NOVEMBER 1996

SPECIAL PAPER TWENTY-FOUR

MARKET STRUCTURE AND TRADE POLICY IN DEVELOPING COUNTRIES: A GENERAL EQUILIBRIUM APPROACH

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AFRICAN ECONOMIC RESEARCH CONSORTIUM

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Market structure and trade policy in developing countries: A general equilibrium approach

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Market structure and trade policy in developing countries: A general equilibrium approach

Benoit Dostie, John Cockburn
and Bernard Decaluwe

AERC Special Paper 24
African Economic Research Consortium, Nairobi
November 1996

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Published by the African Economic Research Consortium
P.O. Box 62882
Nairobi, Kenya

Printed by
The Regal Press Kenya Ltd.
P.O. Box 46166
Nairobi, Kenya

ISBN 9966-900-89-6

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Market Structure and Trade Policy in Developing Countries: *A General Equilibrium Approach*†

Benoit Dostie, John Cockburn and Bernard Decaluwé ‡

October 1996

Abstract

Trade policy analysis has experienced major changes over the last decade on both the theoretical and empirical fronts. The "new" trade theory points out that the presence of imperfect competition in a market renders theoretically ambiguous the magnitude and the direction of trade policy effects, particularly on resource allocation, factor payments and welfare. On the empirical front, the computable general equilibrium model (CGEM) has emerged as a leading tool for empirical analysis of trade policy. In this paper, we explore the convergence of these two developments - CGEMs with imperfect competition - and their applicability to developing countries. For these countries, the principal application of this theory is in the study of the impact of trade policy when domestic markets behave in a non-competitive way. In particular, taking into account the market power of local firms on the domestic market can modify the magnitude and the direction of welfare changes and resource reallocations to be expected from trade liberalization. A survey of CGEMs with imperfect competition shows that these impacts depend on the way imperfect competition is modelled. In a final section, we illustrate the ambiguous effects of trade policy with a series of simple CGEMs with and without imperfect competition and scale economies.

† A preliminary version of this paper was presented at the December 1995 meeting of the African Economic Research Consortium (AERC) and at the May 1996 meetings of the Société canadienne de sciences économiques (SCSE). This research was conducted under the auspices of the Programme d'analyses et de recherches économiques appliquées au développement international (PARADI), which is funded by the Canadian International Development Agency (CIDA) as a Centre of Excellence. The institutions affiliated with PARADI are the Centre de recherche et développement en économique (C.R.D.E.) of the Université de Montréal and the Centre de recherche en économie et finance appliquées (CREFA) of Université Laval. We would also like to thanks Shanta Devarajan, Jaime de Melo and Tobias Muller for helpful comments. The usual caveat apply.

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1 Introduction

In recent years, economic analysis of trade policies has undergone a significant transformation as the presence of imperfect competition has been taken into account. Though first applied to industrialized nations, we shall see that introducing imperfect competition is at least as pertinent, if not more so, in the case of developing countries. We know that the presence of imperfect competition has serious economic consequences which must be taken into account in the analysis of trade policy: sub-optimal levels of production and consumption, higher prices, 'sur or super-profits', etc.

Under these conditions, trade policy may have some unexpected effects. As we will explore later, by creating a more competitive environment, trade liberalization may paradoxically lead to an expansion of previously highly protected sectors (generally manufacturing) and a contraction in activities (generally agriculture) which were relatively unprotected.

To accurately capture the complex effects of trade policies on relative prices, factor payments, sectorial resource allocation, etc., computable general equilibrium models (CGEMs) have become over the last decade the empirical tool of choice. In this paper, we study the methodology and the impacts of incorporating imperfect competition into CGEMs in the analysis of trade policies such as unilateral trade liberalization and regional integration schemes. We believe that CGEMs are particularly useful in empirically resolving the theoretical ambiguities of trade policy effects under imperfect competition so as to better appreciate the likely impacts of trade policy.

In the presence of monopoly power, it is useful to follow Krugman (1989) and classify the analysis of trade policies into three cases: depending on whether the monopoly power is exercised by **i)** domestic firms on the domestic market, **ii)** foreign firms on the domestic market, or **iii)** both on global markets.

Monopoly Power Held by Domestic Firms on the Domestic Market

Despite the virtual absence of empirical studies, there are several reasons to believe that non-competitive markets exist in developing countries (cf. in particular Rodrik (1988), Krugman (1989) and Lee (1992)). First, barriers to the entry of new firms are significant in developing countries: absence of antitrust legislation, complex and costly regulatory and licensing procedures, the absence of well developed capital markets, etc. Furthermore, in developing countries control of major firms is often held by an ethnic minority, a situation which can be conducive to collusion.

In this context, it is often argued that protectionnist trade policies simply increase the market power and profits of domestic firms. This can lead to a situation where a relatively large number of domestic firms produce at sub-optimal levels. If we consider the import substitution trade policies practised by many developing country governments since the 1960s, and the limited domestic market and excess production capacity observed in most developing nations, the argument for the existence of unexploited economies of scale in these countries is also very strong.

However strong the theoretical case for economies of scale may be, the fact is that not many studies have actually found evidence of them. The most comprehensive set of studies on scale economies in developing countries have been made in Chile with the work of Tybout, de Melo, and Corbo (1991) and Westbrook and Tybout (1993) (see also Little (1987)). Tybout (1993) concludes that most industries in developing countries (as in developed countries!) do not depart significantly from constant returns to scale. He suggests that improvements in scale efficiency following a change in trade policy are more likely to come from the exit of inefficient firms, giving way to an increase in the production of more efficient firms. This is also the conclusion reached by Rodrik (1995). Consequently, issues of entry/exit and scale economies are closely related.

Monopoly Power Held by Foreign Firms on the Domestic Market

When foreign companies hold monopoly power in a market, Brander and Spencer (1984) suggest that the local government may be in a position to extract monopoly rents from abroad by the imposition of a tariff. Fearful of the possibility that local competitors may appropriate some share of the excess profits, these companies will absorb part of the tariff, bearing in mind the domestic demand conditions. The argument advanced by Brander and Spencer is similar to that applied to a large country seeking to impose an optimal tariff policy to change its terms of trade[2].

The relevance of an optimal tariff policy has come under much criticism (cf. Alam (1994)). For example, the optimal intervention by the government requires knowledge of the demand schedule, which is difficult, if not impossible to obtain[3]. Similarly, the level of the optimal tariff depends upon parameters like the price-elasticities of supply and demand which are not readily measurable, so the implementation of such a scheme is fraught with difficulties. In addition, from a political perspective, the retribution of foreign governments can be dissuasive. Finally, when interest groups are able to control a government's tariff policy, serious distortions may result. All things considered, when we take into account the small size of many developing countries, we have some serious reasons to doubt that they can significantly influence the pricing policy of foreign firms in their local markets.

Monopoly Power Held by Foreign and Domestic Firms on Global Market

In this third scenario, the government uses trade policy to influence the nature of the competitive relationship between foreign and domestic firms on the global market. A traditional example is the case of a government which uses a subsidy to enable domestic producers to assume an aggressively competitive stance, thus discouraging entry by foreign firms. The strategic behavior implied by the analysis in these models have been mostly applied to global high tech-

[1] An argument made by Katrak (1977)

[2] In the opposite case, if there is some market power exerciced by domestic firms on foreign markets, the optimal trade policy in terms of national welfare would be an export tax.

[3] Some cases are best handled with import tariffs, and others with import subsidies (cf. Helpman and Krugman (1989)).

nology industries dominated by a few players, such as aircraft manufacturing.

It has been shown, however, that the optimal policy to follow crucially depends on the specific behavioral assumptions made (cf. Helpman and Krugman (1989)). The absence of a generalized approach detracts from the appeal of these theories. In addition, numerical simulations show that not only are welfare gains resulting from such policies minimal, but that they can easily be translated into welfare losses when the underlying assumptions are modified, sometimes even slightly (cf. Dixit (1988), among many others). Finally, as most developing countries have small domestic markets, strategic trade policies have little relevance to them: small countries are rarely home to companies which are major international forces in their market, and even when they are, their limited finances prevent them from playing an important role in the interactions of these companies (Krugman (1989)).

Consequently, this paper will focus primarily on trade policies affecting the monopoly power of domestic firms on the domestic market. We shall pay particular attention to the impact of trade liberalization and regional integration under conditions of imperfect competition and possible economies of scale. We deem these the most pertinent situations to examine for developing countries as a whole.

The remainder of this paper is divided into five sections. Section 2 comprises a brief survey of studies using CGEMs with imperfect competition. There have been many recent studies examining the impact on an economy of dismantling tariff barriers in the presence of monopoly power and inefficient scales of activity of domestic firms. As we show in the following section, trade policy measures have analytically ambiguous effects under these conditions so that we must use applied analysis to better understand its consequences. The fourth section outlines different ways of modelling monopoly power and scale economies on the domestic market, and a comparison with perfect competition formulations. This section, in addition to clarifying the choices which model builders must make, reveals the mechanisms by which the magnitude and even the direction of the effects of trade policy may vary depending on whether and how imperfect competition is incorporated into the model. In a fifth section, we present an example of a simple CGEM in which we illustrate the importance and the manner of taking imperfect competition into account when analyzing trade liberalization. We present some conclusions in a final section.

2 A Brief Review of the Litterature

Among developed countries, studies of trade liberalization using CGEMs with imperfect competition have focused mainly on Canada. Harris (1984), (1985), (1986), Cox and Harris (1985) and Hazeldine (1990) have studied the economic costs of existing tariff structures. They estimated the impact of reducing tariffs on the allocation of resources and on the level of welfare. Also in Canada, Delorme and van der Mensbrugghe (1989) have studied the impact of liberalizing

trade in agricultural produce. Finally, in a recent study, Melo and Tarr (1992) used a CGEM to analyze foreign trade policy in the United States.

There have been few CGEMs applications of industrial organization theory to trade policy analysis in developing countries despite the extent of policy reforms currently undertaken in these countries. Aside from the work by Melo and Roland-Holst (1991b), (1991a), and (1994) and by Gunasekara and Tyers (1991) on South Korea, a country which is better described as newly industrialized than as developing, we note the studies of trade liberalization in Cameroon by Devarajan and Rodrik (1989) and (1991) and in Tunisia by Kress (1995).

The literature on regional integration was mainly developed to answer questions posed by North American and European integration. In North America, Wigle (1988) and Brown and Stern (1989a) and (1989b) conducted a number of studies to evaluate the impact of the Free Trade Agreement. Among examinations of the North American Free-Trade Agreement, Cox and Harris (1992) and Cox (1994) focused on the effects on Canada, while Brown (1992) and (1994) and Brown, Deardorff, and Stern (1992) concentrated on the United States, and Sobarzo (1994) on Mexico. Further analysis was conducted on a sectorial basis: Cox and Harris (1986) analyzed the effect of the FTA on the Canadian manufacturing sector while Hunter, Markusen, and Rutherford (1992) and Lopez-de Silanes, Markusen, and Rutherford (1994a) and (1994b) studied NAFTA's implications for the automobile industry.

As to Europe, the impetus came from a 1988 study by Smith and Venables which, although it took a partial equilibrium approach, introduced a new method of modelling regional integration. In addition to the usual tariff reductions, they assumed that the elimination of trade barriers would render it impossible for firms to practise price discrimination on different markets within the region, hypothesis which appears to have particular pertinence to the European situation. Their partial equilibrium work was later transferred to a general equilibrium setting by Gasiorek, Smith, and Venables (1991), Burniaux and Waelbroeck (1992) and (1994)[4], Kempeneers (1993), Haaland and Norman (1992), Harrison, Rutherford, and Tarr (1994), Mercenier (1994a) and (1994b) and, respectively with special emphasis on the countries in EFTA[5] and Switzerland, Norman (1990) and Antille, Bachetta, Carlevaro, Maranon, Muller, and Schmitt (1991). Quite recently, a few models with imperfect competition were also built to study the impacts of the Uruguay Round (cf. Haaland and Tollefsen (1994) and François, MacDonald, and Nordström (1995)).

As in the case of trade liberalization, few CGEMs incorporating imperfect competition have been used to study regional integration in the context of developing countries. To our knowledge, only the work by Flôres Jr. (1994), on welfare gains associated with MERCOSUL, fits this description. Nonetheless, we suspect that imperfect competition and increasing returns to scale are important features of these countries (cf. Rodrik (1988)).

[4]These authors further assumed that regional integration led to a change in consumers' preferences through a change in the elasticity of substitution between products according to their origins in the utility functions.

[5]The EFTA is comprised of Austria, Finland, Iceland, Norway, Sweden and Switzerland.

Note that it would be dangerous to mechanically apply to developing countries models developed for industrial countries without accounting for the significant structural differences which distinguish them. Note, for example, the large proportion of imports used as intermediate inputs, the higher degree of structural rigidity impeding the entry and exit of firms, the preponderance of excess profits, and the tendency of international trade to be inter-, rather than intra-, industry. All of these factors may, if they are correctly incorporated, change the conclusions for developing economies.

3 Ambiguous Effects of Trade Policy

From a theoretical perspective, the introduction of imperfect competition may significantly modify the results of trade policy analysis in CGEMs. As previously indicated, we shall examine trade liberalization and regional integration, and focus on impacts on welfare, sectorial resource allocation and factor payments. In this section, references to trade liberalization specifically pertain to the elimination or reduction of tariffs and quotas.

3.1 Resource Allocation

In standard CGEMs with perfect competition, reductions in trade barriers lead to a decrease in relative prices in the protected sectors (usually manufacturing, in developing countries) and a corresponding increase in the relative prices of the sectors which are less sheltered (usually agriculture). These relative price changes induce a reallocation of resources from the formerly protected sectors to the others; that is, a contraction in manufacturing production and an expansion in agricultural production. Trade liberalization similarly encourages an outward orientation of the economy as it increases the price of exports relative to import-competing products.

However, if firms in the protected sectors operate under conditions of imperfect competition, this may modify these conclusions. Consider the example, illustrated in figure 1 in which a single firm satisfies the entire demand for a given good; the case of pure monopoly. If this good is an imperfect substitute for some imported goods, reductions in trade barriers will have two effects. Consumers will reallocate some expenditures to now cheaper imports and consequently reduce their purchases of domestic goods. This causes a shifting inward of the demand curve. Secondly, the increased competition from foreign firms will reduce the monopoly power of the domestic producer. This results in an increase in the slope of the demand and marginal revenue curves facing him. This is the pro-competitive effect of liberalization.

While the first (demand) effect tends to reduce the output of the domestic producer, the second (supply) effect tend to increase it as the firm reduces its mark-up and increase production closer to optimal levels. It is impossible to know, a priori, whether the monopoly's output will increase or decrease. In

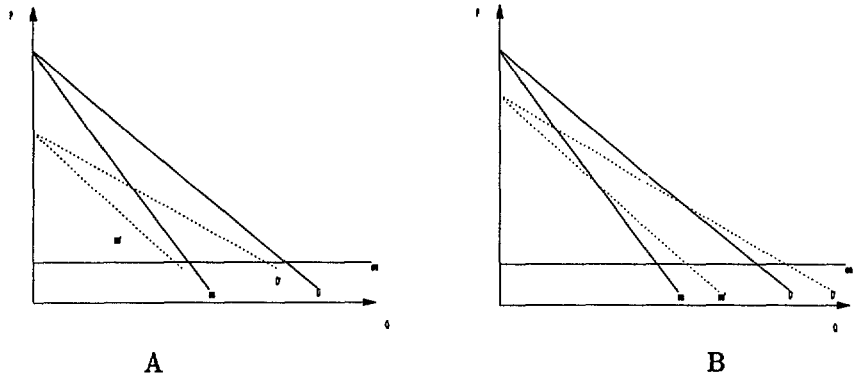


Figure 1: Ambiguous effects of trade liberalization

panel A, trade liberalization causes a decrease in production. The opposite effect is illustrated in panel B. An applied analysis is needed to know the more likely result in any particular sector and country.

It is still true that the sectors which were previously highly protected will tend to experience the largest influx of competing imports and, consequently, the largest inward shift in the demand curve subsequent to trade liberalization. However, if these sectors are also monopolistic or oligopolistic (often the case in highly protected sectors), they will react to this increased competition and resulting decline in their monopoly power, by reducing their mark-up and increasing production. As imperfect competition is generally more prevalent in highly protected sectors, manufacturing in particular, this pro-competitive effect is strongest in these sectors. In theory, it can be sufficiently strong that the highly protected sectors actually increase output after trade liberalization while the others contract. Contrary to traditional conclusions, agriculture production and exports could actually decline while manufacturing and import- competing production could increase.

In the case of regional integration schemes, traditional resource allocation effects depend upon how the relative price structure in the economy is modified by changes in regional and external tariffs rates. As these schemes imply a reduction in tariff rates on intra-regional trade, sectors which export within the region are expected to expand while those which compete on the local market with regional imports contract. The impact on sectors which compete on the local market with extra-regional imports depends on whether a common external tariff is established and whether this tariff is superior or inferior to the pre-existing external tariff rate in the country. While extra-regional export tariffs are not necessarily modified in regional integration schemes, changes in the prices of other goods modify their relative prices and their relative attraction for resources.

Taking into account imperfect competition within the region may, once again, modify these traditional results. Sectors which face increased compe-

tition on the local or regional market as a result of the RI scheme are traditionally expected to contract. However, if these sectors are also characterized by imperfect competition, they will react to this increased competition, and the consequent decline in their market power, by lowering their mark-up rate. This will lessen the decline in their production and potentially lead to an expansion in their output.

Consequently, it is necessary to turn to empirical studies. Given the magnitude of changes involved in most trade liberalization episodes and the need for detailed sectorial analysis, CGEMs are the appropriate tool. The ambiguous effects of trade policy in the allocation of resources has been illustrated in several CGEMs. Devarajan and Rodrik (1991) find that subsequent to trade liberalization in Cameroon, manufacturing increases while agricultural production declines. In Harris (1984), simulations of trade liberalization in Canada with perfect competition show a contraction in the manufacturing sector while the opposite occurs when imperfect competition is taken into account. Harris (1984) notes that, with imperfect competition, the direction of the variations in production changes in almost half of the sectors. Note that these effects depend on the prior structure of protection. In Europe, where protection is concentrated on the perfectly competitive agricultural sector, Harrison, Rutherford, and Tarr (1994) find that changes in output are in the same direction whether imperfect competition in the industrial sector is incorporated or not. In this case, the pro-competitive and the demand effects act in the same direction and, consequently, variations in output are greater in the oligopolistic case.

In the same way, taking into account imperfect competition may modify the conclusions as to the structure of trade following trade liberalization. In the empirical litterature, the inclusion of imperfect competition increases estimations of the volume of inter-industry trade after regional integration in Brown and Stern (1989a) and Harrison, Rutherford, and Tarr (1994). It also appears that, in general, perfect competition models show a strong tendency toward increased intra-industry trade while the opposite occurs in monopolistic models. These results illustrate the importance of accounting for imperfect competition when evaluating the effects of trade policy measures on resource allocation.

3.2 Welfare

In the preceding section, we saw that, depending on the relative importance of the demand and pro-competitive effects, production in previously protected sectors could either increase or decrease following trade liberalization or regional integration. The question we now address is which of these results is more desirable from a welfare point of view. The traditional approach to trade policy analysis focuses on the welfare gains anticipated from the elimination of distortions in domestic prices relative to world prices and the consequent reallocation of domestic resources from protected to unprotected sectors. However, if protected sectors are characterized by the presence of imperfect competition, it is possible that they are producing at sub-optimal rather than supra-optimal levels. If so, a contraction of these sectors could be welfare-reducing. This

possibility is even greater if these same sectors have unexploited economies of scale.

Rodrik (1988) has proposed a simple analytical model of the possible gains and losses from tariff reform in the presence of non-competitive markets and economies of scale. We shall ignore income effects and represent the economy by an expenditure function $E(p, W)$, where p is the vector of prices and W an index of welfare. E represents the smallest expenditure compatible with a welfare level W. From the envelope theorem, consumption of i, denoted C_i, is equal to the partial derivative of the expenditure function with respect to the price of good i. If we assume that each sector i consists of n_i identical firms, then a representative firm's output, x_i, is equal to the total production in the sector, X_i, divided by n_i.

The technology of industry i is characterized by a unit cost function $c_i(w, x_i)$, where w represents the vector of payments to factors. Since x_i is an argument of $c()$, this model allows for increasing returns to scale, in which case the partial derivative of the cost function with respect to the firm's production is strictly less than zero. Application of Sheppard's lemma to the cost function yields the factor demand for each unit produced. Equation (3.1) ensures equality between supply and demand in the factor market:

$$v_i = \sum_i X_i(\frac{\partial c_i}{\partial w_j}); \quad \forall j, \tag{3.1}$$

where v_j is the economy's fixed endowment of the j-th factor of production. Net imports of i, M_i, are simply equal to the difference between domestic demand C_i and supply X_i as, in this model, domestic and foreign goods are assumed to be homogeneous.

We may represent the initial equilibrium in the economy with the equality of aggregate income and aggregate demand. In our model national income is the sum of three elements: **i)** rents accruing from quotas and income generated by tariffs, **ii)** pure profits, and **iii)** factor income. Consequently, the national accounting identity may be written:

$$E() = \sum_i (p_i - p_i^*)M_i + \sum_i [p_i - c_i()]X_i + \sum_j w_j v_j \tag{3.2}$$

where p_i and p_i^* are, respectively, the domestic and foreign prices of good i. While we do not explicitly consider intermediate demand, X_i may be interpreted as net production.

Now, let us examine a partial tariff reform. What will be the welfare effects? We begin our analysis by totally differentiating equation (3.4) and evaluating the derivative in the neighborhood of the initial equilibrium. After several substitutions and supposing that $dp_i^* = 0$, we obtain:

$$E_W dW = \overset{(a)}{\sum_i (p_i - p_i^*)dM_i} + \overset{(b)}{\sum_i (p_i - c_i)dX_i} + \overset{(c)}{\sum_i n_i c_i [1 - \frac{1}{g_i}]dx_i} \tag{3.3}$$

where g_i is the scale parameter and is equal to the ratio of average cost to marginal cost.

Each of the three effects, (a), (b), and (c), correspond to a unique source of market failure. Expression (a) shows that it is desirable to increase imports of protected goods or, as $M_i = C_i + X_i$, to increase domestic consumption and reduce the domestic production of these goods (the demand effect of section 3.1). The ensuing welfare gains will be directly proportional to the size of the initial gap between domestic and global prices caused by tariffs. This is the traditional welfare gain associated with trade liberalization; trade barriers lead to sub-optimal levels of imports and consumption and supra-optimal levels of production of protected goods.

Expression (b) reflects excess profits. In non-competitive industries the market price is higher than marginal costs which suggests that local producers operate at sub-optimal levels. In consequence, expression (b) demonstrates that welfare gains can be expected if increased competition brought on by trade liberalization or regional integration leads to an increase in production in these non-competitive sectors (the supply effect of section 3.1).

However, a sector may be affected simultaneously by these two market imperfections. In developing countries, manufacturing sectors are usually heavily protected and also show a tendency to having a non-competitive market structure. Under these conditions, it is unclear whether they are producing sub- or supra-optimally and, consequently, whether it is desirable from a welfare viewpoint that they contract or expand. If we substitute $dM_i = dC_i + dX_i$ into expression (a), we can resolve this ambiguity. Ignoring, for the moment, expression (c), equation (3.3) becomes:

$$E() = \sum_i (p_i - p_i^*) dC_i + \sum_i [p_i^* - c_i()] dX_i \tag{3.4}$$

Thus, it becomes clear that an increase in the production of a sector is desirable if it produces at a marginal cost which is inferior to the world price, and a contraction is preferable on the contrary. Rodrik (1988) argues that the latter case is more probable as unit costs tend to be higher in highly protected sectors.

Term (c) captures the influence of possible economies of scale. This term will be positive in the case of increasing returns to scale. If industries characterized by increasing returns to scale already produce at costs inferior to world prices, this will simply add to the welfare gains (losses) to be expected from their expansion (contraction). However, if their costs are initially above world prices, this effect will reduce or possibly eliminate the welfare losses (gains) to be expected from their expansion (contraction).

There remain some issues which have not been addressed. In particular, this model does not reflect possible welfare gains from an increase in the variety of products available. This is likely to be non-negligible in developing countries subsequent to trade liberalization. Also, the process by which firms enter and exit non-competitive markets is not explicitly accounted for in this model [6].

[6] See the work of Melo and Roland-Holst (1991a).

If, subsequent to trade liberalization, inefficient companies are squeezed out, the three previously identified effects (*a*), (*b*), and (*c*) may all work in the same direction. If a large number of firms exit, the remaining firms would produce at a larger scale even if total production stagnates or declines. Hence, this rationalization effect may enhances welfare through the scale effect previously mentioned. The most commonly made assumption is that, as the industry's profit levels fall with the elimination of tariff protection and export subsidies, some firms will exit the market. If the industries in question are characterized by economies of scale, the welfare of the entire economy will tend to increase.

The consensus which appears to be emerging from analysis performed with CGEMs with economies of scale and imperfect competition is that accounting for monopoly power by domestic firms magnifies the benefits resulting from trade liberalization and regional integration (cf. a review of the literature by Richardson (1990)). Harris (1984) estimated possible welfare gains of 8% to 10% of GDP for the Canadian economy. Hazeldine (1990), for Canada, and Nguyen and Wigle (1992), for estimates of world multilateral liberalization, show similar but not as large results about the effect of taking into account imperfect competition although Hazeldine finds that this result is sensitive to the hypotheses concerning firm behavior. Total welfare gains double in the monopolistic model of Brown and Stern (1989a) relative to the perfection competition case. The inclusion of imperfect competition has a similar effect in Norman (1990) and François, MacDonald, and Nordström (1995) as welfare also roughly doubles.

In studies of developing countries the benefits are equally significant. Estimates by Gunasekara and Tyers (1991) in the case of South Korea are of a similar order. Studying Cameroon, Devarajan and Rodrik (1989) obtain welfare gains of 0.5% when they assume perfectly competitive markets, and 2% when imperfectly competitive markets and economies of scale are incorporated. Although welfare increases when imperfect competition is taken into account, one should note that the effect is not as strong as in Gunasekara and Tyers's model. In fact, the results of the two models differ in the way firms respond to trade liberalization. While the rationalization process is important in Gunasekera and Tyer's results, it is practically absent in Devarajan and Rodrik (1991)'s model. However, both studies underscore the importance of accounting for imperfect competition and economies of scale when analyzing the benefits of trade liberalization policies.

3.3 Payments to Factors

We conclude this section with a short note on the possible effects of trade policy on payments to factors. In a model with two mobile factors (labor and capital), a decrease in tariffs will normally have the effect of increasing payments to the factor which is used relatively less intensively in the protected sector by increasing the value of its marginal product (the Stolper-Samuelson effect). Consequently one of the two factors will have its real income reduced from the tariff reduction.

In empirical studies it has sometimes been observed that other effects may

come into play. As we have seen, taking into account imperfect competition may imply that the protected sector expands, increasing payments to the factor which is used relatively more intensively in this sector. Concretely, if we assume that the industrial sector is protected and relatively intensive in capital, wages may fall rather than increase following trade liberalization. The introduction of increasing returns to scale will have an additional impact on these conclusions. If scale effects resulting from the liberalization are sufficiently positive, it is conceivable that the two factors will split the gain from increases in production in such a manner that real incomes in terms of domestic production will increase for both.

An illustration of this can be found in Brown (1994). In her model of NAFTA, returns to both capital and labor increase in the three countries. In the case of United States this is due to changes in terms of trade, as its economy was the least protected before integration. For Mexico and Canada, positive scale effects explain this result.

In consequence, we cannot determine on a theoretical basis whether or not a factor will gain from liberalization. The evolution of factors' income will depend on these three effects[7], namely the Stolper-Samuelson effect, the pro-competitive effect and, finally, effects on the scale of production. Once again, empirical analysis taking into account imperfect competition is required if we wish to have more precise answers.

4 Market Structure

As we saw in the preceding sections, the inclusion of imperfectly competitive markets in CGEMs is increasingly preoccupying researchers in trade policy. However, to date no consensus has emerged as to the best way to integrate these features into these models and into economic theory in general. This section presents a brief survey of how firm behavior is modelled in the economic literature, particularly in the CGEM literature. In addition to clarifying the choices which model builders must make, this section reveals the mechanisms by which the magnitude and even the direction of the effects of trade policy may vary depending on whether and how imperfect competition is incorporated into the model.

For each case we shall analyze the implications in terms of model building, the realism of the underlying assumptions and the likely impacts on the results of trade liberalization. We also take into account the broader general equilibrium context within which the relevant market operates. Our review will not dwell on the technical aspects of the models, we will simply refer the reader to relevant studies. We will first see the case in which all the firms in a same sector produce a homogeneous good. We will suppose further that the sector's producers compete with foreign goods (imports) which are imperfect substitutes. This is the familiar Armington approach where products are differentiated at the national level.

[7] Abstracting from changes in the terms of trade.

	perfect competition	monopolistic competition	oligopoly	monopoly
number of sellers:	many	many	few	one
product type:	homogeneous	differentiated	both	one
barriers to entry:	none	weak	important	important
η_i,	infinite	$\widetilde{\sigma}_i$	$\frac{\varepsilon_i}{s_i}$	ε_i

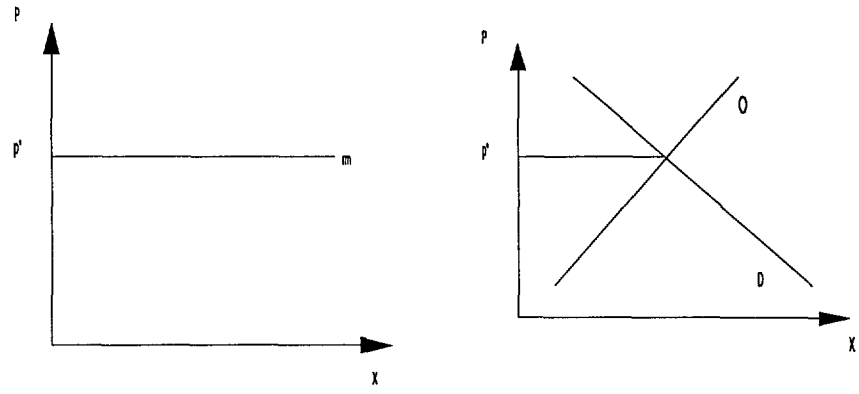
where:
ε_i = market price-elasticity of demand for domestic good
$\widetilde{\sigma}$ = elasticity of substitution among varieties
s_i = firm's market share
η = price elasticity of the firm's demand

Table 1: Market Taxonomy

An alternative approach, used in some of the studies presented in the preceding section, would be to consider that foreign and domestic goods are perfect substitutes. However, it should be noted that under these conditions, imperfect competition is possible only in the presence of a quota. Otherwise, the domestic producer would simply be forced to charge a price equal to the world price multiplied by one plus the tariff rate.

In section 4.1.1, we will quickly recall the basic elements of our reference model - perfect competition - then we will examine, in turn, monopoly and oligopoly cases. The following section will present the case of firm-level product differentiation in oligopoly models. In table 1, the reader will find a summary of the various market structures we will review. A final subsection deals with the modelling of returns to scale.

As we made clear in the introduction, we are concerned here primarily with market structure on a domestic or regional market and therefore exclude from our analysis strategic trade policy issues popularized by Krugman. The latter, generally involving high-technology world markets such as for airplanes and micro-chips, requires an entirely different theoretical framework, and is of limited interest outside these few industries. For a review of this literature, see Brander (1995). Consequently, market structure is defined solely relative to domestic firms or, in the case of multi-country regional integration models, in terms of firms implanted within the region. As we will see below, foreign competition and, consequently, Devarajan and Rodrik's pro-competitive effects, are taken into account through their impact on the slope of the market demand curve (price-elasticity) faced by local firms. Foreign firms are assumed to be perfectly competitive although they produce imperfect substitutes for domestic goods. The latter therefore have their own distinct market demand curve.



Firm Branch

Figure 2: Perfect Competition

4.1 Homogeneous Goods

4.1.1 Perfect Competition

The Walrasian model of general equilibrium under perfect competition postulates a finite but large number of producers, consumers and goods in the economy; the latter may be both inputs to and outputs of a production process. On the production side, returns to scale are non-increasing, production without inputs is impossible, complete inactivity is possible and the production process is irreversible. Each producer maximizes total profits over a given vector of exogenous prices, (cf. Decaluwé and Martens (1988)). It is this last assumption which is characteristic of perfect competition.

In CGEMs with perfect competition, we postulate that the economy is divided into branches, and that there is a sufficiently large number of firms per branch so that each one assumes that the impact of its output on the market price is negligible; each firm produces a tiny proportion of the total output in its branch. Clearly, if all the firms simultaneously decide to increase production, we expect the market price to fall. The important fact here is that under perfect competition the marginal revenue of an individual firm is constant and equal to p, the market price. It is not the same as the marginal revenue associated with the entire market or branch (see figure 2).

Algebraically, the firm's problem is:

$$\max_x px - c(x) \tag{4.1}$$

where x represents output, p the constant market price, and $c(x)$ the cost function. The first order condition is simply that the firm sets production levels such that marginal cost equals market price:

$$p = c_x(x) \tag{4.2}$$

This condition is rarely explicitly introduced into CGEMs with perfect competition. It is implicit, however, in the factor demand functions which equalize the value of the marginal product of each factor with its marginal cost.

Furthermore, when the n firms are identical, each one produces the same share of the total output of branch X, that is $\frac{X}{n}$. In this case it is not necessary to model each firm individually. Most models make the assumption that there is a representative firm for the branch and that the entire branch can be captured in its behavior.

Given condition (4.2) and the absence of internal returns to scale in the perfect competition model, equation (3.3) simply becomes:

$$E_W dW = \sum_i (p_i - p_i^*) dM_i \tag{4.3}$$

Three main points can be made about the welfare effect of trade liberalization from this simplification of equation (3.3). First, in the absence of other distortions in the economy, evaluation of welfare gains will be unambiguously positive. Second, these gains will come exclusively from the reallocation of resources from formerly relatively protected to formerly unprotected sectors. Suppose that agricultural is the relatively unprotected sector and let P_{IND}, P_{AGR}, X_{IND} and X_{AGR} be the price and level of production of the agricultural and industrial good respectively. Following trade liberalization, P_{AGR}/P_{IND} will increase given that $\downarrow P_{IND} > \downarrow P_{AGR}$. This change in relative price will render production in the agricultural sector more profitable, giving way to an increase in the production in this sector. The inverse argument can be made for the industrial sector. Finally, we see from equation (4.3) that the welfare gains resulting trade liberalization in a context of perfect competition will be, as we said before, proportional to the former wedge between domestic and international price. In that case, welfare effects of trade liberalization tend be relatively small (see /citeNDecaluwé/Martens:1988).

As we have seen earlier, the effects of regional integration depend on the details of the scheme. However, it is still true that only the traditional demand effect, and not the pro-competitive or scale effects, come into play if imperfect competition is not taken into account.

4.1.2 Monopoly

In the case of a monopoly, there is only one firm producing a given good. This firm faces total market demand as the demand for its product, and production in the branch is equal to production of the firm: $X = x$. When, as usual, the market demand schedule is downward sloping, the firm must make a trade-off between price and quantity. In other words, the firm's marginal revenue is below the market price; if one more unit is sold, the price of all the other units it sells must fall. Marginal revenue is thus equal to the price of the extra unit minus the revenue lost due to the decrease in the price of all other units.

Algebraically, the firm knows that the market price is determined by its

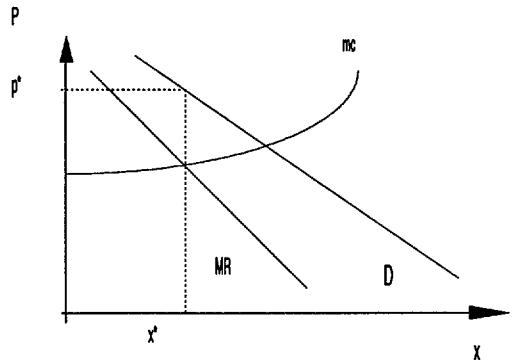


Figure 3: Monopoly

output level, so that $p = p(X)$. The monopolist's maximization problem is:

$$\max_{x} p(X)X - c(X) \tag{4.4}$$

The first order condition of this problem is:

$$p(X) + \frac{\partial p(X)}{\partial X} X = c_X(X) \tag{4.5}$$

In consequence, we see that to the extent that the demand schedule is downward sloping $\frac{\partial p(X)}{\partial X} < 0$, marginal revenue (mr)[8] will lie below the market price, p. Furthermore, as we see in figure 3, the price charged by the firm will exceed marginal cost, and hence will be greater than the price which would prevail under perfect competition. A monopolistic market structure will thus yield a higher price and a lower output than perfect competition.

We can rewrite equation (4.5) to render explicit the gap between price and marginal cost:

$$\frac{p(X) - c_X(X)}{p(X)} = \frac{1}{\varepsilon} \tag{4.6}$$

where $\frac{1}{\varepsilon - 1}$ represents the monopolist's mark-up rate and ε is the price elasticity of demand in the branch, $\varepsilon = |\frac{\partial X}{\partial P}\frac{P}{X}|$. Equation (4.6) is often called the Lerner equation, it results directly from profit optimization by the firm. We see that more the demand for the monopolist's good is inelastic (ε small), the greater will be his mark-up.

ε is generally determined endogenously by the model based, however, on a partial equilibrium derivation of the demand function. In particular, it does

[8]Note that in this case the firm's marginal revenue (mr) is equal to the marginal revenue for the branch (MR). Also the price-elasticity of demand within the branch ε is equal to the price-elasticity perceived by the firm, η.

not incorporate income effects which a change in output or price may engender. To illustrate, assume that the demand facing the producer comes from a representative agent who has a linear demand for a composite good which is a CES aggregate composed of the imported and domestic goods. In this case, the partial equilibrium derivation of the price-elasticity of demand for the domestic good is:

$$\varepsilon_i = [\sigma_i + (1 - \sigma_i)\frac{P_i^d X_i^d}{P_i^d X_i^d + P_i^m M_i}], \tag{4.7}$$

where P_i^d and P_i^m represent the prices of the domestic good d and of the imported good m in sector i, respectively; X_i^d and M_i represent the volume of the domestic good and the imported good consumed domestically; and σ_i represents the elasticity of substitution between the domestic and imported goods.

How will incorporating the monopolistic behavior of certain sectors likely modify the simulation results obtained from a CGEM relative to the case of perfect competition? We can see that ε_i varies positively with the relative price of imports (P_i^m/P_i^d). Consequently, trade liberalization will diminish the mark-up charged by domestic firms and cause them to increase production. This is the pro-competitive effect described by Rodrik (1988) which, as we have seen, goes counter to the traditional negative effect of trade liberalization on output in highly protected sectors. The extent of this pro-competitive effect depends fundamentally on the variation in ε_i subsequent to trade liberalization. From equation (4.7), the variation in ε_i is determined by the extent of trade liberalization $(\triangle P_i^m)$. For a given variation in P_i^m, the magnitude of the pro-competitive effect varies positively with the share of the domestic good in total domestic consumption and the elasticity of substitution between domestic and foreign goods.

As for the probable welfare effects, equation (3.3) becomes:

$$E() = \sum_i (p_i - p_i^*)dC_i + \frac{c_X(X)}{\varepsilon - 1}dX_i \tag{4.8}$$

The smaller is ε_i, the greater is the monopolist's monopoly power and markup and the more likely it is that he is producing sub-optimally. Thus the smaller is ε_i, the greater are the welfare gains (losses) to be expected from the expansion (contraction) of this sector.

4.1.3 Oligopoly

In contrast to monopoly, with a single firm per branch, and perfect competition, with a large number of firms per branch, the oligopolistic market is characterized by the presence of a small number of large firms relative to the market. Unlike producers in monopoly and perfect competition, oligopolists must take into consideration the possible actions of other firms in the branch. We can distinguish between models in which those firms behave in a cooperative or a non-cooperative way.

Cooperative oligopoly: Collusion Collusion is a situation in which firms agree among themselves to jointly fix prices or production levels in order to maximize profits over the entire branch. The optimal strategy is for these firms to fix the market price at the level which would prevail under monopoly, and then distribute the resulting profits proportionally among themselves. Note that this type of arrangement may be very difficult to maintain, as each firm has an incentive to cheat and sell more than its allotted quota as long as the others are respecting the agreement. In consequence, there are some conditions which are more conducive to collusion than others. For example, if there is a credible threat to respond rapidly to cheating, barriers to entry, a small number of firms, or if the firms have symmetric cost structures, collusion is more likely or, at least, more sustainable (cf. Tirole (1988)).

With a profit-maximizing collusion, the pro-competitive and welfare effects of trade policy are identical to those of a monopoly provided that the collusion does not break apart as a result of the modified trade policy environment.

The Eastman-Stykolt Hypothesis In a context in which a domestic industry faces foreign competition, the presence of policies to protect the domestic market, which result in a domestic price above the international price, provides a natural framework for collusion. In this context, Harris (1984) introduced the idea of a focal price as a collusion mechanism for local firms. Domestic producers agree to sell at the world price plus the applicable tariff, thus preventing foreign competition. Let t_i represent the tariff rate imposed on good i at the border, then the price of the import competing good may be set at: $p_i = p_i^* (1 + t_i)$ .The existence of this target price facilitates collusion. This form of price collusion has been designated under the name of "Eastman Stykolt" hypothesis Eastman and Stykolt (1966).

Note that under these conditions, the domestic price simply falls in the same proportion as the import price subsequent to trade liberalization. The pro-competitive effect in this scenario is thus much greater than with profit-maximizing collusion. The likelihood that production is sub-optimal under this scenario, and the resulting welfare gains (losses) to be expected from an expansion (contraction) of this sector, would be greater than with profit-maximizing collusion if, for the same unit cost, the domestic price is higher; that is:

$$p^*(1+t) > c_X(X)(1 + \frac{1}{\varepsilon - 1})$$

While the hypothesis of a focal price has been used by Delorme and van der Mensbrugghe (1989) and Nguyen and Wigle (1992), this approach is open to criticism. First, as domestic and imported goods are assumed to be imperfect substitutes, this price setting behavior does not, in effect, prevent foreign competition nor maximize profits. Further, Wigle (1988) emphasized that the conditions for such effective collusion are rarely observed, particularly the presence of significant barriers to entry. He also notes that the application of the "Eastman Stykolt" assumption leads to exaggeration of the potential welfare

gains resulting from the elimination of tariffs by supposing such an implausible market structure. Also, it should be noted that this pricing hypothesis is purely ad hoc. It is not inferred from any profit maximization problem: the firm does not recognize the market power embodied in the use of the national product differentiation hypothesis (see section 4.2) [9].

Non-Cooperative Oligopoly In contrast to collusion, firms do not coordinate their actions when they act in non-cooperative ways. Two main formulations may be conceived: firms compete based either on prices, or on quantities. In the Cournot model, firms choose the quantity they will produce, with the price determined by the market. In the Bertrand model, on the other hand, prices are set by firms which then sell all they can at that price. The two models share the assumption that firms take their competitors behavior as given when deciding their own strategy. In fact, these models are purely static by definition; the firm does not form expectations as to how the others may react to its decisions. A third formulation allows this expectation to be taken into account: the conjectural variations model. However, this model also has its weaknesses which we shall discuss later.

We are particularly interested in the optimal decision rule of firms in oligopolistic markets. Be it because of the small number of firms in the market, or because of product differentiation, firms in oligopoly possess a certain degree of monopoly power allowing them to set prices above marginal cost, as in the case of monopolists. We shall see that the size of the gap between price and marginal cost and, consequently, the magnitude of the pro- competitive and welfare effects of trade liberalization, depends upon the nature of the competition between firms as well as on the degree of product differentiation and their market share.

The Cournot Model with Homogenous Products A Cournot-Nash equilibrium occurs when each firm's expectation as to their rival's level of production is verified. It is possible to derive an expression for the company's optimal mark-up from the profit maximization problem. This problem is written:

$$\max_{x_i} p(X)x_i - c_i(x)x_i, \tag{4.9}$$

where X represents total production in the branch and is equal to $\sum_i^n x_i$ if we assume that there are n firms in the industry. The firms marginal cost is assumed constant at $c_i(x)$. First order conditions for firm i are:

$$p(X) + \frac{\partial p(X)}{\partial x_i} x_i = c_i(x), \tag{4.10}$$

[9] Models where collusion would be on stronger theoretical ground may be found, for example, in Rothemberg and Saloner (1986) and (1990).

This equation may be solved for the markup[10], yielding:

$$\frac{p(X) - c_i(x)}{p(X)} = \frac{s_i}{\varepsilon} \tag{4.11}$$

where s_i is the market share of firm i equal to $\frac{x_i}{X}$ and ε the price elasticity of demand within the branch. If we suppose that all firms are identical, then the market share of a representative firm will be equal to $\frac{1}{n}$. The optimal mark-up will therefore be:

$$\frac{p(X) - c_i(x)}{p(X)} = \frac{1}{n\varepsilon} \tag{4.12}$$

where the price-elasticity faced by the firm (η_i) is equal to $n\varepsilon$.

Note that the Cournot model generates a form of mark-up on marginal costs with some interesting properties:

1. Each firm recognizes that it has some degree of monopoly power.
2. As in the case of monopoly, this monopoly power is an inverse function of the market price-elasticity.
3. This gap is also proportional to the firm's market share.
4. In this perspective, we see that the Cournot equilibrium is an intermediate form between monopoly ($s_i = 1$) and perfect competition ($s_i \approx 0$).

From equations 4.11 and 4.12, we see that the mark-up of the oligopolist will be less than that of a monopolist. Consequently, if a branch is oligopolistic rather than monopolistic, its level of production will be higher. It follows that the pro-competitive and welfare effects will not be as strong as in the monopoly case while they increase with s_i.

It is of some use to examine how marginal revenue, as perceived by the firm in the Cournot model, compares to marginal revenue in monopoly. We can, in fact, show that it is a weighted average of marginal revenue in monopoly and in perfect competition (cf. figure 4) (respectively, MR and P):

$$mr(.) = \frac{1}{n}MR(\cdot) + (1 - \frac{1}{n})P(.) \tag{4.13}$$

where n is the number of firm in the sector. Thus, the optimal decision for the firm does not correspond to the point where marginal cost equals marginal revenue. This is because each firm calculates its marginal revenue taking as given not only the price of the foreign imports but the output of the other firms of the sector as well. However, the Cournot model has been subject to several criticisms. The main one being that firms' choice variable is price, not quantity[11]. At the time, this was Bertrand's criticism.

[10] We divide through by p and multiply the second term of equation (4.10) by $\frac{X}{X}$, substituting the price-elasticity of demand ε, defined as $\left|\frac{\partial X(p)}{\partial p}\frac{p}{X}\right|$, and reorganizing noting that $\partial x_i = \partial X$, we obtain equation (4.11).

[11] Recently, models have been built in which firms first choose the production capacity, then compete on price. Under certain restrictive assumptions (cf. Tirole (1988)) the results of this behavior will be the same as those of a Cournot model.

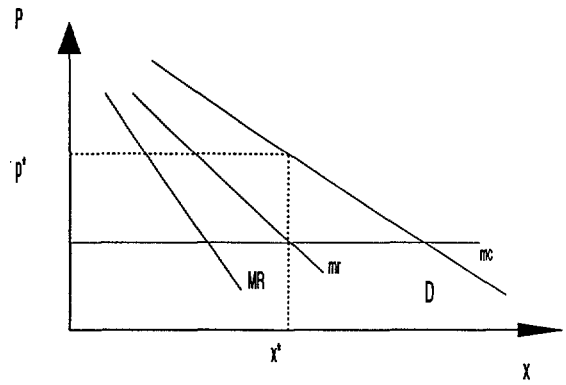


Figure 4: Oligopoly

The Bertrand Model with Homogenous Products In the Bertrand model, each firm sets its own price on the assumption that competitors' prices are fixed. With homogenous products, equilibrium occurs when price is equal to marginal cost, just as in perfect competition. To see that this must be so, consider the case of a firm which sets a higher price. Any other firm will be able to appropriate the entire market by charging slightly less. Therefore, the only stable equilibrium results when all firms set their price at marginal cost. This is known as the Bertrand paradox, and it is indeed paradoxical for a market with an arbitrarily small number of firms to behave so competitively. The operative question in this case is whether the firms' products are homogeneous or display some degree of differentiation. In the presence of differentiation, the Bertrand model yields less paradoxical results, as we shall see in the next section. With homogeneous products, it is unrealistic for firms to expect no price reaction from their rivals. Of course, trade liberalization yields only the traditional results under these conditions.

Conjectural Variations In the Cournot and Bertrand models, the behavior of a firm's rivals is exogenous to the firm's decision. However, it is generally admitted that a firm's rivals will modify their own decisions in reaction to the firm's decisions. The conjectural variations hypothesis was introduced to capture these reactions. A firm's conjectural variation is defined as its expectation of how competitors will respond to a change in its production (Cournot) or price (Bertrand). For example, in the case of a change in production, firm i may postulate:

$$\frac{\partial X}{\partial x_i} = 1 + \gamma_i \tag{4.14}$$

where:

$$\gamma_i = \left[\frac{\partial X_{-i}}{\partial x_i}\right] \tag{4.15}$$

constitutes the firm's expectation of its rivals' response. The Lerner equation can be rewritten to incorporate these expectations:

$$\frac{p-c}{p} = \frac{s_i(1+\gamma_i)}{\varepsilon}; \quad i = 1, \ldots, n. \tag{4.16}$$

When all firms are identical $s_i = \frac{1}{n}$ and $\gamma_i = n-1$ we obtain a situation of price-maximizing collusion as it implies that all competitors match firm i's changed strategy. Then, the firm cannot expect to increase its market share by raising production, and is better off producing its share of the collusive output and receiving a mark-up which reflects monopoly profits.

Cournot and Bertrand behavior are also special cases of equation (4.16), the former when γ_i is equal to 0, that is when competitors are expected to keep their production constant; and the latter when the conjecture is such that other firms will cut their output just enough to keep their own prices constant. In this latter case, the value of γ_i will depend on the slope of the demand function. Thus, the pro-competitive and welfare effects will resemble those of the preceding market structures according to the value taken by γ_i.

The concept of conjectural variations has been severely criticized from a theoretical perspective. According to Shapiro (1989), the underlying idea is conceptually false, as it attempts to capture dynamic behavior in a static formulation[12].

Furthermore, conjectural variations are inherently difficult, if not impossible, to quantify. A number of authors use the concept to reconcile divergences between independent estimations of the left-hand side of equation (4.16)[13], determined by evaluations of returns to scale and profits, with the right-hand side, determined by econometric estimations of the price elasticity of demand in the market.

Another problem with this approach is that there is no reason to assume that the firm's expectations will remain the same in the event of a policy change, such as trade liberalization. Rather, we would expect them to change. There are, however, no rules regarding their evolution. Melo and Tarr (1992) assume that the change in conjectures will be proportional to the entry or exit of firms from the market. If $\Omega_i^0 (= 1+\gamma_i)$ is the initial conjecture, it will evolve according to:

$$\Omega_i = \Omega_i^0 \frac{\bar{N}_i}{N_i}, \tag{4.17}$$

where $\bar{N}_i$ represents the initial number of firms and N_i the number at equilibrium. While arbitrary, this formulation reflects the fact that if the number of firms increases, the coefficient of conjectural variation will diminish, and the market will approach the competitive equilibrium.

[12]Shapiro adds: "This is a fortiori true for the so-called "consistent conjectures" which impose the requirements that in the neighborhood of the equilibrium, a firm's conjecture about a rival's response equal the slope of that rival's reaction curve".

[13]Consider, for example, Kempeneers (1993), Burniaux and Waelbroeck (1994), Lopez-de Silanes, Markusen, and Rutherford (1994b), and Mercenier (1994a).

4.2 The Case of Differentiated Products

We have seen examples in the preceding section where, while the domestic sector was producing a homogeneous good, this good was an imperfect substitute for imports. That is the assumption that products are differentiated according to their geographic origin (the Armington (1969) hypothesis). According to this hypothesis, consumers consider domestic and foreign products to be imperfect substitutes. This assumption is useful to explain the relatively stable market shares we observe in international trade. Usually, this hypothesis is modelled with a functional form such as the CES in which the aggregate foreign good and the aggregate domestic good are imperfectly substitutable like the example we saw earlier. A similar distinction is made on export markets.

This assumption has come under some criticisms. Brown and Stern (1989a) have illustrated some consequences of employing this assumption instead of modelling product differentiation directly at the firm level. In this latter case, each firm, home or foreign, produce a differentiated product.

Although several good arguments may be advanced in the defence of the Armington hypothesis, like real differences between imported goods and their domestic substitutes including: the manufacturing technology, the production standards under which they were made, distribution channels, etc., modelers should be aware of the consequences of such a specific formulation and be ready to try some alternatives such as directly modelling product differentiation at the firm level.

Under these circumstances, the decision whether and how to model product differentiation at the firm level seems more important. Some authors have completely avoided the Armington approach by modelling product differentiation only at the firm level (cf. Norman (1990), Burniaux and Waelbroeck (1994)). Others have incorporated both concepts. In this case, a third level is built into the utility function: expenditure on imports is divided between different countries subsequent to the decision on how much of the domestic aggregate and how much of the foreign aggregate to buy [14].

Accounting for product differentiation at the firm level implies changing how demand is specified in CGEMs. We shall begin by examining these changes, using the methodology introduced by Spence (1976a), (1976b) and Dixit and Stiglitz (1977) (SDS)[15]. Next we shall look at different ways of modelling product

[14] In their research on the Free Trade Agreement between Canada and the United-States, Brown and Stern (1989a) draw attention to some issues arising from applying this hypothesis in models with product differentiation at the firm. In particular, the introduction of Armington hypothesis introduces a bias in results on intra-branch adjustment, weakens the results of rationalization associated with factor intensities, and increases the monopoly effect on domestic markets, leading to a higher optimal tariff. From an empirical perspective, Brown and Stern conclude that the Armington hypothesis yields a good approximation for intra-industry trade, but performs poorly on the level of evaluating welfare changes and inter-industry trade. Similar criticisms can be found in Norman (1990).

[15] A different approach to product differentiation was proposed by Lancaster-Hotelling (see the description in Vousden (Vousden 1990)). Briefly, this method assumes that the consumer selects from a set of available products the one whose characteristics most closely match his tastes. Unfortunately, an analytical treatment of this model requires the imposition of several

differentiation at the firm level. Unlike product differentiation at the country level, product differentiation at the firm level implies that the firms will behave in a non-competitive manner, each firm having monopoly power over the variety it produce. As a result, we will examine how trade policy may influence this monopoly power.

4.2.1 The Demand for Differentiated Products

The appeal of the SDS method for use in CGEMs lies in its relative simplicity. Its basic assumption is that the representative consumer has a preference for diversity. This approach is also useful because it allows the set of available products to vary. The utility function of the representative consumer take the following CES form:

$$U = (\sum_{i=1}^{N} D_i^{\rho})^{\frac{1}{\rho}}, \tag{4.18}$$

where ρ is a parameter of substitutability between goods and N the set of available products (not fixed) and is equal to the sum of domestic n and foreign n^*. If we assume that each firm produces only one variety of the good, the number of varieties is equal to the number of firms[16].

If firms enter and exit the market, the number of varieties available to consumers varies correspondingly. The demand for each good is thus given by:

$$D_i = D(\frac{p_i}{P})^{-\widetilde{\sigma}}, \tag{4.19}$$

where:

$$D = (\sum_{i=1}^{N} D_i^{\rho}), \tag{4.20}$$

$$P = (\sum_{i=1}^{N} p_i^{\frac{-\rho}{\rho-1}})^{\frac{\rho-1}{\rho}}, \tag{4.21}$$

and p_i represent the price of variety i. We may interpret D as an index of total consumption and P as a price index.

The main characteristic of this formulation is that, since marginal utility is diminishing, the representative consumer will see his welfare increase as more varieties enter the market. As a consequence, anything that influences the number of varieties of the differentiated good on the market will have an impact on consumer's welfare. In Harris' model, the number of varieties of the domestically manufactured good, n_i, is determined endogenously and is dependent on

restrictive and generally unrealistic assumptions.

[16]Some authors (Harris (1984), Smith and Venables (1988)) have considered the possibility that a given firm may produce more than one variety (the multi-product firm). This specification does not materially alter the analysis very much, however, so it has not been pursued by many researchers. The most notable effect of assuming multi-product firm is to lower the cost of adjustment following trade liberalization.

the number of firms while the number of varieties of the imported good, n_i^*, is adjusted so as to keep the ratio n_i/n_i^* constant. One difficulty with this approach, as Harris rightly remarks, is that, if the domestic sector is rationalized, foreign producers do not fill the demand for varieties discontinued by domestic producers. This reduction in the number of available varieties results in a welfare loss in the economy under the SDS hypothesis, which may significantly reduce the welfare gains expected from the elimination of tariff barriers.

This specification may also be criticized on the basis that the elasticity of substitution ($\widetilde{\sigma} = \frac{1}{1-\rho}$) between products is independent of the number of varieties available. One would tend to think that, as the number of products increases, the elasticity of substitution between them should also increase with the convergence of their characteristics. Consequently, consumers will use all of the varieties available to them as long as the prices are finite. Finally, we should also pay heed to the role played by the elasticity of substitution; the greater it is, the less welfare increase consumers derive from an increase in the number of varieties of available products.

4.2.2 Product Differentiation in the Cournot and Bertrand models

Optimal behavior by firms in these models may be described by a generalized Lerner equation:

$$\frac{p(X) - c_i(x)}{p(X)} = \frac{1}{\eta_i} \tag{4.22}$$

where η_i is the firm price-elasticity of demand. For example, in the Bertrand model. It can be shown from equations (4.19), (4.20) and (4.21) that the price-elasticity of demand faced by a firm (η_i) is given by:

$$\eta_i = \widetilde{\sigma} + (1 - \widetilde{\sigma})s_i \tag{4.23}$$

Consequently, η_i depends on s_i which represents firm i's market share and $\widetilde{\sigma}$, which represents the degree of substitution between different varieties of the same good. Equation (4.7) is a special case with one imported and domestically produced good. Smith and Venables (1988) (and all related works), Brown and Stern (1989b), Burniaux and Waelbroeck (1994) and Mercenier (1994b) apply the Bertrand model to this issue.

In the Bertrand model with product differentiation (cf. equation (4.23)), a policy of liberalizing trade decreases the firm's market share. The price-elasticity facing the firm consequently increases but, for low values of s_i, this effect is generally very small. Under these conditions, the pro-competitive effect will also tend to be very small. Some modelers have suggested that this pro-competitive effect is complemented by a change in the decision rule of the firm following trade policy reform. For example, in most models of product differentiation and oligopolistic competition, regional integration is formulated as a loss of the ability by firms to practice price discrimination. When markets were segmented, producers could establish an optimal price for each country. The creation of a free-trade zone obliges them to make decisions for the whole area. This is the approach generally used to model European integration.

If one prefers to suppose that firms compete on a quantity basis - the Cournot model - then the inverse of the price-elasticity of demand faced by a firm takes the following form[17]:

$$\frac{1}{\eta_i} = \frac{1}{\tilde{\sigma}} + (1 - \frac{1}{\tilde{\sigma}})s_i \tag{4.24}$$

Examples of Cournot competition with product differentiation can be found in Harris (1984), Norman (1990), Gunasekara and Tyers (1991), Burniaux and Waelbroeck (1994) and Mercenier (1994a).

As a rule, employing the Bertrand hypothesis translates into assuming more competitive behavior by firms. This is due to the fact that, in this model, if a producer lowers his price he will capture some of his competitors' clients. In the Cournot model, on the other hand, the quantity produced by his competitor is fixed. As a consequence, we should expect the pro-competitive effect to be stronger in the Cournot. In practice, it seems to be difficult to find big differences in simulation's result between the two alternatives. This is at least the conclusion drawn by Burniaux and Waelbroeck (1992) and Mercenier (1994b) who experiments with those market structures. In Mercenier (1994a), results for the Bertrand case are not reported as trade liberalization has almost no effect. We should bear in mind, however, that these two models were created to represent different realities. We may speculate, for example, that the Bertrand model is more appropriate for industries characterized by a relatively flat marginal cost curve, as it is easier for them to adjust production in response to changes in demand. The Cournot model, conversely, would be more applicable to industries with steep marginal cost curves[18].

Monopolistic Competition The most commonly used model of firm-level product differentiation in the literature is monopolistic competition. This structure occurs when the following three criteria are met:

1. Each firm faces a negatively sloped demand curve.
2. There is free entry/exit to the market (hence profits are nil in equilibrium).
3. The price charged by one firm has negligeable effect on the demand faced by another firm.

Clearly, the last hypothesis is both the most controversial and the most important. It is easy to conceive of differentiated products which still compete intensely on the market. The reason for using this formulation is not to study

[17]In this case, $\eta_i = |\frac{1}{\frac{\partial P(x)}{\partial x}\frac{x}{p}}|$ where $P(x)$ is the inverse demand function derived from equations (4.19), (4.20) and (4.21). Note that difficulties arise when we try to find a similar expression for the firm price elasticity of demand when substitution possibilities exist among intermediate inputs. It is necessary to resolve the models' demand system to obtain this elasticity. This is rarely done analytically.

[18]One opinion is that a model of competition on prices reflects producer behavior more accurately, but that predictions generated by the Cournot model match the empirical evidence better (cf. (Shapiro 1989)).

strategic interaction among firms, but rather to examine several other issues, such as the number of products supplied in an economy, or the relationship between product diversity and welfare.

The assumptions of this model also yield a particularly simple form for the elasticity η_i. In fact, assuming that each firm is small relative to the market[19], the price elasticity of demand facing the firm is simply the elasticity of substitution between the products, $\widetilde{\sigma}$:

$$\eta_i = \widetilde{\sigma} \tag{4.25}$$

This could be interpreted as a model of oligopoly with product differentiation where each firm become "small" relative to the market, that is, the market share of each firm tends to zero ($s_i \longrightarrow 0$ in equation (4.23) and (4.24)). Since the price-elasticity of demand is equal to the elasticity of substitution between the different varieties of the product, trade policy will not affect the domestic producer's monopoly power unless it alters this elasticity too. Thus there is no pro-competitive effect in such a model.

In light of this, some model builders have suggested that consumers' perceptions of products change with trade policy. In their models of regional integration, François, MacDonald, and Nordström (1995) assume that trade liberalization has the effect of rendering domestic and foreign products more substitutable. Subsequent to the creation of a free-trade zone, for example, consumers will tend to consider the products of all member nations equally, while continuing to treat goods from other parts of the world as imperfect substitutes.

We conclude that their is no 'best' model of oligopolistic behavior. As far as the structure of the market is concerned, the model builder must choose formulations which in his opinion best reflect the functioning of the economy he is modelling. It is important to realize that these models are not in competition. The wealth of behavioral assumptions available to choose from should not be seen as a problem, the different models may describe different sectors or industries, depending on conditions. In any case, the behavior of firms is likely to be much more complex than our descriptions of them can be. Nonetheless, these models may, given the right circumstances, provide good approximations to reality. Several recent models incorporate varying market structures, where each sector is modelled according to the researcher's conception of how it works (Nguyen and Wigle (1992)).

4.3 Increasing Returns to Scale

One common explanation for the existence of imperfectly competitive markets is the existence of increasing returns to scale. In this case, bigger firms have an advantage over smaller ones through lower costs so that the market tends

[19]Referring to equations (4.20) and (4.21), this suggests that each firm considers its impact on P and D to be negligible.

to be dominated by a small number of large firms[20]. Modelling increasing returns to scale can have important impacts on the results of policy simulations, particularly on predictions about welfare and efficiency effects.

Let us formally define returns to scale: let $y = f(x)$, where y represents a firm's production and x a vector of inputs. Suppose further that $f(kx) = k'y$. We say that returns to scale are increasing, constant, or decreasing if k' is greater than, equal to, or less than k, for $k \geq 1$. Thus, with increasing returns to scale, average cost is less at $k'y$ than at y[21].

Incorporating increasing returns to scale into standard CGEMs is a fairly standard procedure. First, we must model the imperfectly competitive behavior of firms in the affected sector using one or the other of the market structure hypotheses presented in section 4. As for the actual modelling of scale economies, two options can be pursued. The first one involves adding a fixed cost to the usual cost function. Consequently, when the firm increases its scale of production, the fixed cost is spread over a larger number of units and hence average cost decreases toward marginal cost, which is constant. In this case, returns to scale tend to be exhausted as firms become large.

To give an example, Harris (1984) postulates a fixed cost given by:

$$F_i(r, w) = rf_K^i + wf_L^i, \tag{4.26}$$

where rf_K^i and wf_L^i respectively represent the minimal cost of capital and labor required to start a company; w and r are respecticely the remuneration of labor and capital. Total costs are the sum of fixed costs plus a constant marginal cost (v^i), which is equal to the average variable cost, multiplied by the quantity produced:

$$TC_i = F_i(w, r) + v^i(P)y_i \tag{4.27}$$

where P is the vector price of intermediate good prices.

The second option consists in modelling the cost function as log-linear. In this way, it is possible to choose the parameters of the function such that marginal costs and average costs become smaller as the firm increases its production[22]. For example, in his model, Cockburn (1994) uses a Cobb-Douglas function where the sum of the share parameters are greater than one. Given doubts about whether marginal costs are constant or decreasing, Smith and Venables (1988) create a weighted combination of the two functional forms to model economies of scale.

A measure of scale economies for which estimates are often avalaible is the scale elasticity. More specifically, if $y = f(x)$, where x is a vector of inputs, the

[20]Note that perfect competition is possible when economies of scale are external. Cf. Varian (1992).

[21]Note, however, that the inverse is not necessarily true because of the possibility of substitution among inputs (cf. Panzar (1989)).

[22]Bearing in mind that there exists a floor below which marginal costs cannot go; they can never be negative.

scale elasticity is defined as:

$$\theta = \frac{\frac{\partial y}{y}}{\frac{\partial x}{x}} = \sum_{i=1}^{n} f_i(\frac{x_i}{y}) \tag{4.28}$$

where n represents the number of factors. Observing θ, we can say that returns to scale are increasing, constant or decreasing as θ is greater, equal or smaller than one. Under certain regularity conditions, there is a relationship between the scale elasticity and another measure of scale economies called the elasticity of total cost. It can be shown that if C represents total costs for the firm, then:

$$E_C = \frac{\frac{dC}{C}}{\frac{dy}{y}} = \frac{1}{\theta} = \frac{MC}{AC} \tag{4.29}$$

where MC represents marginal cost and AC average cost[23].

From this relationship, it is possible to calibrate the value of fixed costs:

$$F = MC(\theta - 1)y \tag{4.32}$$

Consequently it is possible to calibrate fixed costs from an estimation of scale elasticity or vice-versa.

Finally, another frequently used measure of scale economies is the cost disadvantage ratio CDR, which is simply equal to:

$$CDR = 1 - \frac{1}{\theta} \tag{4.33}$$

which is greater than zero if returns to scale are increasing.

Note that the variation in the production of affected sectors, whether it be an expansion or a contraction, will be amplified if the sector is characterized by declining marginal cost. Also, the existence of scale economies will increase (reduce) welfare if the affected sector expands (contracts).

5 A Case Study

This section illustrates modelling techniques according to the market structure hypotheses presented in section 4 and illustrates the ambiguity of the impacts of trade liberalization depending on behavioral hypotheses and critical parameters.

[23]Proof for the case of two inputs: as $C = w_1x_1 + w_2x_2$, we have that $dC = w_1dx_1 + w_2dx_2$, which we may rewrite as $dC = w_1x_1(dx_1/x_1) + w_2x_2(dx_2/x_2)$, but, by definition all inputs change in the same proportion: $(dx_1/x_1) = (dx_2/x_2) = (dx/x)$. Therefore:

$$dC = (\frac{dx}{x})(w_1x_1 + w_2x_2) = (\frac{dx}{x})C \Rightarrow \frac{dC}{C} = \frac{dx}{x} \tag{4.30}$$

or, multiplying by $(\frac{y}{dy})$:

$$\frac{dC \cdot y}{dy \cdot C} = \frac{dx \cdot y}{dy \cdot x} \tag{4.31}$$

Our base model is PARADI's model 3 (MOD3) (Decaluwé, Martin, and Souissi 1995), a standard CGEM with constant returns to scale and perfect competition. This is a teaching model of an open economy with three sectors (industrial, agriculture and administrative services). The use of a simple model allows us to focus on fundamental aspects of trade liberalization in the context of imperfect competition and increasing returns to scale.

We shall review the principal characteristics of the MOD3 in a first section. In the following section we will see the changes needed in order to model a monopoly. The modelling of a monopoly will be useful to underline the main effects of trade liberalization in a non-competitive context. We will then explore the model of Cournot oligopoly with homogeneous products. In this latter model, we will explore one way of assessing the impact of trade policies on a possible rationalization of the industry. In each case, we have simulated the effect of the elimination of all trade barriers. The complete set of equations of these models are presented in appendix A.

5.1 The Model

5.1.1 Perfect competition

Since this is a conventional model, we shall place more emphasis on incorporating imperfect competition. The fictitious social accounting matrix which we shall use is in the appendix. The non-competitive sector shall be "industry".

A representative consumer maximizes a Cobb-Douglas utility function. Products are differentiated by origin (local vs imports) and by destination (local vs exports), with aggregate CES functions. Further, we assume that domestic industrial goods are homogeneous at the level of the firm and sold on the local market and export market.

The total production of each branch is X_i^S. Production functions are Leontief for intermediate consumptions IC_J and value added VA_i:

$$IC_i = io_i X_i^S, \tag{5.1}$$

$$VA_i = \nu_i X_i^S \tag{5.2}$$

where io_i and v_i are the shares of intermediate demand and value added respectively, IC_j is total intermediate demand for good i. Value added is described by the Cobb-Douglas formulation for labor L_i and capital K_i:

$$VA_i = A_i L_i^{\alpha_i} K_i^{1-\alpha_i} \tag{5.3}$$

where $A_i$and α_i are respectively a scale parameter (not to be confused with the scale elasticity) and a share parameter. Consequently, we can write the production function as:

$$X_i^S = \frac{A_i L_i^{\alpha_i} K_i^{1-\alpha_i}}{v_i} \tag{5.4}$$

Labor and capital are assumed mobile across different sectors of the economy. Total labor supply is assumed fixed, with wages adjusting to maintain full employment. Labor and capital demands, derived from the profit maximization

problem, take the following form:

$$L_i = \frac{\alpha_i P_i^{VA} VA_i}{w} \tag{5.5}$$

$$K_i = \frac{(1-\alpha_i) P_i^{VA} VA_i}{r} \tag{5.6}$$

where $P_i^{VA} = \frac{P_i X_i^S - \sum_i P_i^Q ICJ_{ji}}{VA_i}$, P_i^Q is the consumer price of the composite good i, $ICJ_{ij} = a_{ij} IC_j$ and a_{ij} is the share of intermediate consumption of good j used in the production of composite good i.

In terms of model resolution, factor demands can be substituted into equation 5.4 to obtain the supply function for the sector. Equilibrium price and quantity are determined by supply and demand conditions. As we pointed out, although the profit maximization condition is not introduced explicitly, it can be inferred from the fact that the value of the marginal product of each factor is equal to its remuneration, as in equation 4.2. Results of trade liberalization under Perfect Competition (PC) are reported in section 5.1.4.

5.1.2 Monopoly

To adapt the model to incorporate a monopolistic sector, we must alter certain equations pertaining to this sector. The rest of the model remain unchanged. We must first render the profit maximization condition explicit. The monopolist maximizes profits in the domestic market according to equation (4.6)[24]:

$$\frac{P^D(X) - MC(X)}{P^D(X)} = \frac{1}{\varepsilon^D} \tag{5.7}$$

where P^D, MC, ε^D are respectively the domestic price, marginal cost and domestic price-elasticity faced by the producer.

Conditional factor demands for labor and capital are the solution to the minimization of total cost under the technological constraints in equation (5.1) and (5.2):

$$L_i = \left[\frac{\alpha_i r}{(1-\alpha_i) w}\right]^{1-\alpha_i} \cdot \frac{v_i X_i^S}{A_i} \tag{5.8}$$

$$K_i = \left[\frac{(1-\alpha_i) w}{\alpha_i r}\right]^{\alpha_i} \cdot \frac{v_i X_i^S}{A_i} \tag{5.9}$$

Note that equations (5.7), (5.8) and (5.9), do not all appear in the model presented in the appendix. In the solution to the model, the level of production and the price are determined by demand for the industrial product and the profit

[24]We use the contestable market hypothesis to model export markets. Hence, firms price the export good at average cost:

$$P^E = AC$$

where P^E is the export price of the monopolist AC average cost.

maximization condition respectively. Given this production level and one of the conditional factor demand functions, the production function (5.1) implicitly determines the demand for the other factor. Consequently, one of the equations (5.8) and (5.9) becomes redundant and may be discarded. We have eliminated the demand function for capital in our model.

We now require an expression for marginal cost (MC) and for the price-elasticity of demand, ε^D, facing the firm in equation 5.7. We derive the function for marginal cost by substituting the conditional demand for labor and capital and the demand for intermediate goods into the equation of total costs (TC), which is then differentiated with respect to the output of the branch, X_i^S. Total costs are given by:

$$TC_i = wL_i + rK_i + \sum_j P_j^Q ICJ_{ij} \tag{5.10}$$

where P_j^Q is the consumer price for the composite good j.

Substituting equations (5.1), (5.8) and (5.9) into the total cost equation (5.10), differentiating this equation with respect to production X_i^S and simplifying, we obtain an expression for marginal cost:

$$MC_i = \frac{1 - io_i}{A_i} \cdot \left(\frac{w}{\alpha_i}\right)^{\alpha_i} \cdot \left(\frac{r}{1-\alpha_i}\right)^{(1-\alpha_i)} + io_i \cdot \left(\sum_j a_{ji} P_j^Q\right) \tag{5.11}$$

Given the Armington hypothesis of imperfect substituability between imported and domestic goods, the price-elasticity of demand in the branch and, by extension, facing the monopolist, takes the form given in equation (4.7):

$$\varepsilon_i^D = \left[\sigma_i + (1-\sigma_i)\frac{P_i^D X_i^D}{P_i^Q X_i^Q}\right], \tag{5.12}$$

where P_i and X_i represent the price and quantity of the CES composite good Q_i and of the domestic good D_i respectively; and σ_i represents the elasticity of substitution between the domestic and imported good. It is inherent in the structure of this model that a rise in the price of imported products will cause an increase in the price-elasticity of demand facing the monopolist. Consequently, we can see how the pro-competitive effect of trade liberalization come into play.

The monopolist's profits are determined residually as the difference between the value of production and the cost of factors:

$$PR_i = P_i X_i^S - \sum_j P_j^Q ICJ_{ij} - wL_i - rK_i \tag{5.13}$$

These profits are directly allocated to households in our model.

To incorporate returns to scale we add a fixed cost for capital, yielding:

$$K_i = KV_i + \overline{KF_i}. \tag{5.14}$$

In this way we may partition the monopolist's capital usage into a variable component KV_i and a fixed component $\overline{KF_i}$. We then must determine the share of fixed costs in total costs or, equivalently, the magnitude of attainable economies of scale. This step is often complicated by the absence of estimates of fixed costs. It is easier, however, to estimate the economies of scale available for a given level of production, and derive the fixed costs after the fact. We thus have calibrated the model, supposing that the (inverse of) the scale elasticity (PS_i) is known:

$$PS_i = \frac{AC_i}{MC_i} \tag{5.15}$$

where AC_i represents average cost. One can determine the associated level of fixed cost from equation (4.32). Consistently, the link between average and marginal costs is also:

$$AC_i = MC_i + \frac{R * \overline{KF}_i}{X_i^S} \tag{5.16}$$

This is the approach followed by most authors. This parameter may originate in econometric analysis of firms' cost structures, or it may be derived from engineering studies.

Calibration The calibration of the model is fairly standard, hence we will limit ourselves only to elements specific to the introduction of the monopoly. First, we have to evaluate the level of super-profits in the industrial sector. We have choosen a value of 550, as specified in the social accounting matrix. For our fictional case, this is a purely arbitrarily value. In practice, estimations of super-profits must be made carefully since they are hard to pin down and can substantially affect the results of the model. For example, it is possible that part of the monopoly profits take the form of higher remuneration for some factors of production. A monopolist may produce at a higher cost than a competitive firm. Some of these profits may also be invested in lobbying to retain monopoly power.

We have made a simulation with Constant Returns to Scale (MCRS) and another one with Increasing Returns to Scale (MIRS). In the latter simulation we fixed the elasticity (PS) of scale at 1.1 and calibrated the fixed costs compatible with this parameter.

Given the rate of profits and scale economies given previously, we have calibrated the perceived price-elasticity of demand residually so as to be consistent with the observed mark-up. Other possibilities include residually calibrating the marginal cost, the rate of profits or the number of firms. We will explore some of those possibilities later in the Cournot model.

Finally, the numeraire is the world price of imports. Under perfect competition, the choice of the numeraire has no impact on the simulation results. However, several authors have demonstrated that this is not true when conditions of imperfect competition prevail. The problem arises because the goal of the firm is to maximize profits in terms of a basket of goods specified by a process of normalization. When the firm recognizes that it has influence over prices,

the maximization goal will depend upon the numeraire. One way of resolving this is to specify that the objective of the firm is to maximize the utility of its owners rather than profits. For this to work we require detailed information about the structure of corporate ownership in the economy.

There are reasons to believe, however, that the choice of numeraire has little real impact. First, the choice of numeraire only has a significant impact when the imperfectly competitive sectors constitute a large share of the economy. In most countries, this is not the case. Second, it can be shown that if we select the numeraire from among the competitively traded goods, choices made by producers in the non-competitive sectors are not affected. For these two reasons this particular issue has not posed a serious concern to most model builders[25]. The reader interested in pursuing this is invited to consult Ginsburgh (1994) among others.

5.1.3 Cournot Model with Homogeneous Products

As the Cournot model can be interpreted as an intermediate case between monopoly and perfect competition, one could expect that the effect of trade liberalization will be also intermediate between these two extremes. The main difference regarding the modelling of oligopoly is the explicit introduction of a limited (but greater than one) number of firms. Thus, it will be useful in the model to define per-firm output (X^{S_f}), exports (X^{E_f}) and domestic demand (X^{D_f}):

$$X_i^{S_f} = \frac{X_i^S}{N_i} \tag{5.17}$$

$$X_i^{E_f} = \frac{X_i^E}{N_i} \tag{5.18}$$

$$X_i^{D_f} = \frac{X_i^D}{N_i} \tag{5.19}$$

and

$$X_i^S = X_i^E + X_i^D \tag{5.20}$$

where N_i is the number of identical firms in sector i.

The profit maximizing decision takes the following form:

[25]Besides the issue of choice of numeraire, the introduction of imperfect competition and returns to scale in CGEMs raises questions concerning the uniqueness of equilibrium and the level of aggregation. The addition of economies of scale introduces non-convexities into the model. Consequently, one of the necessary conditions for the existence and uniqueness of equilibrium in models with constant returns to scale does not obtain here.

Nonetheless, research to date has not yielded a measure of the magnitude of the problem, and the existence of multiple equilibria seems to be the exception. See Mercenier (1995) for a dissenting view.

The degree of aggregation of the model assumes particular importance in the case of CGEMs with imperfect competition and increasing returns to scale. The bias introduced by the aggregation of cost functions in sectors with economies of scale causes us to under-estimate savings related to the scale of production, (cf. Harris (1984)). Consequently, we should expect that a more aggregated model will produce lower estimates of welfare gains.

$$\frac{P^D(X) - MC(X)}{P^D(X)} = \frac{1}{N_i \varepsilon_i^D}. \tag{5.21}$$

where ε_i^D is the same as in equation (5.12).

Finally, to incorporate increasing returns to scale at the level of the firm, one must modify equations (5.14) and (5.16) in the following way:

$$KV_i = K_i - N_i \cdot \overline{KF}_i \tag{5.22}$$

$$AC_i = MC_i + \frac{R \cdot \overline{KF}_i}{X_i^{S_f}} \tag{5.23}$$

Calibration We have used the same value for industry super-profits and firm returns to scale as the case with monopoly. However, we have tried different ways of calibrating the oligopoly mark-up. We first calibrated residually the number of firms. One should take caution before interpreting this number as the true number of firms in the economy. In fact, it should be interpreted as the Cournot-equivalent number of firm. The second method of calibration, given the knowledge of the number of firms in the industry, involve the introduction of a parameter, determined endogenously to reconcile data about super-profits, returns to scale and price-elasticity of demand.

Call this parameter γ and set it so that:

$$\frac{P^D(X) - MC(X)}{P^D(X)} = \frac{(1+\gamma_i)}{N_i \varepsilon_i^D}. \tag{5.24}$$

Notice that this is the mark-up derived in the oligopolist model with conjectural variations. But given the conceptual difficulties associated with conjectural variations, one could interpret γ_i (as Saloner (1994)) as an indication of the level of competition in the industry. For example, if γ_i is greater than zero, this simply means that the firms are able to fix a mark-up higher than in the pure Cournot model.

Simulations We simulated a removal of all tariffs under six different scenarios. The first scenario is the one with Perfect Competition (PC), the second and third one are those of Cournot oligopoly with Constant (OCRS) and Increasing (OIRS) Returns to Scale.

In a fourth case, we experimented with the so-called Contestable Market case (OCM) (cf. Baumol and Lee (1991)). In this latter case, we suppose that there is no cost to entry or exit so that firms fix their domestic price equal to average cost to discourage entry:

$$P_i = AC_i \tag{5.25}$$

Although purely hypothetical, simulations results under this scenario are useful since they let us distinguish between results due to market conduct and market structure.

We drop the hypothesis of no Entry and Exit in the fifth scenario (OEE). In this scenario, firms are assumed to enter or exit the market in response to changes in profitability. This scenario should be interpreted as representing the long run. This characterization of long-term equilibrium raises a question about the assumption of free entry/exit of firms. Mercenier and Schmidt (1995) argue that if this occurs without costs, then the estimates of welfare gains from trade liberalization will be biased upwards. We may, however, assume that a significant share of the fixed costs paid by the firm cannot be recuperated. The existence of these sunk costs will create a barrier to exit, a firm will stay in the market as long as its revenues cover variable costs. These costs also constitute a barrier to entry since they impose a burden on would-be entrants.

A conceptual problem with making a distinction between the short and long run lies in determining the rate of profits at the equilibrium. How should profits come down to zero in the long term in the case of a non-competitive market structure. Should we not suppose that the firm retain some market power. In fact, it his hard to believe that trade liberalization will wipe out all super-profits from the economy. In this context, the effect of trade liberalization and those resulting from an assumption of zero profits in the long run are conceptually different. A way around those difficulties lies in comparing the results of that simulation, not with our base case, but with one where we allow firm entry and exit but keep the structure of protection constant. That is the reference point in the results presented here.

5.1.4 Results

The results of the three scenarios are summarized, for selected variables, in table 2. We will limit ourselves to drawing attention to the following points:

1. Under the hypothesis of perfect competition (CP), we obtain the traditional results.
2. The unprotected sector (agriculture) expands and the protected sector (industry) contract following a reduction in taxes on imports.
3. This contraction is reflected both in a decline in output as well as in a fall in relative prices.
4. As labor is used more intensively in agriculture, the wage rate increases relative to the return to capital.
5. The net effect of liberalization is an increase in household income in nominal terms and, even more, in real terms.

These results undergo qualitative changes when we introduce the monopoly sector and imperfect competition:

1. The fall in price-elasticity of demand for the monopolist's output forces him to reduce his mark-up (and price) and increase his production relatives to the competitive case.

		PC	MCRS	MIRS	OCRS	OIRS	OCM	OEE
Welfare		0,43	4,32	5,59	0,41	1,01	0,62	1,85
Price	Ind.	-1,00	-24,99	-25,84	-1,85	-2,54	-0,62	-1,66
	Ser.	0,15	-0,62	-0,40	-0,11	-0,04	-0,10	0,00
Imports	Agr.	-13,66	-4,00	35,58	0,82	2,22	-0,74	2,31
	Ind.	15,83	874,94	318,35	19,29	19,81	19,05	20,06
Production	Agr.	0,30	-12,81	-15,06	-2,28	-2,47	-1,62	-2,16
	Ind.	-0,14	10,40	14,84	1,87	2,54	1,05	2,42
	Ser.	-0,15	0,62	0,40	0,11	0,04	0,10	-0,02
Wage		0,90	3,99	4,23	0,66	0,85	0,54	0,82
Return to capital		0,70	12,60	12,10	2,10	2,00	1,80	1,26
Output price index		-0,65	-16,45	-16,99	-1,22	-1,67	-0,42	-1,05
Profits			-97,95	-96,67	-2,39	-3,37		
Elasticity			-85,23	-64,95	-0,79	-0,78		-0,94
Scale Parameter				0,63		0,13	0,13	0,00

Table 2: Simulation Results : Elimination of import taxes

2. Profits (super-profits) decrease.
3. Welfare gains increase slightly when imperfect competition is introduced, even more when we include increasing returns to scale[26]
4. Wage and return to capital (net of profits) increase in real terms.

Clearly, these effects depend on the assumptions underlying the model, but they reveal the importance of accounting for imperfect competition when it is suspected of playing an important role in the economy. Like we said before, oligopoly being a intermediate case between monopoly and perfect competition, the results reported here are also intermediate. In particular, note that welfare decreases relative to the perfect competition case when we take into account imperfect competition but increases when we add scale economies. As in the monopoly case, the pro-competitive effect is also present but to a lesser extent as the industrial sector expands[27]. Finally, although some firm exit in simulation

[26]Welfare changes are measured by equivalent variations. Foreign savings are constant so the national economy cannot get a "free lunch". Government expenditures are also constant to keep focus on the representative agent. Accordingly, there is lump-sum tax on household to compensate the government for any loss of revenue incurred because of the trade liberalization. Finally, the volume of investment is fixed to abstract form intertemporal issues.

[27]One should note that the allocation of resources is sensitive to the elasticity of substitution between imports and domestic production as reported by Devarajan and Rodrik (1991). We have used a value for this elasticity of 1.0. Sensitivity tests (not reported here) show that the pro-competitive effect grows weaker as this elasticity increases.

OEE, the effect is not very strong. Hence, one should not expect rationalization to follow automatically from trade liberalization in those simulations.

6 Conclusion

This paper does not pretend to present a comprehensive analysis of the issues involved in integrating economies of scale and imperfect competition into CGEMs; we have rather attempted to emphasize some of the main features of this exercise. Given the conditions in developing countries, we argued that imperfect competition and economies of scale are probably the norm, not the exception. Next we reviewed studies in which CGEMs have been applied to situations of imperfect competition and economies of scale. Then we summarized the available methods of incorporating monopoly power into these models. Implications of imperfectly competitive markets for trade policy were considered, and we ascertained that only empirical analysis can establish the size and direction in which key variables will move. Finally, using a simple model of monopoly, we provided an example of the usefulness of computable general equilibrium models for the analysis of the effects of trade policy on the monopoly power of domestic firms.

The results of our simple model of an hypothetical economy confirm those of the literature, namely that (1) taking into account imperfect competition can affect the resource allocation pattern; (2) the impact on welfare remains uncertain, although incorporating economies of scale will almost surely increase it. Given the poor evidence for scale economies in developing countries, this should be considered with care; (3) even if rationalization of the industry has been shown to have a big impact in some CGEMs, we show like Devarajan and Rodrik that it does not automatically follow from trade liberalization. In fact, given the strong barriers to entry/exit in developing countries, it is doubtful whether trade liberalization will in itself be sufficient for such a rationalization.

However, the case for trade liberalization remain strong. The framework with which we experimented does not capture many features like increased product diversity or dynamic gains like increased productivity. Even in a static framework, some work should be done on the hypothesis of the representative firm. In reality, big and small, more or less efficient firms coexist (cf. Lee (1992)). One could think of a model where trade liberalization increase the market share of the more efficient firms (cf. Westbrook and Tybout (1993)). Taking account imperfect competition and scale economies has deepened our understanding of trade liberalization but there is still a long way ahead!

have used a value for this elasticity of 1.0. Sensitivity tests (not reported here) show that the pro-competitive effect grows weaker as this elasticity increases.

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7 Appendix A

7.1 Sets

i,j All sectors
(AGR,IND,SAD)

m Commercial sectors
(AGR,IND)

nm Non-commercial sectors
(SAD)

cp Competitive sectors
(AGR)

ncp Non-competitive sectors
(IND)

7.2 Model

7.2.1 Production and factor demand

Perfect Competition

$$VA_m = a_m^v {L_m^d}^{\alpha_m} {K_m}^{1-\alpha_m} \tag{7.1}$$

$$CI_m = \frac{io_m VA_m}{v_m} \tag{7.2}$$

$$CI_{nm} = \frac{io_{nm} L_{nm}^d}{u_{nm}} \tag{7.3}$$

$$X_i^s = \frac{CI_i}{io_i} \tag{7.4}$$

$$CIJ_{i,j} = aij_{i,j} CI_j \tag{7.5}$$

$$L_m^d = \frac{\alpha_m P_m^{VA} VA_m}{w} \tag{7.6}$$

Monopoly

$$VA_m = a_m^v {L_m^d}^{\alpha_m} {KV_m}^{1-\alpha_m} \tag{7.7}$$

$$CI_m = \frac{io_m VA_m}{v_m} \tag{7.8}$$

$$CI_{nm} = \frac{io_{nm} L_{nm}^d}{u_{nm}} \tag{7.9}$$

$$X_i^s = \frac{CI_i}{io_i} \tag{7.10}$$

$$CIJ_{i,j} = aij_{i,j} CI_j \tag{7.11}$$

$$L^d_{cp} = \frac{\alpha_{cp} P^{VA}_{cp} VA_{cp}}{w} \tag{7.12}$$

$$L^d_{ncp} = \frac{\alpha_{ncp} r}{(1-\alpha_{ncp})w}^{(1-\alpha_{ncp})} \cdot \frac{v_{ncp} X^S_{ncp}}{a^v_{ncp}} \tag{7.13}$$

$$\frac{P^D_{ncp} - MC_{ncp}}{P^D_{ncp}} = \frac{1}{\varepsilon^D_{ncp}} \tag{7.14}$$

$$P^E_{ncp} = AC_{ncp} \tag{7.15}$$

$$MC_{ncp} = \frac{v_{ncp}}{a^v_{ncp}}\left(\frac{w}{\alpha_{ncp}}\right)^{\alpha_{ncp}}\left(\frac{r}{1-\alpha_{ncp}}\right)^{(1-\alpha_{ncp})} + io_{ncp}\sum_j aij_{j,ncp} P^Q_j \tag{7.16}$$

$$AC_{ncp} = MC_{ncp} + \frac{r\overline{KF}_{ncp}}{X^S_{ncp}} \tag{7.17}$$

$$PR_{ncp} = P^{VA}_{ncp} VA_{ncp} - wL^d_{ncp} - rK_{ncp} \tag{7.18}$$

$$\varepsilon^D_{ncp} = \sigma^s_{ncp} + (1-\sigma^s_{ncp})\frac{P^D_{ncp}(1+t^X_{ncp})X^{D_d}_{ncp}}{P^Q_{ncp} X^Q_{ncp}} \tag{7.19}$$

$$KV_{ncp} = K_{ncp} - \overline{KF}_{ncp} \tag{7.20}$$

$$PS_{ncp} = \frac{AC_{ncp}}{MC_{ncp}} \tag{7.21}$$

Oligopoly

$$VA_m = a^v_m {L^d_m}^{\alpha_m} {KV_m}^{1-\alpha_m} \tag{7.22}$$

$$CI_m = \frac{io_m VA_m}{v_m} \tag{7.23}$$

$$CI_{nm} = \frac{io_{nm} L^d_{nm}}{u_{nm}} \tag{7.24}$$

$$X^s_i = \frac{CI_i}{io_i} \tag{7.25}$$

$$X^{S_f}_{ncp} = \frac{X^S_{ncp}}{N_{ncp}} \tag{7.26}$$

$$CIJ_{i,j} = aij_{i,j} CI_j \tag{7.27}$$

$$L^d_{cp} = \frac{\alpha_{cp} P^{VA}_{cp} VA_{cp}}{w} \tag{7.28}$$

$$L^d_{ncp} = \frac{\alpha_{ncp} r}{(1-\alpha_{ncp})w}^{(1-\alpha_{ncp})} \cdot \frac{v_{ncp} X^S_{ncp}}{a^v_{ncp}} \tag{7.29}$$

$$\frac{P^D_{ncp} - MC_{ncp}}{P^D_{ncp}} = \frac{1}{N_{ncp}\varepsilon^D_{ncp}} \tag{7.30}$$

$$P^E_{ncp} = AC_{ncp} \tag{7.31}$$

$$MC_{ncp} = \frac{v_{ncp}}{a^v_{ncp}}\left(\frac{w}{\alpha_{ncp}}\right)^{\alpha_{ncp}}\left(\frac{r}{1-\alpha_{ncp}}\right)^{(1-\alpha_{ncp})} + io_{ncp}\sum_j aij_{j,ncp}P^Q_j \quad (7.32)$$

$$AC_{ncp} = MC_{ncp} + \frac{r\overline{KF}_{ncp}}{X^{S_f}_{ncp}} \quad (7.33)$$

$$PR_{ncp} = P^{VA}_{ncp}VA_{ncp} - wL^d_{ncp} - rK_{ncp} \quad (7.34)$$

$$\varepsilon^D_{ncp} = \sigma^s_{ncp} + (1-\sigma^s_{ncp})\frac{P^D_{ncp}(1+t^X_{ncp})X^{D_d}_{ncp}}{P^Q_{ncp}X^Q_{ncp}} \quad (7.35)$$

$$KV_{ncp} = K_{ncp} - N_{ncp}\overline{KF}_{ncp} \quad (7.36)$$

$$PS_{ncp} = \frac{AC_{ncp}}{MC_{ncp}} \quad (7.37)$$

Contestables markets The monopoly mark-up is replaced by the following eqution:

$$P^D_{ncp} = AC_{ncp} \quad (7.38)$$

7.2.2 Income and Saving

$$Y^M = w\sum_i L^d_i + r\sum_m K_m + \sum_{ncp} PR_{ncp} + eTRM - TMG \quad (7.39)$$

$$Y^M_d = (1-ty)Y^M \quad (7.40)$$

$$UTI = \prod_m C_m{}^{beta^C_m} \quad (7.41)$$

$$r = \frac{P^{VA}_{cp}VA_{cp} - wL^d_{cp}}{K_{cp}} \quad (7.42)$$

$$Y^G = tyY^M + \sum_m TXS_m + \sum_m TXM_m + \sum_m TXE_m + eTRG + TMG \quad (7.43)$$

$$TXS_m = t^X_m(P_mX^S_m) \quad (7.44)$$

$$TXM_m = t^M_m eP^{WM}_m X^M_m \quad (7.45)$$

$$TXE_m = t^E_m P^E_m X^E_m \quad (7.46)$$

$$S^M = pms \cdot Y^M_d \quad (7.47)$$

$$S^G = Y^G - \sum_i \beta^G_i CT^G \quad (7.48)$$

7.2.3 Demand

$$CT^M = Y^M_d - S^M \quad (7.49)$$

$$P_i^Q C_i^M = \beta_i^C CT^M \tag{7.50}$$
$$P_i^Q C_i^G = \beta_i^G CT^G \tag{7.51}$$
$$C_i = C_i^G + C_i^M \tag{7.52}$$
$$DI_i = \sum_j aij_{i,j} CI_j \tag{7.53}$$
$$P_i^Q INV_i = \beta_i^I VIT \tag{7.54}$$
$$IT = \sum_m INV_m \tag{7.55}$$

7.2.4 Prices

$$P_m^{VA} = \frac{(P_m X_m^S - \sum_j P_j^Q CIJ_{j,m})}{VA_m} \tag{7.56}$$
$$wL_{nm}^d = P_{nm} X_{nm}^S - \sum_j P_j^Q CIJ_{j,nm} \tag{7.57}$$
$$P_m^M = e(1+t_m^M) P_m^{WM} \tag{7.58}$$
$$P_m^E = \frac{eP_m^{WE}}{(1+t_m^E)(1+t_m^X)} \tag{7.59}$$
$$P_m^Q X_m^Q = P_m^D X_m^{D_d}(1+t_m^X) + P_m^M X_m^M \tag{7.60}$$
$$P_{nm}^Q = P_{nm} \tag{7.61}$$
$$P_m X_m^S = P_m^D X_m^{D_s} + P_m^E X_m^E \tag{7.62}$$
$$IGP = \sum_i \beta_i^X P_i \tag{7.63}$$

7.2.5 Foreign Trade

$$X_{cp}^S = a_{cp}^t (\delta_{cp}^t X_{cp}^{E\,\rho_{cp}^t} + (1-\delta_{cp}^t) X_{cp}^{D_s\,\rho_{cp}^t})^{\frac{1}{\rho_{cp}^t}} \tag{7.64}$$
$$X_{nm}^S = X_{nm}^Q \tag{7.65}$$
$$X_{cp}^E = (\frac{P_{cp}^E}{P_{cp}^D})^{\sigma_{cp}^t} (\frac{(1-\delta_{cp}^t)}{\delta_{cp}^t})^{\sigma_{cp}^t} X_{cp}^{D_s} \tag{7.66}$$
$$\frac{X_m^E}{\overline{X^E}_m} = \frac{P_m^E}{\overline{P^E}_m}^{\eta_m} \tag{7.67}$$
$$X_{ncp}^S = X_{ncp}^{D_s} + X_{ncp}^E \tag{7.68}$$
$$X_m^Q = a_m^s (\delta_m^s X_m^{M\,-\rho_m^s} + (1-\delta_m^s) X_m^{D_d\,-\rho_m^s})^{\frac{-1}{\rho_m^s}} \tag{7.69}$$
$$X_m^M = (\frac{\delta_m^s}{1-\delta_m^s})^{\sigma_m^s} (\frac{P_m^D(1+t_m^X)}{P_m^M})^{\sigma_m^s} X_m^{D_d} \tag{7.70}$$
$$BOC = \sum_m P_m^{WM} X_m^M - TRG - TRM - \sum_m P_m^{WE} X_m^E \tag{7.71}$$

7.2.6 Equilibrium

$$LS = \sum_i L_i^d \tag{7.72}$$

$$KS = \sum_m K_m \tag{7.73}$$

$$X_i^Q = C_i + DI_i + INV_i \tag{7.74}$$

$$X_m^{D_s} = X_m^{D_d} \tag{7.75}$$

$$VIT = S^M + S^G + eBOC \tag{7.76}$$

7.3 Endogeneous Variables

X_i^S : Branch i's production
VA_m : Branch m's value added
L_i^d : Branch i's labor demand

Y_M : Total household income
S_M : Household savings
YD_M : Household disposable income
Y_G : Government revenue
S_G : Government savings
TX_i^S : Indirect taxes
TX_i^M : Revenue from import duties
TX_i^E : Revenue from export tariffs
BOC : Current account balance (in foreign currency)

C_M : Total household consumption (val)
C_i : Consumption of good i (vol)
CI_i : Total intermediate consumption by branch
CIJ_{ij} : Intermediate consumption of good i by branch j
ID_i : Intermediate demand of good i
IT : Total investment (val)
INV_i : Consumption of good i for investment uses (vol)
$X_i^{D^s}$: Local supply of the domestically produced good
$X_i^{D^d}$: Local demand of the domestically produced good
$X_i^{E^S}$: Exports supply (FOB volume)
$X_i^{E^D}$: Exports demand (FOB volume)
X_i^M : Imports (CAF volume)
X_i^Q : Supply of the composite good

$X_i^{D_f^s}$: Local supply of the domestically produced good per firm
X_i^E : Exports supply per firm (FOB volume)
$X_i^{S_f}$: Branch i's production per firm

w	:	Wage rate
r	:	Rate of return of capital
IGP	:	General price index
P_m^{VA}	:	Value added price
P_i	:	Producer price
P_i^D	:	Price of domestically produced and consumed goods
P_i^Q	:	Price of composite goods
P_i^M	:	Domestic price of imports
P_i^E	:	Domestic price of export

K_m	:	Branch n's capital stock
PS_{ncomp}	:	Scale parameter
AC_{ncomp}	:	Average cost
MC_{ncomp}	:	Marginal cost
PR_{ncomp}	:	Profits
ε_{ncomp}^D	:	Price elasticity of domestic demand
N_{ncomp}	:	Number of firms

7.4 Exogeneous Variables

K^S	:	Total capital supply
KF	:	Fixed capital
L^s	:	Total labor supply
P_m^{WM}	:	World price of imports (in foreign currency) (numéraire)
P_m^{WE}	:	World price of exports (in foreign currency)
C_G	:	Public consumption (value)
T_{EG}	:	Foreign transfer payments to the government
T_{EM}	:	Foreign transfer payments to the households
e	:	Nominal exchange rate

7.5 Parameters

a_{ij}	:	Technical coefficients in intermediate consumption
io_i	:	Technical coefficients in production
v_m		Idem
v_{nm}		Idem
a_m^v	:	Scale factor in value added function
α_m	:	Labor elasticity in value added function
a_m^T	:	CET scale parameter
δ_m^T	:	CET distributive share
ρ_m^T	:	CET elasticity of transformation
σ_m^T	:	Elas city of transformation
a_m^S	:	CES scale parameter
δ_m^S	:	CES distributive share
ρ_m^S	:	CET elasticity of transformation
ε_m^E	:	Export price elasticity
σ_m^S	:	Elasticity of substitution
pms	:	Household marginal propensity to save
t_Y	:	Household income tax rate
t_i^X	:	Indirect tax rate
tm_m	:	Import duty rate
te_x	:	Export tax rate
β_i^c	:	Share of good i in household consumption
β_i^g	:	Share of good i in public consumption
β_i^i	:	Share of good i in total investment
β_i^x	:	Branch i's share in total production

Appendix B: The data

		Factors			Agents			Sectors			Products for				Accumu lation	Total
											Domestic market		Exports market			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	Labor							900	500	300						1700
2	Capital							300	550							850
3	Pure profits								550							550
4	Household	1700	850	550												3100
5	Government				200						20	100				320
6	Rest of the world				200						130	300				630
7	Agriculture										1200		300			1500
8	Industry											2850		100		2950
9	Public administration					350										350
10	Agriculture				500			100	300	0					450	1350
11	Industry				1200			200	1050	50					750	3250
12	Agriculture						300									100
13	Industry						100									300
14	Accumulation				1000	-30	230									1200
Total		1700	850	550	3100	320	630	1500	2950	350	1350	3250	300	100	1200	