

Modelling Agricultural Commodity Markets under Imperfect Competition

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Abstract

In this paper, we develop a model that explains the exporters' behaviour in international commodity markets considering explicitly the case of an imperfectly competitive structure of these markets. More specifically, drawing from the imperfect competition and trade literature, we derive price transmission equations between producer and consumer prices and between producer and export prices that can be included in large commodity models in order to verify how results of these models change assuming the imperfect competition hypothesis. The results obtained carrying out a simple simulation exercise, with two competing exporting countries and one importing region, show the relevance of assuming imperfect competition in commodity markets.

Keywords: Imperfect Competition, State Trading Enterprises, Policy simulation, Cereal markets

JEL Codes: Q12, Q17, Q18

1. Introduction

The recent high volatility in international cereal prices, with the extraordinary peak reached in 2008, the rapid fall in 2009 and the recent surge started in August 2010, has brought under scrutiny the predictive capacity of the models currently used by governments and international organizations to make projections on agricultural and food commodity markets as well as to analyse policy reform scenarios¹. The difficulty of models in predicting such a volatility in prices is clearly a good reason for revising their structure and characteristics, which are often too simplified for representing the complexities of agricultural commodity markets and for answering the increasingly sophisticated questions posed by researchers and policy makers.

In order to discuss the structure of these forecasting models, the starting point must be the set of assumptions underlining each of them. One of the key assumption of all these models is that both domestic and international agricultural commodity markets are perfectly competitive, despite a number of evidences that make this assumption clearly unrealistic. For example, focusing on the cereal markets, imperfect competition is likely to come from the presence of State Trading Enterprises (STEs) that manage the total amount of some countries' exports (i.e. Canada and Australia). Moreover, some large multinational companies hold relevant shares of the total world cereal trade, such that importers around the world can choose among a limited set of sources, either STEs or multinational trading firms. In principle, high market concentration by private firms does not automatically entails non-competitive behaviour, since such concentration may be motivated by other reasons than gaining market power, like, for example, strong economies of scale. STEs may exert market power either through the payment mechanisms to farmers or through storage management, even if their ability to hold stocks is limited by storage capacity (Sexton et al, 2001). In addition to that, national legislations normally impose some relevant constraints to STEs activities (i.e. they cannot impose production quotas), such that their market power may turn out to be rather limited.

In any case, the role of STEs has become one of the key issue in the on-going multilateral trade negotiation managed by the World Trade Organization (WTO), since some member countries ask for stronger regulation of their activities. For this reason, a relevant flow of scientific literature

¹ Examples of such models are the AGLINK model managed by the Organization of Economic Cooperation and Development (OECD, 1998), the FAPRI model managed by the FAPRI consortium (Devadoss et al, 1993), and the WEMAC model, developed by the INRA team based in Rennes (INRA, 2010).

has been produced to analyse the problems entailed by the presence of STEs in agricultural commodity markets and, in general, the role of imperfect competition in these markets. McCorrison and MacLaren (2007a), using a simulation model, show the distorting impact of STEs on commodity markets, both when they operate in developed countries and in developing countries. The same authors show, in two related papers, the distorting impact of the Australian Wheat Board on international cereal trade, calculating the welfare loss of its presence (McCorrison and MacLaren, 2007b), as well as the distorting role of state trading in China for a number of agricultural commodities (McCorrison and MacLaren, 2010). Scoppola (2007a and 2007b) and Mirza (2006) study the relationship between international trade and market structure, while Sexton et al. (2007) show how imperfectly competitive behaviour may affect welfare distribution and economic development of developing countries as a result of trade liberalization. Thus, this set of results clearly shows that, if one wants to simulate the behaviour of economic agents operating in cereal markets, the imperfectly competitive structure of these markets should be taken into account.

Thus, it is interesting to analyse how the results of a simulation model would change if the imperfectly competitive structure of the cereal markets is properly considered. Therefore, the objective of this paper is to develop alternative behavioural equations that take explicitly into account the imperfectly competitive structure of agricultural commodity markets, such as the international cereal market. In perspective, these equations, that take the form of price transmission equations, could be included in larger models used for policy simulations.

The paper is structured as follows: in the next section, the relevant methodological literature is reviewed, while in the following section the theoretical model underlining the new behavioural equations is presented. In section 4, a parameterised version of the model is derived, which can be used for empirical purposes, while in section 5 some simulation results are presented using a stand-alone version of the model calibrated on artificial data. Finally, some general conclusions are drawn.

2. Literature review

Imperfect competition has been largely covered in the international trade literature for agricultural products. Given the complexity of the problem, empirical applications are usually limited to a restrict number of products/regions, while theoretical models can be more general.

The key assumptions of these models relate to the homogeneous/differentiated goods hypothesis and the type of price/quantity competition (Bertrand, Cournot, ...). The degree of differentiation certainly depends on the type of product, even if the definition is not a clear cut. In general, large simulation models such as AGLINK or FAPRI assume homogeneous goods and, consequently, a single world price for each commodity. Studies including the imperfect competition hypothesis vary in this aspect. Patterson and Abbott (1994) adopt a homogeneous good assumption to test for imperfect competition in the US exports of wheat and corn; similarly Hamilton and Stiegert (2002) use a homogeneous good setting to test for the rent-shifting hypothesis generated by the Canadian Wheat Board (CWB). Thursby and Thursby (1990) build a Canada-US duopoly model for wheat exports to Japan assuming goods are differentiated by country but homogeneous across firms. This setting is similar to that by McCorrison and MacLaren (2007a), who evaluate the general STE trade-distorting effects, by Dong et al. (2006), who analyse the STE effect in the barley market, and by Goldberg and Knetter (1999), who study competition in the German export of beer and linerboard paper.

In general, agricultural economics trade studies set up models within quantity setting maximizing frameworks. The rationale for this is confirmed, for example, by the study of Dong et al. (2006), that find support in favour of a quantity-setting oligopoly in the barley market instead of a price-setting mechanism: their results show that the market behave as in Cournot competition, a result similar to that of Hamilton and Stiegert (2002), although obtained in a different setting. Thursby and Thursby (1990) test for firms behaviour concluding that wheat exports to Japan are

more competitive than Cournot but less competitive than Bertrand. Based on the results by Dong et al. (2006) and Hamilton and Stiegert (2002), Cournot behaviour is used as a maintained hypothesis in the structural framework developed by McCorriston and MacLaren (2007a).

In the above studies the main differences stay in some structural aspects, such as the explicit modelling of the domestic market, the presence of STEs, and the definition of the STE's objective function². This last aspect is a key element to correctly analyse the STE's impact on export markets. Sexton and Lavoie (2001) review this literature highlighting the importance of the definition of the STE's objective function and its strategic interaction with other agents. They quote different studies where the objective has been alternatively defined as maximization of total sales, revenues, producer returns, and revenues in the handling market, depending on the relevant hypothesis concerning government views on the role of the STE.

McCorriston and MacLaren (2007a) stress the role of STE playing as an export subsidy equivalent. They set up a model where STEs maximize a general welfare function that is the sum of consumer surplus, producer surplus and profits from sales to the domestic and international markets. Weights are eventually imposed on the two surplus measures in order to reflect the government view on which category to favour. Moreover, as in Thursby and Thursby (1990), it is assumed that profits can be costlessly transferred by the government to consumers and/or producers, with no impact on markets (i.e. government transfers are assumed to be fully decoupled).

Dong et al. (2006) and Hamilton and Stiegert (2002) focus on the role of the delayed producer payment system as a mean of exerting market power in the export market. STEs set a low initial price to producers that allow them to better compete in the export market, similarly to an export subsidy; in a later phase, STEs provide a lump-sum payment to producers considering all returns from sales. Strategic interaction is modelled as a two-stage game solved by backward induction. Hamilton and Stiegert (2002) find a significant role of the delayed payment system of the CWB in extracting rents from the international wheat market. On the contrary, Dong et al. (2006) reject this hypothesis for the malting barley market.

3. Theoretical model

Following Thursby and Thursby (1990) and McCorriston and MacLaren (2007a) we set up a partial equilibrium model where an exported good is differentiated by exporting country but homogeneous across domestic firms. The domestic market is segmented from the international market, while we assume the absence of two-way trade (i.e. the exporting country does not import the same good). Within the exporting country there are intermediate marketing agents (exporters) that buy the good from competitive producers and decide how much to sell on the international market and on the domestic market. The international market is made by different importing countries that competitively import the good and do not export it.

More specifically, consider the exporting country u ($u = 1, \dots, U$) with M^u ($i, j = 1, \dots, M^u$) exporting firms and $N^u - M^u$ ($i, j = M^u + 1, \dots, N^u$) firms selling only domestically (to simplify notation, in the following descriptions we drop the u superscript from the number of firms). Firms i sell a homogeneous product and face a domestic inverse demand

$$(1) \quad P_d^u = P_d^u(Y^u, Z_d^u)$$

² An alternative option is that of considering countries as agents, a hypothesis often considered in earlier works, from McCalla (1966) to Kolstad and Burris (1986). As mentioned by Sexton and Lavoie (2001), considering countries as agents is controversial: STEs or government intervention on exports and exporters could support this assumption, but the same behaviour could be modelled considering strategic interaction among firms and specific objective functions, such as in Thursby and Thursby (1990).

where P_d^u is the consumer's price in country u , $Y^u = \sum_i^N y_i^u$ is the total quantity supplied to the domestic market by all the N intermediate marketing agents, and Z_d^u is a vector of demand shifters in the domestic market. The M firms face an international inverse import demand:

$$(2) \quad P_w^u = P_w^u(X^1, \dots, X^U, Z_w^u)$$

where P_w^u is the export price, $X^u = \sum_i^M x_i^u$ is the total quantity exported by the M exporters operating in country u , and Z_w^u is a vector of export demand shifters for country u . The upstream market is made by competitive producers showing a domestic inverse supply:

$$(3) \quad P_s^u = P_s^u(X^u + Y^u, Z_s^u)$$

where P_s^u is the producer's price in country u , and Z_s^u is a vector of supply shifters for country u .

The objective of the i^{th} exporter in the $u=h$ (home) country is to maximize the following profit function:

$$(4) \quad \begin{aligned} \text{Max}_{x_{i1}, \dots, x_{iK}, y_i} \quad \pi_i^h = & P^h(Y^h) y_i^h + \sum_k^K P_w^h(X^1, \dots, X^U) x_{ik}^h - P_s^h(X^h + Y^h) (\sum_k^K x_{ik}^h + y_i^h) \\ & + \sum_k^K g_k^h x_{ik}^h + g_h^h y_i^h - \sum_k^K tr_{ik}^h x_{ik}^h - tr_{ih}^h y_i^h \end{aligned}$$

where x_{ik}^h is the quantity exported by exporter i to the importing country k ($k = 1, \dots, K$), g^h allows for the possibility of government intervention in the domestic or in the international market, in the form of per unit subsidy to the intermediate agent, and tr_i^h can be considered as a general marketing cost of the exporter, specific for each importing country.

The first order conditions of problem (4) are:

$$(5) \quad \begin{aligned} P_w^h + \left[\sum_u^U \sum_j^M \frac{\partial P_w^h}{\partial X^u} \frac{\partial X^u}{\partial x_j^h} \frac{\partial x_j^h}{\partial x_{ik}^h} \right] \sum_k^K x_{ik}^h - P_s^h \\ - \left[\sum_j^M \frac{\partial P_s^h}{\partial (X^h + Y^h)} \frac{\partial (X^h + Y^h)}{\partial x_j^h} \frac{\partial x_j^h}{\partial x_{ik}^h} \right] (\sum_k^K x_{ik}^h + y_i^h) + g_k^h - tr_{ik}^h = 0 \quad k = 1, \dots, K \end{aligned}$$

$$(6) \quad P_d^h + \left[\sum_j^M \frac{\partial P_d^h}{\partial Y^h} \frac{\partial Y^h}{\partial y_j^h} \frac{\partial y_j^h}{\partial y_i^h} \right] y_i^h - P_s^h - \left[\sum_j^M \frac{\partial P_s^h}{\partial (X^h + Y^h)} \frac{\partial (X^h + Y^h)}{\partial y_j^h} \frac{\partial y_j^h}{\partial y_i^h} \right] (\sum_k^K x_{ik}^h + y_i^h) + g_h^h - tr_{ih}^h = 0,$$

where it is implicitly assumed that firms do not make conjectures about a specific firm's reaction in another exporting country ($\frac{\partial x_i^u}{\partial x_{ik}^h} = 0$, with $u \neq h$), while they consider only the total quantity exported by a rival country X^u . Equations (5) and (6) can be rearranged in flexibility form:

$$(7) \quad P_w^h \left[1 + \sum_u^U \sum_j^M f_{wu}^h \frac{\sum_k^K x_{ik}^h}{X^u} v_{X^u, x_j} v_{x_j, x_{ik}} \right] - P_s^h \left[1 + \sum_j^M f_s^h \frac{\sum_k^K x_{ik}^h + y_i^h}{X^h + Y^h} v_{X^h + Y^h, x_j} v_{x_j, x_{ik}} \right] + g_k^h - tr_{ik}^h = 0 \quad k = 1, \dots, K$$

$$(8) \quad P_d^h \left[1 + \sum_j^M f_d^h \frac{y_i^h}{Y^h} v_{Y^h, y_j} v_{y_j, y_i} \right] - P_s^h \left[1 + \sum_j^M f_s^h \frac{\sum_k^K x_{ik}^h + y_i^h}{X^h + Y^h} v_{X^h + Y^h, y_j} v_{y_j, y_i} \right] + g^h - tr_{ih}^h = 0,$$

where $f_{wu}^h = \frac{\partial P_w^h}{\partial X^u} \frac{X^u}{P_w^h}$ is the flexibility of import demand of country h with respect to exports of each of the U exporting countries, and v_{\dots} indicates the different types of firm's conjectures:

$$v_{X^u, x_j} = \frac{\partial X^u}{\partial x_j^h}, \quad v_{x_j, x_{ik}} = \frac{\partial x_j^h}{\partial x_{ik}^h}, \quad v_{X^h + Y^h, x_j} = \frac{\partial (X^h + Y^h)}{\partial x_j^h}, \quad v_{Y^h, y_j} = \frac{\partial Y^h}{\partial y_j^h}, \quad v_{y_j, y_i} = \frac{\partial y_j^h}{\partial y_i^h}, \quad v_{X^h + Y^h, y_j} = \frac{\partial (X^h + Y^h)}{\partial y_j^h}.$$

v_{X^u, x_j} indicates the (quantity) responses of an exporting country u to a change in exports by firm j in country h ; $v_{x_j, x_{ik}}$ indicates the response of firm j to a change in exports by firm i (both operating in the same exporting country h) to the importing country k ($v_{x_j, x_{ik}} = 1$ when $i=j$); $v_{X^h + Y^h, x_j}$ indicates the domestic supply response to a change in exports by a domestic firm; v_{Y^h, y_j} indicates the domestic demand response to a change in domestic sales by an exporting firm; v_{y_j, y_i} indicates the response of domestic sales by the exporting firm j to a change in sales by the exporting firm i ($v_{y_j, y_i} = 1$ when $i=j$); and $v_{X^h + Y^h, y_j}$ indicates the domestic supply response to a change in sales to the domestic market by an exporting firm.

Since the objective of the paper is to carry out an analysis at the market level, equations (7) and (8) need to be aggregated over the M exporting firms. Assuming symmetry among exporting firms, firm's export and domestic supplies can be defined, respectively, as $x_i^h = \frac{X^h}{M}$ and $y_i^h = \frac{Y^M}{M}$, with $Y^M = Y^h - Y^{N-M}$. Since the symmetry assumption is quite unrealistic, following Thursby and Thursby (1990), we can interpret M as the "Herfindahl equivalent number of symmetric firms". This is computed as the inverse of the Herfindahl index (H^h) for the exporting country. Therefore, writing $H^h = \frac{1}{M}$, equations (7) and (8) can be rewritten as:

$$(9) \quad P_w^h \left[1 + \sum_u^U f_{wu}^h H^h \frac{X^h}{X^u} \sigma_{X^u, x_{ik}} \right] - P_s^h \left[1 + f_s^h H^h a_s^h \sigma_{X^h + Y^h, x_{ik}} \right] + g^h - tr_k^h = 0 \quad k = 1, \dots, K$$

$$(10) \quad P_d^h \left[1 + f_d^h H^h a_d^h \sigma_{Y^h, y_i} \right] - P_s^h \left[1 + f_s^h H^h a_s^h \sigma_{X^h + Y^h, y_i} \right] + g^h - tr_h^h = 0$$

where $a_s^h = \frac{(X^h + Y^M)}{X^h + Y^h}$ and $a_d^h = \frac{Y^M}{Y^h}$ are, respectively, the shares of exporters in total supply and total demand of the country, and σ_{\dots} indicates the representative firm's conjectures:

$$\sigma_{X^u, x_{ik}} = \sum_j^M \frac{\partial X^u}{\partial x_j^h} \frac{\partial x_j^h}{\partial x_{ik}^h}, \quad \sigma_{X^h + Y^h, x_{ik}} = \sum_j^M \frac{\partial (X^h + Y^h)}{\partial x_j^h} \frac{\partial x_j^h}{\partial x_{ik}^h}, \quad \sigma_{Y^h, y_i} = \sum_j^M \frac{\partial Y^h}{\partial y_j^h} \frac{\partial y_j^h}{\partial y_i^h}, \quad \sigma_{X^h + Y^h, y_i} = \sum_j^M \frac{\partial (X^h + Y^h)}{\partial y_j^h} \frac{\partial y_j^h}{\partial y_i^h}.$$

$\sigma_{X^u, x_{ik}}$ indicates the export response of country u to a change in exports of all exporting firms of the home country caused by a change in exports of firm i ; $\sigma_{X^h + Y^h, x_{ik}}$ indicates the domestic supply response in the home country to a change in exports of all domestic exporting firms caused by a change in exports of firm i ; σ_{Y^h, y_i} indicates the domestic demand response in the home country to a change in domestic sales of all domestic exporting firms caused by a change in domestic sales of

firm i ; and $\sigma_{X^h+Y^h, y_i}$ indicates the domestic supply response in the home country to a change in domestic sales of all domestic exporting firms caused by a change in domestic sales of firm i . Under the Cournot hypothesis conjectures $\sigma_{X^h+Y^h, x_{ik}}$, σ_{Y^h, y_i} , and $\sigma_{X^h+Y^h, y_i}$ are equal to one, while the conjectures $\sigma_{X^u, x_{ik}}$ are equal to one when $u = h$ and equal to zero in all other cases³.

In the transmission equations (9) and (10), the representative exporting firm maximizes its profit equating the perceived marginal revenue (the first term on the left hand side) to the perceived marginal cost. The possibility of the firm to influence market prices depends on how much it changes the other firms quantity setting decisions, on the characteristics of domestic and import demand (flexibilities), on its share on total exports of the country, on the share of exporters in the domestic market, on the share of exporters on domestic production, and on the ratio between exports of the home country and exports of any rival country. When the representative exporter's share on total exports of the country ($1/M$) tend to zero the transmission equation is equivalent to the perfect competition case, and the difference between producer and consumer price, or between producer and export price, is only explained by marketing costs and/or government intervention. The same happens when exports are very small compared to total production and consumption of the country.

In case exports are managed by STEs the above maximization problem needs to be revised, since the objectives of STEs can be different from those of private firms. Following McCorriston and MacLaren (2007a), equation (4) can be rewritten for a STE biased in favour of producers:

$$(11) \quad \begin{aligned} \underset{x_1, \dots, x_K, y}{Max} \quad W^h = & P_d^h(Y^h)y^h + \sum_k^K P_w^h(X^1, \dots, X^U)x_k^h - \int_0^{X^h+Y^h} P_s^h(X^h+Y^h)d(X^h+Y^h) \\ & + \sum_k^K g_k^h x_k^h + g_h^h y^h - \sum_k^K tr_k^h x_k^h - tr_h^h y^h \end{aligned}$$

Following the above procedure, the first order conditions lead to the following expressions

$$(12) \quad P_w^h \left[1 + \sum_u^U f_{wu}^h \frac{X^h}{X^u} \sigma_{X^u, x_{ik}} \right] - P_s^h + g_k^h - tr_k^h = 0 \quad k = 1, \dots, K$$

$$(13) \quad P_d^h \left[1 + f_d^h a_d^h \sigma_{Y^h, y_i} \right] - P_s^h + g_h^h - tr_h^h = 0.$$

Equations (1), (2), (3), (9), and (10) are the starting point to define the equilibrium conditions for the exporting country u that can be used for empirical purposes. To close the model we need to define the behaviour of the $N-M$ firms selling only domestically. Assuming these firms behave as price takers, they influence the equilibrium conditions only through the share parameters a_s^h and a_d^h , the first one depending on the exporter's quantity setting decision and the second one being a constant, since both exporters and domestic sellers face the same total domestic demand and sell a homogeneous product. Therefore, the following equations close the model:

$$(14) \quad \begin{aligned} Y^M &= Y^h a_d^h \\ Y^{N-M} &= Y^h (1 - a_d^h) \end{aligned}$$

³Alternatively to the symmetry assumption, Goldberg and Knetter (1999) prefer to interpret the result of aggregation as an industry average, with averages computed as share weighted means for all firms of the exporting country. Assuming symmetry among firms, also price transmission equations obtained from share weighting reduce to (9) and (10).

In the complete model, the whole set of equations is repeated for the U exporting countries. Finally, equations (9) and (10) are replaced by (12) and (13) when a STE is operating in the exporting country, and the share parameter $a_d^h=1$ when the STE manages the whole domestic supply.

The dimension and complexity of the above model depends on the number of u exporting countries and k importing regions that need to be modelled. Note that, as it is written, the model is still in general form, since it does not specify functional forms and allows for different types of conjectures (i.e different type of strategic behaviour by firms).

4. Empirical model

In this section, we present a simulation exercise based on a simple case consisting of two exporting countries and one importing region. The empirical specification of equations (1)-(3) leads, respectively, to the following equations expressed in double-log form:

$$(15) \quad \begin{aligned} \ln Y^u &= \alpha_d^u + \varepsilon_d^u \ln P_d^u + \beta_d^u \ln GDP^u + \gamma_d^u Trend \\ \ln(Y^u + X^u) &= \alpha_s^u + \varepsilon_s^u \ln P_s^u (-1) + \gamma_s^u Trend \quad \text{with } u=1,2 \\ \ln X^u &= \alpha_w^u + \varepsilon_{u1} \ln P_w^1 + \varepsilon_{u2} \ln P_w^2 + \beta_w^u \ln GDP^k + \gamma_w^u Trend, \end{aligned}$$

where GDP indicates the gross domestic product of the exporting country u and of the importing region k , $\varepsilon_d^u, \varepsilon_s^u$, and $\varepsilon_{u.}$ are price elasticities, α, β and γ are parameters, and the variable $Trend$ captures the effects of other exogenous time varying shifters. Equations are specified in direct form: this implies that flexibilities of transmission equations are written as the inverse of elasticities. Since we assume two exporting countries with differentiated goods, for the import demand equation the full elasticity matrix needs to be inverted.

Artificial data are used for the simulation exercise. We assume for the base year that exporting countries are symmetric in variables and parameters, with the following values:

- prices equal to 100 for all price categories;
- domestic production equal to 100 for both countries;
- the domestic market is as large as the export market for each country (50, 50);
- exporting and non-exporting firms equally share the domestic market (25, 25);
- firms behave as Cournot;
- domestic price elasticities are $\varepsilon_d^u = -1.5$, $\varepsilon_s^u = 0.5$, $\varepsilon_{uu} = -1.5$, and $\varepsilon_{u.} = 0.5$;
- parameters are $\beta_{1d}^u = \beta_{1w}^u = 1$, $\gamma_d^u = \gamma_w^u = 0$, $\gamma_s^u = 0.002$ (technological trend);
- when a STE is present, it manages the whole domestic supply ($a_d^h = 1$);
- the intercept parameters α^u are computed in the calibration procedure at the first year of the simulation period.

5. Results of the simulation exercise

5.1 Simulations

Table 1 shows the results of the simulation exercise concerning market prices. Different hypotheses are compared based on the structure of the exporters in the two exporting countries: both monopolists, both perfectly competitive, one monopolist and one perfectly competitive, and the presence of a STE compared to monopolistic, oligopolistic and perfectly competitive markets. Dynamics for the simulation are introduced assuming a GDP^k increase of 2% per year and a positive technological trend for the domestic supply function of 0.2%. Given the symmetric values of variables and parameters for the two countries, differences in the results only depend on the market structure hypotheses.

Reacting to the increasing import demand, export prices increase. As expected, when both exporters are monopolists we have the highest increase of the export price, since both of them tend to react less in quantity terms. The producer price goes in the opposite direction, since a larger export quantity increases the exporters' share in the input market, thus increasing their monopsony power. The domestic consumer price shows a smaller increase compared to the export price because of a lower flexibility (in absolute value) of the domestic inverse demand⁴ and a lower degree of market power on the domestic market, since the (monopolist) exporter holds only 50% of this market.

Opposite to the previous case, the quantity reaction is larger when both exporting countries have competitive exporters. Considering no transportation and marketing costs, all prices are the same and show the smaller increase. Note that, compared to the previous case, consumer prices are higher. Hence, even if there is no mark-up between farm and consumer price, the higher farm level prices due to the perfectly competitive structure generate higher prices in the final domestic market.

When one country is characterized by a monopolist exporter while the other have competitive exporters the results are not symmetric anymore. The monopolist act similarly to the first case, even if the price response is slightly lower. This depends on the degree of substitution of the exported product with the product exported by the perfectly competitive country. In this last country, as in the previous case, producer, consumer and export prices coincide, even if they grow slightly more because of the substitution effect with the monopolist's product. Producers in the perfectly competitive country benefit from higher prices when the other country act as a monopolist, while consumers pay higher prices in the final market.

The presence of a STE changes the results for both producers and consumers. For the first category no monopsony power is exercised, while for the second only one agent is now managing the entire domestic production. Contrary to a monopolist, when a STE faces a perfectly competitive exporter the following events occur: 1) the producer price increases in the simulation period (since the STE is biased toward producers, its share in the input market has no impact); 2) producers are stimulated to raise production that is sent to a larger extent on the export market, that weights 15% more than the national market (10% in the monopoly case); 3) larger exports generate a smaller increase in the export price; 4) a STE biased toward producers and acting as a full monopolist in the domestic market constrains domestic supply, thus raising consumer price; and, 5) in the perfectly competitive country prices are slightly lower as compared to the previous case, because of the competition with the lower export price of the STE.

An oligopoly or a monopoly competing with a STE increase generate stronger increases in the export price, domestic price and consumer price in the country having the STE. The producer price decreases for the oligopolistic/monopolistic country because of the stronger market power of the buying agent. Related to this is the level of the consumer price in this country, that increases in the oligopoly case as compared to perfect competition, but decreases in the monopoly case for the prevailing effect of the lower input price.

Comparing the monopoly/monopoly case with the STE/monopoly one, it turns out how the consumers of the STE's country are those paying higher prices while export prices are lower in both countries. The monopoly country shows similar results in the two cases, even if the mark-up is slightly lower when the competing country have a STE, since the smaller quantity exported reduces the exporter's weight (market power) in the input market.

5.2. Sensitivity analysis

⁴ Price elasticities are the same for the domestic and international market (-1.5). However, the inversion of the full elasticity matrix leads to a own price flexibility of -0.75 for the import demand and of -0.67 for the domestic demand. A lower flexibility in absolute value means that the ratio between consumer and producer price is smaller; therefore, also the degree of price transmission is smaller.

In order to analyse the properties of the model, we have carried out some sensitivity analysis concerning some of the exogenous parameters of our equations. Comparison is made at the last year of the simulation (2018), where differences are of larger magnitude.

Figure 1 shows changes in prices for different values of the Herfindahl index (H) in the two countries. The figure reproduces at the two extremes the first two cases illustrated in table 1. It is evident how prices do not linearly depend on H and, interestingly, how the function of the consumer price is concave with a maximum corresponding to the central values in the 0-1 Herfindahl interval: the higher market power on consumers is mitigated by the lower producer price.

Figure 2 highlights the price transmission properties between the producer price and the domestic (export) prices. Values represent the following ratio: $\frac{P_s^u(t) - P_s^u(t-1)}{P_{d(w)}^u(t) - P_{d(w)}^u(t-1)}$, where t is a time

period of the simulation. Price transmission is equal to one in case of perfect competition and decreases non linearly with firms' concentration. For high levels of concentration transmission becomes negative: it means that prices move in the opposite direction, as it is for the two-monopolists case of table 1.

When Country 1 is a monopolist the variation in the exporters' structure of Country 2 has relatively little impact on its market prices (figure 3), while prices in Country 2 show a similar pattern to what described in figure 1, with values scaled upward (figure 4). The same reasoning applies for price transmissions illustrated in figure 5. Figures do not substantially change when a STE is present in Country 1, although it is interesting to note how the degree of transmission in this country shifts upward and become positive (figure 6). Differently from the monopoly case, the change of the exporter's share in the domestic market has no impact on the producer price, which moves in the same direction of the downstream market prices, since there is no monopsony power.

The market prices and their transmission levels described in the previous figures clearly depend on the assumption about the magnitude of the different parameters and variables of the model: Cournot behaviour, elasticities, share of exports on domestic production, share of exporters on the domestic market, government intervention, and marketing costs. For example, more elastic import demand reduces the price response, higher cross-price elasticities increase the reciprocal influence between exporters, and higher shares in the domestic market increase the influence of exporters on domestic prices.

Since the final objective of the model is policy simulation, as last example it is interesting to evaluate how market power can influence the impact of policy measures, such as export subsidies. Considering different levels of concentration in Country 1 and oligopolistic exporters in Country 2 ($H=0.2$), figure 7 shows the effect of the introduction of a per-unit export subsidy equal to 5. In the perfect competition case the difference between export prices and domestic prices is given by the level of the subsidy, with the export price being lower. As concentration increases, following the pattern described in the previous figures, the producer price decreases and the consumer price follows a concave pattern. With higher firm concentration, export prices can result to be higher than producer prices at the end of the simulation period, since exporters take full advantage of the increasing import demand without transmitting the price increase in the domestic market. Thus, the subsidy becomes a pure form of coupled transfer to producers, highlighting how final results of government intervention can be quite different depending on the competitive form of the subsidized market.

6. Conclusions

In this paper, we have developed a model that explains the exporters' behaviour in international commodity markets considering explicitly the case of an imperfectly competitive structure of these markets. The main reason that motivates our research is that virtually all models currently used to simulate agricultural and food policy scenarios assume perfectly competitive

markets, both domestically and internationally, despite a number of evidences that make this assumption unrealistic. Thus, drawing from the imperfect competition and trade literature, in our model we have derived price transmission equations between producer and consumer prices and between producer and export prices that can be included in large commodity models in order to verify how results of these models change assuming the imperfect competition hypothesis.

Our model considers both the case in which imperfect competition may come from high concentration of firms operating in the export market (i.e. large national or multinational trading companies) or from the presence of State Trading Enterprises (STEs), as those operating in the cereal market in countries like Canada and Australia. The model has the advantage of being sufficiently general to include different numbers of importing and exporting countries, also distinguishing for the number of exporting firms and their share in the export and domestic markets. Firm's conduct is not constrained to a particular behaviour, although the model is based on a classical quantity setting framework.

In order to analyse the properties of the model, we have carried out a simple simulation exercise with two competing exporting countries and one importing region. The results presented in the previous sections show the relevance of assuming imperfect competition in commodity markets. For example, comparing the two extreme cases (i.e. two monopolists vs. two perfectly competitive exporting countries) we have rather strong differences in prices: under imperfect competition, the (farm level) producer price turns out to be 3.7% lower and the export price 4% higher, while, quite surprisingly, the consumer price is lower (-1%).

In fact, one of the most interesting results of the model is the “concave” behaviour of consumer prices with respect to increasing level of concentration in the export market. Market power exerted by exporters increases domestic consumer prices up to an intermediate level of concentration, while moving toward the monopoly case the impact is mitigated by the lower price of the agricultural input. Under our assumptions concerning the parameters of the model (i.e. import demand elasticities, domestic demand and supply elasticities), consumer turn out to pay lower prices under the monopolist case than under the perfect competition case.

Other important results come from the asymmetric cases considered in our analysis: for example, producers in a perfectly competitive country benefit of higher prices when the competitive exporter is a monopolist (or a STE), while consumers pay higher prices in the final market. As expected, the role of STEs is rather different from that of a private monopolist: producers in the STE's country always benefit of higher prices, although lower than in the perfect competition case, while consumer in the same countries always pay higher prices. Consumers pay higher prices also in countries competing with a STE, as long as their exporting structure is perfectly competitive or oligopolistic.

The above results clearly depends on some key assumptions of the model, such as the symmetry of firms (the standard condition for aggregation), that determines a direct link between market power and market structure, as well as the type of STE's objective function. Further investigation in this area could provide more insight on the relevance of these assumptions for policy modelling purposes. Finally, in terms of using our transmission equations in large commodity models routinely used for policy analysis, the key problem to be solved is adapting such models to the so called “Armington assumption” considered in our model and in large part of the literature addressing the issue of imperfect competition (i.e. products are differentiated among exporting countries and their export prices may be different), since the price transmission equations used in these models typically assume only one export/world price for each commodity.

Table 1 – Dynamic of prices over the simulation period under different market structure hypotheses for the two exporting countries

Country 1 vs Country 2	Variables	Years							
		2011	2012	2013	2014	2015	2016	2017	2018
Both monopolists									
	PW1	100.00	101.02	102.09	103.17	104.27	105.38	106.51	107.65
	PP1	100.00	99.95	99.90	99.86	99.82	99.77	99.73	99.70
	PC1	100.00	100.38	100.78	101.19	101.60	102.02	102.44	102.87
	X1	50.00	50.49	50.96	51.43	51.91	52.39	52.87	53.35
	Y1	25.00	24.86	24.71	24.56	24.41	24.26	24.11	23.96
Both perfect competition									
	PW1	100.00	100.64	101.03	101.54	102.02	102.52	103.02	103.54
	PP1	100.00	100.64	101.03	101.54	102.02	102.52	103.02	103.54
	PC1	100.00	100.64	101.03	101.54	102.02	102.52	103.02	103.54
	X1	50.00	50.68	51.48	52.25	53.04	53.84	54.64	55.45
	Y1	25.00	24.76	24.61	24.43	24.26	24.08	23.90	23.72
Monopolist vs perfect competition									
	PW1	100.00	100.94	101.86	102.81	103.77	104.74	105.73	106.73
	PP1	100.00	99.95	99.90	99.86	99.82	99.78	99.74	99.70
	PC1	100.00	100.35	100.70	101.05	101.41	101.78	102.15	102.53
	X1	50.00	50.46	50.89	51.33	51.77	52.22	52.66	53.11
	Y1	25.00	24.87	24.74	24.61	24.48	24.35	24.22	24.08
	PW2	100.00	100.69	101.16	101.72	102.26	102.82	103.40	103.98
	PP2	100.00	100.69	101.16	101.72	102.26	102.82	103.40	103.98
	PC2	100.00	100.69	101.16	101.72	102.26	102.82	103.40	103.98
	X2	50.00	50.71	51.60	52.44	53.31	54.19	55.07	55.96
	Y2	25.00	24.74	24.57	24.37	24.18	23.98	23.78	23.58
STE vs perfect competition									
	PW1	100.00	100.73	101.36	102.03	102.71	103.39	104.09	104.81
	PP1	100.00	100.18	100.34	100.51	100.68	100.85	101.02	101.20
	PC1	100.00	100.55	101.02	101.52	102.03	102.55	103.07	103.60
	X1	50.00	50.61	51.25	51.90	52.54	53.20	53.85	54.51
	Y1	50.00	49.59	49.24	48.88	48.52	48.15	47.78	47.41
	PW2	100.00	100.66	101.09	101.61	102.11	102.64	103.17	103.72
	PP2	100.00	100.66	101.09	101.61	102.11	102.64	103.17	103.72
	PC2	100.00	100.66	101.09	101.61	102.11	102.64	103.17	103.72
	X2	50.00	50.69	51.53	52.33	53.16	53.98	54.82	55.67
	Y2	25.00	24.76	24.60	24.41	24.23	24.04	23.86	23.67
STE vs oligopoly (H=0.2)									
	PW1	100.00	100.74	101.39	102.08	102.77	103.47	104.19	104.92
	PP1	100.00	100.18	100.35	100.52	100.69	100.87	101.05	101.23
	PC1	100.00	100.55	101.05	101.56	102.08	102.61	103.14	103.69
	X1	50.00	50.61	51.27	51.92	52.58	53.25	53.91	54.59
	Y1	50.00	49.59	49.23	48.85	48.48	48.11	47.73	47.35
	PW2	100.00	100.69	101.24	101.85	102.45	103.07	103.70	104.35
	PP2	100.00	100.36	100.64	100.95	101.25	101.57	101.89	102.23
	PC2	100.00	100.63	101.13	101.68	102.23	102.80	103.37	103.96
	X2	50.00	50.67	51.42	52.16	52.91	53.66	54.43	55.19
	Y2	25.00	24.77	24.58	24.38	24.19	23.99	23.79	23.59

cont.

Table 1 – cont.

STE vs monopolist									
PW1	100.00	100.79	101.52	102.28	103.05	103.83	104.62	105.43	
PP1	100.00	100.20	100.38	100.57	100.76	100.96	101.16	101.36	
PC1	100.00	100.59	101.14	101.71	102.28	102.87	103.47	104.08	
X1	50.00	50.64	51.35	52.05	52.76	53.47	54.18	54.90	
Y1	50.00	49.56	49.15	48.75	48.33	47.92	47.51	47.09	
PW2	100.00	100.96	101.95	102.95	103.96	104.99	106.04	107.10	
PP2	100.00	99.95	99.90	99.86	99.82	99.78	99.74	99.70	
PC2	100.00	100.36	100.73	101.11	101.49	101.87	102.26	102.66	
X2	50.00	50.47	50.92	51.37	51.83	52.29	52.75	53.21	
Y2	25.00	24.87	24.73	24.59	24.45	24.31	24.17	24.03	

Figure 1- Prices at the end of the simulation period (2018) for different symmetric levels of concentration in the two countries

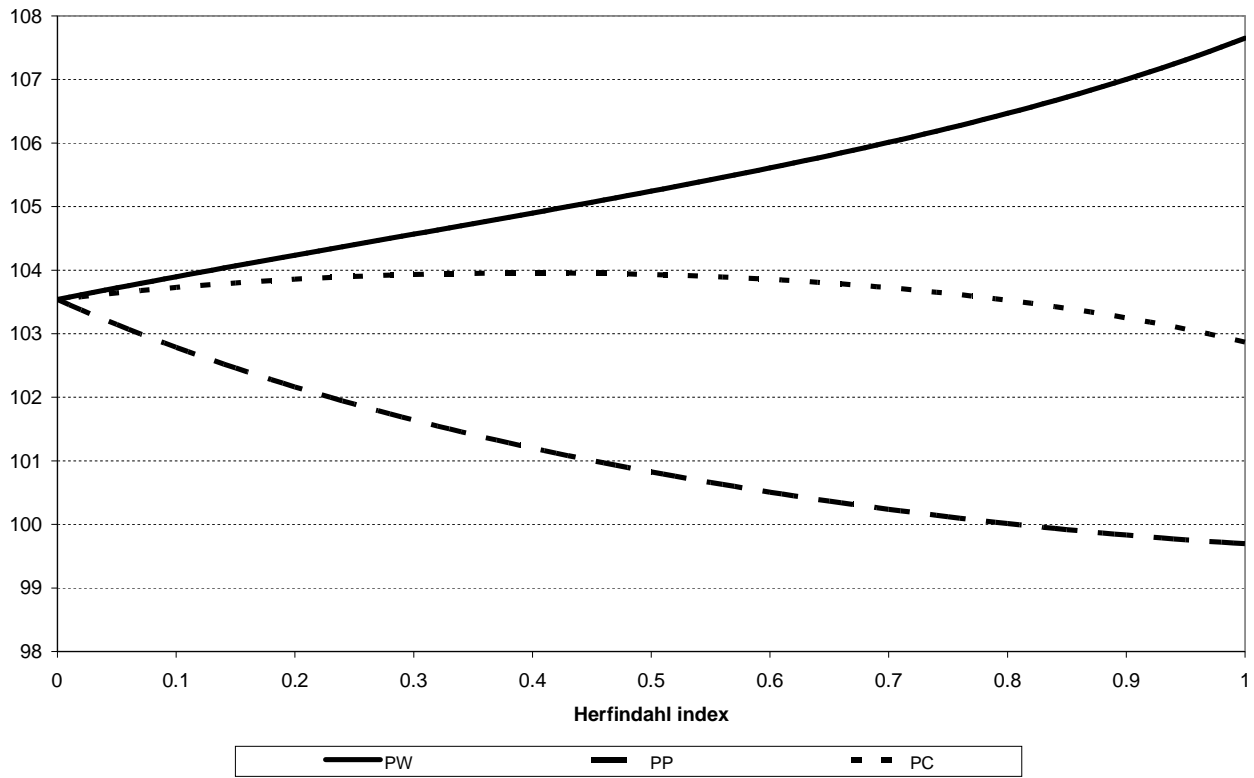


Figure 2 - Price transmission between producer and export and consumer prices for different symmetric levels of concentration in the two countries

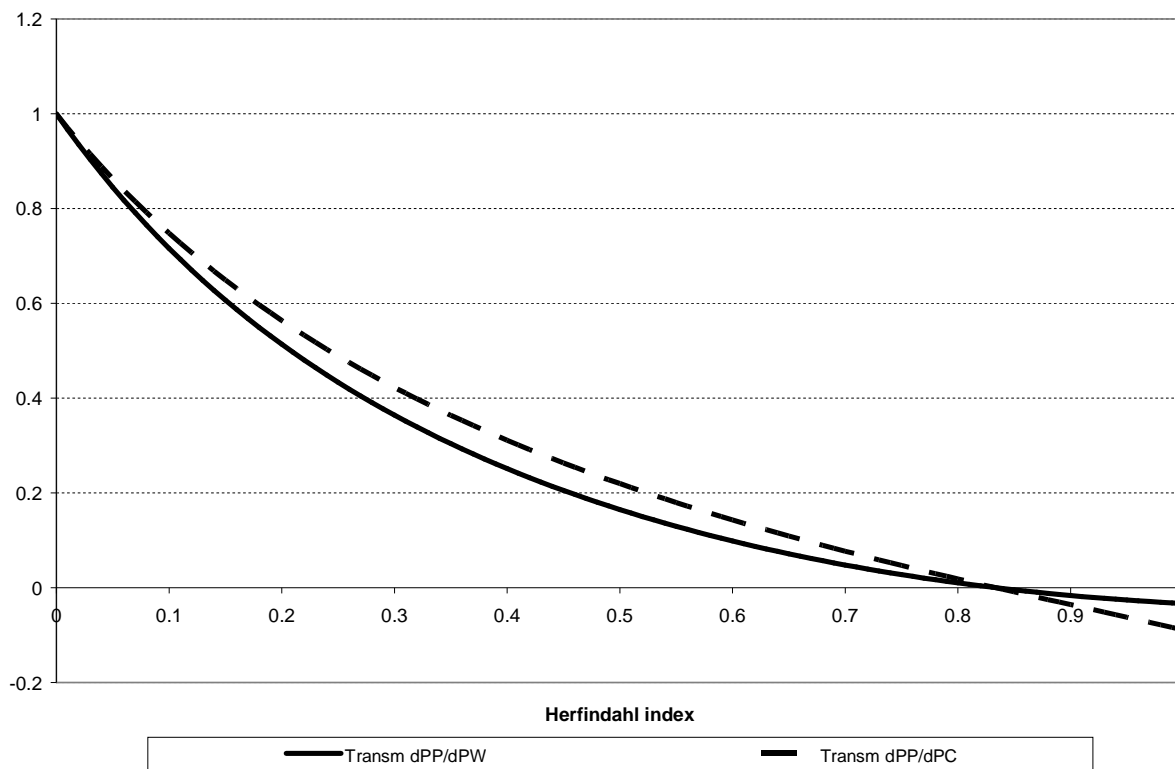


Figure 3 - Prices in Country 1 at the end of the simulation period (2018) for different levels of concentration in Country 2 (Country 1: monopoly)

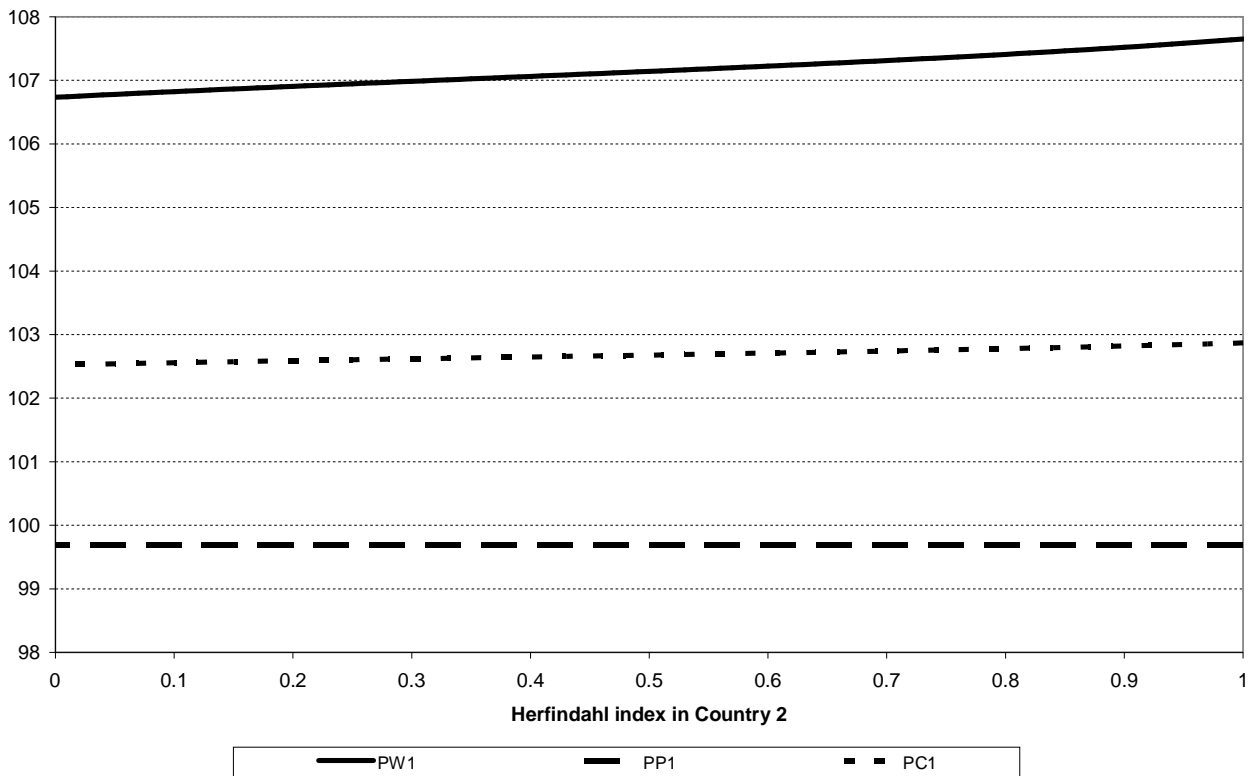


Figure 4 - Prices in Country 2 at the end of the simulation period (2018) for different levels of concentration (Country 1: monopoly)

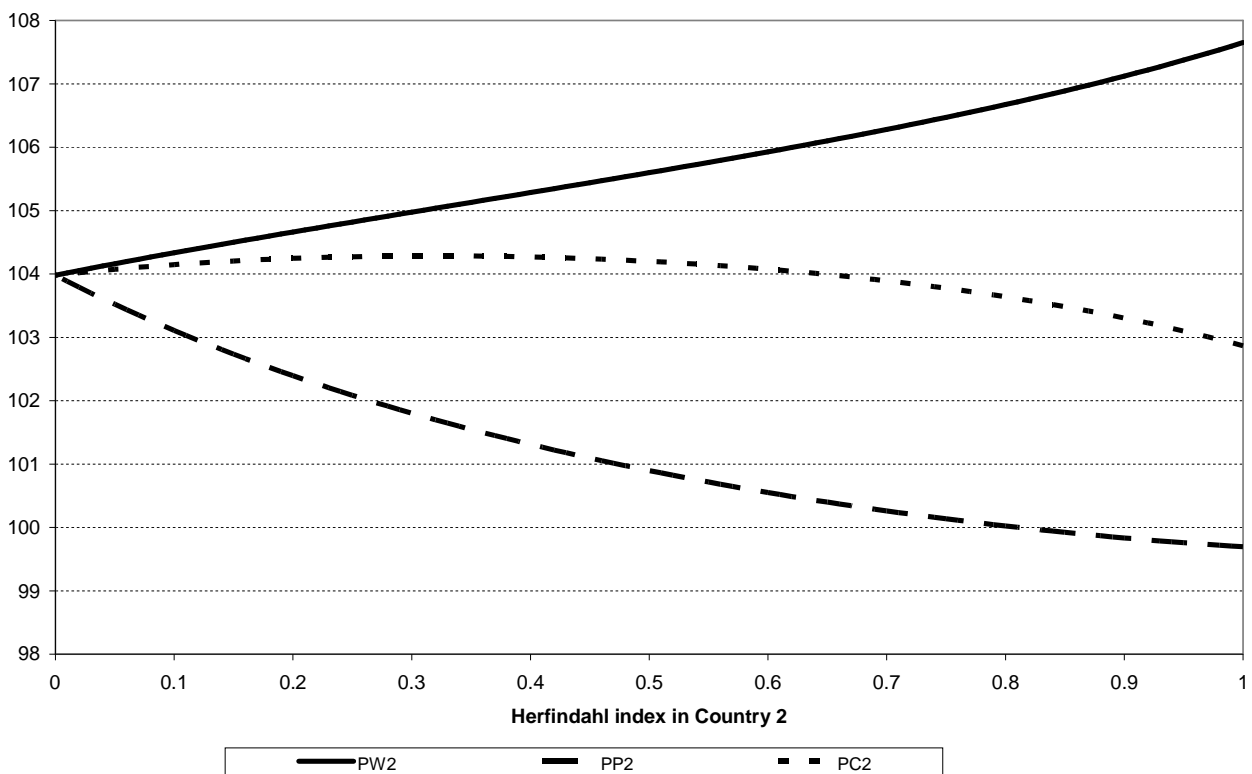


Figure 5 - Price transmission between producer and export and consumer prices for different levels of concentration in Country 2 (Country 1: monopoly)

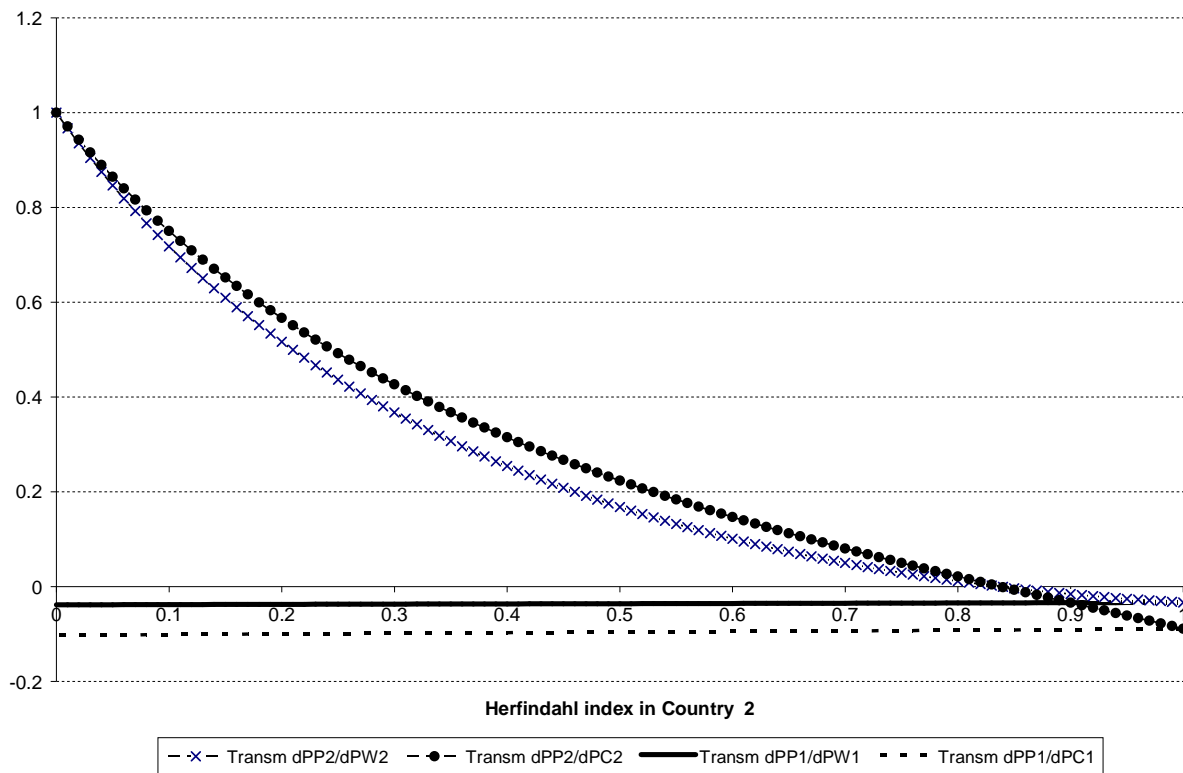


Figure 6 - Price transmission between producer and export and consumer prices for different levels of concentration in Country 2 (Country 1: STE)

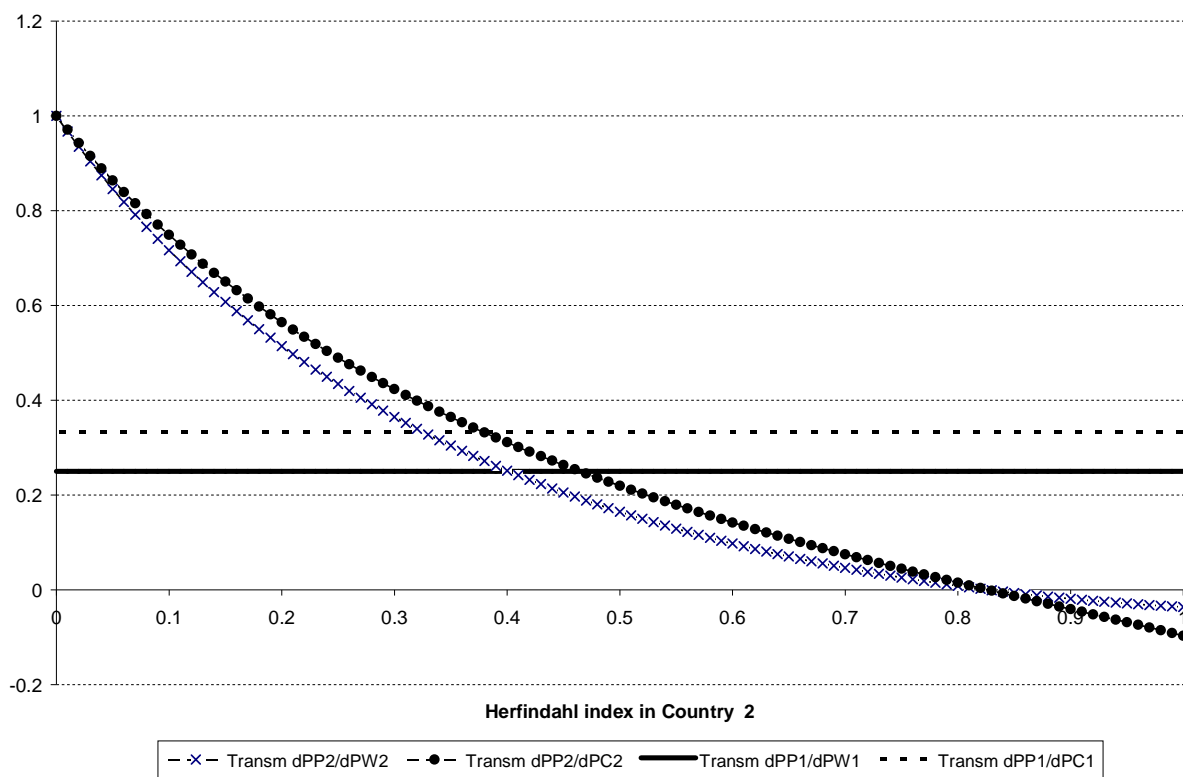
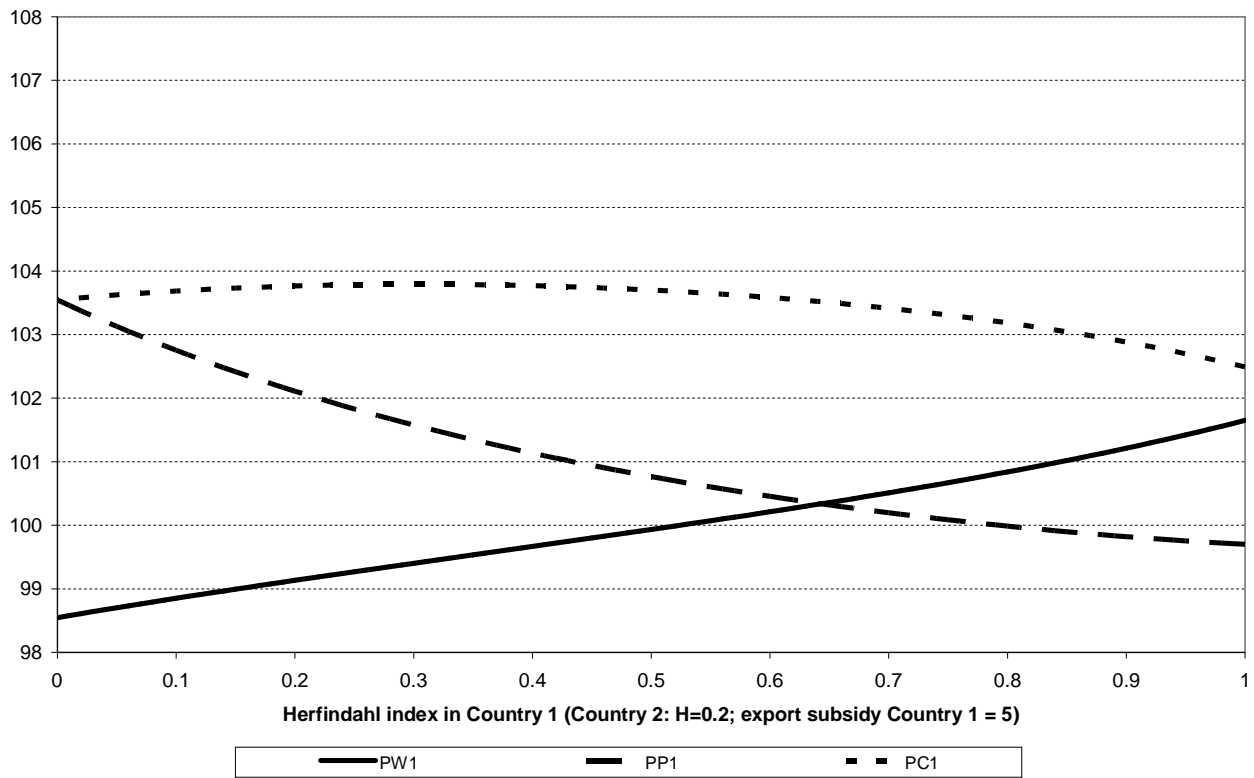


Figure 7 - Prices at the end of the simulation period (2018) for different levels of concentration and an export subsidy of 5 in Country 1 (Country 2: $H = 0.2$)



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