. No bargaining power for the union implies $a = 0$. But then $k = \frac{a\gamma}{1-a+a\gamma} = 0$, so that $A = 3$ and $D = 3\frac{\gamma}{\theta}$. Inserting these into (3.15), and using (3.10) and (3.11), gives: $\frac{dq_1}{d\phi_1} = \frac{-\frac{2}{P'}\frac{1}{\phi_1^2}\frac{\gamma}{\theta}\bar{w}}{D} > 0$, $\frac{dq_2}{d\phi_1} = \frac{\frac{1}{P'}\frac{1}{\phi_1^2}\frac{\gamma}{\theta}\bar{w}}{D} < 0$ and $\frac{dw_1}{d\phi_1} = 0$ ■

Proposition 3 then replicates the result in Brander and Spencer (1983); if the home government subsidizes R&D in the home firm, it can credibly commit to acting more aggressively in the export game and increase its exports which, in turn, induces the foreign firm to decrease its exports. Union members receive only the competitive wage $\bar{w}_1$.

Proposition 4 *Subsidies to R&D that increase the home firm's productivity always affect the home firm's exports and the foreign firm's exports conversely. For example, if a higher productivity in the home firm increases domestic exports, the foreign firm will necessarily decrease its exports. But the opposite also holds.*

Proof. This follows immediately from the symmetry in (3.15). ■

The result in proposition 4 is also the one expected, as the output of the home firm and the foreign firm are strategic substitutes. To illustrate the more interesting mechanisms in the model, we must assume that $D > 0$ always holds in (3.15). As shown in appendix 3.C, this is always true if the union is wage-oriented, $\theta > \gamma$. Although this is also probable in the case of an employment-oriented union, it is very cumbersome to derive the exact conditions.

We can then state the following corollary:

Corollary 5 *The impact of the R&D subsidy through an increase in the home firm's threat-point, will increase domestic exports, if the union is wage-oriented and decrease exports if the union is employment-oriented.*

The impact on the foreign firm is the converse.

Proof. Note the impact of the term $\frac{\phi_1 k \Psi'(\phi_1)}{q_1} > 0$ in (3.15). ■

Having made these observations, let us now review the change in exports in (3.15).

Wage-oriented union

First, note that a wage-orientation implies $\theta > \gamma$. Then, turning to the expression for $\frac{dq_1}{d\phi_1}$ in (3.15), we can see that there is an additional term $-\left(\frac{\gamma-\theta}{\theta}\right)\frac{\phi_1^2 k \Psi'(\phi_1)}{q_1} > 0$, which strengthens the increase in exports above the standard term $\frac{\gamma}{\theta}\bar{w}_1 > 0$, discussed in proposition 3. The opposite holds for the foreign firm's exports.

At first, this result seems somewhat counterintuitive. Why would domestic exports increase further, if the union is wage-oriented? The union should be more likely to try to skim off the subsidy-increased rents by increasing its wage demands, which would tend to intimidate domestic exports.

To see why this is not the case, we must investigate how the subsidy affects the bargaining situation. The R&D subsidy creates an improved technology. Since this technology is both applicable to a home factory and to a factory located in the third country, the subsidy will increase profits in both locations, thereby strengthening the home firm's bargaining position against the union. Since the union is wage-oriented, however, it will use its bargaining power in a biased way towards excess wages rather than towards high employment.[8] The impact of a better bargaining position for the firm will thus weaken the union's ability to obtain excess wages and, the competitiveness of the home firm is, in effect, strengthened in the output-game.

Employment-oriented union

What is the impact of the R&D subsidy, if the union is employment-oriented? Once more examining $\frac{dq_1}{d\phi_1}$ in (3.15), the first term in the bracketed expression is positive, indicating that the standard effect will increase exports. But in this case, the increased bargaining power of the firm tends to lower production, as is shown by the second term. This might seem odd, but the same reasoning applies. An employment-oriented union will use its bargaining power with a bias towards employment. The firm is obliged to

[8] Differentiating (3.10), (3.11) and (3.12) in q_1, q_2, w_1 and $\frac{\gamma}{\theta}$, yields: $\frac{dw_1}{d(\frac{\gamma}{\theta})} = -\frac{(w_1-\bar{w}_1)(3-k)(P')^2}{D} < 0$ and $\frac{dq_1}{d(\frac{\gamma}{\theta})} = -\frac{(w_1-\bar{w}_1)2P'}{D} > 0$. Note that the increasing wage-orientation implies that $\frac{\gamma}{\theta}$ decreases. For an illustration, compare figures 3.D.2 and 3.D.3 in Appendix 3.D.

be more aggressive in the output game than it would be, if facing a competitive labor market, since higher production creates employment for a larger number of union members. However, the increase in the firm's threat-point puts the firm in a stronger position against the union and enables it to lower production, thereby leaving the total effect ambiguous.

3.3.2 Union wage, union utility and profits

After reviewing the effects on output and noting that the subsidy improves the firm's bargaining position, what is then the effect on the actual wage paid to labor in the home firm? To summarize:

Proposition 6 *The effect of the R&D subsidy on the union wage is ambiguous.*

Proof. Follows directly from (3.15). ■

On the one hand, the standard rent-shifting effect tends to increase the wage, which is the first term in the expression for $\frac{dw_1}{d\phi_1}$ in (3.15).[9] On the other hand, the deteriorated bargaining position for the union tends to decrease the union wage, as shown by the second term in the same expression. Hence, the union wage might even decrease. This result is surprising, but arises due to the fact that the subsidy does not only affect the product market, but also the relative strengths of the parties on the labor market.

The ambiguous effects on the union wage makes it difficult to determine the effects on firm profits and union utility. It can be shown that the firm always gains if the union is wage-oriented, but this is not necessarily true if the union is employment-oriented. In the latter case, signing the effect on profits is further complicated by the ambiguity in the change of the home firm's exports. As explained in the previous section, even though the firm enjoys higher productivity, its improved bargaining position paradoxically makes the commitment effect of the subsidy weaker when the union is employment-oriented.

Union utility cannot be signed, whatever the union's preferences: The increased flow of rents towards the home firm benefits the union, at a given union share of these rents. The union's weakened bargaining position tends to decrease this share, however. Finally, due to higher productivity, a smaller number of union members are employed, at a given level of production.

Fortunately, one can be more specific about the welfare effects of the subsidy.

---

[9] $\frac{A}{\phi_1}\left\{w_1\left(\frac{3-A}{A}\right)+\frac{\gamma}{\theta}\left(w_1-\bar{w}_1\right)\right\}$ must be positive since $A=\left(3-2k+\frac{2k\Psi}{P'q_1^2}\right)<3$.

3.3.3 Domestic welfare

We have the following proposition:

Proposition 7 *The home government can increase domestic welfare by R&D subsidies, if the union is wage-oriented.*

Proof. Define domestic welfare as $W = \left[P - \frac{w_1}{\phi_1}\right] q_1 + (w_1 - \bar{w}_1) L_1$, that is, the sum of the home firm's profits and the excess wage earned by all employed union members.[10] By using the production function $q_1 = \phi_1 L_1$, this can be simplified to:

$$W = \left[P - \frac{\bar{w}_1}{\phi_1}\right] q_1 \tag{3.16}$$

Writing (3.16) in a reduced form, $W(q_1(\phi_1), q_2(\phi_1), \phi_1)$, we can compute the total derivative (3.17):

$$\frac{dW}{d\phi_1} = \frac{\partial W}{\partial q_1}\frac{dq_1}{d\phi_1} + \frac{\partial W}{\partial q_2}\frac{dq_2}{d\phi_1} + \frac{\partial W}{\partial \phi_1} \tag{3.17}$$

Then, using (3.16), (3.17) can be written:

$$\frac{dW}{d\phi_1} = \left[P + P'q_1 - \frac{\bar{w}_1}{\phi_1}\right]\frac{dq_1}{d\phi_1} + P'q_1\frac{dq_2}{d\phi_1} + \frac{\bar{w}_1}{\phi_1^2} q_1 \tag{3.18}$$

Using the CC-condition (3.10) to rewrite $P + P'q_1$, and inserting this into (3.18), we finally get (3.19):

$$\frac{dW}{d\phi_1} = \left[\frac{1}{\phi_1}\left(1 - \frac{\gamma}{\theta}\right)(w_1 - \bar{w}_1)\right]\frac{dq_1}{d\phi_1} + P'q_1\frac{dq_2}{d\phi_1} + \frac{\bar{w}_1}{\phi_1^2} q_1 \tag{3.19}$$

Since the union is wage-oriented $\theta > \gamma$, $\frac{1}{\phi_1}\left(1 - \frac{\gamma}{\theta}\right)(w_1 - \bar{w}_1)$ is positive. Furthermore, from (3.15), wage-orientation implies $\frac{dq_1}{d\phi_1} > 0$ and $\frac{dq_2}{d\phi_1} < 0$. Finally, since $P' < 0$, we must have:

$$\frac{dW}{d\phi_1} > 0.$$

■

Welfare unambiguously increases if the union is wage-oriented. But expression (3.19) also shows that the welfare change is ambiguous in the case of an employment-oriented union. To explain this, I will review the two polar cases more closely.

---

[10] Costs of the R&D subsidy can easily be allowed for.

Wage-oriented union

Let us call the three terms in (3.19) - from the left to the right - the *indirect welfare effect*, the *strategic welfare effect* and the *direct welfare effect* of the R&D subsidy.

Start with the *indirect effect*, $\left[\frac{1}{\phi_1}\left(1-\frac{\gamma}{\theta}\right)(w_1-\bar{w}_1)\right]\frac{dq_1}{d\phi_1}$, which contains two distinct terms. First, from (3.15), we know that domestic exports will unambiguously increase in this case, so that $\frac{dq_1}{d\phi_1}>0$. As explained in the previous section, exports will increase for two reasons. (i) Higher productivity in the home firm improved its competitiveness in the Cournot-game. (ii) The bargaining position of the home firm against the union was improved, since the subsidy also increased the profit of the home firm as a multinational and, accordingly, also its threat-point, thus relieving the firm of wage pressure. The second term in the indirect effect, $\frac{1}{\phi_1}\left(1-\frac{\gamma}{\theta}\right)(w_1-\bar{w})$, can be written as (3.20):

$$\frac{\partial W}{\partial q_1}=P+P'q_1-\frac{\bar{w}_1}{\phi_1}=\frac{1}{\phi_1}\left(1-\frac{\gamma}{\theta}\right)(w_1-\bar{w}_1)>0 \tag{3.20}$$

where we recognize $P+P'q_1-\frac{\bar{w}}{\phi_1}$ as the difference in marginal revenue, MR, and marginal cost, MC, in the home firm, when it faces the competitive wage for employed labor.[11]

Note that if $\theta>\gamma$, we must have $MR>MC$ and accordingly, the home firm's export production is too small, compared to the case of a competitive domestic labor market, since exports should be optimally chosen, so that the marginal revenue for an additional unit exactly equals the social marginal cost for this unit. This case is illustrated in figure 3.D.2 in appendix 3.D. Thus, increasing domestic exports should increase welfare (profits), which is exactly what is shown by the first term in (3.19).

Similarly, the *strategic effect* in (3.19), $P'q_1\frac{dq_2}{d\phi_1}>0$, represents the domestic welfare increase, due to the decrease in foreign exports. By proposition 4, we know that if domestic exports increase, foreign exports will necessarily decrease. In fact, we can interpret $P'q_1\frac{dq_2}{d\phi_1}$ as follows: $\frac{dq_2}{d\phi_1}<0$ is the decrease in foreign exports due to the subsidy. This reduced supply of the good implies an increase in the price of $\frac{dq_2}{d\phi_1}P'$, which, in turn, affects the total volume of domestic exports q_1. $P'q_1\frac{dq_2}{d\phi_1}$ then represents subsidy-induced transfers of rents from the foreign firm to the domestic firm. Finally the *direct effect* in (3.19), $\frac{\bar{w}}{\phi_1^2}q_1>0$, represents direct savings in resources required for producing domestic exports.

These three effects indicate that the R&D subsidy must increase domestic welfare, if the union is wage-oriented.

[11] $MC=\frac{\bar{w}_1}{\phi}$, where $\bar{w}_1$ can be considered as the shadow price of labor, since this is the competitive wage-level in the rest of the domestic economy.

Employment-oriented union

Once more, start with the *indirect effect*, $\frac{1}{\phi_1}\left(1-\frac{\gamma}{\theta}\right)(w_1-\bar{w}_1)\frac{dq_1}{d\phi_1}$. Note that if the union is employment-oriented $\theta<\gamma$, the sign of (3.20) is reversed. Hence:

$$\frac{\partial W}{\partial q_1}=P+P'q_1-\frac{\bar{w}_1}{\phi_1}=\frac{1}{\phi_1}\left(1-\frac{\gamma}{\theta}\right)(w_1-\bar{w}_1)<0 \tag{3.21}$$

which implies $MR<MC$. The union then forces the firm to export a higher amount than would be chosen if facing a competitive labor market. This is illustrated in figure 3.D.3 in appendix 3.D. However, in this case, we cannot sign $\frac{dq_1}{d\phi_1}$ in (3.15). On the one hand, the improved competitiveness in the home firm works towards increased exports. One the other hand, the effect of an improved bargaining position of the firm works towards decreased exports, as the union uses its bargaining power with a bias towards employment and thus excess production.

If domestic exports were to decrease, $\frac{1}{\phi_1}\left(1-\frac{\gamma}{\theta}\right)(w_1-\bar{w})\frac{dq_1}{d\phi_1}>0$. The *indirect welfare effect* then increases welfare, since exports are reduced towards a level where the marginal revenue of an additional unit of exports equals its true marginal cost, $MR=MC$. However, from proposition 4, we know that $\frac{dq_1}{d\phi_1}$ and $\frac{dq_2}{d\phi_1}$ always carry different signs, so that a decrease in home exports is accompanied by an increase in foreign exports. Hence, the *strategic effect* will be negative, $P'q_1\frac{dq_2}{d\phi_1}<0$. In this case, the commitment effect of the subsidy is completely off-set by weakening the union.

In fact, the indirect welfare effect and the strategic effect will always carry different signs if the union is employment-oriented. Although the *direct effect* is positive, $\frac{\bar{w}}{\phi_1^2}q_1>0$, it is then impossible to sign the change in welfare.

3.4 Conclusions

In Brander and Spencer (1983), it is shown how a government can use R&D subsidies to increase the market share of domestic firms on international, profitable markets. This result arises since the subsidy increases the productivity in the home firm, thereby enabling it to credibly commit to a larger export volume.

The robustness of this result has been checked, by allowing for multinational production and unionized labor. The analysis then shows that union preferences have a strong influence on the results.

If the union emphasizes wages rather than employment, the home firm's exports, market share and domestic welfare unambiguously increase. Besides the standard commitment effect, the increased market share is also due to the reinforcement of the firm's position on the labor market. The intuition is simply that the firm may shift to local production during a strike. Since productivity improvements can also be implemented in such production, the firm's threat-point (or alternative pay-off) when bargaining with the union also increases, thus inducing the union to moderate its wage demands. Finally, since exports are too low, due to excess wages, an increase in exports must increase welfare.

On the other hand, if the union emphasizes employment rather than wages, neither the effect on exports and the market share, nor the effect on welfare can be signed. This is basically due to the fact that in this case, the union makes the firm produce more than it would, facing a competitive labor market. By weakening the union, the firm acts less aggressively in the output game, and this effect tends to limit the commitment effect of the subsidy.

Hence, the argument for strategic R&D subsidies is strengthened in the presence of a wage-oriented union, but ambiguities arise when the union is employment-oriented. An evaluation of these results obviously hinges on the empirical question of the shape of union preferences.

3.5 References

Binmore, K. and A. Wolinski. "The Nash bargaining solution in economic modelling". *Rand Journal of Economics*, 17, 1986.

Blomström, M. "Competitiveness of firms and countries". *Skandinaviska Enskilda Banken Quarterly Review*, 1-2, 1991.

Blomström, M. and A. Kokko. Multinational corporations and spillovers: A review of the evidence. Mimeo, Stockholm School of Economics, 1995.

Brander, J.A. Strategic trade policy. NBER Working Paper No. 5020, 1995.

Brander, J.A. and B.J. Spencer. "International R&D rivalry and industrial strategy". *Review of Economic Studies*, 50:707–722, 1983.

Brander, J.A. and B.J. Spencer. "Export subsidies and market share rivalry". *Journal of International Economics*, 18:83–100, 1985.

Brander, J.A. and B.J. Spencer. "Unionized oligopoly and international trade policy". *Journal of International Economics*, 24:217–234, 1988.

Caves, R.E. *Multinational Enterprise and Economic Analysis.* Cambridge and New York: Cambridge University Press, 2nd edition, 1996.

Flam, H. "EC members fighting about surplus: VERs, FDI and Japanese cars". *Journal of International Economics*, 36:117–131, 1994.

Fung, K. "Rent shifting and rent sharing: A re-examination of the strategic industrial policy problem". *Canadian Journal of Economics*, 2:451–462, 1995.

Helpman, E. and P.R. Krugman. *Trade Policy and Market Structure.* Cambridge, MA: MIT Press, 1989.

Horstmann, I. and J.R. Markusen. "Endogenous market structures in international trade (*natura facit saltum*)". *Journal of International Economics*, 32:109–129, 1992.

Markusen, J.R. "The boundaries of multinational enterprises and the theory of international trade". *Journal of Economic Perspectives*, 9:169–89, 1995.

Markusen, J.R. and A.J. Venables. "Multinational firms and the new trade theory". *Journal of International Economics*, 1998. Forthcoming.

McDonald, I. and R. Solow. "Wage bargaining and employment". *American Economic Review*, 71:896–908, 1981.

Mezetti, C. and E. Dinopoulos. "Domestic unionization and imperfect competition". *International Journal of Economics*, 31:79–100, 1991.

Nash, J. "The bargaining problem". *Econometrica*, 18:155–162, 1950.

Nash, J. "Two person cooperative games". *Econometrica*, 21:128–140, 1953.

Pemberton, J. "A managerial model of a trade union". *The Economic Journal*, 98:755–771, 1988.

Segendorff, B. *Essays on Bargaining and Delegation.* PhD thesis, Stockholm School of Economics, 1998.

Slaughter, M. Multinational corporations, outsourcing, and American wage divergence. NBER Working Paper No. 5253, 1995.

Smith, A. "Strategic investment, multinational corporations and trade policy". *European Economic Review*, 31:89–96, 1987.

Tirole, J. *The Theory of Industrial Organization.* Cambridge, MA: MIT Press, 1988.

3.A Appendix - The multinational profit function

In this appendix, the home firm's profit during a conflict with the union is derived. This is the firm's threat-point in the bargaining with the union and it will be shown that this threat-point is increasing in the subsidy.

If the home firm serves the market locally, the cost is given by (3.A.1):

$$C_1^M(\bar{w}_3, q_1^M, \phi_1) = \frac{\bar{w}_3 q_1^M}{\phi_1} \tag{3.A.1}$$

where q_1^M is outsourced production and $\bar{w}_3$ is the local wage. Note that ϕ_1 is also present in (3.A.1), indicating the public-good character of the home firm's technology.

Using (3.A.1) and (3.3), we can write the profit functions as:

$$\Pi_1^M = \left(P - \frac{\bar{w}_3 q_1^M}{\phi_1}\right) q_1^M \tag{3.A.2}$$

$$\Pi_2^N = \left(P - \frac{\bar{w}_2 q_2^N}{\phi_2}\right) q_2^N \tag{3.A.3}$$

where Π_1^M (with the superscript M), indicates that local production is chosen by the home firm, whereas Π_2^N indicates that the foreign firm still exports. Having noted this difference, these superscripts will be omitted to keep the presentation clear.

Production quantities are now derived from the following system of first-order conditions, which defines the outcome of the Cournot game, if the negotiations between the domestic firm and the union break down:

$$\Pi_{1,1} = P + P'q_1 - \frac{\overline{w}_3}{\phi_1} = 0 \tag{3.A.4}$$

$$\Pi_{2,2} = P + P'q_2 - \frac{\overline{w}_2}{\phi_2} = 0 \tag{3.A.5}$$

where $\Pi_{1,1} = \frac{\partial \Pi_1}{\partial q_1}$ and $\Pi_{2,2} = \frac{\partial \Pi_2}{\partial q_2}$. q_1 is the level of local production by the domestic firm and q_2 is the level of the foreign firm's export choice. Totally differentiating the above system of first-order conditions, we have:

$$\Pi_{1,11} dq_1 + \Pi_{1,12} dq_2 + \Pi_{1,1\phi_1} dq\phi_1 = 0 \tag{3.A.6}$$

$$\Pi_{2,21} dq_1 + \Pi_{2,22} dq_2 + \Pi_{2,2\phi_1} d\phi_1 = 0 \tag{3.A.7}$$

where $\Pi_{i,hh}$ for $h = \{1,2\}$ is an abbreviation of second-order derivatives. For example, $\Pi_{1,11}$ is the change in the domestic firm's marginal profits from a small increase in its local production. It is obvious from the first-order conditions that $\Pi_{2,2\phi_1} = 0$, since only a domestic R&D subsidy is investigated. Then, from (3.A.6) and (3.A.7), we can solve for $\frac{dq_1}{d\phi_1}$ and $\frac{dq_2}{d\phi_1}$. These are:

$$\frac{dq_1}{d\phi_1} = -\frac{\Pi_{1,1\phi_1}\Pi_{2,22}}{D} > 0 \qquad \frac{dq_2}{d\phi_1} = \frac{\Pi_{1,1\phi_1}\Pi_{2,21}}{D} < 0 \tag{3.A.8}$$

where $\Pi_{1,1\phi_1} = \frac{\bar{w}_3}{\phi_1^2}$, $\Pi_{2,22} = 2P'$, $\Pi_{2,21} = P'$ and, finally, $D = \Pi_{1,11}\Pi_{2,22} - \Pi_{1,12}\Pi_{2,21} = 3\left(P'\right)^2 > 0$.

We can then derive a reduced-form profit function $\Psi(\phi_1)$, which we define as the home firm's threat-point or disagreement level of profits.

$$\Psi(\phi_1) = \Pi_1(q_1(\phi_1), q_1(\phi_1), \phi_1) \tag{3.A.9}$$

When the government increases its subsidy to R&D in the domestic firm in stage one, (3.A.9) and (3.A.8) can be used for deriving the change in the threat-point as (3.A.10):

$$\frac{d\Psi}{d\phi_1} = \underbrace{\frac{\partial \Pi_1}{\partial q_1}}_{=0}\underbrace{\frac{dq_1(\phi_1)}{d\phi_1}}_{(+)} + \underbrace{\frac{\partial \Pi_1}{\partial q_2}}_{(-)}\underbrace{\frac{dq_2(\phi_1)}{d\phi_1}}_{(-)} + \underbrace{\frac{\partial \Pi_1}{\partial \phi_1}}_{(+)} > 0 \tag{3.A.10}$$

where we have used $\frac{\partial \Pi_1}{\partial q_1} = 0$ from (3.A.4), $\frac{\partial \Pi_1}{\partial q_2} = P'q_1 < 0$ and $\frac{\partial \Pi_1}{\partial \phi_1} = \bar{w}_3\left(\frac{q_1}{\phi_1}\right)^2 > 0$ from (3.A.2).

3.B Appendix - Comparative statics

Differentiating the NBC-condition (3.11), the CC-equation (3.10) and the first-order condition for the foreign firm (3.12) in q_1, q_2, w_1 and ϕ_1, we obtain the system:

$$\begin{bmatrix} 2\phi_1 P' & \phi_1 P' & \frac{\gamma}{\theta} - 1 \\ P'(2-k) + \frac{k\Psi}{q_1^2} & P' & -\frac{1}{\phi_1} \\ P' & 2P' & 0 \end{bmatrix} \begin{bmatrix} \frac{dq_1}{d\phi_1} \\ \frac{dq_2}{d\phi_1} \\ \frac{dw_1}{d\phi_1} \end{bmatrix} = \begin{bmatrix} -(P + P'q_1) \\ \frac{k\Psi'(\phi_1)}{q_1} - \frac{w_1}{\phi_1^2} \\ 0 \end{bmatrix} \tag{3.B.11}$$

Using Cramer's rule:

$$\frac{dq_1}{d\phi_1} = \frac{D_{q_1}}{D} \qquad \frac{dq_2}{d\phi_1} = \frac{D_{q_2}}{D} \qquad w_{1\phi_1} = \frac{D_{w_1}}{D} \tag{3.B.12}$$

where the appropriate determinants can be expressed:

$$D = (P')^2\left\{3 + \left(\frac{\gamma}{\theta} - 1\right)\left[3 - 2k + \frac{2k\Psi}{P'q_1^2}\right]\right\}$$

$$D_{q_1} = -2P'\frac{1}{\phi_1\theta}\left\{\theta\left(P+P'q_1\right)-(\gamma-\theta)\left[\frac{\phi_1 k\Psi'(\phi_1)}{q_1}-\frac{w_1}{\phi_1^2}\right]\right\}$$

$$D_{q_2} = P'\frac{1}{\phi_1\theta}\left\{\theta\left(P+P'q_1\right)-(\gamma-\theta)\left[\frac{\phi_1 k\Psi'(\phi_1)}{q_1}-\frac{w_1}{\phi_1^2}\right]\right\}$$

$$D_{w_1} = (P')^2\left\{-\left(P+P'q_1\right)\left[3-2k+\frac{2k\Psi}{P'q_1^2}\right]-3\left[\frac{\phi_1 k\Psi'(\phi_1)}{q_1}-\frac{w_1}{\phi_1^2}\right]\right\}$$

Rearrange the CC-condition (3.10) into (3.B.13):

$$\left(P+P'q_1\right)=\frac{1}{\phi_1\theta}\left[\left(\theta-\gamma\right)w_1+\gamma\bar{w}_1\right] \tag{3.B.13}$$

After inserting the above determinants into (3.B.12) and using (3.B.13), the desired changes are:

$$\frac{dq_1}{d\phi_1} = \frac{-\frac{2}{P'}\frac{1}{\phi_1^2}\left\{\frac{\gamma}{\theta}\bar{w}_1-\left(\frac{\gamma-\theta}{\theta}\right)\frac{\phi_1^2 k\Psi'(\phi_1)}{q_1}\right\}}{D} \tag{3.B.14}$$

$$\frac{dq_2}{d\phi_1} = \frac{\frac{1}{P'}\frac{1}{\phi_1^2}\left\{\frac{\gamma}{\theta}\bar{w}_1-\left(\frac{\gamma-\theta}{\theta}\right)\frac{\phi_1^2 k\Psi'(\phi_1)}{q_1}\right\}}{D} \tag{3.B.15}$$

$$\frac{dw_1}{d\phi_1} = \frac{\frac{A}{\phi_1}\left\{w_1\left(\frac{3-A}{A}\right)+\frac{\gamma}{\theta}\left(w_1-\bar{w}_1\right)\right\}-\frac{3\phi_1 k\Psi'(\phi_1)}{q_1}}{D} \tag{3.B.16}$$

where:

$$D=3+\left(\frac{\gamma}{\theta}-1\right)A \qquad \textit{and} \qquad A=3-2k+\frac{2k\Psi}{P'q_1^2} \tag{3.B.17}$$

3.C Appendix - The determinant D

Here, it is shown that if the union is wage-oriented, we have $D > 0$ in (3.15).

From the definition of D in (3.15), we have $D = 3 + \left(\frac{\gamma}{\theta} - 1\right)A$, where $A = \left(3 - 2k + \frac{2k\Psi}{P'q_1^2}\right)$. Rewrite this as:

$$D=3+\left(\tfrac{\gamma}{\theta}-1\right)(3-2k)+\left(\tfrac{\gamma}{\theta}-1\right)\tfrac{2k\Psi}{P'q_1^2} \tag{3.C.18}$$

where the last expression (3.C.18) is positive if the union is wage-oriented or $\theta > \gamma$. Then, note that:

$$\inf\left\{3 + \left(\frac{\gamma}{\theta} - 1\right)(3 - 2k)\right\} = 2k$$

Hence, $D > 0$, if $\theta > \gamma$. In the text, we also assume that $D > 0$ holds when $\gamma > \theta$. It is then assumed that the threat-point Ψ is not too high, in the sense that $0 < A < 3$.

3.D Appendix - Graphical illustration

In this appendix, the results are illustrated graphically. Conditions for the bargaining problem (3.7) to be well-posed, are also discussed.

Figures 3.D.2 and 3.D.3 below are drawn in the $w_1 q_1$-space for a given level of the foreign firm's exports q_2 and cannot be used in comparative statics exercises. They are only presented for illustrative purposes. The different curves are derived as follows:

Indifference curves and isoprofit curves

Start with the union's indifference curves. These have the slope $\left.\frac{dw_1}{dq_1}\right|_{\bar{U}} = -\frac{\gamma}{\theta}\frac{(w_1 - \bar{w})}{q_1} < 0$, they are of the usual convex form and approach $w_1 = \bar{w}_1$

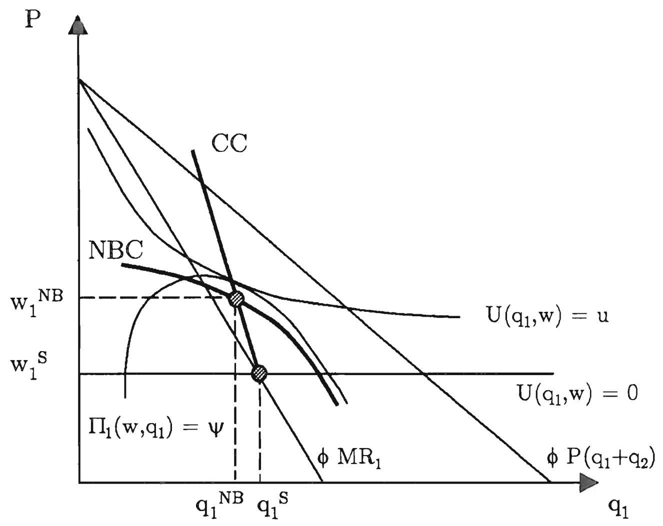


FIGURE 3.D.2. The case of a wage-oriented union

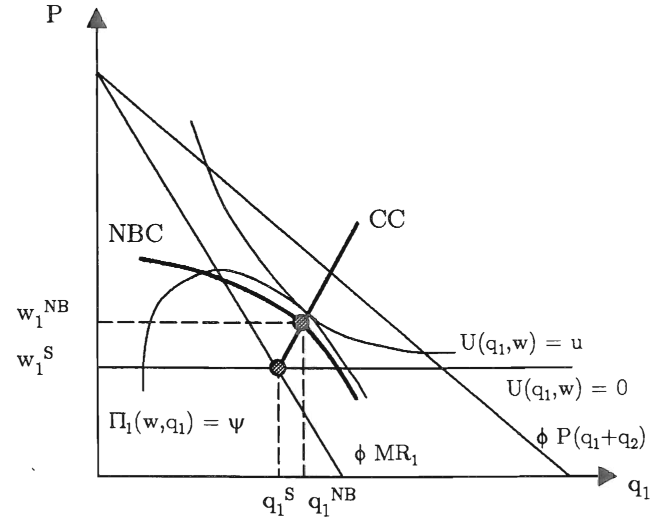


FIGURE 3.D.3. The case of an employment-oriented union

asymptotically. The union's threat-point is zero, and the corresponding indifference curve is simply the straight line $w_1 = \bar{w}_1$. Turning to the firm, the slope of an isoprofit curve is $\left.\frac{dw_1}{dq_1}\right|_{\bar{\Pi}} = \frac{\phi_1 MR - w_1}{q_1}$, where $MR = P + P'q_1$. The isoprofit curve for the firm's threat-point is $\Pi(q_1, w_1) = \Psi(\phi_1)$. Again, this is the profit level of the firm in case of a breakdown in negotiations, when the market is served from abroad.

The contract zone

Note that the union's utility is increasing in the north-eastern direction and that the firm's profit increases in the southern direction. The area surrounded by the parties' reservation pay-offs, $w_1 = w_1^S = \overline{w}_1$ and $\Pi(q_1, w_1) = \Psi(\phi_1)$, is the contract zone. The contract zone is thus all points (q_1, w_1), such that both the union and the firm receive at least their disagreement utilities.

For a settlement to be reached, the contract zone must be nonempty. Obviously, this implies an agreement such that $w_1 \geq \bar{w}_1$ and $\Pi(q_1, w_1) \geq \Psi(\phi_1)$. That is, union members require at least the wage predominant in the rest of the domestic economy. Turning to the firm, an intuitive condition for the latter inequality is that the marginal cost in local production is no less than the corresponding marginal cost in domestic production. That is:

$$\frac{\overline{w}_3}{\phi_1} \geq \frac{\overline{w}_1}{\phi_1} \Longleftrightarrow \overline{w}_3 \geq \overline{w}_1 \tag{3.D.19}$$

(3.D.19) might be the result of transfer costs arising when production is shifted abroad during a conflict, due to the fact that employees abroad are shifted into a new production line, or simply assume the wage level to be higher in the third country.

The CC- and the NBC-curves

The contract curve (CC), derived as (3.10) in the text, is one of the two bold curves running through the contract zone. It is the locus of all points in the q_1, w_1-space, where the isoprofit curves and the indifference curves are tangent to each other. Differentiating the expression for CC yields $\left.\frac{dw_1}{dq_1}\right|_{CC} = -\frac{2\theta\phi_1 P'}{(\gamma-\theta)}$, so that the contract curve is negatively sloped, if the union is wage-oriented (fig 3.D.2) and positively sloped if the union is employment-oriented (fig 3.D.3). In either case, the contract curve is linear and starts at $w_1 = \bar{w}$.

Now turn to the *Nash-bargaining curve* (NBC), derived as (3.11) in the text. It is convenient to rewrite (3.11) into (3.D.20):

$$w_1 = \phi_1 \{kP + (1-k)(P + P'q_1)\} - \frac{\phi_1 k \Psi(\phi_1)}{q_1} \tag{3.D.20}$$

which shows that the NBC is a weighted average of the "demand curve" $\phi_1 P$ and the "marginal revenue curve", $\phi_1 (P + P'q_1)$, plus a term involving the threat-point.[12] Differentiating (3.D.20) yields:

$$\left.\frac{dw_1}{dq_1}\right|_{NBC} = \phi_1 \left[P'(2-k) + \frac{k\Psi(\phi_1)}{q_1^2}\right]$$

$$\left.\frac{d^2 w_1}{dq_1^2}\right|_{NBC} = -\frac{\phi_1 k \Psi(\phi_1)}{q_1^2} < 0$$

showing that the NBC is a strictly concave function.

The Nash-Bargaining solution

The Nash-Bargaining solution, $\left(q_1^{NB}, w_1^{NB}\right)$, is obtained at the intersection of the contract curve (CC) and the Nash-Bargaining curve (NBC). Assuming the threat-point $\Psi(\phi_1)$ not to be too high, the NBC will intersect the contract curve. The Nash-bargaining solution can be compared with the outcome with a competitive labor market ($w_1^S = \overline{w}_1$), indicated as $\left(q_1^S, w_1^S\right)$. Comparing $\left(q_1^S, w_1^S\right)$ with $\left(q_1^{NB}, w_1^{NB}\right)$ in figures 3.D.2 and 3.D.3, we can verify that the firm under exports, as compared to the socially optimal level when the union is wage-oriented (cf. figure 3.D.2), whereas the opposite holds when the union is employment-oriented (cf. figure 3.D.3).

[12] $\phi(P + P'q)$ is also the firm's demand curve for labor.

3.E Appendix - Second-order conditions

In this appendix, the second-order conditions for the bargaining problem (3.7) are checked.

From (3.8) and (3.9), we can retrieve the first-order derivatives:

$$\begin{aligned} G_w &= a\theta\left(\phi_1\left(P - \tfrac{w_1}{\phi_1}\right)q_1 - \Psi\right) && (3.E.21)\\ &\quad - (w_1 - \bar{w}_1)(1-a)\,q_1 \\ G_q &= a\gamma\left(\left(P - \tfrac{w_1}{\phi_1}\right)q_1 - \Psi\right) && (3.E.22)\\ &\quad - (1-a))\left(\tfrac{w_1}{\phi_1} - P - P'q_1\right)q_1 \end{aligned}$$

For a well-posed maximization problem, (3.7) must be concave and the matrix Q, defined in (3.E.23), must be negative definite:

$$Q = \begin{bmatrix} G_{w_1w_1} & G_{w_1q_1} \\ G_{q_1w_1} & G_{q_1q_1} \end{bmatrix} \qquad (3.E.23)$$

In turn, this requires that $|Q| > 0, G_{w_1w_1} < 0$ and $G_{q_1q_1} < 0$. Using (3.E.21), (3.E.22) and (3.B.13), these expressions can be written as follows:

$$\begin{aligned} G_{w_1w_1} &= -a_2q_1 < 0 \\ G_{w_1q_1} &= -(w_1 - \bar{w}_1)\,a_1 < 0 \\ G_{q_1w_1} &= -a_1q_1 < 0 \\ G_{q_1q_1} &= -\tfrac{\gamma}{\theta}(w_1 - \bar{w}_1)\,a_1 + 2q_1(1-a)\,P'q_1 < 0 \\ |Q| &= -a_2q_1\left[2(1-k)\,P'q_1 - \frac{a_1}{a_2}(w_1 - \bar{w}_1)(1-a)\left(\tfrac{\gamma}{\theta} - 1\right)\right] \end{aligned}$$

where $a_1 = a\gamma + 1 - a > 0$ and $a_2 = a\theta + 1 - a > 0$. We can see that $G_{w_1w_1} < 0$ and $G_{q_1q_1} < 0$ are fulfilled. $|Q| > 0$ is always the case if the union is employment-oriented ($\gamma > \theta$). But $|Q| > 0$ need not be the case if the union is wage-oriented ($\theta > \gamma$). As long as the wage-orientation is not too strong, however, the second term within the bracketed expression in $|Q|$ should be small, and the sign of the determinant should be positive.

4

Multinational firms, technology and location

4.1 Introduction

Multinational firms (MNFs), that is, firms performing economic activities in more than one country, are dealt with in a large and growing literature. In this literature, it is generally agreed that firm-specific assets - such as marketing ability, product differentiation or technology - play a fundamental part in explaining the existence of multinational firms.[1]

The propriety ownership of such assets can be considered to have two fundamental properties: (i) In an environment of market rivalry, they enable a firm to overcome any additional costs - such as communication, transport or start-up costs - arising from expanding a firm's home-market operations into foreign markets, and (ii) within the firm, they have the characteristics of a public good or a joint input, which creates firm-level scale economies. An example of this is that knowledge of a production process is not connected to a single physical unit, and can be put to use in other factories at low additional costs.[2]

These features have been incorporated in recent imperfect competition models of multinationals in a number of papers, for example, Horstmann and Markusen (1992), Brainard (1993), Ethier and Markusen (1996) and in a series of papers by Markusen and Venables (1996a, 1996b, 1998). In general, they show that firms are more likely to expand production across borders, when the proximity to consumers is important, due to high trade barriers or trade costs (t), and when firm-level fixed costs (F) are high, relative to plant level fixed costs (G). F then refers to fixed costs incurred in developing the firm's propriety assets, whereas G refers to fixed costs tied to an actual production unit.

In this type of model, the level of the firm-specific fixed cost F is typically exogenously fixed and therefore independent of how the firm serves its markets. This implies that the quality or the size of the firm-specific assets is not dependent on whether the firm chooses to expand sales across borders by producing abroad or exporting, or even by refraining from foreign sales

[1] See Dunning (1977) and Markusen (1995).

[2] The characteristics of a public good in these assets also imply that these are most profitably utilized within the firm, due to problems of asymmetric information and control over technology or quality, for example.

altogether.

But - as has been suggested by Caves (1996) - a firm may not only expand sales abroad in order to draw on its propriety asset, it may also be done to gain resources to develop this asset.[3] This suggests a modified approach, which does not only endogenize a firm's choice of location for its production, but also models how this location choice affects the development of its propriety asset.[4] Hence, in contrast to the earlier work, this paper attempts to model this interaction and - in the process - investigate how the development of a firm's technology is related to its choice between export or foreign production, as its alternative ways of serving a foreign market. To the best of my knowledge, the only recent work sharing this approach are Sanna-Randaccio (1998), Sanna-Randaccio and Petit (1998) and Pavelin (1997).

To this end, it will be assumed that a firm's propriety asset can be represented by its technology, and that these assets can be enhanced by investing in costly R&D. While "process R&D" simplifies the analysis, the results in the paper also extend to other types of propriety assets.[5]

More specifically, I use a Cournot-framework with endogenous technology and an endogenous market structure, developed from Leahy and Neary (1996), where two firms compete on a foreign market.[6] In the first period, the firms invest in costly R&D to improve their technologies, thereby decreasing their unit cost of production. At the beginning of the second period, they either implement their technology in an affiliate which supplies the market from a local plant, or in a domestic plant which supplies the market by export production. Given these location choices, Cournot competition then takes places at the end of the second period.

When faced with the decision of what investments should be made in R&D and where to locate the technology, the firms take the fact that export production is subject to a trade cost into account, whereas implementing

---

[3] Fors (1996) and Svensson (1996) do find evidence of a two-way relationship between foreign sales and R&D, but they do not address the question of how foreign sales are divided by export and affiliate production.

[4] In Brainard (1993), firms develop their technologies by investing in Research and Development (R&D). A fixed R&D requirement is used in her paper, however, when a firm decides whether to produce abroad or to export.

[5] Assumptions based on Bertrand competition with differentiated products were also made, and the results seem robust to this type of market interaction. This was also the case with a simple model of quality improvements. In addition, a framework with " process R&D" may still be valid for " product R&D", if we consider products as delivering services to consumers. If the development of new goods decreases the costs of such services, the effect is similar to that of a pure cost-reduction. See Spence (1984) for a formal argument.

[6] Leahy and Neary (1996) study strategic trade policy in the tradition of Brander and Spencer (1983, 1985). In contrast to the present paper, this literature does not allow for FDI.

the technology abroad is more costly, due to technology transfer costs.[7]

When solving the model, the nature of the transfer cost turns out to be crucial. If transfer costs are independent of the R&D choice of the firm, high-tech firms will choose foreign direct investment (FDI). If transfer cost are related to R&D levels, on the other hand, the opposite holds. In the first case, FDI tends to be chosen, since larger sales are facilitated by avoiding trade costs of physical goods. This, in turn, boosts R&D expenditures, thereby increasing the difference between the two alternatives in marginal costs. In the second case, however, increasing the level of R&D is, in itself, a reason for maintaining production at home, since transfer costs are related to R&D.

I then proceed to test these predictions on a data set consisting of Swedish multinational firms, provided by the Research Institute of Industrial Economics (IUI) in Sweden. Both countries with foreign production and countries exclusively supplied by exports, are included in a two-stage estimation procedure. Furthermore, the simultaneity problems often encountered in other studies are also avoided by instrumenting for R&D and using the share of foreign sales accounted for by overseas affiliate production as the dependent variable in the OLS-regressions.

The empirical analysis produces a persistent negative correlation between R&D intensity and the affiliate share of foreign sales, on the one hand, and the probability that any affiliate sales are recorded, on the other. It may seem surprising that high-tech production, on the margin, shows a preference for export production rather than affiliate production. This result is, however, robust in the following way:

- It is explained theoretically by relating technology transfer costs to the technology level of production.
- Examining the results in Brainard (1997) more closely, her US data shows that an increase in R&D increases both exports and affiliate sales, but the response in exports is much stronger. This indicates that our findings may not be unique to this specific sample.[8] [9]
- The effects of transport costs, scale economies at the plant level and experience of foreign production are similar to the results in Brainard (1997), Ekholm (1998) and Swedenborg (1982).

[7]Teece (1977) provides strong evidence for the existence of such technology transfer costs.

[8]While Brainard's results on levels of export and affililiate sales indicate that her data replicates our negative relationship between R&D intensity and the affiliate share of foreign sales, she does, however, find that R&D increases the probability of finding affiliate production in a country.

[9]Lall (1980), who also uses US industry data, finds that the share of *exports,* out of foreign sales, is positively related to R&D.

Finally, some restrictions of the theoretical model should be noted. We abstract from any home market influence on the choice between FDI and exports. This assumption simplifies the analysis, but does not seem too restrictive when the focus is on a country like Sweden, where the home-market may be of neglible size for its *large* international firms.[10] Moreover, there are no local firms. Hence, I also abstract from possible licensing agreements. For functional forms, I use linear and quadratic functions. While this approach supports analytical solutions, future research should incorporate more general function forms.

The paper proceeds as follows: In section 4.2, a theoretical framework is derived. In subsections 4.2.2 and 4.2.3, this model is explored under two alternative assumptions of how technology is transferred. In Section 4.3, an empirical analysis based on our findings in section 4.2 is performed. Section 4.4 concludes.

4.2 Theory

In this section, a theoretical attempt is made to study the interaction between the R&D decisions of different firms and their choice between local and export production, as alternative means of serving a foreign market. First, the general structure is presented and the notation is explained. Then, two almost identical models are presented, which differ only in their assumption of the cost of transferring technology.

4.2.1 Structure

The structure of the complete game is illustrated in figure 4.1. Imagine an international industry with two firms, firm 1 and firm 2, both producing a homogeneous good. These firms may or may not originate from the same country. The demand is located in another country, which may be considered as the world market for the good in question. Thus, we assume away any potential demand effects from the home market of these firms.

The sequence of events is as follows: In the first period, the firms invest in costly R&D. We assume the technological level of the firms to be represented by their cost levels, and that R&D lowers their marginal costs. At the beginning of period two, they implement their technology either in export production from a domestic factory (henceforth denoted N), or they make direct investments (henceforth denoted FDI) and produce in an affiliate abroad (henceforth denoted M). Finally, firms are assumed to act

[10] Although more difficult to handle, similar results may be derived in a model where home-market effects are accounted for. This is shown in Sanna-Randaccio (1998), Sanna-Randaccio and Petit (1998).

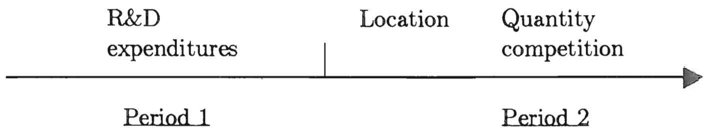


FIGURE 4.1. Structure of the game

as Cournot competitors, when market interaction takes place at the end of period two.

Since the model involves two firms acting in four potential market structures, the notation can easily become complicated. The convention here is to use subscripts for denoting firm identity, and superscripts for denoting market structure. For example, q_h^{ij} is the output choice of firm h in market structure ij, for $h = \{1, 2\}$ and $ij = \{N, M\}$. To be more concrete, for $h = 1$, $i = N$ and $j = M$, q_1^{NM} is the export quantity of firm 1, when firm 2 has chosen FDI and established an affiliate.

4.2.2 Model 1 - Fixed technology transfer costs

The marginal cost in production for each firm in the market structure ij, is given in (4.1):

$$\begin{aligned} c_h^{ij} &= c_h^i - \theta x_h^{ij} \\ c_h^N &= c_0 + t, \qquad c_h^M = c_0 \end{aligned} \tag{4.1}$$

where θ and c_0 are positive constants. Several factors affect the production costs. From (4.1), we can see that the firms choose levels of R&D, indicated by x_h^{ij} , which lower their marginal costs. Export production is also subject to a transport cost or a tariff barrier, t, which can be avoided by FDI.

The inverse demand is given by (4.2):

$$P^{ij} = a - \frac{\left(q_1^{ij} + q_2^{ij}\right)}{s} \tag{4.2}$$

where $a > 0$ is a demand parameter and $s > 0$ can be interpreted as a measure of the size of the market. The total profits in each firm for the market structure ij, are given in (4.3) and (4.4):

$$\Pi_1^{ij} = \left(P^{ij} - c_1^{ij}\right) q_1^{ij} - \frac{\gamma \left(x_1^{ij}\right)^2}{2} - G_1^i - T_1^i \tag{4.3}$$

$$\Pi_2^{ij} = \left(P^{ij} - c_2^{ij}\right) q_h^{ij} - \frac{\gamma \left(x_2^{ij}\right)^2}{2} - G_2^j - T_2^j \tag{4.4}$$

In both (4.3) and (4.4), the first term indicates variable profits and the last three terms indicate different types of fixed costs. From the left to the right, these fixed costs are as follows:

First, R&D is assumed to incur quadratic costs, so that x_h^{ij} gives rise to firm-specific fixed costs of $\frac{\gamma(x_h^{ij})^2}{2}$, where γ is a positive constant.[11] Note that this term corresponds to the F-type of firm-specific costs discussed in the introduction, which are usually modelled as exogenous in the literature. Here, these costs are endogenous.

Second, both firms are assumed to have production units at home, but initiating production abroad involves additional plant-level investments. Plant-level fixed costs are then defined in (4.5):[12]

$$G_1^i = \begin{cases} G, & \text{for } i = M \\ 0, & \text{for } i = N \end{cases} \qquad G_2^j = \begin{cases} G, & \text{for } j = M \\ 0, & \text{for } j = N \end{cases} \tag{4.5}$$

Third, following Teece (1977), technology transfer costs for implementing the technology in a factory located abroad are assumed to be higher. To simplify, let us normalize such that new technology can be implemented at home without cost, whereas an additional cost T of transferring the technology abroad arises, since it must be adapted to local conditions. Then, we have

$$T_1^i = \begin{cases} T, & \text{for } i = M \\ 0, & \text{for } i = N \end{cases} \qquad T_2^j = \begin{cases} T, & \text{for } j = M \\ 0, & \text{for } j = N \end{cases} \tag{4.6}$$

Profit maximizing production quantities, q_h^{ij}, are chosen so that (4.7) must hold:

$$\frac{\partial \Pi_h^{ij}}{\partial q_h^{ij}} = P^{ij} - c_h^{ij} - \frac{q_h^{ij}}{s} = 0 \qquad h = 1, 2 \tag{4.7}$$

where we have used $\frac{dP^{ij}}{dq_h^{ij}} = -\frac{1}{s}$ from (4.2). Furthermore, we shall assume R&D to be chosen in order to minimize costs.[13] In other words, the firms choose R&D levels, x_h^{ij}, taking the production levels implied by (4.7) as

[11]See Cheng (1984).

[12]Equation (4.5) mimics the effect of plant-level fixed costs in a model, including a home market (e.g. the Horstmann and Markusen (1992) type of model). In this case, multinational production incurs costs of $2G$, versus concentrated export production requiring G only in plant-level fixed costs.

[13]That is, a firm bases its cost-mimimizing R&D expenditures on where it believes the opponent will implement its technology at the beginning of period two. It is straightforward to also explicitly allow the firms to take the strategic effect of R&D on output in the Cournot game into account. But - as tedious calculations will show - this does not qualitatively change the results.

given. Optimal R&D levels then require that (4.8) must hold:

$$\frac{\partial \Pi_h^{ij}}{\partial x_h^{ij}} = \theta q_h^{ij} - \gamma x_h^{ij} = 0 \qquad h = 1,2 \tag{4.8}$$

where $\frac{dc_1^{ij}}{dx_h^{ij}} = -\theta$ is derived from (4.1). Using (4.2) and (4.7), optimal production quantities are given by (4.9):

$$q_1^{ij} = s\frac{a - 2c_1^{ij} + c_2^{ij}}{3}, \qquad q_2^{ij} = s\frac{a - 2c_2^{ij} + c_1^{ij}}{3} \tag{4.9}$$

From (4.8), we can solve for the optimal R&D levels. These are given in (4.10):

$$x_1^{ij} = \frac{\theta}{\gamma}q_1^{ij}, \qquad x_2^{ij} = \frac{\theta}{\gamma}q_2^{ij} \tag{4.10}$$

As shown by Leahy and Neary (1996), the linear specification then allows us to solve all endogenous variables in a parameter η, defined as $\eta = \frac{\theta^2 s}{\gamma} \geq 0$, which may be interpreted as the relative return to R&D. Note that η is zero, if R&D is completely ineffective ($\theta = 0$), inexcessively expensive ($\gamma = \infty$) or if the size of the market is very small ($s = 0$).

To ensure well-behaved solutions, the following assumptions are required:

A1 The parameter values are such that both firms always have strictly positive marginal costs which, by (4.1), implies that $c_h^i > \theta x_h^{ij}$ holds.

A2 The parameter values support both firms being active in all market structures. This, in turn, implies cases where $\eta < 1$.[14]

In appendix 4.D, it is shown that the latter assumption guarantees that the second-order condition for the firms' maximization of (4.3) and (4.4) is fulfilled.

Then, by inserting (4.10) into (4.9) and using (4.1), we can solve for the optimal production levels of both firms in the market structure ij. The production quantities of firm 1 in the four possible market structures are then given in (4.11):

$$\begin{aligned} q_1^{NN} &= s\frac{A-t}{3-\eta}, \qquad q_1^{MN} = s\frac{A(1-\eta)+t}{(1-\eta)(3-\eta)} \\ q_1^{NM} &= s\frac{(1-\eta)(A-t)-t}{(1-\eta)(3-\eta)}, \qquad q_1^{MM} = s\frac{A}{3-\eta} \end{aligned} \tag{4.11}$$

[14] From (4.11) and (4.12) below, it is clear that $0 \leq \eta < 1$ is a necessary condition for an interior solution of the model, where both firms are always active in equilibrium.

where it will be assumed that $A - t > 0$ and $A = a - c_0 > 0$.[15] The quantities for firm 2 are given in (4.12):

$$\begin{aligned} q_2^{NN} &= s\frac{A-t}{3-\eta}, \qquad q_2^{NM} = s\frac{A(1-\eta)+t}{(1-\eta)(3-\eta)} \\ q_2^{MN} &= s\frac{(1-\eta)(A-t)-t}{(1-\eta)(3-\eta)}, \qquad q_2^{MM} = s\frac{A}{3-\eta} \end{aligned} \tag{4.12}$$

Note that since firm 1 and firm 2 face symmetrical cost conditions, (4.11) and (4.12) are completely symmetric.

We can then use (4.3), (4.4), (4.7) and (4.10) for deriving expressions for the total profits of the firms. In the market structure ij, we have:

$$\begin{aligned} \Pi_1^{ij}(\eta) &= \pi_1^{ij}(\eta) - T_1^i - G_1^i \qquad (4.13) \\ &= \frac{1}{2s}\left(q_1^{ij}\right)^2(2-\eta) - T_1^i - G_1^i \\ \Pi_2^{ij}(\eta) &= \pi_2^{ij}(\eta) - T_2^i - G_2^i \qquad (4.14) \\ &= \frac{1}{2s}\left(q_2^{ij}\right)^2(2-\eta) - T_2^i - G_2^i \end{aligned}$$

where variable profits are denoted $\pi_h^{ij}(\eta)$ and production quantities are given by (4.11) and (4.12), whereas fixed costs are given by (4.5) and (4.6). Note that both profit expressions are functions of η, that is, the relative return to R&D.

Equilibrium market structure with fixed transfer costs

To illustrate the workings of this model, let us explore the variable profit function of, say, firm 1, in the *NN* and *MN* structures. We can state and prove the following proposition:

Proposition 8 *The variable profits of firm 1 for exporting $\pi_1^{NN}(\eta)$ and its corresponding profit in affiliate production $\pi_1^{MN}(\eta)$, when firm 2 exports, are both increasing in the relative return to R&D, η. However, affiliate production always yields higher variable profits than export production and affiliate profits $\pi_1^{MN}(\eta)$ increase at a faster rate in η, compared to export profits $\pi_1^{NN}(\eta)$.*

[15] These conditions are necessary in order to guarantee that export production is profitable.

Proof. Calculations show that

$$\begin{aligned}
\frac{\partial \pi_1^{NN}}{\partial \eta} &= \frac{s}{2}\frac{(A-t)^2(1-\eta)}{(3-\eta)^3} > 0 \\
\frac{\partial \pi_1^{MN}}{\partial \eta} &= \frac{s}{2}\frac{(A(1-\eta)+t)\left(A(1-\eta)^3+t\left(13-12\eta+3\eta^2\right)\right)}{(1-\eta)^3(3-\eta)^3} > 0 \\
\pi_1^{MN} - \pi_1^{NN} &= \frac{st}{2}\frac{(2-\eta)^2(2A(1-\eta)+t\eta)}{(1-\eta)^2(3-\eta)^2} \\
\frac{\partial\left(\pi^{MN} - \pi^{NN}\right)}{\partial \eta} &= \frac{1}{2}st(2-\eta)\frac{2A(1-\eta)\left(4-3\eta+\eta^2\right)+t\left(6-2\eta^2-\eta+\eta^3\right)}{(1-\eta)^3(3-\eta)^3} > 0
\end{aligned}$$

since η is restricted to take on values between zero and one. ∎

What is the economic intuition behind proposition 8? First, the profit in export and affiliate production increases in η simply because a higher return to R&D implies higher spending on R&D, thereby lowering the marginal costs. The remaining claims in the proposition require some further elaboration, however.

Since FDI avoids the transport cost, larger sales in affiliate production also imply increased spending on R&D, as compared to the alternative of exports. Accordingly, production will expand further, due to lower production costs and a contracting output of firm 2.[16] Therefore, the difference in marginal costs between the two location alternatives will exceed the transport cost t, as η increases. This can be seen in (4.15), where the difference in marginal costs, $\triangle c(\eta) = c_1^{NN}(\eta) - c_1^{MN}(\eta)$, is evaluated using (4.1) and (4.11).

$$\begin{aligned}
\triangle c(\eta) &= t\left(1+\frac{\eta(2-\eta)}{(1-\eta)(3-\eta)}\right) > 0 \qquad (4.15)\\
\frac{\partial \triangle c(\eta)}{\partial \eta} &= 2t\frac{3-3\eta+\eta^2}{(1-\eta)^2(3-\eta)^2} > 0
\end{aligned}$$

FDI then always allows the firm to obtain a more cost-efficient technology, favoring FDI. This efficiency bias is larger, the higher is the relative return to R&D, η, which is the reason why affiliate profits are more responsive in η.

It can also be shown that similar properties are present in the remaining production structures. The information needed for solving the equilibrium production structure is collected in proposition 9. The proofs are submitted in appendix 4.A.

[16] From (4.11), we have $q_1^{MN} - q_1^{NN} = st\frac{2-\eta}{(1-\eta)(3-\eta)} > 0$. Then by (4.10), $x_1^{MN} - x_1^{NN} > 0$. Also note that $q_2^{NN} - q_2^{MN} = st\frac{1}{(1-\eta)(3-\eta)} > 0$, $\frac{\partial}{\partial\eta}\left(q_2^{NN} - q_2^{MN}\right) = 2st\frac{2-\eta}{(1-\eta)^2(3-\eta)^2} > 0$.

Proposition 9 *Variable profits in market structures, NN, MN, MM and NM, have the following properties:*

$$\begin{aligned}
\frac{\partial \pi_1^{MN}}{\partial \eta} &> 0, \quad \frac{\partial \pi_1^{MM}}{\partial \eta} > 0, \quad \frac{\partial \pi_1^{NN}}{\partial \eta} > 0, \quad \frac{\partial \pi_1^{NM}}{\partial \eta} \gtreqless 0 \\
\pi_1^{MN} &> \pi_1^{NN}, \quad \pi_1^{MM} > \pi_1^{NN}, \quad \pi_1^{MM} > \pi_1^{NM} \\
\pi_1^{NN} &> \pi_1^{NM}, \quad \pi_1^{MN} > \pi_1^{MM}, \quad \frac{\partial(\pi_1^{MN} - \pi_1^{NN})}{\partial \eta} > 0 \\
\frac{\partial(\pi_1^{MM} - \pi_1^{NN})}{\partial \eta} &> 0, \quad \frac{\partial(\pi_1^{MM} - \pi_1^{NM})}{\partial \eta} > 0, \quad \frac{\partial(\pi_1^{NN} - \pi_1^{NM})}{\partial \eta} \gtreqless 0
\end{aligned}$$

Proof. See appendix 4.A. ■

Using the information in proposition 9, we can now solve for the equilibrium production structure by letting firm 1 and firm 2 choose their respective location in order to maximize their total profits, that is, variable profits net of fixed investment costs in (4.13) and (4.14).

Using our assumption that only affiliate production bears plant-specific costs $G > 0$ and transfer costs $T > 0$, figure 4.2 illustrates how the equilibrium market structure depends on the relative return to R&D, η. Four total profit curves are drawn - one associated with each possible production structure. Once more, it can be noted that the symmetrical cost-conditions imply $\Pi_1^{ij}(\eta) = \Pi_2^{ji}(\eta)$, for $ij = \{N, M\}$.[17] For expositional reasons, the notation for firm 1 has been used.

Depending on the size of the relative rate of return to R&D, η, three types of Nash-equilibria in locations can arise:

First, for $\eta \in [0, \eta_B)$, it can easily be seen that export production (NN) is the unique Nash-equilibrium, corresponding to the AB-segment in figure 2. At lower values of η, the firms spend less on R&D, which results in higher marginal costs. Therefore, the advantage of avoiding the transport cost in affiliate production is not sufficient to cover the higher plant-level fixed cost.

Second, for $\eta \in [\eta_B, \eta_E]$, the market structure will be an asymmetric Nash-equilibrium $(MN$ or $NM)$, where either firm 1 or firm 2, but not both firms, chooses direct investment. As expressed in figure 4.2, this means that as η increases, one firm moves along the BC-segment, while the other moves along the DE-segment.

The intuition behind this asymmetry is the following: Affiliate profits, $\Pi_1^{MN}(\eta)$, are more responsive in η than export profits, $\Pi_1^{NN}(\eta)$, so that the curves intersect at point B. But, while an increasing η increases the incentive to outsource export production in both firms, it will only be profitable for one of the firms to move. This is due to the fact that when the competitor direct invests, it can support a lower marginal cost through larger sales, which, in turn, lowers the market price. This will affect affiliate

[17]Parameter values set at $A = 5$, $s = 5$, $t = 0.2$, $G = 1.9$ and $T = 0.6$.

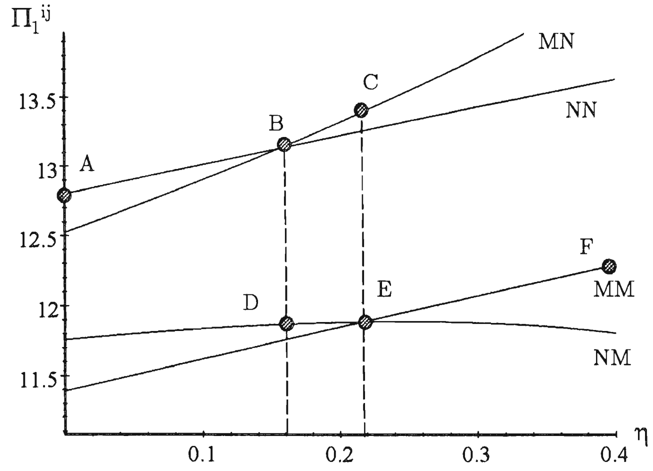


FIGURE 4.2. Equilibrium market structure in model 1

production more negatively than export production in the firm contemplating direct investment, due to the higher production volume in the former alternative.[18]

Third, increasing η from η_E, the market structure once more becomes a symmetric Nash-equilibrium, but an equilibrium where both firms choose FDI (*MM*). At higher levels of η, the advantage of supporting a much lower marginal cost when affiliate production is chosen, is sufficiently strong to induce the exporting firm to direct invest, despite the presence of the competitor's affiliate. This is shown as the movement along the EF-segment in figure 4.2.

The equilibrium market structure can then be summarized as the two paths *ABCEF* and *ABDEF* in figure 4.2, which gives rise to the following proposition.

Proposition 10 *The firms tend to be more inclined to choose affiliate production instead of export production, the larger is the relative return to R&D, η. But, while larger values of η tend to promote affiliate production, affiliate competition may require an even higher η to induce direct investment.*

[18]To see this, note that the profit function in (4.13) and (4.14) is convex. Furthermore, affiliate production is always higher than export production, due to the transport cost. It must then be the case that any change that expands output in both alternatives, increases profits more in affiliate production. Thus, any change that contracts output in both alternatives decreases profits less in export production. The latter is the outcome of an FDI-induced decrease in the marginal cost of the foreign firm.

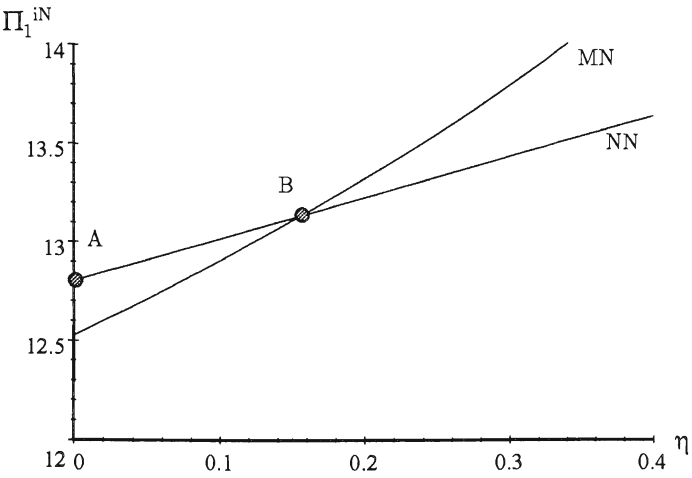


FIGURE 4.3. The MN-NN structure in model 1.

Accordingly, the model predicts that firms in knowledge-intensive industries, that is, industries with a relatively high relative return to R&D, are inclined to locate production abroad, while the opposite holds for firms in industries with a lower return to R&D.

Comparative statics

In this section, I will infer how the above prediction is affected by various exogenous changes. The previous section identified two critical values of η, associated with points B and E in figure 4.2: η_B, which is the level where one of the two firms will direct invest and η_E, which is the level where the remaining firm will also establish an affiliate. Comparative statics then involves investigating how η_B and η_E are affected by changes in the exogenous variables of the model. As it is straightforward to show that η_E is affected in a, qualitatively, identical way as η_B, I will focus on the behavior of η_B and, without loss of generality, assume that firm 1 is the firm which chooses FDI at B. To keep illustrations simple, I also reproduce point B and its corresponding profit curves, Π_1^{MN} and Π_1^{NN}, in figure 4.3.

For a given value of the vector of exogenous variables, $\mathbf{z}$, η_B is defined by the equality (4.16), stating an equalized profit in export and affiliate production.

$$\Pi_1^{MN}(\eta_B, \mathbf{z}) = \Pi_1^{NN}(\eta_B, \mathbf{z}) \tag{4.16}$$

Using the implicit function theorem, straightforward differentiation yields expression (4.17), which shows the effect on η_B of an increase in the exogenous variable z.

$$\frac{d\eta_B}{dz} = -\frac{\frac{\partial\left(\Pi_1^{MN}-\Pi_1^{NN}\right)}{\partial z}}{\frac{\partial\left(\Pi_1^{MN}-\Pi_1^{NN}\right)}{\partial \eta}} \tag{4.17}$$

In table 4.1 below, we evaluate (4.17) and report the signs of these derivatives. The explicit expressions are given in appendix 4.B. The first column indicates an increase in the exogenous variable z, while the second column shows the corresponding qualitative effect on η_B. A decrease in η_B is indicated by a minus sign, an increase in η_B by a plus sign. Finally, the last column gives the "marginal effect" on the firm's incentive to choose FDI and locate production abroad. This sign can be interpreted as the effect on the location decision in a marginal firm endowed with a relative return to R&D of η_B.

TABLE 4.1. Comparative statics results in model 1

Variable name	*Effect on* η_B	*Marginal effect on FDI-decision*
G	+	-
T	+	-
t	-	+

Let us then review the signs in table 4.1. Begin with the effect of higher transport costs. An increase in t will lower η_B and induce the marginal firm to produce abroad. This occurs since the marginal cost in export production does not only increase due to increased transport costs, but also due to the fact that a less extensive export production lowers R&D expenditures. In addition, higher transport costs also reduce the exports of the competitor, which increases affiliate production and R&D expenditures, thereby reducing the marginal cost if FDI is chosen. These effects magnify the difference in marginal costs between export and affiliate production (cf. eq. 4.15), which, in turn, allows profits in these two alternatives to be equalized at a lower η_B.[19] Hence, higher transport costs favor FDI, since a larger range of η permits direct investment.

The effects of other variables can be described in a similar way. It is not surprising that an increase in the plant-level fixed cost G benefits export

[19] In figure 4.3, $\Pi_1^{MN}(\eta)$ shifts upwards and $\Pi_1^{NN}(\eta_B, \mathbf{z})$ shifts downwards, thereby causing a fall in η_B, and a larger range of firms will face profitable FDI possibilities.

production, as it increases η_B and contracts the range over η, which allows for FDI. When G is increased, affiliate production requires a larger relative return, η, in order to equalize total profits between the two alternatives. In the same way, a larger technology transfer cost T also increases η_B and decreases the range over which FDI occurs.

4.2.3 Model 2 - Variable transfer costs

Foreign investment may well be more expensive than domestic alternatives, but transfer costs may also quite possibly be associated with the technological level, that is, with the R&D level. More complex technologies may require closer interchange of information with manufacturing, thereby increasing communication and information costs if production is located abroad. Indeed, Teece (1977) finds, among other things, that transfer costs increase with technological complexity.[20]

We incorporate variable transfer costs by rewriting profit expressions (4.3) and (4.4) in the following way:

$$\begin{aligned} \Pi_1^{ij} &= \left(P^{ij} - c_h^{ij}\right) q_1^{ij} - \frac{\gamma\left(\left(1+\delta_1^i\right)x_1^{ij}\right)^2}{2} - G_1^i \qquad (4.18) \\ &= \left(P^{ij} - c_h^{ij}\right) q_1^{ij} - \frac{\gamma\left(x_1^{ij}\right)^2}{2} - T_1^i - G_1^i \\ \Pi_2^{ij} &= \left(P^{ij} - c_2^{ij}\right) q_2^{ij} - \frac{\gamma\left(\left(1+\delta_2^j\right)x_2^{ij}\right)^2}{2} - G_2^j \qquad (4.19) \\ &= \left(P^{ij} - c_2^{ij}\right) q_2^{ij} - \frac{\gamma\left(x_2^{ij}\right)^2}{2} - T_2^j - G_2^j \end{aligned}$$

In (4.18) and (4.19), marginal costs, inverse demand and plant-specific costs are still defined by (4.1), (4.2) and (4.5). However, whereas we assumed the transfer cost T to be fixed in (4.6), the transfer cost in (4.18) and (4.19) is now made dependent on the actual level of R&D. This is done by introducing a parameter δ, such that $\delta_h^M = \delta > 0$, if FDI is chosen and $\delta_h^N = 0$, if export production is chosen. It simply means that a given level of R&D, x, equally lowers the cost of production, irrespective of location (cf. equation (4.1)), but that the implementation of the technology abroad requires additional R&D efforts of δx. From (4.18) and (4.19), we can then

[20] In a general sense, locating production abroad may also generate other types of costs: Horn and Persson (1998) show that if FDI requires acquisition of local assets, competition between the firms contemplating such investment decisions may increase the price of these assets. When producing abroad, there is a greater risk that the technology is dissipated, which requires additional measures for protecting firm-specific assets.

restate the resulting transfer costs as:

$$
\begin{aligned}
T_1^i &= \begin{cases} \frac{\delta(2+\delta)}{2}\left(x_1^{ij}\right)^2 > 0, & \text{for } i = M \\ 0, & \text{for } i = N \end{cases} \\
T_2^j &= \begin{cases} \frac{\delta(2+\delta)}{2}\left(x_2^{ij}\right)^2 > 0, & \text{for } j = M \\ 0, & \text{for } j = N \end{cases}
\end{aligned}
\tag{4.20}
$$

where we note that $T(\cdot)$ is indeed increasing with the level of R&D, x.

The model can, once more, be solved by letting the firms maximize (4.18) and (4.19) in x_h^{ij} and q_h^{ij}. This is done exactly as in model 1, so that it will suffice to present equilibrium quantities and profits. If we define a parameter α as a measure of the impact of the transfer cost:

$$
\alpha \equiv \frac{1}{(1+\delta)^2} < 1 \tag{4.21}
$$

the solution for the equilibrium quantities in the four different market structures for firm 1 is given in (4.22):

$$
\begin{aligned}
q_1^{NN} &= s\frac{A-t}{3-\eta}, \qquad q_1^{MN} = s\frac{A(1-\eta)+t}{(2-\alpha\eta)(2-\eta)-1} \\
q_1^{NM} &= s\frac{(1-\alpha\eta)(A-t)-t}{(2-\alpha\eta)(2-\eta)-1}, \qquad q_1^{MM} = s\frac{A}{3-\alpha\eta}
\end{aligned}
\tag{4.22}
$$

whereas the symmetric quantities for firm 2 are given in (4.23):

$$
\begin{aligned}
q_2^{NN} &= s\frac{A-t}{3-\eta}, \qquad q_2^{NM} = s\frac{A(1-\eta)+t}{(2-\alpha\eta)(2-\eta)-1} \\
q_2^{MN} &= s\frac{(1-\alpha\eta)(A-t)-t}{(2-\alpha\eta)(2-\eta)-1}, \qquad q_2^{MM} = s\frac{A}{3-\alpha\eta}
\end{aligned}
\tag{4.23}
$$

Finally, we can write the corresponding total profits as, (4.24) and (4.25)

$$
\Pi_1^{ij}(\eta) = \begin{cases} \frac{1}{2s}\left(q_1^{Mj}\right)^2(2-\alpha\eta) - G \\ \frac{1}{2s}\left(q_1^{Nj}\right)^2(2-\eta) \end{cases} \tag{4.24}
$$

$$
\Pi_2^{ij}(\eta) = \begin{cases} \frac{1}{2s}\left(q_1^{iM}\right)^2(2-\alpha\eta) - G \\ \frac{1}{2s}\left(q_1^{iN}\right)^2(2-\eta) \end{cases} \tag{4.25}
$$

where quantities q_h^{ij} are given by (4.22) and (4.23).

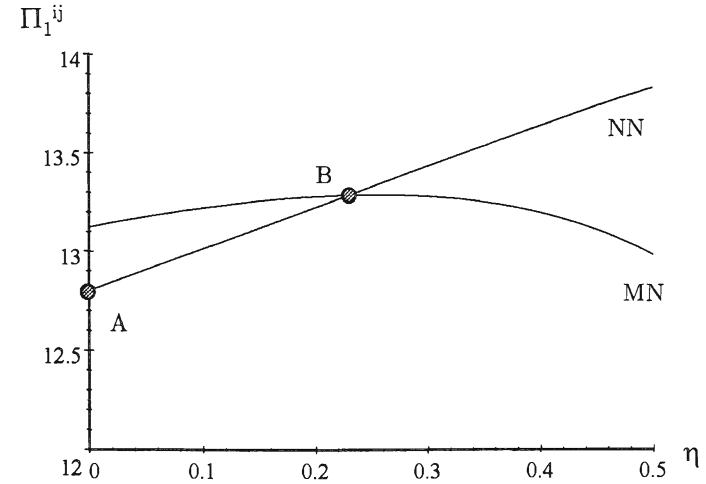


FIGURE 4.4. The MN-NN structure in model 2

Equilibrium market structure with variable transfer costs

As was the case in model 1, the symmetry of (4.24) and (4.25) can be used and an analogue to figure 4.2 can easily be obtained. We can pick the quantities and the associated profit function for one of the firms, draw the curves and then solve for the equilibrium structure.

In this case it is, however, difficult to derive a counterpart to proposition 9, but the main insights can be obtained by a simulation exercise. I will present the counterpart to figure 4.3 and study the MN-NN structure, where only firm 1 contemplates the FDI-decision.[21] This is done in figure 4.4.

Apart from the transfer cost parameters α and T, identical parameter values are used in figures 4.3 and 4.4.[22] Two features may be observed:

First, note that the NN-curves in figures 4.3 and 4.4 are identical - that is, when exports are chosen, transfer costs are zero. However, whereas the MN-curve is initially below the NN-curve in figure 4.3, the opposite holds in figure 4.4 (compare point A in figures 4.3 and 4.4). This different pattern arises, since no R&D occurs at a zero return to R&D.[23] Thus, at $\eta = 0$, transfer costs are not present in figure 4.4, whereas the transfer cost is still

[21] It is straightforward to derive the entire equilibrium structure, as in figure 4.2.

[22] Parameter values set at $A = 5$, $s = 5$, $t = 0.2$, $G = 1.9$ and $\alpha = 0.8$.

[23] As in model 1, the R&D quantities in model 2 are proportional to production quantities, that is: $x_1^{MN} = \frac{\theta}{\gamma}\alpha q_1^{MN}$ and $x_1^{NN} = \frac{\theta}{\gamma} q_1^{NN}$. Combining this with (4.22), we get: $x_1^{MN} = \frac{\alpha\eta}{\theta}\frac{(1-\alpha\eta)(A-t)-t}{(2-\alpha\eta)(2-\eta)-1}$ and $x_1^{NN} = \frac{\eta}{\theta}\frac{A-t}{3-\eta}$. Compare this with model 1, where: $x_1^{MN} = \frac{\eta}{\theta}\frac{(1-\eta)(A-t)-t}{(1-\eta)(3-\eta)}$ and $x_1^{NN} = \frac{\eta}{\theta}\frac{A-t}{3-\eta}$.

$T > 0$ in figure 4.3.

Second, there is also a reversal of slopes in the two figures. Note that the MN-curve is always steeper than the NN-curve in figure 4.3, but that the opposite holds in figure 4.4. This pattern arises due to the advantage of avoiding the transport cost - larger sales facilitate additional R&D - which is countervailed by a two-fold disadvantage in figure 4.4. High technology transfer costs tend to restrict the firm's own R&D, while the other firm, which does not face the transfer cost, can increase its R&D expenditures.[24]

Which is then the relationship between technology and location in figure 4.4? Since the MN-curve is above the NN-curve up to point B, and then falls below it, the conclusion is the opposite from the one in the previous section. In this case, low-tech (low η) firms choose FDI and produce abroad, whereas high-tech firms (high η) choose export production. We then have the following proposition:

Proposition 11 *When technology transfer costs are related to a firm's level of R&D, the firm tends to be more likely to choose export production rather than affiliate production, the larger is the relative return to R&D, η.*

The intuition behind proposition 11 is simply that a firm with a high ability to perform R&D will want to make further investments in R&D. But, as the firm devotes more resources to R&D, the cost of transferring its technology also increases. Therefore, with transfer costs related to the level of R&D, high-tech firms may gain more by avoiding transfer costs than by avoiding transport costs of physical units.[25]

Finally, comparative statics tends to give results similar to those in model 1. As such exercises were described in detail in the previous section, only the results will be given here. Increasing transportation costs will increase η_B and expand the region over which FDI takes place, whereas an increase in the transfer parameter δ (i.e. a decrease in α) or an increase in the fixed cost G will decrease η_B, thereby diminishing the region over which FDI occurs.

Accordingly, if technology transfer costs are dependent on the size of R&D, the prediction of how technology affects a firm's choice between ex-

---

[24] For firm 1, we have $x_1^{MN} = \frac{\theta}{\gamma}\alpha q_1^{MN}$, where $\alpha < 1$. For firm 2, we have $x_2^{MN} = \frac{\theta}{\gamma} q_2^{MN}$.

[25] The transfer parameter δ must reach a certain size to in order to make the MN and NN- curves intersect. In figure 4.4, α is set to 0.8, which by (4.21), implies a value of δ of approximately 0.12. Hence, the reversal of slopes occur at rather low values of δ. But since we are assuming quadratic transfer cost (cf. equation (4.20), even at such low values of δ, the effects are quite strong. However, the result in proposition 11 do not require quadratic transfer costs. It is possible to construct examples where the transfer cost is only proportional to the R&D effort, x, where the NN-curve slopes more steeply than the MN curve at an increasing η. What seems to be important for the result in proposition 11 is then that the transfer cost influences the level of R&D, x.

port and affiliate production is reversed. Then firms in industries with a relatively high relative return to R&D are more inclined to locate production to the home country, while firms in industries with a lower return to R&D tend to choose FDI.

4.3 Empirical analysis

The theoretical section gives an ambiguous view of the relation between a firm's technology and its choice between affiliate and export production. Since the two models give rise to different predictions about this relationship, this provides an opportunity to test the impact of technology transfer cost and, in effect, the relevance of the two specifications.

4.3.1 Data

The primary data source is a data set from the Research Institute of Industrial Economics (IUI), based on a questionnaire sent to all Swedish MNFs every fourth year, on average. Data is available for seven years: 1965, 1970, 1974, 1978, 1986, 1990 and 1994. The survey covers almost all Swedish multinational firms in the manufacturing sector, and detailed information is available on variables such as R&D, employment, production and their distribution between domestic and foreign units, as well as on internal and external trade flows.

This rich data set has been used in the following way: (i) All firms with at least one production affiliate abroad are included in the sample. (ii) Within this set of firms with production affiliates, we focus on foreign sales to the OECD countries.[26] (iii) All exports sales are sales of final goods, that is, the impact of input goods is removed. (iv) Exports back to Sweden from the affiliates have been removed from affiliate production.

Let me briefly comment on these conditions. Ideally, firms without production affiliates should be included in the sample, but corresponding firm-level data for purely exporting firms is simply not available.[27] I have chosen to focus on OECD countries, since the modelling framework does not emphasize differences in factor costs. In addition, sales to OECD countries cover the vast majority of foreign sales in these firms. Finally, the last two criteria are chosen to comply with the absence of input-goods and home-market effects in the theoretical section.

[26] The countries included are: Belgium, France, Italy, Holland, Germany, Luxemburg, UK, Norway, Ireland, Denmark, Spain, Portugal, Greece, Finland, Austria, Switzerland, USA, Canada, Japan, Australia and New Zealand. The last two countries are combined into one single country observation.

[27] The IUI database does include firms with sales affiliates, but R&D is not recorded for such firms.

Additional information on country and industry specific variables are taken from World Development Indicators (1997), OECD (1997) and SCB.

4.3.2 Dependent variable

The models presented in the previous section predict a firm's choice between implementing its technology in export or affiliate production. This is, however, a discrete choice which cannot easily be observed from the data. In the estimations below, we will therefore follow Brainard (1997) and use the share of foreign sales accounted for by the affiliates as our dependent variable. This variable is labeled $AFSHARE_{ijt}$, and is defined:

$$AFSHARE_{ijt} = \frac{SQ_{ijt}}{SQ_{ijt} + SX_{ijt}} \tag{4.26}$$

where SQ_{ijt} denotes the level of production for firm i in country j at time t and SX_{ijt} is the corresponding export level. This relative measure indirectly captures the implementation choices of the firms.[28] It also subsumes the two endogenous variables, export and affiliate production, into a single variable. The log of $AFSHARE$ will be used. Logs are also used in all continuous, independent variables.

4.3.3 Method

The dependent variable in (4.26) is censured - it can take on any values between zero and one. A closer look at the data set reveals that the firms only have production affiliates in a minority of the countries for which foreign sales are recorded. Thus, $AFSHARE_{ijt}$ contains a large number of zeros. Omitting these observations will result in a systematic selection bias causing any OLS-estimates on $AFSHARE_{ijt}$ to be both biased and inconsistent.[29] Therefore, a two-stage selection biased corrected regression model from Heckman (1979) is employed.

In the first stage, a probit is estimated for the overall sample, in order to obtain the probability for firm i of undertaking any production in country j at time t:

$$\Pr(AFSD_{ijt}) = \Phi(\alpha_0 + \mathbf{Z}_{ijt}^{'}\alpha_1) \tag{4.27}$$

---

[28] Strictly speaking, the theoretical section makes a prediction on a dichotomous choice - to invest at home or abroad - suggesting that we should look at cases where $AFSHARE$ is zero or one. This is also done in the probit stage of the estimation method described below. It should be noted, however, that many of the firms studied here are large multi-affiliate firms with multiple product lines. Therefore, studying the variation in $AFSHARE$, when this variable is not zero or one, is still valid.

[29] Taking logs of $AFSHARE$ implies that all observations where $AFSHARE = 0$, that is, where the market is exclusively served by exports, are treated as missing values. This problem can be circumvented by using the two-stage method.

where $\Phi(.)$ denotes the standard cumulative normal distribution, $AFSD_{ijt} = 1$, if $AFSHARE_{ijt} > 0$ and $AFSD_{ijt} = 0$ otherwise. The parameters in $\boldsymbol{\alpha}_1$ show the effect of the independent variables contained in $\mathbf{Z}$, on the probability that a firm undertakes production in a certain country.[30] Based on this probit, a sample correction variable λ_{ijt} is calculated for all observations:

$$\widehat{\lambda}_{ijt} = \frac{\phi(\widehat{\alpha}_0 + \mathbf{Z}'_{ijt}\widehat{\boldsymbol{\alpha}}_1)}{\Phi(\widehat{\alpha}_0 + \mathbf{Z}'_{ijt}\widehat{\boldsymbol{\alpha}}_1)} \tag{4.28}$$

where $\phi(.)$ is the standard normal density function and $\Phi(.)$ is defined as in (4.27).

In the second stage, OLS is applied to the restricted sample for which $AFSHARE_{ijt} > 0$, with the correction variable $\widehat{\lambda}_{ijt}$ included.

$$AFSHARE_{ijt} = \beta_0 + \mathbf{X}'_{ijt}\boldsymbol{\beta}_1 + \beta_\lambda \widehat{\lambda}_{ijt} + \varepsilon_{ijt} \tag{4.29}$$

where the parameters in $\boldsymbol{\beta}_1$ indicate the marginal effects of the explanatory variables in $\mathbf{X}$ on the share of affiliate production in foreign sales. Finally, note that since $\widehat{\lambda}_{ijt}$ is included, the estimates in (4.29) will be consistent, but their standard errors will be heteroskedastic. We will therefore use White's (1980) correction for heteroskedasticity to obtain efficient standard errors.[31]

4.3.4 Exogenous variables

In table 4.2, the independent variables in equations (4.27) and (4.29) and the corresponding exogenous variables from the theoretical section (for which they act as proxies), are presented. For convenience, I also reproduce their expected sign, based on my findings in the theoretical section. Two kinds of independent variables will be used; core variables and additional variables.

Core variables

This group of independent variables is closely attached to the exogenous variables encountered in the theoretical section.

---

[30] The error term u_{ijt} in the model (4.27) is assumed to have standard properties. That is, $u \sim (0, \sigma_u^2)$, $E(u_{hjt}, u_{ijt}) = 0$ for $h \neq i$, $E(u_{ijt}, u_{ikt}) = 0$ for $j \neq k$ and $E(u_{ijs}, u_{ijt}) = 0$ for $s \neq t$.

[31] With the sample selection correction variable included and the use of the White (1980) method, the residuals in (4.29) are assumed to have standard properties. That is, $\varepsilon \sim (0.\sigma_\varepsilon^2)$, $E(\varepsilon_{hjt}, \varepsilon_{ijt}) = 0$ for $h \neq i$, $E(\varepsilon_{ijt}, \varepsilon_{ikt}) = 0$ for $j \neq k$ and $E(\varepsilon_{ijs}, \varepsilon_{ijt}) = 0$ for $s \neq t$.

TABLE 4.2. Description of variables

Variable name	*Proxy for*	*Expected sign*	*Description and source*
RDINT	η η	+ −	share of a firm's total R&D expenditures in its total sales, lagged eight years in table 4.3, present intensity in table 4.4, (IUI-database).
TREMB	t t	+ +	share of transport and packing costs in total variable costs at the three- or four-digit level in the Swedish industry to which the firm belongs, (SCB).
DIST	t t	+ +	distance from Sweden to the respective countries where the firm records foreign sales, (IUI-database).
AGE1	T δ	+ +	weighted average of the mean age of the firm's affiliates in the respective countries where production takes place. Weights calculated as the share of the firm's total foreign sales attributed to the individual countries, (IUI-database).
RD1	T δ	+ +	dummy variable that takes on the value of one if the firm undertakes any R&D abroad, zero otherwise, (IUI-database).
GSCALE1	G G	− −	average size of the affiliates divided by the average size of the firms in terms of employees at the three- or four-digit industry level to which the firm belongs, (IUI-database).

TABLE 4.2. Continued

Variable name	*Proxy for*	*Expected sign*	*Description and source*
AGE2	T δ	+ +	mean age of a firm's affiliates in a specific country, (IUI-database).
RD2	T δ	+ +	dummy variable that takes on the value of one if the firm undertakes any R&D in a country, zero otherwise, (IUI-database).
GSCALE2	G G	– –	average size of plants with more than one hundred employees divided by total industry mean size at the three- or four-digit level Swedish industry, to which the firm belongs, (SCB).
GDP			PPP-adjusted, deflated GDP, (OECD, 1997; World Bank, 1997).
INCOME			ratio between PPP-adjusted, deflated GDP per capita in Sweden and the respective countries where the firm records foreign sales, (OECD, 1997; World Bank, 1997).
OPEN			index measuring the openness of a country to FDI, (Wheeler and Moody, 1992).
AGGLOM			share of total employment in an industry at the three- or four-digit industry level in the respective countries where a firm records foreign sales, (Braunerhjelm and Svensson, 1996 and OECD, 1997).

Note: Column two describes the exogenous variable to which the proxy refers. As the theoretical section involves two models with both different variables and different predictions, the top row for each exogenous variable corresponds to model 1, whereas the bottom row corresponds to model 2.

R&D intensity.

R&D intensity, RD_{ijt}, defined as the share of R&D expenditures in the total sales of the firm, is used as a proxy for the relative return to R&D, η, and as such, it is the variable of most interest.[32] I will use two different intensities in the estimations below, the use of which can be rationalized as follows: The structure in our theoretical models - in which R&D expenditures are set before location decision and market interaction - suggests that a lagged R&D intensity should be used. Ravenscraft and Scherer (1982) propose a lag of approximately five years between R&D expenditures and profits. This suggests a four-year lag to be appropriate. However, since lagged R&D expenditures are endogenously determined in the theoretical section, we must instrument in order to avoid simultaneity bias.

First, the eight-year lag on R&D intensity will be used.[33] In addition, I will also report estimations, using the present R&D intensity as an instrument, thereby avoiding a large loss of observations associated with the eight-year lag due to the unbalanced nature of the data set.[34] Note also that given that R&D is conducted before any market interaction, R&D in time t should be uncorrelated with the error terms in (4.27) and (4.29).

Plant-specific costs

Unfortunately, no direct measure of the plant level fixed costs G can be calculated, as the data base lacks information on individual plants in the *Swedish* part of the corporation. Information on plant size is available for affiliates, but using this information without care gives rise to two immediate problems:[35] (i) If plant-level scale economies are sufficiently large, then we would suspect that domestic production is preferred, thereby indicating that proxies for G based solely on affiliate information may be misleading. (ii) Relating large affiliate plants directly to $AFSHARE$ may give a spurious correlation - large affiliates should account for a large share of foreign sales, a relationship which may have little to do with the effect of scale economies on the location decision.

We will rely on two different industry proxies for G. The first, $GSCALE1_{it}$,

[32] In appendix 4.C, it is also shown that R&D intensity, defined as the share of R&D expenditures in total sales, is positively correlated with our theoretical measure of return to R&D, η.

[33] Essentially, this is a two-period lag. For most observations, this implies an eight-year difference. However, since no survey was conducted in 1982, we use 1978 as an instrument for both 1990 and 1986.

[34] In principle, we have a panel data set, in the sense that the activities of the firms included are recorded over time. In practice, however, this panel is extremely unbalanced as many firms disappear, when they are acquired or reorganized over time. Any lag structure in such data material will involve a substantial loss of observations.

[35] To be more specific, we have data on individual affiliates. But these are often synonymous with individual plants.

uses the IUI-sample. It is defined as the ratio between the average number of employees in affiliates and the average number of employees in the corporations at the three- or four-digit industry level. The second, $GSCALE2_{it}$, is calculated from Swedish industrial statistics. It is defined as the average size of plants with more than one hundred employees divided by total industry mean size, at the three- or four-digit industry level to which the firm belongs.[36] $GSCALE1$ is used in the probit (4.27), whereas $GSCALE2$ is included in the OLS (4.29).

Transport costs

Turning to transport costs, $TREMB_{it}$ is calculated as the share of transport and packing costs in total variable costs, and once more, Swedish three- or four-digit industry level data are used. In addition to packing and transport costs, total variable costs include costs for electricity, raw materials and wages for blue-collar workers. The second measure, $DISTW_{jt}$, is an index measuring the geographical distance from Sweden to the respective countries.

Transfer cost

It is very difficult to find a variable which accurately captures the effect of technology transfer costs. Following Swedenborg (1982), it may be argued that more experience of production abroad should lower technology transfer costs to units abroad, and that this should also be the case for firms performing R&D abroad.

To capture the effects of experience in foreign production, $AGE1_{it}$ reflects a weighted average of the age of the affiliates of a firm, irrespective of their location. $AGE2_{ijt}$ is simply the mean age of the affiliates in a particular country. To measure the effects of R&D abroad, we construct two dummy variables; $RD1_{it}$ takes on the value of one, if the firm performs any R&D abroad, and $RD2_{ijt}$, which takes on the value of one if the firm performs any R&D in the country in question.

Additional variables

In addition to the core variables, a set of dummy variables and a set of control variables will also be included.

Dummy variables

By using additive dummies, we will control for region-specific effects, industry-specific effects and time-specific effects. The regions are EFTA, the EC, North America and the Far East. Industry dummies are employed at the two- or three-digit industry level.

---

[36] Plants with less than a hundred employees are excluded, since this group is likely to mainly consist of smaller firms producing predominately for the Swedish market.

Control variables

The first control variable is the size of the respective country measured as PPP-adjusted, deflated GDP, GDP_{jt}.[37] Following Brainard (1997), I also control for differences in factor proportions through the variable $INCOME_{jt}$, measuring per capita income differences between Sweden and the respective countries where the firm operates. $OPEN_{jt}$ is an openness index taken from Wheeler and Moody (1992), measuring the openness of a country to FDI. Finally, following Braunerhjelm and Svensson (1996), I control for the influence of agglomeration effects on the location decision through the variable $AGGLOM_{ijt}$. This variable is defined as the share of all employees in the manufacturing sector in the industry to which the investing firm belongs, out of all employees in the manufacturing sector in the respective countries. If pecuniary externalities in terms of cost and demand linkages are present in an industry, thereby attracting direct investments, such agglomeration forces should be captured by this variable.[38]

4.3.5 Estimation results

The results of three different specifications are reported in this section. For each of these, the results of the probit and the OLS are reported separately.

Lagged R&D intensity

Table 4.3 reports the results using the eight-year lag on R&D intensity. Specification (i) reports the results of the core variables. Both the probability effect and the marginal effect are significantly negative for $RDINT$. That is, the larger the lagged R&D intensity, the smaller the probability that a firm locates production in a country and - given that production is established - the smaller is the share of foreign sales accounted for by the affiliates. Note that this negative, significant sign supports the relationship predicted in model 2, where transfer costs were assumed to be variable, and thereby rejecting the prediction in model 1, where transfer costs were assumed to be fixed.

Turning to transport costs, $TREMB$ has the predicted, positive sign in both equations. $DIST$ is also significant, but appears with different signs in the probit and the OLS. Thus, when the geographical distance increases, the probability of a firm locating production in a country decreases, whereas - given that affiliates are established - a larger distance favors local pro-

[37] The reason why size is only used as a control variable is that s is included in the definition of η, and therefore affects the R&D intensity. But since I aim at capturing the implementation choices of new technologies through $AFSHARE$, it is still necessary to control for size effects.

[38] This type of externalities may involve the use of joint networks of suppliers and distributions (see Krugman (1991a, 1991b) and Venables (1996)).

duction. The latter result is predicted in the theory section, whereas the former is somewhat unexpected. As Ekholm (1998) argues, it may be the case that a larger distance also reflects cultural and institutional factors, in which case the increasing cost of FDI dominates the effects of transport costs.

Variables $AGE1, RD1$ and $GSCALE1$ all have the predicted signs in the probit, although $RD1$ is not significant. Hence, more experience in foreign production clearly increases the probability of producing abroad, whereas scale economies at the plant-level work in the opposite way. Turning to the regression, the corresponding variables, $AGE2, RD2$ and $GSCALE2$, reveal similar information, with the difference that the R&D dummy is now significant. Thus, if the firm has established R&D laboratories in a host country, this obviously facilitates transfers of technology and production to such a country. We also note that a sample selection bias indeed exists, as the coefficient on $LAMBDA$ is positive and highly significant.

Specification (ii) adds dummies for regions, industries and time, as well as the GDP-level in the different countries. The results are quite robust to the inclusion of these variables. No sign changes are recorded, even though the estimated coefficient of some of the variables changes somewhat. The effect of distance is substantially strengthened in the probit estimation, whereas transport costs are now insignificant.

The GDP-variable exerts a significant positive influence - the size of a country is of great importance for a firm's decision to establish production. Once affiliates are established, local production seems be chosen over exports to a larger extent, when country size increases. Finally, the error correction variable is positive and highly significant.

Specification (iii) adds three variables: $INCOME$, FDI and $AGGLOM$. As compared to specification (ii), the parameter estimates are quite similar, even though the GDP-variable in the regression is now only marginally significant. The coefficients on $INCOME$, proxying for differences in relative factor endowments, are positive and significant in both the probit and the OLS. Hence, within this set of OECD countries, factor proportions seem to explain some of the variation in the dependent variable. The same pattern is also found for the openness of a country to FDI, even though this variable is only weakly significant. Finally, pecuniary externalities in the shape of cost and demand linkages in the host countries, significantly increase the share of foreign sales of the affiliates, but they do not seem to affect the probability of establishing production.

TABLE 4.3. Two-stage Heckman estimation: lagged R&D-intensity

Variables	Specification (i)		Specification (ii)		Specification (iii)	
	Probit	OLS	Probit	OLS	Probit	OLS
RDINT	-0.084 (-3.307)	-0.126 (-4.818)	-0.098 (-2.971)	-0.197 (-5.690)	-0.090 (-2.496)	-0.189 (-5.239)
TREMB	0.125 (2.783)	0.243 (5.679)	0.076 (1.002)	0.118 (2.329)	0.164 (1.922)	0.162 (3.321)
DIST	-0.171 (-5.752)	0.221 (5.587)	-0.558 (-9.173)	0.182 (2.212)	-0.455 (-5.098)	0.401 (4.292)
AGE1	0.165 (5.083)		0.119 (3.294)		0.121 (2.994)	
RD1	0.079 (1.073)		0.225 (2.657)		0.273 (2.939)	
GSCALE1	-0.233 (-6.701)		-0.354 (-7.636)		-0.351 (-6.932)	
AGE2		0.171 (5.954)		0.144 (5.376)		0.118 (4.132)
RD2		0.193 (3.800)		0.180 (3.446)		0.199 (3.737)
GSCALE2		-0.493 (-5.349)		-0.308 (-2.908)		-0.290 (-2.684)
GDP			0.385 (13.387)	0.133 (2.893)	0.371 (10.091)	0.075 (1.704)
INCOME					0.230 (1.868)	0.181 (1.924)
OPEN					0.365 (1.775)	0.263 (1.829)
AGGLOM					0.087 (1.034)	0.180 (2.072)
LAMBDA		0.488 (3.519)		0.688 (4.816)		0.507 (3.500)
Prediction errors (%)	32.5		26.9		29.2	
Chi2	125.98		467.38		369.31	
AdjR^2		0.2559		0.2992		0.3092
F		22.47		9.78		7.81
No. of var.	6	7	23	24	26	27
No. of obs.	2300	760	2300	760	1851	668

Note 1: The dependent variable in the OLS columns is the affiliates' share of foreign sales for firm i in country j at time t. The dependent variable in the probit columns is a dummy variable which equals one if production is registered, zero otherwise.

Note 2: Numbers in parenthesis are t-statistics. Prediction errors are formed at a critical probability of 0.5. All variables are in logs, except RD1, RD2 and LAMBDA. Sample size differences reflect missing observations. Intercept and dummies for region, industry and time are not shown for Specifications (ii) and (iii).

TABLE 4.4. Two-stage Heckman estimation: present R&D-intensity

Variables	Specification (i)		Specification (ii)		Specification (iii)	
	Probit	OLS	Probit	OLS	Probit	OLS
RDINT	-0.088	-0.171	-0.085	-0.233	-0.084	-0.236
	(-4.234)	(-7.226	(-3.437)	(-8.634)	(-3.100)	(-8.791)
TREMB	0.034	0.194	0.056	0.122	0.080	0.108
	(1.293)	(5.431)	(1.124)	(2.605)	(1.462)	(2.126)
DIST	-0.119	0.147	-0.592	0.166	-0.556	0.311
	(-5.350)	(5.534)	(-12.069)	(2.561)	(-7.880)	(4.218)
AGE1	0.213		0.196		0.194	
	(11.312)		(9.434)		(8.528)	
RD1	0.078		0.220		0.277	
	(1.592)		(4.075)		(4.725)	
GSCALE1	-0.220		-0.237		-0.245	
	(-8.536)		(-7.156)		(-6.764)	
AGE2		0.144		0.134		0.107
		(6.057)		(6.065)		(4.655)
RD2		0.233		0.235		0.247
		(5.509)		(5.375)		(5.482)
GSCALE2		-0.316		-0.152		-0.158
		(-4.545)		(-1.702)		(-1.759)
GDP			0.348	0.058	0.344	0.017
			(15.770)	(1.639)	(12.188)	(0.504)
INCOME					0.213	0.100
					(2.148)	(1.186)
OPEN					0.153	0.078
					(0.966)	(0.631)
AGGLOM					0.172	0.245
					(2.656)	(3.487)
LAMBDA		0.421		0.494		0.324
		(4.005)		(4.416)		(2.801)
Prediction errors (%)	25.5		23.3		25.7	
Chi2	315.26		829.90		658.64	
AdjR^2		0.1964		0.2512		0.2749
F		21.76		10.32		8.53
No. of var.	6	7	23	24	26	27
No. of obs.	4434	1144	4434	1144	3570	1011

Note 1: The dependent variable in the OLS columns is the affiliates' share of foreign sales for firm i in country j at time t. The dependent variable in the probit columns is a dummy variable which equals one if production is registered, zero otherwise.

Note 2: Numbers in parenthesis are t-statistics. Prediction errors are formed at a critical probability of 0.5. All variables are in logs, except RD1, RD2 and LAMBDA. Sample size differences reflect missing observations. Intercept and dummies for region, industry and time are not shown for Specifications (ii) and (iii).

Present R&D intensity

In table 4.4, specifications (i) to (iii) are estimated on basis of the contemporaneous R&D intensity. Overall, the results are quite similar in tables 4.4 and 4.3, indicating that the loss of observations due to the eight-year lag do not affect the results in a dramatic way.[39] This is especially true for the core variables, including the R&D variable $RDINT$.

It should be noted, however, that the effect of experience in foreign production is stronger in table 4.4. This is the case for both $AGE1$ and $AGE2$. Plant scale economies, as measured by $GSCALE2$, are weakened in the regression, and differences in factor proportions, as measured by $INCOME$, now only significantly affect the probability of finding any affiliates in a country. The size variable, GDP, follows the same pattern. Furthermore, note that agglomeration forces, as measured by the variable $AGGLOM$, have a stronger impact when the contemporaneous R&D intensity is used. These differences may reflect the fact that using the lagged R&D intensity predominantly includes the older, more established firms in the sample.

4.4 Conclusions and discussion

The purpose of this paper was to model how a firm's choice of technology interacts with the way in which a foreign market is served, and to test the insights gained from this theoretical exercise. Theory produced an ambiguous relationship. I found that avoiding transport costs generates an additional incentive to increase R&D efforts as sales increase, thereby generating a wedge in units cost between export and affiliate production, which exceeds the trade cost. Hence, firms which produce abroad to a higher degree, should also perform R&D to a larger extent.

However, this result was derived under the assumption that technology transfer costs are independent of how advanced the technology is. Relaxing this assumption and assuming that transfer costs were dependent on the level of R&D efforts, the prediction was reversed, simply because the cost of transferring the technology also increases in R&D.

Turning to the empirical results, these confirm the findings of other stud-

---

[39] One might argue that there is an autocorrelation problem in (4.29), due to rigidities in the dependent variable over time, so that $E(\varepsilon_{ijt}, \varepsilon_{ijs}) \neq 0$ for $t \neq s$. In other words, a high (low) affiliate share of foreign sales today would imply a high (low) share tomorrow. However, this need not be a great problem since (i) the dependent variable is a share recorded with rather long intervals, and (ii) only a minority of the firms are recorded in multiple consecutive time periods.

I also estimated fixed effects regressions controlling for country-specific, firm-specific and time-specific effects, which partly reduce the problem with autocorrelation. The results, which are not given here, were more or less the same.

ies to a great extent. This is the case with plant-level scale economies, transport costs, distance and experience of FDI (e.g Brainard, 1997; Ekholm, 1998; and Swedenborg, 1982). However, we do find that an increasing R&D intensity tends to favor export production rather than affiliate production. Even though this export bias in R&D intensive production is perfectly consistent with a theoretical model in the presence of R&D related transfer costs, it may seem surprising, as the literature suggests a positive correlation between R&D intensity and foreign production.[40]

Indeed, using the same type of two-stage estimation on US industry data, Brainard (1997) finds that R&D intensity increases the probability of an industry locating production in a foreign country. But, R&D intensity is not included as an independent variable in her second-stage regression, since she cannot theoretically pin down the sign of the relationship between technology and the way in which the market is served. However, she does find that when levels of affiliate production and exports are separately regressed against R&D intensity; both increase in R&D, but the elasticity of exports is much stronger. Note that this is quite consistent with the export bias in my OLS-results.[41]

Finally, it should be noted that I have derived my results from a sample of Swedish MNFs with producing affiliates. Firms which exclusively serve foreign markets by exports are not included in this sample. This suggests that the inclusion of exporting firms may reverse the sign of the coefficient on R&D in the probit equation, which would confirm Brainard's findings. However, the negative relationship between R&D and the affiliate share will not be affected since this regression, by definition, only includes firms with producing affiliates.

To further investigate the relationship between technology and location, future research should involve efforts broadening the sample with not only exporting firms, but also firms predominately producing for the domestic market.

4.5 References

Blomström, M. and Y. Wang. "Foreign investment and technology transfer: A simple model". *European Economic Review*, 36:137–155, 1992.

Brainard, S.L. A simple theory of multinational corporations and trade with a trade-off between proximity and concentration. NBER Working Paper No. 4269, 1993.

Brainard, S.L. "An empirical assessment of the proximity-concentration

[40] See Caves (1996) and Markusen (1995).

[41] Brainard finds that the elasticity of affiliate sales with regard to R&D is 0.1840. The corresponding elasticity for exports is 0.4599. Hence, the affiliate share of foreign sales should decrease in R&D intensity. Lall (1980) finds this correlation in US industry data.

trade-off between multinational sales and trade". *American Economic Review*, 87:520–544, 1997.

Brander, J.A. and B.J. Spencer. "International R&D rivalry and industrial strategy". *Review of Economic Studies*, 50:707–722, 1983.

Brander, J.A. and B.J. Spencer. "Export subsidies and market share rivalry". *Journal of International Economics*, 18:83–100, 1985.

Braunerhjelm, P. "Utlandsinvesteringar, kunskapsintensitet och förädlingsvärde – Svensk tillverkningsindustri 1974-1994". *Ekonomisk Debatt*, 24, 1996.

Braunerhjelm, P. and R. Svensson. "Host country characteristics and agglomeration in foreign direct investment". *Applied Economics*, 28:833–40, 1996.

Caves, R.E. *Multinational Enterprise and Economic Analysis.* Cambridge and New York: Cambridge University Press, 2nd edition, 1996.

Cheng, L. "International competition in R&D and technological leadership". *Journal of International Economics*, 17:15–40, 1984.

Dunning, J.H. "Trade, location of economic activities and the MNE: A search for an eclectic approach". In P.-O. Hesselborn, B. Ohlin and P.-M. Wijkman, editors, *The International Allocation of Economic Activity*, pages 395–418. London: MacMillan, 1977.

Ekholm, K. *Multinational Production and Trade in Technological Knowledge.* PhD thesis, University of Lund, 1995. Lund Economic Studies No. 58.

Ekholm, K. "Proximity advantages, scale economies and the location of production". In P. Braunerhjelm and K. Ekholm, editors, *The Geography of Multinational Firms*, pages 59–76. Boston: Kluwer Academic Publishers, 1998.

Ethier, W.J. and J.R. Markusen. "Multinational firms, technology diffusion, and trade". *Journal of International Economics*, 41:1–28, 1996.

Flam, H. "EC members fighting about surplus: VERs, FDI and Japanese cars". *Journal of International Economics*, 36:117–131, 1994.

Fors, G. *R&D and Technology Transfers by Multinational Enterprises.* PhD thesis, Stockholm School of Economics, 1996.

Heckman, J. "Sample selection bias as a specification". *Econometrica*, 47:153–161, 1979.

Horn, H. and L. Persson. "The equilibrium ownership of an international oligopoly". 1998. In L. Persson, PhD Thesis, Stockholm University. Monograph Series, No. 35.

Horstmann, I. and J.R. Markusen. "Strategic investments and the development of multinationals". *International Economic Review*, 28:109–121, 1987.

Horstmann, I. and J.R. Markusen. "Endogenous market structures in international trade (*natura facit saltum*)". *Journal of International Economics*, 32:109–129, 1992.

Knickerbocker, F. *Oligopolistic Reaction and Multinational Enterprise.* Boston: Harvard University, 1973.

Krugman, P.R. *Geography and Trade.* Cambridge, MA and Leuven: MIT and Leuven University Press, 1991a.

Krugman, P.R. "Increasing returns and economic geography". *Journal of Political Economy*, 99:483–500, 1991b.

Lall, S. "Monopolistic advantages and foreign involvement by U.S. manufacturing industry". *Oxford Economic Papers*, 32:105–122, 1980.

Leahy, D. and P. Neary. "International R&D rivalry and industrial strategy without government commitment". *Review of International Economics*, 4:322–338, 1996.

Markusen, J.R. "Multinationals, multi-plant economies, and the gains from trade". *Journal of International Economics*, 16:205–26, 1984.

Markusen, J.R. "The boundaries of multinational enterprises and the theory of international trade". *Journal of Economic Perspectives*, 9:169–89, 1995.

Markusen, J.R. and A.J. Venables. "The increased importance of multinationals in North American economic relationships: A convergence hypothesis". In W.J. Ethier M. Canzoneri and V. Grilli, editors, *The New Transatlantic Economy.* London: Cambridge University Press, 1996a.

Markusen, J.R. and A.J. Venables. The theory of endowment, intra-industry, and multinational trade. NBER Working Paper No. 5529, 1996b.

Markusen, J.R. and A.J. Venables. "Multinational firms and the new trade theory". *Journal of International Economics*, 1998. Forthcoming.

Motta M. "Multinational firms and the tariff-jumping argument". *European Economic Review*, 36:1557–1571, 1992.

OECD. *Economic Outlook No 61: Annual Data.* OECD Publishers, 1997.

Pavelin, S. Playing away to win at home: A strategic model of the choice between exporting and multinational production with cost reducing R&D expenditures. Discussion Paper No. 9706, The Economics Research Centre, School of Economic and Social Studies Univeristy of East Anglia Norwich, 1997.

Ravenscraft, D. and F. Scherer. "The lag structure of returns to research and development". *Applied Economics*, 14:603–620, 1982.

Rowthorn, R. "Intra-industry trade and investment under oligopoly: The role of market size". *The Economic Journal*, 102:402–414, 1992.

Sanna-Randaccio, F. The impact of foreign direct investment on home and host countries with endogenous R&D. University of Rome "La Sapienza", Rome, Italy, 1998.

Sanna-Randaccio, F. and M. Petit. "Endogenous R&D and foreign direct investment in international oligopolies". 1998. Forthcoming in : International Journal of Industrial Organization.

Smith, A. "Strategic investment, multinational corporations and trade policy". *European Economic Review*, 31:89–96, 1987.

Spence, A.M. "Cost reductions, competition, and industry performance". *Econometrica*, 52, 1984.

SCB Statistiska Central Byrån. *Industristatistiken*. Various issues.

Swedenborg, B. *Svensk industri i utlandet. En analys av drivkrafter och effekter (Swedish Industry Abroad. An Analysis of Driving-Forces and Effects)*. Stockholm: IUI, 1982.

Teece, D.J. "Technology transfer by multinational firms: The resource cost of transferring technological know-how". *Economic Journal*, 87:242–61, 1977.

Venables, A.J. "Equilibrium locations of vertically linked industries". *International Economic Review*, 37:341–359, 1996.

Wheeler, D. and A. Mody. "International investment location decisions: The case of U.S. firms". *Journal of International Economics*, 33:57–76, 1992.

White, H. "A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity". *Econometrica*, 48:827–838, 1980.

World Bank. *World Development Indicators*. World Bank, 1997.

4.A Appendix: Proposition 9 and figure 4.2

This appendix addresses the statements in proposition 9 and how these can be used to derive figure 4.2.

4.A.1 Proof of proposition 9

In some of the expressions, I have used the condition $(1-\eta)(A-t)-t > 0$, which ensures that both firms produce positive outputs in all market structures (cf. equations (4.11) and (4.12)). By calculation:

$$\frac{\partial \pi_1^{MN}}{\partial \eta} = \frac{s}{2}\frac{(A(1-\eta)+t)\left(A(1-\eta)^3+t\left(13-12\eta+3\eta^2\right)\right)}{(1-\eta)^3(3-\eta)^3} > 0 \tag{4.A.1}$$

$$\frac{\partial \pi_1^{MM}}{\partial \eta} = \frac{1}{2}sA^2\frac{(1-\eta)}{(3-\eta)^3} > 0 \tag{4.A.2}$$

$$\frac{\partial \pi_1^{NN}}{\partial \eta} = \frac{s}{2}\frac{(A-t)^2(1-\eta)}{(3-\eta)^3} > 0 \tag{4.A.3}$$

$$\frac{\partial \pi_1^{NM}}{\partial \eta} = \frac{1}{2}s\left((1-\eta)(A-t)-t\right)\frac{A(1-\eta)^3-t(2-\eta)\left(\eta^2-4\eta+7\right)}{(-1+\eta)^3(-3+\eta)^3} \lesseqgtr 0 \tag{4.A.4}$$

$$\pi_1^{MN} - \pi_1^{NN} = \frac{st}{2}\frac{(2-\eta)^2(2A(1-\eta)+t\eta)}{(1-\eta)^2(3-\eta)^2} > 0 \tag{4.A.5}$$

$$\pi_1^{MM} - \pi_1^{NN} = \frac{1}{2}st(2-\eta)\frac{2A-t}{(3-\eta)^2} > 0 \tag{4.A.6}$$

$$\pi_1^{MM} - \pi_1^{NM} = \frac{1}{2}(2-\eta)^2 st\frac{(1-\eta)(2A-t)-t}{(1-\eta)^2(3-\eta)^2} > 0 \tag{4.A.7}$$

$$\pi_1^{NN} - \pi_1^{NM} = \frac{1}{2}(2-\eta)st\frac{2(1-\eta)(A-t)-t}{(1-\eta)^2(3-\eta)^2} > 0 \tag{4.A.8}$$

$$\pi_1^{MN} - \pi_1^{MM} = \tfrac{1}{2}s(2-\eta)t\frac{(2A(1-\eta)+t)}{(1-\eta)^2(3-\eta)^2} > 0 \tag{4.A.9}$$

$$\frac{\partial\left(\pi^{MN}-\pi^{NN}\right)}{\partial\eta} = \frac{st(2-\eta)}{2}\frac{2A(1-\eta)\left(4-3\eta+\eta^2\right)+t\left(6-2\eta^2-\eta+\eta^3\right)}{(1-\eta)^3(3-\eta)^3} > 0 \tag{4.A.10}$$

$$\frac{\partial\left(\pi_1^{MM}-\pi_1^{NN}\right)}{\partial\eta} = \frac{st\,(2A-t)}{2}\frac{1-\eta}{(3-\eta)^3} > 0 \tag{4.A.11}$$

$$\frac{\partial\left(\pi_1^{MM}-\pi_1^{NM}\right)}{\partial\eta} = \frac{(2-\eta)st}{2}\frac{((A-t)(1-\eta)-t)((1-\eta)(2-\eta)+4)+(1-\eta)(2-\eta)(A(1-\eta)-t)}{(1-\eta)^3(3-\eta)^3} > 0 \tag{4.A.12}$$

$$\frac{\partial\left(\pi_1^{NN}-\pi_1^{NM}\right)}{\partial\eta} = \frac{1}{2}st\frac{2A(1-\eta)\left(2\eta^2-7\eta+7\right)+t\left(-27-21\eta^2+40\eta+4\eta^3\right)}{(1-\eta)^3(3-\eta)} \gtreqless 0 \tag{4.A.13}$$

4.A.2 Derivation of figure 4.2

To show that the above statements can indeed constitute the basis for figure 4.2, one only needs to assume that point B in figure 4.2 exists.

Let $\Pi^{NN}(0,\mathbf{z}) > \Pi^{MN}(0,\mathbf{z})$ hold, so that the extra fixed costs in affiliate production outweigh the advantages of avoiding the transport costs for small values of η. Then (4.A.5) and (4.A.10) will generate a unique η_B, if such a point B exists. Existence will be guaranteed if the plant level investment cost in affiliate production G and transfer costs T are not too high, so that the curves will actually intersect for some $\eta < 1$. Assume this to be the case.

Then note that the MM-curve must be below the MN-curve, since competition is more intense in the MM-structure, where firm 2 also produces abroad (fixed costs G and T are the same). This is shown by (4.A.9). For exactly the same reason, the NM-curve must always be below the NN-curve (fixed costs are zero in both structures). This is shown by (4.A.8).

Finally, note that from (4.A.12), the MM-curve must cut the NM-curve from below, at η_C. The exact location of the point C is determined by the parameters of the model; if $\eta_C < \eta_B$, the section of asymmetric equilibria disappears, if $\eta_C > \eta_B$, we get the case described in the text.

4.B Appendix: Comparative statics

This appendix presents the expressions used for deriving the signs in table 1. Thus, table 1 is produced by inserting the appropriate expressions (4.B.14)-(4.B.17) into (4.17) and evaluating the sign.

$$\frac{\partial\left(\Pi_1^{MN}-\Pi_1^{NN}\right)}{\partial\eta} = \frac{1}{2}st\,(2A-t)\frac{1-\eta}{(3-\eta)^3} > 0 \tag{4.B.14}$$

$$\frac{\partial\left(\Pi_1^{MN}-\Pi_1^{NN}\right)}{\partial t}=\tfrac{s}{4}\left(3-2\eta\right)\tfrac{(1-\eta)(A-t)+t\eta}{(1-\eta)^2(2-\eta)}>0 \quad (4.B.15)$$

$$\frac{\partial\left(\Pi_1^{MN}-\Pi_1^{NN}\right)}{\partial G}=-1<0 \quad (4.B.16)$$

$$\frac{\partial\left(\Pi_1^{MN}-\Pi_1^{NN}\right)}{\partial T}=-1<0 \quad (4.B.17)$$

4.C Appendix: R&D intensity

In this appendix, it is shown that our measure of effectiveness in R&D, η, is positively correlated with R&D intensity in the MN- and NN-structures of model 1. It is also shown that the R&D intensity is always higher in affiliate production.

R&D intensity is defined as outlays on R&D, divided by total sales. Using (4.10) and remembering that total outlays on R&D are $\frac{\gamma x_1^{iN\,2}}{2}$ and total sales are $P^{iN}q_1^{iN}$, R&D intensity, RD_1^{iN}, is given by (4.C.18).

$$RD_1^{iN}=\frac{\eta q_1^{iN}}{2sP^{iN}}:i=N,M \quad (4.C.18)$$

Furthermore, using (4.2) and ((4.11), the R&D intensities for both cases in the benchmark equilibrium are given by (4.C.19) and (4.C.20). From (4.C.21), it is also clear that if a firm chooses affiliate production, it will always have a higher R&D intensity.

$$RD_1^{NN}=\frac{1}{2}\eta\frac{A-t}{a\left(1-\eta\right)+2c_0+2t}>0 \quad (4.C.19)$$

$$RD_1^{MN}=\frac{\eta}{2}\frac{A\left(1-\eta\right)+t}{\left(1-\eta\right)\left(a\left(1-\eta\right)+t+2c_0\right)}>0 \quad (4.C.20)$$

$$RD_1^{MN}-RD_1^{NN}=\frac{1}{2}\eta t\frac{A(1-\eta)+a(1-\eta)(2-\eta)+2c_0(2-\eta)+t(3-\eta)}{(1-\eta)[a(1-\eta)+2c_0+2t][a(1-\eta)+t+2c_0]}>0 \quad (4.C.21)$$

Finally, we can use (4.C.19) and (4.C.20) to show that both RD_1^{NN} and RD_1^{iMN} are increasing in η.

$$\frac{\partial\left(RD_1^{NN}\right)}{\partial\eta}=\frac{1}{2}\left(A-t\right)\frac{a+2c_0+2t}{\left(-3a+a\eta+2A-2t\right)^2}>0 \qquad (4.C.22)$$

$$\frac{\partial\left(RD_1^{MN}\right)}{\partial\eta}=\frac{1}{2}\frac{A(1-\eta)^2(a+2c_0+t)+t(a(1-\eta)(1+\eta)+2c_0+t)}{(1-\eta)^2(a(1-\eta)+2c_0+t)^2}>0 \qquad (4.C.23)$$

4.D Appendix: Second-order conditions and stability

In this appendix, we check the firm's second-order conditions for the maximization of (4.3) and (4.4).

To have a well-posed maximization problem, the Hessian, defined in (4.D.24), must be negative definite:

$$Q_h^{ij}=\begin{bmatrix}\Pi_{h,q_h,q_h}^{ij} & \Pi_{h,q_h,x_h}^{ij}\\ \Pi_{h,x_h,q_h}^{ij} & \Pi_{h,x_h,x_h}^{ij}\end{bmatrix} \qquad (4.D.24)$$

where, for example, $\Pi_{h,q_h,x_h}^{ij}=\frac{\partial^2\Pi_h^{ij}}{\partial q_h^{ij}\partial x_h^{ij}}$. This, in turn, requires that $\left|Q_h^{ij}\right|>0, \Pi_{h,q_h,q_h}^{ij}<0$ and $\Pi_{h,x_h,x_h}^{ij}<0$. We can show that this will hold if $\eta<2$. By calculation:

$$|Q| = \frac{\gamma}{s}(2-\eta) \qquad (4.D.25)$$

$$\Pi_{h,q_h,q_h}^{ij} = -\frac{2}{s}<0 \qquad (4.D.26)$$

$$\Pi_{h,x_h,x_h}^{ij} = -\gamma<0 \qquad (4.D.27)$$

Making the same type of calculation in model 2, it is easy to show that $\Pi_{h,q_h,q_h}^{ij}=-\frac{2}{s}$ and $\Pi_{h,x_h,x_h}^{ij}=-\frac{\gamma}{\alpha}$, whereas $|Q|=\frac{\gamma}{s}(\frac{2}{\alpha}-\eta)$. Hence, uniqueness requires $\eta<2$ in model 1, whereas the corresponding condition in model 2 is $\alpha\eta<2$.

Finally, stability of the Cournot game requires that the reaction function of firm 1 is more steeply sloped than the corresponding reaction function of firm 2 in the q_2q_1-space. This requires $(3-\eta)(1-\eta)>0$ in model 1, and $(2-\alpha\eta)(2-\eta)-1>0$ in model 2. Since $\alpha<1$, $\eta<1$ ensures stability in both models.

5

Cumulative effects of labor market distortions in a developing country

5.1 Introduction

A number of recent papers emerging from the "new" trade theory focus on pecuniary externalities, arising in models with imperfect competition and scale economies. Rodrik (1995), Rodriguez - Claire (1996) and Krugman and Venables (1995) are some well-known examples. The interest in such models can partly be explained by the fact that they give rise to multiple equilibria. On the positive side, such models can explain why an economy may be trapped in a bad equilibrium, but they can also provide normative conclusions and prescribe how government policy should be used to push the economy into a superior equilibrium.

Clearly, these properties make such models interesting for analyzing problems in developing economies.[1] The purpose of this paper is to investigate to what extent labor market distortions, in terms of labor unions, can act as impediments to development. It will be shown that even if only a limited share of the population is unionized - a reasonable assumption for a developing country - the costs of this labor market distortion may be disproportionately high, since the economy is kept at a low level of activity.

An open two-sector model, which draws on Venables (1996), is used to make this point. A central feature is then that an input-output structure in the modern, industrial sector creates complementarities or pecuniary externalities between an upstream industry (which uses labor in order to produce intermediate input goods) and a downstream industry (which uses domestic and imported intermediate inputs, together with labor and sector-specific capital, in order to produce final goods).

These complementarities arise through a *demand-linkage,* as an increase in final good production benefits the upstream industry through an increasing demand for inputs. But they also arise through a *cost-linkage,* as expanding upstream production reduces downstream production costs through the entry of new firms, since a larger variety of inputs then becomes

[1] These models formalize some previous ideas in development economics such as Rosenstein-Rodan's (1943) Big Push or Scitovsky's (1954) work on externalities. For a presentation, see Matsuyama (1993) or Krugman (1992).

Workers in final good producing firms are assumed to be unionized. The unions attempt to appropriate the rents accrued by capital owners, and the extent to which they succeed can be controlled by the government. In the model, I investigate the possible effects of the institutional setting being changed in favor of the employers, thereby reducing union wages.

When there are multiple equilibria, for which the conditions are explicitly identified, the following picture emerges: If the low-level equilibrium is the initial equilibrium, decreasing union wages will increase the downstream production of final goods and, subsequently, the downstream producers' demand for intermediate inputs. For sufficiently large wage cuts, domestic upstream firms can enter; thereby lowering downstream production costs through the cost linkage, and facilitating additional downstream expansion. A cumulative, circular process is then begun, where the expansion in the up- and downstream industries reinforce each other, which triggers a discontinuous jump from the low-level equilibrium to the high-level industrialized equilibrium.

This model is mainly applicable to developing countries, although the mechanisms described can also be generalized to developed countries. The economy is small on the world market, which implies that the number of foreign intermediate inputs and their price, as well as the world market price of final goods, are taken to be completely exogenous. Domestic intermediate inputs are not exported.[2] The labor market institutions constitute a segmented labor market, where workers in the upstream industry and the agricultural sector receive competitive wages, whereas a close relationship between the unions in the rent-yielding final good industry and the political system, enables the unions to extract excess wages. The analysis shows that large wage premiums for unions can have considerable effects on industrial output and employment, given that industrial output is, initially, very low.[3] [4]

High union wages are only one impediment among several which may preserve the economy in a low-level equilibrium. As is shown in Venables (1996), import substitution policies through tariffs on imported inputs may also reduce industrial output by increasing downstream costs. The extent to which vertical linkages between firms are internalized by vertical inte-

---

[2]This assumption follows Venables (1996). Exports of upstream goods can easily be included.

[3]Pencavel (1997) argues that in many developing countries, union wages may not only affect the unionized sector, but also spill over into other sectors. If the union wage in the downstream firms is also binding for workers in the input industries for reasons such as legislation or collective agreements, for example, these effects are stronger.

[4]In labor market economics, there is a large literature on centralized contra decentralized wage-setting, where the effects of various types of externalities are discussed. Even though input externalities have been noticed (see, for example Wallerstein (1990)), the above context, involving vertical linkages and multiple equilibria is, to my knowledge, new. For a survey, see Calmfors (1993).

gration, for example, is also of great importance.

In these three respects, it is tempting to show the example of the East-Asian NIC countries. They may have been more open (more inclined to use export-promotion rather than import-substituting policies) than other developing countries, large conglomerates of vertically integrated firms are common, and, which is of interest for the ideas presented in this paper, their labor markets have remained competitive during the transition.[5]

The paper is organized as follows. Section 5.2 describes the model and subsection 5.2.4 describes the effects of a decreased union wage. Section 5.3 concludes.

5.2 The model

I start with a quick overview of the basic structure before proceeding to details. The model appears in table 5.1.

I will focus on a small open economy with two sectors and labor as the common factor exogenously fixed at L. The industrial sector, sector 1, has two industries. The upstream industry, X, employs labor for producing differentiated intermediate input goods, which are combined with imported differentiated inputs, labor and sector-specific capital into a final good in the downstream industry, Y. Final goods are tradable on the world market and can be sold at the fixed world-market price q. Sector 2 constitutes the rest of the economy, and will be referred to as the agricultural sector. Agricultural goods are produced with labor using a constant returns to scale technology and are also tradable at the world-market price. The agricultural good will be used as numeraire.

5.2.1 Production

The downstream industry is perfectly competitive. I follow the literature and depict the downstream industry by using a *representative* firm.[6] The production of final goods requires three distinct inputs; labor, capital and intermediate inputs. Using the Cobb-Douglas technology:

$$Y = X^a L_Y^b K^{1-a-b} \tag{5.1}$$

where a is the expenditure share of intermediate inputs, X is the amount used of a bundle of intermediate inputs (defined below), L_Y is employment

[5] The World Bank (1993) stresses the effect of high openness and competitive labor markets. Rodrik (1994, 1995a and 1995b) particularly emphasizes the possibility of a co-ordination failure.

[6] See, for example, Uddén-Jondal (1993) and Oswald (1982).

TABLE 5.1. The structure of the model

Imports		**Sector 1**		**Sector 2**
Imports of intermediate inputs Fixed number of foreign varieties at fixed world-market price	⟹	Upstream industry Produces differentiated intermediate goods using labor as the single input Monopolistic competition Free entry and scale economies Downstream industry Labor, capital and intermediate inputs used in the production of final goods, sold at fixed world-market price "Love of variety" for intermediate inputs Sector-specific capital Labor organized in unions, wage negotiations Benchmark wages from sector 2	⟸	Agriculture CRS with labor as input Fixed world-market price Competetive wage

in the downstream industry and the production function $Y(\cdot)$ exhibits constant returns to scale (CRS). In the production of final goods, intermediate inputs are assembled into an aggregate input good X, defined in (5.2):

$$X = \left(\int_0^{\bar{n}} x(\omega^*)^{\frac{\sigma-1}{\sigma}} d\omega^* + \int_0^{n} x(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}} \tag{5.2}$$

where x is the amount used of a single variety, whereas ω (ω^*) indicates domestic (foreign) varieties. n and $\bar{n}$ are the number of available domestic and foreign varieties, where the latter is taken to be fixed in accordance with our assumption of a small open economy. $\sigma \in (1, \infty)$ is the elasticity of substitution between *any* two varieties, implying that varieties of inputs are symmetric but imperfect substitutes among themselves.[7] In turn, this give rise to a property in (5.2), often referred to as "love of variety", which originates in the works of Dixit and Stiglitz (1977) and Ethier (1982). To see this, note that the symmetric use of inputs in (5.2) yields $X = \left(\bar{n}x^{\frac{\sigma-1}{\sigma}} + nx^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$, which is an increasing convex function in the number of available domestic inputs n. This suggests that increased efficiency is gained in downstream firms, when a larger range of varieties becomes available.[8] Using (5.2), we may define the minimum-cost for one unit of the intermediate input bundle X, P, as:

$$\begin{aligned} P &\equiv \min_{\{x(\omega^*), x(\omega)\}} \left[\int_0^{\bar{n}} x(\omega^*)\bar{p}d\omega^* + \int_0^{n} x(\omega)pd\omega \mid X = 1 \right] \\ &\equiv \left(\bar{n}\bar{p}^{1-\sigma} + np^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \end{aligned} \tag{5.3}$$

where p is the price of domestic varieties, whereas $\bar{p}$ is the fixed world-market price of foreign varieties. Since varieties of intermediate inputs are imperfect substitutes, additional intermediate inputs enhance the efficiency in downstream production, as illustrated by the price index which is decreasing in n.

The capital stock is sector-specific, so that capital can only be used in final good production. We normalize so that $\bar{K} = 1$. The production function for final goods (5.1) then becomes:

$$Y = X^a L_Y^b \tag{5.4}$$

[7] $\sigma > 1$ is assumed, since the elasticity of substitution equals one in the production function (5.2). Essentially, this means that final good producers find it easier to substitute between any two intermediate inputs, than between any intermediate input and the primary factors, capital and labor. Restricting the substitution elasticity so that it is smaller than infinity, simply means that the intermediate inputs are differentiated goods.

[8] Adam Smith introduced the notion that efficiency is enhanced by the division of labor. This idea was formalized by Ethier (1982).

The representative firm takes the price for the bundle of intermediate inputs P as given. For a given wage in the downstream industry w and a given world-market price for final goods, q, profit-maximizing yields the profit function:

$$\Pi(w) = (1-a-b)\left(\frac{a}{P}\right)^{\frac{a}{1-a-b}}\left(\frac{b}{w}\right)^{\frac{b}{1-a-b}} q^{\frac{1}{1-a-b}} > 0 \qquad (5.5)$$

where $\Pi(w) > 0$ follows from $1-a-b > 0$. This profit may be interpreted as compensation to the owners of the firm's capital stock K (the specific factor). Furthermore, the supply function is:

$$Y(w,P,q) = \left(\frac{a}{P}\right)^{\frac{a}{1-a-b}}\left(\frac{b}{w}\right)^{\frac{b}{1-a-b}} q^{\frac{a+b}{1-a-b}} \qquad (5.6)$$

Next, we turn to upstream firms, where monopolistic competition is the upstream market form. From (5.3) and (5.5), it can be shown that the demand faced by an individual domestic intermediate input producer is:

$$x = P^{\sigma-1}p^{-\sigma}aqY \qquad (5.7)$$

In this demand function, the individual upstream firm takes the price index P and the downstream expenditure on differentiated goods, aqY, as given. Profits are then:

$$\pi = px - \bar{w}(x+F) \qquad (5.8)$$

where $\bar{w}$ is the wage paid to upstream workers. Note the unit labor requirement in production and the fixed cost F in terms of labor for entering the market. Assuming free entry and exit, and using the demand function (5.7), the pricing condition and zero-profit condition may be written as:

$$p\left[1-\frac{1}{\sigma}\right] = \bar{w} \qquad (5.9)$$

$$px = \bar{w}(x+F) \qquad (5.10)$$

where it can be noted that the price elasticity EL_px has been approximated with the substitution elasticity σ. As is commonly known, these two equations determine a unique size of each domestic firm:

$$x = (\sigma-1)F \qquad (5.11)$$

We can use (5.3), (5.7), (5.9) and (5.11) to derive the number of domestic intermediate input producers n, for a given level of final good production

Y and a given upstream wage $\bar{w}$:

$$n = \frac{\frac{aqY}{F(\sigma-1)\left(\frac{\sigma}{\sigma-1}\bar{w}\right)^{\sigma}} - \bar{n}\bar{p}^{1-\sigma}}{\left(\frac{\sigma}{\sigma-1}\bar{w}\right)^{1-\sigma}} \tag{5.12}$$

Note that (5.12) implies a minimum level of final good production to be associated with active domestic production of differentiated inputs. Setting $n = 0$ in (5.12), we can derive:

$$Y_C = \frac{\bar{n}\bar{p}^{1-\sigma}F(\sigma-1)\left(\frac{\sigma}{\sigma-1}\bar{w}\right)^{\sigma}}{aq} \tag{5.13}$$

where it can be noted that the critical size of final good production, Y_C, is increasing in the upstream fixed entry cost F, but decreasing in the cost-share for intermediate inputs in final good production a.

Inserting the number of firms given by (5.12) into (5.3) and using the pricing rule (5.9), the unit cost of input bundles X, $P^S(Y)$, becomes:

$$P^S(Y) = \begin{cases} \left(\frac{aqY}{F(\sigma-1)\left[\frac{\sigma}{\sigma-1}\bar{w}\right]^{\sigma}}\right)^{\frac{1}{1-\sigma}} & \textit{if } Y > Y_C \\ \left(\bar{n}\bar{p}^{1-\sigma}\right)^{\frac{1}{1-\sigma}} & \textit{if } Y \leqslant Y_C \end{cases} \tag{5.14}$$

Equations (5.12), (5.13), (5.14) and (5.6) describe the *vertical linkages* in the model. Note that $P^S(Y)$ then consists of two segments. For $Y \leqslant Y_C$, no domestic production of differentiated inputs occurs. The demand from final good production is insufficient for the existence of any domestic upstream firm, as entry costs cannot be recovered.[9] Foreign imports only are used, so that final good producers face a fixed price for the aggregate input good X.

If final good production increases so that $Y > Y_C$, domestic upstream firms will enter; this is the *demand linkage* (cf. equation (5.12)). An increasing number of suppliers of differentiated input goods enhance the productivity in the downstream industry, since a larger range of differentiated inputs becomes available. This lowers downstream production costs as the unit cost of the input bundle $P(Y)$ decreases; this is the *cost linkage* (cf. equation (5.14)). A lower unit cost of the aggregate input good will then increase the supply of final goods Y (cf. equation (5.6)), and an increase in output may become cumulative, due to these vertical linkages.

[9] This is another notion introduced by Adam Smith, namely that the division of labor (the range of differentiated inputs) is limited by the size of the market.

5.2.2 Labor market

The downstream industry is unionized and each final good producing firm is assumed to have a separate union. The wage for downstream workers is determined in negotiations between the representative firm and the representative union. Using the Nash-bargaining solution, the negotiated wage is the solution of (5.15):[10] [11]

$$\begin{aligned}
w &= \arg\max G \qquad (5.15)\\
G &= [\Pi(w)]^c \, [U(w)]^{1-c}\\
\Pi(w) &= (1-a-b)\left(\frac{a}{P}\right)^{\frac{a}{1-a-b}}\left(\frac{b}{w}\right)^{\frac{b}{1-a-b}} q^{\frac{1}{1-a-b}}\\
U(w) &= (L_Y)^{\gamma}\,(w-\bar{w})^{\theta}\\
\bar{w} &= Qf_L'\\
L_Y &= -\frac{\partial \Pi(w)}{\partial w}\\
c,\gamma,\theta &\in [0,1]
\end{aligned}$$

where $c \in [0,1]$ is the bargaining power of the firm and the demand for labor $L_Y = -\frac{\partial \Pi^*(w)}{\partial w}$ follows from Hotelling's Lemma.[12] The union has preferences over excess wage $(w - \bar{w})$ and downstream employment L_Y of the Stone-Geary type, where θ and γ are the excess wage and employment elasticities of the utility function.[13] The fall-back wage of an individual employed in the industrial sector is defined as $\bar{w} = f_L'$, where f_L' is the constant marginal product of labor in agricultural production. In other words, $\bar{w}$ is simply the competitive wage paid in agricultural production and accordingly, the wage union members will receive during a conflict. Finally, note that the price of the intermediate input bundle P is treated

---

[10] The generalized Nash-Bargaining solution can be derived from a few reasonable axioms, but can also be given a microeconomic foundation. Binmore et al. (1986) show that the generalized Nash-Bargaining solution can be obtained as the limit solution of a non-cooperative sequential offer game, when the length of each bargaining round approaches zero.

[11] It is straightforward to verify that there exists a unique solution, as $G(w)$ is a strictly concave function in w.

[12] See Varian (1992).

[13] See McDonald and Solow (1981) and Mezetti and Dinopoulos (1991). Pemberton (1988) derives $U(\cdot)$ as the maximand of a "managerial union" with a leadership interested in size (employment) and union members (median worker) interested in excess wages. Parameters θ and γ then correspond to the bargaining power of workers and leadership, respectively.

as fixed in the wage negotiation. It is straightforward to derive:[14]

$$
\begin{aligned}
w &= \Psi\bar{w} \\
\Psi &= \frac{1}{1-\frac{(1-a-b)\theta}{b\mathcal{F}(c)+(1-a)\gamma}}
\end{aligned}
\tag{5.16}
$$

where $\mathcal{F}(c) = \frac{c}{1-c}$ and $\Psi > 1$ is the mark-up over the competitive wage level $\bar{w}$. It follows from (5.16) that Ψ is a decreasing function of the bargaining power of the firms c, $\frac{\partial\Psi}{\partial c} < 0$. Since upstream workers are paid the competitive wage $\bar{w}$, it is clear from (5.16) that downstream workers earn a wage premium compared to upstream and agricultural workers. All workers are then assumed to have the same skills, that is, the labor market is segmented. There is, however, no unemployment. The labor market condition $L = L_X + L_Y + L_A$, where the first two terms represent the demand for labor in industrial production, determines the level of employment in agriculture L_A, which, in turn, determines the size of the agricultural sector.

5.2.3 Solving the model

A simple intersection of supply and demand price curves is used for solving the model. Following Markusen (1989), it will be solved by using the price of the aggregate intermediate input good X, rather than the price of an individual variety, x. Due to the presence of vertical linkages in this model, these prices will be expressed in final good production Y.

The supply function for *final* goods, $Y(w, P)$, is given in (5.6). This function may be inverted in order to derive the maximum price that final good producers are prepared to pay for the aggregate intermediate input good X, for a given level of output Y, $P^D(Y)$:

$$
P^D(Y) = \frac{aq^{\frac{a+b}{a}}}{Y^{\frac{1-a-b}{a}} w^{\frac{b}{a}} b^{-\frac{b}{a}}}
\tag{5.17}
$$

A corresponding supply price must also be found in order to derive an equilibrium. That is, we need to find the minimum price at which the upstream suppliers will supply the aggregate intermediate input good. However, this is only the unit cost for X, $P^S(Y)$, which was derived in (5.14) by using the pricing rules of the individual firms (5.9). Equating $P^S(Y)$ and $P^D(Y)$, we can solve for final good production Y in terms of the downstream union

[14] The negotiated wage has a particularly simple form, since the Cobb-Douglas technology generates constant factor shares. For a more elaborate discussion, see Skedinger (1992).

wage w:

$$Y(w) = \begin{cases} C_1 w^{\frac{b(\sigma-1)}{a\sigma+(1-\sigma)(1-b)}} : \textit{if } Y > Y_C \\ C_2 w^{-\frac{b}{1-a-b}} : \textit{if } Y \leqslant Y_C \end{cases} \tag{5.18}$$

where $C_1$and C_2 are positive constants consisting of different parameters of the model. Defining the inequality (5.19):

$$a\sigma + (1-\sigma)(1-b) < 0 \tag{5.19}$$

we can make the following propositions:

Proposition 12 *$Y(w)$ is a monotone function of the union wage w. For $Y > Y_C$, it is decreasing in w if and only if (5.19) holds, and increasing in w if this inequality is reversed. For $Y \leqslant Y_C$, it is always decreasing in w.*

Proof. Follows directly from (5.18) ■

Proposition 13 *For $Y > Y_C$, $Y(w)$ is a unique stable equilibrium if and only if (5.19) holds. But if this inequality is reversed, $Y(w)$ is unstable and multiple equilibria exist. For $Y \leqslant Y_C$, $Y(w)$ is always a stable equilibrium.*

Proof. Define the elasticity $EL_Y P^D = -\frac{\partial P^D}{\partial Y}\frac{Y}{P^D}$ and $EL_Y P^S$ similarly. Then, using (2.17) and (2.14), we get $EL_Y P^D = \frac{1-a-b}{a}$ and $EL_Y P^S = \frac{1}{\sigma-1}$. For $Y > Y_C$, $EL_Y P^D - EL_Y P^S = -\frac{a\sigma+(1-\sigma)(1-b)}{(\sigma-1)a}$, which is positive if and only if (5.19) holds, and negative if this inequality is reversed. For $Y \leqslant Y_C$, $EL_Y P^D - EL_Y P^S > 0$, since $EL_Y P^S = 0$. Uniqueness follows from the segmented shape of the supply price curve. ■

To get some intuition, we illustrate these results graphically. Figure 5.1 illustrates a situation where inequality (5.19) holds. Note the segmented supply price function $P^S(Y)$, which is constant for $Y \leqslant Y_C$, but decreasing and convex for $Y > Y_C$. As described in the previous section, $P^S(Y)$ is constant for $Y \leqslant Y_C$. This is due to the fact that only a fixed number of foreign varieties enter the price index at a fixed price, since final good production is too small to admit domestic input production.

For $Y > Y_C$, the downward slope of the supply price curve $P^S(Y)$ is due to the vertical linkages. As downstream output expands, the demand for upstream production increases, which induces an additional entry of upstream firms, thereby lowering the price index P. The demand price curve $P^D(Y)$ is downward sloping for all levels of final good production Y, due to the diminishing returns in final good production arising from the fixed factor. This reduces the price the downstream industry can pay for inputs at successively higher output levels.[15]

[15] Assuming a fixed factor is not essential. Introducing a downward sloping final de-

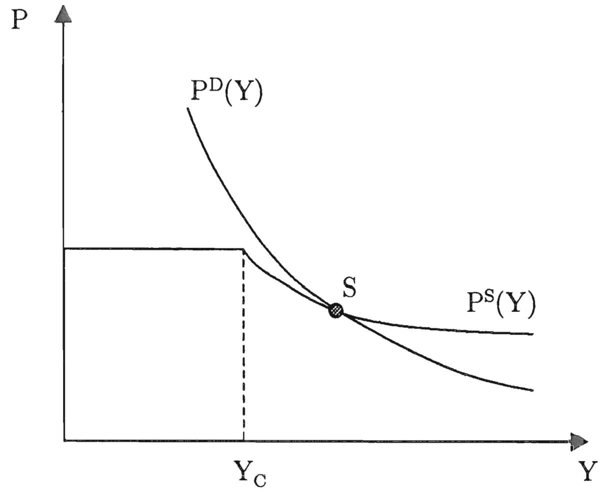


FIGURE 5.1. Unique equilibrium at weak linkages

Assuming that upstream producers enter in response to instantaneous profits, upstream firms will enter whenever $P^D(Y) > P^S(Y)$. To see this, note that this condition states an excess demand on the aggregate intermediate input good X, which implies that there must also be an excess demand for individual varieties x. Since $P^S(Y)$ is derived by imposing zero profits on upstream firms, individual firms must make positive profits, and entry takes place until demand and supply prices are equalized. For the same reason, upstream firms exit whenever $P^D(Y) < P^S(Y)$. Therefore, equilibrium S in figure 5.1 must be stable, which is exactly what the proof in proposition 13 suggests; in any stable equilibrium the demand price curve $P^D(Y)$ is more output elastic or steeper than the supply price curve $P^S(Y)$. Since $P^D(Y)$ is always steeper than $P^S(Y)$, S must also be a unique stable solution, regardless of whether the demand curve cuts the supply curve for $Y \gtrless Y_C$.

Figure 5.2 illustrates a situation where (5.19) is reversed, which gives rise to an unstable equilibrium I. In this case, $P^D(Y)$ is less output elastic or flatter than the supply price curve $P^S(Y)$, thus making I unstable. Two more stable equilibria arise, however. The first, S_1, occurs for $Y \leqslant Y_C$,

mand curve $q(Y)$ and abandoning price-taking behavior in the downstream industry, would then permit the use of a constant returns to scale technology. Qualitatively, the model would be solved in the same way, since a downward-sloping final demand curve $q(Y)$ would translate into a downward-sloping demand price curve $P^D(Y)$, simply because larger levels of final output would decrease the price of the final good q, thus decreasing the price final good producers would be prepared to pay for the aggregate input.

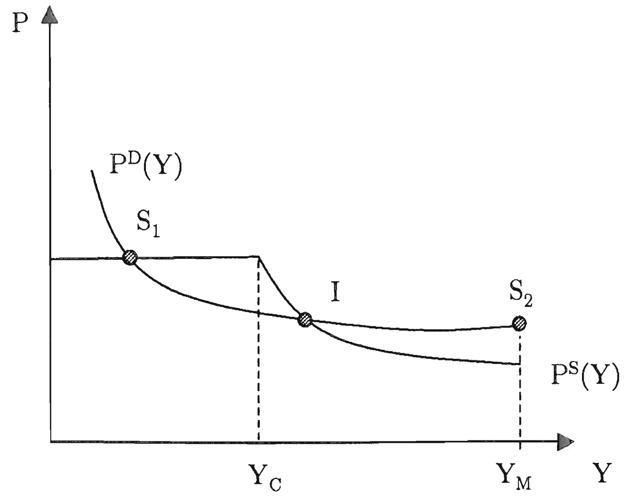


FIGURE 5.2. Multiple equilibria at strong linkages

where the final good production cannot sustain any domestic upstream production. The second stable equilibrium, S_2, for which $P^D(Y) > P^S(Y)$, is an equilibrium where the economy is completely specialized in industrial production, so that $Y = Y_M$ is the maximum amount of the final good that can be produced when all labor resources are devoted to industrial production. Note that as long as equilibrium I exists, the economy must have multiple equilibria, due to the segmented shape of $P^S(Y)$ and due to $P^D(Y)$ being flatter than $P^S(Y)$ at I.

What economic conditions will then make an economy face a situation like the one in figure 5.1 or figure 5.2? It is useful to rewrite the stability condition (5.19) in the following way:

$$\frac{1-a-b}{a} > \frac{1}{\sigma - 1} \tag{5.20}$$

which simply restates the stability requirement $EL_Y P^D > EL_Y P^S$. We then have the following corollary:

Corollary 14 *The stability condition (5.19) is more likely to hold, the larger is the capital share $1 - a - b$, the smaller is the share of intermediate inputs a and the larger is the elasticity of substitution σ.*

Proof. This follows directly from (5.20) ■

Generally, a unique stable solution will exist if the demand and cost linkages are not "too strong". Obviously, such a case would require the cost-share of intermediate inputs to be small, but is also more likely to occur for a large cost-share of capital, due to the diminishing returns arising from this fixed factor. These two effects tend to limit the demand-linkage, thereby producing a very steep demand price curve $P^D(Y)$.[16]

Furthermore, we recognize the right-hand side of (5.20) as the elasticity $EL_Y P^S$. This elasticity can be interpreted as a measure of the cost-linkage (cf. equation (5.3)). To see this, note that variety is valued less for a larger substitution elasticity between intermediate inputs σ. This implies that as upstream entry occurs in response to an increase in downstream demand Y, the price index will fall at a slower rate, resulting in a flatter supply-price curve $P^S(Y)$, which indicates a weaker cost-linkage. Thus, a smaller cost-share of intermediate inputs a, a larger cost-share of capital and a larger substitution elasticity σ, tend to create a unique stable equilibrium, as illustrated in figure 5.1.

On the other hand, a larger cost-share of intermediate inputs and a smaller cost-share of capital result in a flatter demand curve, thereby revealing a stronger demand linkage. Furthermore, at a smaller substitution elasticity, downstream firms value variety in intermediate inputs more highly, as efficiency is enhanced in a more pronounced way by additional inputs. Therefore, as upstream entry occurs in response to an increase in demand from downstream firms, the price index P will decrease at a greater rate, thus producing a steeper supply curve $P^S(Y)$, and revealing a stronger cost-linkage. This is illustrated in figure 5.2, where the inequality (5.20) fails to hold, producing a situation with multiple equilibria.[17]

5.2.4 Institutional change

Assume that an institutional change reform occurs, where the government intervenes on the labor market by weakening the union's ability to mark-up wages in final good production.[18] In our model, we simply assume that this

[16] Any decrease in P will translate into a smaller increase in downstream supply, limiting the demand effect on upstream suppliers.

[17] The size of the substitution elasticity σ is important in yet another way. It is easy to see that σ is positively related to scale economies in the upstream industry, since output per firm is increasing in σ (cf. equation (5.11)). This is due to the fact that the mark-up over wage costs for the typical upstream firm is decreasing in σ (cf. equation (5.9)). A smaller mark-up then generates less rents to cover fixed costs, which discourages entry and tends to increase the critical level of downstream production Y_C required to support active domestic input production.

[18] Union bargaining power will depend on the unions' right to organize the supply of labor and their ability to inflict damage on firms during a conflict. But the right to organize and the right to strike is governed by the institutional framework in the economy. Institutional changes may then affect their bargaining power in several ways. Such changes may decrease the incentive to become a member of a union. With a smaller number of members, the union is weaker in its negotiations with the firm. This will be the result if union control over labor supply is diminished by limiting the legal bargaining monopoly of the unions. Reformation of employment security laws is another example. In this case, the firing costs for the firms will decrease.

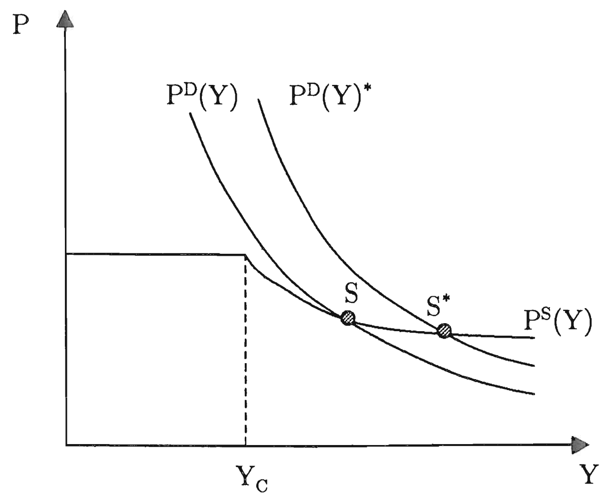


FIGURE 5.3. Deregulation at weak linkages

will increase the bargaining power of the firms in the downstream industry, c. By (5.16), this implies a decreased wage mark-up and thus a decreased union wage. What are the effects?

Begin with the situation of a unique stable equilibrium, which is the case of weak linkages, where (5.20) holds. By proposition 12, we know that the production of final goods must always increase. This is illustrated in figure 5.3, where a deregulation will shift the demand price curve $P^D(Y)$ upwards, due to decreasing downstream wage costs, but will not affect the supply price curve $P^S(Y)$, as upstream workers are still paid the competitive wage.[19] The economy moves from S to S^*.

Then, proceed to a situation with multiple equilibria, where linkages are strong. (5.20) fails to hold and the economy in figure 5.2 has three equilibria; I which is unstable and S_1 and S_2 which are stable. It turns out that a lower union wage might then have a much more dramatic effect on output. Assume that, initially, we are in the stable low-level equilibrium S_1. Remember that no domestic input production takes place in S_1, due to insufficient demand from final good producers, as production is too small, that is, $Y \leqslant Y_C$. As in the previous case, a deregulation will decrease wages in final good production but will not affect the wages in input production and will thus shift $P^D(Y)$ upwards along an unaffected $P^S(Y)$.

This is illustrated in figure 5.4, where we note that the unstable equilibrium I moves backwards, which is consistent with proposition 12. At some

[19]Formally, we may calculate $EL_w P^D = \frac{\partial P^D}{\partial w} \frac{w}{P^D} = -\frac{b}{a}$. The fact that the wage will decrease confirms the shift of the curve.

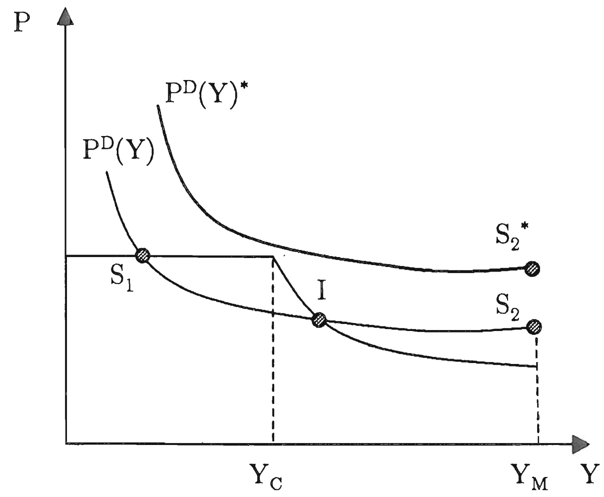


FIGURE 5.4. Deregulation with multiple equilibria

point, $\tilde{c}$, S_1 and I will coincide. A marginal increase in c then shifts $P^D(Y)$ further to the right so that $P^D(Y) > P^S(Y)$, which generates entry of domestic upstream firms which, in turn, further reduces the production costs of the downstream firms through a greater range of available inputs, thus facilitating additional downstream expansion. Due to stronger demand- and cost-linkages in this case, a circular, cumulative process is begun where the expansion in the up and downstream industries reinforce each other. Cumulative causation will take the economy out of the low-level equilibrium S_1 and into the new industrial equilibrium S_2^*, where the economy is completely specialized in industrial production.[20]

5.3 Conclusion

In this paper, I have shown that labor market imperfections may have considerable effects in an environment with scale economies and imper-

[20] This result is quite extreme, but arises as the competitive wage is unaffected by industrial expansion. It is, however, easy to "convexify" the model by introducing a fixed factor, that is, land, in agriculture. Then, as industrial expansion draws labor from the agricultural sector, an increasing land/labor ratio increases the competitive wage. Adding this general equilibrium effect to the cost-linkage will tend to make the supply price curve U-shaped, which, in turn, makes it possible to derive the high-level equilibrium S_2 through intersecting demand and supply price curves, so that S_2 becomes an equilibrium without specialization. This improved realism, however, comes at the cost of analytical tractability. But it is easily shown that the qualitative effects of a deregulation do not change in the extended model

fect competition, where pecuniary externalities and vertical linkages exist between firms.

Conditions with particularly strong vertical linkages were identified, thus creating possibilities for multiple equilibria. It was shown that, in such cases, a "deregulation" of the labor market may trigger a discontinuous expansion of output, as the economy moves between equilibria. This process worked through the "positive feedbacks" inherent in this type of economy. As final good producers increased production in response to reduced wage costs, upstream producers benefitted through higher demand for inputs. This permitted entry of additional upstream firms, which decreased production costs for final good producers even further, through a more efficient use of intermediate inputs.

As noted by several writers, the existence of such "positive feedbacks" indicates a coordination failure between firms, since the pecuniary externalities are not internalized. Union wage policy may worsen this coordination failure, which is the very reason for the (potentially) considerable effects of weakening the union. It should be pointed out, however, that disarming union power may not be sufficient for industrial take off – the economy can still remain in a bad equilibrium if firms do not internalize the pecuniary externalities by, for example, integrating vertically. Such internalization may fail to materialize, partly because the scope of the linkages may be considerable, but also because the incentives for an individual firm to take these "positive feedbacks" into account, are much smaller than the social benefit.

This suggests that the government might also use other measures. Direct subsidies to alleviate the coordination failure between firms are one alternative. Another alternative is to increase the openness of the economy, as decreasing tariffs on imported inputs (Venables, 1996), or promoting exports of domestic intermediate inputs or even opening the economy for foreign direct investments (Markusen and Venables, 1997), for example, might have a similar, cumulative effect on output.

5.4 References

Binmore, K. and A. Wolinski. "The Nash bargaining solution in economic modelling". *Rand Journal of Economics*, 17, 1986.

Calmfors, L. "Centralization of wage bargaining and macroeconomic performance". *OECD Economic Studies 21*, 1993.

Dixit, A.K. and J.E. Stiglitz. "Monopolistic competition and optimum product diversity". *American Economic Review*, 67:287–308, 1977.

Driffil, J. and F. Van der Ploeg. "Trade liberalization with imperfect competition in goods and labor markets". *Scandinavian Journal of Economics*, 97:223–243, 1995.

Ethier, W.J. "National and international returns to scale in the modern theory of international trade". *American Economic Review*, 72:389–405, 1982.

Haggard, S. *Politics and Institutions in the World Bank's East Asia*, volume 11 of *Policy Essay*. Overseas Development Council, Washington, DC, 1994.

Harrison, A. and E. Leamer. "Labor markets in developing countries: An agenda for research". *Journal of Labor Economics*, 15:1–19, 1997.

Horton, S., R. Kanbur, and D. Mazumbar. "Labor markets in an era of adjustment - Evidence from 12 developing countries". *International Labor Review*, 130, 1991.

Krugman, P.R. "Towards a counter-counter revolution of development theory". In *Proceedings of the World Bank Annual Conference on Development Economics*, 1992.

Krugman, P.R. and A. Venables. "Globalization and the inequality of nations". *Quarterly Journal of Economics*, 60:857–880, 1995.

Markusen, J.R. "Trade in producer services and in other specialized intermediate inputs". *American Economic Review*, 79:89–95, 1989.

Markusen, J.R. and A.J.. Venables. Foreign direct investment as a catalyst for industrial development. NBER Working Paper No. 6241, 1997.

Matsuyama, K. Modelling complementarity in monopolistic competition. IIES Seminar Paper No. 534, Institute for International Economic Studies, Stockholm, 1993.

McDonald, I. and R. Solow. "Wage bargaining and employment". *American Economic Review*, 71:896–908, 1981.

Mezetti, C. and E. Dinopoulos. "Domestic unionization and imperfect competition". *International Journal of Economics*, 31:79–100, 1991.

Oswald, A. "Trade unions, wages and unemployment; what can simple models tell us?". *Oxford Economic Papers*, 34, 1982.

Pack, H. and L. Westpahl. "Industrial strategy and technological change: Theory versus reality". *Journal of Development Economics*, 22:87–128, 1986.

Pemberton, J. "A managerial model of a trade union". *The Economic Journal*, 98:755–771, 1988.

Pencavel, J. The role of labor unions in fostering economic development. World Bank Policy Research Working Paper 1469, 1997.

Rodriguez-Clare, A. "The division of labor and economic development". *Journal of Development Economics*, 49, 1996.

Rodrik, D. "King Kong meets Godzilla - The East Asian miracle". In Wade et al., editor, *Miracle and Design - Lessons from the East Asian Miracle.* 1994. Policy Essay No 11, Overseas Development Council, Washington DC.

Rodrik, D. "Coordination failures and government policy: A model with applications to East-asia and Eastern Europe". *Journal of International Economics*, 40, 1995a.

Rodrik, D. "Getting interventions right: How South Korea and Taiwan grew rich". *Economic Policy 20, April*, 1995b.

Rosenstein-Rodan. "Problems of industrialization of Eastern Europe and South-Eastern Europe". *Economic Journal*, 53:202–211, 1943.

Scitovsky, T. "Two concepts of external economies". *Journal of Political Economy*, 62:143–151, 1954.

Skedinger, P. *Essays on Wage Formation, Employment and Unemployment.* PhD thesis, Uppsala University, 1992.

Uddén-Jondahl, E. *Wage Formation in a Unionized Economy.* PhD thesis, Stockholm School of Economics, 1993.

Varian, H. *Microeconomic Analysis.* W.W. Norton & Company, New York, London, 1992.

Venables, A. "Trade policy, cumulative causation and industrial development". *Journal of Development Economics*, 49:179–197, 1996.

Wallerstein, M. "Centralized bargaining and wage restraint". *American Journal of Political Science*, 34, 1990.

World Bank. *The East Asian Miracle: Economic Growth and Economic Policy.* Oxford University Press, 1993.

Department of Economics
STOCKHOLM UNIVERSITY, SE-106 91 Stockholm, Sweden
Phone +46 8 16 20 00 Fax +46 8 15 94 82
E-mail info@ne.su.se http://www.ne.su.se/