

Sensitivity of CGE Trade Policy Analysis under Imperfect Competition to the Specification of Firm Conduct

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Abstract:

In order to contribute to a more comprehensive understanding of the robustness of the quantitative results of applied trade policy simulations to variations in the assumptions about firm conduct, the present paper provides a systematic synopsis of alternative formulations of imperfectly competitive supply behaviour in applied general equilibrium trade models and examines the sensitivity of simulated trade policy effects to the specification choice within a stylised three-region prototype model.

Keywords: Trade policy; Imperfect competition.

1. Introduction

Starting with the “industrial organization revolution” in trade theory in the 1980s, a growing number of applied quantitative partial and general equilibrium trade policy studies featuring imperfectly competitive supply behaviour and economies of scale has been presented in the literature. The apparent advantage of these studies over conventional studies based on a framework of perfect competition lies in their ability to account for potential scale effects and pro-competitive price mark-up effects commonly emphasized by proponents of trade liberalization and regional integration schemes.

Yet the design of a structural model allowing for such effects faces an immediate problem: Once the fairly clear-cut world of perfect competition is abandoned, a vast range of a priori plausible alternative specifications of firm conduct opens up.

The possibility that the choice of specification may crucially predetermine the tenor of CGE simulation results would seem to call for extensive sensitivity analyses across a wide spectrum of alternative oligopoly models, given that the empirical industrial organization literature provides little guidance with respect to the appropriate choice in this respect. However, it goes without saying that practical feasibility constraints necessarily limit the scope for sensitivity analysis in large-scale multi-region models and some model pre-selection is required to reduce the range of specification

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alternatives under consideration in any applied study. Correspondingly, while the existing applied trade policy literature as a whole employs a wide array of different models of firm conduct, individual studies offer at best only rudimentary sensitivity results for narrow subsets of specification alternatives.

In order to contribute to a more comprehensive understanding of the robustness of the quantitative results of applied trade policy simulations to variations in the assumptions about firm conduct, the present paper provides a systematic synopsis of alternative formulations of imperfectly competitive supply behaviour in applied general equilibrium trade models and examines the sensitivity of simulated trade policy effects to the specification choice within a simple proto-type model.

The paper is organized as follows. Section 2 sets out the generic analytic framework into which the various models of firm conduct are embedded. Since all models of firm conduct under consideration are based on profit maximisation behaviour subject to given perceptions about the type of oligopolistic interaction, firms' supply behaviour is generically characterised by a Lerner-type mark-up equation which relates equilibrium price-cost margins to perceived elasticities of demand. Section 3 is deliberately boring and describes in explicit algebraic detail the endogenous determination of these perceived elasticities: Section 3.1 considers supply behaviour in models with intra-industry product homogeneity across firms located in the same region while section 3.2 turns to models featuring intra-industry product differentiation. In each case, we distinguish (i) between Bertrand- and Cournot-type behaviour including conjectural variations extensions of each, (ii) between international market integration and market segmentation regimes, and (iii) between alternative assumptions about agents' preference relations among goods of different regional origin, i.e. between alternative demand-side commodity nesting hierarchy specifications. In order to compare the comparative-static behaviour of the various imperfect competition models under consideration and to assess the sensitivity of results to the choice of model, all specifications are calibrated to the same hypothetical benchmark data set as detailed in section 4, and subjected to the same trade policy shock in section 5. Section 6 draws conclusions.

2. The Generic Analytical Framework

The generic analytical framework for the illustrative simulations presented below distinguishes three countries (A,B,C), two industries / commodity groups per country (PC, IC) one of which is perfectly competitive, and one primary factor of production which is mobile across sectors but immobile across countries.

All produced output enters into final demand only and there is a representative rational price-taking final demand agent in each region. Demand for top-level commodity groups is governed by Cobb-Douglas preferences so that

$$(1) \quad A_{i,r} = \alpha_{i,r} Y_r / P A_{i,r}, \quad i \in I = \{PC, IC\}, \quad r \in C = \{A, B, C\},$$

where A is an Armington-type composite defined over domestic and imported goods, PA its dual price index,

$$(2) \quad Y_r = w_r L_r + \pi_r + T_r, \quad r \in C$$

denotes aggregate income, where w is the wage rate, L the inelastic labour endowment, π eventual pure profits earned in the IC industry, and T_r is the lump-sum redistribution of tariff revenue.

In line with the demand system specification typically adopted in existing large-scale multi-country applied general equilibrium models – such as the GTAP model (Hertel / Tsigas, 1997), the GEM-E3 model employed in various European Commission studies (e.g. Capros et al., 1998), or the Harrison / Rutherford / Tarr (1996, 1997) model – the demand nesting structure at the commodity group level is given by

$$(4) \quad A_{i,r} = [\delta 1_{i,r} D_{i,r}^{(\sigma_A-1)/\sigma_A} + \delta 2_{i,r}) M_{i,r}^{(\sigma_A-1)/\sigma_A}]^{\sigma_A/(\sigma_A-1)}, \quad i \in I, r \in C,$$

$$(5) \quad M_{i,r} = \left[\sum_{o \neq r} \gamma_{i,o,r} M_{i,o,r}^{(\sigma_M-1)/\sigma_M} \right]^{\sigma_M/(\sigma_M-1)}.$$

$D_{i,r}$: Demand for domestic i -type output in region r ;

$M_{i,r}$: Composite i -type import demand by region r ;

$M_{i,o,r}$: Type i imports of origin o demanded by region r ;

σ_A : Elasticity of substitution between domestic output and import composite;

σ_M : Elasticity of substitution between imports of different geographic origin.

In the special case $\sigma_A = \sigma_M$, the demand nesting hierarchy collapses towards a flat nesting structure with a uniform constant elasticity of substitution between goods of all geographic origins.

The lower-level demand functions for output of *origin* r (dropping the industry subscript) take the form

$$(6) \quad D_r(.) = \delta_r^{\sigma_A} \left(\frac{P_{r,r}}{PA_r} \right)^{-\sigma_A} A_r(.)$$

$$(7) \quad M_{r,s}(.) = \gamma_{r,s}^{\sigma_M} \left(\frac{P_{r,s}}{PM_s} \right)^{-\sigma_M} M_s(.), \quad M_s(.) = (1 - \delta_s)^{\sigma_A} \left(\frac{PM_s}{PA_s} \right)^{-\sigma_A} A_s(.),$$

where $P_{r,s}$ is the demand price faced by region s for goods of origin r and PM_s is the import price index faced by region s dual to the import quantity index M_s

In the comparative analysis, we consider both model specifications with product homogeneity and specifications with horizontal product differentiation between IC firms located in the same region. In the latter case, D_r and $M_{r,s}$ represent Dixit-Stiglitz (1977)-type composites defined over firm-specific varieties and the $P_{r,s}$ are the associated price indices, i.e.

$$(8) \quad D_r = \left[\sum_{v=1}^{n_r} x_{r,r}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)}, \quad M_{r,s} = \left[\sum_{v=1}^{n_r} x_{r,s}^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)},$$

where $x_{r,s}$ is the quantity of a firm-specific variety of origin r demanded by region s and σ is the elasticity of substitution between firm-specific varieties produced in the same region.

In this case, the demand functions for an individual firm-specific variety produced in region r take the forms

$$(9) \quad x_{r,r} = \left(\frac{P_{r,r}}{pc_{r,r}} \right)^\sigma D_r(.) \quad , \quad x_{r,s} = \left(\frac{P_{r,s}}{pc_{r,s}} \right)^\sigma M_{r,s}(.), \quad s \neq r,$$

where $pc_{r,s}$ denotes the consumer price per variety of origin r in region s . The combination of international product differentiation a la Armington with intra-industry product differentiation a la Dixit-Stiglitz may arguably be considered as a theoretically unappealing concoction, if one takes the view that the introduction of the love-of-variety approach into trade theory by Krugman(1979;1980) has provided a deeper and hence superior explanation for the intra-industry trade phenomenon than the "ad hoc" Armington approach.¹ While the demand system (4)-(5)-(8) contains the pure undiluted love-of-variety model of new trade theory as a special case ($\sigma=\sigma_M=\sigma_A$) and is treated as such in the simulations below, we also allow for the general case $\sigma>\sigma_M\geq\sigma_A$ for several reasons. First, the question as to which demand system specification is preferable is ultimately an empirical one and cannot be decided by theoretical reasoning or on the basis of aesthetic grounds alone. Second, the latter specification has indeed been adopted in a number of existing CGE studies (e.g. Harrison/Rutherford/Tarr, 1997) and is therefore included in the comparative analysis. Third, unlike the pure love-of-variety model, the mixed Armington-Dixit-Stiglitz model with its additional free parameters allows to calibrate the model in such a way that it can replicate at the same time extraneous information on price-cost margins, concentration levels, and trade elasticities.²

Technologies in the PC sectors are characterised by constant returns to scale and are represented by linear production functions with factor productivity parameter $a_{PC,r}$. The imperfectly competitive sector in each region r is populated by n_r symmetric firms. A recurrent fixed labour requirement Lf_r is required in each firm before output can be produced according to a linear technology with factor productivity parameter $a_{IC,r}$.

The factor market clearing conditions are thus

$$(10) \quad L_r = \frac{X_{PC,r}}{a_{PC,r}} + n_r \left(\frac{x_{IC,r}}{a_{IC,r}} + Lf_r \right), \quad r \in C$$

where X_{PC} is industry output in the PC sector and x_{IC} denotes output per firm in the IC sector.

Profit maximisation behaviour in the PC industries entails

¹ See Norman(1990, p.726) and Francois /Reinert (1997, p.8).

² See Willenbockel (1994, p.114-7) for a detailed discussion of this point.

$$(11) \quad p_{PC,r} = w_r / a_{PC,r} \quad , \quad r \in C$$

where p denotes the supply price.

Price-setting behaviour in IC industries depends on firms' perceptions of domestic and foreign rivals' behaviour as well as on the type of international market regime and is described by the generic mark-up formulae

$$(12a) \quad p_{IC,r} = \frac{w_r}{a_{IC,r} [1 - 1/\varepsilon_r(.)]} \quad , \quad r \in C$$

if markets are internationally integrated so that the law of one price reigns globally and firms must charge a uniform supply price across all regional market segments, where ε_r denotes the perceived price elasticity of global demand for the output of a firm located in r - or

$$(12b) \quad p_{IC,r,d} = \frac{w_r}{a_{IC,r} [1 - 1/\varepsilon_{r,d}(.)]} \quad , \quad r, d \in C$$

if markets are internationally segmented so that the absence of cross-border arbitrage allows firms to engage in regional price discrimination, whereby $p_{IC,r,d}$ is the supply price for output of origin r in market destination d and $\varepsilon_{r,d}$ is the associated perceived demand elasticity. The explicit functional forms for $\varepsilon(.)$ are contingent on the assumed form of oligopolistic interaction as well as on the assumed demand nesting hierarchy as detailed in section 3.

In all scenarios considered below we assume free entry or exit of firms in response to the occurrence of pure profits, so that equilibrium firm numbers are endogenously governed by the zero profit conditions³

$$(13) \quad \begin{aligned} \pi_r &= [(p_{IC,r} - w_r / a_{IC,r})x_{IC,r} - Lf_r]n_r = 0 \quad \text{or} \\ \pi_r &= [\sum_d p_{IC,r,d} x_{IC,r,d} - w_r x_{IC,r} / a_{IC,r} - Lf_r]n_r = 0 \quad , \quad r \in C \end{aligned}$$

3. Firm Conduct and Perceived Demand Elasticities: A Synopsis

This section provides a synopsis of the operational formulae for the endogenous determination of the perceived demand elasticities which govern equilibrium mark-ups in IC industries via (12a) or (12b) under alternative assumptions about oligopolistic interaction.

³ No integer constraint is imposed on n as this would in my view constitute a fallacy of misplaced concreteness at all practically feasible industry aggregation levels in actual multi-country models – within the model n serves as a concentration index and is reasonably treated as a continuous variable.

In all cases under consideration, the individual IC firm takes aggregate income as independent of its own decisions and assumes that the elasticity of the demand for composite commodity $A_{IC,r}$ with respect to $PA_{IC,r}$ is equal to Ω . Here Ω serves as a generic parameter to encompass alternative assumptions in existing models as special cases and to accommodate non-homothetic top-level preferences. Setting $\Omega=0$ corresponds to the assumption that firms perceive to have no influence on top-level composite demand *quantities* (as e.g. in Böhringer / Welsch / Löschel, 2000), while $\Omega=1$ is equivalent to assuming that firms perceive to have no influence on top-level commodity-group *expenditure* levels. In accord with (1), Ω is set to unity in all simulations presented below.

3.1. Intra-Industry Product Homogeneity

- **Domestic Cournot oligopoly under global market integration**

With globally integrated markets, the individual Cournot oligopolist from region r chooses its profit-maximising supply quantity x_r to the world market under the assumption, that *domestic* rivals' supply quantities do not respond to changes in its own supply. Following the implicit assumption in Francois / Roland-Holst (1997, p.346) and Francois (1998), the more distant *foreign* rivals, who produce similar goods in the same commodity group are from not considered as players in the oligopoly game contemplated by the r firm under consideration.⁴ An alternative would be to extend the Cournot conjecture to foreign rivals. However, the assumption that foreign rivals' quantities remain fixed implies that rivals' prices must respond to variations in x_r , given that any variation in x_r entails a shift in foreign rivals' demand curves, and the determination of these Cournot-equivalent foreign rival price responses is a somewhat tedious task, as demonstrated further below for the case with product differentiation.

The total demand function for output of origin r is

$$(14) \quad X_r(.) = D_r(.) + \sum_{s \neq r} M_{r,s}(.)$$

with (6) and (7). Under the domestic Cournot assumption, perceived marginal revenue is

$$(15) \quad \frac{\partial(P_r x_r)}{\partial x_r} = P_r + \frac{\partial P_r}{\partial X_r} \frac{\partial X_r}{\partial x_r} x_r = P_r \left(1 + \frac{\partial P_r}{P_r} \frac{X_r}{\partial X_r} \frac{x_r}{X_r} \right) = P_r \left(1 - \frac{1}{E_r n_r} \right),$$

⁴From the perspective of classical oligopoly theory, one could describe the setting equivalently as one where the individual oligopolist from r holds the Cournot conjecture for domestic rivals and the Bertrand conjecture for foreign rivals (namely that foreign rivals' prices do not change in response to changes in its own supply behaviour). However, the point is that the equilibrium of the model under consideration is not a global Nash equilibrium among all firms supplying the integrated market, but rather a general equilibrium involving three separate (but mutually consistent) Cournot-Nash equilibria corresponding to three separate simultaneous output games played among the domestic firms from each region.

where $E_r = -\hat{X}_r / \hat{P}_r$ denotes the perceived elasticity of the total market demand function (14), i.e. $\varepsilon_r = E_r n_r$ in the mark-up formula (12a) and E_r is found by log-differentiation of (14) with (6), and (7). Note that

$$\frac{P\hat{A}_s}{\hat{P}_r} = \frac{P\hat{A}_s}{P\hat{M}_s} \frac{P\hat{M}_s}{\hat{P}_r} = S_{r,s} \quad \text{and} \quad \frac{P\hat{M}_s}{\hat{P}_r} = SM_{r,s} ,$$

$S_{r,s}$: Share of region r in region s 's total commodity group expenditure.

$SM_{r,s}$: Share of region r in region s 's import bill for the commodity group.

Note also: $S_{r,s} = (1 - S_{s,s})SM_{r,s}$.

With these notational conventions for value shares, the perceived elasticity is

$$(16) \quad E_r = \frac{D_r}{X_r} [\sigma_A - (\sigma_A - \Omega)S_{r,r}] + \sum_{s \neq r} \frac{M_{r,s}}{X_r} [\sigma_M - (\sigma_M - \sigma_A)SM_{r,s} - (\sigma_A - \Omega)S_{r,s}] .$$

In the special case $\sigma_A = \sigma_M$, the elasticity formula simplifies to

$$(16') \quad E_r = \sigma - (\sigma - \Omega) \sum_s \frac{M_{r,s}}{X_r} S_{r,s} , \quad (M_{r,r} \equiv D_r) .$$

Note that (16') is exactly equivalent (for $\Omega=1$) to (18)-(19) in Francois/Roland-Holst (1996).⁵

• Cournot oligopoly under regional market segmentation

When markets are geographically segmented, the individual Cournot oligopolist located in region r is able to choose the supply quantity to each regional market separately. The relevant elasticities in the mark-up equations (12b) are $\varepsilon_{r,s} = n_r E_{r,s}$ where

$$(17) \quad E_{r,r} = -\frac{\hat{D}_r}{\hat{P}_{r,r}} = \sigma_A - (\sigma_A - \Omega)S_{r,r}$$

$$(18) \quad E_{r,s} = -\frac{\hat{M}_{r,s}}{\hat{P}_{r,s}} = \sigma_M - (\sigma_M - \sigma_A)SM_{r,s} - (\sigma_A - \Omega)S_{r,s} , \quad s \neq r .$$

• Oligopoly with conjectural output variations

The Cournot model presented above can be seen as special case of a general conjectural variations model in outputs, in which each oligopolist is assumed to conjecture that the relation between changes in domestic industry supply and changes in its own supply quantity is given by $dX = v dx$, where v is a constant parameter. In

⁵ It can be shown that the bulky inverted bracket term in Francois/Roland-Holst's (19) is just equal to $S_{r,s}$.

this case perceived marginal revenue under global market integration takes the form (compare Francois/Roland-Holst(1996))

$$(19) \quad \frac{\partial(P_r x_r)}{\partial x_r} = P_r + \frac{\partial P_r}{\partial X_r} \frac{\partial X_r}{\partial x_r} x_r = P_r \left(1 + \frac{\partial P_r}{P_r} \frac{X_r}{\partial x_r} \frac{x_r}{X_r} v_r \right) = P_r \left(1 - \frac{v_r}{E_r n_r} \right),$$

i.e.), i.e. $\varepsilon_r = E_r n_r / v_r$ in (12a) (or $\varepsilon_{r,s} = E_r n_{r,s} / v_{r,s}$ in (12b) under market segmentation) whereby the perceived market demand elasticity is still given by (16) (or (17)-(18)). The conjectural variations approach has been used in a number of simulation studies – e.g. Dixit(1987;1988) – in order to break the link between observed price-cost margins in the benchmark data set and substitution elasticities: Given that benchmark firm numbers are set in accordance with extraneous industry concentration data, while the benchmark value shares in (16) as well as benchmark price-cost margins are predetermined by the benchmark data set, the substitution elasticities in (16) would have to be calibrated residually to ensure that the model replicates the price-cost margins of the benchmark data set. However, the resulting substitution elasticity values may imply implausible magnitudes for the price elasticities of model trade flows. By introducing an additional parameter, v , the conjectural variations approach allows to set substitution elasticity values extraneously, while v is calibrated residually. From the perspective of theoretical rigour, the conjectural variations approach is unsatisfactory, “as it does not subject itself to the discipline imposed by game theory” (Tirole, 1988, 244-5) and the resulting equilibrium is not a Nash equilibrium.

As Paul Krugman noted in a comment on Venables/Smith(1986:662-3) in this context, “nobody likes the conjectural variation approach... . The only justification for committing conjectural variations is that nothing else is available. Some day clean industrial organization models that also fit the facts may be available. In the mean time, while we wait for tungsten steel to be invented, we will chip away at the problem with our blunt stone axes”.

• Bertrand oligopoly

The assumption of a Bertrand-type oligopoly game among domestic firms leads to counterfactual implications under product homogeneity with recurrent fixed costs: In a short-run equilibrium with a fixed number of firms, the Bertrand-Nash equilibrium is characterised by marginal cost pricing, yet due to the presence of the output-invariant cost element all firms make a loss and exit would take place. In the long-run zero-profit equilibrium a single firm which sets price at average cost survives.

3.2. Intra-Industry Product Differentiation

We are turning to models featuring horizontal product differentiation (PD) between firms within the same region and industry. As noted earlier, in the special case $\sigma = \sigma_A = \sigma_M$ the demand side nesting hierarchy collapses to a pure “love of variety”-type specification as used in theoretical intra-industry trade models in the tradition of Krugman(1979;1980).

For clarity of exposition and to allow easier comparisons with the existing related theoretical and applied literature, it appears appropriate to treat this latter case first in

all model variants before presenting the required modifications for the case $\sigma \neq \sigma_A \neq \sigma_M$ (in the following referred to as A-DS (Armington-Dixit-Stiglitz) case) .

- **Global Bertrand PD oligopoly under regional market segmentation**

Each firm conjectures that all (domestic and foreign) rivals keep their supply prices in market s fixed when it varies its own price p^* in market s . In this case

$$(20) \quad \varepsilon_{r,s} = -\frac{\partial x_{r,s}^*}{\partial p_{r,s}^*} = \sigma + (\Omega - \sigma)s_{r,s},$$

where $s_{r,s} = S_{r,s}/n_r = p_{r,s}x_{r,s}/(P_A A_s)$ is the market share of a *single firm* of origin r in market s . In the A-DS case, the perceived elasticities expand to

$$(20') \quad \begin{aligned} \varepsilon_{r,r} &= \sigma - (\sigma - \sigma_A)/n_r - (\sigma_A - \Omega)s_{r,r}, \\ \varepsilon_{r,s} &= \sigma - (\sigma - \sigma_M)/n_r - (\sigma_M - \sigma_A)SM_{r,s}/n_r - (\sigma_A - \Omega)s_{r,s}, \quad r \neq s \in C \end{aligned}$$

for its home and export markets respectively.

- **Global Bertrand PD oligopoly under global market integration**

With Bertrand conjectures, the perceived demand elasticity is simply the output-weighted average of the perceived Bertrand elasticities in the various destination markets as given by (20) or (20') above, i.e.

$$(21) \quad \varepsilon_r = -\frac{\hat{y}_r^*}{\hat{p}_r^*} = \sum_{s \in C} w_{r,s} \varepsilon_{r,s}, \quad w_{k,i} \equiv \frac{x_{k,i}}{x_k}.$$

- **PD Oligopoly with conjectural price variations under market segmentation**

A generalisation of the Bertrand set-up can be developed by assuming that the firm under consideration conjectures that rivals respond to changes in its own price by a certain non-zero price reaction. Let v denote the constant conjectural elasticity of rivals' prices with respect to a change in p^* , i.e.

$$(22) \quad \hat{p}_{j,s} = v \hat{p}_{r,s}^*.$$

If this conjectural price response elasticity is the same for rivals from all regions competing in market s , the perceived elasticity becomes

$$(23) \quad \varepsilon_{r,s} = -\frac{\partial x_{r,s}^*}{\partial p_{r,s}^*} = \sigma + (\Omega - \sigma)(v + s_{r,s}(1 - v)).$$

Note: In the special case $v=1$ (any price change is fully matched by rivals) the perceived elasticity becomes Ω and unless $\Omega>1$, mark-up pricing breaks down. In the A-DS case we have

$$(23') \quad \varepsilon_{r,r} = \sigma - (\sigma - \sigma_A)(v + (1-v)/n_r) - (\sigma_A - \Omega)(v + (1-v)s_{r,r})$$

$$\varepsilon_{r,s} = \sigma - (\sigma - \sigma_M)(v + (1-v)/n_r) - (\sigma_M - \sigma_A)(v + (1-v)SM_{r,s}/n_r) - (\sigma_A - \Omega)(v + (1-v)s_{r,s})$$

If our firm holds non-zero conjectural price variations only with regard to domestic rivals as in Delorme/van der Mensbrugghe[1990:eq.(7)], we have instead

$$(24') \quad \varepsilon_{r,r} = \sigma - (\sigma - \sigma_A)(v + (1-v)/n_r) - (\sigma_A - \Omega)(S_{r,r}v + (1-v)s_{r,r})$$

$$\varepsilon_{r,s} = \sigma - (\sigma - \sigma_M)(v + (1-v)/n_r) - (\sigma_M - \sigma_A)(SM_{r,s}v + (1-v)SM_{r,s}/n_r) - (\sigma_A - \Omega)(S_{r,s}v + (1-v)s_{r,s})$$

- **PD Oligopoly with conjectural price variations under market integration**

With conjectural price variations as given by (22) in a, the perceived global demand elasticity under market integration is a weighted average of the destination-specific elasticity expressions above.

- **Global Cournot PD oligopoly under regional market segmentation**

Each firm conjectures that all domestic and foreign rivals keep their supply quantities to market s fixed when it varies its own quantity x^* in market s . (Note that the Cournot conjecture is formally equivalent to a certain conjectural price variation: A change in x^* and thus p^* shifts the demand curves for rivals' varieties and thus implies that rivals must adapt their prices so that their output stays put in response to this shift). In this case

$$(25) \quad \varepsilon_{r,s} = \frac{\sigma\Omega}{(\sigma - \Omega)s_{r,s} + \Omega} \Leftrightarrow \frac{1}{\varepsilon_{r,s}} = \frac{1}{\sigma} + \frac{\sigma - \Omega}{\sigma\Omega}s_{r,s} = \frac{1}{\sigma} - \left(\frac{1}{\sigma} - \frac{1}{\Omega}\right)s_{r,s}$$

or in the A-DS specification

$$(25') \quad \frac{1}{\varepsilon_{r,r}} = \frac{1}{\sigma} - \left(\frac{1}{\sigma} - \frac{1}{\sigma_A}\right)\frac{1}{n_r} - \left(\frac{1}{\sigma_A} - \frac{1}{\Omega}\right)s_{r,r}$$

$$\frac{1}{\varepsilon_{r,s}} = \frac{1}{\sigma} - \left(\frac{1}{\sigma} - \frac{1}{\sigma_M}\right)\frac{1}{n_r} - \left(\frac{1}{\sigma_M} - \frac{1}{\sigma_A}\right)\frac{SM_{r,s}}{n_r} - \left(\frac{1}{\sigma_A} - \frac{1}{\Omega}\right)s_{r,s}.$$

(25') is equivalent to Harrison/Rutherford/Tarr(1996:346, eq.(1)) and in the case of a unit value for the conjectural variations parameter equivalent to Harrison / Rutherford / Tarr (1997:1420, eq.(2)). Compare also Willenbockel(1994:130-1), Capros et al.(1998:34-6, 85-90), and Burniaux / Waelbroeck(1992:71-2) for similar Cournot-type perceived elasticity formulae.

- **PD Oligopoly with conjectural output variations under market segmentation**

A generalisation of specification (25) can be obtained by assuming that the firm conjectures that domestic and foreign rivals' supply quantities to any market segment respond to changes in its own supply quantities according to

$$(26) \quad \hat{x}_{j,s} = v\hat{x}_{r,s}^* \quad \forall j \in C.$$

Given that the conjectural elasticity of rivals' quantities with respect to changes in own quantity, v , is assumed to be identical across rivals from all regions competing in destination s , we have $\frac{\hat{A}_s}{\hat{x}_{r,s}^*} = v + (1-v)s_{r,s}$ and thus

$$(27) \quad \frac{1}{\varepsilon_{r,s}} = \frac{1}{\sigma} - \left(\frac{1}{\sigma} - \frac{1}{\Omega} \right) (v + (1-v)s_{r,s})$$

or in the A-DS case

$$(27') \quad \frac{1}{\varepsilon_{r,r}} = \frac{1}{\sigma} - \left(\frac{1}{\sigma} - \frac{1}{\sigma_A} \right) (v + (1-v)/n_r) - \left(\frac{1}{\sigma_A} - \frac{1}{\Omega} \right) (v + (1-v)s_{r,r}),$$

$$\begin{aligned} \frac{1}{\varepsilon_{r,s}} = & \frac{1}{\sigma} - \left(\frac{1}{\sigma} - \frac{1}{\sigma_M} \right) (v + (1-v)/n_r) - \left(\frac{1}{\sigma_M} - \frac{1}{\sigma_A} \right) (v + (1-v) \frac{SM_{r,s}}{n_r}) \\ & - \left(\frac{1}{\sigma_A} - \frac{1}{\Omega} \right) (v + (1-v)s_{r,s}) \end{aligned}$$

Harrison/Rutherford/Tarr(1997:1492) incorporate conjectural output variations in a slightly more pragmatic and for calibration purposes more convenient manner, namely by simply multiplying the ordinary Cournot elasticities (25') with some fixed conjectural variations parameter. If that parameter is literally meant to represent rivals' given uniform conjectured output variation, this specification would be "incorrect" as elaborated by de Santis(1999) at some length. Equations (27') show that when conjectural variations are entered via (26) – i.e. in a form which clearly spells out the conjectural output response for each rival - the perceived elasticities are themselves nontrivial functions of the conjectural variation parameters v . However, the specification of Harrison et al. should reasonably seen as an alternative formulation capturing the fact that if firms expect some sort of output reaction by rivals "in the aggregate", the perceived optimal mark-up is different vis-a-vis the pure Cournot mark-up.

- **Global Cournot PD oligopoly under global market integration**

The model-consistent derivation of the perceived elasticity for this case is a slightly more intricate affair. The Cournot conjecture is now that domestic and foreign rivals keep their world-wide supply quantities fixed when the firm from region k under consideration varies its supply quantity. Since the rival price responses implied by the Cournot conjecture must now be determined simultaneously, some resort to matrix algebra is required in order to find a closed-form expression for the perceived elasticity. In the following, bold-face symbols are used to indicate vectors or matrices of the corresponding scalar variables by region.

For the firm in question we have

$$(28) \quad \hat{y}_r^* = -\sigma \hat{p}_r^* + (\sigma - \Omega) \mathbf{w}_r \mathbf{P} \hat{\mathbf{A}},$$

where $\mathbf{w}_r := [w_{r,1}, \dots, w_{r,R}]$ is a $(1, R)$ row vector of quantity weights as defined above and $\mathbf{P} \hat{\mathbf{A}}$ is the $(R, 1)$ vector of top-level price index changes by region implied by the Cournot conjecture.

For rivals the Cournot conjecture entails

$$(29) \quad \hat{\mathbf{y}} = \mathbf{0} = -\sigma \hat{\mathbf{p}} + (\sigma - \Omega) \mathbf{W} \mathbf{P} \hat{\mathbf{A}} \Rightarrow \hat{\mathbf{p}} = \frac{\sigma - \Omega}{\sigma} \mathbf{W} \mathbf{P} \hat{\mathbf{A}},$$

where $\hat{\mathbf{p}}$ denotes the $(R, 1)$ vector of rivals' price responses that would be required to keep their sales constant when the firm under consideration varies its output and price, and $\mathbf{W} = [\mathbf{w}_1, \dots, \mathbf{w}_R]'$ is the (R, R) matrix of quantity weights for firms from all regions. Recalling that $s_{j,i}$ denotes the market share of a single firm/variety from region j in market i , the relation between conjectured Cournot-equivalent price and the top-level price index reactions as perceived by our representative firm in region r can be written as

$$(30) \quad P \hat{\mathbf{A}}_i = \sum_{j=1}^m s_{j,i} n_j \hat{p}_j + s_{r,i} (\hat{p}_r^* - \hat{p}_r),$$

or in matrix notation, defining $\mathbf{S} = [S_{ij}] = [s_{ij} n_i]$ and $\mathbf{s}_r = [s_{r,1}, \dots, s_{r,m}]'$,

$$(31) \quad \mathbf{P} \hat{\mathbf{A}} = \mathbf{S}' \hat{\mathbf{p}} + \mathbf{s}_r (\hat{p}_r^* - \hat{p}_r).$$

From (29) we know that the Cournot-equivalent price reaction of *domestic* (i.e. region r) rivals is

$$(32) \quad \hat{p}_r = \frac{\sigma - \Omega}{\sigma} \mathbf{w}_r \mathbf{P} \hat{\mathbf{A}}.$$

Using (29) and (31) and (32), we find

$$(33) \quad \mathbf{P}\hat{\mathbf{A}} = \left[\mathbf{I} - \frac{\sigma - \Omega}{\sigma} (\mathbf{S}'\mathbf{W} - \mathbf{s}_r\mathbf{w}_r) \right]^{-1} \mathbf{s}_r \hat{p}_r^*.$$

Finally, inserting (33) in (28), we find that the perceived Cournot elasticity for our individual firm from region r takes the unappealing form

$$(34) \quad \varepsilon_r = \sigma - (\sigma - \Omega)\mathbf{w}_r \left[\mathbf{I} - \frac{\sigma - \Omega}{\sigma} (\mathbf{S}'\mathbf{W} - \mathbf{s}_r\mathbf{w}_r) \right]^{-1} \mathbf{s}_r.$$

I am only aware of three applied studies considering a Cournot scenario with market integration along these lines, Smith/Venables(1988)⁶, Haaland /Norman(1992) and Willenbockel(1994). Burniaux /Waelbroeck(1992:73) approximate the perceived Cournot elasticity under market integration by computing the output-weighted average of the corresponding Cournot elasticities under market segmentation.

The corresponding derivation of an explicit elasticity expression for the A-DS case is a particular tedious and joyless task but proceeds along similar lines, and is skipped here for brevity's sake. For practical computational purposes it is in fact not necessary to have an explicit analytical expression for ε . Equations (28)-(30) form a simultaneous equation sub-system (for each r) in the unknowns ε , $\hat{P}_i / \hat{p}_r^*$, $\hat{p}_i / \hat{p}_r^*$ and can be entered as such to the model code.

- **Domestic Cournot PD oligopoly under global market integration**

Is the derivation of a Cournot elasticity less burdensome, if we assume in analogy to section 3.1 above that the firm holds the Cournot conjecture only with respect to domestic rivals? The answer is "not really", since with product differentiation across domestic firms one still has to take account of the perceived domestic rivals' price reactions implied by the Cournot assumption:

In this case (29) is replaced by

$$(29') \quad \hat{y}_r = 0 = -\sigma \hat{p}_r + (\sigma - \Omega)\mathbf{w}_r \mathbf{P}\hat{\mathbf{A}} \Rightarrow \hat{p}_r = \frac{\sigma - \Omega}{\sigma} \mathbf{w}_r \mathbf{P}\hat{\mathbf{A}},$$

(30) simplifies to

$$(30') \quad \hat{P}_i = S_{r,i} \hat{p}_r + s_{r,i} (\hat{p}_r^* - \hat{p}_r),$$

and thus

$$(31') \quad \mathbf{P}\hat{\mathbf{A}} = (\mathbf{S}_r - \mathbf{s}_r) \hat{p}_r + \mathbf{s}_r \hat{p}_r^*.$$

Using (viii') with (x') in (vii), we end up with

$$(34') \quad \varepsilon_r = \sigma - (\sigma - \Omega)\mathbf{w}_r \left[\mathbf{I} - \frac{\sigma - \Omega}{\sigma} (\mathbf{S}_r - \mathbf{s}_r)\mathbf{w}_r \right]^{-1} \mathbf{s}_r.$$

⁶ The exposition of the derivation of the perceived demand elasticity for this case in Smith/Venables(1988) contains a number of obvious errors and/or typos - see Willenbockel (1994:77-8) for an attempt at correction.

- **Chamberlinian Large Group Monopolistic Competition**

In all pure Bertrand and Cournot cases considered in section 3.2, the perceived elasticity converges to σ with a rising number of firms – i.e. in the limit all models of oligopolistic interaction converge to a Chamberlinian large-group monopolistic competition framework with a fixed trade-policy-invariant mark-up, in which the individual firm conjectures that its influence on the group price indices PA and or PM is negligible.

4. Benchmark Data Set and Calibration

All model versions considered below are calibrated to the following benchmark data set: The matrix of aggregate commodity flows by origin and destination in value terms for each of the two commodity groups is given by

Origin / Destination	A	B	C
A	80	10	10
B	10	80	10
C	10	80	80

and the matrix of sectoral factor allocations (value added) is given by :

Sector / Region	A	B	C
PC	100	100	100
IC	100	100	100

It is assumed that the benchmark equilibrium is a free trade equilibrium.

In all models of firm conduct under consideration, the perceived elasticity formula in conjunction with the given expenditure shares of the benchmark data set and the Lerner condition (12) establishes a relationship

$$(35) \quad m_0 = f(\sigma, n_0)$$

between benchmark equilibrium mark-ups m_0 , the initial number of firms n_0 and the (bottom level) elasticity of substitution σ for each IC industry in each region. Unless the conjectural variations approach is adopted, two of the three parameters in (35) must be set extraneously while the remaining one has to be calibrated residually. In principle, three alternative calibration strategies are conceivable, and indeed examples for each can be found in the literature:

- (i) Set n_0 and m_0 (e.g. on the basis of extraneous concentration statistics and scale elasticity estimates) and calibrate σ residually (e.g. Gasiorsek / Smith / Venables, 1992; Haaland / Norman, 1992; Willenbockel, 1994);
- (ii) Set n_0 and σ and calibrate m_0 residually (e.g. Brown / Stern, 1989);
- (iii) Set m_0 and σ and calibrate n_0 residually (e.g. Devarajan / Rodrik, 1991).

We assume that data on the initial model-equivalent number of symmetric firms are available – e.g. computed on the basis of inverse Herfindahl concentration indices from production census data as exemplified in Capros et al.(1998) and Willenbockel (1994, 229-31) – and given by $(n_a, n_b, n_c) = (10, 5, 20)$.

For the models with inter-firm product homogeneity of section 3.1, we adopt calibration strategy (ii) and assume that the choice of σ is based on an educated guess which takes into account the existing econometric evidence on trade flow elasticities.

The factor productivity parameters a_{IC} and the fixed-cost parameters L_f must then be calibrated residually using (12) and (10).

This calibration strategy determines the initial potential for unexploited economies of scale as measured by the scale elasticity (i.e. the percentage increase in total cost associated with a one-percent increase in firm output) residually. The benchmark scale elasticities (with $p_0 = w_0 = 1$) are here just equal to $1/a$, the benchmark marginal cost, and $a-1$ is the benchmark mark-up rate $(p-mc)/mc$.

For example, for the domestic Cournot model with integration and $\sigma_A = \sigma_M = 2$, the calibration leads to $a = (1.081, 1.175, 1.042)$. Note that due to the symmetry of our benchmark data set, ε_0 is the same across countries, but since initial firm numbers are assumed to differ, regional industries with higher concentration (lower n) have higher mark-ups and a higher economies-of-scale potential (i.e. a lower scale elasticity) due to a higher ratio of fixed to marginal cost.

For the models with inter-firm product differentiation we consider both calibration strategies (i) and (ii) in order to explore the potential sensitivity of results to the calibration strategy for a *given* choice of oligopoly model.

5. Comparative Analysis of Responses to a Trade Policy Shock

In all simulations the trade policy shock under consideration is the unilateral imposition of a 20 percent ad valorem tariff by country A on IC imports from regions B and C starting from an initial free trade equilibrium.

We first consider the models without firm-level product differentiation discussed in section 3.1. Table 1 reports the simulated aggregate welfare effects for all regions as measured by the Hicksian equivalent variation / benchmark income ratio, as well as the effects on selected IC industry variables for the tariff-imposing country A. It is useful to begin with the predictions of a corresponding model with price-taking behaviour and constant returns in both sectors

The import tax raises the consumer price for imports of IC goods from origin B and C faced by residents of A relative to the domestic IC variety. The protected IC sector of country A expands in response to the increased demand by domestic residents (this output effect is the stronger, the higher σ_A) at the expense of the PC sector, while the intersectoral reallocation effects in countries B and C go in the opposite direction. reduction in export demand by country A. The drop in the demand by A for IC exports from B and C enforces a drop in B's and C's supply prices in both sectors relative to A's prices in order to restore external balance, i.e. country A's overall terms of trade improve. The lower the σ 's, the stronger the terms-of-trade effect required to maintain trade balance equilibrium. As is typical for models with an Armington demand system, the terms of trade gain for the tariff-imposing country dominates the efficiency losses due to the domestic price distortion, so that A enjoys a

welfare gain at the expense of B and C under all elasticity configurations under consideration.

The basic pattern of global welfare changes trade and intersectoral factor reallocation effects predicted by the perfect competition model carries over to the models with oligopolistic behaviour and increasing returns. Under the integrated market regime, the tariff raises the mark-up for country A's oligopolists, since the perceived elasticity drops due to the rise in the home market share and the rise in the weight of home sales in overall sales according to (16). If firm numbers were fixed, country A firms would enjoy pure profits. With free entry new firms are attracted and equilibrium output per firm shrinks while unit costs rise, i.e. protection leads to inefficient entry as in the theoretical model of Horstmann / Markusen (1986). Correspondingly, the predicted welfare gain for A is lower under imperfect competition compared to the perfect competition scenario. The difference in the simulated welfare effect is small for the low Armington elasticity scenarios, but becomes more noticeable in the high-elasticity scenarios. The calibrated initial mark-ups are lower and therefore the slopes of the average cost curves become flatter with higher σ_A . Thus stronger entry effects with associated stronger plant output reductions are required to drive profits back to zero in this case. Though not reported in the Table, it is noteworthy that IC industries in B and C experience mark-up increases and reductions in output size per firm with associated unit cost increases as well. For firms in B and C the loss of export sales to A is associated with an increase in their own home market share as well as with a rise of the weight of the low home market elasticity in (16), and thus with a drop in the perceived global elasticity.

In the market segmentation scenarios, the tariff-induced mark-up increase occurs only in the home market, while the export mark-ups drop slightly according to (18). Nevertheless the signs and the orders of magnitude of the industrial organisation effects in A's IC industry are remarkably similar to the corresponding market integration case with the same Armington elasticity configuration.

The main general conclusion from Table 1 is that the simulation results are clearly far more sensitive to the choice of values for the elasticities of substitution in demand than to the choice of assumption about firm conduct – at least as long as this latter choice is restricted to specifications in which endogenous variations in mark-ups are explicitly based on optimising behaviour.⁷

[Table1 (see end of paper) about here]

Tables 2 and 3 report results generated by the models with intra-industry product differentiation of section 3.2 for the case of an equal elasticity of substitution between firm-specific varieties from all regions. The results in Table 2 are based on calibration strategy (i) of section 4, i.e. we assume that the modeller has information or prior guesses about the benchmark price-cost margin m_A and on industry concentration, and calibrates σ residually (without trying to match the resulting price elasticity of model trade flows with extraneous econometric evidence). In contrast, Table 3 assumes that the modeller follows calibration strategy (ii) and sets σ so that model trade flow elasticities are within a range suggested by the empirical literature (without trying to

⁷ Of course, more dramatic differences between simulation results of perfect and imperfect competition models can always be generated by recourse to ad hoc price setting assumptions such as the focal-point pricing rule in Harris' [1984] seminal contribution

match the resulting benchmark mark-ups and scale elasticities with extraneous priors).⁸

A comparison across Tables 2 and 3 shows the potential sensitivity of results to the choice of calibration strategy for a *given* choice of model specification. Of course if the chosen model is the “true” model and the modeller has either correct information on m or on σ , the two calibration strategies would yield identical results. Yet in the practically relevant situation of incomplete, missing or contradictory information about appropriate figures to be used at the calibration stage and about the “true” model, the message suggested by the two tables is that model predictions may be far more sensitive to the choices made at the calibration stage, than to the choice of imperfectly competitive firm conduct model. As long as the calibrated or set elasticities of substitution are not in double-digit regions (implying dramatically higher industry-level trade flow elasticities than typically considered as plausible in CGE trade policy studies under perfect competition), the predicted results are again quite robust to the specification of oligopolistic interaction.

The global distribution of welfare effects and the signs of the industrial organization effects follow the same general pattern as in Table 1. Again all models predict positive entry effects with associated reductions in production run lengths in the tariff-imposing country, while the magnitude of these effects is far more sensitive to the choice of σ than to the choice of oligopoly model. In contrast to the models with intra-industry product homogeneity, the predicted entry effect is not necessarily inefficient, since the increase in product variety has per se a welfare-raising effect.

[Tables 2 and 3 (see end of paper) about here]

6. Concluding Remarks

This paper has provided a technical synopsis of alternative optimization-based specifications of non-collusive imperfectly competitive supply behaviour in multi-region applied general equilibrium models and has explored the robustness of trade policy simulation results to the choice of specification within a stylised prototype model. Section 3 spelled out in explicit detail the algebra required for the endogenous determination of price mark-ups under different types of oligopolistic interaction and different demand nesting hierarchies. While this section is probably not a particularly exciting read, it may be of some use for applied modellers in its own right, given that the formal derivation of the required perceived elasticities is error-prone and the related existing literature is notoriously opaque. Although this paper follows the new trade theory literature by characterizing the alternative models of oligopolistic interaction by resort to the language of classical oligopoly theory, it should be emphasized that all models except the conjectural variation models under consideration are compatible with a game-theoretic interpretation – i.e the equilibria under consideration are Nash equilibria of simultaneous-move one shot games in quantities or prices.

⁸ In an ideal world, the modeller would have hard data on both σ and m and would let the benchmark data set pick the model which best fits the facts. As noted before, the conjectural variations approach and the resort to the A-DS specification can be viewed as alternative ways to set up a model that is able to replicate simultaneously both types of information when the pure DS specifications are “rejected” by the data.

The main message from the illustrative structural sensitivity analysis in section 5 may be summarized as follows: The simulated responses to a trade policy shock are far more sensitive to the direct or indirect choices of demand substitution elasticity figures at the calibration stage, than to the prior choice of firm conduct specification. When the different models of oligopolistic interaction are calibrated to the same substitution elasticity configuration, results remain generally remarkably robust to the choice of model. The main practical implication for applied studies allowing for imperfect competition is that it is more important to give careful consideration to – and provide a clear documentation of – the numerical specification choices at the calibration stage and to perform sensitivity analyses with regard to the demand elasticity figures, than to conduct structural sensitivity analyses across a wide spectrum of different models of imperfectly competitive conduct. Given that there is no general answer to the question for the “true” model of firm conduct, this is actually good news.

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Table 1: Models with Intra-Industry Product Homogeneity*(Percentage Changes)*

	EV _A	EV _B	EV _C	X _{IC,A}	x _A	n _A	m _A	ToT _A
$\sigma_A=2, \sigma_M=4$								
Perfect Competition	+0.49	-0.35	-0.35	+1.43	-	-	-	+3.72
Cournot - Integrated	+0.46	-0.49	-0.39	+1.40	-0.86	+2.28	+0.86	+3.71
Cournot - Segmented	+0.52	-0.39	-0.36	+1.41	-0.85	+2.28	+12.52	+3.72
$\sigma_A=4, \sigma_M=8$								
Perfect Competition	+0.21	-0.29	-0.29	+3.96	-	-	-	+3.17
Cournot - Integrated	+0.12	-0.50	-0.34	+3.82	-4.25	+8.43	+4.44	+3.16
Cournot - Segmented	+0.15	-0.33	-0.36	+3.72	-5.51	+9.77	+44.73	+3.14
$\sigma_A=2, \sigma_M=2$								
Perfect Competition	+0.78	-0.49	-0.49	+1.45	-	-	-	+5.17
Cournot - Integrated	+0.75	-0.60	-0.52	+1.43	-0.47	+1.90	+0.46	+5.16
Cournot - Segmented	+0.79	-0.55	-0.50	+1.43	-0.45	+1.89	+11.25	+5.15
$\sigma_A=4, \sigma_M=4$								
Perfect Competition	+0.44	-0.40	-0.40	+4.04	-	-	-	+4.28
Cournot - Integrated	+0.34	-0.59	-0.45	+3.86	-3.82	+7.99	+3.97	+4.27
Cournot - Segmented	+0.37	-0.33	-0.30	+3.80	-4.52	+8.72	+12.52	+4.23

EV: Equivalent variation/ Y_0 ; X: Industry output; x: Output per firm; n: Number of firms; m: mark-up rate (home market mark-up for segmentation case); ToT: Terms of trade.

Table 2: Models with Intra-Industry Product Differentiation ICalibration strategy: residual calibration of σ for given mark-up and n *(Percentage Changes)*

	EV _A	EV _B	EV _C	X _{IC,A}	x _A	n _A	ToT _A	M _{IC,A}	σ_{IC}
m_A=8.1%									
Global Cournot-Integrated	+0.11	-0.76	-0.52	+2.03	-12.90	+17.15	+6.79	-93.6	24.8
Global Cournot-Segmented					n f*				
Domestic Cournot-Integrated	+0.40	-0.77	-0.62	+1.59	-18.31	+24.36	+7.72	-80.0	15.6
Bertrand-Integrated	+0.64	-0.66	-0.65	+3.22	-1.87	+5.18	+7.41	-76.9	14.3
Bertrand –Segmented	+0.68	-0.62	-0.65	+3.23	-1.83	+5.18	+7.44	-59.3	14.5
Monopolistic Competition	+0.68	-0.66	-0.66	+3.35	0.00	+3.35	+7.43	-74.5	13.4
<i>Conj. Price Var.-Integrated</i>	+1.34	-0.83	-0.91	+2.60	-0.55	+3.17	+7.19	-34.3	4
<i>Perfect Competition</i>	+0.51	-0.56	-0.56	+3.20	-	-	+7.08	-75.9	14
m_A=25.0%									
Global Cournot-Integrated	+1.02	-0.93	-0.82	+2.39	-2.53	+5.05	+7.52	-46.2	6.1
Global Cournot-Segmented	+1.15	-0.72	-0.73	+2.24	-4.28	+6.81	+7.73	-45.9	7.7
Domestic Cournot-Integrated	+1.05	-0.95	-0.84	+1.96	-4.23	+6.47	+7.58	-43.7	5.6
Bertrand-Integrated	+1.14	-0.87	-0.85	+2.68	-0.77	+3.48	+7.37	-41.9	5.3
Bertrand –Segmented	+1.19	-0.81	-0.85	+2.68	-0.76	+3.48	+7.40	-40.6	5.3
Monopolistic Competition	+1.17	-0.87	-0.87	+2.80	0.00	+2.80	+7.34	-40.2	5
<i>Conj. Price Var.-Integrated</i>	+1.29	-0.91	-0.93	+2.53	-0.56	+3.10	+7.19	-34.4	4
<i>Perfect Competition</i>	+0.77	-0.60	-0.60	+2.59	-	-	+6.74	-45.1	6

M_{IC,A}: IC Imports to A. *Calibration not feasible since m_A<s_{A,A}, i.e. model "rejected" by benchmark data set.**Table 3: Models with Intra-Industry Product Differentiation II**Calibration strategy: residual calibration of mark-ups for given σ and n *(Percentage Changes)*

	EV _A	EV _B	EV _C	X _{IC,A}	x _A	n _A	ToT _A	M _{IC,A}	m _A
$\sigma=2$									
Global Cournot-Integrated	+1.66	-1.41	-1.36	+1.87	-0.39	+2.27	+6.38	-21.2	112
Global Cournot-Segmented	+1.73	-1.29	-1.34	+1.87	-0.35	+2.23	+6.44	-12.6	117
Domestic Cournot-Integrated	+1.64	-1.41	-1.36	+1.81	-0.51	+2.33	+6.40	-21.2	110
Bertrand-Integrated	+1.65	-1.38	-1.36	+1.97	-0.20	+2.17	+6.38	-21.1	107
Bertrand –Segmented	+1.69	-1.31	-1.35	+1.96	-0.19	+2.16	+6.43	-16.7	109
Monopolistic Competition	+1.65	-1.36	-1.36	+2.07	0.00	+2.07	+6.42	-21.0	100
<i>Conj. Price Var.-Integrated</i>	+1.71	-1.20	-1.33	+2.02	-0.20	+2.22	+6.37	-21.0	25
$\sigma=4$									
Global Cournot-Integrated	+1.24	-1.01	-0.93	+2.23	-1.40	+3.69	+7.24	-34.6	40
Global Cournot-Segmented	+1.40	-0.86	-0.90	+2.15	-1.57	+3.79	+7.29	-26.4	45
Domestic Cournot-Integrated	+1.23	-1.01	-0.93	+1.96	-2.38	+4.44	+7.31	-34.6	38
Bertrand-Integrated	+1.27	-0.95	-0.93	+2.49	-0.56	+3.07	+7.19	-34.5	36
Bertrand –Segmented	+1.32	-0.89	-0.92	+2.49	-0.55	+3.05	+7.21	-32.3	36
Monopolistic Competition	+1.27	-0.93	-0.93	+2.64	0.00	+2.64	+7.19	-34.3	33
<i>Conj. Price Var.-Integrated</i>	+1.29	-0.91	-0.93	+2.53	-0.56	+3.10	+7.19	-34.4	25

M_{IC,A}: IC Imports to A. m_A: Calibrated benchmark mark-up in percent.