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Product Standards, Imperfect Competition, and Completion of the Market in the European Union

Modeling the static and steady-state effects on trade, production, and market structure of completion of the European Union's internal market.

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Summary findings

Harrison, Rutherford, and Tarr model the static and steady-state effects on trade, production, and market structure of completion of the European Union's (EU's) internal market.

The impetus for change comes from the removal of border costs and the costs of producing to different national standards. It also comes from consumers' greater ability to substitute among the products of producers in different EU countries, once the European Union adopts its program on standards.

In the analysis of the static scenario, removing border costs and the costs of supply-side standards improves the welfare of EU countries by only about 0.5 percent of GDP. Results vary greatly across the countries of the European Union, however, because the benefits to a country are roughly proportional to its share of intra-EU trade in its GDP. This is the first model to identify these country differences because of the greater country disaggregation.

The additional effect of the program of standards on consumer demand elasticities increases the competition and reduces markups in imperfectly competitive industries. Then there are additional gains from rationalization, as well as consumer efficiency gains in imperfectly competitive sectors, that result in an increase in the estimated gains to about 1.2 percent of GDP (again with wide differences across EU countries).

The steady-state results let the capital stock in each country adjust to its new higher equilibrium value, which acts as an additional endowment of capital, allowing the European Union to produce a higher level of income. The gains to the European Union then rise to about 2.6 percent of GDP.

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Product Standards, Imperfect Competition and Completion of the Market in the European Union

by

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1. Introduction

How large are the static welfare benefits of completion of the internal market in the European Community? What are the economic mechanisms underlying these estimates? Are the long-run estimates significantly different from the short-run effects? The size of existing estimates, and their rationale, vary a great deal.

First consider the static welfare effects. The official forecasts were that the welfare gains would be between 4.3% and 6.4% of 1988 GDP, albeit based on heroic extrapolations of partial equilibrium calculations for a handful of industries.[1] Academic numerical general equilibrium calculations[2] tend to be much lower, ranging from 0.25% to 1.35% of GDP. These studies produce a range of estimates varying, most importantly, with the nature of the assumed market structure and pricing policy. When countries within the EC are assumed to have segmented markets, lower estimates are derived (about 0.25 to 0.50 percent of GDP). In this segmented markets case the benefits of EC integration derive from the removal of border costs *and* the reduction in costs from producing to a common standard. A commonly held view, however, is that EC92 will have its strongest impact in imperfectly competitive markets by increasing competition and inducing rationalization. The higher estimates derive from models which assume that completion of the market will induce a single integrated market in which international price discrimination is impossible, i.e., a uniform EC-wide price is imposed.

These larger estimates are sometimes characterized as hypothetical because no clear rationale is articulated for how the integration process will induce a common price. That is, if arbitrage fails to eliminate price differences (net of transportation, border and standards costs) prior to 1993,[3] it is not

[1] This range is reported in Cecchini et al. [1988; p.83] and Emerson et al. [1988; Table 10.1.1, p.203], which are extrapolations of the work of Smith and Venables [1988] for a number of sectors which experience increasing returns to scale. Winters [1992; p.105] has appropriately characterized these extrapolations as "heroic".

[2] Due to Gasiorek, Smith and Venables [1992], Haaland and Norman [1992] and Mercenier [1992], all of which are summarized below.

[3] We use the date "1993" to refer to the nominal year in which completion of the market is to begin. The delays in national legislative efforts to implement necessary statutes, as well as other delays in application of those laws, makes this date a matter of pedagogic convenience rather than a prediction about when the EC will in fact have completed the single-market program.

clear why it would eliminate price differences (net of transportation costs) after 1993.[4] We briefly review the empirical work testing for price discrimination in the United States. It shows that even in the United States, which is more fully integrated than the EC is likely to become in the near future, price discrimination appears to exist in a wide variety of markets. Moreover, a number of monopolistic competition models have recently been developed that indicate that price discrimination may exist even when market power arises only from monopolistically competitive product differentiation. Thus, both theory and empirical work on the relatively integrated markets in the United States indicate the implausibility of the modelling exercises that assume that no price discrimination is possible after the implementation of the EC92. In addition, we note that the imposition of uniform pricing results (due to the elimination of reciprocal dumping implied by uniform pricing) in the counterintuitive result that intra-EC trade *declines* subsequent to the EC92 program.[5] Thus, we believe that it is necessary to model market integration within the EC92 program with an approach that captures the idea that EC92 will increase competition and rationalization in imperfectly competitive markets without imposing ***complete*** elimination of firm level price discrimination across the EC.

We model the effects of completion of the internal market in the EC on trade, production and market structure. The impetus for change in our framework comes from two interrelated effects. One effect is the, now standard, reduction of border and standards costs (analogous to the segmented markets approach of previous studies, where the benefits of reduced standards costs is limited to the impact on improved economies of scale). In addition, we maintain that the single market program on standards will have the impact of increasing the ability and willingness of buyers to substitute among the products of

[4] Karp [1992; p.63] makes the same point: "If it were possible to price discriminate before 1992, then lowering transportation costs (broadly defined) might either increase or decrease the incentive for price discrimination." Smith and Venables [1988; p.1523] note that "... it is not obvious that there exist feasible changes in EC trade policy and competition policy that could impose such a change. In practice policy may be expected to be some combination of our two experiments."

[5] See, for example, Smith and Venables [1988; pp.1520-1523].

producers in different countries. We review the theory and evidence regarding the impact of standards which shows that the impact of standards, especially in the manner implemented in the EC92 program, should be to increase the substitution possibilities of EC buyers for the products of EC producers. In many cases, such as common interconnection in telephone equipment, it is because the products are physically altered so that the products of different producers become interchangeable. In other cases it is because protectionist barriers are eliminated, as occurred with German beer purity restrictions. For other products a quality assurance standard may reduce the advantages of product differentiation, such as occurred in the United States as a result of SAE standards for motor oil and brake fluid.

These effects are appropriately modelled as a change in the elasticity of substitution of consumers in EC countries for the varieties of output of other EC firms. We simulate this change along a continuum from an initial situation, characterized by firm level product differentiation where consumers regard the output of other EC firms are equally substitutable with other *non-EC imports*, to where consumers regard the varieties of all other EC firms as equally substitutable with *home varieties*. A monopolistic competition model is developed in which each firm's post-1992 markup is endogenously determined as a function of the substitutability of the outputs of different EC firms in the preference structure of national consumers. We show, however, that even in the extreme case of no national preferences, pricing differences and market segmentation are not eliminated. As long as arbitrage is imperfect, price differences (net of transportation costs) may persist, and firms determine their optimal markups in each national market based on perceived elasticities that vary with (among other things) the firm's market share in each national market.[6] Thus, an important contribution of this paper is that we provide a rationale for

[6] Haaland and Wooton [1992] have shown that if trade barriers or national preferences continue to exist in the post-1992 environment, the uniform EC-wide pricing that results from complete elimination of segmentation can, contrary to the conventional wisdom, reduce welfare. The reason is that if firms are forced to charge a uniform price across the EC, but national preferences are retained, they will raise prices on their intra-EC exports and this may dominate the effects of lower markups on their domestic sales. In other words, EC92 could reduce welfare due to the loss of the beneficial aspects of a type of reciprocal dumping described by Brander and Krugman [1983]. A similar result is shown analytically by Malueg and Schwartz [forthcoming]. The Haaland-Wooton model does not,

the reduction of price discrimination occasioned by the 1992 program that we numerically implement, in which the extent of remaining price discrimination is endogenously determined.

Our estimates are that the reduction of border and standards costs associated with the EC92 program will result in welfare gains of about 0.5% of EC welfare, a nontrivial welfare increase, but not overwhelming given that increasing returns to scale sectors are in the model. Allowing for the additional effects of standardization on consumer substitution elasticities (our version of integration), however, more than doubles the estimated welfare gains.

Turning to the estimates of long-run welfare effects, the benefits appear to be much greater. In a widely cited study Baldwin [1989; pp. 266, 269] employed estimates from comparative statics models of the effects of EC92 as an exogenous input into a single sector Solow-type growth model. He suggests that the long run effects will be at least *double* the static effects and probably will be as much as four times larger.

We also estimate the steady state growth effects of EC92. Our approach differs from Baldwin [1989; 1992] in that we integrate our multisector approach and the steady state effects into a single model. Consequently, the interaction between long run growth effects and comparative static effects at any initial income level is determined endogenously in our model. We estimate that the benefits in the steady state more than *quadruple* the estimate of the welfare benefits (about 2.4% of EC GDP) compared to the segmented markets comparative statics estimate, explaining some of the anticipatory euphoria surrounding the completion program even before it is fully enacted.

Our general equilibrium model is described in section 2, and the main policy simulations discussed in section 3 (static welfare effects) and section 4 (steady state welfare effects). We compare our model and simulations in some detail with the previous literature, pointing out the differences in our

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however, explain why EC92 would force uniform pricing in markets which were previously characterized by price discrimination. The problems that they identify, however, have led Winters [1992; p.20] to call for further research to distinguish trade barriers and consumer preferences as a rationale for home market bias.

approach. Compared with earlier estimates our greater regional disaggregation reveals sharp differences of expected benefits from EC92 among EC countries based on intra-EC trade intensities. We emphasize: the endogenous determination of the extent of reduction in price discrimination deriving from the impact of the EC92 product standardization program on consumer perceptions of substitutability, the estimation of steady state growth effects in a unified endogenous framework, and the considerably greater regional and commodity disaggregation in our model. In most other respects our model is of the same genre as earlier general equilibrium work.

2. A Multi-Regional Trade Model

General Model Features

In this subsection we focus on general modelling features. Due to their importance in modelling the process and effects of integration in the EC, we discuss in some detail below how we model (i) the reduction of border and standards costs as a result of the EC92 program, (ii) market integration as an endogenous consequence of other aspects of the EC92 program and (iii) the extension of static estimates of welfare effects to steady state estimates. Appendix A provides a detailed algebraic formulation of the model and the decomposition algorithm employed for solution (see Rutherford [1992a,b]).

The model separately identifies nine regions of the EC: Belgium, Denmark, France, Germany, Italy, the Netherlands, Portugal, Spain, and the United Kingdom. It also identifies Morocco, Turkey, and a residual Rest of World (ROW), making twelve regions in all. The present version identifies twenty-six sectors per region, listed in Table 1. Twelve sectors in each region are characterized by increasing returns to scale (IRTS), as identified in Table 1 in the column reporting the Cost Disadvantage Ratio (CDR). The CDR, which is defined as the ratio of fixed to total costs, provides a measure of the importance of scale

Table 1: Sectors of the Model

ID	Sector	Eurostat Sectors	Value Added	CDR (%)
AGR	Agriculture	010	3%	
FOO	Food	310, 330, 350	3	11
BET	Beverages and Tobacco	370, 390	2	
ENE	Energy	030, 050, 070, 110	4	
UTI	Utilities	090	2	
STE	Iron and Steel	130	1	5
NMM	Non-Metallic Mineral Products	150	1	6
CHM	Chemicals	170	2	6
MET	Metal Products	190	2	5
IMA	Industrial Machinery	210	2	6
OMA	Office Machinery	230	1	4
ELG	Electrical Goods	250	3	5
VEH	Motor Vehicles	270	2	11
OTE	Other Transport Equipment	290	1	14
TXC	Textiles and Clothing	410, 430	2	
WOO	Wood	450	1	
PAP	Paper and Printing	470	2	11
RPL	Rubber and Plastics	490, 510	[illegible]	4
CON	Construction and Repair	530, 550	8	
TRA	Trade	570	12	
FIN	Financial Services	690, 710, 730	15	
TRN	Transport and Communication	610, 630, 650, 670	6	
HEA	Health Services	750, 850	4	
EDU	Education Services	770, 890	4	
SER	Other Market Services	590, 790	6	
PUB	General Public Services	810, 930	10	

economies.[7] The market structure in IRTS sectors is monopolistically competitive, with free entry and exit. All other sectors exhibit constant returns to scale (CRTS) and have a competitive market structure.

[7] The methodology for estimation of the CDR is discussed in Appendix B.

Table 1 also shows the original *Eurostat* sectors from which our aggregation was obtained, and the aggregate EC share of each sector in value added.

We adopt a relatively detailed level of sectoral and regional disaggregation in our model, since disaggregation has (as we show below) an important impact on the estimated effects of EC92. As Gasiorek, Smith and Venables [1992] (GSV) note, regional aggregation entails a nontrivial assumption in these exercises since it is primarily through the reduction in border and standards costs of exporting that the EC92 program will have its impact. Regional aggregation in effect converts exports, on which a cost reduction would be achieved, into domestic production. Moreover, we show below that greater regional disaggregation is fundamental in revealing the considerable differences in the welfare benefits that will accrue to the EC countries with different intra-EC trade intensities. Table 2 lists the nine EC countries in our model and their intra-EC trade intensities.

Regarding sectoral aggregation, previous studies have employed reasonable aggregation structures for IRTS sectors, but have employed one or at most two large residual CRTS sectors representing at least two-thirds of the economy. Table 8 offers a summary of the main model features of previous studies. Our 26 sector model allows us to keep separate virtually all of the sectors which have significant IRTS as estimated at the 44-sector level. It also allows us to maintain some disaggregation of CRTS sectors, along the lines that might be expected to influence results (viz., traded *versus* non-traded, labor-intensive *versus* capital-intensive). By received standards in the literature this makes for a "big model".

The rest of our static model is relatively standard. We have multiple price-wedge distortions, such as factor taxes in production, value-added taxes, import tariffs, export subsidies, voluntary export restraints (represented as *ad valorem* equivalents) and non-tariff barriers (also represented as *ad valorem* equivalents). Production entails the use of intermediate inputs and primary factors. Primary factors are mobile across sectors within a region, but are internationally immobile. Each region has a single representative consumer, as well as a single government agent.

Modelling the Reduction in Border and Standards Costs of Intra-EC Trade

The two types of real trade costs which constitute the "sand in the gears" in our model are border costs and standardization costs on the supply side. Border costs represent the costs of undertaking trade, such as administrative costs of transacting and transporting over international boundaries. Standardization costs on the supply side are due to differences in technical specifications and regulations across national boundaries, being associated with the production costs of fulfilling technical regulations in foreign EC markets. Standardization costs, which would include the costs on the demand side of fewer or less adequate substitutes as discussed below, are viewed as being much more of a barrier to intra-EC trade than explicit border costs (see Emerson et al. [1988; p.32ff.]), and their removal was one of the most ambitious aspects of the EC92 program. It is also the aspect of the program that has naturally been the hardest to enforce, given the welter of national legislation and regulatory directives involved. No observer of intra-EC trade would doubt that substantial standardization costs will continue to exist in the EC for many years to come.

Virtually all studies of the welfare effects of EC92 use a joint *ad valorem* production cost for these items of 2.5%. We follow this assumption, but decompose this value into an amount attributable to border costs and an amount attributable to production standardization costs. The reason for doing this is that we model the effects of each in different ways. Border costs are modelled as additional purchases of the domestic "transportation" good in each region. This good represents the activity of shipping, handling and warehousing for customs purposes. Standardization costs on the supply side are more likely to be reflected in extra costs of producing the specific good itself, rather than the purchase of inputs of any specific good. Thus we model supply side standardization costs as additional value-added in each sector in which trade takes place. These costs are treated as falling on imports to, and exports from, the region. They do not fall on domestic sales, and hence should be interpreted as the *differential* costs of transacting with other EC countries.

Estimates of border costs for many EC regions and sectors can be extracted from Cawley and Davenport [1988; Tables B2, A3]. The weighted averages of these border costs for trade with other EC regions is shown in Table 2. The EC average is about 1.7%, based on these estimates. If we assume that the real trade costs from border costs *and* supply side standardization costs amounts to 2.5% for each region, the region-specific standardization costs are derived residually and are shown in Table 2. These estimated supply side standardization costs are then assumed to apply to all traded goods within the indicated region.

Theory and Evidence Against Uniform Pricing

Previous studies have modelled completion of the market in two stages, with the first stage being the same as ours. In the second stage, previous studies have attempted to capture the presumption that EC integration will have its strongest impact by increasing competition in IRTS sectors. Their second stage involves a shift in the pricing behavior of national firms as the result of completion. Pricing is originally undertaken with "segmented markets", and with monopolistic competition in IRTS sectors this results in lower prices in foreign markets than at home.[8] With completion of the market these segmented markets are replaced with an integrated market in which price discrimination between home and foreign markets is assumed to be impossible.

We claim that it is inappropriate either on *theoretical or empirical grounds* to model EC integration as a process that imposes complete pricing uniformity. First consider the theory. Although the possibility of price discrimination by a monopolist selling in segmented markets has long been accepted in economic theory, recent theoretical work has shown the existence of price discrimination equilibria in a variety of multi-firm settings, even with free entry (e.g., Katz [1984], Borenstein [1985]

[8] This result assumes, plausibly enough, that foreign market shares for a given firm are smaller than domestic market shares. Hence the perceived demand elasticity is different in the two markets, resulting in differences in mark-ups.

Table 2: Border, standard costs ar... intra-EC trade intensities for EC regions (in percentage)

Country	*Border costs*	*Standardization costs*[a]	*Intra-EC*[b] *trade intensity*
Belgium	1.692	0.808	35.6
Denmark	1.695	0.805	14.9
France	1.717	0.783	11.1
Germany	1.807	0.693	11.9
Italy	1.576	0.924	10.1
Netherlands	1.623	0.877	29.1
Portugal	1.540	0.960	12.0
Spain	1.663	0.837	08.8
United Kingdom	1.903	0.597	11.9

a. Border plus standard costs sum to 2.5 percent.
b. Defined as one-half intra-EC exports plus imports divided by GDP.

and Holmes [1989])[9]. These analyses suggest that price discrimination may arise even when market power over price arises only from monopolistically competitive product differentiation.

On empirical grounds, consider the United States market, which is considerably more integrated than the EC is likely to become in the immediate future. Although there are generally alternative theoretical explanations for the observed pricing practices,[10] there are a wide variety of observed pricing practices in the United States that are consistent with price discrimination. These include: (1) two-part tariffs, in which a lump sum fee is charged and a usage charge per unit applies;[11] (2) discount coupons, which allow those consumers with lower opportunity cost of time to obtain a lower price; (3) selling the

[9] See Varian [1989] for a review of the theory of price discrimination under non-monopoly conditions.

[10] See Carlton and Perloff [1990] for alternate explanations. The welfare economics of these practices is a separate matter which we do not address.

[11] Tie-in sales, where the purchaser of the product is required to purchase related products, is one type of two part tariff. For example, IBM, in requiring purchasers of its computers to buy its tabulating cards was able to obtain a higher price for the machine from the more intensive users. Xerox, is charging a per unit rental fee for copies that exceeded the marginal maintenance costs, price discriminated against intensive users. See Scherer and Ross [1990].

same product under different brand names and charging a premium for the label as occurs in supermarkets;[12] (4) discounts on products that face stiff competition, for example in the shoe machinery (Kaysen [1956]) and computer markets (Fisher, McGowan and Greenwood [1983]); and (5) geographic price discrimination under single or multiple basing points, with some absorption of transportation charges by the producer.[13]

A further highly counterintuitive result of the uniform pricing assumption is that intra-EC trade declines as a result of EC integration. This is because firms charge higher markups on their domestic sales than on export sales prior to integration. Uniform pricing in the EC causes firms to raise export markups and lower domestic markups, which reduces intra-EC trade.

Modelling the Price Effects of Integration

Impact of Standards on Substitution. As a result of the concerns raised above, reservations have been expressed regarding the manner in which integration has been modelled in previous studies of EC92.[14] Our approach is based on a review of the theoretical and empirical literature on standards which is presented in Appendix C. We conclude that the impact of the standards component of the single market program (which is regarded by businessmen as the most important component of the single market

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[12] See Wolinsky [1987].

[13] Some form of basing point system has been adopted by many U.S. industries including the steel, cement, lead and wood pulp industries. See Scherer and Ross [1990] for an elaboration. In addition, recent studies have found evidence of price discrimination in monopolistically competitive markets. Using data from retail gasoline markets, Borenstein [1991] used a model of spatial competition in which differences in the willingness of buyers to switch stations results in price discrimination between leaded and unleaded gasoline. As gasoline stations which offered leaded gasoline diminished, the relative price of leaded to unleaded gasoline rose. Shepard [1991] found the price difference between full service and self-service gasoline in stations that offered both services was considerably greater than the price difference across different stations that only offered one type of service. Based on a similar model, Borenstein and Rose [1991] found price discrimination in the U.S. airline industry. Pashigian and Bowen [1991] have found that the greater use of sales in the pricing of apparel in retail stores is consistent with a price discrimination theory of pricing (as well as greater uncertainty), in which consumers who are more interested in being in fashion have less elastic demand and pay higher prices early in the season.

[14] For example, see Karp [1992; p.63], Smith and Venables [1988; p.1523], Mercenier [1992; p.1] and Winters [1992; p.20].

program) will be to substantially increase the ability and willingness of EC buyers to substitute among the products of EC suppliers. Thus, one of the key features of our modelling approach is that the increased competitiveness in IRTS sectors comes about through the greater ability and willingness of EC buyers to substitute among the products of EC producers due to the single market program on standards.

Standards arise from a variety of reasons. Taking the United States as an example, there are literally thousands of industrywide product standards. Most of these are voluntary, arise from the demand from buyers, and may be classified into *uniformity* standards and *quality* standards.[15] There are also situations in which suppliers desire product standards, most notably for anticompetitive reasons.[16] We explain why the single market program on standards should increase the ability of buyers to substitute among the products of competing suppliers in each of these cases.

First consider uniformity standards. The most important aspect of these is interchangeability standards, which are designed for the express purpose of allowing buyers greater substitution possibilities among different suppliers. Well known interchangeability standards are those in the auto industry which were imposed on parts suppliers by the Society of Automotive Engineers (SAE) on behalf of auto assemblers; these standards were designed so that assemblers would be able to substitute among different suppliers of parts such as wheel rims, spark plugs and screws and bolts. Other examples are standardized socket sizes in lamps that allow substitution among light bulbs. A photographer may interchangeably choose among various films, cameras, tripods, lens, filters and exposure meters due to standardization. To facilitate replacement, bricks sizes were standardized under government regulation. Operating controls for forklift trucks are almost all standardized so that training of drivers is interchangeable among different manufacturers products. Despite the enormous variety of paper towels, virtually all are eleven inches wide

[15] See Hemenway [1975] for an excellent and more elaborate treatment of the theory and evidence on industrywide voluntary standards.

[16] Another prominent reason for suppliers to desire standards is to gain economies of scale. This was discussed above and included in the model.

to fit the standardized dispenser.

Regarding quality standards, these also increase the substitution possibilities of consumers because the reduce the product differentiation advantages of producers. In the spirit of the Akerlof [1970] model, problems of degradation of product quality often arise in markets where buyers have less information than sellers and it is costly to produce higher quality products. Brand names will often develop to resolve the degradation of product quality problem, but then consumers are reluctant to substitute among competing suppliers due to product differentiation. Grading of products then will allow greater substitutability among competing brands. The auto industry succeeded in imposing quality standards on most of its raw material suppliers such as steel, rubber, petroleum and machine products. Among these industries, opposition from steel suppliers was strongest because steel suppliers were reluctant to lose product differentiation advantages associated with brand names. Similarly oil viscosity standards for auto motor oil were imposed on reluctant refineries. In general, products that are graded for quality have little product differentiation advantages.[17]

Standards are sometimes imposed by suppliers for anticompetitive purposes. For example, fearing anticompetitive standards, the U.S. Federal Communications Commission mandated standardized interconnection for terminal equipment and open network architecture (ONA), which means that the components of the telephone system are made available on an unbundled basis so that competing supplier services can be combined in any manner desired. These standards have been highly successful, at least judged by the wide variety of independent supplier equipment and services that have developed.[18]

As part of its single market program, EC policy is attempting to implement similar reforms in standards. The EC green paper on telecommunications policy indicates that through the promotion of Europe-wide standards it shall provide equal access to all market participants (EC [1987; p.5]).

[17] This includes milk, eggs, meat, lumber, soybeans, diamonds and mushrooms.
[18] See Besen and Saloner [1987] for further details.

Moreover, ONA has been mandated by the Maastricht treaty partly to insure the uniform interpretation of essential requirements across the Community in order to limit the possibilities for the imposition of restrictive licensing conditions.[19]

Probably the best known example of supplier-based anticompetitive standards is national standards that have the force of law for the purpose of protection, which the EC refers to as technical regulations. For example, EC courts interpreted German beer purity laws as protectionist and required that beer manufactured in any member state could be imported into Germany. This is an application of the mutual recognition principle in which products produced in one member state may be sold throughout the EC. In the absence of specific EC legislation however, EC states may still block intra-EC imports if certain national interests are involved. So the EC has attempted to achieve harmonization of technical regulations in which EC directives indicate mandatory requirements for national regulations.[20] In either event, the European consumer will be able to consume products from other EC states that previously were illegal to import.

It is likely that considerations such as these led businessmen who were surveyed in the "Costs of non-Europe" project to conclude that they would have greater access to new regional markets and there would be increased price and non-price competitiveness as a result of the single market (Nerb [1988; p.27]). Moreover, the survey led some observers to conclude that "there is a dynamic of demand associated with the learning process of consumers and enterprises which is released or accelerated when barriers are removed" (Nerb [1988; p.26]). Thus, the theory and empirical work on standards indicates that the impact of the EC92 program of standards will be to substantially increase the ability of buyers to substitute among the products of EC suppliers, justifying our modelling focus.

[19] See *XIII*, September 1993, p.12 (the magazine of DG XIII of the EC) and Emerson et al. [1988; p.86].

[20] A manufacturer may meet the technical requirements either by producing a product that meets the defined essential requirements (which allows manufacturer variety subject to the constraint of meeting the essential requirements of the product) or by producing a product in conformity with European standardization bodies (Emerson et al., 1988, p.40).

Modelling the Impact of Increased Substitution. We employ a flexible demand structure in which consumers may have preferences for the products of firms depending on region of origin. As a result of standardization EC buyers may substitute more readily among products from different EC firms. Then the perceived elasticity of demand of EC firms on intra-EC exports increases, and intra-EC export price margins are reduced endogenously. Consequently, as markets become more integrated intra-EC trade generally expands. Firms in CRTS sectors will not directly be led to change their prices by this change in EC consumer perceptions, but there will be indirect effects due to the general equilibrium interactions induced by changes in the prices of IRTS sectors.[21] We discuss this aspect of the model in greater detail below.

More formally, prior to the EC92 program we envisage consumers as possessing weakly separable utility functions that allow multiple stage budgeting of their choice decisions. First, based on a Cobb-Douglas utility function at the top level, they choose between the 26 different composite goods which are listed in Table 1, such as "motor vehicles" and "textiles and clothing". Having chosen how much to spend on each aggregate commodity, they then choose between domestic and imported composites of this commodity: between "domestic autos" or "imported autos", for example. This decision is based on a CES sub-utility function. Having decided how much to allocate to imported autos, consumers then decide how much to allocate to imports from different regions in the model. This decision is also based on a CES sub-utility function. Finally, given the decision on how much to spend on autos from each country, consumers allocate expenditures on the different varieties from each country based on the lowest level CES sub-utility function.[22] Figure 1 displays this structure of preferences (after the

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[21] A CRTS sector might use as an intermediate input the output of an IRTS sector whose price changes, thereby changing the costs of the CRTS sector. Alternatively, the CRTS sector may be a substitute in demand for the IRTS sector, and therefore experience a change in demand due to the change in relative prices between the two.

[22] Given that the elasticities of substitution for these last two levels of choice with respect to foreign country and foreign firm variety (within a country) are the same, the structure is equivalent to firm level competition among all imports. A special case of this structure, with all elasticities of substitution equal, yields firm level competition among all firms that is independent of the country of origin.

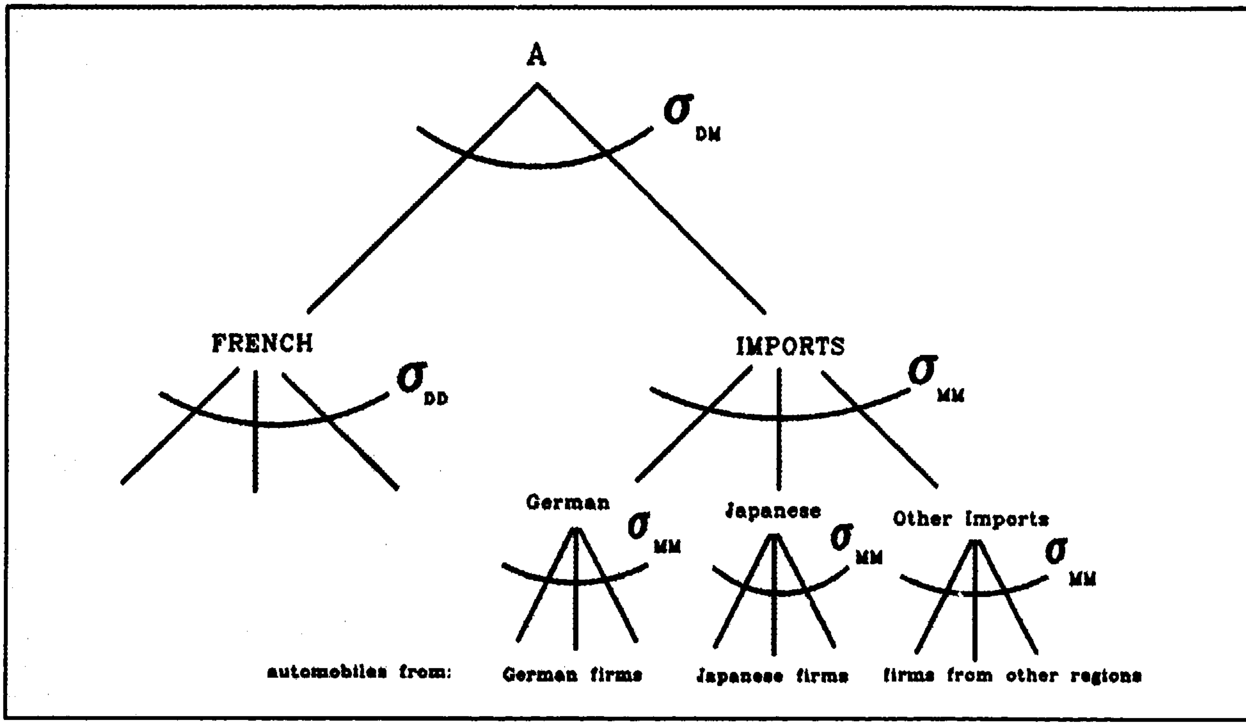

Figure 1: Structure of Preferences *Before* the EC92 Program

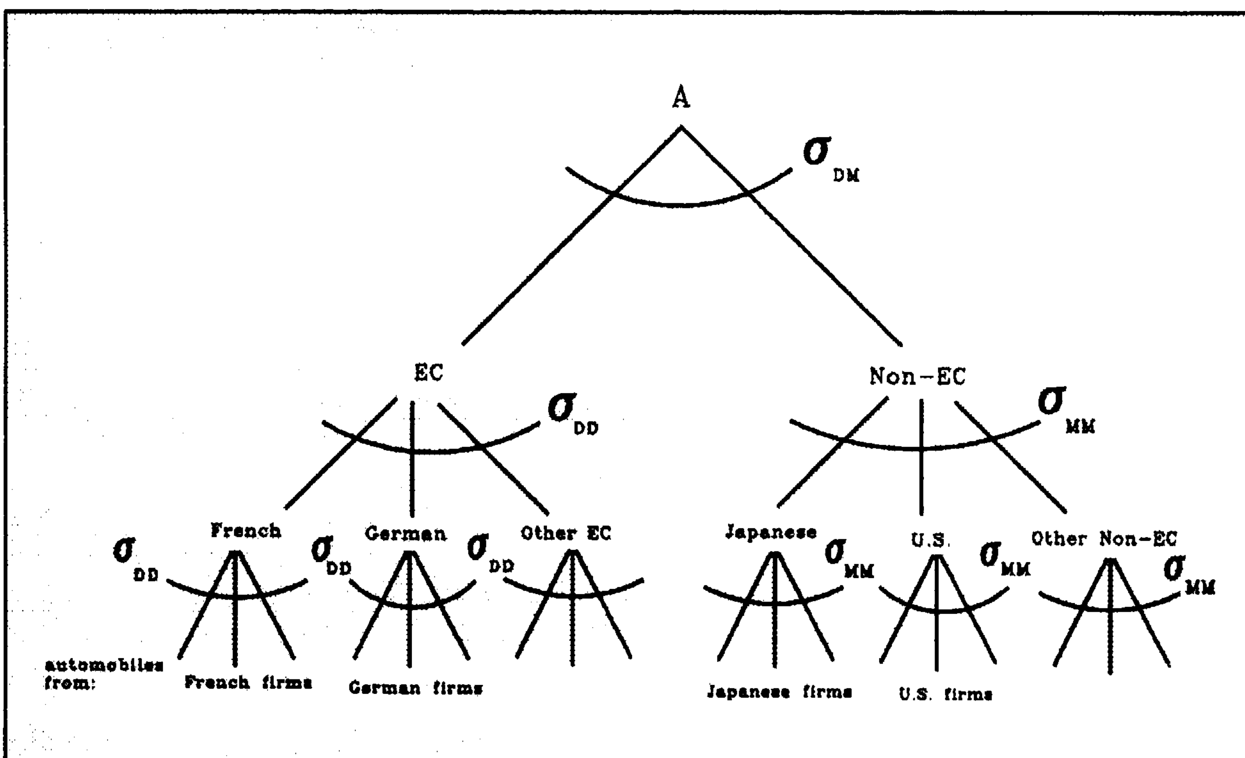

Figure 2: Structure of Preferences *After* the EC92 Program

initial Cobb-Douglas choice of how much to spend on the aggregate commodity).

After the EC92 program is completed, we envisage consumers have a different preference structure to reflect the notion that, due to EC92 programs regarding standards, EC-produced goods are now better substitutes than before. They are better substitutes for other EC-produced imports, and they are better substitutes for domestic varieties. We simulate this preference change along a continuum where in the limit consumers regard the products of all EC firms as equally substitutable. The latter preference structure is shown in Figure 2.

Specifically, in the fully integrated scenario the preference structure of consumers is directly analogous to the segmented scenario prior to EC92. Having decided how much to spend on any aggregate commodity, such as autos, consumers allocate that income among imported and domestic varieties of the commodity. However, now the notion of a "domestic variety" includes all other EC-produced varieties, even if they are not produced in the EC country in which the consumer lives. That is, we shift from treating other EC products as being "foreign varieties" and treat them as if they were "domestic varieties".[23]

These two preference structures represent extremes, reflecting the situation before EC92 and the situation after the successful completion of the EC92 program. It is then a simple matter to model the path towards completion of the market as a weighted average of these two preference structures. Thus a 25% weighting on the pre-EC92 preference structure could be interpreted as saying that a quarter of the (homogeneous) consumers in that country perceive no change in the substitutability of EC-produced

[23] This representation of preferences as changing "structure" just reflects presumed changes in the off-diagonal elements of an implicit Slutsky substitution matrix between domestic and foreign varieties. It is possible to represent this change explicitly in a CGE model, using flexible functional forms such as the non-separable CES structure developed by Perroni and Rutherford [1992], but we opt for the simpler more easily interpreted formulation presented here. The crucial modelling feature here is not the use of different utility function structures; rather it is the correct characterization that EC goods are now better substitutes for home goods.

goods.[24]

In most circumstances, economists are reluctant to consider changes in preferences as the basis for a policy exercise, in large part because the created difficulties in evaluating welfare measures, such as Hicksian equivalent or compensating variation. In the present model, however, we modify preferences in such a way that indices of welfare change remain well defined. This is because the changes in preferences do not alter the optimality of the initial allocation. In the absence of monopolistic pricing, the change in preferences alone do not disrupt the benchmark equilibrium.

The key elasticities of substitution are denoted σ_{DM}, σ_{DD} and σ_{MM}, and reflect the substitutability between domestic (D) and imported (M) goods, alternative domestic varieties, and alternative foreign countries (and varieties). These elasticities are crucial to the effects of EC92. Our priors are that $\sigma_{DM} < \sigma_{MM} < \sigma_{DD}$. Our priors derive from our above discussion and appendix on standards which indicates that products produced in the same country will be more substitutable among themselves than products from different countries. This gives us the relationship that $\sigma_{MM} < \sigma_{DD}$; this inequality plays an important role in the analysis below.[25] Although it does not play an important role in the analysis, we also posit that domestic consumers are less willing to substitute foreign varieties for domestic varieties than they are among different *varieties* from foreign sources. In the absence of data-based estimates of these elasticities we initially specify $\sigma_{DM} = 5$, $\sigma_{MM} = 10$, and $\sigma_{DD} = 15$. Our priors for the three key elasticities of substitution remain the same when applied to pre or post EC92 preference structure.

A formal derivation is provided in Appendix A, but intuition into how market integration affects

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[24] We assume that this fraction is constant across all countries, reflecting the overall progress towards completion of the EC92 program. It would be a simple matter to let it vary across EC countries, perhaps reflecting the differential speed with which EC countries are accepting EC-wide standards and are removing border costs on EC imports. There is some anecdotal evidence of such differentials, at least as measured by the speed of enacting national legislation to implement the EC92 program (e.g., *The Economist*, July 3-9, 1993, Survey on the European Community).

[25] It also gives us $\sigma_{DM} < \sigma_{DD}$.

markups and intra-EC trade can be obtained through examination of the markup equations. Define the markup for firms from one EC country (r) selling into another EC country (r') in the segmented market situation as $m_{rr'}$, and in the fully integrated equilibrium as $m^{*}_{rr'}$. It follows from equations (47) and (49) of Appendix A that the markup under segmented markets is:

$$m^{*}_{rr'} = \frac{1}{\sigma_{MM}} + \left[\frac{1}{\sigma_{DM}} - \frac{1}{\sigma_{MM}}\right]\frac{\theta_{rr'}}{N_r\theta^{M}_{r'}} + \left[1 - \frac{1}{\sigma_{DM}}\right]\frac{\theta_{rr'}}{N_r} \tag{1}$$

and the markup under fully integrated markups is:

$$m_{rr'} = \frac{1}{\sigma_{DD}} + \left[\frac{1}{\sigma_{DM}} - \frac{1}{\sigma_{DD}}\right]\frac{\theta_{rr'}}{N_r\theta^{EC}_{r'}} + \left[1 - \frac{1}{\sigma_{DM}}\right]\frac{\theta_{rr'}}{N_r} \tag{2}$$

where

$$\theta^{M}_{r'} = \sum_{r \neq r'} \theta_{rr'} \qquad \theta^{EC}_{r'} = \sum_{r \in EC} \theta_{rr'}$$

and $\theta_{rr'}$ denotes the market share of region r firms in region r'.

Then the change in markup (defined as the fully integrated minus the segmented markup) simplifies to

$$m^{*}_{rr'} - m_{rr'} = \left[\frac{1}{\sigma_{DD}} - \frac{1}{\sigma_{MM}}\right] + \frac{\theta_{rr'}}{N_r}\left[\frac{1}{\theta^{EC}_{r'}}\left[\frac{1}{\sigma_{DM}} - \frac{1}{\sigma_{DD}}\right] - \frac{1}{\theta^{M}_{r'}}\left[\frac{1}{\sigma_{DM}} - \frac{1}{\sigma_{MM}}\right]\right] \tag{3}$$

When this expression is negative, markups on intra-EC trade will fall and trade will tend, *ceteris paribus*, to increase. As we have argued above, there is likely to be greater similarity and substitutability among the products of domestic producers than among the products of foreign producers, and still less between domestic and foreign, and we have chosen elasticities accordingly, i.e., $\sigma_{DM} = 5$, $\sigma_{MM} = 10$, and $\sigma_{DD} = 15$. The first term in this simplified expression is negative when $\sigma_{DD} > \sigma_{MM}$, and for our specific values equals -0.033; but there is some ambiguity with respect to the second term. Given the ranking of the elasticities of substitution, the second term will be positive the smaller is $\theta_{r'}^{EC}$ in relation to $\theta_{r'}^{M}$, i.e., the smaller the share domestic firms have of the domestic market relative to non-EC imports in the domestic market.[26] Given our specific values, the change in the markup equals

$$-0.033 + \frac{\theta_{rr'}}{N_r}\left[\frac{(.133)}{\theta_{r'}^{EC}} - \frac{(.1)}{\theta_{r'}^{M}}\right].$$

Numerically, we find that the sign of the second term is positive in most cases, but considerably smaller than the first term because it is multiplied by the ratio of a share ($\theta_{rr'}$) divided by the number of firms, where for example for Belgium's markup in Germany we have the share of Belgian exports in the German market divided by the number of Belgian firms. Thus, we find that the change in the markup is uniformly negative, where in most cases the decline in the markup is between 2 and 3.3 percent.

We discuss how we model the steady state effects of completion of the market in section 4.

3. The Static Effects of Completion of the Market

Static Welfare Effects

Table 3 displays the results of completion of the market on aggregate EC welfare. In effect, this measure of the welfare effects adopts a utilitarian social welfare function for the EC, such that we simply add up the welfare effects for individual EC countries. In Table 3 we display a matrix of results where we simulate partial and full removal of border and supply side standards costs and well as partial and complete change in the elasticities of substitution (referred to in the table as percent of integration). Although the steady state results are presented in Table 3, we defer discussion of them to section 4.

[26] Specifically, the second term will be positive if and only if $4\sum_{r\notin EC}\theta_{rr'} + \sum_{\substack{r\in EC\\ r\neq r'}}\theta_{rr'} > 3\theta_{r'r'}$.

Table 3: Welfare effects of EC92 on the EC[a]

	Percent Removal of Border and Standards Costs									
	0%		*25%*		*50%*		*75%*		*100%*	
Percent Integration	*Static (1)*	*Steady state (2)*	*Static (3)*	*Steady state (4)*	*Static (5)*	*Steady state (6)*	*Static (7)*	*Steady state (8)*	*Static (9)*	*Steady state (10)*
0%										
IRTS	0.00	0.00	0.12	0.38	0.25	0.85	0.38	1.33	0.52	1.79
CRTS	0.00	0.00	0.11	0.34	0.22	0.74	0.34	1.15	0.46	1.56
25%										
IRTS	0.11	0.30	0.24	0.72	0.37	1.14	0.51	1.57	0.66	2.03
CRTS	0.00	0.00	0.11	0.33	0.23	0.70	0.35	1.08	0.47	1.48
50%										
IRTS	0.23	0.59	0.36	0.98	0.50	1.38	0.65	1.80	0.81	2.25
CRTS	0.00	0.00	0.11	0.30	0.23	0.64	0.35	0.99	0.49	1.37
75%										
IRTS	0.36	0.83	0.50	1.20	0.65	1.59	0.81	2.00	0.98	2.44
CRTS	0.00	0.00	0.11	0.27	0.23	0.57	0.36	0.90	0.50	1.24
100%										
IRTS	0.50	1.04	0.65	1.38	0.82	1.76	0.99	2.16	1.18	2.60
CRTS	0.00	0.00	0.11	0.23	0.23	0.49	0.36	0.79	0.50	1.10

a. Welfare effects are in each case the aggregate equivalent variation as a percent of aggregate EC GDP.

Source: Model estimates.

First, consider the static welfare effects with IRTS in Table 3. These estimates imply that *removal of internal trade barriers and market integration are complementary* to each other, which is consistent with the received wisdom from previous studies. Full integration with complete removal of internal trade barriers results in an aggregate welfare gain of 1.13% of GDP per annum.

The *relative contribution of market integration and removal of trade barriers appears to be roughly additive and, as it turns out, somewhat symmetric*. That is, $x\%$ integration and $y\%$ removal of sand achieves about the same welfare increase as $y\%$ integration and $x\%$ removal of sand, provided neither x nor y are zero.

CRTS Results and Comparison with IRTS. Despite the fact that we have argued strongly that it is appropriate to model 12 of the 26 sectors (about 21 percent of value-added) as being subject to IRTS, it is helpful in understanding the results to consider the results in the counterfactual case in which all sectors are subject to CRTS. We implement this by setting the CDR equal to zero for all sectors. Given that there are no rationalization gains to be realized from improved scale efficiency in a CRTS model, we would expect that the welfare effects of EC92 would be much smaller, and indeed they are. In Table 3 the effect of assuming IRTS and monopolistically competitive pricing in our model is seen to increase the welfare gains by almost nothing (if we assume zero price integration) or by as much as 100% (if we assume full price integration).

In Table 4 we present results showing the distributional effects across countries. We find considerable disparity in the welfare effects across EC countries, even though all gain. Table 4 shows the effect on welfare in percentage and in absolute terms (equivalent variation as a percent of GDP and in billions of 1985 U.S. dollars, respectively), the percentage change in the real wage and the real price of capital, and finally the percentage change in the real cost of living. The numbers without parentheses are for the IRTS fully integrated scenario in which all border and standards costs "sand" are removed. The CRTS results are in parentheses.

Examining Table 4 for the distribution of welfare gains across the countries of the EC in the CRTS case, one sees that Belgium and the Netherlands are the countries which experience the largest increase in welfare as a percent of GDP. The key to understanding this is to recognize that we have modelled the impact of the EC92 program on standards and borders costs as costs which will be reduced on intra-EC exports only, i.e., there are no cost reductions on production for the domestic market. Border costs require resources of the domestic transportation sector in our model and supply side standards costs are a component of value-added to the extent that the good is exported. Since the single market program is assumed to reduce the border and standards costs of intra-EC exporting by 2.5 percent, the first order

Table 4: Country composition of the welfare effects of EC92[a]: 100% integration and removal of border and standards costs

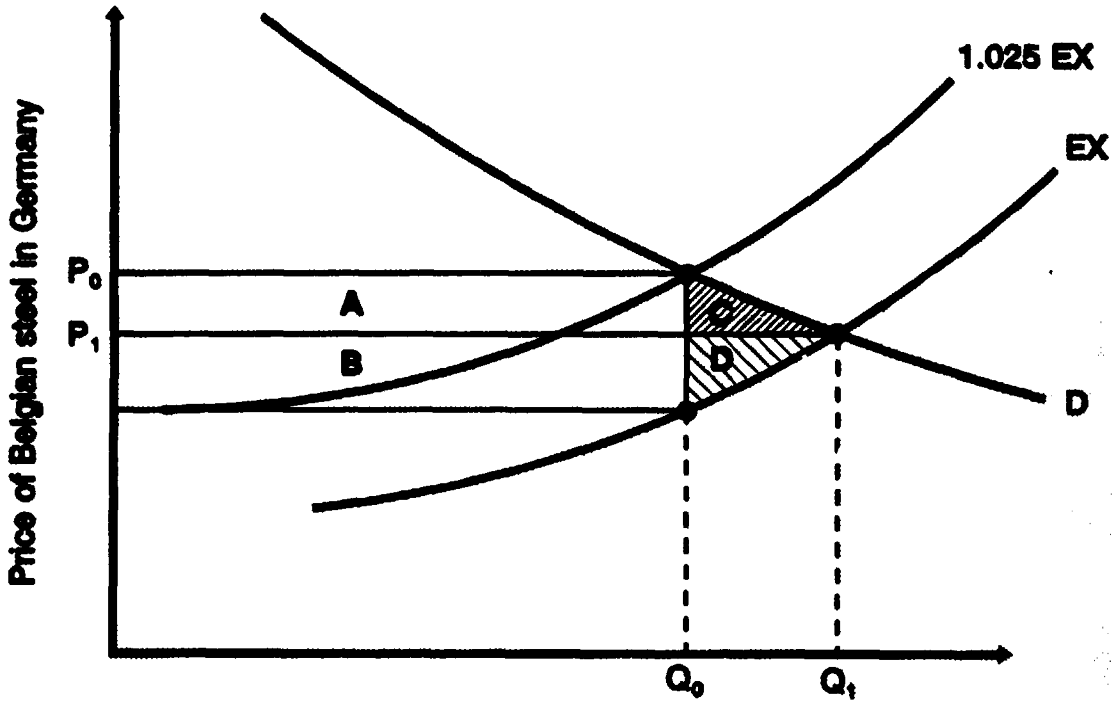
Region	Welfare[b]		Welfare in dollars[c]		Real wages		Real price[d] of capital	Real consumer prices	
							Percent change in:		
	Static	Steady state	Static	Steady state	Static	Steady state		Static	Steady state
Belgium (BE)	3.37 (1.53)	6.39	3.32 (1.51)	6.31	5.2 (2.6)	6.7	3.3 (1.3)	1.4 (0.7)	1.0
Germany (DE)	1.10 (0.44)	2.03	7.27 (2.90)	13.39	1.0 (0.4)	1.6	0.9 (0.3)	0.1 (0.1)	0.1
Denmark (DK)	1.82 (C.81)	3.78	1.21 (0.54)	2.51	2.4 (1.2)	3.0	1.7 (0.8)	0.7 (0.4)	0.4
Spain (ES)	0.80 (0.36)	1.96	2.19 (0.98)	5.36	0.8 (0.4)	1.4	1.2 (0.5)	0.4 (0.2)	0.0
France (FR)	1.13 (0.50)	2.47	7.07 (3.14)	15.44	1.1 (0.5)	1.8	1.4 (0.7)	0.3 (0.2)	0.1
Italy (IT)	1.05 (0.46)	2.03	4.62 (2.03)	8.88	1.0 (0.4)	1.5	0.8 (0.3)	0.0 0	-0.1
The Netherlands (NL)	2.48 (1.20)	7.73	3.41 (1.65)	10.63	3.0 (1.3)	4.9	4.0 (2.5)	1.2 (0.7)	1.1
Portugal (PT)	1.04 (0.42)	1.72	0.53 (0.21)	0.87	0.5 (0.3)	0.6	1.3 (0.8)	-0.2 0	-0.6
United Kingdom (UK)	0.80 (0.29)	1.49	4.31 (1.57)	7.97	0.1 (-0.2)	0.4	1.0 (0.4)	-0.3 (-0.3)	-0.3
Rest of World (ROW)	-0.00 (-0.005)	0.05	-0.35 (-0.42)	4.06	-0.00 (-0.1)	0.0	0.3 (0.1)	0 0	0.0

a. Numbers without parentheses are for IRTS in fully integrated scenario with all border and standards costs removed. Results for experiment with all sectors subject to constant returns to scale are in parentheses.
b. Equivalent variation as a percent of GDP.
c. Equivalent variation in billions of 1985 U.S. dollars.
d. Real price of capital is fixed in the steady state scenario.

effect on welfare (as a percent of GDP) will be approximately equal to the share of intra-EC trade in GDP times 2.5 percent. But there will be additional gains from removing distortion costs.

In Figure 3 we depict the welfare economics of a 2.5% reduction in the costs of intra-EC exporting under CRTS (in partial equilibrium). We take the example of Belgian exports of steel to Germany. There is a rectangle of benefits from the reduction of the costs of exporting Belgian steel to

FIGURE 3: Distribution of EC 92 Benefits under CRTS: Case of Belgian Steel in Germany



NOTE: The initial equilibrium for Belgian steel in Germany is at (P_0, Q_0), determined by the intersection of the export supply curve of Belgian steel producers to Germany (1.025 EX), and the demand by German consumers for Belgian steel (D). Following the changes of EC92, the export supply curve shifts down by 2.5 percent to EX, resulting in a new equilibrium (abstracting from general equilibrium effects) at (P_1, Q_1). There are rectangles of benefits **A** (to Germany) plus **B** (to Belgium), the sum of which is 2.5 percent of the initial exports; plus triangles of benefits from reduced distortion costs equal to **C** (to Germany) and **D** (to Belgium).

Germany, equal to 2.5% of the initial costs of exporting. Provided neither German demand for steel, nor Belgian supply of steel, are limiting elasticity cases, the initial rectangle of benefits will be shared between the exporting and importing country (*A* to German consumers and *B* to Belgian producers in the figure). In addition, the border and standards costs are analogous to distortions to trade, which when removed allow a reallocation of resources with an increase in intra-EC trade. That is, there are "triangles" of benefits that augment the benefits from the reduced costs of exporting. In Figure 3 triangle *C* is a benefit to German consumers and triangle *D* is a gain to Belgian exporters. These reallocation benefits will be increased or decreased to the extent that the country is responsive to changes in relative prices of imports and exports. Figure 3 also reveals an important feature which impacts on the sharing of the benefits of EC92 across the EC countries. The more elastic is a country's demand or supply curves in relation to the other countries of the EC, the smaller will be its share of the benefits of EC92.

In Table 2 we list the intra-EC trade intensities of the EC countries in our model. The three countries that trade most intensely within the EC are Belgium, Netherlands and Denmark, and these are the three countries that gain the most from the EC92 program in the CRTS case. For the remaining countries there is little difference in their intra-EC trade intensities (ranging from 12% to 8.8%), and there is also not a large difference in their welfare gain as a percent of GDP (ranging from 0.5% to 0.29%).

The benefits for all countries under CRTS exceed the first order effect of the lowering of the cost of production. In particular, 2.5% times the trade intensity ratio yields the following first order welfare effect in percent of GDP: Belgium 0.89, Netherlands 0.37, Denmark 0.37, Germany 0.30, Portugal 0.30, U.K. 0.30, France 0.28, Italy 0.25, and Spain 0.22. Other than for the U.K. and Denmark, the welfare benefits are between 1.4 and 2.2 times this "first order" effect, suggesting that the triangles in Figure 3 are quite large.[27] By the standards of CRTS models, we have assumed rather large trade elasticities in our benchmark equilibrium, so the triangles in figure 3 are almost as large as the rectangles.[28] Examining Figure 3 reveals that the benefits would be closer to the rectangles the more inelastic are the demand elasticities.[29] When we counterfactually reduce all three import demand elasticities for all countries in our model to one-fourth of their original values, the benefits for most EC countries are reduced to between 1.17 and 1.28 of the rectangle effect.[30]

Thus, the intensiveness with which a country engages in trade is of first order importance in explaining the benefits that are likely to be achieved from CRTS sectors. More aggregated models have aggregated small countries such as Belgium with larger countries. In so doing they have produced a region which is closer to average with respect to trade intensities, which will mask important distributional effects across the EC countries.

In column 9 of Table 3 the CRTS welfare gain to the aggregate EC from complete removal of border and standards costs barriers to intra-EC trade varies from 0.46% to 0.5% with CRTS, depending on the degree of market integration. Market integration, which in our model is greater substitutability among EC products, has only a very small effect on welfare in a CRTS model (by inducing slightly more resource movement) because it does not affect markups or entry and exit.

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[27] For the U.K. the benefits are close to the first order effect; this indicates that the U.K. is obtaining a relatively small share of the benefits of integration. As discussed above, this suggests that U.K. import demand or export supply is more elastic than that of the other EC countries.

[28] Similar to the approach of Gasiorek, Smith and Venables [1992], we choose to calibrate with elasticities to be consistent with price-cost margins given by estimates of the CDR subject to a zero profit model assumption. Nonetheless, the trade elasticities are small in relation to those used in their models.

[29] We show below, however, that the higher elasticities reduce the additional welfare gain from rationalization and consumption efficiency gains in IRTS sectors. Thus, the high elasticities have offsetting effects regarding their welfare impact.

[30] Exceptions are Denmark, which remains an outlier, obtaining benefits equal to 1.78 times the rectangle effect, and Germany and the U.K. which obtain less than the rectangle effect. Note also that the large demand elasticities that we have employed, however, result in somewhat higher estimates of the welfare effects and of the adjustment across industries in both the CRTS and IRTS cases.

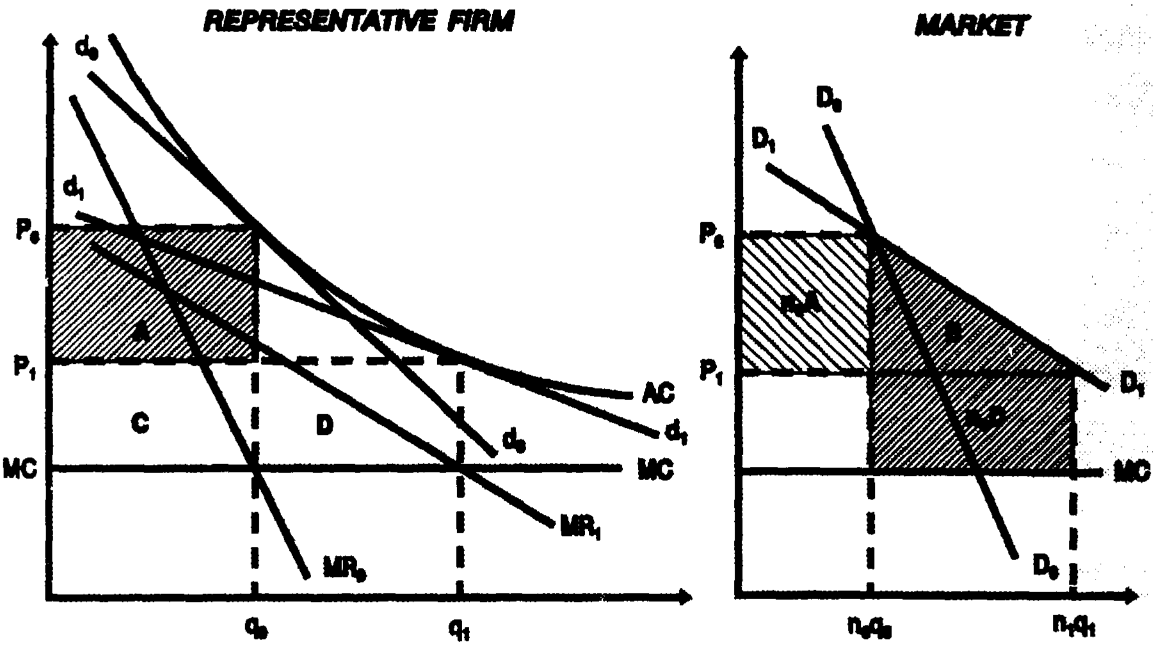
The Impact of IRTS. Examination of Tables 3 and 4 reveals that the welfare benefits of the complete removal of border and standards costs roughly double. both for the aggregate EC as well as for individual EC regions, when the impact of IRTS with full market integration is incorporated. The key to explaining the impact of IRTS is the role of market integration on elasticities, markups and entry and exit. To clarify this point first compare the CRTS and IRTS results with 0% integration (row 1 of Table 3). Then the static effects of removing border or standards costs are virtually identical between IRTS and CRTS. That is, without additional effects from market integration, the beneficial effects of removing border and standards costs can be attributed to "traditional" efficiency gains found in a standard CRTS framework.

The key to understanding the impact of IRTS in our model is that integration increases the elasticity of demand on intra-EC exports, thereby inducing markup declines. The equation for the markup was discussed earlier. A decline in the equilibrium markup can only be achieved through an improvement in the realization of scale efficiency.

Despite the fact that we employ equivalent variation in general equilibrium, to isolate the crucial variables in IRTS sectors, in Figure 4 we present a partial equilibrium, consumers surplus interpretation of a symmetric monopolistically competitive industry with a given level of fixed costs per firm and constant marginal costs (MC). An additional simplification in Figure 4 is that it presumes a homogeneous output, so the elasticity increase is represented simply as a rotation of the market demand curve.[31] Originally there are n_o firms charging price P_o and producing q_o. We assume zero profits, so rectangles $A+C$ equal fixed costs per firm. As a result of an increase in the market elasticity of demand, the perceived marginal revenue of the firm will equal marginal costs at a larger output level. In the absence of general equilibrium effects which change factor costs, the marginal and average cost curves for the

[31] The analysis of Figure 4 extends naturally to our firm level product differentiation case by defining the market output as the CES aggregate of the output of the individual firms, and the market price as the price dual to the CES quantity aggregate.

FIGURE 4: Rationalization and Consumption Efficiency Gains from Increased Elasticities



NOTE: Increased market demand elasticity induces representative firms to lower price and some to exit industry in the new zero profit equilibrium. The welfare gain equals the area under the market demand curve above MC, i.e., the consumption efficiency gain B plus the rationalization gain n_0D, where $n_0D = n_0A$.

representative firm remain unchanged. Then, due to the zero profit constraint, exit must occur such that the new perceived demand curve of the representative firm, d_1, is tangent to the average cost curve at the new lower markup. It follows that $P_1 < P_0$ and industry output increases.

Welfare effects are shown in the panel of Figure 4 labelled Market, where D_0 and D_1 are the initial and new market demand curves. Since price exceeds marginal costs in the initial equilibrium, the expansion of output increases welfare; but the welfare gain is decomposed into two parts. First there is the typical consumption efficiency triangle B (as would occur for example with removal of a tax).[32] Unlike a tax, however, there is an additional gain of consumers' surplus equal to the rectangle n_0A that has no offsetting cost or lost tax revenue. The additional consumers' surplus gain derives from the rationalization gain of spreading fixed costs. That is, the expansion of output costs society resources at the rate of MC per unit but is valued as the area under the demand curve.[33] These consumption efficiency and rationalization gains from increased elasticities in IRTS sectors are gains from the single market program over and above the gains from the reduction of the costs of exporting that were characterized in Figure 3.[34]

A similar interpretation will apply even when general equilibrium effects are incorporated that will induce shifts in the market demand curves. For IRTS industries that experience output decline or only small output increase, exit occurs. For those that experience output increases, entry can occur with a markup decline only with a significant output expansion. All of these scenarios result in rationalization

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[32] Following the procedure of Burns [1973], the efficiency triangle is obtained by connecting the pre and post equilibria by a straight line.

[33] Since fixed costs per firm are unchanged $A+C = C+D$, i.e., $A=D$ and $n_0A = n_0D$. Then the welfare increase equals the area under the demand curve between n_0q_0 and n_1q_1 that lies above industry marginal costs.

[34] The greater the absolute value of the decline in the markup, the larger will be the welfare benefits from rationalization and consumption efficiency. A proportional reduction in the elasticities of substitution in the model, however, will increase the absolute value of the decline in the markup. That is, given benchmark elasticities, $\sigma_{DD} = 15$, $\sigma_{MM} = 10$, the dominant first term in equation 3 is (1/15)-(1/10) = -1/30. If the elasticities of substitution were scaled down, for example by 1/5, then the first term in equation 3 would equal (1/3)-(1/2) = -5/30. This would result in a larger drop in the new equilibrium price in Figure 4 and greater welfare gains.

in the use of fixed costs and, since price-marginal costs markups decline, a decrease in consumption deadweight loss. These are benefits above what would occur in a CRTS sector.

In Table 5 we present some of the key data for the IRTS sectors in three representative countries: Belgium, France and Spain. We focus on these countries because: Belgium is the country that gains the most from the EC92 program; France is a representative large country; and Spain is a country with relatively small trade shares in Germany. The table presents results for the scenario of 100 percent integration and 100 percent removal of border and standards costs.

In the first three columns we present the percent decline in the "Lerner" markup ([price-marginal costs]/price). The equation for the change in the Lerner markup is presented in equation 3. Note that for the industries in all three countries, their markups on their export sales in Germany change between -1.0 and -3.3 percent. For some products there are no exports to Germany in the benchmark data, hence the markup equation is not applicable. Since the Spanish share of the German market is small, when the markup equation applies, the decline in the markup is close to -3.3 percent, which is the value of the first term in the change in the markup equation.

In columns 4-6 we present the percent change in entry and exit, and in columns 7-9 we present the percent change in output per firm. The key differences appear in the output per firm columns. We see that rationalization is much greater in Belgium than in the other two countries. Again the reason is that the intra-EC trade intensity of Belgium is much greater than the other two countries in the table. Since export sales constitute a much larger percentage of output for Belgium, the same percentage decline in markup on exports to the various EC markets induces a much larger reallocation of resources in Belgium's IRTS sectors.

Columns 10-12 show the percent change in output in the IRTS sectors, and the numbers in parentheses show the percent change in production when these sectors are presumed to operate under CRTS. One can see that different IRTS scenarios expand and contract in the different countries (a full

Table 5: Changes in IRTS sectors in Belgium, France and Spain: 100% integration and removal of border and standards costs

	Percentage change in:											
	Mark up in Germany			*Number of firms*			*Output per firm*			*Production*[a]		
	BE (1)	*FR (2)*	*SP (3)*	*BE (4)*	*FR (5)*	*SP (6)*	*BE (7)*	*FR (8)*	*SP (9)*	*BE (10)*	*FR (11)*	*SP (12)*
Food	-3.3	-3.2	-3.3	-19.6	-7.7	-1.0	30	11	6	4.7 (-5.2)	2.9 (1.8)	5.1 (1.6)
Steel	-1.6	-2.9	-3.3	4.5	0	-6.2	54	12	4	60.9 (32.1)	12.3 (6.0)	-2.7 (-7.3)
Nonmetallic minerals	NA[b]	NA	NA	-33.1	-11.0	2.4	17	5	9	-21.6 (-11.3)	-6.6 (-1.1)	11.1 (0.5)
Chemicals	-2.8	-3.1	NA	-4.1	-4.6	-8.6	28	7	-1	22.8 (4.3)	1.8 (1.0)	-9.8 (-4.5)
Metal products	NA	-3.3	-3.2	-27.2	1.4	1.4	5	3	5	-23.9 (-11.8)	4.9 (1.7)	6.9 (-1.5)
Industrial machinery	-2.8	-3.1	-3.3	-10.9	-5.3	-11.2	33	-1	0	18.5 (11.3)	-5.9 (-4.4)	-11.1 (-12.4)
Office machinery	NA	-2.6	-3.1	-29.6	-8.8	-0.1	13	15	1	-20.7 (-12.1)	5.3 (2.6)	0.6 (0.0)
Electrical goods	-1.0	-3.2	-3.3	-22.9	-8.3	-12.5	44	1	2	11.1 (9.7)	-7.4 (-3.0)	-10.7 (-0.4)
Motor vehicles	-3.1	-3.2	-3.3	49.5	-16.3	-12.1	60	27	20	139.4 (45.5)	6.7 (2.7)	5.4 (-6.1)
Other transport equipment	NA	-3.0	NA	-29.1	-6.7	-12.6	20	12	8	-14.8 (-12.3)	4.8 (0.4)	-5.3 (0.0)
Paper	-3.3	-3.3	-3.3	-17.0	-11.2	-7.8	51	8	11	25.2 (-0.5)	-4.5 (-2.0)	2.8 (3.8)
Rubber and plastics	NA	-3.3	-3.3	-10.2	-2.7	-2.8	46	0	0	30.8 (25.0)	-2.8 (-2.7)	-2.3 (-8.7)

a. Value in parentheses is percent change in production under CRTS.
b. NA = Not applicable since there are no exports to Germany from this country of this product in the benchmark.

presentation of the output changes by industry and region are presented in the Appendix). The interesting pattern is that the sign of the output change in the IRTS scenario is generally the same as the sign of the output change in the CRTS scenario. The magnitude of the change in absolute value, however, is generally larger with IRTS. Thus, traditional determinants of resource allocation, factor intensities and remaining tax wedges, play a key role in influencing industrial structure. Shifts in relative costs that occur in a CRTS world provide an impetus for output decline or expansion. If relative costs decline and output expands due to a change in factor intensities, in an IRTS world the output expansion induces a further decline in average costs and price, which magnifies the output increase.

Returning to Table 4, note that despite the fact that markups decline, and real incomes[35] increase, with integration, real prices also increase. For a sharp example, in Belgium real incomes increase while real prices also increase by 1.4% despite some significant declines in specific IRTS sectors.[36] The key is that the relative price of labor increases by 5.2%, and the relative price of capital by 3.3%, so factor earnings increase at a faster pace than commodity prices.[37] Factor earnings increase so much in Belgium because resources are being allocated more efficiently, hence the value of the marginal product of each factor is greater than with the previous allocation of resources. In addition to the benefits that occur under CRTS as discussed above, there are significant gains from rationalization and markup declines. All of these gains are dependent on the intra-EC trade intensity of the country.

Intra-EC Trade. In the Appendix we present the percentage change in exports and imports to EC countries and non-EC countries, respectively. We have argued that a counterintuitive feature of modelling EC integration as uniform pricing is that intra-EC trade declines as a consequence. With our approach to integration, however, there is a strong increase in trade among the EC countries, and a modest decline in trade between EC countries and the rest of the world. We also note, without showing in a table, that

[35] Our numeraire is a basket of final consumption in the Rest of the World.

[36] For example, the following IRTS sectors experience price declines: Food by 3.3%, Iron & Steel by 4.7%, Chemicals by 3.2%, Industrial and Office Machinery by about 4.5%, and Vehicles by 5.5%. Most CRTS sectors in Belgium experience an increase in relative prices (e.g., Beverages & Tobacco by 2.4%, Utilities by 2.6%, and virtually all service sectors by about 3%). In the CRTS version of the model the Belgian increase in the price level is only about 0.7%. The structural pattern of price increases and decreases is approximately the same as in the IRTS version, even though no sector has IRTS in this case.

[37] The same qualitative effect occurs in the CRTS model, with the relative price of labor increasing by 2.6% and the relative price of capital by 1.3%.

domestic sales of EC firms typically decline. Although domestic markups increase for EC firms, the largest declines in domestic sales are not explained by differences in markup changes; rather the largest declines in domestic sales occur in those countries that have the highest intra-EC trade intensities.

Thus, overall we have a picture of EC countries trading much more with each other, relying less on their domestic markets for sales, and, since their economies become more trade intensive, there is only a slight decline in trade with countries outside of the EC.

Regarding the decline in EC trade with the rest of the world, we have modelled EC92 as a shift in relative costs for EC countries toward trading with EC countries rather than non-EC countries. That is, the 2.5% cost decrease on exports to EC countries accrues only to firms in EC countries. It is possible that some, if not all, of the border and standards costs reductions that accrue to EC firms will also benefit non-EC firms.[38] To the extent that this occurs then there would be an increase in non-EC exports and imports to and from the EC for ROW relative to what we have reported. This would also allow a welfare increase for the rest of the world in the static model since then a picture similar to figure 3 would also apply to the rest of the world exports to EC countries.

Comparing the Static Effects

All four of the previous studies summarized in Table 6 followed Smith and Venables [1988] by first simulating a 2.5% reduction in border and standards costs, and then by simulating the same reduction in costs along with uniform pricing across EC markets (what they call "market integration"). The different results are partly explained by the different structural features of their models. We emphasize that there were good reasons for these features and aggregation schemes to be chosen for the purposes of the original studies; we caution, however, that this can affect the economics of the analysis

[38] For example, a Moroccan truck delivering vegetables to Belgium should have reduced border costs as it passes between Spain and France and between France and Belgium.

Table 6: Key modelling assumptions and results of GE studies

	Harrison, Rutherford & Tarr (present study)	*Gasiorek, Smith & Venables (1992)*	*Haaland & Norman (1992)*	*Mercenier (1992)*
	Modelling assumptions			
Percent of economy subject to IRTS[a]	21	34	23	6
Weighted average CDR[b]	1.6% (8%)	2.4% (7%)	1.9% (8%)	1.1% (19%)
Number of EC (non-EC regions)	9 (3)	7 (1)	1 (4)[c]	5 (1)
Number of IRTS (CRTS) sectors	12 (14)	14 (1)	11 (2)	5 (4)
	Welfare effects, static model			
Remove border & standard costs ("sand in the gears")[d]	0.52	0.44	0.25[e]	n.a.
Market integration	1.18	1.35	0.48[e]	0.87[f]

a. We calculate sector shares based on value-added estimates for EUR12 from Emerson et al. [1988; table C2, pp. 271-275].
b. Weighted average CDRs are CDR values weighted by the share of total value-added of the sector. Weighted average CDR values in parentheses are CDR values weighted by the sector's share of value-added within IRTS sectors.
c. Haaland and Norman [1992] decompose each of the EC and EFTA into 6 identical regions.
d. EC-wide welfare effects are a GDP-weighted average of the individual country welfare effects. A reduction of real trade costs of 2.5% is simulated.
e. Haaland and Norman [1992; Table 3.4] report welfare gains as a percent of expenditures on tradeable goods, which are 25% of their total expenditures. We scale their estimates (by 1/4) to place them on a comparable basis.
f. Mercenier's [1992] Cournot competition, free entry and international factor mobility case (Table 6d).

Source: Authors' calculations.

dramatically.

All of the models in Table 6 included at least one sector with IRTS. Although for different reasons in our model versus the others, in general the single market program results in a rationalization of resources in the IRTS sectors across the EC, which increases welfare due to the greater realization of scale efficiency. Then the larger the share of the IRTS sectors and the greater the extent of unrealized scale economies in those sectors, the larger the benefits.

The first row of Table 6 shows the combined share of value-added of the IRTS sectors in the respective models. *Ceteris paribus*, we would therefore expect GSV to find the largest gains from the single market program. The extent of unrealized scale economies in the IRTS sectors is measured here by the CDR applied in the initial equilibrium. As shown in row 2 of Table 6, Mercenier [1992] assumed higher values for the CDR in his IRTS sectors than the others, and thus there were considerable gains from scale to be realized in his IRTS sectors.[39] Thus, despite the fact that the Mercenier [1992] model has a smaller share of the economy subject to IRTS than the Haaland and Norman [1992] model, it generates larger welfare estimates.

In aggregate, our static results would appear to be most closely comparable to those of GSV. However, closer examination will show that the way in which EC92 has it's effects on the economy is quite different. In addition to the fundamentally different way in which integration in IRTS sectors is approached, which we have emphasized above, our aggregation schemes are quite different.

First consider the regional aggregation questions. Table 6 shows that GSV offer the most regionally disaggregated model within the EC. GSV correctly note that the choice of regional aggregation can be relevant to estimates of welfare effects. They emphasize that since it is the elimination of barriers *between regions* within the EC that one gets the benefits of the single market program, the fewer the number of EC regions identified in the model structure, the smaller is the opportunity for sand in the gears to be present and to play a role in the simulations. We have shown above, however, that the role of trade intensities is crucial in explaining the different impacts across countries. The relatively homogeneous distribution of benefits found in GSV is a natural consequence of a regional aggregation scheme that aggregates over regions with diverse trade intensities.

Haaland and Norman [1992] refer to their model as the "twin" to GSV, with greater disaggregation of the non-EC regions, but they treat the EC and EFTA as six identical regions. Obviously

[39] The weighted average CDRs are calculated two ways. In the first, the sector weight is its share of value-added in the total economy; in the second, the sector weight is its share of value-added within the sectors with IRTS.

their approach will not allow an analysis of the distribution of benefits within the EC.

We now turn to sectoral aggregation questions. The reason that previous studies choose their aggregation schemes is that lumping together two IRTS sectors with different CDRs (or an IRTS sector and a CRTS sector) will result in a weighted average CDR for the aggregate sector between the CDRs of the separate sectors, the exact value depending on the relative size of the aggregated sectors. Examination of the database on CDR estimates assembled in Appendix B, employing the original 44-sector *Eurostat* classification, reveals considerable variance in the CDR estimates across sectors. Given that returns to scale are presumed to be the driving force behind the larger welfare gains of EC92, previous studies have chosen correctly to keep as many IRTS sectors separate as computational considerations permitted, and to lump the remaining sectors into one residual CRTS sector. This way the resulting model reflects well the "returns to scale relief" of the original 44-sector database.

Theoretically, however, it is possible that one can cause similar biases by excessive aggregation of the CRTS sectors. For example, these biases may originate from the differences in factor intensities that are being "lost" as one aggregates. Assume for the sake of argument that IRTS sectors expand due to EC92 and that they are relatively capital-intensive. The ability of these IRTS sectors to expand will depend on the factor intensities of other sectors, since they are the ones that will have to release resources to allow the IRTS sectors to expand. Aggregation over two CRTS sectors, one of which is capital intensive and the other of which is labor intensive, will result in an aggregated sector which is a weighted average of the two regarding factor intensities. Since different regions will specialize in different sectors, the results at the regional level could be very different.[40] These welfare effects will also depend on whether or not the CRTS sectors are the beneficiaries of reduced trade barriers. Whether or not sectoral

[40] A similar point applies with respect to aggregations over sectors with disparate trade policies when one is studying the effects of movements towards uniform policies; the greater is the model aggregation, the less welfare benefits would such uniformity policies be expected to generate, as emphasized in Harrison, Rutherford and Tarr [1993; p. 195] in the context of a single-open economy model.

aggregation of CRTS sectors makes much of a difference to the estimated impact of EC92, however, is an open issue.

To investigate this we have aggregated all 14 of our CRTS sectors into a single large sector, and consider a version of our model with 12 IRTS sectors and one CRTS sector. At the aggregate EC level, the welfare improvement is equal to 1.17% of GDP in the case of 100 percent removal of border and standards costs and 100 percent integration. This amounts to little difference compared to analogous 26 sector experiment where 1.18 percent welfare increase was obtained. For individual countries, however, there are significant differences with the following welfare increases (as a percent of GDP) by country in the 13 sector model: BE 2.93, DE 1.13, DK 1.29, ES 0.44, FR 1.11, IT 1.33, NL 2.88, PT 0.52, and UK 0.81. For the Netherlands, this constitutes an increase of 0.8% of GDP compared with the analogous scenario in which the CRTS sectors are disaggregated, placing it almost equal to Belgium as the country with the largest percentage gain in welfare. The gain for Portugal is reduced by a significant 0.5%. We conclude that at the level of specific regions there are significantly different results introduced by the aggregation bias.

4. The Steady-State Effects of Completion of the Market

Modelling the Steady State Welfare Effects

It is apparent that the political rhetoric surrounding major policy initiatives such as the EC92 program, as well as other regional trade liberalizations in process, revolves around the steady state effects rather than the static effects. This rhetoric has fed on arguments and calculations based on static effects, but has not been checked by the extension of those arguments and calculations to properly quantify the possible extent of steady state effects. We propose doing so for EC92 with a simple extension of our model. The present goal is not to describe the path of the EC after EC92, nor even to quantify the net long-run welfare effects of that path taking into account the costs of transition to a higher steady state growth rate. Rather, we attempt to show how one can extend a relatively rich, detailed static model to address the *upper bound* welfare effects of EC92 in the long run.[41]

Our steady state calculations build on our static calculations in a simple way. In the static calculation we allow the price of capital to vary within each country, while holding constant the aggregate stock of capital in each country. The steady state calculation essentially reverses this: we allow the capital stock in each country to be endogenously determined while holding constant the price of capital in each country. This approach is in the spirit of the equilibrium concept proposed by Hansen and Koopmans [1972] and Dantzig and Manne [1974] for multisectoral planning models: solve for a time-invariant capital stock. An invariant capital stock equilibrium is a set of prices, production and investment levels for which the economy is able to grow at a steady rate with constant relative prices. In our model the optimal capital stock is defined as the stock such that the cost of investment, including depreciation and interest, is exactly equal to the capital rental rate. This can be viewed as a multisectoral version of the "golden rule" equilibrium from older growth theories.

The most important difference between our steady state calculation and the Hansen and Koopmans [1972] approach is that we do not explicitly measure the commodity-composition of investment. Hence there is some uncertainty regarding the determination of the steady-state capital price. We simply assume that the price of capital, within each region, is identical to the price of a basket of consumption goods. When we further assume that the benchmark capital stock is optimal, then the steady-state calculation reduces to fixing the capital price and permitting the capital stock to find an endogenous level.

We emphasize that this calculation measures an *upper bound* on potential welfare gains in the long run. In the public finance literature there are many examples in which steady state gains are large but in the corresponding intertemporal model the gains are virtually offset by adjustment costs. After all, the

[41] We would also argue that such a calculation, while being of interest in its own right, is also an important (numerical) input into any calculation of the longer run growth *path* that took account of transitional dynamics.

capital stock can only be produced through investment, and that requires reduced consumption along the transition path. For sufficiently high discount rates, the cost of the foregone consumption could easily outweigh the longer-run benefits of the capital accumulation it allows.

We believe that our approach is defensible because it provides a meaningful upper bound on the potential gains from classical (Solow-type) growth effects. Of course, the values calculated in this way could fail to capture growth effects arising from induced improvements in productivity or innovation (so called "learning by doing").

Steady-State Welfare Effects

Table 3 shows the baseline steady-state welfare effects of the EC92 program. The gains are slightly more than double those from the comparable static model. Completion of the program results in an aggregate steady-state welfare gain of 2.38% of GDP for the EC. The distribution of these welfare gains, and related economic effects, is shown in Table 4.

Explaining the Steady State Effects

In large measure the steady state effects are a reflection of the static effects. Examination of detailed production, trade, and pricing patterns reveals the same story as described earlier. The exception, of course, is that the capital stock is free to grow or contract to that level that keeps the price of capital at its benchmark value. Since we generated an increase in the relative price of capital in all regions in our static model, this implies that there must be an expansion of the capital stock in each region in the steady state. This expansion of the capital stock then works through in the model like an "endowment effect", generating larger welfare gains since there are more resources to be employed.

5. Conclusion

We model the static and steady state effects of completion of the internal market in the European Community on trade, production and market structure. The impetus for change comes from the removal of border costs and standard costs, as well as an increase in the perceived similarity of national products due to increased acceptance of common technical standards. Removing the border and standards costs of intra-Community trade results in relatively small welfare gains. The additional effect of standardization of consumer perceptions on market structure more than doubles the estimated benefits; and the steady state growth effect more than quadruples the welfare gains, explaining some of the anticipatory euphoria surrounding the completion program even before it is fully enacted.

References

Akerlof, G., "The Market for 'Lemons:' Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, 84, 1970, 489-500.

Baldwin, Richard, "The growth effects of 1992", *Economic Policy*, October 1989, 248-270.

Baldwin, Richard E., "Measurable Dynamic Gains From Trade", *Journal of Political Economy*, 100(1), February 1992, 162-174.

Besen, Stanley and Garth Saloner, "The Economics of Telecommunications Standards," in R. Crandall and K. Flamm (eds.), *Changing the Rules: Technological Change, International Competition and Regulation in Communications* (Washington, D.C.: The Brookings Institution, 1987).

Borenstein, Severin, "Price Discrimination in Free-Entry Markets," *Rand Journal of Economics*, 16, Autumn 1985, 380-397.

Borenstein, Severin and Rose, N.L., "Competition and Price Dispersion in the U.S. Airline Industry," *Working Paper #3785*, National Bureau of Economic Research, July 1991.

Brander, James A., and Krugman, Paul R., "A Reciprocal Dumping Model of International Trade," *Journal of International Economics*, 15, 1983, 313-321.

Brooke, Anthony; Kendrick, David, and Meeraus, Alexander, *GAMS: A User's Guide* (Redwood City, CA: The Scientific Press, 1988).

Burns, Michael, "A Note on the Concept and Measure of Consumers' Surplus", *American Economic Review*, 63(3), 1973, 335-344.

Carlton, Dennis and Perlof, Jeffrey, *Modern Industrial Organization* (New York: Harper Collins, 1990).

Cawley, Richard, and Davenport, Michael, "Partial Equilibrium Calculations of the Impact of Internal Market Barriers in the European Community", *Economic Paper No. 73*, European Commission, Brussels, 1988.

Cecchini, Paolo; Catinat, Michel; and Jacquemin, Alexis, *The European Challenge: 1992* (Aldershot, UK: Wildwood House, 1988).

Chipman, John, "Homothetic Preferences ıd Aggregation", *Journal of Economic Theory*, 8, 1974, 26-38.

Dantzig, George, and Manne, Alan S., "A Complementarity Algorithm for an Optimal Capital Path with Invariant Proportions", *Journal of Economic Theory*, 9, 1974, 312-323.

Eisenberg, E., "Aggregation of Utility Functions", *Management Science*, 7, 1961, 337-350.

Emerson, Michael; Aujean, Michel; Catinat, Michel; Goybet, Philippe; and Jacquemin, Alexis, *The Economics of 1992: The E.C. Commission's Assessment of the Economic Affects of Completing the Internal Market* (Oxford: Oxford University Press, 1988).

European Community, *Towards a Dynamic European Economy: Green Paper on the Development of the Common Market for Telecommunications Equipment* (Brussels: EC Commission, 1987).

Fisher, Franklin; McGowan, John; and Greenwood, Joel, *Folded, Spindled and Mutilated: Economic Analysis and U.S. v. IBM* (Cambridge, MA: MIT Press, 1983).

Gasiorek, Michael; Smith, Alasdair; and Venables, Anthony J., "1992: Trade and Welfare; A General Equilibrium Model", in Winters, L.A. (ed.), *Trade Flows and Trade Policy After '1992'* (New York: Cambridge University Press, 1992).

Haaland, Jan I, and Wooton, Ian, "Market Integration, Competition and Welfare", in Winters, L.A. (ed.), *Trade Flows and Trade Policy After '1992'* (New York: Cambridge University Press, 1992).

Hansen, Terje, and Koopmans, Tjalling, "On the Definition and Computation of a Capital Stock Invariant Under Optimization", *Journal of Economic Theory*, 5, 1972, 487-523.

Harrison, Glenn W.; Jones, Richard; Kimbell, Larry J., and Wigle, Randall, "How Robust Is Applied General Equilibrium Modelling?", *Journal of Policy Modelling*, 14, 1992.

Harrison, Glenn W.; Rutherford, Thomas F., and Tarr, David G., "Trade Reform in the Partially Liberalized Economy of Turkey", *The World Bank Economic Review*, 7(2), may 1993, 191-217.

Harrison, Glenn W.; Rutherford, Thomas F., and Wooton, Ian, "An Empirical Database for a General Equilibrium Model of the European Communities", *Empirical Economics*, 16, 1991, 95-120.

Hemenway, David, *Industrywide Voluntary Product Standards* (Cambridge, MA.: Ballinger, 1975).

Holmes, T.J., "The Effects of Third Degree Price Discrimination in Oligopoly," *American Economic Review*, 79, March 1989, 244-250.

Katz, Michael, "Price Discrimination and Monopolistic Competition," *Econometrica*, 52, November 1984, 1453-1471.

Kaysen, Carl, *United States versus United States Shoe Machinery Corporation* (Cambridge, UK: Cambridge University Press, 1956).

Karp, Larry, "Discussion of Gasiorek, Smith and Venables," in Winters, L.A. (ed.), *Trade Flows and Trade Policy After '1992'* (New York: Cambridge University Press, 1992).

Krugman, Paul, "Endogenous Innovations, International Trade and Growth," *Unpublished Manuscript*, 1988.

Malueg, David, and Schwartz, Marius, "Parallel Imports, Demand Dispersion and International Price Discrimination", *Journal of International Economics*, forthcoming.

Melo, Jaime de, and Tarr, David, *General Equilibrium Analysis of U.S. Foreign Trade Policy* (Cambridge, MA: MIT Press, 1992).

Mercenier, Jean, "Completing the European Internal Market: A General Equilibrium Evaluation Under Alternative Market Structure Assumptions", *Working Paper 0892*, Department of Economics, University of Montreal, March 1992.

Nerb, G., "The Completion of the European Market: A Survey of European Industry's Perception of the Likely Effects," *The Costs of Non-Europe* (Luxembourg: Office for Official Publications of the European Communities, 1988, Volume 3).

Norman, Victor, "EFTA and the Internal European Market", *Economic Policy*, October 1989, 423-465.

Pashigian, Peter and Bowen, Brian, "Why Products are Sold on Sale?: Explanations of Pricing Regularities," *Quarterly Journal of Economics*, 106, November 1991, 1015-1038.

Perroni, Carlo, and Rutherford, Thomas F., "Regular Flexibility of Nested CES Functions", *European Economic Review*, forthcoming.

Rutherford, Thomas F., "Extensions of GAMS for Complementarity and Variational Problems Arising in Applied Economics", *Economics Working Paper 92-9*, Department of Economics, University of Colorado at Boulder, 1992a.

Rutherford, Thomas F., "Sequential Joint Maximization", *Economics Working Paper 92-8*, Department of Economics, University of Colorado at Boulder, 1992b.

Scherer, F.M., and Ross, David, *Industrial Market Structure and Economic Performance* (Boston: Houghton Mifflin, 1990).

Shepard, Andrea, "Price Discrimination in Retail Configuration," *Journal of Political Economy*, 99, February 1991, 30-53.

Smith, Alasdair, and Venables, Anthony J., "Completing the Internal Market in the European Community: Some Industry Simulations", *European Economic Review*, 32, 1988, 1501-1525.

Solow, Robert M., "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, 70, February 1956, 65-94.

Tarr, David, "A Permanent Income Approach to the Growth of Income by Sectors in a Leontief Economy," *Quarterly Journal of Economics*, February 1975, 89, 145-150.

Tarr, David, "On Distributed Lags, Morishima Matrices, and the Stability of Economic Models," *Econometrica*, May 1976, 44, 597-600.

Tarr, David, "The Steel Crisis in the United States and the European Community: Causes and Adjustments," in R. Baldwin, C. Hamilton and A. Sapir (eds.), *Issues in U.S.-EC Trade Relations* (Chicago: University of Chicago Press for the NBER, 1988).

Tarr, David, "Comments on Trade Policy Under Imperfect Competition," in A. Smith and P. Krugman (eds.), *Strategic Trade Policy* (Chicago: University of Chicago Press, forthcoming).

Varian, Hal R., "Price Discrimination," in R. Schmalansee and R. Willig (eds.), *Handbook of Industrial Organization* (Amsterdam: North Holland, 1989).

Winters, L. Alan, "The Welfare and Policy Implications of the International Trade Consequences of '1992'", *American Economic Review (Papers & Proceedings)*, 82, May 1992, 104-108.

Winters, L. Alan (ed.), *Trade Flows and Trade Policy After '1992'* (New York: Cambridge University Press, 1992).

Wolinsky, Asher, "Brand Names and Price Discrimination," *Journal of Industrial Economics*, 35, March 1987, 255-268.

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Table A1 Effects of EC92 on output: IRTS compared with CRTS[a]
(percentage change)

Sector	*BE*	*DE*	*DK*	*ES*	*FR*	*IT*	*NL*	*PT*	*UK*	*ROW*
AGR	2.2 (-2.0)	-5.0 (-3.0)	18.2 (7.2)	2.3 (0.7)	3.3 (2.6)	-4.3 (-2.6)	11.9 (2.5)	2.1 (1.1)	0.1 (-0.4)	0.50 (0.2)
FOO	4.7 (-5.2)	-7.2 (-2.5)	27.8 (8.9)	5.1 (2.0)	2.9 (1.8)	-6.2 (-2.4)	32.7 (10.9)	4.4 (1.6)	-2.1 (-1.5)	0.0 (0.0)
BET	-6.6 (-1.0)	1.8 (1.4)	1.3 (0.8)	-0.5 (-0.7)	3.6 (3.6)	-2.8 (-3.7)	-6.2 (-3.5)	10.5 (8.6)	0.0 (-0.6)	0.0 (0.0)
ENE	2.4 (5.4)	-5.3 (-5.6)	0.8 (3.6)	2.7 (1.7)	-0.8 (-1.7)	-0.2 (-0.4)	5.9 (10.3)	8.6 (6.8)	4.4 (3.6)	0.2 (-0.2)
UTI	7.6 (4.2)	0.6 (0.1)	1.7 (1.1)	0.5 (0.4)	1.5 (1.2)	-2.0 (-1.8)	4.1 (1.4)	-1.2 (-2.2)	0.3 (0.0)	-0.1 (0.0)
STE	60.9 (32.1)	3.5 (0.2)	-9.5 (1.2)	-2.7 (-0.8)	12.3 (6.0)	-14.4 (-6.2)	35.6 (21.6)	-19.5 (-7.3)	-4.7 (-2.8)	-3.6 (-1.6)
NMM	-21.6 (-11.3)	-3.0 (-0.2)	-13.8 (-5.0)	11.1 (3.7)	-6.6 (-1.1)	-2.1 (0.0)	-14.5 (-8.8)	-2.3 (0.5)	17.7 (4.6)	0.1 (0.1)
CHM	22.8 (4.3)	1.7 (0.7)	-17.2 (-7.8)	-9.8 (-3.1)	1.8 (1.0)	-4.8 (-1.4)	23.8 (7.9)	-13.0 (-4.5)	4.2 (1.6)	-0.6 (-0.1)
MET	-23.9 (-11.8)	-0.7 (0.3)	18.5 (6.0)	6.9 ([illegible])	4.9 (1.7)	4.9 (2.0)	2.7 (-0.5)	-0.8 (-1.5)	-4.3 (-1.8)	-0.3 (-0.1)
IMA	18.5 (11.3)	-0.6 (0.2)	-4.2 (-4.1)	-11.1 (-4.7)	-5.9 (-4.4)	5.1 (2.9)	10.3 (3.2)	-28.9 (-12.4)	-9.2 (-4.4)	-0.4 (-0.2)
OMA	-20.7 (-12.1)	3.8 (2.3)	-12.7 (-7.4)	-0.6 (-1.7)	5.3 (2.6)	-3.5 (-2.7)	-6.0 (-4.8)	0.0 (0.0)	2.6 (2.0)	-0.3 (-0.1)
ELG	11.1 (9.7)	7.2 (3.1)	-11.1 (-1.7)	-10.7 (-4.7)	-7.4 (-3.0)	3.8 (0.7)	31.3 (20.1)	8.2 (-0.4)	-3.9 (-2.7)	-0.4 (-0.1)
VEH	139.4 (45.5)	4.4 (2.7)	-40.0 (-15.9)	5.4 (1.4)	6.7 (2.7)	0.6 (-2.4)	19.6 (-0.6)	-6.6 (-6.1)	-11.3 (-6.3)	-0.2 (-0.1)
OTE	-14.8 (-12.3)	6.6 (2.3)	-1.4 (-8.1)	-5.3 (-2.3)	4.8 (0.4)	0.1 (2.0)	16.4 (0.2)	0.0 (0.0)	4.9 (2.4)	-0.9 (-0.2)
TXC	-0.5 (9.2)	1.1 (0.6)	-1.9 (2.0)	0.6 (-0.5)	-1.5 (-1.2)	3.9 (3.4)	7.0 (9.4)	1.5 (0.8)	-1.5 (-2.0)	0.1 (0.0)
WOO	8.8 (16.7)	0.5 (-0.1)	34.8 (37.0)	0.2 (0.2)	-6.3 (-7.4)	4.3 (3.1)	-17.5 (-14.3)	14.8 (13.6)	-0.4 (-2.4)	0.1 (0.0)
PAP	25.2 (-0.5)	9.4 (3.7)	3.5 (-0.2)	2.8 (0.7)	-4.5 (-2.0)	-0.5 (-0.1)	-1.6 (-4.3)	10.7 (3.8)	-4.6 (-1.2)	-0.1 (0.0)
RPL	30.8 (25.0)	-7.0 (-2.7)	-9.4 (-4.8)	-2.3 (-1.3)	-2.8 (-2.7)	25.5 (10.5)	-16.9 (-10.5)	-15.0 (-8.7)	-0.8 (0.2)	-0.2 (0.0)
CON	1.7 (0.5)	1.0 (0.4)	1.1 (0.3)	0.6 (0.3)	0.8 (0.4)	0.3 (0.1)	1.9 (0.7)	0.7 (0.2)	1.2 (0.6)	0.0 (0.0)
TRA	-5.4 (-3.2)	0.4 (0.2)	0.0 (-0.1)	0.4 (0.2)	1.2 (0.8)	0.1 (-0.1)	-1.3 (-1.2)	0.4 (0.2)	0.0 (-0.1)	0.1 (0.1)
FIN	-3.7 (-1.6)	0.7 (0.3)	-1.6 (-1.7)	0.8 (0.3)	0.0 (-0.2)	0.9 (0.5)	0.7 (-0.3)	-1.0 (-1.0)	1.0 (0.6)	-0.1 (0.0)
TRN	-16.4 (-11.2)	-2.3 (-2.5)	-3.2 (-2.2)	-0.4 (-0.6)	-1.1 (-1.6)	-0.8 (-0.9)	-18.7 (-13.4)	0.5 (-0.9)	2.1 (1.0)	0.4 (0.2)
HEA	1.7 (0.8)	0.7 (0.2)	0.9 (0.4)	0.4 (0.2)	0.5 (0.2)	0.4 (0.2)	0.9 (0.4)	0.3 (0.1)	0.0 (0.0)	0.0 (0.0)
EDU	0.2 (0.0)	0.5 (0.2)	0.6 (0.2)	0.1 (0.1)	0.4 (0.2)	0.2 (0.1)	0.2 (0.1)	0.3 (0.1)	0.0 (0.0)	0.2 (0.0)
SER	0.4 (0.2)	1.0 (0.5)	0.6 (0.1)	0.3 (0.1)	0.5 (0.2)	0.4 (0.2)	-4.6 (-3.5)	0.0 (-0.1)	0.4 (0.3)	0.0 (0.0)
PUB	0.9 (0.3)	0.8 (0.3)	0.8 (0.4)	0.6 (0.3)	0.7 (0.3)	0.6 (0.3)	-0.9 (-0.3)	0.6 (0.3)	0.6 (0.2)	0.2 (0.1)

a. CRTS results are in parentheses. Shaded sectors are those subject to IRTS.

Table A2 Change in the value of exports to and imports from EC countries, by region and product
(in percentage)

	BE		DE		DK		ES		FR		IT		NL		PT		UK		ROW	
	EX	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*	*EX*	*IM*
AGR	49	52	54	93	38	26	35	156	41	88	42	148	18	52	0	0	35	17	3	-1
FOO	132	135	118	792	111	35	117	32	111	105	126	309	97	14	140	38	102	168	0	-1
BET	2	1	58	27	51	46	45	62	48	0	0	0	34	65	84	5	32	40	5	-9
ENE	17	0	0	0	35	39	40	36	49	63	50	51	20	18	66	53	14	7	1	0
UTI	13	35	86	56	45	51	69	32	41	13	80	569	41	66	63	88	24	180	9	-1
STE	74	41	66	70	6	47	81	97	81	64	87	261	64	40	107	214	38	45	-10	2
NMM	15	121	44	64	47	159	104	3	61	160	63	84	51	124	81	102	83	39	-5	-5
CHM	66	35	68	62	0	0	0	0	76	71	89	206	62	31	0	0	68	57	-4	0
MET	89	2161	76	99	100	60	111	55	115	47	116	63	110	126	144	169	104	285	-3	2
IMA	50	30	67	56	89	91	78	107	74	77	89	53	80	57	96	434	34	107	-8	2
OMA	0	0	36	24	0	0	72	84	41	37	53	96	0	0	0	0	0	0	-1	0
ELG	34	28	71	49	27	57	92	203	86	159	103	93	52	24	119	95	69	116	-4	0
VEH	132	69	58	53	-17	552	71	65	63	60	79	96	73	64	105	262	39	143	-5	4
OTE	15	103	56	43	85	165	61	130	75	60	34	45	87	49	0	0	48	48	-6	2
TXC	7	12	24	25	13	21	21	24	21	30	25	12	22	23	28	18	21	41	1	-2
WCO	42	22	23	28	76	21	31	34	23	87	52	35	25	120	36	2	41	47	3	0
PAP	78	50	94	58	99	100	105	92	94	140	109	124	83	115	80	41	85	210	-2	0
RPL	37	17	0	0	0	0	113	167	96	133	103	23	0	0	62	313	0	0	-2	0
CON	-4	113	22	5	0	0	0	0	17	16	20	65	7	19	30	14	42	2	2	-6
TRA	0	0	0	0	0	0	35	12	24	0	22	312	10	23	19	0	50	2	7	-89
FIN	-19	37	16	12	9	709	17	-7	21	22	23	9	-6	6	0	0	36	7	4	-4
TRN	-25	28	9	18	4	3	11	5	14	9	17	3	-11	64	23	10	35	1	1	-27
EDU	0	0	0	0	0	0	0	0	0	0	0	0	-7	0	0	0	0	0	6	-26
SER	11	155	33	9	0	0	19	17	0	0	10	42	0	0	50	77	48	4	6	0
PUB	0	0	52	-17	37	0	0	0	0	0	56	0	-10	40	0	0	0	0	8	44

a. See table 1 for sector names.

Table A3 Change in the value of exports to and imports from non-EC countries, by country and product
(in percentage)

	BE		DE		DK		ES		FR		IT		NL		PT		UK		ROW	
	EX	IM	EX	IM	EX	IM	EX	IM	EX	IM	EX	IM	EX	IM	EX	IM	EX	IM	EX	IM
AGR	-4	13	0	-26	-4	22	-2	6	-2	4	-1	-6	-11	46	-3	2158	5	-4	0	-3
FOO	0	0	0	-3	-3	2	-4	4	-3	-1	0	-8	-5	20	0	0	4	-8	1	-1
BET	0	0	-2	4	0	0	-3	0	-3	3	-1	0	-15	3	-3	0	1	0	3	1
ENE	-8	33	-2	-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
UTI	-19	57	2	3	-4	13	0	0	-2	3	0	0	-10	3	0	0	0	0	0	0
STE	0	0	4	-15	0	0	3	-6	3	-15	0	-15	2	-8	0	0	4	-23	1	-5
NMM	-16	0	0	0	-4	-4	-2	5	-1	-2	1	-1	-6	-7	1	-1	5	-4	1	0
CHM	-2	0	0	-1	-3	-6	-4	-2	-1	-2	1	-5	0	-2	1	-24	4	-2	1	0
MET	-7	0	-1	-1	-1	-321	0	-1	1	1	1	0	-1	-3	5	-2	6	-4	1	-4
IMA	-2	-4	-1	-1	-1	-4	0	-6	0	-5	2	-1	2	-5	7	-560	4	-3	0	-1
OMA	-11	-2	-2	0	-6	-4	4	-28	0	0	1	-5	-6	12	0	0	3	0	0	0
ELG	-7	-23	-2	-1	0	0	-1	-9	-2	-3	3	-5	-1	82	0	0	5	-9	2	0
VEH	25	178	0	-1	0	0	4	-1	2	-4	3	-5	2	-27	9	-6	6	-13	-1	0
OTE	-14	-10	-1	-6	1	0	-3	-2	1	-1	-2	-5	5	-4	0	0	2	-4	0	0
TXC	0	0	-1	1	0	0	-4	0	-4	1	-2	1	0	0	-1	0	3	-2	2	-7
WOO	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	-25	0	0
[illegible]	0	0	1	0	0	0	-2	-2	-2	-7	0	-4	-7	-3	5	0	2	-8	1	0
RPL	-4	150	-2	0	-7	1	-4	0	-2	-2	5	-24	-2	-5	4	-8	5	-2	2	-2
CON	-13	5	0	0	0	0	0	0	-3	0	0	0	-9	0	5	-1	5	0	0	0
TRA	-24	2	0	0	-9	0	-2	1	-3	0	0	0	-14	1	0	0	6	0	3	1049
FIN	-19	12	0	0	0	0	0	0	-4	2	-1	3	-20	0	0	0	2	1	9	0
TRN	-22	0	-1	0	-8	0	0	0	-3	1	0	0	-15	1	3	0	5	0	4	25
HEA	0	0	0	0	-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EDU	0	0	0	0	-10	0	0	0	-2	2	0	0	-16	0	0	0	0	0	0	0
SER	-18	20	-2	18	0	0	-4	1	0	0	-3	117	0	0	0	0	0	1	3	-4
PUB	0	0	0	0	0	0	0	0	0	0	6	0	-10	1	0	0	0	0	0	0

Appendix A: Algebraic Formulation of the Model

This appendix presents the mathematical structure of a multi-regional general equilibrium model which has been developed for trade policy analysis. We refer to the model as MRT. These notes provide a detailed reference which complements the model's GAMS source code. Details of data preparation and calibration are provided separately in Appendix D.

Section 1 presents a general overview of the equilibrium structure. Section 2 presents a more detailed algebraic representation of equilibrium conditions for the central model. Section 3 develops the pricing equations for monopolistic sectors. Section 4 describes how the central equilibrium structure is represented using dual joint maximization. Section 5 summarizes the partial equilibrium submodels which determine price-cost margins and the number of firms in monopolistic sectors.

1 Model Structure - An Overview

1.1 Key Features

The main features of the model are described in the text. They are:

- 12 regions: Belgium, Denmark, Spain, France, Italy, Netherlands, Portugal, United Kingdom, Morocco, Turkey and Rest-of-World.
- 26 traded commodities.
- Monopolistic competition with increasing returns to scale in a subset of 12 industries.
- A flexible Armington structure in which commodities are distinguished by country and/or region of origin. Market integration is represented by a change in the preferences of consumers within the EC so that intra-EC goods become closer substitutes. This induces changes in producer pricing for sectors subject to monopolistic competition.

- Two types of resource-consuming non-tariff barriers: "borders costs" and "standards costs", both of which are affected by the EC92 program.
- Multiple price-wedge distortions: factor taxes in production, tariffs, export subsidies, voluntary-export restraints (represented by *ad valorem* equivalents), non-tariff import restrictions (also represented by *ad valorem* equivalents).
- Full general equilibrium structure with input-output tables and fully endogenous primary factor markets in all regions.

1.2 Markets and prices

The following notational conventions are adopted:

i,j are used to index goods.

r,r' are used to index countries/regions.

f is used to index primary factors (labor and capital)

P_x refers to a market price index. Unless otherwise noted, the benchmark value for any market price is unity.

$\bar{X}$ refers to the benchmark value of a quantity variable X. When reference prices are unity, all quantities are measured in billions of 1985 U.S. dollars.

The equilibrium structure of the model is based on the following market prices:

PU_r Price index for final consumption in region r.

PS_{ir} Consumer price for the Armington aggregate of good i in region r, inclusive of all applicable tariffs, border costs and monopolistic markups.

PY_{ir} Supply price (marginal cost) of good i from region r, excluding fixed costs associated with the production of goods in industries subject to increasing returns.

PV_{ir} Price index for factor inputs (value-added) in sector i, region r. This price is gross of all applicable factor use taxes.

PM_{ir} Aggregate price index for imports of good i into region r - applicable when region r has not been integrated.

PE_{ir} Aggregate price index for imports and domestic supplies of good i from all EC countries in an EC region r - applicable only when EC markets are integrated.

PN_{ir} Aggregate price index for imports of good i from non-EC countries within an EC region r - applicable only when EC markets are integrated.

PF_{fr} Price for factor f in region r.

1.3 Equilibrium Summary

Final demand in each region arises from a single representative agent maximizing a Cobb-Douglas utility function subject to a budget constraint. Income consists of returns to primary factors (labor and capital) and tax revenue rebated to the consumer in a lump sum.

Within each region, final and intermediate demand are expressed for the same Armington composite of domestic and imported varieties of individual goods. In the non-EC regions (and in the EC regions prior to market integration), the composite "supply" is a nested CES aggregate in which at the first level domestic varieties trade off with imported varieties while at the second level there is substitution between imports from different regions. After integration, within EC regions, the structure of this Armington aggregation changes to reflect improved substitutability between commodities from different EC member states.

Production has a standard structure with fixed coefficients for intermediate inputs and a CES aggregate of individual primary factors comprising value-added.

Two types of costs are associated with inter-regional trade. First, we introduce "standards costs" through which a product variety produced in one country requires additional value-added in order to be sold in a second country. Second, we account for "borders costs" representing costs of transporting goods between different regions. Both of the costs are zero for domestic sales.

Some of the commodities are produced subject to increasing returns to scale with free entry driving profits to zero. In this framework price-cost margins are determined by Cournot competition (with fixed conjectural variations). In equilibrium firms enter the market to the point that revenues from markups on marginal cost exactly balance the fixed costs of production. Changes in market share or elasticities of substitution in demand affect the optimal Cournot markup, so our modification of intra-EC elasticities (which would have not effect in a model of perfect competition) here causes significant changes in supply prices and market share.

2 Equations for the Central Model

2.1 Markets - Primal Form Equations

(i) Regional output:

$$Y_{ir} = \sum_{r'} X_{irr'} \tag{1}$$

where Y_{ir} is output of good i in region r,

$X_{irr'}$ is exports of good i from region r to r'.

(ii) Regional demand:

$$S_{ir} = C_{ir} + \sum_{j} a_{ijr} Y_{jr} + T_{ir} \tag{2}$$

where S_{ir} is total supply (production plus imports),

C_{ir} is total final consumption,

a_{ijr} is intermediate demand coefficient, and

T_{ir} is demand for good i in transport costs.

(iii) Value-added:

$$V_{ir} = a_{ir}^{V} Y_{ir} + \sum_{r' \neq r} a_{irr'}^{S} X_{irr'} + f_{ir} N_{ir} \tag{3}$$

where V_{ir} is total sector i value-added,

a_{ir}^{V} is value-added demand coefficient,

$a_{irr'}^{S}$ is the standards cost coefficient for shipments of good i from region r to region r',

f_{ir} is the fixed cost per firm, and

N_{ir} is the number of firms (for IRTS sectors).

(iv) Primary factor markets:

$$\bar{F}_{fr} = \sum_{i} a_{fir}^{F} V_{ir} \tag{4}$$

where $\bar{F}_{fr}$ is the endowment of factor f in region r, and

a_{fir}^{F} is the *price-responsive* demand coefficient for factor f in sector i.

(v) Armington supply for non-integrated regions r:

$$S_{ir} = \bar{S}_{ir} \left[\alpha_{ir}^{D} \left[\frac{X_{irr}}{\bar{X}_{irr}} \right]^{\rho_{DM}} + (1-\alpha_{ir}^{D}) \left\{ \sum_{r' \neq r} \theta_{ir'r}^{M} \left[\frac{X_{ir'r}}{\bar{X}_{ir'r}} \right]^{\rho_{M}} \right\}^{\rho_{DM}/\rho_{M}} \right]^{1/\rho_{DM}} \tag{5}$$

where $\bar{S}_{ir}$ is the benchmark supply,

α_{ir}^{D} is the value-share of domestic supply

$\bar{X}_{irr'}$ is benchmark exports of good i from region r to region r',

$\theta_{irr'}^{M}$ is the benchmark value share of region r exports in region r' imports, and

ρ_{DM}, ρ_{MM} are determined by the Armington elasticities of substitution, σ_{DM} and σ_{MM}: $\rho = \frac{\sigma}{\sigma - 1}$.

(vi) Armington supply for integrated regions r:

$$S_{ir} = \bar{S}_{ir}^{*} \left[\alpha_{ir}^{EC} \left\{ \sum_{r' \in EC} \theta_{ir'r}^{EC} \left[\frac{X_{ir'r}}{\bar{X}_{ir'r}} \right]^{\rho_D} \right\}^{\rho_{DM}/\rho_D} + (1-\alpha_{ir}^{EC}) \left\{ \sum_{r' \notin EC} \theta_{ir'r}^{N} \left[\frac{X_{ir'r}}{\bar{X}_{ir'r}} \right]^{\rho_M} \right\}^{\rho_{DM}/\rho_M} \right]^{1/\rho_{DM}} \tag{6}$$

where α_{ir}^{EC} is the benchmark value-share of EC imports,

$\theta_{irr'}^{EC}$ is the value share of imports from region r in all imports from EC countries, and

$\theta_{irr'}^{N}$ is the value share of imports from region r in all imports from non-EC countries.

(vii) Value-added supply:

$$V_{ir} = \bar{V}_{ir} \left\{ \sum_{f} \alpha_{fir}^{F} \left[\frac{a_{fir}^{F}}{\bar{a}_{fir}^{F}} \right]^{\rho_{ir}^{F}} \right\}^{1/\rho_{ir}^{F}} \tag{7}$$

where $\bar{V}_{ir}$ is benchmark value-added,

α_{fir}^{F} is the benchmark value share of factor f,

$\bar{a}_{fir}^{F}$ is the benchmark input coefficient, and

ρ_{ir}^{F} is determined by the elasticity of substitution.

(viii) Border/transport cost:

$$T_{ir} = \begin{cases} \sum_{jr'} \beta_{jrr'} X_{jrr'} & i = i_\tau \\ 0 & i \neq i_\tau \end{cases} \tag{8}$$

where τ is the index of the single commodity employed, for transport services, and

$\beta_{jrr'}$ is the transportation cost coefficient.

(ix) Welfare index:

$$W_r = \prod_i \left[\frac{C_{ir}}{\bar{C}_{ir}}\right]^{\alpha_{ir}} \tag{9}$$

where $\bar{C}_{ir}$ is benchmark final demand for good i, region r.

2.2 Profit conditions

(i) Value-added:

$$PV_{ir} = \frac{1+t^F_{ir}}{\overline{PV}_{ir}} \left[\sum_f \alpha^F_{fir}\, PF_{fr}^{1-\sigma_{ir}^F}\right]^{\frac{1}{1-\sigma^F_{ir}}} \tag{10}$$

where t^F_{ir} is the ad-valorem factor tax rate

$\overline{PV}_{ir}$ is the benchmark (tax-inclusive) price

(ii) Marginal cost:

$$PY_{ir} = a^V_{ir} PV_{ir} + \sum_j a_{jir} PS_{jr} \tag{11}$$

(iii) Armington composite supply price for non-integrated regions:

$$PS_{ir} = \left\{ \alpha^D_{ir} \left[\frac{PD_{ir}}{\overline{PD}_{ir}}\right]^{1-\sigma_{DM}} + (1-\alpha^D_{ir})\left[\frac{PM_{ir}}{\overline{PM}_{ir}}\right]^{1-\sigma_{DM}} \right\}^{\frac{1}{1-\sigma_{DM}}} \tag{12}$$

in which:

$$PD_{ir} = (1+\mu_{irr})PY_{ir} \tag{13}$$

and

$$PM_{ir} = \left\{ \sum_{r' \neq r} \theta^M_{ir'r} \left[(1+\mu_{ir'r})(1+\hat{t}_{ir'r})\left(PY_{ir'} + \beta_{ir'r} PT_{r'} + a^S_{ir'r} PV_{ir'}\right)\right]^{1-\sigma_M} \right\}^{\frac{1}{1-\sigma_M}} \tag{14}$$

and

$$PT_{ir} = PS_{t,r} \tag{15}$$

where $\mu_{irr'}$ is the markup on marginal cost on sales of good i from a firm in region r in region r'.

$\hat{t}_{ir'r}$ is the ad-valorem tax rate which incorporates import tariffs, export subsidies and various non-tariff barriers,

$\overline{PD}_{ir}$ is the benchmark supply price for goods from domestic producers,

$\overline{PM}_{ir}$ is the benchmark supply price for imports.

(iv) Armington composite supply price for integrated regions:

$$PS_{ir} = \left\{ \alpha_{ir}^{E} \left[\frac{PE_{ir}}{\overline{PE}_{ir}} \right]^{1-\sigma_{DM}} + (1-\alpha_{ir}^{E}) \left[\frac{PN_{ir}}{\overline{PN}_{ir}} \right]^{1-\sigma_{DM}} \right\}^{\frac{1}{1-\sigma_{DM}}} \tag{16}$$

in which:

$$PE_{ir} = \left\{ \sum_{r' \in EC} \theta_{ir'r}^{E} \left[(1+\mu_{ir'r})(1+\hat{t}_{ir'r})\left(PY_{ir'} + \beta_{ir'r} PT_{r} + a_{ir'r}^{S} PV_{ir'}\right) \right]^{1-\sigma_{D}} \right\}^{\frac{1}{1-\sigma_{D}}} \tag{17}$$

and

$$PN_{ir} = \left\{ \sum_{r' \notin EC} \theta_{ir'r}^{N} \left[(1+\mu_{ir'r})(1+\hat{t}_{ir'r})\left(PY_{ir'} + \beta_{ir'r} PT_{r} + a_{ir'r}^{S} PV_{ir'}\right) \right]^{1-\sigma_{M}} \right\}^{\frac{1}{1-\sigma_{M}}} \tag{18}$$

where $\overline{PE}_{ir}$ is the benchmark supply price for imports from EC countries, and

$\overline{PN}_{ir}$ is the benchmark supply price for imports from non-EC countries.

(v) Regional income, including factor income, tax revenue and profits from monopolistic sectors:

$$I_r = \sum_f \bar{F}_{fr} PF_{fr} +$$

income from primary factors

$$\sum_{ir'} \theta^t_{ir'r}\ \hat{t}_{ir'r} \left(PY_{ir'} + \beta_{ir'r} PT_{r'} + a^S_{ir'r} PV_{ir'}\right) X_{ir'r} +$$

net tax revenue and NTB rents on imports

$$\sum_{ir'} (1-\theta^t_{irr'})\ \hat{t}_{irr'} \left(PY_{ir} + \beta_{irr'} PT_r + a^S_{irr'} PV_{ir}\right) X_{irr'} + \tag{19}$$

net tax revenue and NTB rents on exports

$$\sum_i t^F_{ir}\ PF_{fr}\ a^F_{fir}\ V_{ir} +$$

factor tax revenue

$$\sum_i \sum_{r'} \left[\mu_{irr'}\ (1+\hat{t}_{irr'}) \left(PY_{ir} + \beta_{irr'} PT_r + a^S_{irr'} PV_{ir}\right) X_{irr'} \right] - PV_{ir}\, f_{ir}\, N_{ir}$$

monopoly markup revenue less fixed costs

where $\theta^t_{ir'r}$ is the share of trade taxes accruing to the importing country, r. In most calculations, free entry assures that monopoly profits are zero.

(vi) Final demand:

$$C_{ir} = \frac{\alpha_{ir}\ I_r}{PS_{ir}} \tag{20}$$

(vii) Free entry zero profit condition for monopolistic firms:

$$N_{ir} = \frac{\sum_{r'} \left[\mu_{irr'}\ (1+\hat{t}_{irr'}) \left(PY_{ir} + \beta_{irr'} PT_r + a^S_{irr'} PV_{ir}\right) X_{irr'} \right]}{PV_{ir}\ f_{ir}} \tag{21}$$

3 Pricing Equations for Monopolistic Industries

The following features characterize the model representation of industries producing under IRTS:

- Goods are distinguished by firm, by region and by area of origin. An area may contain one or more regions. Within a given country, for example, an area of origin may be "imported" or "domestic". The first of these contains all regions other than the importing country itself. The second contains only a single region.
- Demands arise from a nested Constant-Elasticity-of-Substitution (CES) structure. At the lowest level is a CES aggregate of supply from firms in a single region r. At the next level, region r supply trades off with other regions from the same area, and at the top level, consumers choose between aggregate commodities from different areas. For example, in the EC following integration, consumers distinguish between EC and non-EC commodities. In all other countries as well as within the EC prior to integration, consumers only distinguish domestic and imported varieties. Demand for the final composite arises from consumer maximization of a Cobb-Douglas utility function, so that the Marshallian demand function exhibits a unitary price elasticity of demand.
- Producers compete in quantities based on a Cournot model with fixed conjectural variations. Markups on over marginal cost are based on maximization of profit. Profits fall to zero, however, due to free entry. Fixed costs at the firm level are exogenous, and as markup revenues change, so too does the number of firms producing within a given region.

Algebraic relations for supply of a single commodity to a single market will now be outlined. One such set of equations applies to each market for commodities produced subject to increasing returns to scale. The following notation applies:

X Aggregate demand;

Y_k Supply from area k;

S_r Supply from region r;

q_{fr} Supply from firm f in region r;

P Price index for aggregate demand;

p_k Price index for supply from area k;

w_r Price index for supply from region r; and

π_{fr} Sales price for supply from firm f in region r.

3.1 CES Aggregators (primal form)

$$X = \left[\sum_k \alpha_k^{1/\sigma} Y_k^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{22}$$

$$Y_k = \left[\sum_{r|k_r=k} \beta_{rk}^{1/\eta} \, S_r^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{23}$$

$$S_r = \left[\sum_f q_{fr}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{24}$$

3.2 Associated price indices (CES cost functions)

$$P = \left(\sum_k \alpha_k \, p_k^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{25}$$

$$w_r = \left(\sum_f \pi_{fr}^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}} \tag{27}$$

3.3 Associated demand functions

$$Y_k = \alpha_k \left(\frac{P}{p_k} \right)^{\sigma} X \tag{28}$$

$$S_r = \beta_{rk} \left(\frac{p_k}{w_r} \right)^{\eta} Y_k \quad \text{for } k=k_r. \tag{29}$$

3.4 Firm behavior

Consider the optimization problem facing firm f in region r selling into a given market. Profit is given by:

$$\Pi_{fr}(q) = \pi_{fr} q - C_{fr}(q) \tag{31}$$

First order conditions for profit maximization are:

$$\frac{\partial \Pi_{fr}}{\partial q} = \frac{\partial \pi}{\partial q} q + \pi_{fr} = c_{fr}(q) \tag{32}$$

in which c_{fr} represents the marginal cost of supply which is treated as exogenous in this derivation. The first order conditions may be written:

$$c_{fr} = \pi_{fr} (1 - \bar{m}_{fr}) \tag{33}$$

in which m_{fr} is the markup over marginal cost (expressed on a gross basis):

$$\bar{m}_{fr} = -\frac{1}{e_{fr}} = -\frac{\partial \pi_{fr}}{\partial q_{fr}} \frac{q_{fr}}{\pi_{fr}} \tag{34}$$

In this equation e_{fr} is the "perceived elasticity of demand".

The pricing equations presented here are easy to interpret, but they are somewhat more difficult to derive. The expression for e_{fr} arises from the nested CES structure of demand taken together with the Cournot assumptions concerning the response of other producers.

3.5 The perceived elasticity of demand

Begin with the inverse demand function:

$$\pi_{fr} = \left[\frac{S_r}{q_{fr}} \right]^{1/\epsilon} w_r \tag{35}$$

We then compute the derivative:

$$\frac{\partial \pi_{fr}}{\partial q_{fr}} = -\frac{1}{\epsilon} \frac{\pi_{fr}}{q_{fr}} + \frac{1}{\epsilon} \frac{\pi_{fr}}{S_r} \frac{\partial S_r}{\partial q_{fr}} + \frac{\pi_{fr}}{w_r} \frac{\partial w_r}{\partial q_{fr}} \tag{36}$$

Under Cournot conjectures[1]

[1] For simplicity, the equations presented here are based on unitary conjectural variations. Conjectures departing from one are a simple extension.

$$\frac{\partial S_r}{\partial q_{fr}} = \left[\frac{S_r}{q_{fr}}\right]^{1/\eta} \tag{37}$$

and the term $\frac{\partial w_r}{\partial q_{fr}}$ is computed by applying the chain rule a second time:

$$\frac{\partial w_r}{\partial q_{fr}} = \frac{\partial w_r}{\partial S_r}\frac{\partial S_r}{\partial q_{fr}} \tag{38}$$

Combining, we have:

$$\frac{\partial \pi_{fr}}{\partial q_{fr}}\frac{q_{fr}}{p_{fr}} = -\frac{1}{\epsilon} + \frac{1}{\epsilon}\frac{q_{fr}}{S_r}\left[\frac{S_r}{q_{fr}}\right]^{1/\epsilon} + \frac{q_{fr}}{w_r}\left[\frac{S_r}{q_{fr}}\right]^{1/\epsilon}\frac{\partial w_r}{\partial S_r} \tag{39}$$

Make the substitution:

$$\left[\frac{q_{fr}}{S_r}\right]^{-1/\epsilon} = \frac{\pi_{fr}}{w_r} \tag{40}$$

to obtain:

$$\frac{1}{e_{fr}} = -\frac{1}{\epsilon} + \frac{1}{\epsilon}\frac{\pi_{fr}q_{fr}}{w_r S_r} + \frac{\partial w_r}{\partial S_r}\frac{S_r}{w_r}\frac{\pi_{fr}q_{fr}}{w_r S_r} \tag{41}$$

Apply similar steps at the next level to obtain:

$$\frac{\partial w_r}{\partial S_r}\frac{S_r}{w_r} = -\frac{1}{\eta} + \frac{1}{\eta}\frac{w_r S_r}{p_k Y_k} + \frac{\partial p_k}{\partial Y_k}\frac{Y_k}{p_k}\frac{w_r S_r}{p_k Y_k} \tag{42}$$

Apply the operations again, taking into account the fact that demand elasticity for aggregate X is unity:

$$\frac{\partial p_k}{\partial Y_k}\frac{Y_k}{p_k} = -\frac{1}{\sigma} + \frac{1}{\sigma}\frac{p_k Y_k}{PX} - \frac{p_k Y_k}{PX} \tag{43}$$

We then may assemble all of these equations to obtain an expression for the optimal Cournot markup.

To simplify notation, we introduce:

$$\theta^Y_{rk} = \frac{w_r S_r}{p_k Y_k} \quad \text{for } k=k_r \tag{44}$$

and

$$\theta^X_k = \frac{p_k Y_k}{PX} \tag{45}$$

We then have:

$$\hat{m}_{fr} = -\frac{1}{\epsilon} + \left[\frac{1}{\eta}-\frac{1}{\epsilon}\right]\frac{1}{N_{fr}} + \left[\frac{1}{\sigma}-\frac{1}{\eta}\right]\frac{\theta^{Y}_{rk}}{N_{fr}} + \left[1-\frac{1}{\sigma}\right]\frac{\theta^{X}_{k}\theta^{Y}_{rk}}{N_{fr}} \tag{46}$$

3.6 Application to the EC model

In our modelling we begin with two distinguished supply areas in each market: domestic and imports. There are three associated elasticities of substitution:

σ_{DD} is the elasticity of substitution between goods supply by different domestic firms

σ_{MM} is the elasticity of substitution between any two foreign supplies, whether or not they are firms within the same region, and

σ_{DM} is the elasticity of substitution between goods from any pairs of domestic and foreign firms.

Let $\theta_{rr'}$ denote the market share of region r firms in region r'.

In the benchmark we have only domestic and imported firms distinguished. Applying the formulae above we therefore have two different markup equations (one for sales into the domestic market and the other for export sales):

$$\hat{m}_{rr'} = \begin{cases} \frac{1}{\sigma_{DD}} + \left[\frac{1}{\sigma_{DM}}-\frac{1}{\sigma_{DD}}\right]\frac{1}{N_r} + \left[1-\frac{1}{\sigma_{DM}}\right]\frac{\theta_{rr}}{N_r} & r=r' \\ \frac{1}{\sigma_{MM}} + \left[\frac{1}{\sigma_{DM}}-\frac{1}{\sigma_{MM}}\right]\frac{\theta_{rr'}}{N_r\theta^{M}_{r'}} + \left[1-\frac{1}{\sigma_{DM}}\right]\frac{\theta_{rr'}}{N_r} & r\neq r' \end{cases} \tag{47}$$

where

$$\theta^{M}_{r'} = \sum_{r\neq r'} \theta_{rr'} \tag{48}$$

In the counterfactual experiment which we interpret as "market integration," we modify the structure of demand for consumers within EC countries. In the modified functions, firms within the EC area are distinguished from non-EC firms. The elasticity σ_{DD} determines the trade-off between any pairs of EC firms (whether or not they are in the same country), while σ_{DM} determines substitution possibilities between EC and non-EC supplies. The elasticity of substitution between two non-EC firms remain equal to σ_{MM}.

The mark-up equations for firms selling into the EC market become:

$$\hat{m}_{rr'} = \begin{cases} \dfrac{1}{\sigma_{DD}} + \left[\dfrac{1}{\sigma_{DM}} - \dfrac{1}{\sigma_{DD}}\right] \dfrac{\theta_{rr'}}{N_r \theta_{r'}^{EC}} + \left[1 - \dfrac{1}{\sigma_{DM}}\right] \dfrac{\theta_{rr'}}{N_r} & r \in EC \\ \dfrac{1}{\sigma_{MM}} + \left[\dfrac{1}{\sigma_{DM}} - \dfrac{1}{\sigma_{MM}}\right] \dfrac{\theta_{rr'}}{N_r(1-\theta_{r'}^{EC})} + \left[1 - \dfrac{1}{\sigma_{DM}}\right] \dfrac{\theta_{rr'}}{N_r} & r \notin EC \end{cases} \tag{49}$$

Markup equations for sales into non-EC countries are unaffected.

4 Formulation and Solution using Dual Joint Maximization

It is well known that an undistorted competitive equilibrium can be represented as the solution to an appropriately formulated representative agent problem. In a model with multiple consumers with heterogenous preferences and endowments, the main difficulty with the optimization approach lies in determining a consistent set of Negishi weights on individual agents' welfare. Further difficulties arise when market imperfections such as taxes, tariffs or monopolistic markups on marginal cost are present. Despite these difficulties, the optimization formulation remains attractive because of the efficiency and robustness of commercial solvers for large-scale nonlinear optimization, such as MINOS (Saunders) and CONOPT (Drud) - both of which are available as GAMS subsystems (see Brooke, Kendrick and Meeraus [1986]).

We solve our MRT model using a representative agent approach. The novelty of this work is that we formulate our subproblems in prices rather than quantities, and we employ the Sequential Joint Maximization (SJM) algorithm of Rutherford [1992], in which the Negishi weights are calculated with a simple Jacobi iterations. MRT represents the first large-scale application of the dual-form SJM algorithm.

This section begins with an introduction to the SJM in a general framework. It concludes with an overview of the SJM procedure as it is applied to the MRT model, incorporating monopoly markups and tax distortions.

4.1 Integrability with homothetic preferences

Consider a simple economic equilibrium model in which consumer preferences are *homothetic* (i.e., all income elasticities are unity). Define the expenditure function for household h as:

$$e_h(\pi) = \min \pi^T d$$
$$\text{s.t.} \qquad U_h(d) = 1$$

in which $U_h()$ is the utility function for consumer h, π is a vector of commodity prices, and d is a vector of commodity demands. Without loss of generality, we may assume that $U_h()$ is linearly homogeneous, so $U_h(\lambda d) = \lambda\, U_h(d)$. For this case, the expenditure function provides an index of the "price of a unit of utility".

If consumer h has commodity endowments ω_h, the maximum attainable utility at market prices π is then given by the indirect utility function $V_h(\pi) = \pi^T\omega_h \,/\, e_h(\pi)$.

Let $\Omega = \Sigma_h\, \omega_h$ stand for aggregate endowment vector and initially assume that $\omega_h = \theta_h\, \Omega$. The excess demand function representing these preferences and endowments is "integrable". To see this, consider the joint maximization problem:

$$\max_{d_h} W(U_1(d_1),\ldots,U_H(d_H);\, \theta) \equiv \Pi_h\, U_h(d_h)^{\theta_h}$$
$$\text{s.t.} \qquad \pi^T\, \Sigma_h\, d_h \le \pi^T\, \Omega$$

where $W(.)$ is a Cobb-Douglas welfare function into which are nested the utility functions of the different households. Due to homogeneity, we can reduce this problem to:

$$\max_{U_h} \Pi_h U_h^{\theta_h}$$

s.t. $$\Sigma_h e_h(\pi) U_h \leq \pi^T \Omega$$

where expenditure functions $e_h(\pi)$ are evaluated at prices defined by Lagrange multipliers at the maximum.

A Cobb-Douglas function implies demand functions based on fixed expenditure shares for each household. Here, this implies the following relations:[2]

$$\pi^T d_h \underset{1}{=} e_h(\pi) U_h \underset{2}{=} \theta_h (\pi^T \Omega) \underset{3}{=} \pi^T (\theta_h \Omega) \underset{4}{=} \pi^T \omega_h$$

In other words, the value of consumer *h* expenditures equals the value of consumer *h* endowments. This is true because the Cobb-Douglas value shares in $W(U;\theta)$ correspond *exactly* to shares of aggregate endowments. It follows that for any price vector π, the demand vector arising from the joint-maximization problem is the same as would result from summing *H* independent demand vectors. This result corresponds to Theorem 4 in Eisenberg [1961]; for a rigorous economic interpretation, see Chipman [1974].

4.2 Joint maximization with primal variables

Assume that the demand side of the economy is characterized by linearly homogeneous utility functions $U_h(d)$ and endowment vectors ω_h, not necessarily proportional. Let the supply side be represented by a set of *J* constant returns to scale technologies. A *unit* netput vector for sector *j*, x^j, is selected from a convex production set T^j. Constant returns to scale prevail in all sectors, so that $\lambda x^j \; \forall \; \lambda > 0$ is feasible for any $x^j \in T^j$.

[2] Justification:

1 : Implied by the definition of $e_h()$

2 : Follows from the Cobb-Douglas structure of the aggregation function.

3 : Follows from linear algebra.

4 : From the definition of ω_h.

A competitive equilibrium in this economy is characterized by a vector of market prices, π, and a vector of activity levels, y, which satisfy the following conditions:

Market clearance: $$\sum_j y_j x_i^j + \sum_h \omega_i^h \geq \sum_h d_i^h, \quad \forall i$$

Zero profit: $$-\pi^T x^j \geq 0, \quad \forall j$$

Budget balance: $$\pi^T \omega^h = \pi^T d^h, \quad \forall h$$

In addition, the choices by consumers and producers must be independently rational. Hence, d^h maximizes $U_h(d)$ subject to budget balance, and x^j maximizes unit profit ($\pi^T x$) subject to technology constraints ($x \in T^j$).

The equilibrium is supported as a solution of the joint maximization problem:

$$\max \; W(U) = \prod_h U_h(d^h)^{\theta_h}$$
$$\text{s.t.} \tag{50}$$
$$\sum_j y_j x_i^j + \sum_h \omega_i^h \geq \sum_h d_i^h, \quad \forall i$$

A competitive equilibrium is represented when the Negishi weights are chosen so that θ_h is proportional to $\pi^T \omega^h$. The SJM algorithm searches for θ_h values by successive approximations in which the Lagrange multipliers for the previous iteration are used to form an estimate for the welfare function budget shares in the subsequent iteration.

4.3 Joint maximization in price space

Let $e_h(\pi)$, the unit expenditure function for consumer h, be defined as above. Let $\phi_j(\pi)$ be the analogous "unit revenue function" for sector j, defined as:

$$\phi_j(\pi) \equiv \max \; \pi^T x \;\; \text{s.t.} \;\; x \in T^j$$

Sheppard's lemma characterizes consumer demand and producer netputs:

$$d^h(\pi) = \nabla e_h(\pi) \frac{\pi^T \omega_h}{e_h(\pi)}$$

and

$$x^j(\pi) = \nabla\phi_j(\pi)$$

Using these relations and identifying the Lagrange multipliers as the activity vector y, it is straightforward to show that the Karush-Kuhn-Tucker conditions for the following nonlinear program correspond to a competitive equilibrium for the underlying economy:

$$\max \sum_h \bar{I}_h \log(e_h(\pi)) - \pi^T\omega_h$$

$$\text{s.t.} \quad \phi_j(\pi) \leq 0 \quad \forall j$$

The SJM iterations follow a sequence of maximization problems in which, for iteration k, $\bar{I}_h^{(k)} = \pi^{(k-1)^T} \omega_h$.

4.4 Dual joint maximization with price distortions

In the general equilibrium structure price distortions can, without loss of generality, be applied only to the supply side of the economy. Suppose that x^j is chosen to solve

$$\begin{aligned} &\max \quad \hat{\pi}^T x \\ &\text{s.t.} \quad x \in T^j \end{aligned}$$

in which $\hat{\pi}$ is a vector of tax-distorted prices (users costs), for example: $\hat{\pi}_{ij} = \pi_i(1+t_{ij})$. When tax distortions are present, the tax revenue returned per unit operation of sector j is given by $(\pi-\hat{\pi})^T x$.

In order to accommodate price distortions in the dual joint maximization procedure, the tax distortions are introduced into the constraints, and the tax revenue effects are treated symmetrically with factor endowments - using lagged values for production activities. The generic dual-form optimization problem is:

$$\max \sum_h \left\{ \bar{I}_h \log(e_h(\pi)) - \pi^T \omega_h - \sum_j \theta_j^i \bar{y}_j \bar{x}^j (\pi - \hat{\pi}) \right\}$$

$$\text{s.t.} \quad \phi_j(\hat{\pi}) \leq 0$$

in which θ_{jh} is the fraction of sector j tax revenue which accrues to household h and where $\bar{y}_j$ and $\bar{x}^j$ are lagged values for the sector j activity level and netput vector, respectively.

4.5 Dual joint maximization formulation for MRT

The MRT model is formulated as a joint maximization problem in the space of prices. In every major iteration, the following nonlinear programming problem to refine estimates of prices and quantities (activity levels and trade flows are determined by the value of Lagrange multipliers on the corresponding zero profit constraints):

$$\max \sum_r \bar{I}_r \log \left[\prod_i PS_{ir}^{\alpha_{ir}} \right] - I_r(\bar{X},\bar{V})$$

$$\text{s.t.} \quad (10)-(18)$$

In this calculation $I_r(X,V)$ stands for what appears on the right-hand-side of equation (19), evaluated using the current estimates for trade flows and value-added, $\bar{X}_{irr'}$ and $\bar{V}_{ir}$.

For purposes of determining sectoral prices and incomes, monopoly markup rates ($\mu_{irr'}$) are held fixed. A consistent equilibrium is obtained through a recursive procedure in which calculations of an equilibrium for the central model alternate with single sector simulations for individual markets to determine optimal markups and numbers of active firms.

5 Single commodity submodel for monopolistic sectors

The equilibrium conditions for markets where technologies exhibit increasing returns to scale and firms price above marginal cost do not fit into a Negishi-type computational framework. We have therefore adopted a decomposition procedure to overcome this problem. In our computations, separate systems of nonlinear equations generate consistent approximations of market shares, numbers of firms and markups over marginal cost for each commodity. Demands and supplies for all regions are included in these systems of equations, although factor markets, income effects and intersectoral linkages are ignored. In every iteration, regional demand functions are calibrated to the most recently calculated general equilibrium solution.

The single commodity models are formulated with marginal costs assumed constant. This seems appropriate given the degree of disaggregation (no monopolistic sector commands more than 2% of aggregate expenditure or value-added). Given constant marginal costs, the selling price is then determined solely through the markup equations.

The single commodity models include four classes of equations:

- Inverse demand functions which translate markups and exogenous marginal costs into sales prices.
- Equations relating the number of firms to sales volumes, trade flows and (exogenously specified) fixed costs. These equations embody the assumption that free entry drives profits to zero.
- Markup equations, as derived in section 3, which define markups over marginal cost as a function of market share and numbers of firms.
- Ordinary demand functions which translate sales prices into trade flows.

Appendix B: Calibrating the Cost Disadvantage Ratio

We assume that total costs at the level of the representative firm may be specified as:

$$c = f + mq$$

where f is fixed costs, m is constant marginal costs, and q is firm level output. Average costs are then:

$$ac = \frac{f}{q} + m \ .$$

Assuming zero profits, data in the initial equilibrium provide information on the industry total costs (C) and industry output (Q). If there are n representative firms initially, then $nc_1 = C_1$ and $nq_1 = Q_1$, where the subscript 1 refers to the data of the initial equilibrium. Since

$$\frac{c_1}{q_1} = \frac{nc_1}{nq_1} = \frac{C_1}{Q_1},$$

the initial data provides one point on the firm's average cost curve:

$$\frac{c_1}{q_1} = \frac{f}{q_1} + m.$$

Given the specified functional form of the average cost curve, it may be calibrated if a second point is known. Suppose we have an estimate that if output declines to αq_1 then average costs increase to $\beta\left(\frac{c_1}{q_1}\right)$ where $0 < \alpha < 1$, $\beta > 1$ and where $\beta\alpha < 1$ is required for marginal costs to be non-negative. This provides a second point on the industry average cost curve:

$$\beta\frac{c_1}{q_1} = \frac{f}{\alpha q_1} + m.$$

Multiplying numerator and denominator in the last two equations by n, we obtain equations involving industry output and costs, on which data is available. Thus we have:

$$\frac{C_1}{Q_1} = \frac{F}{Q_1} + m$$

and

$$\beta \frac{C_1}{Q_1} = \frac{F}{\alpha Q_1} + m,$$

where F is industry fixed costs. Solving these equations for industry fixed cost and industry marginal cost yields:

$$F = C_1 \ (\beta - 1) \ \frac{\alpha}{1-\alpha}.$$

and

$$m = \left[\frac{C_1}{Q_1} \right] \ \left[\frac{\beta\alpha - 1}{\alpha - 1} \right].$$

Since the cost disadvantage ratio (CDR) is defined as $\frac{f}{c}$, which by symmetry equals $\frac{F}{C}$, we know that at the initial equilibrium:

$$CDR = \frac{(\beta-1)\alpha}{1-\alpha}.$$

We obtain the values of α and β primarily from engineering studies summarized by Pratten [1987], a synposis of which is available in Emerson et al. [1988]. We enter data for these two parameters at the 44-sector level corresponding to the sectors in the EC input-output tables, and then aggregate to the sectors of our model. The mapping and sources of our CDR estimates are provided in Table B-1. The final, aggregated, CDR estimates used in the model are listed in Table 1 in the text.

Following others such as Gasoriek, Smith and Venables [1992], we assume that the initial output level is at the minimum efficient scale (MES). This is not an unreasonable assumption, since firms should have difficulty competing at less than MES. However, given our assumed functional form, at MES further cost savings can be obtained by expanding output. To the extent that output is less than MES, we have indeed underestimated the CDR, since the slope of the average cost curve increases in absolute value for decreases in output.

Table B-1: Source of Data on CDR Values

Sector	Share of MES [a] Output (α)	Percentage Cost [b] Increase at Output Level (β)	Implied CDR	Source of Data [c]
AGR	-	-	0.000	
BEV	0.33	5	0.025	427, Table 5.5
BUS	-	-	0.000	
CHM	0.33	4-19	0.057	25
COA	-	-	0.000	
COK	-	-	0.000	
COM	0.33	5-10	0.037	344 ("Telecommunications Equipment" in Pratten)
CON	-	-	0.000	No information
EDU	-	-	0.000	
ELE	0.33	5	0.025	Table 5.3a, Sector 16, interpolation
ELO	0.33	5-15	0.049	342, 346
FIN	0.5	5	0.050	Table 10.1 Pratten, interpolation
HEA	-	-	0.000	No information
LEA	0.33	1.5	0.007	451
MAC	0.5	3-8	0.055	321, 322, 326
MEA	0.67	5	0.102	412
MET	0.33	10	0.049	221
MLK	0.67	0	0.000	Interpolation
MSE	-	-	0.300	Table 10.1 Pratten ("Advertising" and interpolation)
NMM	0.33	10-26	0.089	241-247
NUC	0.5	10	0.100	15 Table 5.3a - approximation
OFM	0.33	5-10	0.037	33
OFP	0.67	4-9	0.132	411-412, 420, 422, 423 (ignoring flour)
OIL	0.33	4	0.020	14, Table 5.5
OMP	0.5	3-5	0.040	322
ORE	0.33	10-11	0.052	22
OTR	0.5	8-20	0.140	36
PAP	0.5	9-13	0.110	471, 472 (ignoring printing)
PED	-	-	0.000	
PHE	-	-	0.000	
PSE	-	-	0.000	
PUB	-	-	0.000	
REN	-	-	0.000	
REP	-	-	0.000	
RES	-	-	0.000	
RPL	0.33	5-10	0.037	481
TOB	0.33	2-5	0.017	429
TRA	0.33	-	0.000	Table 10.1 Pratten indicates small RTS
TRN	-	-	0.000	Table 10.1 Pratten
TRS	0.33	2	0.010	Table 10.1 Pratten, Interpolation
TRX	-	-	0.000	Table 10.1 Pratten
TXC	0.5	0-2	0.010	Textiles only is 2-10; Clothing is clearly 0
VEH	0.5	11	0.110	Friedlander, Winston, and Wang.
WOO	-	-	0.000	Table 5.3

[a] Data correspond to the parameter α in the CDR calibration equation.
[b] (β-1) * 100 corresponds to the data in the column where β is from the CDR calibration equation.
[c] Numbers indicated are sectors from Table 5.1 of Pratten [1987] unless otherwise indicated. Where other tables are listed, these are also from Pratten [1987].

For our preferred point estimates of the CDR we use the midpoint of the range of the estimates shown in Table B-1. We take the upper and lower bounds of the range of these estimates for our high and low estimates of the CDR.

Appendix C: Standards and Buyers' Increased Substitution Possibilities

This appendix briefly reviews the theory and empirical work on standards. We conclude from this review that the impact of the EC92 single market program regarding standards will be to substantially increase the ability of EC buyers to substitute among the products of EC suppliers, thereby justifying our modelling focus.

There are literally thousands of industrywide product standards in existence in the U.S. Following the survey by Hemenway [1975], we broadly decompose these into standards on product uniformity and standards on product quality. Uniformity standards refer to matters such as the dimensions or architecture of the product (e.g., electric lamp sockets, telecommunication interconnections, bed sheets, record sizes) that typically allow consumers to interchange products of different suppliers. Product quality standards distinguish products by better or worse. Examples include USDA standards on orange drink, peanut butter and meat.[3]

Most industrywide standards in the U.S. are voluntary,[4] and there are a number of important factual observations regarding them. First, and most important for our purposes, the vast majority of both types of standards serve to significantly increase the ability of buyers to substitute among the products of competing sellers. This is most evident with uniformity standards which are primarily designed to allow buyers to use different sellers products *interchangeably*, if not as perfect substitutes. But an increase in the elasticity of substitution also occurs due to quality standards when, as is typical, they reduce product differentiation advantages of brand names.

[3] Sometimes dimensional standards may have quality aspects as in the case of lumber yard standards on the two by four to prevent adulteration or degradation.

[4] Only about 3 percent of the 14,000 formal industrywide standards in effect in 1964 were written under government auspices. See Hemenway [1975; p.81].

Second, notwithstanding a number of considerations that have induced sellers to seek and obtain standards, the principal beneficiaries of standards are buyers, not sellers, and not surprisingly therefore the principal impetus for standards has come from buyers. Third, standards are most likely to occur in markets where buyers are concentrated. This is because the benefits of standards are like a public good which falls on all buyers, who can free-ride on the lobbying costs of those who incur costs to obtain the standards. The single most telling piece of evidence in support of these latter two points is that the vast majority of industry-wide voluntary standards are in producers goods.

Fourth, since standard setting is so widespread the subject is vast and there are other many considerations that lead the establishment of standards, including supplier driven concerns such as economies of scale benefits, anticompetitive and protectionist motivations, and the desire to avoid free-rider problems on product quality that could destroy the market.[5] These considerations, especially legal prohibitions against intra-EC imports that do not meet national technical requirements, are specifically addressed by the single market program. The single market program will serve to increase buyer elasticities, since the European consumer will be able to consume products from other EC states that previously were illegal to import.

The Auto Case

Before discussing the subject generally, we discuss the case of the U.S. automobile industry since it serves to illustrate and clarify these and other points. During the first decade of the 20th century, the auto industry was composed of a large number of small firms, assemblers and parts suppliers. Products such as wheel rims, spark plugs and nuts and bolts were not standardized; rather parts were manufactured according to the peculiar specifications of each assembler, who often relied on only one parts supplier

[5] For a fascinating survey see Hemenway [1975], which is the source of the information in this appendix unless otherwise cited.

for a particular part. In 1910, a crisis hit the industry in which 18 assemblers and numerous parts suppliers exited the industry. The crisis made clear the advantages to the buyers of standardized parts, because when a parts supplier exited, problems were created for assemblers who could often not substitute among parts suppliers without significant delays. The Society of Automotive Engineers (SAE) was formed about that time, and given that its president believed that the lack of interchangeability among parts of different companies was responsible for the vast majority of assembler production problems, it earnestly set upon the task of defining auto parts standards. In the early years SAE committees were dominated by small auto makers, who were most interested in uniform parts specification. SAE succeeded in defining 224 sets of standards by 1921; as early as 1915 SAE found over 90 percent compliance with its standards among parts suppliers in products such as screws and bolts, wheels and rims, and spark plugs. By the 1920s, the SAE standards committees came to be dominated by large auto assemblers (notably General Motors and Ford), and the emphasis shifted from standard parts specifications (which was of less interest to G.M. and Ford since they could define these independently and obtain some competition among suppliers) to more basic raw material purchase requirements (like steel standards) and standards promoting efficiency of the automobile (like oil viscosity standards). Nownere was the attempt to establish raw material purchase standards more vigorously opposed than in the steel industry; the steel industry was reluctant to lose product differentiation advantages associated with brand names. But the auto industry wrote standards as was able to impose them on the steel industry, as well as in the rubber, petroleum and machine products industries.

Because consumers of autos are atomistic and because auto makers regard it as important to have a cheap high quality complementary products available, SAE extended its standard setting into some products that are complementary with auto purchases, such as brake fluid and oil viscosity. Oil refineries opposed SAE standards in auto oil, which had been classified only as light, medium and heavy because, like the steel industry, they did not want to lose product differentiation advantages of brand names.

Uniformity Standards

The objective of uniformity standards is to insure that the products of different sellers may be used interchangeably by buyers. Of course, quality differences among suppliers remain, so that the products that are interchangeable are not necessarily perfect substitutes; but without the standard for interchangeability no substitution would be possible. Thus, there is generally a strong increase in the ability of buyers to substitute among the products of sellers as a result of uniformity standards.

Well known examples of uniformity standards that increase buyers substitution possibilities among suppliers abound. Standard socket sizes in lamps allow substitution among light bulbs. A photographer may interchangeably choose among various films, cameras, tripods, lens, filters and exposure meters due to standardization. To facilitate replacement, bricks sizes were standardized under government regulation. Operating controls for forklift trucks are almost all standardized so that training of drivers is interchangeable among different manufacturers products. Despite the enormous variety of paper towels, virtually all are eleven inches wide to fit the standardized dispenser.

Quality Standards

One of the most important theoretical contributions on this subject is the model of Akerlof [1970]. He posits a situation characterized by asymmetric information, in which suppliers know the quality of their product and incur a cost for producing higher quality products. Buyers, however, only know the average quality of all products in the market prior to purchase. Then, suppliers of low quality products will free-ride on those who supply high quality products. Akerlof shows that a less than optimal quality product will be produced, and in some cases the market will collapse.

The Akerlof model is typically interpreted (Link [1980]) as showing that both producers and consumers will benefit from grading standards in these markets, i.e., standards which differentiate products according to better or worse qualities. What will often occur, however, without pressure from buyers, is that firms will invest in brand identification. Brand names solves the quality degradation problem since other brands cannot free ride on the higher quality. Buyers will then be reluctant to substitute among suppliers if the brand is of unknown quality, and the quality level of some brands of high quality may be unknown to the buyer. Quality standards then allow greater buyer substitution among competing brands because buyers are assured of quality; at the same time, quality standards reduce product differentiation advantages of sellers.

Typically products that are graded according to quality lack product differentiation advantages. This includes meat, lumber, wool, milk, eggs, soybeans, diamonds and mushrooms. SAE standards on products such as brake fluid and oil are other examples. On the other hand, tire and major paper makers have resisted grading so they could maintain product differentiation advantages.

Other Motivation for Standards

Small Firm Quality Assurance. Japanese exports in the 1950s are an example of where it was in the suppliers interest to e tablish standards. As can be explained by the Akerlof model, small and medium sized Japanese companies had a reputation for poor quality (it was relatively costly for them to create brand identification). But in 1949 Japan enacted, with manufacturers support, its exports standards and inspection law. The law covered 40 percent of Japanese exports and those that passed inspection for quality were entitled to affix the JIS (Japanese Industrial Standard) seal. Part of the increase in Japanese exports is attributed to this guarantor of product quality, which increased the willingness of buyers to substitute with Japanese products.

Anticompetitive Motivation. Suppliers will sometimes impose standards for anticompetitive purposes. Fearing anticompetitive standards, when the Federal Communications Commission introduced competition into the supply of equipment to telephone customers in the 1960s, it required standardized interconnection for terminal equipment so that independent suppliers could effectively compete with AT&T. This policy was extended to the Bell companies after the antitrust suit against AT&T. In addition, the FCC in its Computer III decision of 1986 required open network architecture (ONA), which means that the components of the telephone system are made available to competing suppliers on an unbundled basis so that competing supplier services can be combined in any desired manner. The FCC standardized interconnection and ONA policies have been enormously successful when judged by the wide variety of equipment available and greatly increased range of services that independent suppliers can offer to telecommunications customers. (See Besen and Saloner [1989] for further details).

As part of its single market program, EC policy is attempting to implement similar reforms in standards. The EC green paper on telecommunications policy indicates that through the promotion of Europe-wide standards it shall provide equal access to all market participants (EC [1987; p.5]). Moreover, ONA has been mandated by the Maastricht treaty for among other reasons to insure the uniform interpretation of essential requirements across the Community in order to limit the possibilities for the imposition of restrictive licensing conditions.[6]

Probably the best known example of supplier based anticompetitive standards is national standards that have the force of law for the purpose of protection, what the EC refers to as technical regulations. For example, EC courts interpreted German purity laws for beer as protectionist and required that beer manufactured in any member state could be imported into Germany. This is an application of the mutual recognition principle in which products produced in one member state may be sold throughout the EC. In the absence of specific EC legislation however, EC states may still block intra-EC imports if certain

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[6] See *XIII*, September 1993, p.12 (the magazine of DG XIII) and Emerson et al. [1988; p.86].

national interests are involved. So the EC has attempted to achieve harmonization of technical regulations in which EC directives indicate mandatory requirements for national regulations. A manufacturer may meet the technical requirements either by producing a product that meets the defined essential requirements (which allows manufacturer variety subject to the constraint of meeting the essential requirements of the product) or by producing a product in conformity with European standardization bodies (Emerson et al. [1988; p.40]). In either event, the European consumer will be able to consume products from other EC states that previously were illegal to import.

Conclusion

The theory and empirical work on standards indicates that the impact EC92 program of standards will be to substantially increase the ability of buyers to substitute among the products of EC suppliers. Given the exclusive focus of modelers on the cost savings effects of standards through economies of scale effects, there is a need to model the anticipated strong impact on consumer demand of standardization.

References

Akerlof, G., "The Market for 'Lemons:' Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, 84, 1970, 489-500.

Besen, Stanley and Garth Saloner, "The Economics of Telecommunications Standards," in R. Crandall and K. Flamm (eds.), *Changing the Rules: Technological Change, International Competition and Regulation in Communications* (Washington D.C.: The Brookings Institution, 1989).

Emerson, Michael et al., *The Economics of 1992* (Oxford: Oxford University Press, 1988).

European Community, *Towards a Dynamic European Economy: Green Paper on the Development of the Common Market for Telecommunications Equipment* (Brussels: EC Commission, 1987).

European Community, DG XIII, "Communications Policy on Telecommunications," *XIII* magazine, September 1993.

Farrell, Joseph and Garth Saloner, "Standardization, Compatibility and Innovation," *Rand Journal of Economics*, 16, 1985, 70-83.

Hemenway, David, *Industrywide Voluntary Product Standards* (Cambridge, MA: Ballinger, 1975).

Kindleberger, Charles, "Standards as Public, Collective and Private Goods," *Kyklos*, 36, 1983, 377-396.

Link, Albert, "Market Structure and Voluntary Product Standards," *Applied Economics*, 15, 1983, 393-401.

Tassey, Gregory, *Technology, Infrastructure and Competitive Position* (Norwell, MA.: Kluwer Academic Publishers, 1992).

Appendix D: Data and Benchmarking

This appendix outlines the steps involved in assembly of the raw data and calibration of the monopolistic submodel. Many details are omitted, since complete documentation for the interested reader is provided in the form of GAMS source code.

1. Assembly and Reconciliation of IO and Trade Data

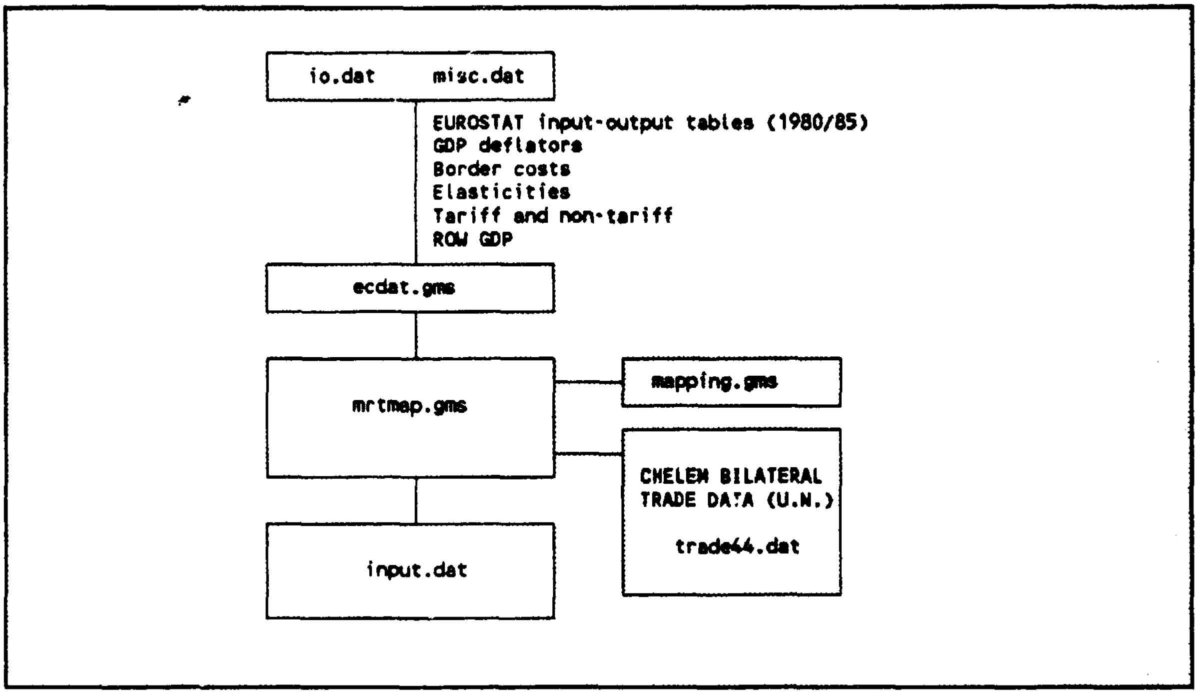
Two primary data sources for the MRT model are a set of *Eurostat* input-output tables for 1980/85, and the CHELEM harmonized accounts on trade and world economy for 1985. In addition, we use selected data from a variety of other sources, including the Penn GDP comparisons and Emerson's 1988 study. Detailed references are provided in the GAMS source code.

The GAMS programs involved in generating the model's input data are displayed in Table D-1. We began with a set of input-output tables in worksheet form obtain from the European Community. Separate region-specific GAMS programs (not shown in Table D-1) cross-check and reconcile the individual input-output tables, and they then generate a single aggregate file (io.dat) with data for all regions, aggregated to 44 sectors.

The CHELEM bilateral bilateral trade data is also obtained in spreadsheet files (for 1985), and written into GAMS-readable format in their most disaggregate form in file trade.dat.

The ECDAT.GMS program reads the Eurostat data and provides a few simple statistical reports for diagnosing errors. This program is used to restart MRTMAP.GMS which reads the commodity aggregation mapping (MAPPING.GMS) and the CHELEM trade data. The MRTMAP program first aggregates the input-output and trade data to a consistent 26-sector aggregation. Although the IO and bilateral trade data are provided at a 44-sector level, 26 was the largest number of sectors for which consistent domestic and trade statistics can be compiled. Following aggregation, the program "sifts" the

Table D-1: Overview of Programs



trade data by setting to zero any bilateral trade flow which is less than 1% of the value of commodity exports and imports. In order to maintain consistency in production accounts, the adjustment of trade flows is accompanied by a corresponding adjustment of domestic consumption.

MRTMAP generates two reports related to the sifting of trade data. Parameter DENSITY (Table D-2) reports the aggregate density of bilateral trade flow matrices before and after adjustment. Parameter CHANGE (Table D-3) reports percentage adjustment in consumption levels incurred by the trade data adjustment.

The second task performed by MRTMAP.GMS is to extract summary statistics comparing the trade flows reported in the *Eurostat* input-output tables with the aggregate trade flows from the Chelem data set. The results of this comparison are provided in parameters TRDVOL (Table D-4) and COMPARE (Table D-5 which presents results for Germany).

The third task performed by MRTMAP.GMS is to adjust bilateral trade flows data and infer trade flows with rest-of-world. This is done by solving a sequence of weighted least-squares problems, one for

Table D-2: Effects of Sifting Trade Flows

---- 11806 PARAMETER DENSITY COMPARISON OF TRADE FLOWS WITH SIFTING

SIFTED: DROP ALL ALL FLOWS WHICH ARE LESS THAN 1% OF MIN(SUPPLY, DEMAND)

	ORIG	SIFTED
AGR	84.028	63.194
FOO	63.889	54.167
BET	50.694	46.528
ENE	41.667	33.333
UTI	33.333	31.944
STE	59.722	54.167
NMM	51.389	40.972
CHM	79.167	61.111
MET	75.000	63.889
IMA	79.167	67.361
OMA	31.250	29.167
ELG	70.139	56.250
VEH	68.750	59.722
OTE	52.083	42.361
TXC	81.944	72.917
WOO	51.389	41.667
PAP	68.750	57.639
RPL	47.917	38.194
CON	51.389	45.139
TRA	38.889	37.500
FIN	61.111	52.778
TRN	76.389	70.833
HEA	6.944	6.944
EDU	10.417	9.722
SER	52.083	47.917
PUB	13.889	13.889

each traded commodity. The input to these problems are CHELEM bilateral trade statistics ($\bar{X}_{rr'}$) and EUROSTAT aggregate import and export statistics ($\bar{E}_r$ and $\bar{M}_{r'}$). The weights ($\omega_{rr'}$) assign a value of unity to intra-EC trade data and zero to trade flows with ROW:

$$\min \sum_{r,r'} \omega_{rr'} \left(X_{rr'} - \bar{X}_{rr'}\right)^2$$

s.t.

$$\sum_{r'} X_{rr'} = \bar{E}_r \qquad r \neq ROW$$

$$\sum_{r'} X_{r'r} = \bar{M}_r \qquad r \neq ROW$$

Following the calibration of trade flows and reconciliation with input-output statistics, the data constitutes a balanced equilibrium data set at a 12-region, 26-sector level. We write this data in GAMS-readable to a text file, input.dat, which is then used for subsequent modelling. The text file is used instead

Table D-3: Consumption Adjustment Required by Trade Data Sifting

---- 11814 PARAMETER CHANGE CONSUMPTION ADJUSTMENT DUE TO SIFTING (%)

+	BE	DE	DK	ES	FR	IT
AGR			1.000			
ENE			3.000			1.000
CHM	-1.000		8.000	2.000		
IMA	-1.000		1.000			
OMA	4.000				1.000	
ELG	-1.000		7.000	1.000		
OTE	5.000	-1.000	1.000	1.000		
TXC			1.000			
PAP			1.000			
RPL	1.000	-1.000	5.000			

+	NL	PT	UK	WR	TY
AGR		2.000		3.000	
FOO		4.000			
ENE	-1.000		-1.000	5.000	
STE		7.000			7.000
NMM		2.000		1.000	1.000
CHM	-1.000	2.000		17.000	
MET		2.000		2.000	
IMA	-1.000	7.000			1.000
OMA				1.000	
ELG	-1.000	9.000		1.000	1.000
VEH				1.000	
TXC				5.000	
WOO				3.000	
PAP		5.000		6.000	
RPL		7.000		1.000	1.000
FIN		2.000			1.000
TRN		1.000		4.000	

of a GAMS "restart" in order to provide a separation between names used in benchmarking and those used in the specification of model and reports. We also anticipate that users of the model will rarely need to go "below" this level, making it efficient to have code and data files that are self-contained from this point on (GAMS "restart" files are naturally very sensitive to the precise version of GAMS used to generate them, and this could cause problems if users employ different versions of GAMS).

2. Calibration of the Monopolistic Submodel

The final stage in data manipulation is to infer values for conjectural variations and numbers of firms which are consistent with specified scale elasticities and industry equilibria. These calculations are performed in program MRTCAL.GMS. This program reads the balanced equilibrium data set (input.dat),

Table D-4: Comparison of Aggregate Trade Volumes

---- 19578 PARAMETER TRDVOL COMPARISON OF AGGREGATE TRADE VOLUMES (INCLUDING ALL REGIONS BUT ROW)

	MTOT_EC	MTOT_CH	XTOT_EC	XTOT_CH
AGR	51	22	28	15
CHM	75	48	89	63
CON	5		8	
EDU			1	
ELG	50	33	52	35
FIN	24		26	
MET	20	17	28	26
NMM	18	7	21	12
PAP	23	19	17	15
PUB	1		4	
RPL	28	54	32	71
TRA	8		33	
TRN	28		63	
TXC	52	44	56	49
VEH	47	43	68	62
WOO	14	8	11	9
FOO	50	63	48	54
BET	7	7	10	11
ENE	175	131	69	60
UTI	2	1	2	1
STE	60	48	54	50
IMA	49	39	74	62
OMA	29	45	24	43
OTE	18	11	29	15
SER	9		6	

the sectoral aggregation (mapping.gms) and the assumed values for elasticities of substitution in production and final demand (esub.gms). This program also installs our estimates of border costs, non-tariff barriers, Armington elasticities and cost-disadvantage ratios (CDRs).

We have specified the value of production at consumer prices in the benchmark data. These numbers together with engineering estimates of cost disadvantage ratios determine the value of fixed costs by sector and region: $FC_{ir} = CDR_{ir}\ YC_{ir}$

The calibration of parameters specific to the monopolistic submodel begins from the free-entry assumption which assures that there are no excess profits. Subject to the zero-profit assumption, mark-ups over marginal cost generate revenue which exactly equals fixed cost. The monopolistic pricing rule is based on elasticities of substitution in demand, the number of firms operating in a given market, and an adjustment parameter, the "conjectural variation", which is equal to unity in markets characterized by

Table D-5: Comparison of Trade Volumes for Germany

---- 19591 PARAMETER COMPARE   COMPARISON OF EUROSTAT AND CHELEM TRADE VOLUMES

INDEX 1 = DE- (GERMANY)

	IO_M	IO_X	CH_M	CH_X	%OUTPUT	%CONSUM
AGR	14	2	4	1	-3	-108
CHM	18	29	10	19	-24	39
CON		3			-4	41
ELG	14	20	8	13	-25	36
FIN	5	3			-2	-2
MET	4	9	4	9	1	-28
NMM	3	4	2	3	-6	-32
PAP	6	6	4	5	-2	-15
PUB	1					
RPL	6	8	11	20	73	-118
TRA	1	6			-6	9
TRN	6	13			-26	47
TXC	16	10	14	9	-3	-7
VEH	8	33	8	30	-11	17
WOO	3	2	2	3	1	-16
FOO	10	8	15	8		12
BET	1	1	1	1	2	
ENE	36	4	29	5	2	-43
UTI	1				-1	
STE	15	14	12	14		-2251
IMA	8	30	7	26	-16	1507
OMA	8	8	10	13	57	-137
OTE	3	4	2	2	-41	172
SER	2	1			-2	-3

"pure" Cournot-Nash players.

We would prefer to work with a model in which all markets are characterized by Cournot-Nash equilibria, but this assumption may not be consistent with the assumption of free-entry and zero profits in the benchmark, given values for elasticities of substitution. We evaluate the consistency of the Cournot-Nash model by solving a sequence of least-squares problems, one for each commodity produced subject to increasing returns to scale. These problems look implicit numbers of firms (Nr) which result in calibrated conjectural variations ($CV_{rr'}$) which are as close as possible to unity:

The constraints in these least-squares problems impose zero-profit -- fixed costs equal the value of markup revenue with markups calculated on the basis of benchmark value shares (θ) and exogenously-specified elasticities (σ). Table D-6 reports values of calibrated conjectural variations for the commodity STE (iron and steel). These results are roughly consistent with those obtained for CHM, MET, IMA, OMA, ELG and RPL -- all calibrate to conjectural variations which are considerably less than unity on domestic

$$\min_{CV^i_{rr'},\ N_i} \sum_{rr'} (CV^i_{rr'} - 1)^2$$

s.t.

$$FC_{ir} = \sum_{rr'} X^i_{rr'} \ M^{G}(CV^i_{rr'},\ N_{ir};\ \sigma,\ \theta)$$

$$0 \le N_{ir} \le 100, \quad CV^i_{rr'} \ge 0$$

markets, indicating more competititve pricing behavior than is predicted by the Cournot model, subject to our assumed value shares and demand elasticities.

The markets can be calibrated to "pure Cournot" pricing include FOO, NMM, VEH, OTE, and PAP. For these markets, we perform a second calculation in which we try to find numbers of firms which are as small as possible, subject to benchmark consistency with Cournot conjectures:

Table D-6: Calibrated Non-Cournot Conjectural Variations

---- 358 PARAMETER OMEGA CALIBRATED NON-COURNOT CONJECTURAL VARIATIONS

	ROW	BE	DE	DK	ES	FR
STE.BE		0.509	0.487		0.738	0.551
STE.DE			0.501			
STE.DK				0.830		
STE.ES					0.526	
STE.FR	0.868		0.887			0.350
STE.IT						
STE.NL	0.286	0.663	0.442			0.805
STE.PT						
STE.UK	0.814	0.735				
STE.MR	0.471					

+	IT	NL	PT	UK	MR	TY
STE.BE	0.645			0.512		
STE.DE						
STE.DK				0.490		
STE.ES						
STE.FR	0.854	0.883				
STE.IT	0.573					
STE.NL	0.849	0.680		0.721		
STE.PT			0.661			
STE.UK				0.381		
STE.MR					0.854	
STE.TY						0.697

$$\max_{N_{ir}} \; \min_{r} \; (N_{ir})$$

s.t.

$$FC_{ir} = \sum_{rr'} X^{i}_{rr'} \; M^{G}(CV^{i}_{rr'}, N_{ir})$$

$$0 \leq N_{ir} \leq 100, \quad CV^{i}_{rr'} = 1$$

3. The Benchmark Equilibrium

The following pages provide a summary of aggregate and sectoral statistics from the constructed benchmark dataset.

---- 12223 PARAMETER INCOME INCOME SOURCES AND CHECK SUMS

	ROW	BE	DE	DK	ES	FR
FACTOR	8287.689	96.338	688.384	65.174	266.373	623.490
VA_TAX		0.024	0.576	0.160	0.191	1.190
TARIFF		0.910	2.756	0.395	0.320	1.537
NTB-M		0.526	1.347	0.334	0.469	1.249
NTB-X	10.308	0.366	1.158	0.149	0.199	0.996
TRDBAL	18.395	0.526	-34.422	0.220	6.146	-2.687
TOTAL	8316.392	98.689	659.798	66.433	273.698	625.776
CHKSUM		1.78787E-10	6.783353E-9	1.01608E-11	1.425462E-9	-1.96758E-9

+	IT	NL	PT	UK	MR	TY
FACTOR	428.378	136.767	41.741	541.456	24.957	150.695
VA_TAX	0.220	0.043	0.048	0.809		
TARIFF	1.064	1.010	0.121	3.195	0.010	0.057
NTB-M	0.675	0.582	0.252	1.334		
NTB-X	0.715	0.344	0.007	0.564	0.006	0.013
TRDBAL	7.555	-1.156	8.277	-10.457	2.390	5.213
TOTAL	438.606	137.589	50.447	536.900	27.363	155.979
CHKSUM	-8.41726E-9	1.73941E-11	-7.2582E-11	2.49884E-10	2.91358E-11	5.29496E-11

```
SET     S   Sectoral identifiers for the 26-sector model
        /        AGR      Agriculture,
                 FOO      Food,
                 BET      Beverages and Tobacco,
                 ENE      Energy,
                 UTI      Utilities,
                 STE      Iron and Steel,
                 NMM      Non-Metallic Mineral Products,
                 CHM      Chemicals,
                 MET      Metal Products,
                 IMA      Industrial Machinery,
                 OMA      Office Machinery,
                 ELG      Electrical Goods,
                 VEH      Motor Vehicles,
                 OTE      Other Transport Equipment,
                 TXC      Textiles and Clothing,
                 WOO      Wood,
                 PAP      Paper and Printing,
                 RPL      Rubber and Plastics,
                 CON      Construction and Repair,
                 TRA      Trade,
                 FIN      Financial Services,
                 TRN      Transport and Communication,
                 HEA      Health,
                 EDU      Education,
                 SER      Other Market Services,
                 PUB      General Public Services/;

     R  Regions in the model /
                 BE       Belgium,
                 DE       West Germany,
                 DK       Denmark,
                 ES       Spain,
                 FR       France,
                 IT       Italy,
                 NL       Netherlands,
                 PT       Portugal,
                 UK       United Kingdom,
                 MR       Morocco,
                 TY       Turkey,
                 ROW      Rest of world/;
```

---- 12302 PARAMETER PRDSHR SHARES OF GLOBAL PRODUCTION (%)

	ROW	BE	DE	DK	ES	FR
AGR	44.64	1.32	6.80	1.47	6.89	11.91
FOO	68.28	1.05	6.15	0.94	3.40	5.90
BET	66.19	1.01	7.62	0.96	3.54	3.65
ENE	52.87	1.60	7.73	0.56	3.97	8.36
UTI	50.58	1.48	14.90	0.87	4.66	8.86
STE	30.46	4.62	24.29	0.14	8.55	9.17
NMM	28.36	2.31	15.97	0.99	6.93	10.55
CHM	49.40	1.81	15.36	0.60	3.80	8.46
MET	27.31	1.46	19.53	1.13	5.00	13.73
IMA	46.23	1.12	19.07	1.14	2.52	6.15
OMA	58.07	0.31	15.11	0.57	3.00	9.20
ELG	46.23	1.29	17.43	0.60	3.12	9.73
VEH	59.78	1.37	15.66	0.34	3.46	7.67
OTE	60.98	0.75	5.94	1.23	2.76	10.82
TXC	63.87	1.03	5.50	0.40	3.19	5.66
WOO	53.21	1.72	10.34	1.06	3.21	7.12
PAP	39.88	1.40	17.48	1.37	3.56	11.37
RPL	48.48	1.43	12.87	0.71	4.57	9.00
CON	37.56	2.55	11.57	1.47	5.94	12.63
TRA	64.72	0.99	7.29	0.78	2.69	6.61
FIN	54.11	1.44	13.49	0.95	3.86	10.66
TRN	49.76	1.57	9.56	1.39	3.94	8.64
HEA	68.94	1.15	9.80	0.91	2.77	8.75
EDU	73.47	1.53	7.28	0.88	2.06	8.54
SER	68.58	0.47	4.84	0.43	4.36	5.39
PUB	74.32	0.60	7.12	0.56	1.42	4.25
VA	73.01	0.85	6.06	0.57	2.35	5.49

+	IT	NL	PT	UK	MR	TY
AGR	7.40	2.62	1.52	6.61	0.14	8.68
FOO	3.90	1.93	0.76	5.07	0.93	1.71
BET	2.70	1.42	0.56	10.36	0.16	1.82
ENE	4.96	3.64	0.55	12.17	0.29	3.31
UTI	5.47	1.64	0.72	8.53	0.24	2.05
STE	9.75	1.59	0.62	10.37	0.10	0.34
NMM	13.27	2.20	1.57	11.97	1.39	4.48
CHM	7.21	2.58	0.65	7.99	0.32	1.83
MET	11.07	2.32	0.88	11.79	0.44	5.34
IMA	8.68	1.24	0.25	12.00	0.19	1.42
OMA	6.07	0.68		6.96	0.04	
ELG	7.08	2.50	0.49	9.86	0.12	1.55
VEH	3.64	0.63	0.63	5.63	0.12	1.07
OTE	4.32	2.12		11.08		
TXC	9.70	0.73	1.52	4.99	0.60	2.81
WOO	9.89	1.41	1.30	6.88	0.52	3.36
PAP	6.99	3.16	0.80	12.35	0.21	1.43
RPL	8.25	1.58	0.78	9.36	0.23	2.74
CON	9.77	3.59	1.21	11.10	0.40	2.21
TRA	5.80	1.64	0.70	6.65	0.26	1.88
FIN	5.96	1.65	0.34	6.60	0.04	0.91
TRN	6.45	2.15	0.65	10.45	0.28	5.16
HEA	5.05	2.28	0.36			
EDU	5.04	0.85	0.34			
SER	4.71	0.92	0.38	8.54	0.38	1.00
PUB	2.32	1.57	0.22	6.92	0.22	0.48
VA	3.77	1.20	0.37	4.77	0.22	1.33

---- 12302 PARAMETER EXPFRC EXPORTS AS FRACTION OF DOMESTIC PRODUCTION (%)

	ROW	BE	DE	DK	ES	FR
AGR	17	23	7	17	7	15
FOO	4	34	12	45	8	13
BET		17	5	7	7	22
ENE	31	48	8	22	16	11
UTI		6		3		3
STE	31	74	24	67	22	39
NMM	4	40	17	21	14	18
CHM	20	90	39	49	18	37
MET	8	36	19	33	15	14
IMA	9	80	46	49	23	36
OMA	31	80	49	82	30	41
ELG	13	72	37	39	12	29
VEH	4	90	51	7	32	41
OTE	14	57	46	54	24	53
TXC	4	77	34	46	21	24
WOO	3	32	14	45	12	9
PAP	9	44	14	12	13	11
RPL	16	88	30	42	14	27
CON		3	4			1
TRA		18	6	16	5	4
FIN		9	2		2	6
TRN	2	44	20	31	20	12
EDU						2
SER		2	2		1	

+	IT	NL	PT	UK	MR	TY
AGR	6	30		13	4	5
FOO	7	39	3	11	7	9
BET	6	27	17	10	13	20
ENE	10	57	10	38		4
UTI		1				
STE	17	83	7	41	73	
NMM	16	24	12	38	45	12
CHM	18	77	16	37		7
MET	14	25	13	10	5	18
IMA	38	60	6	25		15
OMA	42	90		72		
ELG	25	69	23	21		4
VEH	30	49	25	21		6
OTE	36	63		65		
TXC	29	60	29	18	12	34
WOO	13	16	37	10		7
PAP	9	18	22	8		3
RPL	26	61	17	40		8
CON		4		2		
TRA	7	21	2			13
FIN	4	3		3	8	
TRN	17	40	28	10	15	19
EDU		8				
SER				3	7	14
PUB		12				

---- 12302 PARAMETER IMPFRC IMPORTS AS FRACTION OF DOMESTIC CONSUMPTION (%)

	ROW	BE	DE	DK	ES	FR
AGR	10	45	33	16	11	13
FOO	4	32	15	21	6	13
BET	3	17	5	8	6	13
ENE		68	44	57	46	39
UTI		5	1	3		
STE	25	71	26	88	18	40
NMM	13	40	16	28	9	17
CHM	25	87	30	60	24	34
MET	19	44	11	41	8	11
IMA	25	83	21	56	35	41
OMA	25	93	50	78	58	54
ELG	15	74	30	55	24	29
VEH	12	91	21	50	20	33
OTE	25	65	41	50	19	27
TXC	6	77	45	57	9	29
WOO		39	17	41	8	17
PAP	4	48	14	24	12	15
RPL	22	90	24	47	12	28
CON	2	4				
TRA	3	9	1		2	
FIN	1	6	2	9	4	4
TRN	11	9	10	1	6	7
SER		4	4			

+	IT	NL	PT	UK	MR	TY
AGR	19	37	24	21	18	2
FOO	15	28	8	17	8	6
BET	11	24	2	6	5	5
ENE	47	61	55	28	37	34
UTI	4		5			6
STE	31	85	45	46	11	22
NMM	9	40	12	36	13	14
CHM	27	69	44	27	23	34
MET	5	32	15	10	33	24
IMA	21	72	72	23	61	52
OMA	49	93		70	56	
ELG	26	68	42	25	36	29
VEH	35	71	42	31	34	25
OTE	28	57		52		
TXC	12	77	10	27	9	7
WOO	8	52	4	25	13	2
PAP	12	25	12	15	20	9
RPL	17	71	40	36	13	16
CON	1	1		2		
TRA	4	4				
FIN	4		4	3		4
TRN	4	40	13	10	4	6
SER		25		3	1	8
PUB		2				

---- 12302 PARAMETER EXPFRC EXPORTS AS FRACTION OF DOMESTIC PRODUCTION (%)

	ROW	BE	DE	DK	ES	FR
AGR	17	23	7	17	7	15
FOO	4	34	12	45	8	13
BET		17	5	7	7	22
ENE	31	48	8	22	16	11
UTI		6		3		3
STE	31	74	24	67	22	39
NMM	4	40	17	21	14	18
CHM	20	90	39	49	18	37
MET	8	36	19	33	15	14
IMA	9	80	46	49	23	36
OMA	31	80	49	82	30	41
ELG	13	72	37	39	12	29
VEH	4	90	51	7	32	41
OTE	14	57	46	54	24	53
TXC	4	77	34	46	21	24
WOO	3	32	14	45	12	9
PAP	9	44	14	12	13	11
RPL	16	88	30	42	14	27
CON		3	4			1
TRA		18	6	16	5	4
FIN		9	2		2	6
TRN	2	44	20	31	20	12
EDU						2
SER		2	2		1	

+	IT	NL	PT	UK	MR	TY
AGR	6	30		13	4	5
FOO	7	39	3	11	7	9
BET	6	27	17	10	13	20
ENE	10	57	10	38		4
UTI		1				
STE	17	83	7	41	73	
NMM	16	24	12	38	45	12
CHM	18	77	16	37		7
MET	14	25	13	10	5	18
IMA	38	60	6	25		15
OMA	42	90		72		
ELG	25	69	23	21		4
VEH	30	49	25	21		6
OTE	36	63		65		
TXC	29	60	29	18	12	34
WOO	13	16	37	10		7
PAP	9	18	22	8		3
RPL	26	61	17	40		8
CON		4		2		
TRA	7	21	2			13
FIN	4	3		3	8	
TRN	17	40	28	10	15	19
EDU		8				
SER				3	7	14
PUB		12				

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