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REGIONAL INTEGRATION AND PRODUCTION LOCATION: WHAT THEORIES (DO NOT) TELL US[1]

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ABSTRACT

There is broad empirical evidence showing that regional integration considerably influences the choice of firms over the location of production. Traditional preferential trade theory does not include the driving force of these changes, that is, economies of scale. The paper surveys recent contributions from the new economic geography and the multinational enterprise literature addressing the issue of the effects of preferential trade, with the aim of examining the main features of the models, and assessing their predictions and policy implications. The findings appear to be significant when dealing with the agri-food industry, as the production shifting effect due to economies of scale is likely to be considerable for agricultural processed products. Policy implications may be relevant, especially for small developing countries joining preferential trade areas with the expectation of benefiting from the location of economic activity in their territory.

JEL classification: F12, F13, F15
Key words: regional integration, multinational firms, economic geography

INTRODUCTION

There is a host of empirical evidence to show that regional integration influences the choices firms make on the location of production, although the pattern and the consequences of these changes are still debated (Yannopoulos 1990; Blomstrom and Kokko 1997; Dunning 1997a and 1997b; Barba Navaretti and Venables 2004). Several studies have shown that integration in the European Union (EU) has attracted outside firms - in the early decades mainly from the US and, more recently, from Japan - and also has caused an upsurge of intra-

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UE foreign direct investment (FDI); few studies have found that integration has also affected the distribution of the economic activity within a member state. More recently, a number of papers have emphasized how the prospects of entering the Union have profoundly influenced the pattern of FDI and trade between the candidate and the EU member countries. As for other preferential trade agreements (PTAs), such as NAFTA and MERCOSUR, changes have occurred in the location of production, both within participating countries and between the area and the rest of the world.

As for agri-food products, studies on the determinants of FDI have shown that the extensive internationalization in the agri-food industry has been driven, among other reasons, by the aim of firms to jump the tariffs in order to gain access to large consumer markets (e.g., Reed and Ning 1996; Gopinath, Pick and Vasavada,1999; Makki, Somwaru and Bolling 2004; Chevassus-Lozza, Gallezot and Galliano 2005; Wilson 2006). The formation of a PTA, by increasing the size of the internal market and, frequently, also the degree of protection of the area with respect to third countries, is likely to attract outside firms and to affect the organization of the insiders.

This paper surveys the international trade models addressing the issue of the relationship between regional integration and the location of production, in particular the more recent models, and compares and assesses their predictions and their policy implications.

The traditional PTA theory, based on Vinerian's framework assuming perfect competition, does not fully capture the effects of relocation linked with regional integration. This is essentially because the driving force of these changes is the presence of economies of scale. In addition, PTA theories do not take into consideration the multinationality of firms and FDI and, thus, fail to account for the effects of PTAs, not only on the location of production plants, but also on the organization and ownership of firms.

The survey focuses on theoretical papers developed within two general frameworks, the new economic geography (NEG) models and the models including FDI, as they are likely to be the most appropriate to deal with the location effects of PTAs. NEG models focus on the agglomeration factors which induce firms to concentrate geographically, while models with FDI take into account the multinationality of firms and, consequently, deal not only with the location of production, but also with the organization of firms.

A number of key issues are considered in the paper. The first is related to the effects of a PTA on location choices of inside and outside firms: how does a PTA affect the pattern of FDI within the area and between member states and outsiders? And how is the geographical distribution of economic activity within the area likely to change? The second issue is related to the impact of changes in the location of production on internal and external trade: does the upsurge of FDI in the area substitute previous trade or encourage new trade? And how does the new pattern of geographical distribution of economic activities within the area affect trade? The third issue is related to the welfare implications of a PTA when location effects are taken into account: who are the losers and the winners of regional integration? Under what circumstances is it wise for a developing country in particular to join a PTA? And what are the consequences of PTAs for multilateralism?

Table 1 presents a tentative classification of the surveyed papers. The majority of contributions focus on positive analysis - aiming at answering questions like “what are the effects of PTAs on location and trade?” – while only a few of them address normative issues, and focus on the welfare implications of regional integration. A further important distinction is between papers that assume symmetry of firms and countries from those that introduce asymmetries: while the former mainly deal with the location effects of integration between similar (developed) countries, the latter examine the effects of integration between a developed and a less developed country.

Table 1. A classification of the models

		NEG models	Models with FDI	
			Partial Equilibrium	General Equilibrium
Positive analysis	Symmetry between countries	Baldwin, Venables (1995) Puga, Venables (1997) Gao (1999)	Motta, Norman (1996) Neary (2002)	
	Asymmetry between countries	Puga, Venables (1999) Baldwin et al. (2003)	Mountout, Zitouna (2005) Ekholm et al. (2003)	
Normative analysis	Symmetry between countries		Donnenfeld (2003)	Ludema (2002)
	Asymmetry between countries		Raff (2004)	Ethier (1998)

An additional difference among the papers - not included in Table 1 - is the kind of regional agreement that they model. In most papers, regional integration basically means a reduction (or an elimination) of internal trade barriers – a Free Trade Area (FTA) – or a change in the external tariffs - a Custom Union (CU). Some papers specifically consider also the "hub-and-spoke" agreements, that is, bilateral free trade agreements of one country, the hub, with several other countries, the spokes. In all papers assuming symmetry between countries, preferences are modeled as reciprocal, i.e., there is a bilateral reduction of tariffs. Conversely, papers assuming asymmetries between countries generally examine the location effects of a reduction of the industrial tariffs only in the more developed countries. One paper takes into account the fact that regional agreements frequently include other arrangements such as investment liberalization and, for small developing countries, commitments to economic reform. These arrangements may be relevant, as both trade and location effects of a PTA may also depend on the other commitments included in the agreement.

The paper is organized as follows. The next section briefly surveys early contributions, while the following two sections review the main features of the NEG models and of models including FDI. The final section summarizes the main findings of the surveyed literature and presents some concluding remarks.

REGIONAL INTEGRATION, ECONOMIES OF SCALE AND MULTINATIONAL FIRMS: EARLY CONTRIBUTIONS

The consideration of economies of scale in regional integration theory dates back to Corden (1972), who assumes perfect competition and homogenous products. The effects of a

CU under this hypothesis are illustrated in Figure 1.[2] Assume two small integrating countries, H and P, with identical demand ($D_{h,p}$), but different production costs, AC_h and AC_p , with H being the least efficient country. Production costs in the partner countries are assumed to be higher than in the rest of the world; the world price is S_w. In free trade, H and P would not produce, and import from the rest of the world Oq_5 at price OA.

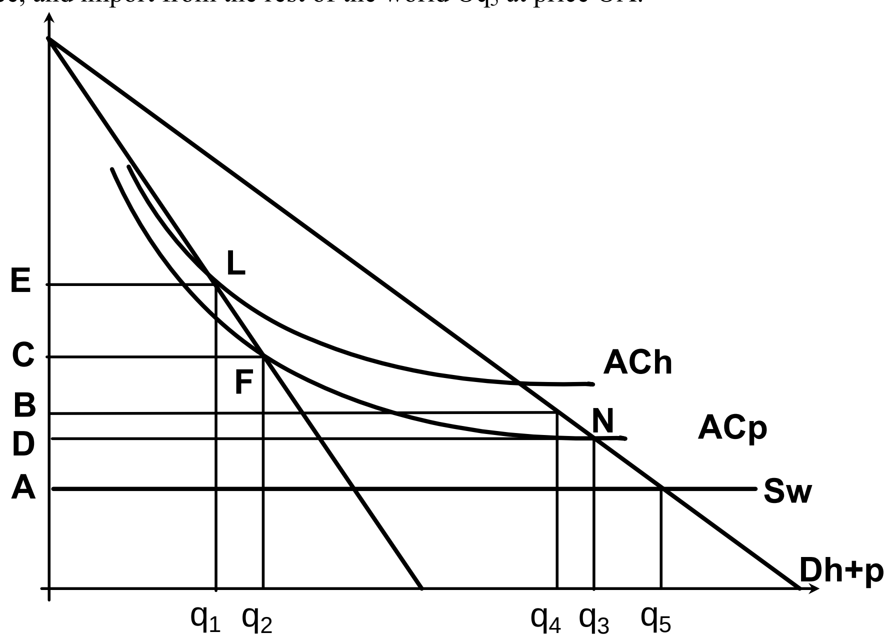

Figure 1. Preferential agreements with economies of scale and perfect competition

Assume that, before the CU, the non discriminatory tariff is equal to AB: in that case, H and P do not produce, but import quantity Oq_4 from the rest of the world at price OB. The formation of a CU permits producers of country P to enter production, as they can benefit from the larger union-wide market and exploit economies of scale. The domestic demand of the CU is entirely satisfied by the production of country P (Oq_3), so that the "rest of the world" production is fully replaced by internal production. This has been called by Baldwin and Venables (1995) the "production shifting" effect of a PTA. From a welfare point of view, the effect of the CU is ambiguous, since the negative effects (trade diversion + loss of tariff revenue) may be (or may not be) counterbalanced by the positive effects from the decrease in the domestic price (from OB to OD).

However, a CU may also be unambiguously welfare improving. This happens if the pre-PTA non discriminatory tariff is large enough (i.e. is such that the world price plus the tariff is higher than the minimum average cost of CU member countries) to allow CU producers to enter production even before the formation of a CU. In Figure 1 this happens when the tariff in country P (H) is greater than AC (AE); before the CU, P and H produce and consume quantities Oq_1 and Oq_2, respectively, and there are no imports. In this case, a CU does not divert trade, and there is only trade creation; production concentrates in the lower cost CU

[2] A later paper by Choi and Yu (1984) further extended Corden's analysis.

country from where the good is exported to the least efficient CU country. As can be seen in the figure, all production will concentrate in P, which produces quantity Oq_3 at price OD. Thus, CU member countries enjoy the positive effects of integration, which are due to the decline in costs and, thus, in prices.

Although quite simple, this framework illustrates two important effects of regional integration in an industry with economies of scale: a) the shifting of the whole production from outside the CU to inside the CU; b) the concentration of the whole production in the most efficient country of the CU. As regards traditional CU theory, the key feature is that, with economies of scale, the rest of the world and the least efficient member countries no longer produce.

Kindleberger (1966) argued that a CU may also imply investment creation and investment diversion. Investment creation is due to an increase of inward FDI flows to the CU from third countries, and is the response of firms from non-member countries to trade diversion: outside firms previously exporting to the area locate plants inside the CU in order to maintain their market share. Investment diversion is the shifting of FDI within the CU and is the consequence of trade creation, that is, the re-organization of production inside the CU, and this implies a shift of investments from one member to another.

Yannopoulos (1990) and Dunning (1993) further extended Kindleberger's ideas by considering the dynamic effects of integration; they identify four types of investment as a response to the static and dynamic effects of a CU:

a. Defensive export-substituting investments are the response of non-member firms to the trade diversion effect in order to maintain market share (investment creation). In this case, FDI replaces trade: the net trade effect is negative, while the net FDI effect is positive.
b. Reorganization investments occur when outside firms are already inside the block before integration, and emerge as a consequence of trade creation (investment diversion); they imply a consolidation of previous operations into fewer larger plants. The net trade and FDI effects are likely to be neutral for the region as a whole; however, the net FDI effect may be positive for some countries (those where FDI are concentrated) and negative for others;
c. Offensive export-substituting investments are the consequence of one of the dynamic effects of the CU, that is, the increase in the growth rate of member countries; firms invest in the CU to take advantage of the growing demand; these investments do not necessarily replace existing trade, even though they may preclude a further expansion of trade; the net FDI effect is positive.
d. Rationalized investments are the consequence of another dynamic effect of regional integration, that is, the possibility to exploit economies of scale and reduce production costs; these investments are thus mainly motivated by international differences in production costs and are likely to be complementary to trade. Further, the net FDI effects are also likely to be positive.

In later contributions, Dunning (1997a and 1997b) emphasizes that regional integration effects are likely to be sector-specific. More significant location effects tend to be found in technology intensive industries in which plant economies are important relative to transport costs, while a less concentrated pattern is expected where products are more dependent on classical resource endowments for their competitiveness.

REGIONAL INTEGRATION AND THE LOCATION OF FIRMS IN THE NEW ECONOMIC GEOGRAPHY

One of the early efforts to address the issue of the effects of regional integration in an economic geography model is found in Baldwin and Venables (1995), followed by two papers by Puga and Venables (1997 and 1999). The three papers develop a model (that we will refer to as the BPV model) to investigate the ways in which regional integration may alter the distribution of economic activity within the area and, thereby, increase regional inequalities.

As in most NEG models (e.g. Krugman 1991; Krugman and Venables 1995) the location of an economic activity is the complex outcome of various forces at work: some forces drive toward dispersion, while others push in the opposite direction and encourage firms to agglomerate. The BPV model has two distinctive features with respect to the basic NEG model developed by Krugman (1991): first, while in the Krugman model agglomeration occurs as a consequence of the labor force migration, here labor is assumed to be immobile between countries; this hypotheses is aimed at extending the basic NEG model to cases where labor mobility is rather limited, as is the case within the European Union; second, the BPV model explicitly considers input-output linkages within the industrial sector; these become the driving forces of agglomeration (Baldwin et al. 2003).

In the BPV model, all countries have identical factor endowment and technology. There are two sectors: the commodity sector is perfectly competitive, the product is homogeneous and there are constant returns to scale, while in the industrial sector firms are imperfectly competitive, products are differentiated and there are increasing returns to scale (Figure 2). As factor of production the commodity sector uses labor, which is assumed to be perfectly mobile among sectors, whereas the industrial product requires labor and production inputs which are themselves industrial differentiated products. The key assumption of the model is that each firm's output is used both as an input by other firms (the input-output linkage) and as a final product by consumers.

Wages are the only source of consumer income and, thus, an increase (decrease) in wages in a given location means an increase (decrease) in consumer demand.

There are trade barriers only for the industrial goods which take the iceberg form, that is, it is assumed that only a fraction of the quantity shipped arrives at the final destination.

In this framework, four locational forces determine the profitability of firms in a particular country. The first two forces, the labor and output market, are "traditional" and induce firms to disperse. A high geographical concentration of industry, on the one hand, increases labor demand and, accordingly, wages, and this induces firms to disperse; on the other hand, there will be a greater competition from other firms producing different varieties and this reduces prices and profitability, and pushes firms to spread the economic activity. In the NEG literature this is referred to as the "competition effect". Thus, low wages and low competition induce firms to disperse their activities, by locating production in each country.

The other two forces, backward and forward linkages, may push firms to agglomerate. Cost linkages (i.e., backward linkages) arise because a greater number of firms in a location mean that more intermediate inputs are locally available at a lower price; this is the consequence of economies of scale in the production of intermediate goods as well. Demand

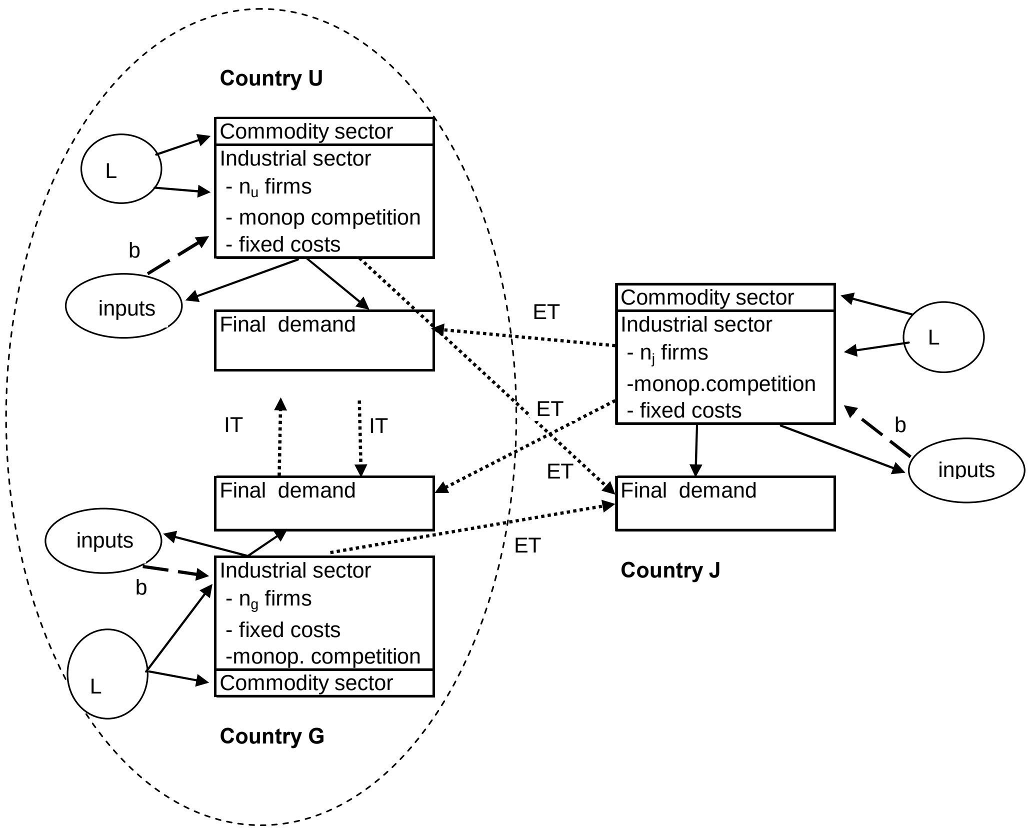

Figure 2. The Baldwin-Puga-Venables model.
Note: ··········▶ : exports
IT: Internal trade costs
ET: external trade costs
b: input-output linkages

(i.e., forward) linkages arise because the presence of more firms in a location means an increase in the demand for intermediate goods and, thus, in sales and profitability, given that firms produce both intermediate and final goods.[3] Therefore, these linkages push firms to agglomerate economic activities in one country.

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[3] It should be noted that the "demand linkages" effect in the BPV model corresponds to the so called "home market" effect of the basic NEG model; however, the home market effect here is due to an expansion of the *firm's* demand for industrial goods, rather than to an increase in the *consumer* demand following an increase of the labour force, given that in the BPV model, as already

The BPV model predicts that, overall, industrial location is dispersed (concentrated) if dispersion forces are higher (lower) than agglomeration forces. The key parameters affecting the final equilibrium are the level of trade barriers, the degree of substitution between industrial goods, the scale economies due to fixed costs, and input-output links. More specifically, agglomeration forces are likely to prevail when the level of internal trade barriers and product substitution are low and economies of scale and input-output links high.

Before analyzing the location effects of a PTA between symmetrical countries, it may be useful to investigate the effects of a non discriminatory reduction of a tariff. In the BPV model, if tariffs are very high, all countries produce both industrial products and commodities and are self-sufficient; countries continue to be totally symmetrical (i.e. they have the same number of firms, the same wages, and so on) and there is no trade. A small reduction of trade barriers induces the development of intra-industry trade - as predicted by the models of the new trade theory assuming differentiated products and increasing returns – but countries are still identical. However, if trade barriers fall below a critical value, then firms agglomerate in some countries, because forward and backward linkages (a lower cost of input and a higher demand for output) give higher profits to firms located in the more industrialized countries.[4] This critical value of the trade barriers is positively correlated with the value of input-output links, external trade barriers and scale economies. Agglomeration triggered by trade liberalization has positive effects in countries where industrial firms agglomerate, and negative effects in the others: countries with (without) industry will be richer (poorer), since wages are higher (lower) and consumer prices are lower (higher).

What if liberalization occurs on a discriminatory basis? On the basis of numerical simulations, the BPV model predicts different location effects depending on the stage of integration.

a. Early stage of integration: if internal trade barriers are above the critical value below which agglomeration forces drive location decisions, then a discriminatory reduction of the trade barriers increases the number of firms within the PTA, and decreases those outside the PTA; this is because the former can enjoy a larger market within the area and save trade costs (the "production-shifting effect"). This will clearly benefit PTA countries, which increase their welfare; the number of varieties increases, by improving consumer welfare; trade costs decrease; competition increases, causing a fall in the firms' mark-up (the so called "pro-competitive effect") and an increase in the production scale, ultimately leading to a reduction of the firms' costs and of prices of goods. At the same time the PTA, for the opposite reasons, is harmful to the rest of the world.

mentioned, labour is immobile. It should be also noted that, with respect to the basic NEG model, here there is an additional agglomeration force that is the "cost linkages".

[4] In this framework, it is not possible to determine in which country firms agglomerate because *ex-ante* countries are identical. Below the trade barriers critical value, there are multiple asymmetric equilibriums. It should be noted that one of the important features of NEG models is that, starting from an initial setting in which countries are identical, a non discriminatory liberalisation may end up with wide asymmetries between countries. This outcome may not be obtained in models that do not take into account agglomeration forces.

b. Intermediate integration*:* if internal trade barriers fall below the critical value, agglomeration forces prevail and industry concentrates in some of the PTA member countries, the “core”, while the others, the “periphery” lose industry shares. [5] At this stage, the rest of the world does not lose any more and can even gain. The wages gap within the PTA increases, because of industrial agglomeration. Preferential liberalization is now clearly welfare improving for the “core”, while the “periphery” is worse off.
c. Deep integration: as liberalization proceeds and internal trade barriers fall further, location become more sensitive to differences in production costs. The periphery of the PTA may once again become attractive, because of low wages and free access to the core market; firms in the PTA periphery increase while those in the rest of the world decrease. The wages gap between the core and the periphery is then reduced. The PTA is now welfare improving for the periphery, while the rest of the world is worse off.

The effects of a PTA among symmetric countries may slightly differ with a hub-and-spoke agreement. In this case, in the early stages of integration firms shift from the spokes to the hub, because from there they can sell the product with lower trade costs to several markets (the hub and all the spokes), while from the spokes they exploit the lower trade costs only when exporting to the hub (the so called hub-effect; Krugman 1993). In an intermediate stage of integration the shift of production to the hub drastically accelerates, as a consequence of the agglomeration forces; the hub may specialize completely in industrial production. With deep integration the spokes may become attractive again, as production costs and wages are lower than in the hub; moreover, they also benefit from the lower cost of intermediates produced in the hub. The model, however, predicts that just one of the spokes may see an increase in firms, while there will be a reduction in the others. As a consequence, a deep hub-and-spoke integration may lead not only to a hub-effect, but also to a divergence between the spokes.

A final question is how results change if countries are initially different. Suppose that, before the PTA, countries have identical factor endowments and technology, but industrial firms are concentrated in one country, while the others produce the commodity only. The model predicts that a reduction of tariffs on a non discriminatory basis initially leads to a shift of some industrial firms to one of the less industrialized countries, since low wages and the reduced cost of intermediates make this country attractive. In an early stage of liberalization, however, the other less industrialized countries may be penalized as they specialize in the commodity sector. Only with deep liberalization will firms also locate in the other less industrialized countries. Conversely, a PTA between a developed and a less developed country will benefit the latter more than multilateral liberalization, as the number of firms in the less developed member of the PTA will be greater; this is because the benefits from improved market access to the industrialized country and the reduction of input costs are, by and large, greater than with multilateral liberalization. However, the improved situation of

[5] In this framework, it is not possible to determine in which country firms agglomerate because *ex-ante* countries are identical. Below the trade barriers critical value, there are multiple asymmetric equilibriums.

one of the less developed countries is at the expense of the others, which suffer a significant reduction in number of firms and welfare. The paper also examines the effects of a PTA between less developed countries and concludes that it may be sufficient to induce industrialization (the driving force of location being only the enlarged market) but, again at the intermediate stage of integration, only in one country.

On the whole, although the BPV model has been mostly used to address positive issues, there are some interesting policy implications. The first is that a PTA between symmetric countries is likely to be beneficial for some (the periphery) only if there is a strong and credible commitment to full integration; this may "convince the peripheral regions to put up with the harder times during the intermediate stages" (Puga and Venables 1997, p. 362). The second is that, even if there is a commitment to full integration, a hub-and-spoke agreement between symmetric countries is not desirable for all the spokes, as some of them are likely to end up worse off. The third implication is that a less industrialized country may find a PTA with a developed country more fruitful than a multilateral liberalization.

The BPV findings rely on numerical simulations, rather than on analytical solutions, and thus predictions may depend on the choice of the values of the parameters; nevertheless, it should be noted that this is common to many new trade theory papers. Further, the model does not consider foreign direct investment and the multinationality of firms, which are modeled merely "as single plant operations" (Puga and Venables 1999, p.26).

Gao (1999) introduced vertical multinationals within a NEG model. Basically, the model is very similar to the BPV one, but with one important distinction. In the manufacturing industry there is a two-stage production technology: the firm first needs to produce headquarter services, which are located in the home country, and then the final product, using labor and headquarter services, which may be located either at home or in a foreign country. Thus, unlike the previous models, there are two kinds of firms: the national firm produces both the headquarter services and the final product at home and then serves the other markets through exports; the multinational firm produces headquarter services in the home country and sets up plants of the final product in the foreign country. The paper shows that the inclusion of multinational production does not qualitatively change the results of the BPV model; rather, it changes the range of parameters in which the different industry structures are stable. More specifically, the critical value of trade costs below which agglomeration forces lead to industrialization at the periphery is higher. Thus, the most relevant conclusion of the paper is that multinational production may speed up the spread of industry and the process of industrialization in the peripheral country.

A further contribution by Baldwin et al. (2003) uses a fairly different model from the BPV one and has a number of interesting policy implications. The authors extend the so called "footloose capital" model – i.e. a more tractable and simple version of the basic core-periphery model - to the three countries case, in order to investigate the effects of preferential agreements. There are many differences between the BPV and the "footloose capital" models. One is the assumption about production factors. In the footloose capital model there are two factors of production, capital and labor; capital, which is used by the industrial sector, is assumed to be mobile among countries; further, owners of capital are assumed to repatriate profits to their own country and, therefore, the country where capital is concentrated may be different from the country where profits are spent. Furthermore, there are no vertical linkages in this model and agglomeration forces are driven only by the "market access advantage", that is, the advantage of shifting production to larger markets protected by trade barriers. Dispersion forces, as usual, are due to the increased competition in the country with the larger number of firms (market-crowding effect). Countries are assumed to be identical from all points of view, with the exception of the size of the market, which is a key variable of production location decisions. This model, thus, limits the mechanisms explaining production location, but gains in analytical tractability; unlike the contributions by Puga and Venables (1997 and 1999) all findings are derived analytically and do not rely on numerical simulations.

In this model, larger countries will host a share of world industry which is larger than their share on world expenditure (the home market effect), as the ratio between the market access advantage and the market-crowding disadvantage increases with the size of the market. Further, this effect is amplified by the openness of trade, since freer trade weakens the market crowding effect much faster than the market access effect.

The model predicts that preferential liberalization will induce a production shifting effect (firms relocate from outside to inside) and this in turn will induce capital to shift inside the area (investment diversion effect). This production shifting effect is larger the lower internal and world-wide trade barriers, and the smaller the size of the PTA, as this increases the amount of outside industry that could be shifted.

It is interesting to see what happens during gradual preferential liberalization. As in Puga and Venables (1997), during the formation of a PTA there will be also an internal home market effect that is industry agglomerates in the largest member country. The critical value of internal trade barriers for agglomeration is higher (i.e., it comes sooner) when the asymmetries in size between member countries are large and when trade barriers with the rest of the world are high.

A first policy implication thus is that a PTA would be more feasible for small countries if accompanied by multilateral liberalization, since this will limit the internal home market effect. Further, small countries might prefer a big-bang PTA rather than a gradual liberalization, because the former will not result in internal relocation and avoids spatial inequalities within the area.

REGIONAL INTEGRATION IN INTERNATIONAL TRADE MODELS WITH FOREIGN DIRECT INVESTMENT

Partial equilibrium models

Partial equilibrium models build on early game theoretical models of multinational firms (e.g., Smith 1987; Horstmann and Markusen 1992; Motta 1992; Markusen 2002) and, therefore, share certain assumptions. Each country has a single firm which makes a choice as to the mode of entry into the foreign market of a homogeneous product. If the firm serves the foreign market by exports, then it faces certain trade costs. The firm may also choose to establish a plant abroad and to serve the foreign market from the local plant; in this case the firm incurs some set-up fixed costs, but it "jumps the tariff".

The most distinctive feature of these papers is their consideration of strategic competition among firms, mainly modeled as a two-stage Cournot game. In the first stage, firms choose how to enter the market, while in the second firms compete *à la* Cournot. In this setting, the key variables affecting the equilibrium are the size of the markets relative to the economies of scale, due to fixed costs, and trade costs: if trade costs are low (high) relative to fixed costs, then firms choose to export (invest abroad).

This basic two-country framework was first extended by Motta and Norman (1996) to three countries, in order to investigate the effects of economic integration on FDI (Figure 3). The distinctive assumption of this model is that countries and firms are totally symmetric (identical consumer preferences; size of the market; marginal and fixed costs); firms compete only within the integrating area, that is, while firms from the outside country sell both at home and in the integrating area (through exports or FDI), firms from the integrating countries sell only within the area, by means of exports or FDI; thus, there is no competition in the outside country.

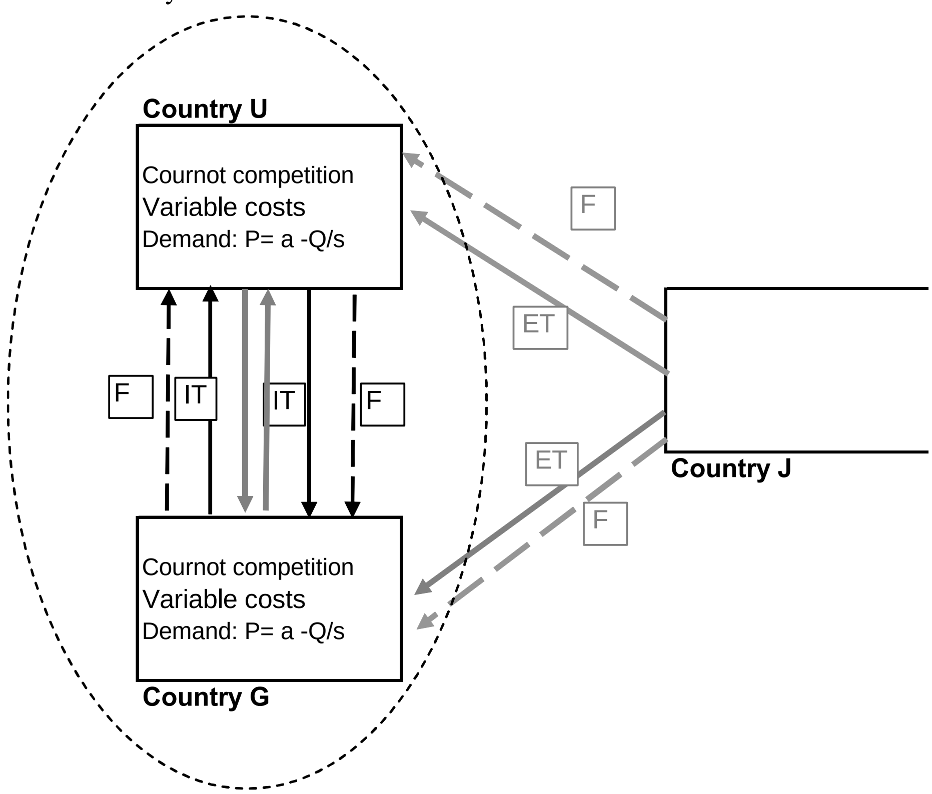

Figure 3. Partial equilibrium models with FDI: the basic framework
Note:

insiders exports	F: Fixed costs
insiders FDI	IT: Internal tariffs
outsider exports	ET External tariffs
outsider FDI	s: market size

The results of the paper suggest that the effects of the PTA depend upon the pre-PTA equilibrium. Among the various equilibria illustrated in the paper, three possible circumstances can be considered.

1. Before the PTA all firms export: this is likely to happen when both internal and external tariffs are low and/or the ratio fixed costs/market size is high and, thus, there are not enough incentives to invest abroad. In this case, a reduction in the internal tariff induces outside firms to invest in one of the integrating countries and to export from that single plant to the other member countries (export platform). Thus, this case depicts a typical investment creation effect of regional integration: FDI substitutes previous exports, but may also create new exports within the area. The reduction in internal trade costs increases competition and reduces profits in integrating countries, but prices decrease and consumers gain. The balance between consumer gains and profit losses is positive, as long as the reduction of internal tariff is large enough.
2. Before the PTA inside firms serve markets through FDI, outside firms through exports: this is an intermediate equilibrium, which is likely to prevail if the value of the pre-PTA internal tariff is intermediate and close to the external tariff and/or the ratio fixed costs/market size is low. In this case, internal firms find it profitable to serve the foreign country by FDI, as fixed costs are not so high relative to the size of the market and the internal tariff induces inside firms to “jump” it; however, incentives for FDI are not strong enough for the outside firm. Under these circumstances, a reduction in the internal tariff makes the option of exporting within the area more profitable. Insiders will dismantle the second plant in the partner country and serve it through exports; the outside firm will rationalize FDI in the integrating area, by leaving a single plant in one member country from which it exports to the others. This case illustrates the investment diversion effect of regional integration. In the area there will be less FDI, more trade, and lower consumption. This leads to an increase in prices as well as profits; nevertheless, the increase in profits offsets the decrease in consumer surplus. Thus, investment diversion is welfare improving.
3. Before the PTA all firms invest abroad: this happens when both internal and external tariffs are very high and/or the ratio fixed costs/market size is low and there are strong incentives to invest abroad. A reduction in the internal tariff induces the outside firm to invest in the area and the inside firms to switch to the export mode. Overall, there will be a replacement of internal FDI by FDI from outside; however, if the fixed costs /market size ratio is large enough, a decrease in the internal tariff may only lead to the exit of the outside firm from the market. This happens because the market share of the outside firm decreases and, if the market is small relative to fixed costs, its profits become negative.

One implication of the results of Motta and Norman (1996) is that countries should have a strong incentive to reduce internal tariffs and encourage market regimes characterized by high levels of intra-regional exports and export platform FDI, as these are welfare improving, mainly because the pro-competitive effects (i.e. the reduction of costs, prices, and profits) are, on the whole, positive for the integrating countries[6].

[6] Neary (2002) developed a very similar model with analogous conclusions.

A later paper, by Mountout and Zitouna (2005), within the same analytical framework, explicitly considered asymmetries between countries. In their model, the two integrating countries, North and South, have different production costs due to different wages; further, firms come only from North and sell the product only in North. In Figure 3 this means that variable costs between U (North) and G (South) are different, while U and J have the same costs; further, demand in country G is by assumption equal to zero; finally, exports and FDI from country G are not considered.

The model considers the effects of a reduction in the internal tariffs between North and South on the strategies of two potential multinationals, one from North and the other from outside. Before the PTA, the inside firm chooses to make an export platform FDI in South if the cost advantages, due to the wages gap, offset fixed costs and trade costs that firms incur re-exporting the product from South to North. On the other hand, the outside firm makes FDI within the area if fixed costs are low relatively to external trade costs; further, it decides to locate in South if cost advantages are high relative to internal trade costs.

Once again the reduction of internal tariffs may have different effects, depending on the pre-PTA equilibrium. The most interesting finding of the paper is that, as a consequence of asymmetries, regional integration acts as a strong incentive for export platform FDI in South, for both inside and outside firms; and this incentive increases if the rival does not invest in South. As a consequence, there may be an "eviction effect", since if the inside (outside) firm locates first in South, then the outside (inside) firm may just exit the market. Thus, the paper puts forward the hypothesis of a possible first-mover advantage, which may be exploited by one firm if it has some *ex-ante* advantage over the rival, such as lower set-up costs.

The effects of regional integration in the presence of asymmetries between countries have been further explored by Ekholm, Forslid and Markusen (2003). There are two integrating countries, W (West) and S (South), which differ because of wages; and an outside country, E (East), which is assumed to be identical to W. The product is consumed only in W and E, and there are two firms from W and E; thus, unlike all the papers considered above, firms in this model compete both in their own and in their rival's market, allowing for two-way flows of both exports and FDI. One distinctive feature is the consideration of two different goods: the intermediate good can be produced only in the home country, and the final good can be assembled in one or all countries[7]. In this setting, it is possible to analyze various kinds of FDI, i.e. to distinguish between horizontal and vertical FDI.

Depending on the relative values of trading cost of the components, fixed cost and assembly cost advantages in S, different market equilibriums arise. When fixed costs and trading cost of components are high, and assembly costs in S are close to those in W and E, then firms only export from their home country, i.e. they are national firms. As the trading cost of components and fixed costs decrease, firms locate a plant in the other firm's country, but do not locate in S (pure horizontal FDI). This implies two-way flows of FDI between the two developed countries. A higher assembly cost advantage for S may lead to a shift to a pure export platform, that is, firms maintain a plant at home which serves the domestic market, but

[7] With respect to the basic framework of Figure 3, there are several important differences: first, South (country G) has no demand and no firms, but benefits from a lower marginal cost; second, the firm from West (country U) can invest or export to East (country J); third, in East (J) the demand is different from zero and equals that in West (country U); finally, there are two integrated sectors.

locate a plant in S from which they export to the rival market. Finally, a further increase in cost advantages and/or a decrease in fixed costs and in the trading cost of components may lead to a vertical export platform strategy, that is firms locate all production in S and serve their own market and the rival market through exports.

The first effect of a PTA (i.e. a decrease in internal trading costs) between W and S is that a firm in W will find it more profitable to shift all production to S (vertical export platform strategy) and to export back to W as well as to E. This will give the firm from W an absolute cost advantage with respect to the firm from E; everything else constant, the firm from W can fully exploit the assembly costs advantage of locating in S, without (any or few) trading costs, i.e. the trading costs of moving components from home to S, and exporting the final good back to the home country. This cost advantage of the inside firm increases with the decrease in the internal tariffs and, more importantly, leads to a profit-shifting effect: the high-cost firm from E loses market shares and profits, while the low-cost firm from W will, symmetrically, gain market shares and increase profits. One interesting policy implication is that a high-wage country may be penalized if its rival negotiates a PTA with a low-wage country and may respond by finding a low-wage partner as well.

The prediction of the papers assuming asymmetries between integrating countries are, thus, slightly different from those assuming symmetry; while in the former regional integration is likely to lead to export-platform FDI only from the outside firms, in the latter regional integration acts as a strong incentive for export-platform FDI also by inside firms and may be much more harmful for outside firms.

While the aforementioned papers deal mainly with positive issues, two papers have addressed the issue of the optimal (preferential) trade policy more explicitly, albeit with rather different objectives, within a partial equilibrium framework.

Donnenfeld (2003) considers several countries forming two regional blocks (CU), with symmetric countries and firms (i.e. identical market size, consumer preferences and fixed and marginal costs). Firms' actions are limited by two assumptions: first, firms from one block make FDI only in the other block, while within their own block they only export to partner countries; second, firms invest in the other block by locating just one plant, from which they export to the other members; this means that the model considers only export-platform FDI, and not dispersed FDI within the blocks[8]. Finally, the formation of the blocks is exogenous, while the external tariff level is determined endogenously.

The main finding of the paper is that the optimal external tariff of a CU is just below the "critical" tariff, that is, the tariff above which outside firms invest to "jump the tariff". This is because: a) a tariff higher than the critical one induces FDI in the block (the consequent reduction of internal firms' profits and losses in tariff revenues more than offsets the increase in consumer welfare); b) a tariff well below the critical one would also reduce national welfare (losses due to the reduction of both tariff revenues and internal firms' profits counterbalance consumer gains).

[8] With respect to the basic framework of Figure 3: there is another country forming a customs union with country J, which is identical to the customs union between U and G; inside FDI flows within the CU are zero; outside FDI are just export platform, that is, FDI goes just to one country; there is two-way FDI, i.e. there is an additional FDI flow from the block on the right hand side to the other block.

In this model, therefore, the growth of regional blocks does not necessarily lead to an escalation of tariffs, as predicted by other models (Panagaryia 2000). Rather, the mutual threat to invade the other's block by FDI has the effect of maintaining the tariffs level just below the critical threshold, which is lower than the tariff that would prevail without FDI. Further, a tariff war is likely to occur when the value of fixed costs is high; the higher the fixed costs, the lower the threat of an invasion of the rival market by FDI. Finally, also the size of the blocks is (negatively) related with the optimal tariff, as the larger the block, the lower the revenue losses due to a tariff reduction, and the higher consumer gains. Therefore, a few large blocks may imply a lower level of protection than several small blocks.

Raff (2004) addresses the issue of how the location choice of multinationals in a PTA interacts with government decisions on both the external tariff and corporate tax policy. On the one hand, if outside multinationals enter through FDI (exports), the PTA governments are likely to increase corporate taxes (external tariffs) to maximize revenues. On the other hand, government decisions have a strong influence on the choices of multinationals, as high (low) corporate taxes and low (high) external tariffs induce multinationals to choose exports (FDI).

From the point of view of the modeling of firms' behavior, the analytical setting is simple: there are no domestic firms in the PTA and one outside multinational has monopoly power and decides either to export or to invest in the area with one or more plants.

The model assumes further asymmetries between countries. The three countries have different production costs; only PTA countries tax profits and imports; while profit taxes are chosen non-cooperatively by PTA countries, tariffs depend upon the agreement: in a FTA they choose external tariffs non-cooperatively and internal tariffs are zero, while in a CU they choose cooperatively a common external tariff.

The equilibrium depends upon relative production costs. If internal costs are low enough with respect to the size of the market and to the costs of the outside country then an FTA may induce a foreign firm to locate at least one plant within the area, from which to serve both markets (FDI creation). FDI creation is welfare improving (consumer gains plus tax revenue increases are higher than the tariff revenue losses) for both FTA countries; but this occurs only if there is no tax competition between the two FTA countries to attract FDI, as this may reduce tax revenues. In this model governments are unlikely to engage in tax competition if there are large differences in production costs between the two PTA countries; in fact, the high-cost country would not gain from tax reduction, as this would not be sufficient to increase FDI, given its cost disadvantage.

The model suggests that a FTA is the optimal agreement if: i) internal production costs are low enough relative to the size of the internal market and to the production costs in the outside country; ii) the gap between production costs in the two FTA countries is sufficiently large.

However, if internal production costs are high relative to those in the outside country, then an FTA is not sufficient to create FDI. In this case, a CU may be the optimal agreement between the two countries: the coordination for a higher external tariff may induce FDI creation and improve welfare, despite the loss of tariff revenues.

General equilibrium models

Ethier (1998) develops a specific factor model with perfect competition and external economies of scale, which distinguishes developed from developing economies. Developed countries have identical endowment of human capital, skilled and unskilled labor, and produce two goods. The commodity is produced only with labor (both skilled and unskilled) and is not tradable, while the industrial good is modeled as a two-stage production process: the first stage uses only human capital and can be located only at home (i.e. the headquarter services); the second stage uses skilled labor and may be located either at home or in a foreign country.

One important assumption is that in the second stage there are international external economies of scale; returns increase, as the global size of the skilled labor employed in producing the final good (and not the firm's or the country's size) increases. Firms in both sectors are assumed to be perfectly competitive. A distinctive feature of the paper by Ethier (1998) is that it is includes an explicit, albeit quite simple, political economy modeling of trade policy decisions; the trade policy of each developed country is the outcome of a political process, in which unskilled labor attempts to secure rents. The government's objective function is assumed to be based on a trade-off between aggregate welfare and unskilled wages.

The paper determines conditions under which multilateralism between developed countries is likely to occur and concludes that the unilateral optimal tariff is greater than zero, even in the absence of a terms of trade effect; this is because tariffs have the effect of increasing the relative price of the non-tradable good[9] and, consequently, raise the wages of unskilled labor; as a result, a unilateral tariff may improve social welfare, as it increases the rents of unskilled labor. A second finding is that, in equilibrium, developed countries set a lower tariff than the unilateral one: the reason is that, by so doing, world-wide production of the industrial good increases, and all countries benefit from international economies of scale which are welfare improving. Thus, in this model the first purpose of multilateralism is to endogenize an externality, that is, the benefits of international economies of scale.

As for developing countries, the model assumes that they only produce one rudimentary good, which uses skilled labor. Governments make a choice between two possible policies: autarchy and reform. If they are successful in carrying out reforms, then firms from developed countries establish subsidiaries in developing countries (export platform FDI). This may have positive effects on the local economy for two reasons. The demand of skilled labor increases and local wages increase. In addition, FDI involves a transfer of global technology, which is also assumed to spill-over to the production of the rudimentary good. However, governments of developing countries are also under pressure from special interest groups for autarchy. Therefore, they choose reform if the benefits from FDI are large enough to outweigh pressure from interest groups.

[9] The decrease in the relative price of the industrial good as a consequence of the tariff is due mainly to a crucial assumption, i.e., industrial products are imperfect substitutes; thus, a tariff on the imported industrial goods has the effect of deflecting spending from the imported goods to the commodities, raising their prices and the wages of unskilled labour.

The main question addressed is whether, within a multilateral framework, developing countries are likely to make a PTA with developed countries, given that this means that they must choose economic reforms. The choice crucially depends upon the expected benefits from FDI. The lower the tariffs in developed countries, the higher the benefits for developing countries from FDI for two reasons. First, higher tariffs mean firms from developed countries cannot fully exploit the international economies of scale, and this may also reduce the size of the spill-over effects. Second, high tariffs reduce the probability of export-platform FDI by firms from developed countries.

The main policy implication of the paper, therefore, is that multilateralism may increase the motivation of developing countries to reform their economies; this is because FDI is more likely to occur if the developing country enters a PTA with the developed country, as a reduction of the bilateral tariffs increases the profitability of export platform FDI, and the probability of receiving FDI.

As multilateralism proceeds, the number of developing countries wishing to sign a PTA and undertake reforms increases (a reform-creation effect). Economic reforms induce firms to invest in certain developing countries, generating an investment creation effect. However, other developing countries, despite their reforms, may not succeed in attracting FDI and lose out as a consequence of an investment diversion effect. Finally, countries which are likely to be left out from FDI in any case may not even begin to consider reforms (a reform destruction effect).

In this framework, thus, the main role of regionalism is to facilitate reforms in developing countries; there is a positive relationship between multilateralism and regionalism, as the latter is the consequence of the success, rather than of the failure, of the former; further, regional agreements are a way in which developing countries undergoing a process of reform compete with each other to attract FDI; finally, as global welfare is assumed to increase with the number of reforming countries, then regionalism, by inducing competition between developing countries for FDI, increases global welfare as it induces a more dispersed pattern of FDI.

Ludema (2002) combines two branches of the literature: the one that explains international agreements on the basis of repeated games, where cooperation is determined by the balance between the one-off incentive for a country to deviate from the agreement, and the discounted benefits of avoiding a future trade war; and general equilibrium models with multinational firms which explain the pattern of FDI on the basis of the balance between proximity factors (i.e., trade barriers and transportation costs) and concentration factors, such as economies of scale (Brainard 1993).

The idea is that PTAs are more likely to be formed between countries among which transport costs are very low, as this reduces the motivation for FDI and also the incentive for governments to deviate from the agreement. The assumption is that FDI is welfare improving and that governments may find it in their interest, under certain conditions, to deviate from the agreement by increasing the tariff to attract FDI. As the probability of tariff-jumping is positively correlated with transport costs, the paper argues that the higher the transport costs, the greater the incentive for governments to deviate from a trade agreement.

In this framework, each country has an incentive to establish unilaterally a higher tariff than the critical one, that is, the level above which foreign firms shift from exports to FDI. A trade agreement is feasible only if the balance between enforcement forces (i.e., losses due to a tariff war in all future periods) and temptation forces (i.e., gains arising from deviating from the agreement, by setting a tariff above the critical one and attracting FDI) is positive. This balance depends upon the values of transport costs, fixed costs and discount factors. High transport costs increase the temptation to deviate (decrease enforcement), as there is a greater probability of attracting FDI; on the contrary, high fixed costs and discount factors reduce the temptation to deviate and increase enforcement.

The paper examines feasible trade agreements in a three country framework, with two countries geographically close, and a third one distant. An FTA between contiguous countries is an equilibrium if internal transport costs are sufficiently low, as in this case enforcement forces are higher than the temptation to deviate for all countries. As internal transport costs increase temptation may counterbalance enforcement for the member countries that may have an incentive to deviate in order to attract FDI. A hub-and-spoke agreement is an equilibrium if transport costs between the hub and the more distant spoke are sufficiently low. Firms from the hub export to the other markets, and benefit from free trade; firms from the nearby member country invest in the distant country and export to the hub; finally, firms from the distant country makes export platform FDI in one of the contiguous countries. The hub is clearly better off and has less incentive to deviate with respect to the two spokes. As transport costs with the distant country increase, consumer surplus decreases and the distant country has a strong incentive to deviate.

Thus, the main implications of the model are the following: i) if transport costs are very high, the only feasible equilibrium is a tariff war; ii) if transport costs are sufficiently low, then a FTA between neighboring countries or a hub-and-spoke agreement are both feasible; iii) with high transport costs between distant countries, the only feasible arrangement is an FTA between contiguous countries.

MAIN FINDINGS AND CONCLUDING REMARKS

The surveyed literature provides a number of interesting findings which may help to answer the questions raised in the introduction.

The first two questions deal with the effects of PTAs on where inside and outside firms choose to locate and, consequently, on trade. The literature emphasizes that a PTA increases economic activity within the area concerned - i.e. in the presence of economies of scale there is a production-shifting effect of PTA – but also may significantly influence the distribution of economic activity within the area. NEG models conclude that concentration of economic activity in the core is likely to occur when agglomeration forces are stronger than centrifugal forces. This happens in the BPV model when economies of scale and input-output links are high enough, and in the footloose capital model when there are large differences between the market size of member countries. FDI models deal with changes in both the geographical location and ownership of production plants and conclude that the former are likely to be more pronounced when the forces determining FDI creation are stronger; on the contrary, the latter will be larger when the investment diversion effect is stronger.

These effects present a "discontinuity". There is a critical tariff level below which agglomeration occurs in NEG models and, in the models with FDI, firms reorganize their production within the area. Therefore, the effects of PTA crucially depend on the starting and finishing points, i.e. whether regional integration leads countries to "cross" that critical threshold or not. In the former case, we should expect relevant location effects, while in the latter the impact is likely to be less important. In NEG models, this means that a low level of integration (i.e. integration not "crossing" the critical value) does not affect the internal geographical distribution of industrial activity, while intermediate integration (i.e. tariffs being just below the critical level) leads to an agglomeration in the core; only deep integration - a wide gap between the starting and finishing point - may spread industrial activity to the peripheral country in the BPV model, while the footloose capital model predicts that this may occur only with a "big bang" liberalization. In models with FDI, a low level of integration may not induce any investment diversion or creation effect, while deep integration considerably changes the way multinational firms locate plants, in most cases leading to a prevalence of export platform FDI within the area, by both inside and outside firms.

The effects of a PTA between similar countries are clearly different compared to when countries are dissimilar. Most partial equilibrium models depict, in a three country framework, this dissimilarity as a gap in production costs – in most cases this is represented as a wages gap - with the aim of capturing the phenomenon of a widespread delocalization in low-cost developing countries. If one of the member countries has cost advantages, then regional integration may trigger delocalization and induce export platform FDI by both inside and outside firms. In multi-country general equilibrium models, this dissimilarity is represented as an asymmetric industrial development. Both NEG models and models with FDI (Ethier 1998) assume less developed countries produce only a non-tradable rudimentary good, while the industrialized sector is located in the developed countries. General equilibrium models predict, by and large, that regional integration may speed up industrialization in less developed countries, even though this may happen in some developing countries and not in others; thus, the main conclusion is that regional integration may lead to an increase of divergences between less developed countries

Finally, the effects of a PTA obviously depend upon the kind of agreement involved. The first distinction to be made is between an agreement implying only a reduction of internal tariffs, from one which also increases the external tariff.[10] In the NEG models, an increase in the external tariff has the effect of changing the critical value of the internal tariff below which agglomeration occurs; this means that the direction of changes is the same but the "point" at which changes occur may be different.

The effect of an increase in the external tariff in models with FDI may be more relevant. If the initial external tariff is higher than the "critical value" above which outside firms invest in member countries to "jump the tariff", then an increase in the external tariff does not affect outside firms. However, if the pre-PTA external tariff is lower than the critical one, then outside firms will change their strategy by substituting exports with FDI.

The second distinction is between FTA/CU *versus* hub-and-spoke agreements. NEG models predict that the location of firms may change significantly with these kinds of agreements; concentration will also occur in the early stages of integration (the hub-effect) and deep integration will create divergences between the spokes. The only paper within the FDI literature addressing this issue concludes that, while with a simple FTA firms from

[10] The former may be an FTA, or a CU with external tariffs not higher than those before the PTA. The latter is a CU which has the overall effect of increasing external tariffs of member countries.

member countries will make FDI in the third country, with a hub-and-spoke agreement firms of the hub will export to all the spokes (Ludema 2002).

The third distinction should be made between a PTA including only trade arrangements, from those including other commitments, such as investment liberalization and economic reform. The only paper addressing this issue is by Ethier (1998) who argues that the commitments to economic reform in the agreements makes a shift of industrial production to some of the less developed countries possible; in other words, a “pure” trade agreement (i.e., a reduction of internal tariffs only) may not be sufficient to induce firms to locate plants in the less developed country.

Turning to the third question, that is, the welfare effects of a PTA, partial equilibrium models with FDI provide contradictory findings, depending mainly on the underlying assumptions in the models. As already mentioned, the first critical assumption is whether models take into account the effects of an increase in internal competition on insider firms’ profits. Raff (2004) assumes no internal firms and eliminates by assumption one component of the welfare of PTA member countries; therefore, regional integration leading to an increase of inward FDI is always welfare improving. Most papers consider the presence of internal firms and the effects of regional integration on insiders’ profits; as a result, welfare implications are not so clear-cut and depend upon other assumptions. Among these, a key assumption is the inclusion of tariff revenues in the welfare of the PTA countries; a PTA inducing FDI which substitutes previous exports is welfare improving in models ignoring tariff revenues (e.g., Motta and Norman 1996), but in models which take tariff revenues into account the welfare of PTA countries declines (e.g., Donnenfeld 2003). The third issue is whether models consider other policies affecting location, for example, tax policies. Raff (2004) shows that the welfare of PTA countries may increase only if countries do not engage in tax competition to attract FDI; in that case, tax revenue plus consumer gains are not large enough to offset losses in tariff revenue.

Welfare implications in NEG models are straightforward, as they are closely linked to the country’s share of industrial activity: therefore, a low level of regional integration improves the welfare of all member countries, as there is a shift of production from third countries to member countries; with an intermediate level of integration, the core will be better off while welfare at the periphery worsens.

In the two papers using general equilibrium models with FDI, the welfare of PTA countries increases with the increase in FDI; however, while in Ethier (1998) the main effect of regional integration is the creation of new FDI in developing countries, in Ludema (2002) regional integration diverts FDI from some member countries to others, and hence decreases the welfare in some of the PTA countries. In the model by Ethier, FDI is welfare improving mainly because of the technological spill-overs in the developing countries, but only some developing countries will benefit from regional integration, i.e. those succeeding in attracting FDI. In Ludema FDI is welfare improving as, by eliminating losses due to transport costs, prices will fall and consumer welfare increase; as a consequence, regional integration is welfare improving only among contiguous countries.

One of the main shortcomings of this literature is that the modeling of the impact of location changes on the economy is rather *naïve*. In partial equilibrium models with FDI and in the NEG models, welfare implications are essentially due to changes in prices, and thus in consumer surplus and in profits. This perspective appears to be limited as it fails to capture the economy-wide effects of a growth of the production plants in a country and of a change in ownership, which are both likely to be important. General equilibrium models are obviously more suited to dealing with economy-wide location effects; however, to our knowledge, only the paper by Ethier (1998) has included economy-wide effects, i.e., technological spill-over, in the model. This still open issue may well be relevant especially as regards the policy implications for developing countries; many small developing countries often join preferential trade areas with large developed countries with the expectation of benefiting by attracting economic activity to their territory; but it is not clear under what circumstances this will improve their welfare.

Overall, this survey has shown that the theory provides us with a number of testable predictions concerning under what circumstances the joining of a PTA may or not increase industrial production and attract a certain type of FDI, even though it is less clear if and how eventual foreign investments and/or increased industrial production following PTA membership translate into benefits for the country. Empirical studies to date have shown that regional integration has influenced FDI and the location of industrial production in the EU and in North America[11]; less evidence is available for other regional agreements between developed and developing countries (North-South), like those of the EU, or between developing countries (South-South). There is little evidence also on the pattern of FDI (horizontal *versus* vertical) and of industrial production (intermediate *versus* final products) resulting from regional agreements, as most empirical studies use aggregated data (e.g. Balasubramanyam, Sapsford and Griffith 2002; Jaumotte 2004; Medvedev 2006); a further empirical issue, which has received little attention to date, is how the relocation of production due to regional agreements has influenced the pattern of trade.

These issues may be relevant also for studies aiming at assessing the effects of agricultural trade concessions. A considerable part of agricultural trade is, in fact, trade in processed products, and trade concessions granted for agricultural products include many agri-food products. In this sector, as in many other manufacturing industries, economies of scale are likely to drive firms' reorganization within the integrated area; the survey has shown that this affects the pattern of trade not only of the final processed products, but also of the (agricultural) inputs, both within the area and with third countries. Therefore, by ignoring the location effects of a PTA on the location of agri-food firms, one may miss important effects also on the trade of agricultural products.

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WHO BENEFITS FROM GLOBAL AGRICULTURAL TRADE LIBERALIZATION? THE CASE OF WHEAT AND MAIZE

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ABSTRACT

The benefits to producers in low and lower middle income (LLMI) countries from liberalizing trade within the white commodities (sugar, cotton, and rice) are well established, but the principle that agricultural trade liberalization is advantageous to LLMI producers is blindly applied to other commodities like wheat and maize. LLMI consumers, however, are often forgotten in trade negotiations. Due to wealth disparities across countries, our model calculates the relative welfare impacts from trade liberalization in the wheat and maize markets so that comparisons can be made across countries. Our results show that producers in LLMI countries will be the primary losers, but the gains to LLMI consumers often outweigh the losses to producers resulting in a net social welfare gain.

Key words: agricultural trade liberalization, welfare analysis
JEL classification codes: Q17, Q18

INTRODUCTION

In the 2003 WTO talks in Cancun, many low and lower middle income (LLMI) countries realized their new bargaining power as a united front and walked away from the table, stating that they believed that the Doha round was moving in the wrong direction in the area of agricultural reform which they viewed as the primary objective of the round (Stiglitz and Charlton).[1] The LLMI countries' stance at the Cancun meetings was that high-income countries' (mainly the EU15 and US) agricultural policies were hampering economic growth and development. While it is widely accepted in the literature that high-income countries' protection of the white commodities (cotton, sugar, and rice), and their preferential treatment

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to commodities such as bananas, have hurt LLMI countries' producers, less attention has been focused on the commodities that are protected to a lesser extent, i.e., maize and wheat.

The positive, and potentially large, welfare impacts to producers in LLMI countries through the reduction of barriers in the white commodities are often used to argue for trade liberalization within those markets, but often the principle that trade liberalization is advantageous to LLMI producers is blindly applied to other commodities like maize and wheat. Unlike cotton and sugar, maize and wheat are typically subsistence crops in LLMI countries making them less sensitive to trade policy. Nevertheless, given the volume of wheat and maize grown globally, trade policy can have implications for poverty reduction.

In the current political economy LLMI producers receive much attention in trade negotiations to reduce poverty; however, LLMI consumers must also receive consideration. In fact, in LLMI countries net buyers outnumber net sellers even in rural areas. This article considers both LLMI consumers and producers and evaluates the relative effects of trade liberalization in the maize and wheat markets. Two distinct objectives are addressed: determine who gains and who loses from liberalization and calculate per capita and relative measures of the welfare impacts.

TRADE LIBERALIZATION'S EFFECT ON LOW AND LOWER MIDDLE INCOME COUNTRIES

Previous research has typically focused on the impact of liberalizing or eliminating high-income countries' trade distortions. The common argument is that removal of these barriers would benefit LLMI countries. Research that has used general equilibrium models to demonstrate this impact includes Tokarick; Dimaranan, Hertel, and Keeney; Anderson et al. 2001; Hertel et al. Partial equilibrium analysis has also been used in the literature to estimate these effects (Hoekman, Ng, and Olarreaga; Tokarick; FAPRI).

Recently, this argument has been challenged by notable economists such as Bhagwati (2005) and Panagariya (2005). Panagariya (2005) stated that as importers, LLMI countries have access to artificially depressed prices. Therefore, if subsidies and tariffs were eliminated in the high-income countries, world price would increase, thus hurting importers. Valdes and McCalla found that 48 out of the 63 low income countries are net food importers and 35 out of the 52 lower middle income countries are net food importers. Tangermann recognized a paradox: quantitative analysis suggests low-income countries would benefit from high-income countries' liberalization, but arguments about low-income countries being net food importers suggest otherwise.

Previous trade liberalization models suggest that the gains in social welfare to countries are primarily from liberalizing their own markets. For instance, Tokarick found that if only developed countries liberalized, 90% of the benefits would be realized by the developed countries themselves. Anderson et al. (2001) found when high-income countries completely liberalize their agricultural markets, low-income countries would receive 9.58% (4.6 billion USD) of the benefits. Conversely if low-income countries were to completely liberalize in agriculture, they would receive 73.6% (12.3 billion USD) of the benefits.

Research has also shown that the removal of tariffs, rather than export and domestic subsidies, is the largest source of welfare gains (Hoekman, Ng, Olarreaga; Tokarick;

Dimaranan, Hertel, and Keeney). Cotton is an exception to this with the majority of its trade distortion being a result of domestic and export subsidies. Anderson, Martin, and Valenzuela found that 96% of the benefits from liberalizing agricultural trade come from removing tariffs, while only 5% and 2% accrue from domestic and export subsidies, respectively. Koo and Kennedy specifically studied the effects of U.S. domestic subsidies for maize. They find that net importing countries benefited from the U.S.'s domestic subsidies.

Anderson, Martin, and van der Mensbrugghe recognized that welfare impacts vary greatly across commodities. They found that 54% of the potential global gains from agricultural liberalization are in rice, sugar, and meats alone. Commodities need to be analyzed individually, rather than making broad statements about impacts of agricultural liberalization.

Wheat and maize are crucial commodities for consumers in various LLMI countries. In some LLMI countries wheat constitutes from 20-54% of their daily caloric intake. While in some of the poorest regions, maize constitutes from 10-34% of the daily caloric intake (FAO 2006a).

Therefore, we use a partial equilibrium analysis to model the welfare effects of liberalizing border protection (import tariffs and export subsidies) in the whole world. Domestic support programs are assumed to be left constant for two reasons. First, research has shown that the primary benefits in agricultural trade liberalization are from the removal of tariffs rather than the removal of domestic subsides. Secondly, "green box" domestic subsidies are allowed by the WTO, and given the current political economy, are not likely to be removed. While it may be argued that removing all border protection may not be likely, evaluating a scenario of complete trade liberalization provides a benchmark to compare other policy options (Martin and Anderson).

MODEL AND DATA

Using historical data from 1998-2002, we compute the change in welfare measures due to elimination of border protection. FAO provided data for domestic producer prices (2006b,converted into USD/ton and inflated into 2002 USD/ton using FX Converter), production (2006c, metric tons), consumption (2006a, which includes feed, seed, and human consumption in metric tons), exports (2006d, metric tons), and imports (2006d, metric tons) for each country/region. Countries/regions with missing domestic price data were excluded from the model. To find the domestic price for regions, each country's domestic price within the region was weighted by its percent of production of the commodity in the region.

The supply and demand curves for a country/region are computed from the elasticities and the given price and quantity for each year. Supply and demand elasticities are obtained from IFPRI's (International Food Policy Research Institute) International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model (Rosegrant et al. (1995)). In some instances the IMPACT model's elasticities were aggregated into regions (i.e. Central Asia) and therefore this model uses the same regional classifications. Formal definitions of each country and region are located in Appendix 1.

In countries with domestic subsidies, the supply and demand are effectively "subsidized" as they are computed with subsidized prices and quantities. The supply and demand curves are assumed to be linear. The slope of the curve, $\frac{dP_D}{dQ_D}$, is

$$\frac{dP_D}{dQ_D} = \frac{P_D}{Q_D} \bullet \frac{1}{\eta} \tag{1}$$

where P_D is the domestic price, Q_D is the domestic quantity produced/consumed, and η is the elasticity of supply/demand. The intercept of curve, b, is

$$b = P_D - \frac{dP_D}{dQ_D} Q_D \tag{2}$$

Two prices were chosen, one above and one below equilibrium price, within the relevant range, and the quantities produced and consumed are computed at each price level, given the supply and demand curves. The world quantity produced/consumed at each price is the sum of quantities across all countries/regions. The world quantity produced/consumed at two prices gives two pairs of points in the world trade sector; the world supply/demand curve is computed by constructing a line between the two points. The world equilibrium quantity and price were computed from the system of world supply and demand equations.

We account for the differences in transportation cost by finding the linear distance between the major port for each country or region (Export 911).[2] Quantity of exports to each country/region was calculated for each commodity, and a percentage, or in the case of regions a weighted percentage, of exports to each country/region is found. Then a weighted distance of exports was computed by finding the sum product of percent of exports to a country/region and the distance between each country/region. It is assumed that there is a constant $/ton/mile expense to ship the commodity (Olowolayemo, personal communication). This is multiplied by the weighted distance of exports to find a $/ton transportation cost. The same process is followed to find the total cost of imports to each country/region.[3]

While a total transportation cost is calculated, that amount needs to be disaggregated by the percentage paid by the importer and exporter. Prices demanded and supplied were computed using a quantity just below the world equilibrium quantity, given the world demand and supply curves. The difference between the price demanded and the world price as a percent of the total difference between price demanded and supplied is the percent of transportation cost paid by the importer. A similar method was used to compute the portion of transportation cost paid by the exporter.

Assuming a perfectly competitive market, the difference between domestic price and the world price accounting for transportation costs (P_W) is viewed as the effect of trade-distorting policies for the country/region ($t = P_D - P_W$, where t is the trade distortion). We compute the change in world price from removing these distortions by shifting demand for net importers and shifting supply for net exporters. The trade sector experiences an increase in effective demand from a country removing its tariff, represented by shifting the country's demand curve up by the tariff amount. For a net exporter, removing an export subsidy reduces supply in the trade sector. Computationally, the shifted intercept is $(P_D - P_W) + b$, where the demand intercept is shifted for importers and the supply intercept is shifted for exporters. After each country/region's demand or supply curve is shifted, they are summed to find excess supply and demand. Equilibrium is computed with the new world supply and demand curves yielding the world price if all border protection were removed. If all border protection were removed, each country/region's domestic price would become the new world price with transportation costs accounted for.

The change in welfare measures are computed from basic welfare analysis and are shown by the following equations:

Net Importer

$$\begin{aligned}\Delta CS &= \left(\frac{1}{2}(b_D{}'-P_W{}')Q_D{}'\right)-\left(\frac{1}{2}(b_D-P_D)Q_D\right)\\ \Delta PS &= \left(\frac{1}{2}(P_W{}'-b_S)Q_S{}'+\frac{1}{2}b_SQ_0\right)-\left(\frac{1}{2}(P_D-b_S)Q_S+\frac{1}{2}b_SQ_0\right)\end{aligned} \tag{3a}$$

Net Exporter

$$\begin{aligned}\Delta CS &= \left(\frac{1}{2}(b_D-P_W{}')Q_D{}'\right)-\left(\frac{1}{2}(b_D-P_D)Q_D\right)\\ \Delta PS &= \left(\frac{1}{2}(P_W{}'-b_S{}')Q_S{}'+\frac{1}{2}b_S{}'Q_0{}'\right)-\left(\frac{1}{2}(P_D-b_S)Q_S+\frac{1}{2}b_SQ_0\right)\end{aligned} \tag{3b}$$

Both

$$\begin{aligned}\Delta REV &= (P_D-P_W)(Q_S-Q_D)\\ \Delta SW &= \Delta CS+\Delta PS+\Delta REV\end{aligned} \tag{4}$$

where ΔCS, ΔPS, ΔREV, and ΔSW are the change in consumer surplus, producer surplus, government revenue, and net (overall) social welfare, respectively.[4] P_D and P_W are the domestic price and world price (accounting for transportation cost), Q_D and Q_S are the quantity demanded and supplied, Q_0 is the quantity when price equals zero, and b_D and b_S are the intercepts for demand and supply, respectively. The *prime* (') denotes the price, quantity, and intercept variables after all trade barriers have been removed. The change in consumer and producer surplus is the difference of the respective surplus after removal of trade barriers and the surplus prior to removal, where the shifted domestic supply and demand curves are used to compute the new surplus. The welfare measures were computed for each year, then averaged over the 5-year period.

Per capita gains/losses in welfare measures were obtained by dividing the total producer surplus for each country/region by the number of farmers in the country/region and total consumer surplus by the total population. This is an important measure because it gives the magnitude of the gain/loss that each consumer/producer faces, respectively. With the inclusion of the per capita gains/loses, it is possible to see the specific welfare impact on an individual consumer and producer. Relative measures are the per capita gain/loss divided by the regional weighted average agricultural GDP per capita for producer surplus and weighted average total GDP per capita for consumer surplus. The agricultural GDP per capita is the value added by agriculture divided by the number of people who farm. The relative measure is of great importance when comparing the effect on countries of heterogeneous income levels. Data on the population, percent of population in agriculture, GDP per capita, and agriculture value added were obtained from the World Bank.

This modeling approach has several limitations. First, as a reviewer noted that cross-price effects are not considered and that more established partial and general equilibrium models incorporate more complexity. Nevertheless, this modeling approach was selected because of the simplistic nature of the data requirements which allows estimates to be obtained for relatively disaggregated regions across the world. Even though this modeling approach may be viewed as a loss to more well-known partial equilibrium models, the results are similar. Second, if the difference between domestic and world price is not equivalent to trade distorting policies then the model may misrepresent the impact of trade liberalization. Factors other than border protection, such as poor domestic price data or misspecified transportation costs, may also result in a difference between domestic price and world price. That being said, obtaining accurate border protection data for every country in the world proved infeasible. So, this assumption provides a proxy for border protection. Third, the quality of the GDP data used in calculating relative surplus measures could bias estimates. That is, in LLMI countries if the informal sector is not accounted in the GDP then GDP estimates are undercounted and relative measures are inflated. Conversely, high income country GDP estimates may include large amounts of government spending and investment which would deflate the model's relative measures.

RESULTS

The results from the model show that world price would increase due to trade liberalization by 5.94% and 4.02% for wheat and maize, respectively. Using a partial equilibrium model, FAPRI found that if trade distortions were removed (domestic support remaining constant) globally, the world price for wheat and maize would increase 7.60% and 6.23%, respectively. Even though the model does not account for cross-price effects, the overall results are comparable to the results from the more established FAPRI model. Tables 1 and 2 show the ten largest relative increases and decreases in consumer and producer surplus from liberalizing wheat and maize trade, respectively. In Appendix 2, the welfare impacts in each country/region from liberalizing trade in wheat and maize are reported. Large gains and losses can be attributed to two factors, either large trade distortions or large volumes of imports or exports or a combination of the two.

Change in Consumer Surplus (Wheat)

The results indicate that eight of the largest ten countries/regions' consumers who gained in relative terms from trade liberalization in the wheat market were from LLMI countries/regions. While it is true that an increase in world price hurts consumers, if world price increases by *X*% and the level of domestic protection before liberalization was *X*+1%, then consumers can still be made better off through trade liberalization. A clear case of this is

Nigeria where the average domestic price between 1998 and 2002 was nearly 350% greater than that of world price due to protection.

Table 1. Ten Largest Relative Increases and Decreases in Consumer and Producer Surplus from Wheat Trade Liberalization

Country	Relative Change in Consumer Surplus	Country	Relative Change in Producer Surplus
O. WANA**	4.56%	Central Asia*	18.54%
Nigeria*	4.42%	Rest Former USSR**	11.17%
N. SSAfrica*	2.71%	East Europe	1.71%
Egypt**	1.49%	O.Developed	0.64%
E. SSAfrica*	1.34%	United States	0.28%
Pakistan*	0.91%	EU15	0.24%
Korea, Republic of	0.68%	Brazil	0.15%
S. SSAfrica*	0.62%	-	-
Turkey**	0.53%	-	-
Japan	0.51%	-	-
-	-	China**	-0.66%
-	-	Argentina	-0.96%
-	-	N. SSAfrica*	-0.99%
United States		Japan	-1.56%
O.Developed	-0.00%	India*	-1.82%
EU15	-0.00%	Pakistan*	-2.53%
Brazil	-0.03%	Egypt**	-2.65%
East Europe	-0.10%	Turkey**	-4.23%
Rest Former USSR**	-0.85%	Australia	-6.37%
Central Asia*	-1.46%	O. WANA**	-10.91%

Note: (*) and (**) denote a low income or lower middle income country/region as classified by the World Bank, respectively

Table 2. Ten Largest Relative Increases and Decreases in Consumer and Producer Surplus from Maize Trade Liberalization

Maize

Country	Relative Change in Consumer Surplus	Country	Relative Change in Producer Surplus
E. SSAfrica*	6.95%	United States	6.21%
Nigeria*	3.47%	Brazil	2.50%
C. & W. SSAfrica*	2.27%	East Europe	2.41%
Korea, Republic of	1.19%	Central Asia*	0.59%
Egypt**	1.12%	Thailand**	0.52%
O. Latin America**	1.09%	Rest Former USSR**	0.32%
O. WANA**	0.90%	Japan	0.00%
Japan	0.74%	-	-
N. SSAfrica*	0.64%	-	-
S. SSAfrica*	0.53%	-	-
-	-	Philippines**	-1.12%
-	-	O. SE. Asia*	-1.20%
-	-	Argentina	-1.87%
Australia	-0.00%	Egypt**	-1.93%
Thailand**	-0.03%	C. & W. SSAfrica*	-2.44%
Rest Former USSR**	-0.04%	O. Latin America**	-2.54%
United States	-0.04%	Mexico	-4.44%
Central Asia*	-0.07%	China**	-5.59%
Brazil	-0.14%	E. SSAfrica*	-6.12%
East Europe	-0.32%	Nigeria*	-6.31%

Note: (*) and (**) denote a low income or lower middle income country/region as classified by the World Bank, respectively

The model shows that the losers from trade liberalization are consumers in Central Asia, Rest of Former USSR, Eastern Europe, and Brazil, countries for which domestic prices were below world price prior to the removal of tariffs (EU15, Other Developed, and The United States also lost consumer surplus but the losses were small on a relative scale), as illustrated in Table 1. Of the countries that had a change of consumer surplus that was negative, none were from Southeast Asia or Sub-Saharan Africa where 29% and 46% of the respective population live off less than $1 per day (United Nations).

When looking at the total change in consumer surplus, Japan is an important example of why per capita and relative change should be included in welfare studies. Japan is the second largest winner in total change in consumer surplus at roughly 25 billion USD, but relatively Japan is the tenth largest winner at merely 0.51% of the average consumer's income. Conversely, E. SS. Africa is only the twelfth largest winner in terms of total consumer surplus, but when analyzing relative change in consumer surplus they are the fifth largest winner.

While the change in consumer surplus in some countries was negative, those with original domestic price below world price, consumers in most countries/regions gained. Again this gain is attributed to the fact that world price was assumed to increase by an average of 5.94% which is less than the difference between original domestic price and the world price.

Change in Consumer Surplus (Maize)

Like wheat, the main benefactors from the liberalization of maize trade were LLMI countries/regions with eight of the ten largest gainers in relative consumer surplus being LLMI countries/regions. Since the projected maize price will only increase on average by 4.02%, consumers in countries with prices above world price will win because the price increase is less in relative magnitude than the old domestic price.

The largest change in total consumer surplus was Japan at 36.01 billion USD, while E. SS. Africa is the sixth largest gainer at over 2.14 billion USD, roughly 17 times less than what Japan gained. When looking at the relative change in consumer surplus, Japan falls to eighth at 0.74% while E. SS. Africa jumps to become the largest relative gainer at 6.95%.

Consumer surplus gains can be attributed to different factors. For instance, even though Nigerian imports are small, their consumers are the second largest relative winner because of the removal of a large trade distortion. Conversely, Egyptian consumers are the fifth largest relative winner, primarily because of their large volume of imports of maize rather than a large trade distortion.

Change in Producer Surplus (Wheat)

Many countries/regions' producers lost as a result of wheat trade liberalization. However, the losses are quite minimal for most regions, especially in relative terms, as 59% of the regions have a reduction in producer surplus less than 1% of their income. O. WANA's producers suffer the largest loss in relative terms with a relative loss of 10.91%. Although O.WANA experiences the largest relative producer surplus loss, it is difficult to draw specific conclusions because of the large and diverse number of countries that the region encompasses. The large loss in Australia is due to the importance of wheat; 23.14% of the arable land is planted to wheat in Australia, and the relatively few number of farmers.[5] Turkey, the next largest loser, lost due to large volumes of wheat production; whereas, Egypt's loss was driven by both a large trade distortion and large production volumes.

It should be emphasized that seven out of the ten largest reductions in relative producer surplus were in LLMI countries/regions. Wheat is an example where many producers in LLMI countries are hurt by trade liberalization. Our model shows that no African or South or South East Asian countries have an increase in producer surplus. The two largest increases in producer surplus in per capita and relative terms are Central Asia and the Rest of Former USSR. This is because wheat is such an important crop to their agriculture, as 46.35% and 19.48% of arable land is planted to wheat in each region, respectively (FAO 2006c). The EU15 and the United States' producer surplus increases are due to large volumes of production while maintaining domestic support.

Change in Producer Surplus (Maize)

Trade liberalization in maize reemphasizes the principle that LLMI countries' producers do not always gain from trade liberalization. The reason some LLMI countries' producers do not benefit in this model is because they are forced to completely liberalize their own distortions as well. This may result in the domestic price of the commodity decreasing after liberalization, because the increase in world price is not large enough to make up for the reduction in protection.

In relative terms, eight out of the ten largest decreases in producer surplus were in LLMI countries/regions. These producers lose from prices being reduced due to the removal of protection in their own countries. In particular, no African producers gain through liberalization. Nigeria and E. SS Africa lose the most in relative terms even though the per capita loss is only 22.35 USD and 8.56 USD, respectively, but to farmers in these low-income countries this loss is substantial relative to their income at 6.31% and 6.12%, respectively. Nigerian, East, and C&W SS. African producers' losses are attributed to large distortions which protect them from lower cost imports. China has the largest reduction in overall producer surplus, but in per capita terms only loses 12.82 USD.[6] Mexico and O. Latin America also suffer large losses in producer surplus.[7] In Mexico, 28.71% of arable land is planted to maize and 14.81% in O. Latin America, indicating that maize is an important crop to producers in these regions. Japan, although largely distorting the market for maize, does not suffer much of a loss in producer surplus because maize is relatively unimportant in Japanese production, sown on only 0.001% of total arable land (FAO 2006c).

The United States has the largest increase in producer surplus in all measures; the per capita increase is 1,109.06 USD. Brazil and East Europe also see a large increase in producer surplus, 2.50% and 2.41% of their incomes, respectively.

Change in Social Welfare (Wheat)

Nigeria experienced the largest increase in relative social welfare at 3.68%, followed by O.WANA and N. SS. Africa at 3.14% and 1.96%, respectively (Table 3). These gains were driven by increases in consumer surplus through the elimination of border protection. Out of the sixteen LLMI countries/regions in the wheat model, only two (12.5%) experienced a net welfare loss. The loss in social welfare in India, a LLMI country, is due to decreases in producer surplus. Conversely, the social welfare loss in Rest Former USSR, another LLMI country, was due to decreases in consumer surplus. Although Japan had the largest gain in total social welfare at 17.1 billion USD, in relative terms they are only the tenth largest winner at 0.35% of GDP. The global change in social welfare is roughly 46.5 billion USD.

Table 3. Ten Largest Relative Increases and Decreases in Social Welfare from Wheat and Maize Trade Liberalization

Wheat		Maize	
Country	Relative Change in Social Welfare	Country	Relative Change in Social Welfare
Nigeria*	3.68%	E. SSAfrica*	4.39%
O. WANA**	3.14%	Nigeria*	1.90%
N. SSAfrica*	1.96%	C. & W. SSAfrica*	1.41%
Central Asia*	0.99%	Pakistan*	1.20%
E. SSAfrica*	0.98%	Korea, Republic of	0.66%
Egypt**	0.95%	O. Latin America**	0.64%
Pakistan*	0.50%	Egypt**	0.63%
Korea, Republic of	0.50%	O. WANA**	0.50%
S. SSAfrica*	0.42%	Japan	0.40%
Japan	0.35%	N. SSAfrica*	0.32%
-	-	-	-
-	-	Brazil	-0.01%
East Europe	-0.01%	Rest Former USSR**	-0.01%
Brazil	-0.01%	East Europe	-0.13%
Rest Former USSR**	-0.06%	O. SE. Asia*	-0.34%
India*	-0.38%	China**	-0.77%

Note: (*) and (**) denote a low income or lower middle income country/region as classified by the World Bank, respectively

Change in Social Welfare (Maize)

E. SS. Africa experienced the largest increase in relative social welfare from the liberalization of the maize market at 4.39% of GDP, followed by Nigeria, C&W SS. African and Pakistan at 1.90%, 1.41%, and 1.20%, respectively (Table 3). Once again all these LLMI countries experienced a social welfare gain due to increases in consumer surplus. In the maize model, only three of the twenty-one (14.3%) LLMI countries experienced a net loss from trade liberalization. Of the LLMI countries who lost, China and O.SE. Asia lost due to decreases in producer surplus, whereas Rest Former USSR lost due to decreases in consumer surplus. As was the case in wheat, Japan is the biggest winner in terms of social welfare at 19.6 billion USD, but in relative terms only experienced the ninth largest gain at 0.40%. The global change in social welfare from maize trade liberalization is roughly 28.85 billion USD.

CONCLUSION

While it is widely accepted in the literature that high-income countries' protection of the white commodities (cotton, sugar, and rice) have hurt LLMI countries' producers, less attention has been focused on the commodities that are protected to a lesser extent (maize and wheat). This study set out to achieve two distinct objectives, first to see who gains/loses from the removal of trade barriers in both the global wheat and maize markets. The second objective is to calculate per capita and relative measures of the welfare impacts on producers and consumers. Due to wealth disparities across countries, it is critical to analyze the welfare impacts of trade liberalization in relative terms, which puts the benefits and losses into better perspective.

Using the model's endogenously determined increase in world price in both wheat and maize (5.94% and 4.02%, respectively) it was found that eight of the ten largest increases in relative consumer surplus were LLMI countries for both the wheat and maize models. Conversely, many producers in LLMI countries were found to be net losers in the wheat and maize models. This being said, these losses may be inflated because producers are also consumers and thus would benefit from lower commodity prices.

The benefits to producers in LLMI countries from liberalizing trade within the white commodities is well established, but the claim that agricultural trade liberalization on a wider scale will further benefit producers in LLMI countries needs to be tempered. Our results show that producers in LLMI countries will be the primary losers from trade liberalization in wheat and maize. Therefore, if the goal of trade negotiations is to help producers in LLMI countries, negotiations should focus on the white commodities. Instead of the producers gaining through trade liberalization in wheat and maize, the consumers in LLMI countries are the ones who benefit, although primarily through the removal of their own tariffs. This is especially important considering roughly 20% of the world's calories come from wheat and an immense number of the world's poor consumers and producers rely on maize as their main dietary staple.

The results show that the gains to consumers often outweigh the losses to producers such that 87.5% and 86% of the LLMI countries experienced a net social welfare gain attributed to wheat and maize trade liberalization, respectively. The current political economy tends to focus on benefits to LLMI producers from trade liberalization of agricultural commodities, but our results show that in the case of wheat and maize LLMI consumers are the primary benefactors of trade liberalization.

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NOTES

[1]Using the World Bank classifications where low, lower middle, upper middle, and high-income countries are defined as having a per capita income less than 825 USD, between 826–3,255 USD, between 3,256–10,065 USD, and above 10,066 USD, respectively.

[2]For most countries/regions only one port was used. In cases where a country/region is set on two bodies of water (i.e. United States, Canada, Mexico, India) or had two major ports on opposite sides of the country (Australia, EU15) multiple ports were used in calculation, selecting the one that minimized cost for the importer/exporter.

[3]The authors recognize that this is not a programming model and thus post liberalization trade patterns can not be identified. Therefore, the model assumes that trade patterns remain the same after trade

liberalization. That being said, this calculation gives a rough estimation of transportation costs so that domestic prices can be adjusted to be compared across countries and regions.

[4]Collecting and quantifying trade policy data for every country proved impractical and unfeasible. Most notably because of the lack of data availability/reliability from small and closed countries, and that countries may have multiple tariff rates which are country specific. Therefore, this model calculates welfare measures treating all trade distortions as tariffs or export subsidies. Certain policies do exist, most notably quotas that would result in no change in government revenue.

[5]Intuitively, it seems odd that Australia, being a member of the Cairns group, would have a change in surplus. However, Australia does have a wheat board which by definitions seeks to bargain for higher prices and we assume that with complete liberalization the market is competitive, thus eliminating the gains extracted from the marketing board.

[6]China has exported maize at prices well below Chinese domestic prices due to export subsidies (Gale). China had an average import tariff on wheat of roughly 74% for this time period as well (Askoy and Beghin).

[7]Mexico imports over 97% of its maize from the United States, has TRQ's imposed on US imports until their gradual phase out in 2008 (Zahniser and Coyle).

Appendix 1: Countries and Region Classifications by Income Group Classification*

Low Income

Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Central and Western Sub-Saharan Africa (C. & W. SS Africa): Benin, Cameroon, Central African Republic, Comoros Island, Congo Democratic Republic, Congo Republic, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Sao Tome and Principe, Senegal, Sierra Leone, and Togo

Eastern Sub-Saharan Africa (E. SS Africa): Burundi, Kenya, Rwanda, Tanzania, and Uganda

Nigeria

Northern Sub-Saharan Africa (N. SS Africa): Burkina Faso, Chad, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Somalia, and Sudan

Southern Sub-Saharan Africa (S. SS Africa): Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Reunion, Swaziland, Zambia, and Zimbabwe

Bangladesh

India

Pakistan

Other South Asia (O.S. Asia): Afghanistan, Maldives, Nepal, and Sri Lanka

Myanmar

Vietnam

Other Southeast Asia (O. SE. Asia): Brunei, Cambodia, and Laos

Other East Asia: Democratic People's Republic of Korea, Macao, and Mongolia

* Region classifications are the same as in Rosegrant et al. (1995)

Lower Middle Income

Rest of Former USSR: Armenia, Azerbaijan, Belarus, Estonia, Georgia, Latvia, Lithuania, Moldova, Russian Federation, and Ukraine

Colombia

Other Latin America (O. Latin America): Antigua and Barbuda, Bahamas, Barbados, Belize, Bolivia, Chile, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Saint Kitts and Nevis, Saint Lucia, Saint Vincent, Suriname, Trinidad and Tobago, Uruguay and Venezuela

Egypt

Turkey

Other West Asia and North Africa (O. WANA): Algeria, Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Saudi Arabia, Syria, Tunisia, United Arab Emirates, and Yemen

Indonesia

Philippines

Thailand

China: includes Taiwan and Hong Kong

Rest of the World: Cape Verde, Fiji, French Polynesia, Kiribati, New Guinea, Papua New Guinea, Seychelles, and Vanuatu

Upper Middle Income

East Europe: Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Poland, Romania, Slovakia, Slovenia, and Yugoslavia

Argentina

Brazil

Mexico

Malaysia

High Income

Australia

European Union (EU 15): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom

Japan

United States of America

Other Developed (O. Developed): Canada, Iceland, Israel, Malta, New Zealand, Norway, South Africa, and Switzerland

Republic of Korea

APPENDIX 2: MODEL ESTIMATES FOR EACH COUNTRY/REGION FOR WHEAT AND MAIZE TRADE LIBERALIZATION

Table 1. Complete Wheat Tariff Liberalization and its Effects on Consumer and Producer Surplus, Government Revenue and Social Welfare: Average of 1998-2002[a]

Country	Change in Producer Surplus	Change in Consumer Surplus	Change in Government Revenue	Change in Social Welfare
	High Income			
EU15	$400,276,616	-$373,038,301	$72,892,536	$100,130,852
	($26.43)	(-$0.98)		
	[0.24%]	[-0.00%]		
Australia	-$732,180,436	$196,112,856	$637,506,420	$101,438,841
	($-846.45)	($9.98)		
	[-6.37%]	[0.05%]		
Japan	-$831,739,927	$25,384,356,472	-$7,421,728,780	$17,130,887,765
	(-$189.85)	($199.25)		
	[-1.56%]	[0.51%]		
United States	$280,233,166	-$16,210,064	$50,712,235	$314,735,336
	($46.23)	(-$0.06)		
	[0.28%]	[0.00%]		
O. Developed	$192,926,759	-$27,873,160	$4,606,380	$169,659,979
	($24.50)	(-$0.28)		
	[0.64%]	[0.00%]		
Korea, Republic of	-$1,460,964	$4,011,331,381	-$1,391,163,518	$2,618,706,899
	(-$0.40)	($84.24)		
	[-0.01%]	[0.68%]		
	Upper Middle Income			
East Europe	$408,969,806	-$436,404,098	-$2,327,225	-$29,761,517
	($24.47)	(-$3.72)		
	[1.71%]	[-0.10%]		
Argentina	-$99,997,929	$44,433,665	$129,637,553	$74,073,289
	(-$27.24)	($1.18)		
	[-0.96%]	[0.02%]		
Brazil	$55,277,718	-$218,649,734	$72,218,323	-$91,153,693
	($2.04)	(-$1.22)		
	[0.15%]	[-0.03%]		
Mexico	-$51,389,529	$241,947,512	-$52,835,383	$137,722,600
	(-$2.26)	($2.40)		
	[-0.22%]	[0.04%]		
	Lower Middle Income			
Rest Former USSR	$3,217,106,894	-$3,334,736,836	-$84,488,033	-$202,117,975
	($114.35)	(-$14.46)		
	[11.17%]	[-0.85%]		
Colombia	-$2,717,720	$212,578,636	-$91,420,702	$118,440,214
	(-$0.32)	($4.88)		
	[-0.03%]	[0.24%]		
O. Latin America	-$85,793,186	$893,006,666	-$305,978,713	$501,234,767
	(-$1.96)	($5.26)		
	[-0.20]	[0.19%]		

Country	Change in Producer Surplus	Change in Consumer Surplus	Change in Government Revenue	Change in Social Welfare
	Lower Middle Income			
Egypt	-$359,285,230	$1,694,427,537	-$332,956,470	$1,002,185,838
	(-$14.37)	($24.24)		
	[-2.65%]	[1.49%]		
Turkey	-$857,824,342	$1,092,059,720	$58,421,679	$292,657,057
	(-$41.31)	($15.68)		
	[-4.23%]	[0.53%]		
O. WANA	-$5,149,238,726	$30,320,048,509	-$5,523,128,008	$19,647,681,775
	(-$93.97)	($140.55)		
	[-10.91%]	[4.56%]		
China	-$1,298,385,563	$2,863,561,334	-$38,925,446	$1,526,250,325
	(-$1.52)	($2.24)		
	[-0.66%]	[0.19%]		
	Low Income			
Central Asia	$1,232,838,152	-$665,441,548	-$175,473,268	$391,923,336
	($85.10)	(-$11.83)		
	[18.54%]	[-1.46%]		
Nigeria	-$22,210,500	$2,024,012,355	-$592,493,344	$1,409,308,511
	(-$0.58)	($16.44)		
	[-0.16%]	[4.42%]		
N. SS Africa	-$122,250,092	$921,759,916	-$197,877,562	$601,632,262
	(-$1.03)	($5.96)		
	[-0.99%]	[2.71%]		
C. & W. SS Africa	-$18,861	$89,590,024	-$19,031,863	$70,539,300
	$0.00	($0.56)		
	[0.00%]	[0.16%]		
S. SS Africa	-$23,947,472	$308,418,307	-$88,715,050	$195,755,785
	(-$0.38)	($3.27)		
	[-0.26%]	[0.62%]		
E. SS Africa	-$40,419,067	$464,658,438	-$114,124,298	$310,115,074
	(-$0.48)	($4.24)		
	[-0.40%]	[1.34%]		
India	-$1,905,231,129	$1,560,312,547	$139,979,848	-$204,938,734
	(-$3.44)	($1.49)		
	[-1.82%]	[0.30%]		
Pakistan	-$397,313,129	$732,146,750	-$11,547,017	$323,286,604
	(-$5.31)	($5.05)		
	[-2.53%]	[0.91%]		
O. S. Asia	-$1,215,270	$30,185,528	-$7,341,449	$21,628,809
	($0.04)	($0.67)		
	[-0.02%%]	[0.13%]		

[a]Using the endogenously determined average price change of 5.942%

Note:Numbers in parentheses () and in brackets [] represent the per capita and relative change, respectively

Table 2. Complete Maize Tariff Liberalization and its Effects on Consumer and Producer Surplus, Government Revenue and Social Welfare: Average of 1998-2002[a]

Country	Change in Producer Surplus	Change in Consumer Surplus	Change in Government Revenue	Change in Social Welfare
High Income				
EU15	-$869,438,021 (-$57.98)[b] [-0.52%][c]	$1,825,530,295 ($4.86) [0.02%]	-$4,254,543	$951,837,731
Australia	-$2,819,538 (-$3.42) [-0.02%]	$2,816,671 ($0.15) [0.00%]	$275,527	$272,661
Japan	-$178,232 (-$0.04) [0.00%]	$36,098,626,256 (-$284.55) [0.74%]	-$16,494,964,796	$19,603,483,227
United States	$6,559,979,070 ($1,109.06) [6.21%]	-$4,031,683,772 (-$14.32) [-0.04%]	-$842,889,627	$1,685,405,671
O. Developed	-$84,565,449 (-$10.87) [-0.28%]	$293,584,371 ($3.01) [0.02%]	-$30,380,564	$178,638,358
Korea, Republic of	-$35,456,146 (-$5.38) [-0.35%]	$6,219,441,329 ($132.29) [1.19%]	-$2,760,946,951	$3,423,038,232
Upper Middle Income				
East Europe	$572,862,232 ($33.44) [2.41%]	-$1,317,866,827 (-$11.06) [-0.32%]	$203,539,217	-$541,465,377
Argentina	-$256,705,274 (-$72.07) [-1.87%]	$83,567,515 ($2.28) [0.03%]	$231,345,140	$58,207,381
Brazil	$857,657,062 ($31.82) [2.50%]	-$911,307,978 (-$5.07) [-0.14%]	-$5,460,688	-$59,111,604
Mexico	-$964,963,946 (-$43.74) [-4.44%]	$2,804,347,381 ($28.69) [0.48%]	-$270,867,582	$1,568,515,852
Lower Middle Income				
Rest Former USSR	$79,783,898 ($2.81) [0.32%]	-$137,151,175 (-$0.59) [-0.04%]	$6,898,612	-$50,468,665
Colombia	-$61,256,940 (-$7.36) [-0.61%]	$403,774,605 ($9.60) [0.46%]	-$120,860,714	$221,656,951
O. Latin America	-$1,132,958,527 (-$26.69) [-2.54%]	$5,158,084,607 ($31.47) [1.09%]	-$969,417,874	$3,055,708,206
Egypt	-$280,693,250 (-$11.79) [-1.93%]	$1,146,343,705 (-$17.22) [1.12%]	-$200,075,820	$665,574,635
Turkey	-$120,123,366 (-$6.02) [-0.48%]	$394,852,462 ($5.90) [0.20%]	-$52,366,112	$222,362,984
O. WANA	-$420,506,865 (-$7.89) [-0.90%]	$5,743,307,364 ($27.37) [0.90%]	-$2,167,576,421	$3,155,224,078
Indonesia	-$97,213,037 (-$1.05) [-0.23%]	$344,498,395 ($1.66) [0.20%]	-$17,427,887	$229,857,471
Thailand	$47,804,381 ($2.03) [0.52%]	-$33,623,517 (-$0.54) [-0.03%]	-$2,072,043	$12,108,821
Philippines	-$118,968,660 (-$4.66) [-1.12%]	$246,618,368 ($3.89) [0.38%]	-$10,857,830	$116,791,878
China	-$10,895,027,776 (-$12.82) [-5.59%]	$1,116,848,403 ($0.90) [0.10%]	$108,910,609	-$9,669,268,764
Low Income				
Central Asia	$41,932,210 ($2.94) [0.59%]	-$26,140,556 (-$0.47) [-0.07%]	-$3,593,451	$12,198,203
Nigeria	-$812,593,217 (-$22.35) [-6.31%]	$1,539,894,657 ($12.92) [3.47%]	-$287,732	$727,013,709
N. SS Africa	-$73,698,975 (-$0.69) [-0.64%]	$178,781,561 ($1.28) [0.64%]	-$7,820,172	$97,262,414
C. & W. SS Africa	-$418,163,106 (-$4.84) [-2.44%]	$1,194,559,928 ($7.95) [2.27%]	-$25,242,860	$751,153,962
S. SS Africa	-$73,655,269 (-$1.21) [-1.10%]	$248,590,115 ($2.75) [0.53%]	-$29,701,072	$145,233,775
E. SS Africa	-$675,981,692 (-$8.56) [-6.12%]	$2,138,170,049 ($20.94) [6.95%]	-$66,871,875	$1,395,316,482
India	-$102,642,511 (-$0.19) [-0.10%]	$220,015,905 ($0.21) [0.05%]	-$2,167,474	$115,205,920
Pakistan	$230,555,719 (-$0.51) [-0.15%]	$527,735,724 ($0.95) [0.18%]	$11,720,720	$770,012,163
O. S. Asia	-$24,157,945 (-$0.78) [-0.47%]	$52,984,823 ($1.21) [0.23%]	-$1,682,178	$27,144,699
O. SE. Asia	-$27,035,046 (-$1.98) [-1.20%]	$8,175,411 ($0.46) [0.17%]	-$297,946	-$19,157,581

[a]Using the endogenously determined average price change of 4.016%

[b]Numbers in parentheses represent per capita change

[c]Numbers in brackets represent relative change

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IMPACTS OF A GENETICALLY MODIFIED FUSARIUM RESISTANT TRAIT ON CONVENTIONAL FUNGICIDE PRICES AND DEMAND

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ABSTRACT

Fusarium resistant wheat (FRW) is a prospective genetically modified (GM) trait being developed by Syngenta that is near commercialization. Release of this trait would impact prices of competing fungicides used on conventional varieties. A Cournot model is developed to determine equilibrium quantities and prices for conventional fungicide and agbiotechnology firms. A market with conventional wheat is compared to a market comprised of both conventional and GM FRW varieties to determine price impacts of introducing the trait. Finally the issues addressed in this paper have important implications for development and trade, particularly as countries confront how to facilitate and address this particular trait.

JEL classification: Q13, Q17
Key Words: commercialization, Cournot equilibrium, effects of competing technologies, fusarium, genetically modified, pricing.

INTRODUCTION

Genetically modified (GM) wheat has not progressed as quickly as GM varieties of other crops due to a combination of complex genetics, market size relative to other crops, greater export volume, and import country regulations. In addition, competition among exporting countries would be affected by the need for dramatic changes in the marketing system (Berwald, Carter and Gruere 2006; Wilson, DeVuyst, Taylor, Koo, and Dahl 2008). Several GM wheat traits are currently being developed. At the forefront is Roundup Ready® wheat (RRW) in North America, commercialization of which has been deferred, fusarium resistant wheat (FRW) by Syngenta, and drought tolerance in the United States and Australia (Wilson, Janzen, and Dahl 2003). These are input traits that are potentially valuable to growers,

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explaining the recent strong support by the major U.S. organizations for further commercialization of GM traits in wheat (National Association of Wheat Growers 2006). Indeed, concerns have now been raised about the loss of competitiveness of wheat in North America due to absence of GM wheat versus other GM crops (Sosland 2008).

Fusarium head blight (FHB) is a fungal disease that can occur in small grain crops and is very common in North Dakota and Canada on spring wheat, durum, and barley (McMullen and Stack 1999; Nganje et al. 2004). Currently, farmers use fungicides, applied at the onset of flowering, to reduce the susceptibility of the plant to the disease. Since the window of application is small, fungicides are not 100% effective. Besides yield reduction, FHB causes reduction in quality, resulting in price discounts and quality concerns shared by elevators, food processors, and consumers. Fusarium resistant GM technology would eliminate the risk related to fungicide application and quality concerns related to this disease.

Farmers apply fungicides to control FHB and to reduce DON and the chemicals typically can be used on both wheat and barley. In addition, farmers apply fungicides for early season leaf disease control and rust. Fungicide brands include Folicure (tebuconazole) which is a Bayer CropScience product, Proline (prothioconazole) which is also a Bayer CropScience product, Tilt (Syngenta), Headline and a few other products. Regulation by the Environmental Protection Administration (EPA) is important for these products. Folicur has been the primary fungicide used for scab control in both wheat and barley, at least through 2007. However, it does not have full federal registration in the United States, though it does in Canada. Proline was registered with a full license in 2007. Syngenta has attempted to promote Tilt as a scab control product, but tests in many states have shown that it doesn't control FHB or reduce DON as well as Folicur or Proline (McMullen, 2008). The industry is thought to be highly concentrated, though USDA only reports use statistics by chemical name and the Department of Commerce SIC data at the 5-digit level (for pesticide and other agricultural chemical manufacturers) does not breakdown fungicides. In the most recent chemical use survey about one-half of the acres planted were treated with Folicur, followed by minor use of each of the remaining alternative products.

GM FRW is expected to be near commercialization in the latter part of this decade. Syngenta's anticipated launch of GM FRW was set for 2007 (Syngenta 2004), though more recent presentations have suggested 2013 (Sears, 2006). In addition to Syngenta, a number of other efforts are seeking GM solutions to the fusarium problem for wheat (Shin et al. 2006) and barley (Clarke et al. 2006). Traits that are currently being field tested include those with altered agronomic properties such as drought and cold tolerance and yield increases. Other traits include herbicide tolerance, virus resistance, and a marker gene. Protection of intellectual proper rights and the ability to recoup research costs through some form or royalties are important features of this industry. It is for these reasons that development of this trait is being concentrated on North American wheat. Indeed, the patent on the trait would provide protection and monopoly power for an extended time which is a central feature to our model

Introduction of GM technology would impact prices of competing technologies. Gianessi and Carpenter (2003) found there were declines in the price of competing technologies (e.g., glyphosate used for soybeans) in the area of 22% following introduction of Roundup Ready ® soybeans in Illinois. The purpose of our study is to analyze prospective changes in prices of competing technologies in the case of GM FRW varieties if and when the trait is introduced and how these prospective changes may affect farmers, fungicide firms, and agbiotechnology firms. GM FRW differs from other traits in a number of respects. Of particular importance for this study is that fusarium is a disease that has a high degree of randomness through time and location. Thus, stochastic simulation is used to implement randomness in a model representing uncertain outcomes. The model is applied in the case of Hard Red Spring (HRS) wheat grown in North Dakota, though similar problems are expected elsewhere, including Canada, the European Union (EU) and Argentina.

PRICE IMPACTS OF GM ADOPTION ON COMPETING INPUTS

This section develops a model to analyze impacts of the introduction of a GM trait on input prices. The theoretical model builds upon that of Lemarie and Marette (2003) and Huso and Wilson (2006) which are based on a vertical differentiation model (Mussa and Rosen 1978) assuming Cournot competition in which the strategic variable of each firm is quantity. The model differs from Huso and Wilson (2006) in that a complementary technology is not required and due to the stochastic nature of this disease. An equilibrium technology price is determined that depends on the production of all firms in the industry, and the amount that one firm produces depends on how much it expects its competitors to produce, and vice versa. The Cournot model is used because firms make production decisions in advance and are committed to selling all of their output. Because prices adjust more quickly than quantities, each firm sets a price that lets it sell all that it produces.

There are two technology choices for FHB control, a fungicide spray or a prospective GM FRW trait seed. For simplicity, it is assumed that one synthetic fungicide is used. Technology choices are indexed by i; i=0 refers to the conventional plant protection solution and i=1 refers to a GM trait. Technology choice i is supplied by n_i firms which compete on quantity. The marginal production cost of manufacturing and distributing this technology, and price are c_i and p_i (both c_i and p_i are expressed in \$/lb), respectively. The conventional and GM inputs are both produced with a constant unit cost ($c_0 = c_1$). Specifically, c_0 refers to the chemical companies' marginal cost of manufacturing fungicide and c_1 the technology companies' marginal cost of developing and distributing GM seed. We do not observe these costs, or the sunk costs of developing these technologies, so we conduct sensitivities on their values. This assumption aids in explicitly modeling innovations that take the form of vertically differentiated inputs (e.g., a more productive seed variety).

In the case of GM FRW, the farmer would pay a premium (p_L) per acre for the GM seed which is determined by the agbiotechnology firm that is assumed to have a monopoly position in the specified GM trait. Use of GM FRW leads to a profit increase of p_L for the agbiotechnology firm. The technical efficiency (or production efficiency) for choice i is x_i, with $x_1 > x_0$. The farmer's choice between the plant protection solutions is made on a per acre basis. Farmers are assumed heterogeneous, and each has a willingness-to-pay equal to θx_i for technology choice i, where θ represents individual fungicide demand or the intensity of production problems for each farmer. θ is assumed uniformly distributed between 0 and 1.[1] A farmer whose crop is highly susceptible to FHB corresponds to a θ close to 1, while those with less susceptibility to the disease correspond to a θ close to 0. Use of technology choice i (at the required per acre dosage of each technology choice, a_i) provides an indirect utility of profit defined as u_i. The indirect utilities are

$$\begin{cases} u_0 = \theta x_0 - a_0 p_0 \\ u_1 = \theta x_1 - p_L \end{cases}. \tag{1}$$

The game is played in stages. The technology firm determines the license price and then fungicide and GM FRW sellers determine the quantities to produce. In the third stage, the farmer selects the technology with the highest indirect utility (i.e., adopt GM FRW if $u_1 > u_0$). If the indirect utility for all choices is negative for a given θ, then no product is purchased. Finally, farmers determine various quantities of these inputs to purchase.

In a market where only conventional fungicides (i.e., technology choice *0*) are available, a farmer who is indifferent between buying technology choice *0* and buying nothing is identified by the preference parameter $\hat{\theta}$. All farmers with $\theta > \hat{\theta}$ purchase technology choice *0*. Total demand for conventional fungicides[2] is

$$Q_0 = Na_0(1-\hat{\theta}), \tag{2}$$

where N is the area planted. Under symmetric Cournot-Nash equilibrium, and assuming profit maximization and other assumptions (see [names withheld]) and solving for the equilibrium price (p_0^*) gives

$$p_0^* = \frac{x_0 + a_0 c_0 n_0}{a_0(n_0+1)}. \tag{3}$$

The farmer's surplus, s_0^* in the one product case is

$$s_0^* = N\left[\left\{\frac{x_0}{2} - \frac{x_0 + n_0 a_0 c_0}{n_0+1}\right\} - \left\{\frac{\hat{\theta}^{*2} x_0}{2} - \frac{\hat{\theta}^*(x_0 + n_0 a_0 c_0)}{n_0+1}\right\}\right], \tag{4}$$

which is comprised of three elements. N is the total number of acres for wheat production. The first bracketed term is the indirect utility of a farmer with $\theta = 1$, or the highest demand for technology choice *0*. The second bracketed term is the indirect utility of a farmer with $\theta = \hat{\theta}$, or the lowest level of adoption for technology choice *0*. The difference between the two terms is the surplus for farmers who adopt technology choice *0*. Multiplying by N gives total farmer surplus. Sector welfare is

$$W = n_0 \pi_0^* + s_0^*. \tag{5}$$

An equilibrium is also derived assuming the two technology choices, conventional (i=0) and GM (i=1). Equilibrium quantities and prices for each technology choice are

$$q_0^* = \frac{Na_0\left(a_0c_0x_1(n_1+1) - x_0(x_1 + c_1n_1)\right)}{x_0\left(x_0n_0n_1 - x_1(n_0+1)(n_1+1)\right)} \text{ and} \tag{6}$$

$$q_1^* = -\frac{Na_1\left(-x_1 - a_0c_0n_0 + x_0n_0 - x_1n_0 + c_1(n_0+1)\right)}{-x_0n_0n_1 + x_1(n_0+1)(n_1+1)}. \tag{7}$$

$$p_0^* = \frac{a_0c_0x_1n_0(n_1+1) + x_0(x_1 + c_1n_1 - a_0c_0n_0n_1)}{a_0\left(-x_0n_0n_1 + x_1(n_0+1)(n_1+1)\right)} \text{ and} \tag{8}$$

$$p_L^* = \frac{x_1^2(n_0+1) - c_1x_0n_0n_1 + x_1(a_0c_0n_0 - x_0n_0 + c_1n_1 + c_1n_0n_1)}{\left(-x_0n_0n_1 + x_1(n_0+1)(n_1+1)\right)}. \tag{9}$$

A farmer purchasing technology choice *1* pays the license price, p_L. Equilibrium quantities, prices, profits, and surpluses differ. Equations 3 and 8 are the equilibrium price of technology *0*, p_0^*, in the market with one choice and the market with two technology choices, respectively. Equation 8 indicates that after the introduction of the new technology choice, p_0^* is dependent on the technical efficiencies of each choice, as well as the number of firms selling each technology choice. As the difference between x_1 and x_0 increases $(x_1 > x_0)$, p_0^* in Equation 8 decreases. Also, as n_0 and/or n_1 increase(s), p_0^* decreases because of increased competition.

The price of technology choice *1* is p_L^*, and one firm supplies the technology. The equilibrium profits to the sellers of technology choices *0* and *1* are

$$\pi_0^* = \frac{N\left(a_0c_0x_1(n_1+1) - x_0(x_1 + c_1n_1)\right)^2}{x_0\left(x_0n_0n_1 - x_1(n_0+1)(n_1+1)\right)^2} \text{ and} \tag{10}$$

$$\pi_B^* = \frac{Nx_1n_1\left(x_1 + a_0c_0n_0 - x_0n_0 + x_1n_0 - c_1(n_0+1)\right)^2}{\left(x_0n_0n_1 - x_1(n_0+1)(n_1+1)\right)^2}. \tag{11}$$

Total farmer surplus is defined over the ranges of adoption for each technology choice:

$$s_0^* = N\int_{\hat{\theta}^*}^{\tilde{\theta}^*} u_0 \, d\theta \text{, and} \tag{12}$$

$$s_1^* = N\int_{\tilde{\theta}^*}^{1} u_1 \, d\theta \tag{13}$$

and sector welfare is

$$W = n_0\pi_0^* + \pi_B^* + s_0^* + s_1^*. \tag{14}$$

EMPIRICAL MODEL DESCRIPTION

The prospective release of FRW is used to evaluate impacts on prices of competing fungicides after the release of a GM wheat trait. The players are the fungicide producing firms, the agbiotechnology firm, and farmers who decide which technologies to adopt. The order of play proceeds with the agbiotechnology firm first determining the license price (p_L), then all sellers of fungicides and GM FRW determine quantities (Cournot competition), and finally, farmers determine the quantities of the technology choices to purchase (i.e., adoption).

The model is solved first for conventional technology. Equilibrium input prices are derived and welfare is measured. Then the model is solved assuming a market with both GM FRW and conventional varieties. Farmers choose between purchasing a conventional wheat variety and applying a fungicide treatment or a GM FRW variety. The agbiotechnology firm providing the GM FRW trait has a monopoly with respect to that trait and receives profits only from the license price for the GM FRW trait. Simulation results reflect the prospective range of outcomes without the availability of historical data.

Data Sources, Distributions, and Assumptions

Data are used to represent HRS wheat production in North Dakota. The idiosyncratic fungicide need for each farmer (θ) is assumed to be uniformly distributed on the interval 0 to 1. Adoption of fungicide is a function of input prices, application rates, and technical efficiencies of each product. Table 1 summarizes the random variables and their densities used in the stochastic simulations, and Table 2 summarizes base case assumptions. Yields are for North Dakota crop reporting district 3 (USDA-NASS 2004; Nganje et al. 2001), one of the targeted areas for the trait. Yield distributions using conventional technology, x_0, were derived for the period 1990-2003. Yield distributions for GM FRW, x_1, are not observed but were derived as an increase relative to x_0 using a random variable of FHB yield loss. The assumption is that yields from conventional varieties are logistically distributed with a mean of 36 b/a. The GM FRW technology would result in a random yield increase (using the distribution shown in Table 1) relative to this value. The GM FRW is assumed 100% effective, which is relaxed in sensitivity. Thus, part of the randomness is due to the inherent yield risk, and part is due to that the effectiveness of the technology which is still in the process of field testing (and whose results have not been released). These distributions were determined using *Bestfit* (Palisade Corporation 2000).

Total HRS wheat acres, marginal cost of production, required per acre dosage, and the number of firms selling conventional fungicides and GM FRW are assigned values rather than simulated. In the base case, it is assumed that the marginal cost of production of both GM FRW and conventional varieties is zero. A large portion of the total cost associated with GM traits is fixed due to extensive research and development over many years, and data do not exist on the value of the marginal cost of production and distribution of a GM seed trait. The base case assumes this value to be nil as in Lemarie and Marette (2003). We recognize that the marginal cost of production is not nil and sensitivity analyses are conducted to illustrate the impact of increasing marginal cost of production. The one-firm solution reflects a monopoly with respect to that product and the two-firm solution indicates more competition.

The model is a set of mathematical relationships of the analytical solution that determine the value of outputs. Simulations are conducted using *@Risk* to account for randomness in some variables. Probability distributions are used to define risk. Ten thousand iterations were performed successively until distributions were adequately filled and simulated results were plausible.

Table 1. Random Variable Distributions

Variable	*Distribution*	*Mean*	*Std. Dev.*	(α_1, α_2)	*(Min, Max)*	*Correlation*
Conventional Yield x_0	Logistic	36	4.14	NA	NA	-0.85 with FHB loss
FRW Yield Increase x_1	BetaGeneral			(.273, .286)	(.015, .359)	-0.85 with Conv. Yield
Fungicide Demand, θ	Uniform	NA	NA	NA	(0, 1)	NA

Table 2. Base Case Assumptions

Variable/Parameter	*Value*	*Logic*
N	15 million acres	Average HRS wheat annual planting acreage in U.S.
n_0	1 or 2	Representing monopoly and competition among conventional fungicide firms
n_1	1	GM FRW agbiotech firm with patent protection.
C_0	0	Assumption for simplicity, No marginal cost to produce
C_1	0	Assumed no additional cost to produce GM seed
a_0	1	Assumption for simplicity
a_1	1	Same as above

BASE CASE RESULTS

The base case compares results under different structural conditions. In the market with conventional products only, fungicide producing firms decide quantity, which ultimately determines prices. This is illustrated for both one (simulation 1) and two competitors (simulation 2). Farmers who are indifferent between purchasing the fungicide and buying nothing are indicated by $\hat{\theta}$; therefore, the demand for the fungicide is determined by those farmers whose need is greater than $\hat{\theta}$. Demand (or adoption) for the conventional technology is 50% (1 - 0.5) of total HRS acres (Table 3). In simulation 2, competition decreases the price of the fungicide, p_0 from \$17.91/lb to \$11.94/lb. The price decrease results in more farmers purchasing the fungicide as indicated by $\hat{\theta}$ dropping to 0.33. Distributions for technology firm profit and surpluses are also shown. Technology firm profit, π_0 is \$136 million in simulation 1 and \$61 million in simulation 2 (simulation 2 includes two firms and total firm profit is \$122 million). Farmer surplus s_0 is \$68 million and \$121 million in simulations 1 and 2, respectively. Sector welfare, *W*, increases from \$204 million in simulation 1 to \$242 million in simulation 2.

Simulations 3 and 4 correspond to an equilibrium with conventional wheat (being provided by one or two firms) and GM FRW (being provided by a single firm owning the trait patent). The total price of the GM plant protection solution is p_L (\$/acre). In the market with two technologies, GM FRW is adopted by farmers with the highest θ value or those with $\tilde{\theta} < \theta < 1$. The conventional technology is adopted by farmers with a θ value such that $\hat{\theta} < \theta < \tilde{\theta}$. Farmers who use neither form of technology have a θ value of $0 < \theta < \hat{\theta}$. In simulation 3, GM FRW is adopted by 36% of the farmers. The conventional technology is adopted by 32% of the farmers, and 32% of the farmers purchase no plant protection. In simulation 4, the adoption of GM FRW is 30%, conventional technology adoption is 47%, and 23% of the farmers purchase no plant protection.

The agbiotechnology firm sets a license price, p_L for GM FRW of \$15.06/acre. Introduction of GM FRW results in a price decrease of 36% for the fungicide, p_0 from \$17.91/lb to \$11.46/lb. Introduction of GM FRW transfers a majority of firm payoffs from the fungicide firms to the agbiotechnology firm. From simulation 1 to 3, payoffs for the fungicide firms decrease from \$136 million to \$56 million (a decrease of 59%) while the payoff to the agbiotech firm is \$83 million in simulation 3. Much of farmer surplus shifts to those farmers who adopt the GM FRW. From simulation 1 to 3, conventional farmer surplus decreases from \$68 million to \$28 million, while the introduction of GM FRW results in a farmer surplus of \$104 million to those farmers who adopt the GM FRW technology in simulation 3. Farmer surplus increases because of more product choices. Sector welfare increases by 32.8% from simulations 1 to 3.

Comparing simulations 2 and 4 (when $n_0 = 2$), the agbiotechnology firm sets a p_L of \$12.35/acre, and the price of the fungicide decreases by 30%, from \$11.94/lb to \$8.44/lb. This lower price allows farmers with a low willingness-to-pay (or low θ) to purchase the conventional fungicide. For this reason, in comparing simulations 3 and 4, adoption of GM

FRW decreases while adoption of the fungicide increases. Introduction of the GM FRW results in a shift of the firm payoffs and farmer surpluses. From simulation 2 to 4, payoffs to the fungicide firms decrease from \$61 million to \$30 million, while the agbiotechnology firm gains a payoff of \$57 million after introduction of GM FRW. The surplus for conventional farmers decreases from \$121 million to \$61 million from simulation 2 to 4, while the surplus to those farmers that adopted GM FRW is \$103 million in simulation 4.

Table 3. Price Impact Model Results – Conventional and GM FRW

Sim.	*Structure* *No. of Conventional Input Suppliers*	*No. of GM Input Suppliers*	P_0 (\$ per acre)	P_L (\$ per acre)	*Conv. Adopt*	*FRW Adopt*	π_0 (\$ million)	π_B (\$ million)	s_0 (\$ million)	s_1 (\$ million)	W (\$ million)
			Conventional Only								
#1	$n_0 = 1$	$n_1 = 0$	17.91		50%		136		68		204
Std							29		14		43
Minimum							-27		-14		41
Maximum							314		160		479
#2	$n_0 = 2$	$n_1 = 0$	11.94		67%		61		121		242
Std							13		25		51
Minimum							-12		-24		-48
Maximum							142		284		568
			Conventional & GM FRW								
#3	$n_0 = 1$	$n_1 = 1$	11.46	15.06	32%	36%	56	83	28	104	271
Std							14	13	7	16	42
Minimum							-10	-22	-5	-24	-61
Maximum							141	147	70	216	574
#4	$n_0 = 2$	$n_1 = 1$	8.44	12.35	47%	30%	30	57	61	103	281
Std							9	13	17	15	45
Minimum							-5	-17	-11	-25	-63
Maximum							79	99	157	204	604

Since there are a number of random variables that impact these results, the cumulative distribution of prices is shown in Figure 1. The range of prospective prices is slightly greater for the conventional technology. Further, the range for the GM FRW indicates that the uncertainties would impact the range of equilibrium prices.

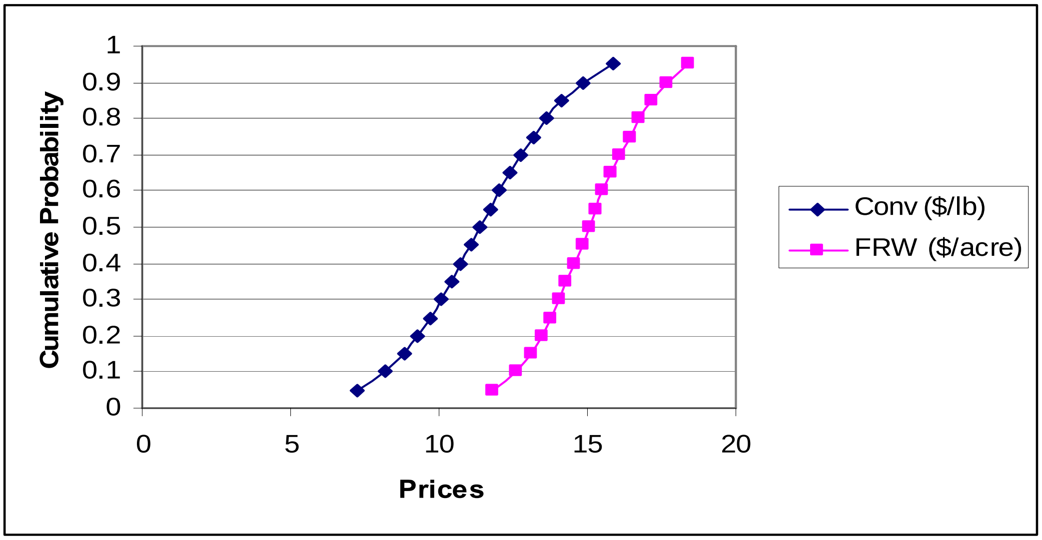

Figure 1. Cumulative probability distribution of prices in simulation 4.

Variations of Surplus

Release of a GM trait, combined with price decreases of conventional technologies, results in some farmers adopting a new technology while others continue using fungicide. Such interactions allow for farmers with a low level of willingness-to-pay for the GM technology to accrue surplus because of the price decreases of the competing fungicide associated with the release of the GM trait. Variation in surplus (Lemarie and Marette 2003) is used to compare farmer surplus as the market shifts from conventional wheat to a market with conventional and GM wheat.

Farmers with the highest willingness-to-pay for the GM trait (i.e., farmers with the highest θ) shift from adopting fungicide to adopting the GM solution. Some farmers continue adopting the conventional protection. Some farmers that did not adopt any plant protection when only conventional protection was available may purchase fungicide in the new market because of their low need or willingness-to-pay. The variations of farmer surplus and changes in firm profits and sector welfare in both market configurations are illustrated in Table 4.

The variations of surplus show the changes in surplus for one group of farmers as the GM FRW is introduced. Moving from simulation 1 to 3, $\Delta S_{\phi\to 0}$ is the change in surplus of those farmers who purchase no plant protection solution in simulation 1, then purchase technology choice *0* (conventional fungicide) in simulation 3. In simulation 1, 50% of farmers adopt no protection and 50% adopt fungicide. In simulation 3, 36% of farmers with the highest θ adopt

GM FRW, 32% adopt fungicide, and 32% adopt no protection solution. This indicates that 18% of farmers moved from purchasing no protection in simulation 1 to purchasing fungicide in simulation 3 (50%-32%). After introducing GM FRW, the surplus for the 18% of total farmers that switched from nothing to fungicide increased by $9 million.

Table 4. Variations of Surplus ($ million)

Comparison	$\Delta S_{\phi\to 0}$	$\Delta S_{0\to 0}$	$\Delta S_{0\to 1}$	ΔS	$\Delta \pi_0$	$\Delta \pi_B$	ΔW
Change in surplus from conventional to GM FRW assuming 1 conventional supplier (#1 to #3)	9	13	42	63	-80	83	66
Change in surplus from conventional to GM FRW assuming 2 conventional suppliers (#2 to #4)	3	20	20	43	-61	57	38

The surplus to farmers who purchase fungicide in both simulations 1 and 3 ($\Delta S_{0\to 0}$) increases by $13 million. Conventional adoption is 50% in simulation 1 and 32% in simulation 3. Adoption of GM FRW is 36% in simulation 3. Thus, farmers with the highest willingness-to-pay for the new technology become adopters in simulation 3. This leaves 14% of farmers purchasing fungicide in both simulations. Therefore, the increase in surplus to those 14% of farmers is a direct result of the price decrease of the fungicide. The surplus to farmers who purchase fungicide in simulation 1 and then adopt GM FRW in simulation 3 ($\Delta S_{0\to 1}$) increases by $42 million. Those 36% of total farmers with the highest willingness-to-pay for GM FRW variety are the ones who moved from fungicide to GM FRW. So, the change in farmer surplus for those 36% of total farmers is an increase of $42 million.

The total increase in surplus from simulation 1 to 3 is $63 million. Because of a price decrease of the fungicide, the total change in payoff for the fungicide producing firms ($\Delta \pi_0$) is a decrease of $80 million from simulation 1 to 3. The total payoffs for the GM FRW agbiotech firm ($\Delta \pi_B$) increases by $83 million. Thus, sector welfare increases by $66 million from simulation 1 to 3. Interpretation of the remaining simulations in Table 4 is identical.

The variation of surplus solidifies the notion that adopters of a new GM wheat trait are not the only group to gain surplus. The increase in surplus for farmers who purchase conventional protection is similar. From simulation 2 to 4, $\Delta S_{0\to 0}$ = $20 million and $\Delta S_{0\to 1}$ = $20 million. This indicates that farmers who continue to use fungicide following introduction of GM FRW benefit almost equally as those who adopt the new GM variety.

SENSITIVITY ANALYSIS

Efficiency of GM FRW

The production efficiency of GM FRW is analogous to the yield loss prevention of the new GM variety. The average HRS wheat yield loss due to FHB over the period 1993-2000 was 18% (Nganje et al., 2001), and we assume GM FRW would provide 100% prevention of the potential losses due to FHB. The base case assumption is that GM FRW completely prevents FHB infestation. Although GM FRW is being tested in field trials, results from those tests have not been released. Conventional varieties do provide some protection against FHB, but not 100%. For these reasons, sensitivity analyses are conducted on the level of FHB control of a GM FRW variety, ranging from 10% to 100% of the total estimated yield benefit using a scalar on production efficiency of the GM FRW variety (i.e., the mean of the distribution was changed by this scalar). Results are shown in Figures 2 and 3.

As the efficiency of the GM FRW variety changes from 10% to 100%, the license price (or tech fee) for GM FRW technology increases from \$9.32/acre to \$12.35/acre (our base case) and the price of fungicide decreases from just under \$9/lb to just over \$8/lb. The adoption level of the GM FRW variety increases from 26% to 30%, and the adoption level of fungicide decreases from 50% to 47%. The increase in efficiency results in a large payoff for the agbiotech firm producing the GM FRW technology (Figure 3) and an increase in total welfare. Farmers purchasing GM FRW also have a small increase in surplus.

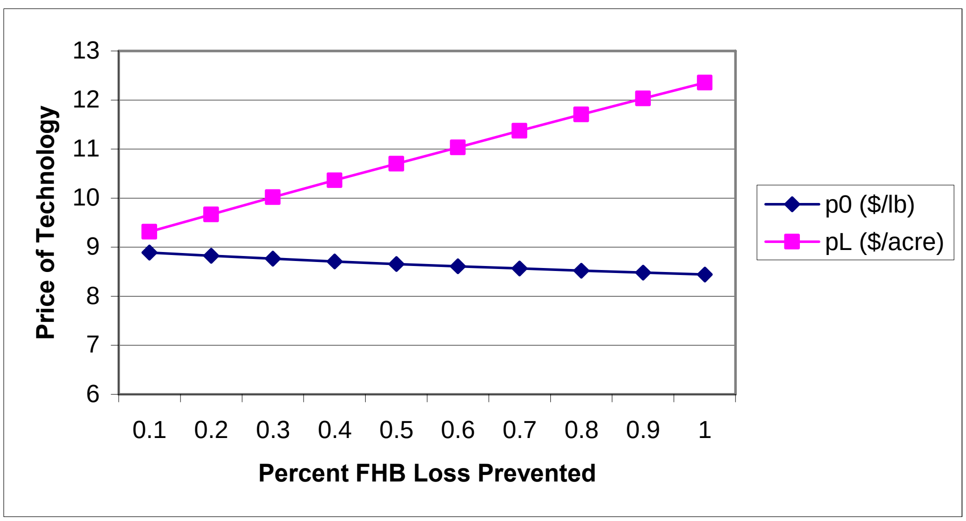

Figure 2. Impact of GM FRW efficiency on technology prices.

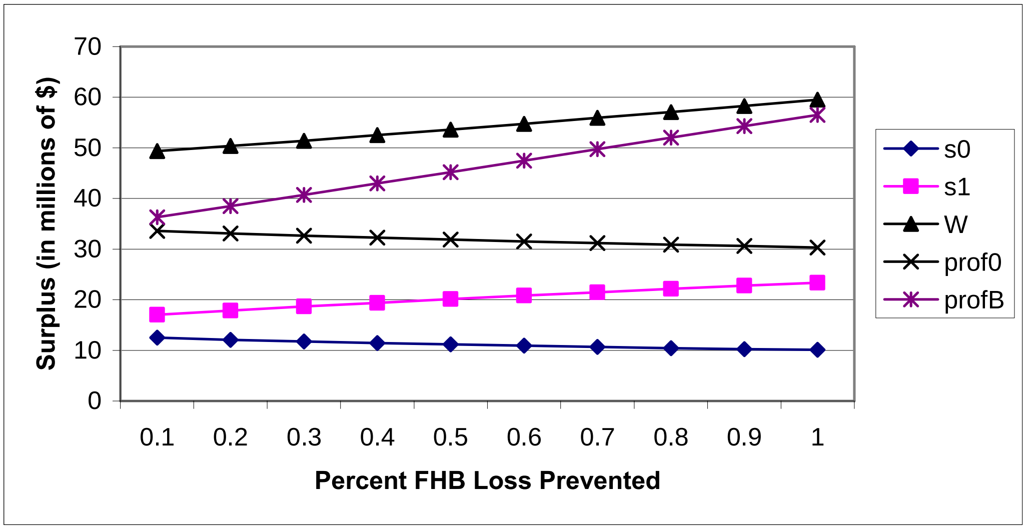

Figure 3. Impact of GM FRW efficiency on producer surplus and firm payoffs.

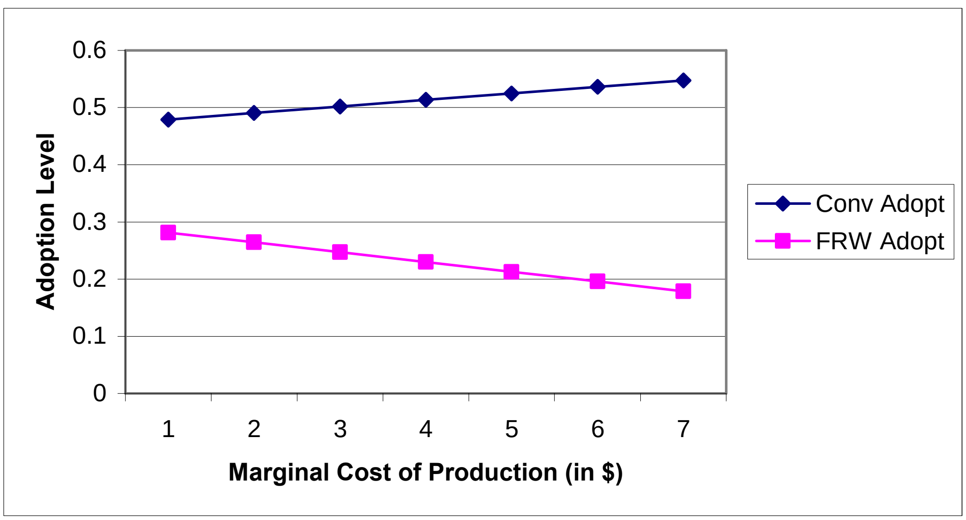

Figure 4. Impact of GM FRW marginal cost on adoption levels.

Marginal Production Cost of GM FRW Technology

In the base case, it is assumed that the marginal cost of production of the GM FRW variety is zero for two reasons. First, a large portion of the total cost associated with a GM trait is fixed due to extensive research and development over many years. Second, data do not exist on the value of the marginal cost of production and distribution of a GM seed trait. Since the marginal cost is not nil sensitivity analyses are conducted to illustrate the impact of increasing marginal cost of production. The marginal cost of fungicide production remains at nil throughout the sensitivity analyses though it could be varied similarly. The marginal cost of GM FRW technology production is varied from \$1 to \$7 to demonstrate its effects on prices, adoption, and farmer and firm surplus.

The increase in marginal cost increases the license price. As the marginal cost of GM FRW production increases from \$1 to \$7, the license price increases from \$12.65/acre to \$14.44/acre, and the price of the conventional technology increases from \$8.64/lb to \$9.85/lb. As the marginal production cost of the GM FRW technology increases, adoption of GM FRW declines from 28% to 18%, while adoption of the conventional technology increases from 48% to 55%. The change in adoption is a result of the increase in the license price of GM FRW variety. As the marginal production cost of the GM FRW technology increases, profits for the agbiotech firm, as well as surplus for the farmers purchasing the GM FRW, decrease while profits for fungicide producing firms and farmers purchasing the conventional technology increase. This result coincides with the changes in prices and adoption levels.

Similar effects would result from sensitivities on the marginal costs of producing fungicide.

SUMMARY

Fusarium resistant wheat (FRW) is being developed by Syngenta and is a prospective GM trait approaching commercialization. This trait would have implications throughout the HRS wheat producing region of the United States and Canada. Typically, adoption estimates of GM crops examine the cost-benefit of the GM variety compared to a conventional variety. Release of a GM variety also impacts prices of competing technologies used on the conventional varieties, making the conventional variety less costly than prior to the GM variety. Considering such price decreases results in lower than expected adoption rates for the GM variety. This causes an increase in surplus for those farmers who adopt the GM variety, as well as those who plant the conventional variety. This also poses major strategic questions for agbiotechnology and fungicide firms in their estimates of adoption rates, prices, and profits.

A Cournot model is used to determine the equilibrium quantities of conventional fungicide and agbiotechnology firms. Our results suggest the release of GM FRW would result in a price decrease of 30-36% for conventional fungicides. This price decrease allows farmers with a low willingness-to-pay for the GM FRW variety to benefit from lower fungicide prices. The surplus for farmers who continue to produce conventional varieties, post-introduction of a GM fusarium resistant HRS wheat variety, increases by \$15-20 million. Assuming competition in the fungicide market and equilibrium quantities of the conventional and GM technologies, adoption rates are determined to be 46% for conventional technologies and 31% for GM FRW, with 23% adopting no product. Using the actual number of firms with conventional fungicides labeled for use on HRS wheat in North Dakota and marginal production costs ranging from \$1 to \$3, introduction of GM FRW would likely cause a 19-22% price decrease for fungicides.

Introduction of GM FRW would improve welfare for both growers who adopt the new GM variety and those using fungicide (due to the price decline), as well as the agbiotechnology firm. There are three effects that contribute to the increase in total surplus (we thank the reviewer for these points). First, introduction of GM FRW would lead to increased competition and less market power for producers of conventional technology, in this case fungicide. Second, the new product is more efficient than the conventional ones, and finally, the production cost is lower for the GM solution.

Several implications arise from these results. First, adoption of a new GM FRW variety may not be as high as expected due to likely concurrent price decrease for fungicides. This price decrease leads to a lower production cost of conventional varieties, and some farmers who would likely adopt the GM variety if there were no price decrease do not adopt because of the lower cost of conventional production. This price decrease must be included in the determination of potential adoption rates by agbiotechnology firms in their pricing decisions. Second, the release of a GM wheat variety results in an increase in surplus for all types of wheat farmers (GM adopters, conventional fungicide adopters, and no technology adopters). GM adopters benefit because of the release of the GM FRW variety. Conventional adopters benefit due to price decreases of the fungicides. Farmers who do not adopt any technology prior to the release of GM FRW may adopt the fungicide because of the lower cost. Third, the release of a GM wheat variety would result in slightly lower payoffs for fungicide producing firms but greater payoffs for agbiotechnology firms. Overall, surplus to farmers and agbiotechnology firms increases due to the release of a GM wheat variety.

There are a multitude of policy issues in the release and adoption of a GM wheat variety. One of the implications of a new technology is its impact on conventional technology prices. The results of this study indicate that all what producers benefit from the introduction of a GM FRW variety because of price decreases of fungicides. Issues addressed in this paper also have implications for trade and development. Both importing and exporting countries will be impacted by the commercialization of this trait. Importers would benefit by reducing their import costs associated with fusarium-free wheat, although this benefit would be realized only if importing countries adopt mechanisms to allow the import of wheat with this GM trait. FHB is devastating to wheat producers. It diminishes wheat production and raises costs not only in North America but also in Argentina, the European Union, China and other wheat producing countries. For these countries, they will have to confront whether the disease is severe enough to warrant allowing GM wheat to be produced. If adopted, commercial mechanisms, such as those developed in this study, would have to be adopted to allow technology firms to be compensated for their development costs. The contribution of this study is that it develops a model to predict price changes of current technologies due to the introduction of a new competing technology. Though this is applied in the case of HRS wheat, similar disease problems exist in other countries and other grains, and one would expect the model could be applied similarly in these cases.

NOTES

1. We used the analytical model to derive a solution and that was used to specify the simulation model. The uniform distribution was chosen because it is continuous and differentiable between 0 and 1 and can be used to derive a closed form solution. Few other continuous density functions allow for closed form solutions and open tailed distributions allow for possibility of negative values. Another possible distribution that was considered and could be used is the triangular. This was not chosen because the mathematics behind implementing it is much more complex and the improvements in the results would likely have been small or marginal. Also, each possible outcome is not “equally likely” in the triangular distribution.

2. The model and assumptions are explained in detail in [names withheld] and the solutions of the market equilibrium conditions were done using Mathematica 3.0.

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THIRD COUNTRY EFFECTS OF PRICE DISCRIMINATION: THE CASE OF THE CANADIAN WHEAT BOARD

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ABSTRACT

This study considers whether the major concern with the behaviour of exporting state trading enterprises (STEs) should be the practice of price discrimination. Using a differentiated products world wheat model, the impacts of Canadian price discrimination on the welfare of competing exporters are considered. The results show that competing exporters could be better or worse off as result of price discrimination, but that the impacts were small. Over a range of possible elasticities US producers were generally better off if North American arbitrage is assumed. Given the small impacts, the study suggests that explicit disciplines on discriminatory pricing of exporting STEs may not be appropriate.

Keywords: Price discrimination, state trading enterprises, trade negotiations
JEL Classification: Q17, F13

INTRODUCTION

The negotiations on the practices of exporting state trading enterprise (STE) at the World Trade Organization (WTO) have been contentious, with allegations of hidden subsidies and abuse of market power. Canada and Australia, who have major exporting STEs, have countered criticisms by claiming that the allegations against their marketing boards are vague and unfounded and accuse the critics of not being able to properly identify what the hidden subsidies actually are. Major issues in this debate include the lack of proper definitions about what STEs actually are, what the actual trade distortion is, and what type of behaviour is leading to the distortion Josling (1997).

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This paper attempts to address the question of how STE practices might affect the welfare of competing exporters. While there have been concerns raised about exporting STEs using indirect subsidies (Goodloe, 2004), these subsidies can be made transparent, notified and disciplined by the WTO.[1] So attention has shifted to concerns about the exercise of market power (Abbott and Young, 2004). Again the problem is that there is no explicit definition of what the exercise of market power involves beyond the idea that prices are not set competitively. Dong, Marsh, and Stiegert (2006) argue that the Canadian Wheat Board (CWB) employs a system of initial and final prices to gain a strategic advantage in international markets for malting barley.

Monopoly pricing involves reducing output in order to extract higher prices from the market. This is hardly the case with international grains markets where the concern is that too much product is being sold at prices that are too low. Another way that market power can be exercised is through third degree price discrimination where inelastic markets are taxed through higher prices and elastic markets receive an indirect subsidy through lower prices. The exercise of market power normally involves output determination by a monopolist's decision rule, while this output is allocated among markets by equating marginal revenue. Schmalensee (1981) established that it is possible for price discrimination to increase social welfare if it leads to an increase in output. In the context of producer marketing boards, the practice of discriminatory pricing is normally combined with price pooling. Whereas monopolistic third degree price discrimination required marginal cost to be equal to marginal revenues across markets, pooling allows marginal revenue to be less than marginal cost inducing extra output by the discriminating exporter (Alston and Gray, 2000). So the welfare effects of this practice are less certain, especially for competing exporters. Sumner and Boltuck (2001) argue that third degree price discrimination is not necessarily harmful to competing exporters if it raises average prices in export markets.

Price discrimination is not prohibited by the WTO. Interpretative notes to GATT Article XVII:1 allow a state trading enterprise to charge different prices for its sale of a product in different markets provided the practice is done for commercial reasons[2] and to meet the market conditions in the export market. Price discrimination is generally considered an acceptable practice that, in some cases, may be desirable (Philps, 1981 and Varian, 1992).

The objective of this paper is to measure the impact of Canadian price discrimination on the welfare of competing exporters. While prior studies have examined Canadian price discrimination, the analysis has focused on the impacts in Canada. This study, however, examines the impacts on third parties. A model is constructed with four competing exporter regions and a sufficient number of importers to accommodate price discrimination. It is constructed on the assumption that wheat from each exporter region is a differentiated product and the US produces two types of wheat. Price discrimination is introduced into the model and the impacts are judged against a competitive baseline. An attempt is made to define the boundary of parameters where competing exporters will be better off as opposed to worse off. This information will be useful in the debate over acceptable STE behaviour.

[1] The Framework agreement introduced disciplines for financing arrangements for exporting STEs that would address many of the concerns about indirect financial support.

[2] Commercial considerations have never been defined at the WTO.

THE INTERNATIONAL WHEAT MARKET

Each year the world grows approximately 580 million metric tonnes of wheat. Most of this grain is consumed in the region that grows it, but roughly 110 million tonnes are traded internationally with Canada exporting roughly 16 million tonnes (IGC 2004). The five major exporting regions include the USA as the largest exporter, and the European Union (EU), Canada, Australia as the second, third, and fourth largest exporters depending on the year considered. The fifth largest wheat exporter is normally Argentina. Large importers include Japan, Indonesia, North Africa, Philippines, Mexico and Korea. China is the world's largest wheat producer, and while historically it was the largest importer, over the last decade it has only been a sporadic importer (IGC 2004).

In general wheat demand tends to be inelastic across importers, but individual traders face greater demand elasticities in a particular market because of the competition that they face from other traders in that market. Like other food products, wheat demand is more elastic for developing countries than for developed country markets. Abbott and Young (1999) also report that countries with importing state trading agencies tend to have more inelastic import demand.

Scoppola (1995) suggests that world grain markets are highly concentrated with five firms accounting for over sixty percent of the trade and that the major traders may not act competitively. However, the degree of market power has not been definitively measured. Opinions in the literature are mixed. Some commentators view international grains markets as fundamentally competitive (Caves and Pugel 1982 and Carter and Smith 2001) while others argue for the existence of market power (Kolstad and Burris 1986). The problem is that statistical estimates of market power are scarce and apply to specific markets (see for example Thursby and Thursby 1990). The choice of a strategic variable is important to the analysis and significantly affects the outcome with price based strategies being closer to competitive behaviour than those outcomes that involve quantity as the strategic variable.

Wheat is a heterogeneous group of commodities that includes hard and soft varieties of different colours and differing characteristics including protein content. If wheat is highly differentiated, or highly segmented, the potential to exercise market power is increased.

PRICE DISCRIMINATION AND WHEAT TRADE

In order for third degree price discrimination to happen, three conditions are necessary: the discriminator must have some degree of monopoly power in the foreign market (either from a lack of competitors or because the product is sufficiently differentiated); the markets must be segmented to prevent arbitrage; and markets must have different demand elasticities (Phlips 1983).

Evidence of international price discrimination is limited. A few researchers have had access to actual contract prices from state trading exporters. The major price dispersion based study of the CWB by Kraft, Furtan and Tyrchniewicz (1996) showed a $23 average premium above U.S. market prices was extracted from inelastic buyers, but they made no attempt to model the mechanisms of the CWB price discrimination. Furthermore, no one has had similar access to those contracts to verify the calculation.

Some price dispersion is always expected in the market for a commodity (Stigler 1961). There is no reason that the dispersion should necessarily imply that explicit price discrimination is being practiced. The differences in prices between different markets can be a result of cost differences in satisfying demand in different markets. Price differences can also be a result of other countries' policies. The policies can be those of the importing country (e.g., Japanese Food Agency) or the policies of a competing exporter (e.g., US Export Enhancement Program).[3]

One practical question needs to be asked: if the CWB price discriminates, how does it prevent arbitrage of prices between markets? Product differentiation limits the potential for arbitrage by competing exporters. Lavoie (2005) found evidence that the CWB can price discriminate due to product differentiation between Canadian and American wheat and that market impediments like export subsidies, levies and transportation costs facilitate market segmentation for the CWB.

International grain markets do have characteristics that make price discrimination more likely. Large overhead costs associated with information and marketing have to be recovered (Caves and Pugel 1982) and differential pricing facilitates this recovery. In the presence of increasing returns to scale, price discrimination can have beneficial effects as the multiple pricing allows more output to be sold than if a single price was charged.

Although price discrimination is frequently mentioned in studies of international grains markets, explicit models or measures of price discrimination are not that frequent. Alston and Gray (2000) used differential price data among Canadian wheat markets as a first step to develop a simulation model of third degree international price discrimination. First they used the quantities and prices (derived from the observed premiums) from the Kraft, Furtan and Tyrchniewicz study to determine the intercepts and slope parameters that would have allowed the CWB to equate marginal revenues across markets. The resulting elasticities of demand ranged from -1.95 for the commercial high-premium markets to -20 (assumed) for low-premium markets affected by U.S. export subsidies.[4] The derived parameters were then used to construct a simulation model that compared the transfer efficiency of price discrimination versus a targeted export subsidy.

SIMULATION MODEL

In order to investigate how price discrimination, by the CWB, affects third country exporters this study uses a nine region empirical model of world wheat production, consumption and trade. There are four exporting regions – Canada, US hard, US soft and another aggregate exporter (which is an aggregate of the EU, Australia and Argentina) – which produce and consume wheat; and five importing regions – the Philippines, Japan, Mexico, Iran and the rest of the world. For computational expedience the importers are assumed not to produce wheat. Unlike the approach used in Alston and Gray (2000) this study does not start by assuming that price discrimination already exists, obtaining price

[3] Wilson and Dahl (2004) argue that it is easier for the CWB to practice price discrimination when EEP is in place.

[4] The demand elasticities that they observed were more elastic than in all other commercial markets; a observation that conflicts with typical empirical estimates that show North American wheat demand to be more inelastic than for developing country markets.

differentials, and then determining the parameters of the model based on these price differences and a monopolist's profit maximizing rule. Rather this study begins with a competitive model[5].

Equation set (1) describes the competitive market for each of the four wheat types examined in this study. The model is calibrated to the actual 2001-2002 wheat trade flows so that it exactly reproduces the base data for that year.

$$D_{ij} = a_i + \sum_{h=1}^{4} (\eta_{ijh} \cdot \frac{D_{ij}^{\ 0}}{P_{ijh}^{\ 0}}) \cdot [P_h + TC_{ih}] \qquad (1a)$$

$$S_i = \alpha_i + (\varepsilon_i \cdot \frac{S_i^{\ 0}}{P_i^0}) \cdot P_i \qquad (1b)$$

$$\sum_{j=1}^{9} D_{ij} \equiv S_i \qquad (1c)$$

The first equation (1a) represents the demand for exporter *i*'s wheat by country *j*. These equations are a linear function of the price of each type of wheat available. Each coefficient $(\eta_{ijh} \cdot \frac{D_{ij}^{\ 0}}{P_{ijh}^{\ 0}})$ is obtained by a calibration method which converts demand elasticities (see below) to slope coefficients by multiplying by the ratio of the initial base quantity demanded to the initial wheat price in question. This coefficient is multiplied by the landed price in the importer's market which is equal to the FOB export price plus the transportation cost to that market.[6] The intercept is determined by subtracting the sum of the product of the relevant coefficients and independent price variables from the base quantity demanded. This method insures that the model is exactly calibrated to observed prices and quantities for the crop year 2001/02.

The second equation (1b) is the supply equation for exporter *i*. This linear equation is calibrated in a similar manner as the demand equations with one slope coefficient derived from the elasticity of supply. Wheat is differentiated by country of origin so there are market clearing conditions and market clearing prices for each exporter's type of wheat. Equation (1c) is the competitive market clearing condition that equates supply to the sum of demand by adjusting the FOB price (P_i) to clear the market. The base data on prices, trade flows, consumption and production were obtained from the International Grains Council *World Grain Statistics* for the year 2001/02. The prices used for each wheat type are based on IGC average export price quotations (FOB) and are quoted in US dollars. The price of Canadian

[5] Given that statistical estimates of conduct parameters are scarce and the choice of the strategic variable is very important, this study proceeds by employing a competitive baseline to calibrate the model. This modelling assumption should not result in a greater loss of generality than calibrating the baseline to the wrong type of strategic behaviour.

[6] These transportation costs were obtained as the relevant ocean freight rate for heavy grain from IGC.(2004).

wheat is the average St. Lawrence price (No. 1 CWRS 13.5%).[7] The US hard wheat price is a weighted average of the Hard Red Winter Ordinary and Dark Northern Spring prices (basis Pacific Northwest) . The US soft wheat price is a weighted average of soft white and soft red wheat prices (basis gulf ports). Data on exports by wheat class were not available from the IGC *World Grain Statistics* so an alternative source of US export data, by class and destination, was obtained from USDA-ERS World Wheat Trade. This data was then used to create an aggregate of hard and soft wheat and export shares of this data were used to pro-rate the IGC data to create two types of US exporters. The other aggregate exporter price is a weighted average of export prices and tonnages shipped for Argentina, Australia and the EU as quoted in the IGC (2004). All transportation costs are IGC freight rates for heavy grain selected routes for each exporter to the destination in question (or a nearby country).

Price discrimination is introduced into this study by assuming that the CWB maximizes revenue from the sale of a crop by equating marginal revenues across all markets. Equation set 2 defines three scenarios: pure monopolistic price discrimination, price discrimination with pooling; and pooled price discrimination combined with Canada-US hard wheat price arbitrage. In the case of pure price discrimination the CWB is assumed to use a monopolist's decision rule and equate marginal revenues across markets to marginal cost. Marginal revenues are obtained from the linear price (own price) dependant demand functions after assuming revenue maximization. Marginal cost is obtained from a price dependant supply curve. This decision rule corresponds to equation 2(a) which is used together with equation (1a) to implement the first scenario.

$$MR_i = MR_{row} = MC_{can} \qquad \forall i = \text{all importers} \quad (2a)$$

$$MR_i . = MR_{row} \qquad \forall i = \text{all importers} \quad (2b)$$

$$\mathrm{P}^{\text{pooled}} = \sum_j \frac{\mathrm{D}_{\text{can j}}}{\sum \mathrm{D}_{\text{can j}}} \cdot P_j \quad (2c)$$

$$S_{can} = \alpha + (\varepsilon_i \cdot \frac{S_i^0}{P_i^0}) \cdot P^{pooled} \quad (2d)$$

$$MR_i . = MR_{row} \qquad \forall i = \text{US(soft), Japan, Philippines, Mexico, Iran} \quad (2e)$$

$$P_{can\,i} = P_{ush\,ush} + 12 \qquad i = \text{Canada, United States} \quad (2f)$$

[7] This price is a posted price and is not necessarily a transaction price. In the absence of actual transaction prices this is the best proxy for a Canadian price.

The second scenario corresponds to price pooling by the CWB. In this case the producer price in Canada is the pooled price which is equal to the sum of revenues from all destinations of Canadian wheat sales divided by the sum of the quantities sold to all destinations. Canadian wheat supply is a function of this pooled price. Equation (1a) plus equations (2b)-(2d) describe the equations necessary to implement the second scenario.

The third scenario combines price pooling, with pricing rules, which impose arbitrage in North American wheat pricing. The rule, equation (2f) maintains a $12 price premium for Canadian wheat over the price of US hard wheat. This rule applies for Canadian wheat sold in both Canada and the US. This rule is consistent with the CWB practice of setting the Canadian price of milling wheat based on the dark northern spring wheat (DNS) price at Minneapolis. Equation (1a) plus equations (2c) to (2f) describe the equations necessary to implement the third scenario.

Microsoft Excel's solver is then used to simulate the entire model. For each of the non-Canadian wheat exporters, conditions equating the supply and demands are added as constraints for the solver, and prices are the choice variables that clear the market. For the Canadian wheat market, conditions equating marginal revenues across markets and one equating the supply of wheat to shipments to all destinations are added as constraints and the choice variables are destination specific sales and Canadian supply. The four markets are linked by cross price elasticities in the demand functions for all the destinations for each type of wheat.

Demand Specification

Wheat is classified into two different broad classes of hard and soft wheat. Durum wheat is considered a fundamentally different product and excluded from this analysis. Although there are additional disaggregated classes of wheat, the choice of this aggregation was made to keep the problem tractable given data limitations with respect to international trade flows. All Canadian wheat is classified in a hard class that is then differentiated by country of origin. Likewise all wheat from the other aggregate exporter is assumed to be soft and then differentiated by the region of origin. The US produces both hard (aggregated from hard red spring and hard red winter) and soft (aggregated from soft red winter, and white) wheat. This set-up is consistent with three stage decision process where the importer first decides how much total wheat it will buy, then it decides how much of this wheat is hard and how much is soft, and finally for each class it decides how much wheat comes from a particular country of origin.

This is an application of the Armington assumption that goods are differentiated by their origin of production plus the assumption that there are different classes of wheat related to the hardness of the milling properties. The individual own and cross price elasticities used in equation (1a) are obtained from Armington's (1961) analysis of change of import demand (equations 25 and 26 of his mathematical appendix). The elasticities used in equation (1a) correspond to the third stage of the model shown in equation set (3). Each country has a separate demand equation for wheat that is produced in each of the four exporting regions. Wheat from one region is a less than perfect substitute for wheat from the other exporting regions. Armington assumptions are used to define a matrix of own and cross price elasticities to calibrate each country's demand functions for the two types of wheat. The individual own and cross price demand elasticities are derived as follows:

Stage 3:

$$\eta_{ijj} = (-1)[(1-S_{ij})\sigma_i + S_{ij}(\eta_{ii})] \qquad \text{within class own price elasticity} \quad 3(a)$$

$$\eta_{ijm} = S_{im}(\sigma_i - \eta_{ii}) \qquad \text{within class cross price elasticity} \quad 3(b)$$

$$\eta_{ijn} = S_{hn} \cdot \eta_{ih} \qquad \text{cross-class cross-price elasticity} \quad 3(c)$$

Stage 2:

$$\eta_{ii} = (-1)[(1-S_i)\sigma + S_i(\eta)] \qquad \text{own price elasticity of class } i \quad 3(d)$$

$$\eta_{ih} = S_h(\sigma - \eta) \qquad \text{cross price elasticity of class } i \quad 3(e)$$

Stage 1:

$$\eta \qquad \text{overall wheat demand elasticity} \quad 3(f)$$

Where η_{ijj} is the own-price elasticity of class *i* wheat from exporter *j*. η_{ijn} is the cross-price elasticity of class *i* wheat from county *j*'s with respect to a change in country *n*'s price. σ_i is the elasticity of substitution between suppliers of class *i* wheat, S_{in} is the value share of class *i* wheat imports from supplier n. In stage 2, σ is the elasticity of substitution between wheat classes. S_i is the value share for class *i* wheat imports, and η is the overall demand elasticity for wheat from stage 1.

The Armington approach is empirically appealing because it accommodates product differentiation while only requiring a minimal number of parameters: market shares, elasticities of substitution, and overall demand elasticities. The market shares are determined from observed values and the substitution and overall demand elasticities are based on previous studies.

Elasticities of substitution are the most difficult parameters to obtain. Although a number of prior studies provide elasticities of substitution for wheat demand, for particular counties (for example the US), they do not provide estimates across a full range of importing countries. The relative order of magnitude of these elasticities is particularly important because the size of the resulting own price elasticities will determine how wheat is allocated across markets with price discrimination. Rather than using a patchwork of substitution elasticities from different studies, we choose to use elasticities from the one study that did provide estimates over a broad range of markets. Haley (1995) developed a world wheat model with 27 importing regions. The study employed a three staged demand for wheat where the elasticities of substitution were based on a grain quality study by the USDA Economic Research Service which surveyed wheat import decisions by a wide variety of countries (Mercier 1993).

The limitations of the Haley estimates are that they are subjective and dated. The strengths of the study are that the relative differences in demand elasticities across countries reflect the responses of surveyed importers; a consistent method is used across all regions; substitution elasticities are available between classes and within classes with respect to the country of origin; and the resulting elasticities of substitution fall within a reasonable range. Haley's elasticities of substitution varied between 0.5 and 4 with lower elasticities for developed countries than for developing countries. Applications of the Armington model to wheat markets typically only had one stage and used substitution elasticities of 3 (Grennes, Johnson and Thursby 1978). Prior econometric estimates range from 0.75 (for Japan by Alston et. al. 1990) to 27 (for Mexico by Ahmadi-Esfahani 1989). Most of the estimates of substitution elasticities are dated, being over 10 years old, with the exception of some recent estimates for US wheat (Marsh 2005, and Mulik and Koo 2006).

Haley's elasticity of substitution between hard and soft classes of wheat was 0.5 for most countries, but in some cases it was as high as 3. In the case of the US, Haley used a substitution elasticity of 1. In this study the hard/soft elasticity of substitution was set at 0.5 for most countries except for select cases: one (US), one (Rest of World) and 20 (Iran). The aggregate Rest of World is a broad grouping of countries with broad variety of end use requirements for the wheat they import, so the hard/soft substitution elasticity was chosen to be at the higher end of the range of substitution elasticities. Iran can be viewed as a market of last resort for the CWB. An embargo prevents the US from exporting to this market but Canadian and wheat from the other aggregate exporter are viewed as highly substitutable. Therefore the hard/soft substitution elasticity was assumed to be 20.

Haley's within wheat class elasticities of substitution from various suppliers ranged from one to 4. For Japan the within-class substitution elasticity between individual exporters of hard wheat was one. This parameter is consistent with Davis and Kruse (1993) and Parcell and Stiegert (2001) who also provide a unitary estimate of the elasticity of substitution for Japan. Koo, Mao and Sakrai (2001) used a translog cost function to estimate derived demands for wheat that is differentiated by class and country of origin. Their estimates of the elasticity of substitution were over 10 times higher than other estimates, with the elasticity of substitution between Canadian hard red spring and US red winter of 18. There are two reasons to doubt the high degree of substitution in the Koo, Mao and Sakari study. Historic market shares, by exporter, are very stable with a 54 % share for US wheat; 25 % share for Canadian wheat, and 21% share for Australian wheat; with coefficients of variation for these shares of 0.03, 0.1, and 0.04 respectively. Second, while the allocation of Japanese wheat imports depends on relative market conditions, wheat class, grade and other quality considerations (Stiegert and Blanc, 1997); imports of wheat are controlled through the Japanese Food Agency through a quota on yearly wheat imports. The Agency's decisions are also determined by political considerations and the shares are more stable than market considerations would dictate (Alston, Carter and Jarvis 1990). For these reasons this study uses an elasticity of one for the Japanese within class substitution elasticity to account for these political realities.

Other within class elasticities of substitution, used by Haley, range from 3 (Mexico, the Philippines, most Latin American and lesser developed Asian markets) to 4 (US hard wheat, sub-Saharan and North Africa and the near east). With a few exceptions this study uses the same within class elasticities as Haley. A lower elasticity of substitution, 2.5, was employed for US substitution between different sources of hard wheat that is consistent with elasticity estimates by Marsh (2005). The Mexican within class substitution elasticity for hard wheat has been increased to 4 to account for increased substitutability between Canadian and US wheat as a result of increased competition due to the preferential trade agreement NAFTA. The within class elasticity of substitution in the Rest of the World was set at 4 to account for a broad range of end use requirements by the many countries in this aggregation.

The overall demand elasticity η_i for milling wheat is regarded as highly inelastic. For Japan the elasticity of demand is assumed to be -0.1. Elasticities of -0.3 are set for the US, Mexico, and the Philippines. These overall elasticity estimates are consistent with Haley (1995). Canadian wheat demand is assumed to be supplied by Canada only. The own price elasticity of demand in Canada is assumed to be -0.7. The Rest of the World is assumed to have an overall demand elasticity of -1. Table 1 shows the own and cross price elasticities that result after the Armington formulas (3a-3f) have been applied.

Supply Specification

Supply functions are required to determine the production of Canadian wheat, US wheat and wheat from the aggregate other exporters (Australia, Argentina, and the EU). Linear supply equations are calibrated from supply elasticities that were used in prior studies and the base prices and quantities for 2001-02[8]. The supply in each region is assumed to be only a function of the own price in that region. The Canadian supply elasticity is assumed to 0.6 (Meilke and Weersink, 1990); the US supply elasticity is assumed to be 0.7 (Haley 1995) and the elasticity of supply in the other aggregate exporting region is assumed to be 0.5.

IMPACTS OF PRICE DISCRIMINATION

Table 2 shows the quantities and prices under the various scenarios of CWB behaviour discussed above. The first two columns recreate the base case that the model is calibrated to, with a single FOB price for each wheat type. The third and fourth columns introduce the first scenario which considers pure price discrimination where marginal cost was equated to marginal revenue across all Canadian markets. Supply is set by equating the marginal cost price (from a price dependent supply function) to the marginal revenues. This scenario is not considered a feasible alternative because the CWB does not have the ability to control production, but this scenario is nonetheless included to help isolate the supply inducing effect of using pooling with price discrimination. The second scenario in columns five and six introduces price discrimination combined with price pooling. Under this scenario, the CWB equates marginal revenues across all markets, the farm price is determined by the pooled price from sales to all markets, and Canadian wheat supply responds to this pooled price. The third scenario, shown in columns seven and eight, also considers price discrimination with pooling but the price of Canadian wheat sold in Canada or the US are held equal and that

[8] 2001/02 was an average year in terms of crop production for most exporters.

price is not allowed to be more than $12 above the US price of US hard wheat.[9] This is consistent with the CWB practice of setting the Canadian price of milling wheat off the Minneapolis price of Dark Northern Spring wheat.

All of the price discrimination scenarios result in higher prices in the most inelastic markets and a lower price in Iran, the most elastic market. In all, but the pure price discrimination scenario, Canadian production increases. The effects on the other exporters are generally small, with small price increases and modest increases in overall sales and a movement of sales towards more inelastic markets.

The first scenario, the pure monopolist's case of third degree price discrimination, has the CWB shorting the supply of Canadian wheat and increasing all prices in all markets relative to the second scenario. The difference between the first and second scenarios can be thought of as the incremental impact of price pooling on supply. Canadian wheat production is 44% higher with pooling than with pure price discrimination. Pure price discrimination, because it shorts the market for Canadian wheat, results in slightly higher prices for all other exporters. It must be kept in perspective, that pooling requires price discrimination in order to get higher averaged prices and the resulting increase in production. So it is not possible to completely parse the effects of the two instruments.

Scenario 2, price pooling, results in a 21% increase in Canadian production relative to the baseline and significant increases in prices for Canadian wheat in Japan and Canada, smaller increases in the Philippines and price reductions in the relatively more elastic markets: Mexico, ROW and Iran. Changes in Canadian prices have cross-price demand side effects that impact the prices and quantities for competing traders. As a result of the second scenario US hard wheat prices increase by $0.50/tonne and soft wheat prices increase by $0.01 while the price of the other aggregate exporter stays the same.

The increase in the price of Canadian wheat, in Canada, is overstated in the second price pooling scenario. NAFTA and the practice of the CWB to tie Canadian wheat prices to the Minneapolis DNS price would not allow a $144 price differential between the Canadian domestic market and the U.S. hard wheat market. The assumption of market segmentation could not hold under those conditions and U.S. hard wheat would flow into Canada and equalize prices.

In the third (North American Arbitrage) scenario, we force arbitrage by imposing a binding constraint on the model which holds the prices for Canadian wheat sold in North America at $12 above the U.S. price for U.S. hard wheat. In order to price discriminate the CWB must reallocate grain between remaining markets. As a result, prices are higher in all off-shore markets, but the pooled price is lower than the second scenario, because of lower Canadian prices. All prices except Iran are also higher than the base case.

Table 3 presents the welfare effects of CWB actions under the three scenarios with changes relative to the base case[10]. The impacts on Canadian welfare are much larger than for

[9] The $12 maximum price difference accounts for average differences between hard red winter and hard red spring wheat in a similar delivery position.

[10] The welfare measures consist of consumers' surplus for final consumers and producers' surplus for primary producers. Since the price dependant demand and supply curves are linear, rather than having to integrate under the respective curves, welfare can be measured as triangles below the demand curve and above the supply curve evaluated at the optimal prices (P^*) and quantities (Q^*). So total consumer surplus is $CS = \frac{1}{2}(P^{\text{intercept}} - P^*)Q^*$ and producer surplus is $PS = P^* \cdot Q^* - \frac{1}{2}(P^* - P^{\text{intercept}}) \cdot Q^*$. The measure of

other regions. There are significant losses in Canadian consumer surplus in the first and second scenarios with unconstrained price discrimination because Canadian prices rise significantly. Canadian producer surplus is highest under a pure monopoly. Under that first scenario, it is assumed that output is determined by the marginal cost price, but in terms of the welfare measurement we assume that the CWB provides producers with lump sum revenue transfers equal to the difference between the pooled price and the marginal cost price. Canadian producer surplus is significantly lower when the more realistic arbitrage constraints are applied to the North American wheat market.

Consumer welfare changes in the US are relatively small in percentage terms (less than 4 percent). In general US consumers are somewhat worse-off because of higher prices. US producers of both hard and soft wheat are best off when the CWB practices lead to high prices for Canadian Wheat in the U.S. This occurs under pure price discrimination with monopolistic output determination and with pooling under arbitrage.

Finally Table 3 shows the welfare impacts on producers for the other exporting regions. The reallocation of Canadian sales from inelastic to elastic markets causes the price of wheat for the other exporter to increase in scenarios one and three. This leads to a minor increase in producer surplus in this region. The second scenario, with price discrimination and pooling, leaves producer surplus virtually unchanged at roughly 0.1 percent higher than the baseline.

Sensitivity Analysis

Table 3 shows a wide range of welfare impacts depending on the scenario considered. The focus of this study is on the effects of price discrimination on third country exporters or more generally the conditions where price discrimination is similar to an export subsidy. Unlike economists' broader focus on the societal welfare of a policy, trade policy (especially US and EU concerns) only considers the wellbeing of competing exporters. So the remaining analysis focuses on the producer surplus of the two other exporters. The wide range of results raises the question of the degree to which the selection of parameters affects the model outcome. The review of the literature above, suggested a broad range of Armington substitution elasticities, both within and between classes of wheat. The following sensitivity analysis considers how the elasticity of substitution, both between classes and within a class from different suppliers, affects the outcomes and the welfare of competing exporters.

producer surplus accounts for the fact that inelastic supply curves intersect the y-axis below the origin. The change in welfare is measured as the difference surplus measures between the scenario and the baseline solution.

Table 1. Own and Cross Price Demand Elasticities across Markets

	Canadian Wheat				Other Wheat			
	η_{icc} Canada	η_{ihc} USA (Hard)	η_{isc} USA (Soft)	η_{iac} Ag Exporter	η_{iaa} Ag Exporter	η_{ica} Canada	η_{iha} USA (Hard)	η_{isa} USA (Soft)
Japan	-0.71	0.44	0.03	0.14	-0.46	0.09	0.14	0.13
Canada	-0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00
USA	-1.88	0.10	0.04	0.00	0.00	0.00	0.00	0.00
Philippines	-1.60	1.23	0.06	0.01	-2.78	0.04	0.03	2.34
Mexico	-2.41	2.05	0.05	0.05	-2.16	0.06	0.08	1.76
ROW	-2.17	1.32	0.06	0.29	-1.25	0.21	0.15	0.61
Iran	-20.00	0.00	0.00	0.00	-20.00	0.00	0.00	0.00

	U.S. Hard Wheat				U.S. Soft Wheat			
	η_{ihh} USA (Hard)	η_{ich} Canada	η_{ish} USA (Soft)	η_{iah} Ag Exporter	η_{iss} USA (Soft)	η_{ics} Canada	η_{ihs} USA (Hard)	η_{ias} Ag Exporter
Japan	-0.60	0.29	0.03	0.14	-0.87	0.09	0.14	0.54
USA	-0.58	1.42	0.49	0.00	-0.77	0.23	0.23	0.00
Philippines	-1.77	1.40	0.06	0.01	-0.66	0.04	0.03	0.22
Mexico	-1.95	1.59	0.05	0.05	-2.24	0.06	0.08	1.84
ROW	-2.68	1.83	0.06	0.29	-3.39	0.21	0.15	2.75
Iran	-20.00	0.00	0.00	0.00	-20.00	0.00	0.00	0.00

Table 2. Market Impacts of Price Discrimination by the CWB

	Base Case		Price Discrimination ΣMR = MC		Price Discrimination Pooling		Price Discrimination Pooling/N.A. Arbitrage	
	Quantities (‘000 mt)	Prices ($US/mt)	Quantities (‘000 mt)	Prices ($US/mt)	Quantities (‘000 mt)	Prices ($US/mt)	Quantities (‘000 mt)	Prices ($US/mt)
Canadian Trade								
Demand								
Japan	1,260	149.0	733	240.4	818	223.2	757	236.0
Canada	6,697	149.0	3,740	302.1	4,136	281.6	6,616	153.2
USA	1,342	149.0	1,054	170.7	1,366	148.1	1,338	153.2
Philippines	738	149.0	523	180.1	825	160.6	523	175.1
Mexico	882	149.0	743	163.4	986	142.2	811	158.0
ROW	7,248	149.0	6,354	160.8	7,446	147.5	6,172	162.0
Iran	1,015	149.0	2,890	135.1	5,306	117.2	3,529	130.4
Supply	19,182	149.0	16,037	195.8*	23,118	169.2	19,745	157.1
US Trade								
Demand for Hard US Wheat								
Japan	2,379	136.7	2,759	142.0	2,719	137.2	2,745	141.2
USA	20,073	136.7	19,985	142.0	20,015	137.2	19,799	141.2
Philippines	699	136.7	862	142.0	771	137.2	835	141.2
Mexico	1230.64947	136.7	1,334	142.0	1,132	137.2	1,276	141.2
ROW	5,642	136.7	5,960	142.0	5,481	137.2	6,121	141.2
Supply of Hard	30,023	136.7	30,900	142.0	30,118	137.2	30,777	141.2
Demand for Soft US Wheat								
Japan	616	122.8	650	124.5	644	122.9	648	124.3
USA	10,500	122.8	10,637	124.5	10,511	122.9	10,578	124.3
Philippines	739	122.8	741	124.5	741	122.9	741	124.3
Mexico	855.350533	122.8	852	124.5	852	122.9	853	124.3
ROW	6,689	122.8	6,728	124.5	6,667	122.9	6,766	124.3
Supply of Soft	19,400	122.8	19,608	124.5	19,415	122.9	19,586	124.3
Other Aggregate Exporter								
Demand								
Japan	1,839	135.3	1,949	136.5	1,924	135.3	1,943	136.5
Philippines	89	135.3	89	136.5	89	135.3	89	136.5
ROW	31,924	135.3	32,468	136.5	31,873	135.3	32,475	136.5
Iran	3,465	135.3	3,029	136.5	3,443	135.3	3,028	136.5
Supply	37,318	135.3	37,535	136.5	37,329	135.3	37,535	136.5

*This price is not marginal cost (which is $108) but the pooled price if the CWB made a lump sum transfer back to producers.

Table 3. Welfare Effects of Price Discrimination by the CWB ($ millions)

	ΣMR = MC	Pooling	Pooling/N.A.
Canadian Market			
• Change In Consumer Surplus	-800	-718	-28
• Change In Producer Surplus	688*	404	157
• Change In Total Surplus	-112	-314	129
US Market			
• Change In Consumer Surplus			
US Hard	-52	-25	-126
US Soft	1	-1	-8
Canadian wheat	-36	3	0
• Change In Producer Surplus			
US Hard	162	17	139
US Soft	34	2	169
• Change In Total Surplus	109	-4	174
Other Aggregate Exporter			
• Change In Producer Surplus	49	2	49

* Producer surplus is measured at pooled prices not at the marginal cost price

A choice has to be made as to which the three scenarios to conduct the sensitivity analysis on. The pure price discrimination scenario with a monopolist's output decision rule is not appropriate because the CWB does not control production decisions. The simple pooling scenario is also not a particularly good basis to conduct the sensitivity analysis because the difference between Canadian and US wheat prices in North America becomes too large. The third scenario with price discrimination combined with pooling, and rules limiting the dispersion of North American prices, is the most realistic case given the stated behaviour of the CWB.

The second choice is which elasticity of substitution to parameterize. Since arbitrage is imposed on North American prices the results are not sensitive to the choice of substitution elasticity for US demands for hard and soft wheat. So the focus of the sensitivity analysis should be on off-shore markets.

Figure 1 describes the impact of CWB price discrimination on the US and the aggregate exporters' producer welfare, at differing levels of elasticity of substitution in the rest of the world: both between soft and hard wheat classes and within class substitution among alternative suppliers. The vertical axis measures the percentage change in producer surplus, for the US and the other exporter, relative to the competitive baseline with no price discrimination. This figure shows sensitivity analyses with respect to both stage 2 and 3 elasticities of substitution. Within class elasticities are shown on the horizontal axis and between class comparisons are shown with different curves for substitution elasticities of 1 (used above) and 3 (an alternative more elastic case).

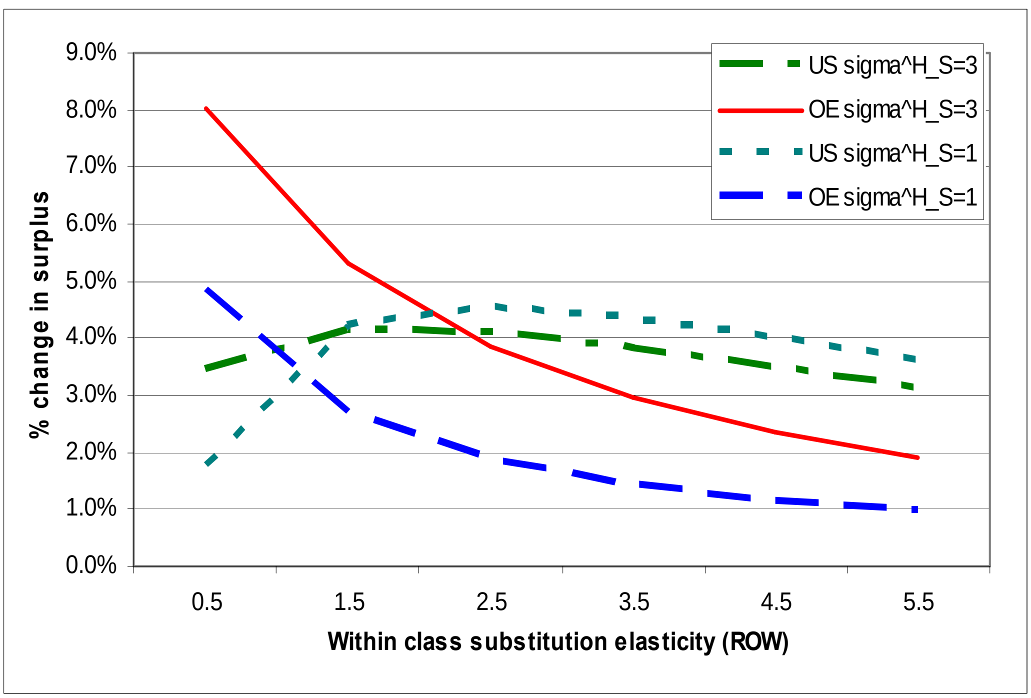

Figure 1. Changes in competitor producer surplus with CWB discrimination

As demand for Canadian wheat in the rest of the world becomes more elastic because of the impact of increasing substitution elasticities in equation (3), Canada ships more wheat to these markets and as a result US exporters of soft wheat and the other aggregate exporter face more competition. This is shown in figure 1 where the welfare of the other aggregate exporter declines as the ROW within-class substitution grows. This occurs for ROW between-class elasticities of both one and 3. The lower the between-class elasticity is, the lower the impact on the welfare of the other exporter. The welfare of the US depends on the welfare of producers of hard and soft wheat (not shown separately). As the within class elasticity of substitution falls from 3 to 0.5, the US becomes a relatively more attractive market for Canadian wheat, as a result US hard wheat prices fall and the welfare of hard wheat exporters falls. As the within-class elasticity increases beyond 3, the welfare of US hard wheat exporters remains relatively constant, but the decline in the welfare of US soft wheat producers begins to dominate, so the curve depicting the welfare of all US producers bends and declines for within-class substitution elasticities of larger than 3.

Increasing the stage 2 between-class ROW elasticity of substitution makes all wheat more homogenous. This dampens the effect on the welfare of the other aggregate exporter (shifting the curve downwards), and the welfare of US producers becomes less sensitive to changes in the within-class elasticity of substitution (making this curve flatter).

The other market where elasticity parameters may also have important implications is Japan. This is the most inelastic market and as a result is the market where generally the highest prices can be charged. As the overall Japanese demand elasticity for wheat is increased the ability of the CWB to price discriminate is reduced .and the potential benefits to other exporters are also reduced. This is illustrated in Figure 2 with modest declines in producer surplus for both the US and the other aggregate exporter as the overall demand elasticity for Japan is made more elastic.

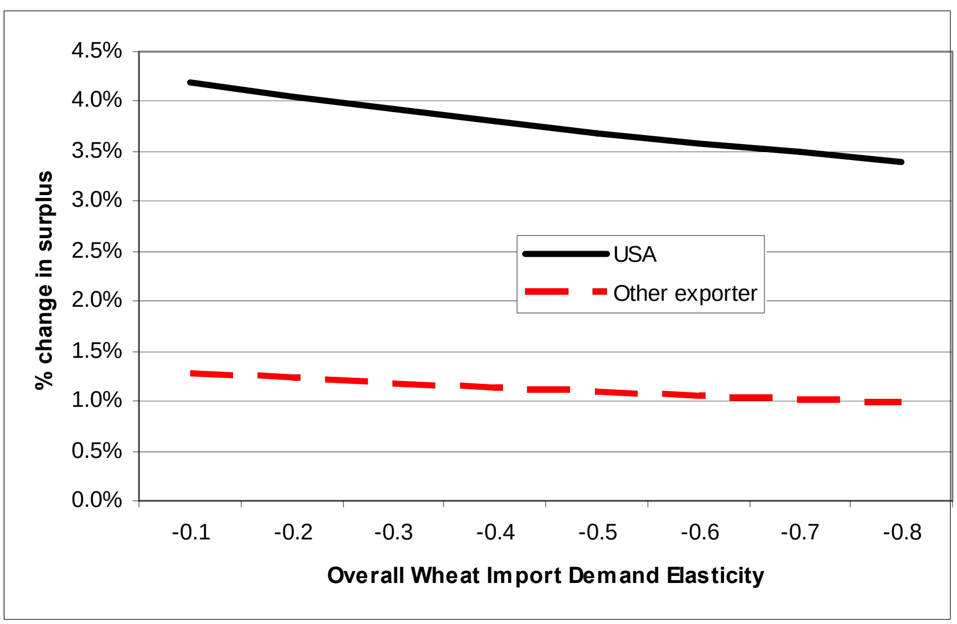

Figure 2. Sensitivity to Japanese import demand elasticity.

CONCLUSIONS

Finding the appropriate disciplines for exporting STEs has been one of the more contentious issues at the Doha Development Agenda WTO negotiations. A big problem has been to define what actually should be disciplined. This paper proposed that price discrimination was at the root of the complaints against STE behaviour. If price discrimination makes competing exporters substantially worse off, then their complaints are legitimate and appropriate disciplines are in order. However, given the aggressive nature of international grain markets, the complaints may simply be a manifestation of fierce competitive behaviour and WTO disciplines would put countries with exporting STEs at a competitive disadvantage.

Price discrimination by a STE does not necessarily put competing exporters at a disadvantage. Sales by the STE to inelastic markets are reduced in favour of sales to more elastic markets and the competing exporters can benefit if they can capture a sufficient share of the inelastic markets to benefit from higher prices. The reallocation of sales, the change in prices, and the degree of substitution among competing exporters are empirical questions that this study addressed.

When the US market is more elastic, the CWB is more likely to redirect sales to that market which puts some downward pressure on US producer revenues. However, as the off-shore markets become more elastic more sales are directed to these markets and this creates opportunities for US traders. The range of studied impacts included mostly positive outcomes, but the size of the impacts was relatively small. The other significant exporter, a composite of Australia, Argentina and the EU, competes less directly with Canadian wheat. Most of the potential impacts were positive, but less than four percent.

Given this study's results, it would be difficult to write a set of disciplines into Article XVII of the GATT with respect to price discrimination and to define acceptable behaviour. Since competitors can better or worse off, new STE rules could not be flexible enough to only discipline negative outcomes. Furthermore since the impacts appear to be small, over a reasonable range of elasticities, the need for disciplines is debatable. Although we treated international grain markets as perfectly competitive there is evidence to suggest that grain traders may not act competitively. Under certain conditions price discrimination can have pro-competitive effects (Scherer and Ross 1990). These potential efficiency gains also add to the doubt of the efficacy of new disciplines. Defining appropriate rules would be as ethereal as defining normal commercial practices.

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THE EMERGENCE OF A U.S. DEMAND FOR PORK AS AN INPUT: APPLYING THE COINTEGRATED VECTOR AUTOREGRESSION MODEL TO U.S. PORK-BASED MARKETS

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ABSTRACT

We apply methods of the cointegrated vector autoregression or VAR model to quarterly U.S. pork-related markets, from the farm gate upstream, to the downstream markets for processed pork and sausage. This study extends previous cointegrated VAR work on U.S. pork-based markets by (i) focusing on upstream/downstream relationships, (ii) applying some advanced methods still new to agricultural economics, and (iii) providing a first-time demonstration on how modeling results can help sort out appropriate specification of econometric demand functions. Results include a U.S. long run demand for pork, as well as updated empirical estimates of market-propelling elasticities and effects of specific market events on these three pork-related markets.

Key words: cointegrated VAR; U.S. demand for pork
JEL classification codes: C22, Q13, Q17

INTRODUCTION AND MOTIVATION

Our study's motivation has three tiers or dimensions. The first is to fill an analytical gap in the literature concerning U.S. pork-related markets. The second is to apply a number of new econometric advancements or refinements that are still new to and unknown in the agricultural economics literature, and particularly literature on U.S. pork-related markets. And finally, we demonstrate, for the first time in the agricultural economics literature, the

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usefulness of some of these econometric tools in resolving a longstanding debate over econometric specification and estimation of demand functions, particularly for U.S. pork.

Lloyd et. al. (2006, 2001), Sanjuan and Dawson (2003), and Andersen et. al. (2007) note that the public is increasingly interested in food safety in Europe, the United States, and other areas in the wake of a series of such food safety episodes as the 1985 U.S. milk salmonella outbreak that elicited some 16,000 cases of illness; the 1996 British outbreak of bovine spongiform encelopathy (BSE) and its human analog of Creutzfeld-Jakub disease that claimed 10 lives; and various Asian flu outbreaks that have collectively claimed some 140 lives since 2003. In turn, such events have prompted a growing interest in/demand for several sorts of empirical findings concerning upstream and downstream markets related to a meat commodity. These include: (a) updated estimates of market-propelling parameters, particularly own-price and cross-price elasticities, and (b) reliable estimates of how specific and important events such as a free trade agreement or other market shocks have influenced the system of meat-related upstream/downstream markets. And a rapidly increasing number of studies on systems of commodity-related markets demonstrates how well-suited the methods of the vector autoregression (VAR) and cointegrated VAR models can be for generation of these increasingly demanded results (see Lloyd et. al. 2006, 2001; Goodwin, McKenzie, and Djunaidi 2003; and Babula, Rogowsky, and Romain 2006). Yet this scarcity of analysis exists for U.S. pork-related markets despite the growing demand for such results and despite these increasing applications to other markets. To mitigate this analytical gap, we propose modeling a quarterly system of U.S. pork-related markets (identified below).

This study's second motivation is methodological. Lloyd et. al. (2006, 2001), Sanjuan and Dawson (2003), Wang and Bessler (2006, 2003), and Babula, Rogowsky, and Romain (2006) demonstrate that modeling a system of U.S. markets that are inter-related through use of such a commodity as pork in order to illuminate increasingly demanded upstream/downstream linkages is a tailor-fit task for methods of the cointegrated vector autoregression (cointegrated VAR) model developed by Johansen (1988) and Johansen and Juselius (1990, 1992). And while facets of this methodology are long-established and widely applied, there have been a number of important refinements and advancements that are provided by the following studies and that are new to the agricultural economics literature: Juselius (1998; 2006), Juselius and Toro (2006), Juselius and Franchi (2007), and Dennis (2006). Our second aim, then, is to apply this refined /advanced cointegrated VAR methodology for the first time to a U.S. system of pork-related markets. Methodological refinements include a comprehensive discernment of the modeled time series stationarity properties and specification implications to utilize inherent information from such properties, a systematic set of tools to achieve a statistically adequate model, expanded methods of discerning reduced rank of the cointegration space, and a new systems-based multivariate test of stationarity, among others.

Finally, our study's motivation has a third dimension: to demonstrate the cointegrated VAR methodology's use in sorting-out issues of appropriate econometric demand specification and estimation under alternative patterns of price-quantity endogeneity. Eales and Unnevehr (1993, p. 265) modeled an array of alternative econometric models of U.S. meat demand systems (including U.S. pork markets), and implemented the Hausman test of endogeneity. Because their results suggested that U.S. pork price and quantity are both likely endogenous, they concluded that U.S. pork demand and price should be appropriately estimated with a simultaneous three-stage least squares (3SLS) estimator, and that price- or quantity-dependent U.S. pork demands modeled with other estimators, as is well-known, could likely be mis-specified, and render biased estimates, and incur compromised inference. From their review of seminal econometric and demand system literature, Wang and Bessler (2006, pp. 87-88) conceptually agree with Eales and Unnevehr (1993). However, Wang and Bessler (2006) noted two clarifications to Eales and Unnevehr's (1993) conclusion. First, such demands (here for U.S. pork) are often not so simultaneously estimated because of a lack of accurate instruments, and because of inadequate estimates (biased estimates, compromised inference statistics) that emerge from well-known econometric issues summarized by Granger and Newbold (1986, pp. 1-4) and Hendry (1986) even after careful estimator assessment. And second, Wang and Bessler (2006) correctly noted that there are conditions where such assumptions of price- and quantity-dependent demands are valid when demanded quantity or price is more exogenous or "predetermined" than the other. And in such cases a quantity-specific or demand-specific demand can be specified and estimated without 3SLS (or two-stage least squares, 2SLS, when appropriate) while avoiding the noted econometric consequences. Yet it is well known that past work has often avoided the issues of simultaneous regressors and resulting estimate bias without using instrumental variable estimators (3SLS, 2SLS), and likely incurred the adverse econometric consequences, with inappropriate arbitrary assumptions that price is more predetermined than quantity to justify a quantity-dependent demand or that quantity is more predetermined than price to justify a price-dependent demand (Wang and Bessler 2006, pp. 87-88). Yet from Houck's (1965) well-known work, one sees that such assumptions on price- or quantity-dependence of demand relationships that are arbitrary should not be, given the potential econometric consequences of compromised inference and/or biased estimates of inappropriately assessing a demand's relative levels of price/quantity exogeneity before estimation.[1]

Wang and Bessler (2006) provide a novel second alternative by combining a cointegrated VAR model with directed acyclic graph or DAG analysis of contemporaneous causality patterns suggested by the current innovation matrix to help sort-out if a demand's (say a U.S. pork demand's) price or quantity are relatively more predetermined, so as to suggest price- or quantity-dependence for non-simultaneous econometric estimation without the noted adverse econometric consequences. Wang and Bessler (2006, pp. 92-93) concluded that a price-dependent U.S. pork demand may be appropriate because evidence from contemporaneous correlations suggests quantity's higher degree of predeterminedness relative to price. Our aim here is, for perhaps the first time for U.S. pork-based markets, to demonstrate how cointegrated VAR methods are useful in sorting out such relative price/quantity exogeneity or predeterminedness in order to suggest appropriate U.S. pork specification in the prior cited studies that opted for a non-simultaneous estimator. As shown below, such is done through analysis of the cointegrating parameter and adjustment speed coefficients (β- and - α estimates, respectively) for a U.S. pork demand that emerges from the error correction space. Finally, and as a collective result of these three motivations, we provide valuable empirical long run estimates of the effects on U.S. pork-related markets of the Uruguay Round and NAFTA agreement implementations during 1994-1995.

[1] For instance, Houck (1965) notes that a price flexibility estimate from an inverse demand is not necessarily inversely equivalent to a quantity-dependent demand's own price elasticity.

Six sections follow. First is a brief review of the limited research that has applied VAR model methods to U.S. pork-related markets. We then provide a discussion of cointgrated VAR econometrics and data used in this study. The third provides our specification efforts and diagnostic evidence that demonstrate the statistical adequacy of the model before cointegration tests were implemented and prior to the exploitation of any cointegration properties. The fourth section establishes rank of the model's error correction space by using a new method of reduced rank determination that considers other sources of evidence in addition to the traditionally used trace test results. The fifth section discusses the application of Johansen and Juselius' (1990, 1992) hypothesis tests and inference on the error correction space parameters, in order to provide empirical estimates of own- and cross-market parameters for U.S. pork-based markets and to empirically illuminate how the markets are inter-related. As well, the section discusses how cointegrated VAR methods are useful in resolving debates on appropriate specification and estimation when price or quantity is weakly exogenous. And finally, we provide a summary and conclusions.

PREVIOUS LITERATURE: VAR METHODS APPLIED TO U.S. PORK-BASED MARKETS

We located three VAR econometric studies of U.S. pork-related market transmissions on direct relevance to our study. Wang and Bessler (2006) focused on causal price/quantity meat market transmission relationships and modeled the following quarterly system of nonstationary and logged variables as a cointegrated VAR where the information inherent in contemporaneously correlated residuals was utilized by an application of directed acyclic graph or DAG analysis: quantities and nominal U.S. retail prices of pork, beef and poultry; two price indexes of non-meat food and other non-food good prices; and nominal food consumption expenditures. Wang and Bessler (2006) noted that contemporaneous correlations within their cointegrated VAR model's current innovation matrix is a logical source of evidence for discerning the relative levels of price/quantity endogeneity/exogeneity, and hence whether a demand estimated non-simultaneously should be quantity- or price-dependent. And as previously discussed, their pork-related results suggested evidence of U.S. pork consumption quantity's predeterminedness relative to price, a finding that they then related to appropriate pork demand model specification as a price-dependent function.

Wang and Bessler (2003) combined cointegrated VAR modeling with DAG analysis to build a quarterly, logged model similar to that modeled by Wang and Bessler (2006) system. They then compared the cointegrated VAR's out-of-sample forecast accuracy levels with such forecast performances of four alternative model frameworks of the same system, and found that cointegrated VAR model forecasted most accurately. Among their pork-related results was an own-price elasticity of percapita U.S. pork consumption of -0.50 that emerged from their error correction space estimates.

Bessler and Akleman (1998) combined Bernanke's methods of the levels-based structural VAR with DAG analysis to utilize information from contemporaneously correlated residuals, and applied the framework to a U.S. monthly, logged system of the general U.S. price level; levels of retail pork, beef, and chicken prices; pork and beef farm values; manufacturing wages; and gasoline prices. By focusing on dynamic farm/retail dynamic relationships, their analysis of selected patterns of FEV decompositions suggested that farm-level shocks are primary explanators of retail pork price behavior, and revealed patterns U.S. pork/beef market causality.

TIME SERIES ECONOMETRICS, MODELED MARKETS, AND DATA

It is well-known that econometric time series often fail to meet the conditions of stationarity and ergodicity required of valid regressions (Wang and Bessler 2006, p. 510; Hendry 1986). And while data series are often individually nonstationary, they can form vectors with stationary linear combinations, such that the inter-related series are "cointegrated" and move in tandem as an error-correcting system (Johansen and Juselius 1990, 1992).

We conducted a thorough search of U.S. pork-related market data for as many relevant quarterly price/quantity variables that were available and that provided adequate samples with which to implement our analysis As a result, we propose modeling the following endogenous variables (denoted throughout by the parenthetical labels) defined and sourced as follows as a cointegrated VAR model:

- U.S. market-clearing quantity of pork meat (QUSPORK) defined as the sum of beginning stocks, production, and imports from the U.S. Department of Agriculture, Economic Research Service (USDA, ERS 2006a, b, c).
- U.S. farm price of pork (PUSFARM). This is the U.S. producer price index or PPI, for slaughter hogs, farm products group, series number WPU0132. This is available from the U.S. Department of Labor, Bureau of Labor Statistics (Labor, BLS 2006).
- U.S. wholesale price for processed pork meat, reflected by the U.S. PPI for fresh and frozen processed pork, not canned or made into sausage, animal (non-poultry) slaughtering group, series no. PCU311611311611G from Labor, BLS (2006).
- U.S. wholesale price for sausage reflected by the U.S. PPI for sausage and similar products (not canned), animal (non-poultry) slaughtering group, series no. PCU311611311611J, from Labor, BLS (2006).

All modeled data are quarterly, not seasonally adjusted, and shown below to be nonstationary and integrated of order-1 [I(1)]. Due to missing values in some series, and because of a desire to craft a sample within the liberalized U.S./Canadian trade regime established by the January, 1989 implementation of the Canada/U.S. Free Trade Agreement (CUSTA), our sample is 1989:01-2006:03. As repeatedly noted in recent time series studies of U.S. systems of commodity-related markets, quantities of the commodity-using downstream products are usually business proprietary and un-available publicly. This necessitated the modeling of the downstream markets in the same manner as prior research as reduced form price equations [See Bessler and Akleman 1998; Lloyd et. al. (2006, 2001); Goodwin, McKenzie, and Djunaidi 2003; and Babula, Rogowsky, and Romain (2006).]

Following Juselius and Toro (2005), Juselius and Franchi (2007), and Juselius (1998; 2006, chapters 1-4), we examined the modeled data's logged levels and differences to assess the data's stationarity properties. Such examinations permitted the formulation of specification implications of these properties that will maximally harness or utilize their inherent stores of information in order to avoid potentially adverse econometric consequences of ignoring such information: compromised inference and spurious regressions (see also Granger and Newbold 1986, pp. 1-5, and Hendry 1986). In turn, using the statistically supported specification implications that utilize such nonstationarity-based information results in a statistically adequate VAR model with which the modeled system's cointegtation properties may be exploited.

A stationary and ergodic series has a constant and finite mean and variance, time-independent observations, and generates regression time-invariant estimates (Juselius 2006, chapters 1-3; Granger and Newbold 1986). Such data series frequently cycle and mean-revert.[2] The following are the highlights summarize the data's behavior and specification implications needed to capture the information inherent in the modeled data's nonstationary elements:

- Pork quantity exhibits trending and seasonal effects throughout the sample, with protracted subsample changes in plotted behavior, probably from a number of policy, institutional, and market events (hereafter, important market events). Specification implications include a linear trend, three quarterly centered seasonal binary variables or binaries, and a number of binaries to capture effects of important market events.
- PUSFARM exhibits a number of subsample episodes of altered plotted behavior, likely from important market events introduced below. PUSFARM differences suggest a number of potentially extraordinary and observation-specific transitory effects – hereafter denoted as outlier events/effects and addressed with outlier binaries. In particular, PUSFARM underwent an extraordinary and rapid decline of 43 percent in a single quarter to all-time 1998:04 lows because of supply-glut conditions and panicky herd slaughter and sell-offs, and then rebounded by an extraordinarily large and rapid 81 percent in the in the ensuing two quarters.[3] Specification implications include a number of permanent shift binaries and a transitory binary for the pork market event just mentioned.
- Processed pork and sausage prices exhibit trending; subsample episodes of changing plotted behavior from important market events introduced later. Specifications include a time trend and permanent shift binaries binaries.

[2] Following a recent application in this journal, we do not provide plots of logged data, that we offer to readers on request: Babula, Rogowsky, and Romain's (2006) cointegrated VAR model application to a quarterly system of U.S. wheat-based markets. Aside from the noted PUSFARM decline in late-1998, the data's behavior is rather routine and adequately captured by the above bulleted behavioral summaries. As a result, and given pressures to save space, we deem that providing the plots would provide very little value-added for readers.

[3] Information provided in a private email to the authors by pork market analysts, U.S. Department of Labor, Bureau of Labor Statistics, January 3, 2007.

THE STATISTICAL MODEL: THE LEVELS VAR AND UNRESTRICTED VEC EQUIVALENT[4]

To avoid confusion, we define a number of terms for use throughout. The *unrestricted levels VAR* denotes a VAR model in logged levels. The *unrestricted vector error correction or VEC* model denotes the algebraic equivalent of the unrestricted levels VAR in error correction form, before the cointegrated space is restricted for reduced rank, or for statistically supported restrictions that emerge from hypothesis tests. The "p" denotes the number of (four) endogenous variables, while "p1" denotes the number of variables in the cointegration space (four endogenous and various deterministic variables introduced later). The letter "r" represents the cointegration space rank (and number of cointegrating relationships).

The Levels VAR and Unrestricted VEC of the U.S. Pork-Based Markets

Sims (1980) and Bessler (1984) note that a VAR model posits each endogenous variable as a function of k lags of itself, and of each of the remaining endogenous variables. Tiao and Box's (1978) lag search procedure suggests a one-lag structure. The above pork-related variables comprise the following unrestricted, 4-equation model:

$$\begin{aligned} X(t) = {} & a(1)*QUSPORK(t-1) + a(2)*PUSFARM(t-1) + a(3)*PUSPROC(t-1) \\ & + a(4)*PUSSAUS(t-1) + a(c)*CONSTANT + a(T)*TREND + \\ & + a(s)*SEASONALS + \varepsilon(t) \end{aligned} \tag{1}$$

Above, the equation-specific notation is suppressed for ease of presentation. Note that X(t) = QUSPORK(t), PUSFARM(t), PUSPROC(t), and PUSSAUS(t). SEASONALS denotes a vector of three quarterly centered seasonal binary variables. The asterisk denotes a multiplication operator. The a-coefficients are ordinary least squares (OLS) estimates with the parenthetical digit denoting the current or lagged values (t, t-1). Equation 1 also includes other permanent shift and outlier binaries not shown.

Johansen and Juselius (1990, 1992) and Juselius (2006, pp. 59-63) demonstrate that a levels VAR of a lag order-k can be rewritten more compactly as an unrestricted VEC:

$$\Delta x(t) = \Gamma(1)*\Delta x(t-1) + \ldots + \Gamma(k-1)*\Delta x(t-k+1) + \Pi*x(t-1) + \varphi*D(t) + \varepsilon(t) \tag{2a}$$

And for the case where k=1, Patterson (2000, p. 600) notes that equation 2a simplifies to equation 2b without the Γ -terms:

$$\Delta x(t) = \Pi*x(t-1) + \varphi*D(t) + \varepsilon(t) \tag{2b}$$

[4] This section draws heavily on the seminal articles by Johansen and Juselius (1990, 1992), and the recent book by Juselius (2006).

The $\varepsilon(t)$ are white noise residuals. The $x(t)$ and $x(t-1)$ are p by 1 vectors of current and lagged endogenous variables in natural logarithms. The Π is a p by p long run error correction term to account for endogenous variable levels. The $\varphi^*D(t)$ is a set of deterministic variables that includes three centered seasonal binaries, a trend, and other binary variables that are added to address issues as they arise as the analysis unfolds. The Π matrix is decomposed as follows:

$$\Pi = \alpha^* \beta' \qquad (3)$$

The α is a p by r matrix of adjustment speed coefficients and β is a p by r vector of error correction coefficients, where here p=4 and the reduced rank (r) of equation 3 to be determined below.

The $\Pi = \alpha^*\beta'$ is interchangeably denoted as the levels-based long run component, error correction term, or the cointegration space of the model. The Π -term retains the levels-based information, and includes non-differenced linear combinations of the individually I(1) endogenous variables; permanent shift binaries that reflect enduring event-specific effects (presented below); and a linear trend.

It is well known that the unrestricted VAR model framework developed by Sims (1980) and introduced early on to the U.S. hog market by Bessler (1984) is a reduced form one, where estimated relations reflect a mix of demand- and supply-side elements, typically without clear structural interpretations (Hamilton 1994, chapter 11). The extension of this framework by Johansen (1988) and Johansen and Juselius (1990, 1992) enables one to identify structural error correction relationships from what was once exclusively the reduced form approach of Sims (1980) and Bessler (1984) by separating-out the long run error correction term from the short run complement; by injecting economic theory and statistical inference through well-known Johansen-Juselius hypothesis test methods; and by applying reduced-rank estimation with statistically-supported restrictions from such hypothesis tests imposed.

In addition to a trend, we considered restricting non-differenced binary variables to the levels-based cointegration space to account for the implementations of the North America Free Trade agreement (NAFTA) in 1994 and the Uruguay Round in 1995.

The starting point for the unrestricted VEC was equation 2b with no trend or binary variables. An adequately specified unrestricted VEC was ultimately achieved in a series of sequential estimations using packages by Estima (2006) and Dennis (2006). We estimated the model after having added the set of seasonal binaries, and then added a linear trend, and a number of quarter-specific outlier binaries – generally one variable per each estimation. Variables were retained if diagnostic test values moved in patterns indicative of improved specification. Juselius (2006, chapters 4, 7, 9) recommends the following battery of diagnostic tests: (a) trace correlation as a goodness of fit indicator, (b) likelihood ratio tests of autocorrelation, (c) Doornik-Hansen test for equation residual normality, and (d) indicators of skewness and kurtosis. The estimations were stopped when the array of diagnostic values failed to further improve with inclusion of additional variables.

The above sequential estimation procedure resulted in the inclusion of three quarterly centered seasonal binaries, the above-defined permanent shift binaries for U.S. implementations of the NAFTA and Uruguay Round agreements in non-differenced form within the error correction space, as well as differenced forms of these shifters to account for short run effects. A trend was initially restricted to the cointegration space.

We also followed Juselius' (2006, chapter 6) method of identifying and including extraordinarily influential effects of quarter-specific "outlier" events through specification of "outlier" binaries. When a potentially included outlier was identified with a "large" standardized residual, an appropriately specified variable was included in equation 2b in differenced form to capture the transitory effect, and retained if the battery of diagnostic variables moved favorably to suggest enhanced specification.[5] Two outlier binaries were ultimately included.[6]

Table 1's battery of diagnostic values for the levels VAR and its unrestricted cointegrated equivalent before and after efforts at specification improvement through inclusion of the statistically supported specification implications suggests clear benefits. Such efforts clearly enhanced the model's ability to explain variation of the data, as reflected from the trace correlation, a goodness of fit indicator, having risen 235 percent from 0.173 to 0.58.

The Doornik-Hansen (D-H) test for system normality suggests that specification efforts on the initially non-normal system resulted in the ultimate achievement of an approximately normal system of residuals, as the value fell from 39.7 that strongly suggested non-normal residual behavior to 8.4 (p-value of 0.39) that strongly suggests normal behavior. Further D-H evidence at the individual equation levels suggests that initially, two of the system's four equations generated non-normal residual behavior, while specification efforts ultimately generated D-H values indicative that all four equations generated normally behaving residuals.

Table 1 also suggests that skewness and kurtosis values were within acceptable ranges for all equations after specification efforts. Table 1's results suggest that we achieved a reasonably specified unrestricted VEC, which we can use to exploit any existing cointegration properties.

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[5] We followed Juselius' (2006, chapter 6) analysis to identify outliers to retain in the model. An observation-specific event was judged as potentially "extraordinary" if its standardized residual was 3.0 or more in absolute value. Such a rule for outliers was designed based on the 70-observation effective sample size using the Bonferoni criterion: INVNORMAL$(1\text{-}1.025)^{T}$ where T=70 and INVNORMAL is a function for the inverse of the normal distribution that returns the variable for the c-density function of a standard normal distribution (Estima 2006). The Bonferoni variate had a 3.4 absolute value. Having realized that there were some quarter-specific events with potentially extraordinary effects with absolute standardized residual values of about 3.0, we opted to choose a conservative Bonferoni absolute value criteria of 3.0 rather than 3.4. Observations with absolute standardized residual values of 3.0 or more were considered potential outliers, and we specified an appropriately defined variable for the relevant observation for the sequential estimation procedure.

[6] The first outlier binary arose with QUSPORK that generated a standardized residual value of 3.0 for 1989:02 suggesting possible extraordinary adjustment effects of the CUSTA agreement, the onset of which served as the starting point for this study's sample. The QUSPORK levels rose during 1989:02 and then receded, suggesting the following values for the transitory binary defined as DFDT89:02: 1.0 for 1989:02, -1.0 for 1989:03, and zero otherwise. The second outlier binary was defined when we noticed that in 1998:04, PUSFARM levels plummeted extraordinarily to all-time lows: by about 43 percent in a single quarter to 31.2 due to conditions of over-supply ensued by panicky herd sell-offs and slaughter. PUSFARM then recovered about as extraordinarily as it had previously plummeted over the ensuing two quarters by having increased by about 81 percent to 56.47 in 1999:02. The differenced binary variable DFSHK98 was defined as follows: 1.0 for 1998:04, 0.0 for 1999:01, -1.0 for 1999:02, and zero otherwise. As noted by market experts and by rapid recovery of PUSFARM from its late-1998 decline, this episode was likely a transitory one (see also Labor, BLS 2007).

Table 1. Mis-specification Tests for the Unrestricted VEC: Before and After Specification Efforts

Test and/or equation	Null hypothesis and/or test explanation	Prior efforts at specification adequacy	After efforts at specification adequacy
Trace correlation	system-wide goodness of fit: large proportion desirable	0.173	0.58
ARCH tests for heteroscedasticity (lags 1, 4)	Ho: no heteroscedasticity by 1st, 4th lag for system. Reject with p-values less 0.05	lag 1: 135 (p=0.01) lag 4: 215.7 (p=0.21)	lag 1: 97.9 (p=0.54) lag 4: 193 (p=0.63)
Doornik-Hansen test, system-wide normality	Ho: modeled system behaves normally. Reject for p-values below 0.05.	39.7 (p=0.01)	8.3 (p=0.63)
Doornik-Hansen test for normal residuals (univariate)	Ho: equation residuals are normal. Reject for values above 9.2 critical value		
ΔQUSPORK		10.6	6.4 (*)
ΔPUSFARM		16.4	3.7(*)
ΔPUSPROC		2.3	0.08
ΔPUSSAUS		0.82	0.08
Skewness(kurtosis) univariate values	skewness: ideal is zero; “small” absolute value acceptable kurtosis: ideal is 3.0; acceptable is 2.5-4.0.		
ΔQUSPORK		0.06 (2.5)	0.4 (2.3)
ΔPUSFARM		-1.3 (7.0)	-0.5 (3.5)
ΔPUSPROC		-0.42 (3.0)	-0.07 (2.7)
ΔPUSSAUS		-0.13 (3.1)	0.06 (2.80)

Notes - An asterisk (*) denotes a favorable movement (decline) in the relevant test/diagnostic value into the range of statistical normality.

COINTEGRATION: CHOOSING AND IMPOSING REDUCED RANK ON THE ERROR CORRECTION SPACE

The endogenous variables are shown below to be I(1), and their differences are I(0). Cointegrated variables are driven by common trends, and stationary linear combinations called cointegrating vectors or CVs (Juselius 2006, p. 80). The Π-matrix in equation 3 is a 4 by 4 matrix equal to the product of two p by r matrices: β of error correction coefficient estimates that under cointegration combine into $r<p$ stationary CVs of the four individually non-stationary pork-related endogenous variables, and α of adjustment speed coefficient

estimates (beta and alpha estimates, respectively). The rank of β'*x(t) is reduced despite x(t)'s four series being nonstationary.

Not widely used yet in agricultural economics, a recent refinement in methods of the cointegrated VAR model is to extend the evidence considered in determining reduced rank beyond a traditional sole reliance on trace test results (see Juselius 1998, 2006; Juselius and Toro 2005; and Juselius and Franchi 2007). Following Juselius' (2006, p. 139) strong recommendations against such sole reliance, we present determination of cointegration rank as a three-tiered process. First, one conducts trace tests of Johansen and Juselius (1990, 1992). Second, one examines patterns of characteristic roots generated under relevant assumptions of reduced rank. And third, one examines statistical significance patterns of adjustment speed coefficient estimates for CVs potentially considered for the error correction space.

Table 2's nested trace tests reject the first null hypothesis that r is zero, but fails to reject the second that r is one or less, suggesting that the reduced rank of Π is 1, and that a single CV error-corrects the system.

Table 2. Trace Test Statistics and Related Information for Nested Tests for Rank Determination

Null Hypothesis	Trace Value	95% Fractile (critical value)	Result
rank or ṛ 0	78.3	67.3	Reject null that rank is zero.
rank or ṛ 1	45.9	46.4	Fail to reject null that rank ṛ 1
rank or ṛ 2	23.4	29.3	Reject null that rank ṛ 2
rank or ṛ 3	7.4	16.0	Reject null that rank ṛ 3

Notes.–As recommended by Juselius (2004, p. 171), CATS2-generated fractiles are increased by 2*1.8 or 3.6 to account for the 2 permanent shift binary variables restricted t lie in the cointegration relations. Trace values are corrected with Bartlett's small sample adjustment programmed by Dennis (2006).

If r=1 is appropriate, there should be p-r=3 characteristic unit roots in the companion matrix under r=1, with the fourth being sub-unity. The first four characteristic roots of the companion matrix under r=1 suggest that r is likely one: 1.0, 1.0, 1.0, 0.84.

If r is an appropriate choice, then some of the α-estimates generated for the unrestricted VEC's CVs in the Π -matrix should have absolute values equal to or above 2.6, with Juselius (2006, p. 142) having noted that this absolute critical value is generally higher than a Student-t critical value. If all of a CV's alpha estimates are insignificant, Juselius (2006, p. 142) contends that the CV contributes little to the error correction process and should perhaps be excluded from the cointegration space. Because of space considerations, we do not report all of the unrestricted VEC's Π -matrix estimates. The third CV generated no strongly statistically significant alpha estimates, suggesting that CV3 should be excluded from the error correction space. CV2 has a single significant alpha estimate for ΔPUSPROC, with a t-value of -3.2. Finally, the first CV1 has strong patterns of alpha estimate significance, with three of the four being significant: ΔQUSPORT with a t-value of 3.6, ΔPUSPROC with a t-value of -4.5, and ΔPUSSAUS with a t-value of -5.8. We conclude that the sharp drop in statistically significance α-estimate patterns from the CV1 set to the CV2 set may suggest more support for a reduced rank of 1 rather than 2. We conclude that evidence from trace tests, patterns of characteristic root values from relevant companion matrices, and the unrestricted VEC's patterns of alpha estimate significance suggest that reduced rank of Π is likely one.

Equation 4 is the single cointegrating relationship or CV that emerged after imposing rank r=1 and re-estimation of the adequately specified unrestricted VEC with the reduced rank estimator developed and applied by Johansen (1988) and Johansen and Juselius (1990, 1992), and normalized on QUSPORK. The parenthetical terms are t-values.

$$\begin{aligned} QUSPORK = &-0\text{-}84*PUSFARM + 0.43*PUSPROC + 1.86*PUSSAUS \\ &(-5.7)\ (0.93)\ (2.9) \\ &-0.26*URUGUAY + 0.21*NAFTA + 0.002*TREND \\ &(-2.9)\ (-2.1)\ (0.66) \end{aligned} \tag{4}$$

HYPOTHESIS TESTS AND INFERENCE ON THE ECONOMIC CONTENT OF THE COINTEGRATING RELATION CV1[7]

We begin with equation 4, the unrestricted CV, conduct a series of tests on $\Pi = \alpha*\beta'$, and then re-estimate the system, with the reduced rank estimator (programmed by Dennis 2006) with the statistically-supported restrictions imposed. Hypothesis tests on the beta coefficients take the form:

$$\beta = H*\varphi \tag{5}$$

The β is a p1 by r=1 vector of β -coefficients on variables in the cointegration space; H is a p1 by s design matrix, with "s" being the number of unrestricted or free beta coefficients; and φ is an s by r=1 matrix of the unrestricted beta coefficients. Johansen and Juselius' (1990, 1992) well-known hypothesis test value is provided in equation for the case where r is 1.

$$-2\ln(Q) = T*[(1-\lambda^*)/(1-\lambda)]\ . \tag{6}$$

The asterisked (non-asterisked) eigenvalue is generated by the model estimated with (without) the tested restriction(s) imposed.

The α or adjustment speed coefficients characterize the relative speeds of error-correcting adjustment with which endogenous variables respond to a given shock (Johansen and Juselius 1990, 1992). The null hypothesis or H(0) is:

$$H(0)\text{: } \alpha = A*\psi \tag{7}$$

[7] This methods section closely follows procedures provided in Johansen and Juselius (1990, 1992) and Juselius and Toro (2005), and thoroughly detailed in Juselius (2006, chapters 10 and 11).

A is a p by s design matrix, is the number of unrestricted coefficients; and ψ is the s by r=1 matrix of the non-restricted or "free" adjustment speed coefficients (Juselius 2004, chapter 11). Equation 6's test statistic also applies here.

Hypothesis Tests on the Beta Estimates

There are two sets of hypothesis tests on the beta coefficients. The first set of 4 tests examines if each endogenous variable is stationary under the imposed rank of 1. And the second set is performed on individual β -estimates in equation 4 after any statistically supported stationarity test conditions are imposed.

Given our multivariate model, we followed a growing literature and employed multivariate unit root tests rather then the more traditionally employed univariate tests: Juselius (1998, 2006), Juselius and Franchi (2007), Juselius and Toro (2005), Hesse (2007), Dennis (2006), as well as this journal's recent study by Babula, Rogowsky, and Romain (2006). While perhaps currently less known to the agricultural economics literature than the univariate tests, recent literature is increasingly establishing the multivariate test as appropriate for models of more than a single variable (especially, see Juselius 2006, p. 297). This test for stationarity utilizes equation 5 that is rewritten as equation 8:

$$\beta^c = [b,\varphi] \tag{8}$$

For each of the four tests of stationarity on each endogenous variable, the β^c is the p1 by r, here 7 by 1, beta matrix with one of the tested endogenous variables (Juselius 2006, p. 183). The b vector is a p1 by 1 (here 7 by 1) vector with the following values: a unity value corresponding to the variable being tested for stationarity, zeros for the other three non-tested endogenous variables, and unity for the three deterministic components restricted to the error correction space (URUGUAY, NAFTA, and TREND).[8] Evidence was sufficient to reject the four null hypotheses that each of the endogenous variables is stationary.[9]

The second set of hypothesis tests on individual beta coefficients are now conducted directly on equation 4, insofar as the first set of tests provided no statistically supported restrictions of stationarity to impose. This second set of hypothesis tests arose from the application of economic and statistical theory, market knowledge, prior research, and/or suggestions implied by coefficient estimates and are tested using equations 5 and 6, and included two hypothesis tests:

- Given equation 4's negligibly valued and highly insignificant trend coefficient (t-value of -0.66), we tested the null hypothesis that β(trend) = 0. The chi-squared test

[8] Note that under r=1 with a single CV, equation 8 substantially simplifies since φ , with dimensions p1 by r-1, is the null vector with dimensions of p1 by r-1, that is, 7 by zero.

[9] With three deterministic components retained and the imposed rank of r=1, then equation 8's test value is distributed under the null hypothesis of stationarity as a chi-squared variable with 3 degrees of freedom. Test values with parenthetical p-values are as follows, with the null of stationarity rejected for p-values less than 0.05: 18.3 (p=0.000) for QUSPORK; 21.7 (p=0.000) for PUSFARM; 18.6 (p=0.000) for PUSPROC); and 20.4 (p=0.000) for PUSSAUS.

value of 0.019 (1 degree of freedom) strongly accepted the restriction insofar as the p-value of 0.90 was far above the 0.05 decision rule. We re-estimated with the zero restriction on the beta coefficient for TREND.

- This subsequent estimation generated a set of results that included an insignificant t-value on processed pork price, and we tested the null hypothesis that β (PUSPROC) = 0. With a chi-square test value of 0.33 (2 degrees of freedom) and a p-value of 0.85, the restriction was strongly accepted, re-imposed, and then the equation was re-estimated final time with the reduced rank estimator.

A U.S. Demand for Pork

Equation 9 emerged as the finally cointegrating relation:

$$QUSPORK = -0.68*PUSFARM + 1.84*PUSSAUS - 0.22*URUGUAY + 0.19*NAFTA \quad (9)$$
$$(-7.4)\ (-7.1)\ (-3.1)\ (2.5)$$

The α-estimates (adjustment speed coefficient estimates) and the parenthetical t-values were generated as follows: α (QUSPORK) = -0.81 (t = -3.3), α(PUSFARM) = 0.27 (t = 2.0); α (PUSPROC) = 0.19 (t = 3.7); α (PUSSAUS) = 0.14 (t = 5.9).

Equation 9 appears to be a U.S. demand for pork as an input. Own-price has a strongly significant negative coefficient, that is translated as an own-price elasticity of demand of -0.68. This estimate falls within the range of alternative price elasticities of U.S. pork demand of from -0.51 to -0.84 reported by Wang and Bessler (2003, pp. 510-511) and approaches the lower limit of the range of -0.8 to -1.2 reported by Eales and Unnevehr (1993, p. 264). As well, normalizing on pork quantity (for reasons provided below) conceptually places it in positive form above the equilibrium on the relation's left side, whereby the α -estimate is a significant -0.81 (t-value of -3.3), and suggestive of a demand's downward adjustment toward the long run equilibrium or "attractor set."

The demand for pork appears positively sensitive to output prices of such downstream pork-based products, as proxied by PUSSAUS. The coefficient of +1.8 suggests an elasticity relationship above unity and may, at first glance, appear rather elastic. However, the modeled QUSPORK series, a commodity quantity, experiences a degree of variability far in excess of that of PUSSAUS, a U.S. producer price index for a manufactured meat product. Having placed all data in natural logarithms, the standard error is interpreted as a proportional change, and as a percentage change when multiplied by 100. QUSPORK's standard error is 21 percent, far exceeds the 7-percent standard error of PUSSAUS, and may thereby render the rather elastic PUSSAUS beta estimate in equation 9. Yet, the result suggests a statistically strong estimate of the cross-price link between demand for U.S. pork and the price of pork-using products downstream.

Econometric Specification and Estimation of U.S. Pork Demand with Weak Exogeneity

For perhaps the first time in the agricultural economics literature, we use analysis of the refined cointegrated VAR's patterns of β- and α -estimates on price and quantity to help resolve whether an econometric demand should be price- or quantity-dependent in cases when demands may be non-simultaneously estimated in situations when price or quantity are relatively more predetermined or exogenous. Prior tests and analyses suggest that QUSPORK exerts statistically significant influence on the error correction mechanism (equation 9), while its significant α -estimate (t-value = 3.7) suggests that quantity in turn responds to the mechanism, thereby rendering the variable a fully endogenous participant (see Juselius 2006, pp. 193-194). Yet pork price's strongly significant β-estimate (t-value of -7.0) and insignificant α -estimate (t-value of 2.0) suggests that pork price is weakly exogenous. That is, the price contributes to, but does not itself respond to, the error-correction process, so as to be a "one-way" source of causal influence (see Juselius 2006, pp. 193-194). These results suggest that price is more predetermined than quantity, such that U.S. pork demand can be specified as a quantity-dependent, rather than price-dependent, function estimated without 3SLS or 2SLS.[10]

This conclusion seems at odds with those of the only two other studies that address this issue for U.S. pork demand: Eales and Unnevehr (1993) and Wang and Bessler (2006). Eales and Unnevehr's (1993) Hausman test finding suggested that both U.S. pork demanded quantity (hereafter pork quantity) and price are equally endogenous and recommend 3SLS simultaneous estimation of U.S. pork demand to avoid the consequences noted previously of compromised inference and estimate bias. Yet this conclusion, as pointed out by Wang and Bessler (2006), may be questioned because of two known limitations of the Hausman test (and its Wu-Hausman test variation): questionable test power properties and the difficulty in procuring acceptable instrumental variables needed to implement the test.

Our conclusion that U.S. pork price is weakly exogenous and relatively more predetermined than quantity so as to justify non-simultaneous estimation as a quantity-dependent U.S. demand function appears at odds with Wang and Bessler's (2006) findings. They utilized another source of evidence, evidence from contemporaneous correlations, and concluded that U.S. pork quantity is likely more predetermined than U.S. pork price so as to justify price-dependent U.S. pork. That is, Wang and Bessler's conclusion opposes Eales and Unnevehr's finding of U.S. pork quantity/price simultaneity, but is not consistent with our finding that price may be more predetermined than quantity.

So currently, the three analyses provide three different conclusions and a seeming impasse over how U.S. demand for pork should be specified and econometrically estimated. Nonetheless, the three analyses differ widely on methodological approach and on the sources of model information and evidence focused on. Our refined methods of the cointeegrated VAR harness evidence from the cointegrating relationships that reflect long run serial relations over time, while Wang and Bessler's (2006) efforts focused primarily on

[10] Our model could have generated the alternative situation where quantity could have been weakly exogenous and price a fully endogenous CV participant. Such would have suggested that quantity was more predetermined

contemporaneous relationships. And while Eales and Unnevehr's (1993) did account for both contemporaneous and serial evidence, their Hausman test results are potentially questionable from the well-known and above-discussed limitations. Given that these three papers comprise the only literature on this issue for U.S. pork demand that one may rely on, we conclude as did Wang and Bessler (2006) who offered their method as a complementary, rather than competing, approach to that of Eales and Unnevehr (1993). In turn, and for the first time for U.S. pork demand, we offer the tools of the cointegrated VAR for assessing weak exogeneity as a useful third complementary approach in assessing U.S. pork price/quantity patterns of predeterminedness or exogeneity for specification and non-simultaneous estimation of U.S. pork demand. We conclude that discernment of which of the three methods is superior must be relegated to future research. We conclude that evidence of price's weak exogeneity suggest that U.S. pork demand may be appropriately estimated as a quantity-dependent function in a non-simultaneous setting without incurring noted econometric consequences. We also note that three alternative approaches have generated three different conclusions on this issue, and the superiority of the approaches must be relegated to future research.

Following our three-tiered motivation, our results and analyses suggest that the Uruguay Round and NAFTA (and concurrent events) modestly augmented QUSPORK by about 7 percent: the Uruguay Round had a positive effect of about 25 percent, NAFTA had a negative effect of about 18 percent, and in turn collectively registered a collectively positive effect on such demand.[11] This net positive effect is likely explained by McMahon's (1998) finding that U.S. implementation of both agreements likely augmented U.S. pork exports by more than imports declined – both of which are included as components in our QUSPORK definition. More specifically, Morrison (1996) noted that during 1990-1995, a period inclusive of the U.S. Uruguay Round and NAFTA implementations, the U.S. transformed from a major pork importer to a major pork exporter, as such U.S. pork-importing trading partners as Korea and Japan rendered concessions under both agreements.[12]

SUMMARY AND CONCLUSIONS

Our motivation for this study was three-fold. First, we mitigate an analytical gap in the literature for U.S. pork-related markets. Given a rising interest in empirical econometric

than price, in which case, our normalization and econometric estimation of the CV as a quantity-dependent function would have been appropriate.

[11] We used Halvorsen and Palmquist's (1980) well-known method of interpretation of binary variable coefficient estimates when regressions are implemented with data converted to natural logarithms. One takes "e," the base of the natural logarithm and raises it to the power of the value of the coefficient estimates, subtracts 1.0, and multiplies the result by 100. What results is an average percentage change effect on the dependent variable of the event (and collectively of other concurrent events) for which the binary variable was defined. Clearly, the Halvorsen-Palmquist calculation has a typical binary variable limitation of imprecision, in that the percent change effect cannot be attributed solely to the event for which the binary was defined (Uruguay Round implementation for URUGUAY in January 1995 or NAFTA's January 1994 implementation), but also to other influential concurrent events.

[12] We acknowledge that the negative impact on QUSPORK from NAFTA in equation 9 is not easily explained. Perhaps because of the close coincidence of the two U.S. implementations – January 1994 for NAFTA and January 1995 for the Uruguay Round – the two variables are collinear, and one emerges as wrongly signed. Nonetheless, the two variables do generate a collectively positive effect on QUSPORK, presumably because of reasons for the McMahon (1998) finding of positive effects of the agreements on U.S. pork exports.

illumination on the workings and inter-relationships among U.S. upstream/downstream markets related to pork, and despite increasing applications of VAR/cointegrated VAR methods to other markets, few applications that can generate such results have focused on U.S. pork-related markets. Our application of Johansen and Juselius' cointegrated VAR methods with recent advancements to U.S. markets for pork, processed pork, and sausage have provided such increasingly demanded empirical results. For example, there appears to be a long run own-price elasticity for U.S. pork of -0.68 that is in line with literature estimates, and that the NAFTA and Uruguay Round agreements have resulted in an average seven-percent rise in U.S. pork demand.

Our second motivation was to introduce some new methodological refinements of Johansen and Juselius' (1990, 1992) well-known and widely applied methodology of the cointegrated VAR model to the agricultural economics literature and perhaps for the first time to literature on U.S. pork-related market issues. Our study applies the following methodological refinements or advancements to three U.S. pork-related markets for perhaps the first time: a systematic method of assessing modeled data's nonstationarity properties and assessing their specification implications in order to utilize such properties' inherent information; a set of sequential steps by which one can achieve, as we did, an underlying statistical model of acceptable statistical adequacy as a basis for ultimate exploitation of cointegration properties; use of a recently developed unit root test to assess data stationarity within a multivariate framework; use of Bonferoni's criterion in assessing specification implications of observation-specific ("outlier") events; and a more thorough and comprehensive method with which to assess the reduced rank of a vector error correction space of cointegrated variables. We particularly note that our work has generated a long run U.S. demand for pork of notable statistical strength as reflected by table 1 and equation 9.

And third, we demonstrate, perhaps for the first time in the agricultural economics literature generally and for literature on U.S. pork markets specifically, the usefulness of cointegrated VAR model methods, particularly those that discern weak exogeneity patterns, in resolving a long standing issue of appropriate econometric specification and non-simultaneous estimation of a demand when price or quantity are more exogenous or predetermined than the other. We demonstrate the usefulness of analysis of an error-correction space's adjustment speed and cointegrating parameter estimates in assessing the relative significance patterns of cointegration space parameters (α- and β-estimates) on price and quantity, and in turn, the usefulness of such patterns in determining if U.S. pork demand can be appropriately specified as a price- or quantity-dependent function and estimated with a non-simultaneous estimator framework. We conclude that because U.S. pork demand's price is likely relatively more pre-determined than quantity, a quantity-dependent variable is likely appropriate. Our method of addressing such issues comprises one of three complementary options that include those of Eales and Unnevehr (1993) and Wang and Bessler (2006).

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THE ROLE OF THE IMPORTS FOR RE-EXPORTS PROGRAM (IREP) IN DETERMINING CANADIAN DEMAND FOR IMPORTED CHEESE: IMPLICATIONS FOR U.S. EXPORTS

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ABSTRACT

Given the importance of the Imports for Re-exports Program (IREP) to Canadian dairy importers and processors, this study assessed the impact of per-unit export returns on total and origin-specific demand for imported cheese in Canada. Demand was estimated using a production version of the Rotterdam model where it was assumed that firms imported cheese in a two-step profit maximization procedure. Unlike consumer-based approaches, this approach allowed for determining the impact of domestic price, export price and resource prices on import demand and the derivation of unconditional price elasticities. Estimation results showed that imports of U.S. cheese were not statistically responsive to export prices. However, results indicated a significant and positive relationship between export prices and imports from Denmark, France, other EU countries, and ROW. Therefore, if Canadian processor and importers increase utilization of the IREP, U.S. exports to Canada will likely remain unchanged while imports from the EU will significantly increase.

Key words: Canada, cheese, import demand, IREP, Rotterdam model
JEL classification code*s*: Q17, Q18, F13

INTRODUCTION

Canada maintains substantial trade barriers where imports have been strictly controlled to protect high internal prices. Although Canada replaced import quotas with tariff rate quotas (TRQ) under the 1994 Uruguay Round agreement, access quantities are small and triple-digit above access tariff rates make importing quite prohibitive (Romain and Sumner 2001; IDFA 2001). The TRQ quota limit for cheese is currently set at 20.4 million kilograms (kg) and above access tariff rates are as high as 245.5% (Canada Border Service Agency 2007).

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Notwithstanding, cheese imports have been significantly higher than the TRQ quota limit. From 2000 to 2006, above access imports have averaged 4.9 million kg annually (UNCOMTRADE 2007).

A significant percent of above access imports go through the Imports for Re-export Program (IREP). IREP imports receive tariff-free access as long they are re-exported within six months of the date of entry (Foreign Affairs and International Trade Canada 2005). Dairy products imported through the IREP are primarily used as ingredients in further processing where whole milk powders, butter fats and oils, and fluid milk account for the majority of imports through this program (38%, 24%, and 15% respectively). Cheese on the other hand is often re-exported with little additional processing and accounts for 7% of total IREP imports (Agriculture and Agri-Food Canada 2007).

Patterson (2006) noted the direct relationship between total cheese imports and IREP imports in recent years. The importance of the IREP to import demand raises the question, how has the re-export market impacted the demand for imported cheese in Canada? The primary goal of this study is to assess the impact of the IREP on import demand. This is accomplished by estimating the derived demand for imported cheese in Canada and assessing the impact of re-export prices on total cheese imports and imports from specific countries. Past import demand studies have typically used demand models derived from consumer theory such as the AIDS model (Deaton and Muellbauer 1980) and Rotterdam model (Theil 1980). Given the intermediate nature of agricultural imports, import demand is modeled as input demand in this study. By allowing imports to be treated as inputs and by specifying an unconditional input demand function (that is aggregate imports as a function of output and re-export prices) this paper makes it possible to relate the re-export price to total demand for cheese imports, but more interestingly, to the demand for cheese from specific markets. It is through the intermediate product assumption and the procedure used in this paper that it is possible to address the effects of the re-export market on the demand for imported cheese from a specific country.

In this paper a production version of the Rotterdam model is used to estimate import demand (differential production model) (Theil 1980; Laitinen 1980). The model is derived from a two-step profit maximization procedure and results in a structural system of import demand equations (total and source-specific). The system of equations allows for simultaneous determination of total import expenditures and source-specific imports. Specific objectives of this study are as follows: (1) Canadian demand for imported cheese differentiated by country of origin is estimated. Instead of assuming that total expenditures are exogenous (which is common practice in most papers) we test for expenditure endogeneity using the Durbin, Wu and Hausman test. Given that total expenditures were found to be endogenous, total and source-specific import demand was estimated using the full information maximum likelihood procedure. (2) Empirical estimates are used to derive sensitivity measures of import demand with respect to changes in import prices, domestic prices, re-export prices and the price of resources used by importers such as labor and energy. Of particular importance is the impact of re-export prices on imports of U.S. cheese.

IREP OVERVIEW

In 2002, the WTO ruled that the "commercial export milk" (CEM) program provided an illegal export subsidy to the Canadian dairy industry in the form discounted milk to processors (Mills and Reyes 2003). The WTO ruling resulted in Canadian processors substituting milk supplies from the CEM program, with raw milk imported through the IREP, increasing dairy imports overall and IREP imports in particular (Agriculture and Agri-Food Canada 2005). From 1997 through 2003, IREP imports increased from 6.7 to 59.1 million kilograms, an increase of 782%. In 2006, IREP dairy imports were 58.4 million kg, accounting for 30.6% of total dairy imports.

Table 1 presents Canada's cheese imports from 2001 through 2006. Above access imports, IREP imports, and IREP import shares are presented as well. From 2001 through 2006, cheese imports above the access limit have been as high as 6.2 million kg, but averaged 4.9 million kg during this period. Since 2002, IREP cheese imports have accounted for about 15% of total cheese imports and over 75% of above access imports. In 2006, IREP imports accounted for 92% of all cheese above the access limit and 16.6%, of total cheese imports (Table 1).

Table 1. Canadian Cheese Imports (kg): Total, Above Access, and IREP

Year	Total Cheese Imports	Above Access Imports	IREP Imports	IREP % of Total Imports	IREP % of Above Access
2001	26,635,049	6,223,183	2,254,617	8.46	36.23
2002	25,613,355	5,201,489	3,968,478	15.49	76.30
2003	24,872,998	4,461,132	3,943,502	15.85	88.40
2004	24,562,777	4,150,911	2,983,484	12.15	71.88
2005	25,263,463	4,851,597	4,139,735	16.39	85.33
2006	24,859,372	4,447,506	4,089,589	16.45	91.95

Sources: United Nations Commodity Trade Statistics, Agriculture and Agri-Food Canada, and USDA, Foreign Agricultural Service

THEORETICAL AND EMPIRICAL MODEL

Consumer approaches to import demand have been used quite extensively in empirical analysis. Empirical models have included (but are not limited to) the Armington (1969) model, AIDS model (Deaton and Muellbauer 1980) and Rotterdam model (Theil 1980).

While these models have found great use in the demand analysis literature, their use in estimating import demand are at times misapplied because traded products are often intermediate in nature (Davis and Jensen 1994; Washington and Kilmer 2002). In consumer applications, production related variables such as resource prices and output prices are for the most part not considered although they may significantly determine import demand. Most goods entering international trade require further processing before final demand delivery, and when products are not physically altered, activities such as handling, insurance, transportation, storing, repackaging, and retailing still occur, resulting in a significant amount of domestic value added before final demand delivery (Kohli 2001, 1978; Sanyal and Jones 1982; Burgess 1974).

The differential production model is used to estimate total and source-differentiated import demand. See Laitinen (1980) and Theil (1980) for theoretical derivation. See Washington and Kilmer (2002), Muhammad (2007), and Muhammad, Jones, and Hahn (2007) for empirical applications. We assume that firms import cheese in a two step procedure where total expenditures on cheese imports are explained by economic factors derived from profit maximizing behavior. The allocation of total expenditures across import suppliers are explained by the level of total expenditures and individual import prices (Brenton, 1989). Follow Armington (1969), it is assumed that cheese imports are differentiated by country of origin where U.S. cheese, French cheese, Italian cheese, etc. are considered to be individual products. Assume that firms import cheese from *n* countries using *m* resources. The resale of imported cheese can be specified by the following supply specification (Theil 1980, p. 38):

(1) $$d(\log Q) = \frac{\psi}{\gamma - \psi}\left[d(\log p) - \sum_{j=1}^{n} \theta_j d(\log w_j) - \sum_{k=1}^{m} \theta_k d(\log w_k) \right].$$

Q represents total output (total imports in this context), *p* is the output price (resell price), w_j is the price of imported good *j* ($j \in$ exporting countries) and w_k is the price of the domestic resource *k* ($k \in$ labor and energy). ψ is a positive scalar and may be regarded as a measure of the curvature of the logarithmic cost function, and γ is the elasticity of total cost with respect to output. $\theta_{j(k)}$ is the marginal share of the *j*th(*k*th) input in total cost, $\left(\theta_{j(k)} = \partial(w_{j(k)} x_{j(k)}) / \partial C\right)$. $x_{j(k)}$ is the quantity of input *j*(*k*) and *C* is total cost.

Assuming that domestic resources and individual imports are weakly dependent, the derived demand for cheese from country *i* is specified as [1]

(2) $$f_i d(\log x_i) = \gamma \theta_i d(\log Q) - \psi \sum_{j=1}^{n} (\theta_{ij} - \theta_i \theta_j) d(\log w_j).$$

[1] The weak dependence between domestic resources and imports implies that changes in the price of resources such as labor do not directly affect individual cheese imports; rather labor prices affect individual imports indirectly, by determining total import expenditures. Given this assumption resources prices needn't be included in equation (2).

f_i is the share of the ith import in total import cost $(w_i x_i / \sum_{i \in n} w_i x_i)$. $\mathbf{\Theta}_{n\times n} = \left[\theta_{ij}\right]$ is a symmetric positive definite matrix where $\mathbf{\Theta} = (1/\psi)\mathbf{F}(\mathbf{F} - \gamma\mathbf{H})^{-1}\mathbf{F}$. $\mathbf{F}_{n\times n}$ is a diagonal matrix with import factor shares (f_i) along the diagonal and **H** is a Hessian matrix of the firm's implicit production function, where the elements of **H** are the second partials with respect to inputs $\partial h^2 / \partial\mathbf{x}\partial\mathbf{x}'$. $\sum_{j=1}^{n} \theta_{ij} = \theta_i$ and $\sum_{i=1}^{n}\sum_{j=1}^{n} \theta_{ij} = 1$.

Summing Equation (2) over i we get the following relationship

$$d(\log X) = \gamma d(\log Q). \tag{3}$$

$d(\log X)$ is the Divisia volume input (import) index where $d(\log X) = \sum_{i=1}^{n} f_i d(\log x_i)$ and is a measure of real import expenditures.[2] Multiplying equation (1) by γ and substituting $d(\log X)$ for $\gamma d(\log Q)$ yields the total import decision where total import expenditures are represented by the Divisia volume index. Substituting $d(\log X)$ for $\gamma d(\log Q)$ in equation (2) results in the import allocation decision. The total import decision and the import allocation decision are respectively specified as

$$d\log(X) = \varphi\, d\log(p) + \sum_{j=1}^{n} \pi_j\, d\log(w_j) + \sum_{k=1}^{m} \pi_k\, d\log(w_k) \tag{4}$$

$$f_i d(\log x_i) = \theta_i d(\log X) + \sum_{j=1}^{m} \pi_{ij}\, d(\log w_j). \tag{5}$$

$\varphi = \gamma\psi/(\gamma - \psi)$, $\pi_j = -\theta_j\left[\gamma\psi/(\gamma - \psi)\right]$ $\pi_k = -\theta_k\left[\gamma\psi/(\gamma - \psi)\right]$ and $\pi_{ij} = -\psi(\theta_{ij} - \theta_i\theta_j)$.

Finite versions of equations (4) and (5) are used for analysis. Letting t denote time, we express the total import decision in finite log changes as

$$\begin{aligned} DX_t &= \varphi_0 + \varphi_1\, Dp_{Dt} + \varphi_2\, Dp_{Xt} + \varphi_D\, d_{WTO} + \varphi_t\, t \\ &\quad + \pi_L\, Dw_{Lt} + \pi_E\, Dw_{Et} + \sum_{j=1}^{n} \pi_j\, Dw_{jt} + \varepsilon_t \end{aligned}. \tag{6}$$

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[2] This relationship is due to $\sum_{i=1}^{n} \theta_i = 1$ and $\sum_{i=1}^{n}\sum_{j=1}^{n} (\theta_{ij} - \theta_i\theta_j)\, d(\log w_j) = 0$ (Theil 1980, p. 35).

DX_t is the finite version of the Divisia volume index, where $DX_t = \sum_{i=1}^{n} \bar{f}_{it}\, Dx_{it}$, $\bar{f}_{it} = (f_{it} + f_{it-1})/2$, and for any variable *y*, $Dy_t = \log(y_t / y_{t-1})$. Equation (6) states that total import expenditures are a function of domestic retail prices (p_D), export prices (p_X), a WTO dummy variable (d_{WTO}), a time trend (*t*), wages (w_L), energy prices (w_E) and individual import prices (w_j). Both domestic and export prices are included in the total import decision because imports are resold domestically as well as re-exported. d_{WTO} is equal to 1 for all years after 1994 and 0 otherwise, and is included in equation (6) to account for the impact of the 1995 WTO agreement on total imports. Labor and energy prices are included in equation (6) to account for the impact of resource prices on import demand. Inputs not included in the model are accounted for by the constant term (φ_0) and trend variable (*t*). $\varphi_0, \varphi_1, \varphi_2, \varphi_D, \varphi_t, \pi_L, \pi_E$ and π_j are parameters to be estimated. ε_t is a random disturbance term.[3]

A finite version of the import allocation decision, equation (5), is as follows:

(7) $$\bar{f}_{it} Dx_{it} = \theta_i DX_t + \sum_{j=1}^{n} \pi_{ij}\, Dw_{jt} + u_{it}\ .$$

θ_i is the marginal import share and π_{ij} is the conditional price effect. Both are assumed constant and are parameters to be estimated. u_{it} is a random disturbance term. Equation (7) states that cheese imports from country *i* (weighted by factor share) is a function of total import expenditures (represented by the Divisia volume index) and individual import prices. The import allocation model requires that the following parameter restrictions be met in order to conform to theoretical considerations: $\sum_j \pi_{ij} = 0$ (homogeneity), $\pi_{ij} = \pi_{ji}$ (symmetry), and the matrix of conditional price effects $\left(\mathbf{\Pi} = \left[\pi_{ij}\right]\right)$ is negative semidefinite. Homogeneity and symmetry are imposed on estimates and statistically tested. The negative semidefinite property is verified by inspection.

From equation 7, we get the typical elasticities found in many import demand studies: the conditional own/cross-price elasticity $\eta_{xw}^{c} = \pi_{ij} / \overline{f_i}$ and the Divisia index (conditional expenditure) elasticity $\eta_{xX} = \theta_i / \overline{f_i}$. The benefit of a production approach is that in addition to the conditional price and expenditure elasticities, the responsive of imports to domestic and

[3] If it were possible to model the actual output market, and if the quantity of labor, energy, and other resource use by this industry were known, equation (6) would be estimated jointly with output supply and resource demand equations. Two studies that modeled the output market for an imported agricultural good are Davis and Jensen (1994), and Koo, Mao, and Sakurai (2001). Davis and Jensen estimated import demand for source differentiated lumber in Japan and considered furniture production and construction as outputs. Koo, Mao, and Sakurai estimated import demand for source differentiated wheat in Japan and considered milled wheat flour varieties as outputs.

resource prices can be derived. Additionally, the total effect of prices on import demand (unconditional price effects) can be determined. Unconditional price effects are more appropriate for analyzing the impact trade policies because the complete effect of prices on demand is accounted for by these estimates (Davis and Jensen 1994).

Substituting the right-hand side of equation (6) for the Divisia index term in equation (7), we get the unconditional elasticities of import demand with respect to the following: domestic retail prices, export prices, wages and energy prices. These are calculated respectively as

(8) $$\eta_{xp_D} = \frac{Dx_i}{Dp_D} = \frac{\theta_i}{\bar{f}_i}\varphi_1$$

(9) $$\eta_{xp_X} = \frac{Dx_i}{Dp_X} = \frac{\theta_i}{\bar{f}_i}\varphi_2$$

(10) $$\eta_{xw_L} = \frac{Dx_i}{Dw_L} = \frac{\theta_i}{\bar{f}_i}\pi_L$$

(11) $$\eta_{xw_E} = \frac{Dx_i}{Dw_E} = \frac{\theta_i}{\bar{f}_i}\pi_E .$$

Equations (8)-(11) give the impact of percentage changes in domestic prices, export prices, wages and energy prices on imports from country *i*.

From the above substitution we also get the unconditional own-price/cross-price elasticity

(12) $$\eta_{xw} = \frac{d\log(x_i)}{d\log(w_j)} = \left[\theta_i\pi_j + \pi_{ij}\right]/\bar{f}_i .$$

Equation (12) measures the impact of a change in country *j*'s price on the quantity imported from country *i*. Note that equation (8) is comprised of two effects: the direct or conditional effect of a price change, which is the impact of relative price changes on individual import demand (π_{ij}), and the indirect effect of a price change, which is the effect of a price change on total import expenditures $(\theta_i\pi_j)$. Note that the former effect is the impact of a change in price holding total expenditures constant. We would expect this effect to be positive (although not always the case) for cross products $(i \neq j)$ indicating that a competitive relationship should exist between any two imports if total imports are held constant. The latter effect should be negative because $\pi_j < 0$ (an increase in import prices should lower total import expenditures) and $\theta_i > 0$ (an increase in total import expenditures should increase imports from a given source). Note that if $|\theta_i\pi_j|$ is sufficiently large, then two imports that are substitutes conditionally would actually be complements unconditionally.

RESULTS AND DISCUSSION

The United Nations Commodity Trade Statistic Division (UNCOMTRADE) provided the data used in this study. The exporting countries were: the U.S., Denmark, France, Italy, other EU (aggregation of remaining EU countries), and the rest of the world (ROW).[4] Cheese quantities were in kilograms and values were in $US. Values included cost, insurance and freight (CIF). Annual data were used for estimation and the time period for the data was 1962 through 2006. Per-unit import values were used as proxies for import prices ($US/kg) and per-unit export values were used as proxies for export prices. Cheese exports were on a FOB (Free on Board) basis. The cheese CPI was used to account for changes in domestic prices and was provided by Agriculture and Agri-Foods Canada. A wage index for the wholesale trade sector and energy price index were used to account for the impact of labor and energy cost on import demand. The wage index was provided by the Bureau of Labor Statistics and the energy price index was provided by Statistics Canada. Descriptive statistics on model variables are presented in table 2.[5]

Table 2. Descriptive Statistics for Model Variables: 1962-2006

Import Cost Share (%)	Mean	Standard Deviation	Minimum	Maximum
U.S.	12.25	3.83	6.28	23.09
Denmark	13.83	4.22	7.09	21.13
France	14.06	5.28	6.52	25.30
Italy	15.38	4.86	7.48	25.85
Other EU	18.90	3.22	13.38	25.15
ROW	25.58	5.23	18.07	36.01
Import Price ($/kg)				
U.S.	3.59	1.39	1.25	5.72
Denmark	3.63	2.13	0.87	8.76
France	4.36	2.24	1.32	9.06
Italy	4.47	2.10	1.10	8.42
Other EU	3.28	1.91	0.88	7.66
ROW	3.03	1.55	1.04	7.41
Import Quantity (1,000 kg)				
U.S.	2,439	1,798	723	8,834
Denmark	2,632	889	1,378	4,030
France	2,414	1,440	351	5,303
Italy	2,296	1,029	965	4,257
Other EU	4,130	1,285	1,056	6,271

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[4] ROW imports are primarily from Switzerland, and to a lesser extent Argentina. A small percent of ROW imports are from Australia and New Zealand.

[5] Import data were fairly consistent throughout the data period with no missing observations. This is verified by the min/max values in Table 2.

	Mean	Standard Deviation	Minimum	Maximum
Total Import Variables				
ROW	5,781	2,003	1,326	8,820
Total Imports (1000 kg)	19,692	5,672	6,633	29,417
Export Prices ($/kg)	2.80	1.39	0.67	5.79
Cheese price index	58.37	33.62	13.63	118.60
Wage index	68.47	29.86	24.60	104.00
Energy price index	54.69	36.44	11.20	132.80

Equations (6) and (7) were estimated jointly using the full information maximum likelihood (FIML) procedure in TSP (5.0) where the Divisia index (DX) and individual imports $(\bar{f}_{it}Dx_{it})$ were simultaneously determined. Given the difficulties in modeling higher stages in consumer demand applications, total import expenditures (DX) are typically assumed exogenous and analysis is usually limited to estimating the import allocation system. Using rational random behavior theory, Theil (1980) shows that if the parameters in equations (6) and (7) are constant and the errors normally distributed, then $\mathrm{cov}(\varepsilon_t, u_{it})=0$. This suggests that the total import decision is independent of the allocation decision and that equations (6) and (7) could be estimated separately. Instead of assuming that this is the case, we test for expenditure endogeneity using the Durbin, Wu and Hausman (DWH) test (Davison and MacKinnon 2004, p. 341; Dhar, Chavas, and Gould, 2003). The DWH test is based on the difference between parameter estimates with and without controlling for expenditure endogeneity. The DWH test statistic can be specified as

$$\text{DWH} = \left(\boldsymbol{\theta}_{LS} - \boldsymbol{\theta}_{FIML}\right)' \left[\text{Var}(\boldsymbol{\theta}_{LS}) - \text{Var}(\boldsymbol{\theta}_{FIML})\right]^{-1} \left(\boldsymbol{\theta}_{LS} - \boldsymbol{\theta}_{FIML}\right) \sim \chi^2_j . \tag{12}$$

$\boldsymbol{\theta}_{LS}$ is a vector of least squares estimates where expenditures are assumed exogenous. $\boldsymbol{\theta}_{FIML}$ is a vector of FIML estimates with expenditures assumed endogenous. Under the null hypothesis of no endogeneity, equation (12) is distributed χ^2_j, where j is the number of potentially endogenous variables. For sufficiently large values of DWU, the null is rejected and endogeneity holds.

The DWU test statistic (28.87) was greater than the $\chi^2_{(5)}$ critical value (11.07) indicting that total import expenditures are endogenous. Consequently, equations (6) and (7) are not independent and least squares estimation would have produced bias estimates. Likelihood ratio (LR) tests were used to test for the economic properties of homogeneity and symmetry. The LR test statistic for homogeneity was 6.95, which was less than the $\chi^2_{(6)}$ critical value 12.59, indicating a failure to reject homogeneity. The LR test statistic for symmetry was 15.89, also less than the $\chi^2_{(15)}$ critical value 25.00, indicating a failure to reject symmetry. All results that follow are the FIML estimates with homogeneity and symmetry imposed. Theory also suggests that the matrix of conditional price effects be negative semi-definite. This property is confirmed when all eigenvalues of the price coefficient matrix are less than or equal to zero. As verified by inspection, all eigenvalues were nonpositive.

Estimates of the total import decision are presented in table 3. Domestic prices and export prices had a significant and positive impact on the Divisia index as expected. The impact of domestic prices (0.490) was larger than the impact of export prices (0.143). The WTO affect on the Divisia index was positive and significant (0.048) indicating that WTO policy had a positive impact on total cheese imports. Consistent with theory, wages and energy prices had a significant negative impact on the Divisia index (-0.471 and -0.229 respectively) indicating that higher labor and energy costs decrease total import expenditures. Each import price should negatively impact total cheese imports. This was the case for Denmark, France, Italy and the EU; however no import price was significant.

Table 3. Full Information Maximum Likelihood Estimates of Total Cheese Imports (Equation 6)

Parameters	Estimate		Import Price Parameters	Estimate	
φ_0 constant	0.090	(.024)***	π_1 U.S.	0.101	(.090)
φ_1 domestic price	0.490	(.210)**	π_2 Denmark	-0.075	(.122)
φ_2 export price	0.143	(.051)***	π_3 France	-0.183	(.147)
φ_D WTO	0.048	(.018)***	π_4 Italy	-0.125	(.083)
φ_t trend	-0.003	(.001)***	π_5 Other EU	-0.091	(.093)
π_L labor	-0.471	(.230)**	π_6 ROW	0.185	(.132)
π_E energy	-0.229	(.114)**			
Equation R^2 = .33					
DW = 2.15					

Asymptotic standard errors are in parentheses.
*** Significance level = 0.01; ** Significance level = 0.05; * Significance level = 0.10

Estimates of the import allocation system are presented in table 4. The marginal import share estimates (θ_i) indicate that the Divisia index or total import expenditures had a significant and positive effect on imports from ROW (0.320), the EU (0.237), Denmark (0.199) and France (0.180). Imports from the U.S. and Italy were statistically invariant to changes in the Divisia index. Consistent with theory, all conditional own-price effects (π_{ii})

were negative and significant at the 0.01 level. Own-price effects for the U.S., Denmark, France, Italy, other EU, and ROW were -0.204, -0.187, -0.123, -0.147, - 0.173, and -0.203 respectively (diagonal elements, table 4). Conditional cross-price estimates indicated competitive relationships between the U.S. and Italy (0.047), U.S. and other EU (0.060), and U.S. and ROW (0.073). A competitive relationship also existed between Denmark and France (0.051), Denmark and ROW (0.062), France and Italy (0.029), France and ROW (0.047) and Italy and Other EU (0.058). Given the insignificant impact of import prices on total imports, the conditional and unconditional cross-price effect should be statistically equivalent.

Table 4. Full Information Maximum Likelihood Estimates of Import Allocation System (Equation 7)

Exporting Country	Marginal Import Shares, θ_i	Price Coefficients, π_{ij}						
		U.S.	Denmark	France	Italy	Other EU	ROW	
U.S.	0.091	-0.204***	0.039*	-0.016	0.047*	0.060**	0.073***	R^2 = .53
	(0.074)	(0.037)	(0.024)	(0.019)	(0.026)	(.028)	(.026)	DW=2.20
Denmark	0.199***		- 0.187***	0.051*	0.011	0.024	0.062*	R^2 = .44
	(0.058)		(0.042)	(0.028)	(0.022)	(0.026)	(0.035)	DW=2.52
France	0.180***			-0.123***	0.029*	0.012	0.047*	R^2 = .50
	(0.044)			(0.035)	(0.017)	(0.021)	(0.028)	DW=1.91
Italy	-0.028				-0.147***	0.058**	0.003	R^2 = .32
	(0.076)				(0.033)	(0.025)	(0.022)	DW=1.87
Other EU	0.237***		Symmetry			-0.173***	0.019	R^2 = .49
	(0.068)					(0.034)	(0.022)	DW=1.96
ROW	0.320***						-0.203***	R^2 = .66
	(0.057)						(0.045)	DW=1.34

Asymptotic standard errors are in parentheses.
*** Significance level = 0.01; ** Significance level = 0.05; * Significance level = 0.10;

We limit the following discussion to the unconditional elasticities presented in tables 5. Conditional elasticities and unconditional cross-price elasticities can be provided upon request. Given that imports from the US and Italy were statistically invariant to changes in the Divisia index, the responsiveness of imports from these countries to domestic price, export price and resource prices were insignificant. For Denmark, France, Other EU and ROW the impact of domestic and export prices were all significant at the 0.05 level. Imports from Denmark were the most responsive to export prices (0.207). Next were France (0.185), other EU (0.179) and ROW (0.179). Overall, individual imports were two to three times more responsive to changes in domestic prices than export prices suggesting that the domestic market has a greater effect on imports than the re-export market. Imports were also two times more responsive to changes in wages than energy prices. The wage elasticities were also relatively more significant, particularly for France and other EU.

Table 5. Unconditional Elasticities of Derived Demand

Exporting Country	Domestic Price	Export Price	Wages	Energy Price	Own-Price
U.S.	0.364	0.107	-0.350	-0.170	-1.597***
	(0.366)	(0.099)	(0.379)	(0.162)	(0.343)
Denmark	0.707**	0.207**	-0.679*	-0.330**	-1.459***
	(0.359)	(0.087)	(0.382)	(0.162)	(0.370)
France	0.631**	0.185***	-0.606**	-0.294*	-1.110***
	(0.273)	(0.056)	(0.268)	(0.167)	(0.179)
Italy	-0.089	-0.026	0.085	0.041	-0.943***
	(0.257)	(0.073)	(0.246)	(0.119)	(0.199)
Other EU	0.610**	0.179**	-0.586**	-0.285*	-1.022***
	(0.275)	(0.079)	(0.274)	(0.164)	(0.208)
ROW	0.611**	0.179***	-0.587*	-0.285*	-0.645**
	(0.282)	(0.070)	(0.310)	(0.148)	(0.304)

Asymptotic standard errors are in parentheses.
*** Significance level = 0.01; ** Significance level = 0.05; * Significance level = 0.10;

The relationship between the re-export market and cheese imports from different countries is implied from the export price elasticities. The insignificant estimate for the U.S. indicates that imports of U.S. cheese were invariant to changes in export prices. A possible explanation is that a significant percent of cheese re-exported from Canada goes to the U.S. It is highly unlikely that the U.S. would be importing its' own cheese. In 2006, cheese re-exports (not necessarily IREP cheese) were valued at $5.35 million. The U.S. was the primary market for cheese re-exports accounting for 78%. If cheese re-exports are primarily for the U.S., then it is unlikely that IREP expansion will significant impact Canadian imports of U.S. cheese.

The unconditional own-price elasticities indicated that the demand for U.S. and Denmark cheeses was the most elastic (-1.597 and -1.469 respectively). The demand for cheese from France and other EU was relatively less elastic (-1.110 and -1.022 respectively), and the demand for cheese from Italy was inelastic, but close to unit elastic (-0.943). ROW cheese was the most inelastic (-0.645). Future trade negotiations will more than likely lead to lower above access tariff rates in the future. The unconditional own-price elasticities give an indication of the impact of tariff reductions on individual imports. Given a proportional reduction in import prices, U.S. cheese exports to Canada will increase by the greatest percent, and given that demand was elastic, expenditures on U.S. cheese should also increase as well (Table 5).

SUMMARY AND CONCLUSION

Given the direct relationship between total cheese imports and IREP imports in Canada, this study investigated the impact of export prices on total and source specific import demand for cheese in Canada. A production version of the Rotterdam model was used to estimate import demand that permitted simultaneous estimation of total import expenditures and import demand from each country. Unlike past consumer-based studies where analysis was limited to conditional expenditure and price effects, the model used in this study allowed for determining the effect of domestic prices, export prices, wages and energy prices on the total import demand and source-specific imports. Theil (1980) theoretically shows that the parameterization of the differential import allocation model results in exogenous import expenditures. While most studies accept this as fact, this was not the case for total cheese imports in Canada. A Durbin, Wu and Hausman test rejected the hypothesis of no expenditure endogeneity. Consequently, total and source-specific imports were simultaneously estimated using the full information maximum likelihood procedure.

The primary goal of this study was to assess the impact of IREP imports on Canadian demand for U.S. cheese. The responsiveness of imports of U.S. cheese to changes in export prices was not statistically significant suggesting that the returns to re-exporting in Canada did not significantly impact imports from the United States. However, results indicated a significant and positive relationship between export prices and imports from Denmark, France, other EU countries, and ROW. Therefore if Canadian processor and importers increase utilization of the IREP, U.S. exports to Canada will likely remain unchanged while imports from the EU and the rest of the world will significantly increase.

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THE EFFECTS OF THE INTERNET ON U.S. BILATERAL AGRICULTURAL TRADE

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ABSTRACT

This research is the first to provide findings of the effect of the Internet and its costs on the level of U.S. agricultural imports and exports at both an aggregated and disaggregated level. Fitting alternative specifications of a simple gravity-like model to data, we find that the number of initial host sites has measurable effects on agricultural trade. The evolution of new sites has undetectable effects, suggesting, among other things, that early establishment of host sites gave firms and countries using those connections an advantage in future trade. The results also suggest that the Internet has differential effects on imports and exports depending on the degree to which products are differentiated and perishable. It appears that the Internet will be more important as trade in higher valued agricultural commodities continues to grow relative to bulk commodities.

Key words: Internet, bilateral trade, information, trade barriers
JEL Classification Codes: F14, F15, Q17

INTRODUCTION

Agricultural trade represents a significant component of U.S. exports. Furthermore, trade in agricultural products with the United States represents an important source of foreign exchange for many countries. The rise of the Iinternet provided a technological improvement in the infrastructure of trade, and accordingly, one would expect it to have some positive impact on trade in many sectors. This article will analyze the effects of the Internet on U.S. bilateral trade of agricultural commodities.

Understanding the determinants of trade has been a major component of the work of economists for decades. Baldwin and Martin (1999) argue that information technologies play a central role in the decline of technical barriers that have led to globalization in recent

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decades. Within that context, we argue that the Internet as an information technology has played an important and measurable role in this process of growing trade.

The reach of the Internet both through search engines and e-mail provides important connections among possible traders and lowers the fixed costs of forming trading relationships internationally. The need to incur sunk costs in developing new but potentially non-persistent relationships will tend to slow the development of trading relationships. Baldwin (1988); Roberts and Tybout (1997); and Freund and Weinhold (2004) all point to the importance of sunk costs in constraining the growth of trade and explaining the persistence of certain trading relationships. If the Internet lowers the initial fixed costs of switching and/or developing new trade relationships, one would expect that lowering these costs would have significant effects on trading volumes. Other research by Fink, Mattoo, and Neagu (2002) provides an alternative perspective where the Internet reduces the transaction costs per load or shipment (i.e., lowers the variable costs of trade). Their research uses a similar econometric method as Freund and Weinhold (2002, 2004) to test the effects of communication costs on international trade in a wide array of products. Their basic idea is that lower costs per unit or load essentially lowers the variable costs in trade and therefore augments the volume. The market integration literature also finds support for the importance of lowered transaction and transportation costs in facilitating greater trade volumes and market integration (Baulch 1996).

As such, the Internet as an information process affects both fixed and variable costs of trade. Rauch and Casella (2003) have argued that group ties provide a method of reducing the fixed and variable costs of negotiating trade internationally. In particular, they remark on the ability of such ties to reduce or mitigate informational asymmetries. Rauch and Watson (2003) have showed that the normal development of trading relationships often requires the slow and careful development of trust to reduce information differences and strengthen a trading relationship, and Rauch and Trindade (2003) have argued that the spread of the Internet can help exporters and importers to sift through the many possible trading partners to find an appropriate match. Rauch and Trindade (2003) propose and prove in a theoretical context that the volume of trade decreases as information about trading partners declines. They further show that the elasticities of substitution between foreign and domestic outputs will increase with improvements in information. By easing the flow of information, the Internet might then provide some substitute for group ties or otherwise impeded relationship development.

MAKING THE CONNECTION: THE DIFFERENT EFFECTS OF THE INTERNET ON TRADE

As discussed above, the Internet serves two functions in facilitating international trade of agricultural commodities: (1) it will tend to lower the fixed costs of arranging international trade and the entry of new markets (Freund and Weinhold 2004); (2) it will tend to reduce the marginal effort incurred in arranging the transport of any given shipment (Fink, Mattoo, and Neagu 2002). Given the broad theoretical support for the Internet as a trade augmenting technology, we will first seek to test whether the Internet has a non-decreasing effect on bilateral trade in agricultural commodities.

Second, the Internet's effect on imports and exports should be conditioned on the relative homogeneity and perishability of goods. Specifically, for goods where quality has greater variability or for goods that are more perishable, the Internet can facilitate more and quicker communications about product quality, attributes, and logistics. For example, one would expect that an information technology such as the Internet would have a greater impact on livestock trade relative to grain trade given the larger number of quality dimensions which must be considered and monitored in trade. Similarly, the ability to monitor and quickly communicate would be more important for fruit and vegetable shipments relative to grain shipments. The idea of a relationship between information availability, product differentiation, and trade originates in the work of Rauch (1999), and we simply add to it the idea of the importance of perishability. Since the Internet eases the process of monitoring and verifying shipment quality and attributes, the Internet will advantage those firms and countries with more experience in using the Internet by lowering informational barriers to trade, specifically for those product for which such monitoring and quality verification is more important (i.e., perishables and differentiated products).

Finally, it is also reasonable to believe that the extent to which the fixed and variable costs of trade are lowered is conditional on the past experience of the United States in shipping to a particular market and conversely on the past experience of other countries shipping to the United States. Greater past experience should lower the total and marginal benefits associated with the Internet. Rauch and Watson (2003) suggest that buyers initiate activities with new suppliers on a smaller scale basis due to limited experience and uncertainty about the future. However, information technology can substitute, to some extent, for such painstaking relationship development between buyers and suppliers.

U.S. exporters have a long history of exporting agricultural products and have many well developed trading relationships; however, many of the countries from whom the U.S. imports, particularly developing countries, have mush less experience in this regard. For example, if a given exporter of grain to China has developed many partners over many years of trade, then the introduction of the Internet is likely to have a minimal effect on the exporter's trade volume. However, a flower exporter from Ecuador who, pre-Internet access, had limited experience in exporting flowers to the United States and faced high information costs should, post access, obtain significant benefits by being able to engage in market research, develop working relationships with U.S. buyers, and manage the logistics of shipment at lower costs. Moreover, the flower supplier's potential buyers will find it less costly in developing such procurement relationships as some cost savings are likely passed forward as well. In short, the Internet will allow such exporters, particularly those from developing countries, a chance to catch up without having to go through the same slow process of relationship development; therefore, the effect of the Internet on imports should be more pronounced.

In summarizing the above discussion, the theoretical research on information and trade leads us to believe that the Internet should have a positive effect on trade, a more pronounced effect on trade in perishable/quality differentiated goods, and a larger impact on U.S. agricultural imports relative to exports.

Modeling the Effects of the Internet on Agriculture

To tests our predictions of the effects of the Internet, we resort to the gravity model used frequently in the trade literature. Deardorff (1998) reviews the litany of empirical and theoretical papers that have attempted to study this problem, with particular emphasis on the usefulness of the gravity model as a tool for such study. Other important papers discussing the gravity model or other questions on bilateral trade include those of Bergstrand (1985, 1989, and 1990). More recently, Hummels (2001) focused on the nature, size, and shape of trade barriers and the volume of trade using the gravity model. The gravity equation has been a workhorse for statistical studies of trade for almost fifty years and remains a useful and parsimonious tool for detecting impacts of policies, events, geography, and other factors on trade.

Given the complexity of how information affects economic activity, it is unlikely that we can identify the distinct variable and fixed cost effects on international transactions that we discussed earlier. However, the gravity econometric framework for estimating the effects of the Internet has been used to test both theories (see Freund and Weinhold (2002, 2004) and Fink, Mattoo, and Neagu (2002)). Recently, Anderson and van Wincoop (2003) discuss some of the weaknesses of the traditional uses of the gravity model. In that research, they derive an updated version of a multi-lateral model of trade, where exports from country i to country j can be represented as follows in equation (1)

$$x_{ij} = \frac{y_i y_j}{y^w} \left(\frac{\tau_{ij}}{P_i P_j} \right)^{1-\sigma} \tag{1}$$

Specifically, this equation states that the volume of exports between country i and country j (x_{ij}) will be a function of these countries' respective gross domestic products (y_i and y_j), the level of world income (y_w), the cost of trade (τ_{ij}), the level of "multilateral resistance" as measured by P_i and P_j where P_i is the resistance to trade of country i. In Anderson and van Wincoop's model, these are the consumer price indices of the respective countries; however, they argue that such resistance could have non-pecuniary interpretations as well. The σ in the above equation is the elasticity of substitution of products between the two countries.

Taking the natural log of both sides of equation (1) yields the following expression:

$$\ln x_{ijt} = k + \ln y_{it} y_{jt} + (1-\sigma) * \ln \tau_{ijt} - (1-\sigma) * P_{it} - (1-\sigma) * P_{jt} \tag{2}$$

The symbol k is a constant which absorbs the world income variable. Notably, in this model, the characteristics of trade costs and the multilateral resistance variables imply that trade does not vary with uniform decreases in trade costs. In other words, the trade effects of changing costs are dependent on heterogeneous changes in costs across countries. If there are uniform changes in costs across countries, then the net effect on trade volumes should be negligible. As shall be seen later in this article, this fact of trade costs could be a limit on the trade effects of contemporaneous changes in our Internet variable.

For our estimation, we will use a modified version of the model proposed by Hummels (2001) to describe trade costs between countries. Our trade cost equation is as follows:

(3) $$\tau_{ijt} = (f_{ijt} + tar_{ijt}) * (dist_{ij})^{\rho} (inet_{jt})^{\gamma_o} (inet_{jo})^{\gamma_1} (e^{(\delta_1^k lang_{ij} + \delta_2^k adj_{ij})})$$

This equation states that trade costs are a function of the freight rates (f_{ijt}), the level of tariffs (tar_{ijt}), distance between two trading partners ($dist_{ij}$), a language dummy variable which is 1 if two countries' citizens speak a common language and 0 otherwise, adjacency (adj_{ij}) which is a dummy variable that equals 1 if two countries share a common border, and Internet penetration (inet) which is a measure of the degree of Internet infrastructure between two partners. In our case, the inet variable will consist of two components $inet_{jt}$ and $inet_{jo}$. The first of these is the number of Internet hosts in a country for a given year, and the second of these is the number of Internet hosts which the country had by the end of 1994.

While the current Internet host level variable derives directly from our earlier discussions, the second merits further explanation and justification. In particular, the size of the initial level of hosts provides an indication of a country's initial stock of knowledge of information technology. A country with a larger initial stock of technological knowledge should be able to more efficiently use later acquisitions of the technology through learning-by-doing. Moreover, initial host levels could be considered a measure of the extent to which firms in a country have made commercial use of the Internet. Those individuals and firms with the greatest expected value of the Internet include commercial users who would likely be the early adopters. Since subsequent adoption will then likely be of lower commercial value, the measure of the effect of current host levels will be muted in subsequent years. As such, including the initial host level variable will allow us to measure the value of the first wave (pre-1994) adoption as well as measure the importance of initial information technology conditions on subsequent development of trade.

Given our earlier discussion on the effect of the Internet, it is then expected that both initial and current Internet hosts will have a negative effect on trade costs and a positive effect on trade itself. The only significant difference between this equation and that which was presented by Hummels (2001) is the use of internet variables. In our model, the Internet variables enter in the same form as distance, and this specification would be consistent with Rauch and Trindade's (2003) view of information as being represented by distance.

With this modification, we restate equation (2) as follows:

(4) $$\ln x_{ijt} = k + \ln y_{it} y_{jt} + (1-\sigma) * \ln(f_{ijt}^k + tar_{ijt}^k) + (1-\sigma)\rho * \ln(dist_{ij}) + (1-\sigma) * \delta_1^k lang_{ij} + (1-\sigma) * \delta_2^k adj_{ij} + (1-\sigma)(\gamma_o \ln(inet_{jt}) + \gamma_1 (inet_{jo})) - (1-\sigma) * P_i - (1-\sigma) * P_j$$

Since the multilateral resistance variables are generally unobservable and given that most such equations are fraught with omitted variable problems, we follow Hummels (2001) and Anderson and van Wincoop (2003) and employ country dummy variables to control for some of the obvious differences between trading partners as well as these multilateral resistance terms. Since we will estimate this model using a panel of data, we will also control for years with time dummy variables. Importantly, this use of country and year dummy variables overcomes the criticisms which Anderson and van Wincoop (2003) make of traditional uses of the gravity model.

Freight and tariff variables are also deleted from the model. Unfortunately, freight data is not available for a broad base of countries, and data on actual or applied tariffs are not available for each year of our sample. Hummel's (2001) reason for using freight and tariff variables was to obtain a direct measure of the trade elasticity of substitution. The information omitted should have the largest impact on our dummy variable coefficients and the coefficient on distance. Once we include country and year dummy variables, our basic estimating equation is consistent with the standard model seen in the literature.

$$\ln(x_{\mathrm{ijt}}) = \beta_{\mathrm{o}} + \beta_1 \ln(y_{it} y_{jt}) + \beta_2 \ln(dist_{ij}) + \beta_3 \ln(inet_{ijt}) + \beta_4 \ln(inet_{ijo}) + \beta_5 adj_{ij} + \beta_6 lang_{ij} + \sum_k \lambda_k D_k + \sum_t \theta_t D_t + \varepsilon_{\mathrm{ijt}}. \tag{5}$$

As with Fink, Mattoo, and Neagu (2002), we recognize that the cost of Internet use might affect trade and consider two alternative specifications for the effects of the price of Internet use on trade. Since we only had Internet price data for 2003 from the World Development Indictors, these regressions are simply cross-sectional; therefore, we omitted country and time dummies. The results from these regressions were ultimately unsatisfactory, and we omit further discussion of them here. Finally, as Freund and Weinhold (2004) note, since the above regressions on level data could be confounded by the many correlations among level effects, we also consider the estimation of a growth equation. As these results are similarly unsatisfactory, we omit further discussion of them.

DATA

Bilateral trade data comes from the Foreign Agricultural Trade of the United States (FATUS) data set of the Foreign Agricultural Service of the United States Department of Agriculture. Table 1 shows the list of trading partners for which these data were collected. We obtained 1995-2004 data on the total value of agricultural exports and imports. At a more disaggregated level, we also collected export value data for the following (i) animals and products, (ii) cotton, excluding linters, (iii) grains and feeds, (iv) fruits and preparations, (v) nursery stocks, bulbs, and related products, (vi) oilseeds and products, (vii) vegetables and preparations, and (viii) wine. For imports, one additional trade value was included (cut flowers) and one was excluded (cotton). The diversity of these data types will allow us to further examine whether product quality/perishability issues have an important relationship to the effects of the Internet on agricultural trade.

Given that we are attempting to test the importance of the Iinternet on trade, we consider two types of data. Our primary measure (as was used by Freund and Weinhold (2002, 2004)) will be a measure of Internet penetration from the Internet Systems Consortium (ISC) survey which reports the number of Internet hosts in a country. Freund and Weinhold (2004) discuss that this may be a relatively weak direct measure for Internet penetration due to the fact that U.S. and European sites may host sites for firms and individuals from other countries. Nonetheless, as Freund and Weinhold argue, it should provide a reasonable proxy and is the best available measure. The specific data used was the number of hosts from 1995 until 2005 which were listed in ISC's January report of each year. Given the fact that these data essentially report the previous year's end-point on levels of hosts, these data are appropriate measures of concurrent host levels.

It would have been worthwhile to consider a slightly earlier starting point for these host levels, but the ISC only began collecting disaggregated country level data in 1995. That being said, based on the ISC's aggregated data, the number of hosts on an aggregated worldwide basis was relatively small in the years preceding 1995, and one might argue that Internet availability only began to achieve a critical mass around 1995. To test the effects of Internet pricing on trade, we obtain World Development Indicator data on the average monthly price for Internet use. As noted, this data is only available for the year 2003, so we are only able to consider its impact in a fairly restricted cross-sectional setting.

Table 1. Country List

Algeria	Italy
Argentina	Japan
Australia	Jordan
Austria	Kenya
Belgium	Korea, Rep.
Bolivia	Kuwait
Brazil	Malaysia
Canada	Mexico
Chile	Morocco
China	Netherlands
Colombia	New Zealand
Denmark	Norway
Ecuador	Pakistan
Egypt, Arab Rep.	Paraguay
Ethiopia	Peru
Finland	Philippines
France	Poland
Germany	Portugal
Ghana	Saudi Arabia
Greece	Singapore
Guatemala	South Africa
Guyana	Spain
Hong Kong, China	Sweden
Hungary	Switzerland
Iceland	Thailand
India	Tunisia
Indonesia	Turkey
Iran, Islamic Rep.	United Kingdom
Ireland	Uruguay
Israel	Venezuela, RB

Other data which are used to control for cross-national differences and causes of bilateral trade include GDP, the distance from the U.S., if a trading partner's national language is English, and whether the U.S. is in a trade agreement or adjacent to a country. The measure of geographic distances between countries is drawn from Fitzpatrick and Modlin (1986). GDP data is obtained from the World Development Indicators. Language data is obtained from the Central Intelligence Agency and is used to distinguish whether a country's primary language is English. Trade agreement data is obtained from the World Trade Organization; while adjacency data includes Mexico and Canada. Given that this research specifically considers

U.S. bilateral trade, the key trade agreement and adjacency dummies only include Mexico and Canada, so we merge them. For a concordance of theoretical variables and data used, please see the appendix.

SOME MEASURES OF THE EFFECTS OF THE INTERNET ON U.S. AGRICULTURAL TRADE

To obtain the following results, we use the panel of data for the years 1995-2004 to estimate equation (5) for imports and exports of each of the commodity groupings listed in the data section. To obtain our estimates we use scaled ordinary least squares (scaled OLS) in order to avoid truncation bias associated with zero observations in the import and export data. While the majority of the trade data considered has few zero observations there are cases (cotton exports, flower imports, nursery imports, seed imports, and wine imports) where zero observations represent greater than 15 percent of the total number of observations. Tobit would be one method for estimating these regressions and eliminating truncation bias; however, other researchers (Eichengreen and Irwin, 1998; Anderson and Smith, 1999; and Tang, 2003) have used scaled OLS given the ease with which coefficients may be interpreted (i.e., as elasticities). The appropriateness of this approach is based on findings by Greene (1981 and 2000, p. 910). Scaled OLS maintains the double-log specification shown in equation (5) but simply adds 1 to all trade data before taking their natural logs (i.e., $\ln(x_{ijt})$ becomes $\ln(x_{ijt} + 1)$). As noted by Eichengreen and Irwin (1998), for large trade values $\ln(x_{ijt} + 1)$ is approximately equal to $\ln(x_{ijt})$, and for small values $\ln(x_{ijt} + 1) \approx x_{ijt}$ and therefore approximates the semi-log Tobit relationship. Other details of the approach are discussed in Eichengreen and Irwin (1998), Anderson and Smith (1999), and Tang (2003).

Given these econometric preliminaries, since our main focus is on the Internet parameters, we only consider the results for those coefficients in our discussion below. The rest of the results are, for the most part, consistent with traditional trade regressions. The results of these estimations appear in tables 2 and 3 below. Table 2 shows the coefficient estimates for the Internet variables from the export regressions where both the equation and at least one Internet hosting parameter were found to be significant at the 5% level or better using White-corrected standard errors. Table 3 shows the analogous estimates for the import regressions.

From table 2, we note that almost all of the coefficients on the log of host variables are not significant in any of these regressions, with one exception being the parameter on current host levels for wine. Nonetheless, we observe that the coefficients on the log of the initial level of hosts are almost all significant at the 5% level (with the exception of oilseed exports). In particular, the initial level of hosts has a positive and significant effect on exports for animal products, fruits and preparations, nursery products, and wine. Each of these products requires very specific shipping conditions and each is subject to perishability problems. Notably, the coefficient on oilseed exports is positive but fails to satisfy the 5% threshold for significance. This smaller effect probably stems from the fact that oilseeds are not as perishable relative to the other products listed.

Table 2. The Effects of the Level of Internet Hosts on U.S. Exports

	Animals and products	Cotton	Fruits and preparations	Nursery stocks, bulbs, and related products	Oilseeds and products	Vegetables and preparations	Wine
LN(Internet Hosts)	0.00	0.03	-0.08	0.06	0.01	-0.01	-0.18*
	(0.96)	(0.81)	(0.40)	(0.43)	(0.92)	(0.94)	(0.00)
LN(1994 Internet Hosts)	0.18*	-0.65*	0.72*	0.45*	0.12*	0.25*	0.48*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.06)	(0.00)	(0.00)
LN(GDP_{US}*$GDP_{partner}$)	2.83*	0.16	6.71*	1.84	2.57*	1.33	2.63*
	(0.00)	(0.91)	(0.00)	(0.07)	(0.00)	(0.25)	(0.00)
LN(Distance)	1.24	-3.40*	5.74*	-0.35	1.42*	-0.56	0.54
	(0.10)	(0.04)	(0.00)	(0.73)	(0.05)	(0.63)	(0.60)
LN(Language)	-0.50	7.95*	-0.66	1.18	-2.95*	-0.89	2.66*
	(0.69)	(0.00)	(0.59)	(0.21)	(0.00)	(0.51)	(0.00)
Constant	-156.06*	25.19	-411.92*	-97.38	-140.31*	-0.59.70	-148.31*
	(0.00)	(0.79)	(0.00)	(0.12)	(0.00)	(0.42)	(0.02)
R-squared	0.88	0.84	0.91	0.88	0.91	0.91	0.92

Note: Values in parenthesis are p-values, and an asterisk (*) indicates a statistically significant coefficient.

Table 3. The Effects of the Level of Internet Hosts on U.S. Imports

	Total agricultural imports	Animals and products	Cut flowers	Fruits and preparations	Nursery stocks, bulbs, and related products	Oilseeds and products	Seeds (field and garden)	Vegetables and preparations	Wine
LN(Internet Hosts)	-0.15*	0.14	-0.05	0.02	0.02	-0.08	0.05	-0.14	-0.08
	(0.03)	(0.08)	(0.40)	(0.82)	(0.74)	(0.61)	(0.62)	(0.08)	(0.46)
LN(1994 Internet Hosts)	0.43*	0.65*	0.50*	0.37*	0.68*	0.34*	0.54*	0.36*	0.93*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LN(GDP_{US}*$GDP_{partner}$)	1.49*	1.14*	1.49	3.79*	1.32	-0.33	2.00	1.37*	0.90
	(0.02)	(0.05)	(0.09)	(0.00)	(0.14)	(0.75)	(0.08)	(0.03)	(0.42)
LN(Distance)	0.88	1.24*	1.09	3.79*	-0.05	-3.44*	1.38	-0.155	1.99
	(0.17)	(0.04)	(0.23)	(0.00)	(0.95)	(0.00)	(0.23)	(0.81)	(0.09)
LN(Language)	6.01*	6.31*	3.61*	2.53*	1.98*	4.52*	3.38*	7.80*	-0.72
	(0.00)	(0.00)	(0.00)	(0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.53)
Constant	-84.20*	-74.14*	-91.23	-235.97*	-73.00	46.65	-121.77	-73.57	-66.53
	(0.03)	(0.04)	(0.10)	(0.00)	(0.19)	(0.47)	(0.09)	(0.06)	(0.06)
R-squared	0.94	0.97	0.91	0.93	0.93	0.90	0.91	0.95	0.94

Note: Values in parenthesis are p-values, and an asterisk (*) indicates a statistically significant coefficient

Finally, the coefficient on cotton exports is negative and significant. In this regard, one might expect that improving information technology had a positive effect on the ability of U.S. competitors in cotton to better compete in markets which have traditionally served as outlets for U.S. exports. In essence, while U.S. cotton exporters may have had the traditional informational and relational advantage in shipping to certain markets, the rise of the Internet has eroded that advantage and thereby weakened its trading position relative to its competitors. However, one would not want to overstate this argument given the dramatic changes in the international cotton markets and general increasing competition from other cotton supplying countries through the 1990s and 2000s (Meyer et al. 1996; Meyer et al. 1999; Meyer, MacDonald, and Skinner 2004). Other factors for which we have been unable to control may also explain this negative relationship. Referring back to the negative coefficient on the current host levels, a similar argument for wine as that for cotton probably holds. Nonetheless, the thrust of these results indicates that initial host levels have had a positive effect on U.S. exports, and particularly so for perishable and differentiated commodities. Results for total agricultural exports (not reported in table 2) indicate that the effects of the Internet variables on total U.S. agricultural exports were statistically insignificant.

The regression results also indicate that the Internet effect on one of U.S. agriculture's largest exports, grains and feed, is insignificant. Such products are much less subject to problems of perishability compared with the other exports for which we found significant results thereby providing further evidence of the differential effect of the Internet on types of products. Further, excepting the case of cotton, the effect of the initial level of Internet hosts was non-negative thereby providing evidence in support of another claim based in the theoretical literature.

The regression results for our import regressions are seen in table 3. For our current Internet hosting variable, only the coefficient for the total agricultural imports regression is significant. Moreover, it is negative. This is a surprising result, however, we must balance this with the coefficient estimated for the initial host levels which is positive and significant for total agricultural imports. Before discussing the rest of the results, we will consider this apparent anomaly here. The economic model upon which our econometric specification is based can be shown to be homogeneous of degree zero in trade costs (Anderson and van Wincoop 2003). Consequently, uniform changes in current costs should have no direct effect on the volume of trade. However, we see a positive relationship between the U.S. trading partner's 1994 level of Internet hosts and the extent to which we import from those countries. That is, the initial differences in informational costs help to account for the volume of trade to the extent that a 1% increase in the initial level of Internet hosts would lead to a 0.42% increase in the value of imports.

The subsequent observation that the current level of Internet hosts is negatively related to the volume of trade could therefore arise from the fact that many countries are "catching up" from a negative competitive position in terms of information costs. These countries started out behind those with a larger Internet infrastructure and therefore had lower imports initially. Their efforts to catch up do not eliminate the gap in trade volumes but simply prevent further erosion of their competitive position. The negative relationship between current hosting levels and the volume of imports would then be an artifact of the different countries' initial levels of infrastructure. Moreover, as we discuss later, the additions of Internet hosts could be those with lower marginal values (e.g., those directed at households rather than commerce) and hence could have minimal effect.

As we consider the more disaggregated distribution of products, we see that coefficients on the initial level of hosts are positive and significant for animal imports, floral imports, fruit imports, nursery stock imports, oilseed imports, seed (field/garden) imports, vegetable imports, and wine imports. Grains and feeds imports are not shown as their parameter estimates were found to be insignificant. With the exception of the total value and oilseeds, the products for which significant effects are found are either perishable or potentially quality differentiated. The list for positive and significant effects on imports overlaps that for exports for animals and products, fruits and preparations, nursery products, oilseeds, vegetables, and wine. This overlap provides further evidence that goods which are more heterogeneous in quality or perishable are more subject to trade effects from the development of the Internet.

For our level regressions which incorporate the price terms, no regression exhibits significance as a whole or in the relevant Internet host and internet pricing variables. While this is disappointing, it may well stem from the limited number of observations used for the 2003 period. As mentioned earlier, the results on our growth estimations are similarly weak.

In concluding this section, it is worthwhile mentioning that we checked the robustness of the coefficients on the initial host levels through a variety of alternative specifications. In particular, we ran regressions excluding the current host levels but including various lags (one, two, and three year) of the host level, and we ran regressions including the current host levels along with the various lags. The coefficient estimates on the initial host levels were robust to these changes in specification, with the possible exceptions of cotton and wine exports and floral imports. While the signs on the initial host levels remained consistent with their earlier results across these three product types, they were not significant. We further tested whether the results on the initial host variable were unique to using 1995 as the starting year and 1994 host levels as the initial host level. Specifically, we ran the regressions with 1996 and 1997 as the starting years and 1995 and 1996 host levels as the initial host levels, respectively. We found that the effects were generally unique to using 1994 host levels as the initial host level variable, strengthening our conviction in the coefficients obtained for that variable.

In contrast to our results, Freund and Weinhold (2002, 2004) find a positive effect of current Internet host levels on aggregate U.S. bilateral trade and in services. Aggregate trade includes final goods while agricultural trade includes bulk and higher value goods for which wholesalers and brokers are the major intermediaries. In this case, it is not surprising that trade in agricultural products is less responsive to new host sites. Further, by failing to control for country specific effects, the Freund and Weinhold analysis is subject to the criticism of Anderson and van Wincoop who argue that country dummy variables, at a minimum, should be used to control for omitted variable biases when fitting gravity-like models to data. Notably, we also found better results on our current host levels when country dummy variables were left out of the regressions; however, since such an approach is burdened by such heavy omitted variable problems, those results would have dubious reliability.

THE VALUE OF THE INTERNET TO TRADE

This section will highlight the economic value of the import and export effects using the level data regression results. The basic idea is to consider how increasing the initial level of hosts across all countries would have affected the value of U.S. exports and imports at the margin. Using the coefficients and our data, we imputed the marginal export/import value for each country from an additional host in 1994 (i.e., $\partial x_{ijt}/\partial hosts_{1994}$.) We then summed these values across countries for a particular product in a particular year to get an aggregated marginal value of additional initial hosts. For purposes of comparison, in 1994, there were a total of 1,625,568 Internet hosts residing in the 60 countries studied here, so these imputed marginal values are based on a modest increase in the total number of hosts in 1994 (i.e., 60 more hosts across the 60 countries.) The imputed values are shown in tables 4 and 5.

From this process, we observe that initial hosting levels have positive although appropriately small effects on the value of exports and imports. In particular, we observe that for animal, fruit, and oilseed exports, the annual value from more initial hosts at the margin would have been between $2 million and $12 million over each of these commodities and years. For cotton, the addition of new hosts in 1994 would have reduced U.S. exports of cotton from between a minimum of $666,284 in 2001 to almost $5 million in 1995. While we showed that the initial level of Internet hosts had a positive and statistically significant effect on nursery and wine exports, the actual economic impact of such additions would have been almost insignificant with contributions of less than $100,000 for each of the years in the sample. Nonetheless, when we look at the sum of the effect of additional hosts in 1994 over all exports, we see that the minimum impact would have been $12 million in 2000 and a maximum of about $19 million in 1997. While small compared to the actual aggregate value of exports, these values provide a measurable marginal impact of the Internet – small, but economically meaningful.

The marginal effects of the Internet on the value of agricultural imports from 1995 until 2004 are shown in table 5. In this case, we were able to take the values from the total agricultural imports as well as those from our other regressions on disaggregated data which yielded significant results. In the results on total agricultural imports, we see an increasing marginal value of the initial stock of hosts on imports. In 1995, the marginal value would have been $6,652,655. This value continues to grow to $15, 058,923 in 2004.

The imputed marginal values from the rest of table 5 suggest that, for the products for which we had significant coefficients, the sum of these values across animal, floral, fruit, nursery, oilseed, seed, vegetable, and wine imports is but a fraction (about 1/3) of the value imputed from the total agricultural imports regression. Other impacts at the product level must be felt but are simply not statistically observable or come from products not included in this study. Nonetheless, for these products the annual effect is generally small, with a maximum impact at around $1.3 million for animal exports in 2004. However, consider the marginal impact on floral imports given that this particular product represents a type of product which could benefit most from the improved logistics associated with new and better information technology. These values range between $254,213 and $369,400 – quite small. However, the vast majority of the marginal gain is attributable to the marginal values associated with Colombia and Ecuador – the two primary sources of floral imports for the United States. If we sum the 2004 values of U.S. imports from those countries, we see that the

Table 4. Imputed Marginal Values of Increased Initial Host Values on Exports (in dollars)

	Animals and products	Cotton	Fruits and preparations	Nursery stocks, bulbs, and related products	Oilseeds and products	Vegetables and preparations	Wine	Total[a]
1995	3,824,673	-4,823,118	6,467,619	69,261	9,360,228	505,020	8,957	15,763,659
1996	3,023,475	-2,321,657	8,591,871	61,605	8,059,173	488,082	12,895	18,352,826
1997	3,111,923	-2,491,704	6,321,229	88,426	11,632,694	492,861	15,533	19,560,015
1998	3,573,472	-2,189,436	4,864,068	85,851	9,397,173	514,086	15,255	16,551,082
1999	2,499,623	-851,282	2,869,886	76,632	6,986,207	515,299	15,130	12,374,787
2000	2,894,632	-1,063,471	3,347,789	53,347	6,228,248	529,873	14,475	12,292,719
2001	2,812,131	-666,284	3,290,642	32,628	7,986,931	562,054	11,316	14,292,952
2002	2,377,714	-1,062,866	3,156,495	32,015	8,244,677	480,414	10,508	13,557,603
2003	3,561,186	-1,437,289	4,579,819	49,105	8,046,793	532,550	11,708	15,833,554
2004	3,540,240	-1,061,453	3,907,922	46,118	6,696,813	1,150,402	14,700	14,918,591

[a] Since the initial host coefficient was statistically insignificant in the total agricultural exports regression, this value is calculated by summing all of the values in the other columns.

Table 5. Imputed Marginal Values of Increased Initial Host Values on Imports (in dollars)

	Animals and products	Cut flowers	Fruits and preparations	Nursery stocks, bulbs, and related products	Oilseeds and products	Seeds (field and garden)	Vegetables and preparations	Wine	Total agricultural imports[a]
1995	601,276	377,077	584,980	18,978	356,489	55,569	354,737	46,824	6,652,655
1996	714,696	308,587	753,205	21,688	293,205	76,391	385,698	69,536	7,268,169
1997	752,385	317,498	837,277	19,443	458,064	54,124	355,106	84,591	8,970,972
1998	740,940	369,400	820,725	27,299	400,630	67,127	399,792	81,138	8,322,094
1999	921,810	291,800	795,455	32,197	375,683	117,816	507,413	91,079	8,194,258
2000	847,445	250,563	785,919	36,343	324,654	116,039	501,587	96,317	9,200,179
2001	1,117,495	254,213	772,724	35,609	428,537	88,274	643,771	112,645	9,267,509
2002	1,064,274	294,658	1,193,787	35,873	548,644	84,880	772,233	114,709	10,048,001
2003	944,333	284,970	1,234,568	41,420	754,941	99,480	857,740	152,724	12,639,186
2004	1,308,333	272,993	1,279,182	54,702	1,191,391	110,682	805,759	144,060	15,058,923

[a] Given that the initial host coefficient was significant in the total agricultural imports regression, this value is imputed from the coefficients obtained from that regression.

U.S. buys about $549 million in floral products from those two countries or approximately 80 percent of all cut flower imports. Moreover, 95 percent of the 2004 marginal value of initial hosts accrues to those two countries. While this value is small, it is nonetheless notable in that such a technological change can have a measurable impact in such a complex trading relationship.

For purposes of comparison of the relative marginal effects of the Internet on exports and imports, Figure 1 graphs the marginal impacts of the Internet on exports and imports. The initial stock of hosts among our trading partners has a positive marginal impact on both exports and imports. However, while initial hosts have a declining marginal effect on exports, the marginal effect on imports is increasing. One interpretation of this observation would be that U.S. firms had an initial advantage in using the available Internet hosts to expand its exports; however, as our trading partners gained more experience, they were better able to use their stock to their advantage. Moreover, the larger was a country's initial host level, the greater was their ability to penetrate U.S. markets later in our period of study. Note that the relative impacts are moving in an inverse relationship such that in the final year the marginal import effect essentially equals the marginal export effect.

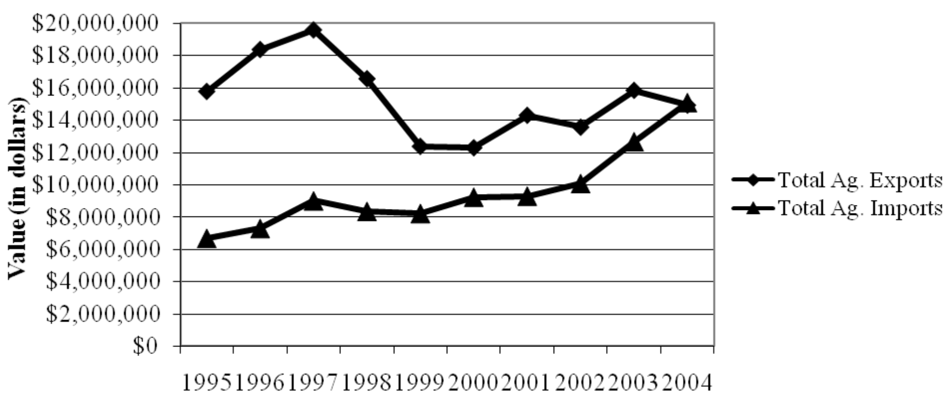

Figure 1. The marginal effects of initial hosting levels on agricultural trade, 1995-2004.

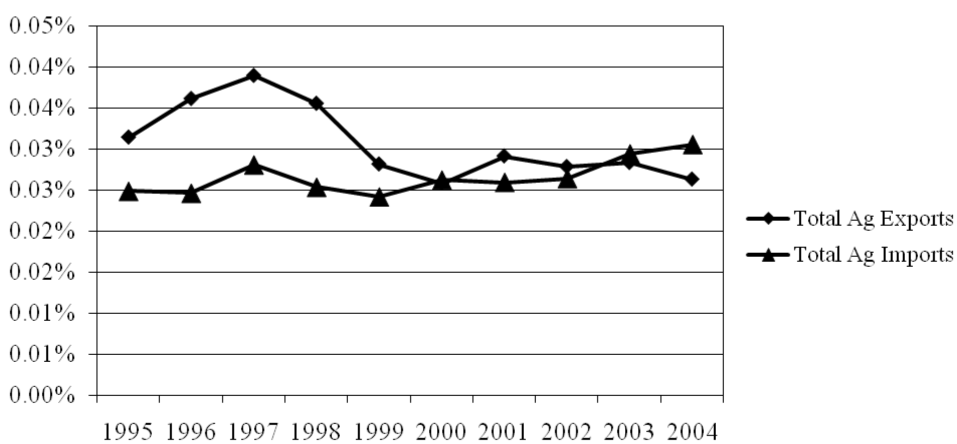

Figure 2. Marginal effects of initial hosts as a percentage of total value.

Table 6 provides another perspective on the marginal impacts of the initial Internet stock on imports and exports. Specifically, we calculate the marginal effects as a percentage of the total value of the respective commodities traded in each year. Goods where the impact of the Internet is at least 0.01% are included in this table (with the exception of wine). The marginal impact as a share of total exports and imports, respectively, remains almost constant at 0.03% - very small. However, for oilseed exports, we observe that the marginal increase in exports amounts to about $1/10^{th}$ of a percent in each of the years of our study. Furthermore, for fruits and preparation exports, this value reaches as high as four tenths of a percent. In other words, the marginal increase in exports amounts to four tenths of a percent of the total volume of trade in a year. For imports, the marginal impact on animal imports lies at about one tenth of a percent. Also, the imputed effect of the internet on floral imports as a share of total current import volume is between 0.04% and 0.09% of total volume of floral trade.

In interpreting these results, recall that these values correspond to the initial level of Internet hosts. With that in mind, these values essentially capture the potential rents or trade shares available to this subset of trading partners had they had a larger initial stock of hosts. Referring back to the underlying trade theory, we recall that it is the differential of transaction costs that will affect trade, not uniform increases or decreases, i.e., one trading partner’s gain could represent a loss to another partner. This marginal gain represents a potential gain but also a loss to those partners who do not “catch up” in their level of hosting. Given the increasing marginal values on imports, incentives appear to exist for our trading partners to increase their stock of hosts to keep even with competition. In other words, those with the highest marginal values on imports (exports for them) will have a higher rate of catch up.

To check or illustrate this simple idea of catch up, we took the average marginal value of total agricultural imports from each country and the average growth rate of hosts over the 1994-2004 period. We then ran a simple regression with the growth rate of Internet hosts being a function of the marginal value of an additional level of hosts in 1994. From that simple regression, we observe that a 1% increase in the marginal value of initial hosting yields a statistically significant 0.14% increase in the growth rate of hosting in subsequent years. This sort of change is notable in the sense that lagging countries are seen as subsequently catching up in order to avoid potential losses in trade due to higher relative costs of trading with them. If these countries failed to catch up, one might argue that their trade position with the United States could deteriorate. In addition to this simple regression, we observe that 9 of the 10 countries with the highest marginal values on initial Internet hosting are in the top 15 in subsequent growth rates on Internet hosting. These countries include major trading partners of the United States as well as some smaller South American trading partners: Argentina, Brazil, China, Colombia, India, Indonesia, Mexico, Peru, and the Philippines.

Table 6. Marginal Effect of Internet Stock as a Share of Total Value of Trade

	Exports							
	Animals and Products	Cotton	Fruits and Preparations	Nursery Stocks, Bulbs, and Related Goods	Oilseeds and Products	Vegetables and Preparations	Wine	Total
1995	0.04%	-0.14%	0.27%	0.03%	0.13%	0.02%	0.004%	0.03%
1996	0.03%	-0.09%	0.36%	0.03%	0.09%	0.01%	0.005%	0.04%
1997	0.03%	-0.10%	0.26%	0.03%	0.11%	0.01%	0.004%	0.04%
1998	0.04%	-0.10%	0.21%	0.03%	0.11%	0.01%	0.003%	0.04%
1999	0.03%	-0.10%	0.13%	0.03%	0.10%	0.01%	0.003%	0.03%
2000	0.03%	-0.06%	0.14%	0.02%	0.09%	0.01%	0.003%	0.03%
2001	0.03%	-0.04%	0.13%	0.01%	0.10%	0.01%	0.002%	0.03%
2002	0.03%	-0.06%	0.12%	0.01%	0.10%	0.01%	0.002%	0.03%
2003	0.03%	-0.05%	0.17%	0.02%	0.08%	0.01%	0.002%	0.03%
2004	0.04%	-0.03%	0.14%	0.02%	0.07%	0.02%	0.002%	0.03%

Table 6. (Continued)

	Imports								
	Animals and Products	Cut Flower	Fruits and Preparations	Nursery Stocks, Bulbs, and Related Goods	Oilseeds and Products	Seed Imports	Vegetables and Preparations	Wine	Total
1995	0.11%	0.09%	0.02%	0.01%	0.02%	0.02%	0.01%	0.004%	0.02%
1996	0.12%	0.06%	0.01%	0.01%	0.02%	0.03%	0.01%	0.005%	0.02%
1997	0.14%	0.06%	0.01%	0.01%	0.02%	0.02%	0.01%	0.005%	0.03%
1998	0.12%	0.07%	0.01%	0.01%	0.02%	0.02%	0.01%	0.004%	0.03%
1999	0.11%	0.05%	0.01%	0.01%	0.02%	0.03%	0.01%	0.004%	0.02%
2000	0.11%	0.04%	0.01%	0.01%	0.02%	0.02%	0.01%	0.004%	0.03%
2001	0.10%	0.05%	0.01%	0.01%	0.03%	0.02%	0.01%	0.005%	0.03%
2002	0.11%	0.06%	0.01%	0.01%	0.03%	0.02%	0.01%	0.004%	0.03%
2003	0.15%	0.05%	0.01%	0.01%	0.04%	0.02%	0.01%	0.005%	0.03%
2004	0.14%	0.05%	0.01%	0.01%	0.04%	0.02%	0.01%	0.004%	0.03%

CONCLUSIONS

This research is the first to provide findings on the effect of the Internet on the level of U.S. agricultural imports and exports at both an aggregated and disaggregated level. Insights are also provided on whether the Internet has differential effects on imports and exports depending on the degree to which products are differentiated and perishable. Finally, we also asked if the effect of the Internet on exports was less than that on imports. With level data on imports and exports, the first approach to investigate these questions was to use a model derived from the standard gravity model found in the trade literature. Given potential problems of using level data, we also tested whether the growth in the level of the Internet variables had a measurable impact on the growth in imports and exports.

We find that the effect of current levels of Internet hosts is almost uniformly insignificant – neither negative nor positive (tables 2 and 3). This result is not too surprising since (a) the important host sites are likely to be associated with firms at the wholesale level of transactions and these firms are likely to be early adopters of this technology and (b) the gains to information for purposes of international transactions in agricultural commodities are likely to accrue to a small proportion of total hosts with the evolution of latter host sites being more directly linked to households. Consistent with this view, we find a frequent positive and significant coefficient on the variable which provides the measure of **initial** levels of host sites.

The one exception to this finding was the effect of initial host levels on cotton exports and the current host levels for wine exports. Excepting these cases, the findings support the notion that the Internet has a positive effect on the volume of trade. The products for which significant coefficients are found include those which fit into the category of being highly perishable and/or differentiated and requiring monitoring and care during transportation. With regard to our third prediction, there does not appear, on balance, to be substantial evidence supporting the idea that the import effect is stronger than the export effect. Eight product groups for imports and seven product groups for exports show a positive relationship between the level of initial hosts and the level of trade, and the coefficients are generally of the same order.

As a final consideration of the value of the Internet to trade, we also computed the marginal values of initial host sites to trade in a variety of products. The marginal values were small relative to the sheer size of agricultural trade; however, they were economically meaningful both in dollar values and as a share of the total volume of agricultural trade. This result suggests that the Internet has lowered costs of trading between partners. Moreover, results indicated that the marginal economic value of higher initial stocks of Internet hosts was greater for those countries with a smaller initial stock of hosts. Given those incentives, we showed that the subsequent decade of expansion of Internet infrastructure was marked by catch up by many of those countries which started with small initial host levels.

From these results, we note that the effects of the Internet on trade are small but of a reasonable magnitude. We further note that the existence of the Internet and its positive effect on the value of trade has presented a challenge to both exporters and importers. Those countries and producers which provide better access to information about their markets will potentially benefit at the expense of those who do not adopt a more progressive stance with regard to the infrastructure of the Internet. One might further extend this argument (as we see with the case of cotton exporters) to the notion that the Internet can help to erode markets for U.S. exporters or producers for the domestic market to the extent that it eliminates the information advantage which domestic producers have traditionally enjoyed in trade. Finally, as the share of higher value-added commodities (e.g., differentiated and perishable) in the value of total U.S. agricultural exports and imports continues to grow, it appears the Internet may become more important in promoting the exports and imports of these commodities.

The estimates obtained and values imputed in this research do not indicate that the Internet has revolutionized trade; however, the results tell us that the Internet has promoted further globalization in the market for agricultural products. In short, the effect of the Internet has been incremental and augmentative to the cause of globalization in agricultural trade.

Appendix Table. Relationship between Theoretical Variables and Data

Variable Name	Proxy
Product of U.S. and its trading partners GDP	GDP data on the U.S. and its trading partners.
Trading costs	
Freight rates and Tariffs	omitted
Distance	measured by direct line distances from Fitzpatrick and Modlin (1986)
Internet penetration	(i) measured by the current and initial level of hosts.
Adjacency	simply includes those countries adjacent to the United States (Mexico and Canada)
Language	includes a dummy variable which is 1 or 0 depending on whether a country's official language is English or not.
Multilateral resistance variables	omitted but proxied with country dummy variables.

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THE 2006 REFORM OF THE EU DOMESTIC POLICY REGIME FOR BANANAS: AN ASSESSMENT OF ITS IMPACT ON TRADE*

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ABSTRACT

The article provides a quantitative assessment of the possible market implications of the December 2006 reform of the EU domestic policy regime for bananas. It is shown that, depending on implementation choices made at the member country level, the impact on trade of the domestic policy reform can be of a larger order of magnitude than that of the controversial "tariff-only" regime the EU introduced earlier in the same year. The simulations presented in the article show that under the implementation choices made in August 2007 by France, Portugal and Spain, EU imports in 2013 will increase by 9% and MFN exports to the EU by 11%. Should they decide to "decouple" payments to their banana producers, EU imports will increase by 13% and MFN exports to the EU by 16%.

Keywords: bananas, trade modelling, trade policy,EPA, EU.
JEL classification codes: Q18, Q17, F17.

INTRODUCTION

The European Union (EU), with more than 30% of total imports, is the largest world importer of bananas, (the US is the second) and among the top 20 largest producers. Banana production in the EU is concentrated in the French Overseas Departments (Martinique and Guadeloupe) and Spain (Canary Islands), but production also takes place in Portugal (Madeira, Azores and in the continental area), Greece (Crete) and Cyprus. Domestic

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production is around one sixth of domestic consumption, with imports from MFN and preferred African, Caribbean and Pacific (ACP) countries accounting for two thirds and one sixth of the EU market, respectively. Bananas account for an important share of export revenue in all major exporting countries; in 2006 it was around 10 per cent for Costa Rica, Ecuador, Guatemala, Honduras and Panama.

On 1 January 2006 the EU introduced a new import regime for bananas, removing the quota for imports under MFN conditions, setting the MFN tariff equal to 176 €/t and expanding the duty-free quota reserved for imports from ACP countries from 750,000 to 775,000 t. In addition, from 1 January 2006 the Everything But Arms (EBA) initiative, which allows least developed country exports quota- and duty-free access to the EU market, has been fully implemented for bananas.

In December 2006 the EU approved a reform of its domestic policies for bananas. The previous Common Market Organization (CMO) regime for bananas provided generous and fully "coupled" support to domestic producers through a "deficiency payment" scheme; the per unit aid was given by the difference between a reference price, which did not change over time, and the observed domestic price. The reform cancelled the CMO for bananas. For banana production outside the "outermost regions" (Greece, Cyprus and continental Portugal) support (€4.6 million) has been fully "decoupled" and included in the "Single Farm Payment" (SFP) introduced by the June 2003 Fischler reform of the Common Agricultural Policy (CAP). For the "outermost regions" (Guadelupe and Martinique in France; Azores and Madeira in Portugal; Canary Islands in Spain)[1] financial resources of a similar order of magnitude to those previously absorbed by deficiency payments (€278.8 million) have been added to the budget allocation of the *Programme d'Options Spécifiques à l'Eloignement et Insularité* (POSEI) (EC 2006); this programme finances the use in EU's "outermost regions" of a wide range of policy instruments, whose aim is to increase in these disadvantaged regions the competitiveness of agricultural production as well as food consumption. The decision on which policy instruments to implement is left to the individual member country; feasible actions under the POSEI programme now include direct payments to banana producers.

The goal of the article is to provide a quantitative assessment of the possible impact on trade of this radical change in the EU domestic policy regime for bananas, an issue which seems to have attracted very little attention so far, despite its potential relevance. The next section presents the structure of the model, the data used and the assumptions made. In section two the results of the simulations performed are presented. Section three contains an assessment of the sensitivity of the results obtained to the assumptions made with respect to some of the exogenous parameters used in the model and section four concludes.

1. The Model

The model used is a revised and expanded version of the one used in Anania (2006); it differs in two ways: the five EU banana producing member states are now modelled

[1] The "outermost regions" include as well La Réunion and Guyane in France, however, banana production in these regions is negligible.

individually and the representation of the domestic policy instruments in the EU is more detailed.

The model used is a single commodity, spatial, partial equilibrium, mathematical programming model (Takayama and Judge 1971), which considers five sources of domestic supply within the EU, fourteen exporting and eight importing countries/regions (table 1). EU domestic production takes place in France (Martinique and Guadalupe), Spain (Canary islands), Portugal (Madeira and Azores),[2] Greece (Crete) and Cyprus.

Table 1. Base Model Input Data and Model Calibration (2002)

Country/Region	Base Net imports (000 t)	*Estimated Net imports[1] (000 t)*	Base Net exports (000 t)	*Estimated Net exports (000 t)*	Import prices ($/t)	Export prices[2] ($/t)	Export supply price elasticities	Import demand price elasticities	Domestic demand income elasticities
EU-15	4059.7	*4193.5*			588.6			-0.50	0,5
Czech Republic	99.6	*103.0*			495.7			-0.75	1
Slovakia	46.0	*46.4*			458.4			-0.80	1
Poland	232.0	*233.,4*			446.3			-0.80	1
Hungary	101.6	*75.5*			391.5			-0.75	1
Other six EU new member states	60.3	*60.8*			549.3			-0.80	1
USA	3490.4	*3411.0*			272.4			-0.40	0,4
Other importers	4510.3	*4433.9*			375.0			-0.80	0,5
Spain			407.3	*407.3*		681.5	1.0		
France			358.9	*358.9*		519.7	1.0		
Portugal			21.9	*21.9*		584.7	1.0		
Greece			2.4	*2.4*		719.8	1.0		
Cyprus			10.5	*13.3*		257.5	1,0		
Ivory Coast			256.0	*247.5*		289.1	1.5		0.5
Cameroon			238.4	*231.1*		217.1	1.5		0.5
Dominican Republic, Belize and Suriname			179.2	*171.7*		404.5	1.0		0.5
Jamaica, Windward Islands and other ACP non-EBA countries			156.2	*97.0*		455.1	1.0		0.5
ACP EBA exporters			2.6	*2.6*		205.1	1.5		0.5
Ecuador			4199.2	*4318.8*		223.0	1.3		0.5
Colombia			1418.1	*1347.8*		283.7	1.3		0.5
Costa Rica			1873.2	*1863.2*		264.3	1.0		0.5
Panama			403.9	*399.4*		270.9	1.0		0.5
Honduras			437.2	*441.2*		246.4	1.5		0.5
Brazil			241	*266.9*		156.1	1.0		0.5
Guatemala			974.0	*981.8*		221.7	1.5		0.5
Other MFN exporters			1327.9	*1338.5*		186.4	1.0		0.,5
EBA non-ACP exporters			47.1	*46.1*		190.6	1.5		0.5

[1]: For EU-15 apparent consumption (imports + domestic production - exports).
[2]: For Spain, France, Portugal and Greece farm gate prices, including basic aid; for Cyprus farm gate price.

Import demand and export supply functions, as well as domestic supply functions in the EU, are assumed to be linear, or to be well approximated by linear functions in the portion relevant for the simulations conducted. Import demand and export supply functions in the base year are obtained from observed imported and exported quantities, observed import and export prices, and import demand and export supply price elasticities at the equilibrium in each country/region (table 1); analogously, supply functions in the EU are obtained from observed produced quantities, relevant prices and supply elasticities. The values of the elasticities used are exogenously determined; they are based on those used in other studies (Arias et al. 2005; Guyomard, Laroche and Le Mouël 1999; Kersten 1995; Spreen et al. 2004;

[2] Banana production in continental Portugal is negligible and has been ignored.

Vanzetti, Fernandez de Cordoba and Chau 2005). Sensitivity analyses with respect to some of the values of the elasticities used have been performed and the results obtained have proved to be robust (these are presented in section 3). The sources for the data in the model are the FAOSTAT and COMTRADE databases, the World Bank and the European Commission.

The base model time reference is 2002. The representation of the EU-15 import regime in 2002 includes:

a. quota A/B: a 2,653,300 t import quota, with all imports occurring on a non-preferential basis subject to a 75 €/t tariff (ACP exports can enter quota A/B duty-free);
b. quota C: a 750,000 t quota allocated to duty-free imports from ACP countries only;
c. an out-of-quotas MFN import tariff of 680 €/t (380 €/t for imports from ACP countries).

The 2002 base model calibration appears satisfactory (table 1). The simple average percentage difference, in absolute value, between observed and predicted exports in 2002 is 5.3%; the analogous value for imports is 4.8%. If the exports- and imports-weighted average per cent differences, in absolute value, are considered instead, the average differences drop to 2.7% and 2.6%, respectively.

In the 2002 base model solution both EU-15 tariff rate quotas (TRQs) - quotas A/B and C - are binding; ACP exports to the EU-15 equal the C quota (750,000 t) and those by non-ACP countries equal the A/B quota (2,653,000 t).

Simulations for all policy scenarios considered have been generated with reference to 2013, when the reform of the CMO is to be fully implemented in all countries[3] and it is possible to assess the market effects of the adjustments in production decisions as a result of the changes in both the EU import and domestic policy regimes.

The 2002 base model has been "extended" to 2013:

a. by modelling the 2004 enlargement of the EU-15 to the 10 new member states;[4]
b. by modelling the introduction on 1 January 2006 of the EU "tariff-only" import regime;
c. by modelling the implementation of the EBA initiative;
d. by modelling the changes in import demand and export supply functions in all countries/regions resulting from expected shifts in domestic demand and supply functions; and
e. by assuming a €/$ exchange rate equal to 1.25.[5]

[3] In Cyprus the full implementation of the reform will take place in 2013.
[4] The 2007 enlargement to Bulgaria and Romania has been ignored in this exercise (total banana imports by these two countries were in 2005 less than 50,000 t).
[5] The exchange rate in 2002 was 0.9456. For the new member states it has been assumed that the exchange rates between their currencies and the US dollar change with the €/$ exchange rate (i.e. their exchange rates with respect to the euro remain constant).

The 2004 EU enlargement has been modelled by removing barriers to trade between the 10 new member states and the EU-15 and by extending to them the import regime in place in the EU-15.

MFN imports are subject to a 176 €/t tariff only (they are not subject to any quantitative limitation); ACP countries are granted preferential duty-free access within a 775,000 t TRQ (out-of-quota ACP exports to the EU are subject to the 176 €/t MFN tariff).

Banana exports from EBA countries[6] are assumed to enter the EU tariff-free and are not subject to any quantitative limitation.

Import demand and export supply functions shift according to expected changes, *ceteris paribus*, in the quantities produced and consumed in each country/region.[7] Consumption has been assumed to vary over time based on per cent yearly changes in population between 1990 and 2003 and in per capita income between 1997-1999 and 2000-2002 (in both cases the data source is the World Bank); the values used for domestic demand income elasticities are provided in table 1. Production in each country/region is assumed to change over time in line with the observed per cent yearly change in banana yields[8] between 1991-1993 and 2000-2002.[9]

With respect to the developments in the WTO Doha Development Agenda round of negotiations, it is assumed that no agreement is reached.

2. THE REFORM OF THE EU COMMON MARKET ORGANIZATION FOR BANANAS

Because of the nature of the POSEI programme, the reform gives ample flexibility to Spain, France and Portugal in the use of the conspicuous resources which have been added to those available under these schemes (EC 2006). In August 2007 the Commission approved the proposals by France, Portugal and Spain on how to introduce in their national POSEI programmes measures supporting banana producers. Although it is unlikely that the choices made will be changed in the near future, these measures can be easily modified if these countries wish to do so. For this reason, and being the time frame used for the simulations 2013 (i.e. relatively far away), three alternative policy choices by France, Portugal and Spain

[6] Least developed countries beneficiary of the EBA initiative where in 2006 banana production exceeded 100,000 t are: Angola, Bangladesh, Cambodia, Central African Republic, Democratic Republic of Congo, Ethiopia, Guinea, Haiti, Liberia, Madagascar, Tanzania, Togo and Uganda; those which in recent years exported bananas include Bangladesh, Burkina Faso, Comoros, Congo, Eritrea, Liberia, Madagascar, Mozambique, Myanmar, Rwanda, Somalia, Tanzania, Uganda and Zambia.

[7] FAOSTAT is the source used for production and consumption in 2002.

[8] The source is FAOSTAT.

[9] Some of the parameters governing these shifts have been judged to be unsustainable over time; in particular, this was the case for (a) negative and (b) very high rates of change in yields, and (c) for extreme (both, positive and negative) rates of change in per capita incomes. As a result, per cent yearly yield changes above 5% have been replaced by 5%, and below 0% by 0%; per cent yearly per capita income changes above 7% have been replaced by 7%, and below -3% by -3% (table 2). The use of the observed per cent changes in population and per capita income for the EBA countries, both ACP and non-ACP ones, would have had a marked negative effect on their export supply over time, leading to decreased or no exports. In order to make these countries more responsive to the structural change associated with the implementation of the EBA initiative than could be predicted on past performance, the rates of change of both variables for ACP and non-ACP EBA exporters have been set equal 0.

- all feasible within the POSEI framework - are considered in this study (all scenarios assume full "decoupling" of support in Greece and Cyprus; this support equals 4.5 million €):

a. a "*Status quo*" scenario, in which France, Portugal and Spain use all financial resources to provide banana producers in their "outermost regions" with fully "coupled" support analogous to that which they enjoyed under the previous policy regime;
b. a "*Full decoupling*" scenario, in which all financial resources are used to provide banana producers with direct payments fully "decoupled" from production; and
c. a "*2007 decision*" scenario, which is based on the actual choices France, Portugal and Spain made in 2007:

    i. In Spain available financial resources (€141.1 million) are devoted to "decoupled" payments and to a specific aid to support open air banana production (1,200 €/ha to be paid on a maximum of 7,600 ha). "Decoupled" payments to individual farms are calculated based on the historical support they received in a reference period; however, in order to receive the "decoupled" payment they are entitled to, farms are required to produce at least 70% of what they produced, on average, in the reference period;
    ii. In France available financial resources (€129.1 million) are entirely devoted to "decoupled" payments. "Decoupled" payments to individual farms are calculated based on the historical support they received in a reference period. However, in order to receive the entire "decoupled" payment they are entitled to, farms are required to produce at least 80% of what they produced, on average, in the reference period; if production is between 70% and 80% of what it was in the reference period the farm will receive 80% of the "decoupled" payment; if it is below 70% it will receive the same percentage of the "decoupled" payment.
    iii. In Madeira and Azores all financial resources (€8.7 million) are devoted to a fixed (rather than variable, as in the "deficiency payment" scheme in place in the pre-2007 regime), fully "coupled" production subsidy.

A scenario with no policy change whatsoever with respect to the situation before 2007 is simulated as well to generate a reference for the assessment of the impact of the three policy choices considered.

"No policy change"

In this reference scenario no change in the domestic aspects of the CMO for bananas takes place; only changes in market access conditions and expected developments in demand and supply functions between 2002 and 2013 are simulated.

The EU "basic" (or "compensation") aid for banana producers is modelled as a fully "coupled" deficiency payment. The per unit payment is calculated as the difference between the given reference price (which does not change over time) and the domestic market price. As long as the domestic market price remains below the reference price, the relevant domestic producer price in the EU (market price + per unit "basic" aid) does not change. As a result, domestic production does not adjust to changes in the EU domestic market (consumer) price; what does change with the latter is the per unit "basic" aid paid to producers and the budgetary cost of the CMO.

The "supplementary aid" is paid only in those countries where the price is lower than the average EU price by more than 10%.[10] In the model both "basic" and "supplementary" direct payments are subject to the "stabilization" mechanism which was part of the pre-2007 CMO.[11] Production decisions are assumed not to react to cuts in "basic" aid in the previous year, if any, as a result of domestic production exceeding the maximum guaranteed volume on which payments are made. This is because farmers are assumed to act as rational "free riders", i.e., they believe that the other farmers will reduce their production expecting the same cut to apply in the following year (hence, there is no reason for them to do so, because, if the others reduce production, there will be no reduction in aid).

Payments are assumed not to be subject to reductions as a result of the existing overall "budget discipline" constraint. "Modulation" does not apply to payments to producers in "outermost regions", which account for about 98% of EU domestic production of bananas, and has been ignored in the simulations.

On 1 January 2008 the EU implemented the "interim" Economic Partnership Agreements (EPA) negotiated with many ACP countries (EC 2007); barriers to trade between the EU and several groups of ACP countries will be progressively removed, creating free trade areas expected to be compatible with WTO rules (a WTO waiver allowing the EU to grant trade preferences to ACP countries under the Cotonou Agreement expired at the end of 2007). The "interim" EPA allow from 1 January 2008 ACP countries to export bananas to the EU quota- and duty-free. In this reference scenario, however, EPA are ignored.

Under a continuation of the domestic policies in place in 2006, banana consumption in the EU-25 in 2013 is expected to reach 6 million t and domestic production and imports to be 1,034 and 4,976 thousand t, respectively (table 3). Even if the relevant farm price (market price + deficiency payment) does not change, domestic production will increase over time because of increasing yields in Cyprus, France and Spain (table 2) and exceed the 854,000 t threshold which "triggers" the financial stabilizer mechanism (cuts in aid payments to be applied in Cyprus, France and Spain).

Imports from ACP countries equal the duty-free 775,000 t quota; those from MFN countries equal 4.103 million t, those from EBA countries 98,000 t.

Increased imports – driven by the increased competitiveness of MFN exports on the EU market as a result of the new import regime in place since 1 January 2006 – are responsible for most of the forecasted reduction in market prices, and, as a result, of the increase in the per unit "basic" aid, which in 2002 was equal to 303.3 €/t and is simulated to reach 419.8 €/t in 2013.[12] Total EU budget expenditure (i.e., the budget expenditure for both "basic" and

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[10] Supplementary aid payments in the 2000-2005 period were between €1.7 million in 2001 and 43.1 in 2005.

[11] If total domestic banana production exceeds the sum of the maximum guaranteed volumes in the producing countries (867,500 t), then a cut in the volume of bananas on which the payments are made is applied in the countries where production has exceeded the maximum guaranteed volume; this cut is adjusted by redistributing *pro rata* among the countries where the cuts apply the difference between maximum guaranteed volume and production in those countries where, on the contrary, this difference is greater than zero.

[12] In the 2000-2005 period the per unit "basic aid" varied between 382.9 €/t in 2000 and 59 €/t in 2005.

"supplementary" aid payments) equals €373.3 million, well above CMO budget costs observed in the past.[13]

Tariff revenue, on the contrary, is now much higher than under the pre-2006 import regime, when imports from MFN countries were subject to a binding quota and a lower tariff (75 €/t) was imposed; it increases from less than €200 million before 1 January 2006 to €722.1 million.

Table 2. Time Shift Parameters

	unadjusted per cent yearly increase in			***adjusted* per cent yearly increase in***		
Country	***population***	***per capita income***	***yields***	***population***	***per capita income***	***yields***
Spain			1.05			1.05
France			3.13			3.13
Portugal			-2.75			**0**
Greece			-1.12			**0**
Cyprus			**5.65**			**5**
Ivory Coast	2.7	**-3.28**	2.38	2.7	**-3**	2.38
Cameroon	2.5	-2.6	**-8.28**	2.5	-2.6	**0**
Dominican Republic, Belize and Suriname	1.6	4.34	0.36	1.6	4.34	0.36
Jamaica, Windward Islands and other ACP non-EBA countries	2	-0.25	**-1.17**	2	-0.25	**0**
ACP EBA exporters	**2.5**	**0.37**	**-0.24**	**0**	**0**	**0**
Ecuador	1.8	**-4.16**	2.3	1.8	**-3**	2.3
Colombia	1.8	**-6.54**	0.02	1.8	**-3**	0.02
Costa Rica	2.1	**13.75**	0.26	2.1	**7**	0.26
Panama	1.7	4.62	**-0.51**	1.7	4.62	**0**
Honduras	2.8	6.83	**-8.84**	2.8	6.83	**0**
Brazil	1.4	**-11.57**	0.45	1.4	**-3**	0.45
Guatemala	2.6	2.11	**8.03**	2.6	2.11	**5**
Other MFN exporters	1.7	1.04	1.77	1.7	1.04	1.77
EBA non-ACP exporters	**2**	**5.11**	**-2.12**	**0**	**0**	**0**
EU-15	0.3	2.08		0.3	2.08	
Czech Republic	-0.1	0.97		-0.1	0.97	
Slovakia	0.1	1.08		0.1	1.08	
Poland	0	4.35		0	4.35	
Hungary	-0.2	2.93		-0.2	2.93	
Other six EU new member states	-0.5	3.54	**5.49**	-0.5	3.54	**5**
USA	1.2	5.04	3.17	1.2	5.04	3.17
Other importers	1.1	0.44	3.44	1.1	0.44	3.44

*: per cent yearly yield changes above 5% replaced by 5%, below 0% by 0%; per cent yearly per capita income changes above 7% replaced by 7%, below -3% by -3% . ACP and non-ACP EBA countries per capita income and population per cent yearly changes have been set equal to zero in order to make them more responsive to the structural change associated with the preferential treatment due to the implementation of the EBA initiative.

[13] In the 1994-2005 period it exceeded €300 million only in 2000, when it was equal to €301.9 million.

Table 3. Simulation Results (2013)

	No policy change	without EPA			with EPA		
		Status quo	2007 decision	Full decoupling	Status quo	2007 decision	Full decoupling
EU-25 production (000 t)	**1,034**	**1,006.1**	**596.1**	**350.7**	**1,006.7**	**595.7**	**346.7**
Spain	*457*	*457*	*294*	*145*	*457*	*294*	*144*
France	*504*	*504*	*255*	*173*	*504*	*255*	*171*
Portugal	*22*	*22*	*22*	*8*	*22*	*22*	*7*
Greece	*2*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*
Cyprus	*49*	*23*	*24*	*24*	*23*	*24*	*24*
EU-25 imports (000 t)	**4,976**	**5,002**	**5,392**	**5,626**	**5,010**	**5,401**	**5,638**
from MFN countries	*4,103*	*4,129*	*4,517*	*4,749*	*3,985*	*4,358*	*4,584*
from ACP countries	*775*	*775*	*775*	*775*	*927*	*943*	*953*
from EBA countries	*98*	*98*	*100*	*102*	*98*	*100*	*101*
USA imports (000 t)	**4,893**	**4,890**	**4,853**	**4,831**	**4,904**	**4,869**	**4,847**
Rest of the world net imports (000 t)	**2,373**	**2,371**	**2,343**	**2,327**	**2,381**	**2,355**	**2,339**
MFN countries, total exports	**11,369**	**11,390**	**11,714**	**11,907**	**11,271**	**11,581**	**11,769**
EU-25 border (cif) price (€/t)	**465.0**	**465.2**	**469.3**	**471.8**	**463.7**	**467.6**	**470.0**
EU-25 consumption (000 t)	**6,010**	**6,008**	**5,988**	**5,976**	**6,016**	**5,997**	**5,985**
EU-25 budget expenditure (mill €)	**373.3** (1)	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**
Basic aid (€/t)	**419.8**						
Production subsidy in Spain (€/t) (2)		**308.8**			**308.8**		
Production subsidy in France (€/t) (2)		**256.3**			**256.3**		
Production subsidy in Portugal (€/t) (2)		**392.7**	**386.9**		**392.7**	**388**	
EU-25 tariff revenue (mill €)	**722.1**	**726.7**	**795.0**	**835.9**	**701.4**	**767.0**	**806.7**

(1) includes supplementary aid budget expenditure computed using the "standard formula".

(2) after reduction, if any, as a result of the financial stabilizer.

"Status quo"

In this scenario France, Portugal and Spain are assumed to decide not to change the support provided to banana producers with respect to the pre-2007 CMO for bananas, while support is now fully "decoupled" in Greece and Cyprus.

The "supplementary" aid is eliminated, and France, Portugal and Spain use all financial resources for the "basic" aid. The per unit payment to banana producers is calculated as the difference between the given reference price (unchanged with respect to the previous regime) and the domestic market price. Farms in Greece and Cyprus are assumed to satisfy cross-compliance conditions at no extra cost.

The financial stabilizer mechanism is now assumed to guarantee that budget expenditure does not exceed the financial resources which the 2006 reform added to the budget of each country's POSEI programme (€129.1 million in France, 8.6 in Portugal and 141.1 in Spain). If expected expenditure in one of the three countries exceeds the financial allocation, then the per unit "basic" aid is reduced in order to make total subsidy expenditure equal that country's financial allocation. Again, production decisions are assumed to be independent of the financial stabilization mechanism.

If France, Portugal and Spain had decided (or will decide between now and 2013) to keep the policy support granted to their banana producers in their "outermost regions" as in the pre-2007 regime, the reform of the CMO for bananas will bring very little change (table 3). The main impact will be through the reduction in banana production in Cyprus and Greece as a result of the "decoupling" of support. However, because of the small amount of bananas being produced in these two countries with respect to that produced in the Canary Islands, Guadalupe, Martinique, Madeira and the Azores, this change will have a very small market impact. If the Economic Partnership Agreements are ignored, then EU domestic price would be expected to increase and consumption decline only marginally. The small increase in imports (26 thousand t) comes almost entirely from MFN countries (ACP exports are constrained by the TRQ and EBA exports increase by a negligible amount). The most significant change is in EU budget expenditure, which is now equal to the maximum amount decided with the reform (€283.3 million) while it is forecasted to increase to €373.3 million when no reform of the policy regime is assumed.

If EPA are introduced in the model then ACP exports enter the EU market duty- and quota-free, as those from EBA countries, and displace part of MFN and EBA exports. The impact of the implementation of EPA on the EU market simulated by the model is minimal, while its effects on trade flows are significant. In fact, when ACP bananas are assumed to enter the EU duty-free and without any quantitative restriction, EU production remains unaffected (in France, Portugal and Spain production depends on the domestic policy regime only) and imports increase only marginally, but MFN exports to the EU decline by 144,000 t[14] and ACP exports increase by 152,000 t .[15] EU tariff revenue declines with respect to the scenario in which the EPA are not implemented as a result of the lower imports from MFN suppliers.

"Full decoupling"

Under this scenario in all countries both "basic" and "supplementary" aid payments in the pre-2007 policy regime are removed and replaced by direct payments to farms fully "decoupled" from the quantity of bananas produced, analogous to those introduced in other sectors with the Fischler reforms of the CAP.[16]

The costs of satisfying "cross-compliance" requirements are assumed to be negligible.

Everything else held constant, the "decoupling" of support is expected to induce a sharp reduction in banana production in the EU, while the impact on farm incomes may be either positive or negative. This is so because, on the one hand, "decoupled" payments now equal €283.4 million, well below those farmers would have received under the previous regime (€373.3 million), but, on the other hand, they now produce only what is profitable at market prices (in the "No policy change" scenario domestically produced bananas are sold on the market at a price below the marginal cost of production).

In this scenario, if EPA are assumed not to have been implemented, EU production is forecasted to equal in 2013 351 thousand t (in the same year under the "Status quo" option it is forecasted to exceed one million t) (table 3). EU banana consumption is only slightly below the level under the reference scenario and the "Status quo" option, as domestic price increases by one per cent only. Increased imports (+ 650 thousand t, +13.1% with respect to the "No policy change" reference scenario) replace in EU consumption the marked reduction in domestic banana production. The small increase in the EU market price drives up prices worldwide and US imports and "Rest of the world" net imports decline by 1.3% and 1.9%,

[14] Total MFN exports decline by 98,000 t only, as lower prices will make banana consumption and imports in third markets increase.

[15] EBA exports decline by 800 t.

respectively. If EPA are ignored, benefits for exporters from the reform of the EU domestic policy regime for bananas are limited to MFN and EBA countries; ACP exports are still competitive on the EU market only and remain constrained by the duty-free TRQ (the quota rent increases with respect to the "No policy change" scenario from 47.5 $/t to 56 $/t). MFN exports are now 4.749 million t, 646,000 t above the level forecasted when no policy change is assumed (table 3).[17]

EU budget expenditure is well below that expected under the "No policy change" scenario, while tariff revenue is higher with respect to both the reference and the "Status quo" scenarios, due to increased imports from MFN countries.

If the effects of the EPA are taken into account, the EU market equilibrium does not change significantly, while the distribution of imports between MFN and ACP suppliers does. MFN exports to the EU are forecasted to be lower than those which would occur under the same domestic policy scenario and no EPA by 165,000 t and ACP ones higher by 178,000 t (table 3).

"2007 decision"

This policy option is the one actually implemented in 2007; however, as mentioned above, France, Portugal and Spain are allowed to modify in the future their choice on how to use the financial resources added to their POSEI programmes as a result of the reform of the CMO for bananas.

Under this option the "basic" and "supplementary" aid payments are removed and replaced by different policy schemes in each country, within the given financial envelopes decided with the December 2006 reform.

The different policy instruments applied in the different countries are modelled as follows:

a. in France the entire budget allocation is devoted to "decoupled" payments. In order to receive their full entitlement of "decoupled" payments, farms have to produce at least 80% of what they produced, on average, in the reference period (globally 255,267 t); if production is between 70% and 80% of what it was in the reference period, the farm will receive 80% of its entitlement of decoupled payments; if it is below 70% it will receive the same percentage of the entitlement. It turns out that the financial incentive is large enough to ensure that farms find it profitable to produce the minimum volume of bananas needed for them to claim the entire amount of "decoupled" payments they are eligible for (these payments are around 11,600 €/ha);
b. in Spain the aid for open air banana production is assumed to be used to its maximum extent (€7,600 ha; 9.1 million) and the remaining budget allocation (€132 million) to be devoted to "decoupled" payments. In order to receive their full entitlement of

[16] The June 2003 reform of the CAP "decoupled" support for arable crops, dairy products and meats; later direct payments for olive oil, tobacco, cotton, sugar and processed fruit and vegetables have also been "decoupled" and included in the "Single Farm Payment".

[17] Total MFN exports increase by a smaller amount (538,000 t), as some of the increase in exports to the EU are exports previously directed elsewhere.

"decoupled" payments, farms have to produce at least 70% of what they produced, on average, in the reference period (in total, 294,000 t). In this case too it turns out that the financial incentive is large enough to ensure that farms find it profitable to produce the minimum volume of bananas needed for them to claim the entire amount of "decoupled" payments they are eligible for ("decoupled" payments are in this case around 11,800 €/ha);

c. in Portugal 100% of the financial allocation is devoted to the introduction of a fully "coupled" production subsidy. The fixed per unit subsidy is given by the financial allocation divided by the volume of banana production in Madeira and Azores used in the proposal put forward to the Commission by Portugal in 2007; this yields a subsidy equal to 455.2 €/t.[18] The subsidy expenditure cannot exceed Portugal's financial allocation (€8.7 million); if production is such that expenditure would exceed the maximum allowed, the per unit subsidy is cut *pro rata* so that the expenditure equals the budget allocation.

The expected impact of this policy option is between those of the "Status quo" and "Full decoupling" scenarios.

In France and Spain banana production equals the minimum threshold required to receive the full amount of "decoupled" payments: 255 and 294 thousand t, respectively, vs. 173 and 145 thousand t produced when farms, under the "Full decoupling" option, are free to produce what they find profitable at market prices, and vs. 504 and 457 thousand t produced when in these two countries the pre-2007 policy regime is extended to 2013. In Portugal, where support is fully "coupled", production equals 22 thousand t, while it is forecasted to equal 8 thousand t when it is "decoupled". In Greece and Cyprus, where payments are "decoupled" in all three scenarios, the minor differences observed in the volume of bananas produced are driven by the small changes in the equilibrium price in the EU market.

EU domestic production is now 596.1 thousand t and imports equal 5,392 million t. MFN and EBA exports are 4,517 and 100 thousand t, while ACP exports remain equal to the volume of the TRQ (the only change is for the quota rent, which now equals 53.0 $/t).

In this case too the impact of the implementation of EPA shows almost entirely in the change in the composition of EU imports. MFN exports to the EU decline from 4.517 to 4.358 million t and ACP ones increase from 775,000 to 943,000 t (table 3).

3. Sensitivity Analyses

As is always the case when attempts are made to model the many forces at work to forecast the outcome of alternative economic policy choices, the results depend, to a certain extent, on the information used and the assumptions made. The main issues to keep in mind when considering the results of a model such as the one used in this study are:

a. the quality of the data available;

[18] The actual policy choice by Portugal is to introduce two different subsidies in Madeira and the Azores, equal to 446 €/t and 600 €/t, respectively; however, the structure of the model does not allow considering banana production in the two outermost regions separately.

b. the assumption that other actors apart from the EU – i.e., multinationals involved in banana production and trade, large retail agglomerations and other countries – behave competitively;
c. the assumption that bananas are a homogeneous product;
d. the assumption that the supply of transportation services is infinitely elastic (i.e. banana trading is not constrained by transportation capacity, and transportation and other transaction costs do not vary either as a function of the volume traded or over time);
e. the assumption that farmers in the EU make production decisions without taking into account expectations on possible cuts in "coupled" direct payments, when they are in place, as a result of financial stabilization mechanisms.

The assumption that the banana market is perfectly competitive seems particularly sensitive, despite the fact that it has been used in all analyses of policy issues in this market so far, that there is no definite evidence of multinationals exerting market power (Deodhar and Sheldon 1996; Herrmann and Sexton 2001; McCorriston 2000), and that the sign of the impact of the import regime introduced by the EU on January 1 2006 on the structure of the banana market remains *a priori* ambiguous (will the elimination of quota A/B licences make the banana market more or less competitive?).

Was the assumption that when farmers make their production decisions they ignore possible cuts of "coupled" direct payments not to hold, the simulations would overestimate production in all EU countries in the "No policy change" reference scenario, and in France, Portugal and Spain in the "Status quo" scenario.

The sensitivity of the results generated by the model to the parameters used has been assessed with respect to those which appear potentially more critical:

a. the €/$ exchange rate;
b. the export supply elasticities in the main ACP exporters; and
c. the demand price elasticity in the EU-15.

These simulations should provide the reader with a sense of "by how much" and "in which direction" the results presented above would change if different assumptions were made with respect to these parameters.

The sensitivity analyses have been conducted only for three of the seven scenarios considered above: the "Status quo", "Full decoupling" and "2007 decision" scenarios (all of them include the implementation of the EPA).

In the simulations presented above the €/$ exchange rate used is 1.25; two alternative values have been considered to test the sensitivity of the results to this parameter: 1.10 and 1.40 (table 4). Changes in the exchange rate modify the competitiveness of imports *vis a vis* domestic production, with a higher exchange rate increasing their competitiveness and a lower exchange rate, on the contrary, making imported bananas less competitive on the EU market. Everything else held constant, when the exchange rate is 1.40 imports are higher and domestic prices lower than those in the simulations presented in section 3; the opposite is the case when the exchange rate is set equal 1.10. When the results presented in table 4 are compared with those presented above, the differences appear relatively small. For example, when the €/$ exchange rate is 1.40 EU imports increase by 3.2% in the "Status quo" scenario, by 3.5% under "Full decoupling" and by 3.1% in the "2007 decision" one; when the exchange rate is set equal 1.10 EU imports decline by 4.1%, 4.4% and 4.4%, respectively.

Table 4. Sensitivity Analysis, €/$ Exchange Rate (2013)

	Status quo, with EPA			2007 decision, with EPA			Full de
	1 € = 1.25 $	1 € = 1.10 $	1 € = 1.40 $	1 € = 1.25 $	1 € = 1.10 $	1 € = 1.40 $	1 € = 1.25 $
EU-25 production (000 t)	**1,006.7**	**1,009.8**	**1,004.6**	**595.7**	**599,4**	**593.2**	**346.7**
Spain	*457*	*457*	*457*	*294*	*294*	*294*	*144*
France	*504*	*504*	*504*	*255*	*255*	*255*	*171*
Portugal	*22*	*22*	*22*	*22*	*23*	*22*	*7*
Greece	*0.7*	*0,8*	*0.6*	*0.7*	*0.8*	*0.6*	*0.7*
Cyprus	*23*	*26*	*21*	*24*	*27*	*21*	*24*
EU-25 imports (000 t)	**5,010**	**4,805**	**5,172**	**5,401**	**5,194**	**5,566**	**5,638**
from MFN countries	*3,985*	*3,883*	*4,047*	*4,358*	*4,254*	*4,422*	*4,584*
from ACP countries	*927*	*835*	*1,017*	*943*	*851*	*1,034*	*953*
from EBA countries	*98*	*87*	*108*	*100*	*89*	*110*	*101*
USA imports (000 t)	**4,904**	**4,914**	**4,898**	**4,869**	**4,879**	**4,862**	**4,847**
Rest of the world net imports (000 t)	**2,381**	**2,389**	**2,377**	**2,355**	**2,362**	**2,350**	**2,339**
MFN countries, total exports	**11,271**	**11,186**	**11,322**	**11,581**	**11,149**	**11,634**	**11,769**
EU-25 border (cif) price (€/t)	**463.7**	**501.7**	**433.5**	**467.6**	**506.2**	**437.0**	**470.0**
EU-25 consumption (000 t)	**6,016**	**5,815**	**6,176**	**5,997**	**5,793**	**6,159**	**5,985**
EU-25 budget expenditure (mill €)	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**
EU-25 tariff revenue (mill €)	**701.4**	**683.5**	**712.3**	**767.0**	**748.6**	**778.2**	**806.7**

The sensitivity of the results obtained to the assumptions made with respect to the elasticity of the export supply functions in the ACP countries has been assessed by assuming those of Ivory Coast and Cameroon (these two countries alone account for two thirds of ACP banana exports) to be much less price responsive, being equal to 1 instead of 1.5 (table 5).

This assessment is specifically relevant for the results obtained when the EPA are included in the modelling and ACP banana exports can enter the EU market duty- and quota-free. When the three simulation scenarios are considered, EU market equilibrium and imports are only marginally effected by the marked change in the price responsiveness of the excess supply functions in Cameroon and Ivory Coast, while the composition of EU imports by supplier, as expected, appears to be relatively sensitive to the assumption made with respect to these parameters; in fact, in all three scenarios ACP exports are lower and MFN exports higher by roughly the same amount in absolute terms, 100,000 t.

Finally, the sensitivity of the results obtained to the assumption made on the price elasticity of the demand function in the EU-15 has been assessed by setting it equal to two extreme values, -0.2 and -0.8, instead of -0.5 (table 6). Under such extreme assumptions regarding the price responsiveness of banana consumption in the EU-25, its consumption and imports change significantly: under all three scenarios, when the demand price elasticity is -0.8 EU consumption and imports are above those when it is -0.5 by 320-330 thousand t; on the contrary, when the demand price elasticity is -0.2 EU consumption and imports are below those when it is -0.5 by 330-350 thousand t.

Table 5. Sensitivity Analysis, Price Elasticity of the Export Supply Functions in Cameroon and Ivory Coast (2013)

	Status quo, with EPA		2007 decision, with EPA		Full deco
	η = 1.5	η = 1	η = 1.5	η = 1	η = 1.5
EU-25 production (000 t)	**1,006.7**	**1,006.7**	**595.7**	**596,1**	**346.7**
Spain	*457*	*457*	*294*	*294*	*144*
France	*504*	*504*	*255*	*255*	*171*
Portugal	*22*	*22*	*22*	*22*	*7*
Greece	*0.7*	*0.7*	*0.7*	*0.7*	*0.7*
Cyprus	*23*	*23*	*24*	*24*	*24*
EU-25 imports (000 t)	**5,010**	**5,005**	**5,401**	**5,396**	**5,638**
from MFN countries	*3,985*	*4,074*	*4,358*	*4,451*	*4,584*
from ACP countries	*927*	*833*	*943*	*845*	*953*
from EBA countries	*98*	*98*	*100*	*100*	*101*
USA imports (000 t)	**4,904**	**4,896**	**4,869**	**4,860**	**4,847**
Rest of the world net imports (000 t)	**2,381**	**2,375**	**2,355**	**2,348**	**2,339**
MFN countries, total exports	**11,271**	**11,345**	**11,581**	**11,659**	**11,769**
EU-25 border (cif) price (€/t)	**463.7**	**464.7**	**467.6**	**468.6**	**470.0**
EU-25 consumption (000 t)	**6,016**	**6,012**	**5,997**	**5,992**	**5,985**
EU-25 budget expenditure (mill €)	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**
EU-25 tariff revenue (mill €)	**701.4**	**717.0**	**767.0**	**783.4**	**806.7**

Table 6. Sensitivity Analysis, Price Elasticity of the EU-15 Domestic Demand Function (2013)

	Status quo, with EPA			2007 decision, with EPA			Full de
	η = - 0.5	η = - 0.2	η = - 0.8	η = - 0.5	η = - 0.2	η = - 0.8	η = - 0.5
EU-25 production (000 t)	**1,006.7**	**1,006.7**	**1,006.7**	**595.7**	**595.7**	**596.2**	**346.7**
Spain	*457*	*457*	*457*	*294*	*294*	*294*	*144*
France	*504*	*504*	*504*	*255*	*255*	*255*	*171*
Portugal	*22*	*22*	*22*	*22*	*22*	*23*	*7*
Greece	*0.7*	*0,7*	*0,7*	*0.7*	*0.7*	*0.7*	*0.7*
Cyprus	*23*	*23*	*23*	*24*	*23*	*24*	*24*
EU-25 imports (000 t)	**5,010**	**4,661**	**5,345**	**5,401**	**5,060**	**5,727**	**5,638**
from MFN countries	*3,985*	*3,652*	*4,305*	*4,358*	*4,033*	*4,669*	*4,584*
from ACP countries	*927*	*913*	*941*	*943*	*929*	*957*	*953*
from EBA countries	*98*	*96*	*99*	*100*	*98*	*101*	*101*
USA imports (000 t)	**4,904**	**4,936**	**4,874**	**4,869**	**4,900**	**4,839**	**4,847**
Rest of the world net imports (000 t)	**2,381**	**2,405**	**2,359**	**2,355**	**2,378**	**2,332**	**2,339**
MFN countries, total exports	**11,271**	**10,993**	**11,537**	**11,581**	**11,310**	**11,841**	**11,769**
EU-25 border (cif) price (€/t)	**463.7**	**460.2**	**467.1**	**467.6**	**464.2**	**470.9**	**470.0**
EU-25 consumption (000 t)	**6,016**	**5,666**	**6,352**	**5,997**	**5,655**	**6,324**	**5,985**
EU-25 budget expenditure (mill €)	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**	**283.4**
EU-25 tariff revenue (mill €)	**701.4**	**642.7**	**757.6**	**767.0**	**709.7**	**821.8**	**806.7**

4. CONCLUSIONS

Because of the difficulty at this stage of making assumptions on the specific measures France, Portugal and Spain will have in place in 2013 regarding how to use the resources transferred to their POSEI programmes, an *a priori* assessment of the impact of the December 2006 reform of the CMO for bananas is impossible. What has been done in this article is to simulate the expected market impact of three different feasible policy choices on their part.

The “Status quo” scenario induces very little change, while the full “decoupling” of support is associated with the greatest impact on banana trade; the impact of the “2007 decision” scenario remains between these two.

The “Full decoupling” of support to banana producers induces a sharp reduction in banana production in the EU, from 1 million to 350 thousand t; while consumption in the EU is only slightly below that in the “Status quo” scenario, EU imports (5.626 million t) are higher by more than 600,000 t. With EPA in place, both MFN and ACP exporters benefit from the slightly higher price and increased exports; had the EPA not been introduced, MFN exports would have increased, while ACP exports would have remained constrained by the quota. Under the “2007 decision” scenario production in Spain and France equals 70% and 80% of production in the reference time period used to define “decoupled” payment entitlements for individual farms, as these find it profitable to produce the minimum required to be eligible for the full amount of the payments; EU production and imports are now 596,100 and 5,392,000 t, respectively.

In all three scenarios, the EPA only affects the relative share of the EU market held by MFN and ACP countries (MFN exports are significantly lower and ACP ones higher as a result of the EPA), while EU consumption and imports remain relatively stable.

Sensitivity analyses with respect to some of the parameters of the model which are potentially more critical have been performed; the results of the simulations appear robust with respect to the assumptions made, as the changes in the simulation results appear to be not of an order of magnitude to modify their normative implications.

Available estimates of the trade impact of the introduction of the EU “tariff-only” import regime for bananas are much smaller than some of those presented in this article for the reform of the EU domestic policy regime. Anania (2006) estimates that the introduction of the so-called “tariff-only” import regime on January 1 2006 will lead to an overall 9.9% increase in EU banana imports, while imports from MFN countries increase by 13.2% and those from ACP countries by 3.3%; Guyomard, Le Mouël and Levert (2006) estimate that the new import regime will increase EU imports by 5-6% and MFN exports to the EU by 11-13%, depending on the assumptions made. The simulations of the possible impact of the new EU domestic policy regime for bananas presented in this article show that, *ceteris paribus*, if France, Portugal and Spain decide by 2013 to decouple payments to their banana producers, EU imports will increase by 13% and MFN exports to the EU by 16%; if they decide not to modify the policy choice they made in 2007, EU imports still increase by 8% and MFN exports to the EU by 10%.

Paradoxically, while the reform of the EU import regime for bananas has attracted much attention and generated considerable debate, very little interest seems to have been shown so far to the reform of the EU domestic policies for bananas and its implications for trade.

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MONETARY POLICY IMPACTS ON COFFEE AND COCOA PRICES

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ABSTRACT

Coffee and cocoa are primarily consumed in the developed countries and their exports are the main determinants of aggregate exports and overall economic performance of several developing countries. This paper measures the extent that monetary factors of importing countries contribute to price instability in cocoa and coffee in the international market. A vector error correction model is used to test the effects of monetary shocks on cocoa and coffee prices. A change in U.S. monetary policy can impact coffee and cocoa prices and transmit disturbances toward developing countries that export coffee and cocoa. Specifically, the link between changes in the U.S. monetary policy and the variability of tropical commodity prices is investigated. Furthermore, the dynamic response of the imported tropical crop prices are compared to the price of industrial goods when there is a macroeconomic disturbance.

Key Words: coffee and cocoa, developing countries, monetary policy shocks, price and income flexibility
JEL Classification: Q11, Q18

INTRODUCTION

Coffee and cocoa are two agricultural commodities produced mainly in developing countries, exported, and consumed almost entirely in high-income industrialized countries. In several developing countries, cocoa and coffee are the main determinants of aggregate exports and overall economic performance. The share of coffee in the total export earnings is greater than 75 per percent in poor and vulnerable countries such as Burundi, Rwanda and Ethiopia. The economies of Cote d'Ivoire and Ghana are heavily specialized in cocoa production. Cocoa alone represents 15 percent of Cote d'Ivoire's GDP and more than 35 percent of her total exports. In Central and South America, coffee and cocoa represent the

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majority of exports for countries such as Colombia, Costa Rica, and Haiti. An established feature of the international markets for cocoa and coffee is their high price variability. For instance, the coefficient of variation for cocoa price and Arabica coffee were, respectively, 21 per cent and 36 per cent from January 1995 to August 2007. The high price variability of these commodities is explained generally by real economic factors such as production dependence on variable biophysical elements, input subsidies favoring excess supply, irreversible investment due to their perennial nature, low-income elasticity, and inelastic demand. But, the price instability of those primary commodities can be also attributed to monetary and financial impacts. Changes in monetary policy can affect nominal commodity prices and possibly real commodity prices.

The objective of this paper is to investigate the extent to which monetary factors contribute to coffee and cocoa price instability using vector error correction models. A modification of the empirical framework developed by Saghaian, Reed and Marchant (SRM, 2002) is used to test the implication of the overshooting hypothesis for cocoa and coffee subsequent to a monetary shock in the United States. Specifically the link between changes in US monetary policy and the variability of tropical commodity prices is investigated.

REVIEW OF THE LITERATURE

There is a growing body of literature focusing on monetary impacts on commodity prices. Bordo (1980) demonstrated that primary commodity prices respond more rapidly to changes in money supply than industrial good prices. Frankel (1986) adapted the overshooting hypothesis first introduced by Dornbusch (1976) to agriculture and analytically derived the dynamics of commodity price in a closed economy. Frankel (1986) modeled the dynamic path of commodity prices relative to their real long-run equilibrium, subsequent to a change in the money market. He assumed that the economy was closed and there were fixed-price and flex-price goods. SRM developed an open economy model that incorporated rigid manufactured good prices and flexible agricultural prices. For monetary policy to have disproportionate impacts on agricultural commodity and industrial good prices, at least one of two key factors must be present. First, the speeds of adjustment of the different prices in the economy must differ. In Dornbusch's model, the exchange rate reacts instantaneously to an exogenous monetary shock while the general price level responds sluggishly. In Frankel's model, the general price level is disaggregated into flexible commodity price and sticky industrial price. The flexible commodity price responds more quickly to changes in money supply than the sticky good price. The second critical factor linking the monetary sphere and the real sphere is the interest rate parity condition which requires equal rates of return on deposits of differing currencies. In Frankel's model, the interest rate parity condition links the returns on agricultural commodities to those of financial assets.

Saghaian, Reed, and Marchant, 2002 (SRM) provided evidence of the causal relationship between monetary policy changes and their short run effects on agricultural prices in an open economy. SRM showed that agricultural prices, in contrast to industrial prices, adjust quickly to changes in monetary policy. Agricultural prices were found to overshoot their long-run equilibrium value in reaction to a positive monetary shock. The overshooting proposition applied to storable agricultural commodities posits that in the short run, monetary policy disturbances affect nominal and real prices. Storable agricultural commodities prices are deemed flexible because commodities tend to be homogenous; they are traded in open and transparent standardized markets where prices respond to information daily. For industrial goods, factors such as long-term contracts, product differentiation, imperfect information, and institutional arrangements prevent price from adjusting immediately to changes in the market environment.

CONCEPTUAL FRAMEWORK OF SAGHAIAN, REED, AND MARCHANT (2002)

The conceptual framework developed by SRM is used to study the reactions of cocoa and coffee price to unanticipated changes in money supply. The dynamic response of the imported tropical crop prices are compared to the price of industrial goods when there is a macroeconomic disturbance. It is assumed that the temporal adjustment path of agricultural prices is distinct from that of exchange rate. Unlike Frankel (1986), whose analysis was based on the interest rate parity condition applied to a storable commodity market, the methodology of SRM employed the open-economy exchange rate arbitrage as originally developed by Dornbusch. The short run overshooting proposition in the open-economy exchange rate model rests on the assumption of flexibility in exchange rate and differing rates of price adjustment between goods.

Within the SRM model, output is assumed exogenous and money is assumed neutral in the long run. An unanticipated permanent increase in money supply is followed by an increase of real money balances in the short-run because prices have different degrees of responsiveness to shocks. The liquidity effect forces the interest rate to decline initially in response to the increase in the real money supply to clear the money market. The decrease in the domestic interest rate causes an outflow of capital from the domestic country to the foreign country. The overshooting of the exchange rate follows from the fact that the interest rate will decrease only if the domestic currency is expected to appreciate. With the assumption of long-run money neutrality and capital outflow resulting from lower domestic interest rates, the exchange rate should depreciate when the money supply increases.

A core of the overshooting hypothesis is to posit that the immediate depreciation of the exchange rate should be larger than the new long-run equilibrium. The large depreciation or overshooting of the exchange rate leads market participants to expect a future appreciation of the exchange rate toward the new long-run equilibrium. The exchange rate in the overshooting model is determined essentially by the money market. The monetary approach to exchange rate determination is opposed to the asset-based approach of exchange rate determination in which the import and export of goods in the real market are critical factors.

The impact of a money shock on the agricultural price in the framework developed by SRM is dependent on the reaction of the exchange rate. Because cocoa and coffee are imported commodities, their prices should move quicker than industrial good prices in response to a monetary policy shock. Agricultural commodity prices should overshoot concurrently with the overshooting of the exchange rate. The theoretical overshooting model for the exchange rate and the commodity price is summarized in the following equations[1]:

[1] For a comprehensive discussion see Saghaian, Reed, and Marchant (2002).

The domestic money market equilibrium is represented by the following traditional LM curve: $m - p = \chi y - \lambda r$, where *m, p, y*, and *r* denote respectively the nominal money supply, the general price level, and the fixed real output and the domestic real interest rate.

The general price level, *p,* is a weighted average of the sluggish industrial good prices p_m, the flexible commodity price p_c, and imported good price p^* such that: $p = \alpha_1 p_m + \alpha_2 p_c + (1 - \alpha_1 - \alpha_2)(e + p^*)$ with $0 \le \alpha_1 + \alpha_2 \le 1$, where the weight of commodity price is α_1, the weight of industrial good prices is α_2, and $(1 - \alpha_1 - \alpha_2)$ is the weight of imported good price and *e* is the domestic currency price of a unit of foreign currency. The parameters χ and λ denote, respectively, the elasticity of money demand with respect to output and the elasticity of money demand with respect to the interest rate.

The uncovered interest rate parity condition is represented by: $r = r^* + \dot{e}$, where *r* is the domestic nominal interest rate, $\dot{e}$ is the rate of change of the exchange rate and r^* is the foreign nominal interest rate. This condition assumes that the risk premium is zero, the international mobility of capital is perfect, and the financial instrument market is competitive so that domestic bonds and foreign bonds are perfect substitutes. Moreover, the domestic country is assumed small so that the foreign interest rate is exogenous. The model assumes rational expectation so that there is no distinction between actual and anticipated changes of prices.

The long-run supply of the flexible good is fixed at *A* and the demand for the flexible good is a function of relative prices, the real interest rate, and income such that $A = \gamma_1(e + p^* - p_c) + \gamma_2(p_m - p_c) - \theta(r - \dot{p}) + \varphi y$, with γ_1, γ_2, θ, and $\varphi > 0$.

The supply of industrial goods adjusts in response to excess demand only gradually over time, in accordance with an expectations-augmented Philips curve (Frankel 1986) such that: $\dot{p}_m = \pi(y^d - y^m) + \mu$, where y^d is the logarithm of the demand for domestic industrial good, y^m is the potential demand for the fixed supply of domestic industrial good and μ is the expected rate of growth of money supply or the rate of inflation. The aggregate demand for industrial goods is defined as a function of relative prices, the real interest rate, and the aggregate output:
$y^d = \delta_1(e + p^* - p_m) + \delta_2(p_c - p_m) - \sigma(r - \dot{p}) + \eta y$ with $\delta_1, \delta_2, \sigma, \eta > 0$

Following Frankel, the adjustment path for the different goods and assets in the economy, which are the exchange rate, the commodity price, and the industrial good prices, all exogenous variables, are arbitrarily set to equal zero. In the long run, the properties of a stationary money supply and interest are assumed such that $m = \overline{m}$ and $r = r^*$, where $\overline{m}$ is the long-run value of money supply.

After solving for the long-run dynamic path of the exchange rate, industrial price, and commodity price and setting the relative price $(p_c - p_m)$ to its long-run value $(\overline{p}_c - \overline{p}_m)$, which for convenience is normalized at zero, the dynamics equations for the flexible commodity, the industrial price and the exchange rate can be represented in the following matrix form:

$$\begin{pmatrix} \dot{e}(t) \\ \dot{p}_m(t) \\ \dot{p}_c(t) \end{pmatrix} = \begin{pmatrix} \frac{1-\alpha_1-\alpha_2}{\lambda} & \frac{\alpha_1}{\lambda} & \frac{\alpha_2}{\lambda} \\ \frac{\pi(\delta_1-\sigma\gamma_1)}{\theta} & -\pi[(\delta_1+\delta_2)-\sigma\gamma_2/\theta] & \pi[\delta_2+\sigma/\theta(\delta_1+\delta_2)] \\ \omega_1 & \omega_2 & \omega_3 \end{pmatrix} \times \begin{pmatrix} e-\overline{e} \\ p_m-\overline{p}_m \\ p_c-\overline{p}_c \end{pmatrix} + \begin{pmatrix} 0 \\ \mu \\ \frac{-\alpha_1\mu}{\alpha_2} \end{pmatrix}$$

The solution of the dynamic system of adjustment paths for the exchange rate, the commodity price, and the industrial price has three characteristic roots. One of the characteristic roots is negative and the other two are positive. The positive characteristic roots are discarded because they yield unstable solutions. Only the negative characteristic root is considered. If $-\beta$ for $\beta>0$, is the negative characteristic root, according to Frankel (1986), the expected future paths of the commodity price, the industrial good prices and exchange rate, as time *t* goes from zero to infinity can, be expressed as:

$$e(t)-\overline{e}(t)=\exp(-\beta t)\left[e(0)-\overline{e}(0)\right]$$
$$p_m(t)-\overline{p}_m(t)=\exp(-\beta t)\left[p_m(0)-\overline{p}_m(0)\right]$$
$$p_c(t)-\overline{p}_c(t)=\exp(-\beta t)\left[p_c(0)-\overline{p}_c(0)\right]$$

Expressing the future paths of the goods and the exchange rate in rate of change:

$$\dot{e}=-\beta(e-\overline{e})$$
$$\dot{p}_m=-\beta(p_m-\overline{p}_m)+\mu$$
$$\dot{p}_c=-\beta(p_c-\overline{p}_c)-\frac{\alpha_1}{\alpha_2}\mu$$

The higher the value of β, the less the flexible prices overshoot. There is no closed-form solution for β given its dependence on large numbers of structural parameters. The characteristic root, β, captures the speed of adjustment of the system toward the long-run equilibrium. The higher the value of β, the faster is the convergence toward the long-run equilibrium.

Dornbusch, Frankel and SRM argued that following an unanticipated permanent increase in money supply, the flexible goods prices and exchange rate must be "overvalued" in the short-run when the interest rate decreases so that there will be an expected price decrease sufficient to offset the lower interest rate. To derive analytically the overshooting result for the exchange rate, SRM first assumed that in the long run $dm=d\overline{e}=d\overline{p}_c=d\overline{p}_m$ and in the short run $\frac{dp_m}{dm}=0$ and then they combined equations (2.11) and (2.17) in a manner that yields:

$$e=\overline{e}-\frac{\alpha_1(p_m-\overline{p}_m)+\alpha_2(p_c-\overline{p}_c)}{\lambda\beta+(1-\alpha_1-\alpha_2)}$$

The formal expression for the impact of a monetary expansion derived by SRM after differentiating the equation (2.21) with respect to the money supply is:

$$\frac{de}{dm} = 1 + \frac{\alpha_1}{\lambda\beta + (1-\alpha_1-\alpha_2)} - \frac{\alpha_2}{\lambda\beta + (1-\alpha_1-\alpha_2)}\left[\frac{dp_c}{dm} - 1\right]$$

The effect of money supply changes on the exchange rate depends on the effect of money supply changes on the price of the flexible agricultural commodity. If the assumption of money neutrality holds for the flexible commodity price, $\frac{dp_c}{dm} = 1$, the following expression shows that the exchange rate overshoots in response to an increase in money supply:

$$\frac{de}{dm} = 1 + \frac{\alpha_1}{\lambda\beta + (1-\alpha_1-\alpha_2)} > 1 .$$

If the commodity price overshoots, $\frac{dp_c}{dm} > 1$, the exchange rate will also overshoot, but the magnitude of the overshooting is lower than the one observed under money neutrality. This analytical result is expected since the burden of adjustment to the monetary disturbance is shared by the flexible agricultural price and the exchange rate. In the alternative case of agricultural price undershooting, $\frac{dp_c}{dm} < 1$, the exchange rate overshoots to a greater degree than what is observed with money neutrality.

The theoretical model of SRM shows that money can have short-run real effects on relative prices. Thus they demonstrated that macroeconomic policy could contribute to the instability of agricultural prices. The impacts of monetary policy on agricultural prices are investigated empirically using multivariate time series models such as the Vector Autoregressive (VAR) and the Vector Error Correction models (VECM). The solution of the theoretical model of SRM serves as a guide for the variables to include in the multivariate time series models. When the variables are co-integrated, the VECM permits a better exploitation of the long-run relationships among the variables by including information about the variables in their non-stationary form. The VECM will help capture the dynamic relationships between monetary variables and agricultural prices. In addition, it provides a framework within which the overshooting and the relative flexibility hypotheses can be tested.

Saghaian, Reed, and Marchant (2002) used a four-variable time series model in their empirical investigation of the overshooting model. The four variables were agricultural prices, industrial prices, money supply, and exchange rate. This analysis adds a fifth variable to their model, the interest rate, which is naturally part of the system. Unlike Saghaian, Reed, and Marchant (2002), the overshooting of the tropical crops prices is investigated with and without the assumption of money neutrality. With the money neutral assumption, the money supply, the agricultural price, and the industrial price are assumed to move proportionately in the long run.

The application of the overshooting model consists of three steps. In the first step, the stationarity property of each variable is examined using the univariate augmented Dickey and Fuller (1979) unit root test and the Philips-Perron (1988) unit root tests. In the second step, the existence of cointegrating relationships among the variables is tested using the Johansen-Juselius procedure. In the third and last step, if cointegration is found, the vector error correction models are estimated under alternative assumptions about the long-run impact of money supply. When the goods prices are cointegrated with the macroeconomic variable, the flexibility of agricultural prices following monetary shocks is investigated. The validity of the overshooting hypothesis of Dornbusch is assessed by analyzing the impulse response functions of agricultural prices subsequent to monetary shocks.

DATA AND METHOD

Monthly time series data from 1995:01 to 2007:8 were assembled and transformed into their natural logarithm. The prices for coffee[2] and cocoa were retrieved, respectively, from the International Coffee Organization and the International Cocoa Organization. During the period under study, active market interventions through international commodity agreements for cocoa and coffee ceased, giving way to agreement agencies whose remaining role is mostly improving information and market transparency (Gilbert, 1995). All US macroeconomic data are publicly available at the Internet site of the Federal Reserve Bank of St Louis. The conceptual variables, interest rate, exchange rate, money supply, and industrial price, are represented by, respectively, the 3-month Treasury bill rate, the trade-weighted exchange value of the U.S. dollar versus currencies of major trading partners[3], the M1 money stock, and the producer price index for finished goods (finished goods excluding foods). Table 1 presents some descriptive statistics of the variables.

Table 1. Selected descriptive statistics

	Cocoa price	Coffee price	Exchange rate	Money supply	Industrial price	Interest rate
Mean	1486.1	106.4	92.6	1201.7	140.8	3.9
Maximum	2230.4	264.5	112.0	1401.2	167.8	6.2
Minimum	860.7	52.0	77.5	1054.7	126.4	0.9
Std. Dev.	311.9	38.8	9.2	118.2	11.5	1.6
Skewness	-0.2	0.9	0.3	0.5	0.8	-0.7
Kurtosis	2.9	4.1	2.0	1.6	2.4	1.9
Observations	152	152	152	152	152	152

[2] Coffee being a heterogeneous commodity with strong differentiation by varieties (Arabica and Robusta) and by country of origin. The specific price considered is "Other mild Arabica".

[3] The exchange rate is refereed to exactly as "weighted average of the foreign exchange value of the U.S. dollar against a subset of the broad index currencies that circulate widely outside the country of issue."

The decision to use U.S. macroeconomic data is dictated by several practical considerations. The world prices of cocoa and coffee are denominated in U.S. dollars. The U.S. is the leading importer of both green coffee beans and cocoa beans with almost 25 percent and 20 percent of world total imports, respectively, in 1998 (Food and Agriculture Organization, FAO). The U.S. also ranks high in world consumption for coffee and cocoa -- in 1998, per capita consumption of coffee and cocoa was, respectively, 4.1 and 2.4 kilograms. Procter & Gamble, Philip Morris, Mars, and Hershey, all U.S. companies, are major players in the market of goods derived from coffee and cocoa beans. Finally, the New York Board of Trade (NYBOT[4]) is one of the main terminal markets for cocoa and coffee.

Unit Root Tests

The augmented Dickey-Fuller tests and the Philips-Perron tests are used to detect the presence of a unit root in each time series[5]. The Schwarz information criterion (SC) and the Akaike Information Criterion (AIC) were used to identity the appropriate lag order for each variable. Those two information criteria are generally minimized with three or four lags in the unit root regression. The unit root tests did not reject the null hypothesis that each of the level series has a unit; at the 5% significance level, the null hypothesis of a unit root is rejected for the first differences series. The unit root test results for the hypothesis of stationarity with unknown mean are presented in Table 2. Regardless of the specification used in the unit root test, with only an intercept or with an intercept and a linear trend, the augmented Dickey-Fuller and the Philips-Perron unit root test results reinforce each other. Consequently, all series are assumed to be integrated of order one.

Table 2. Test for a unit root

	Augmented Dickey-Fuller		Philips-Perron	
	Level	First Δ	Level	First Δ
Arabica price	-2.08	-6.38	-1.88	-10.30
Cocoa price	-1.95	-5.29	-1.58	-10.71
Money supply	0.37	-6.83	0.13	-15.59
Industrial price	0.59	-5.59	0.78	-10.80
Interest rate	-1.75	-3.07	-1.16	-7.05
Exchange rate	-0.94	-5.58	-0.56	-8.67

MacKinnon 5% critical values for rejection of the null hypothesis of a unit root in the ADF test is -2.88.

[4] NYBOT is a fully owned subsidiary of Intercontinental Exchange (ICE) since Jan. 2007
[5] Unit roots at seasonal frequencies were not considered in this paper.

Cointegration Tests

To test for the existence of cointegration among each agricultural price (coffee and cocoa) and the U.S. economic variables (industrial price, money supply, exchange rate, and interest rate), the Johansen-Juselius likelihood procedure is used. If the variables are cointegrated, the VAR model has the following error correction representation:

$$\Delta Z_t = \Pi Z_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \ \Delta Z_{t-j} + \varepsilon_t$$

where Z_t is a vector of stochastic variables containing the agricultural price (either cocoa or coffee), the money supply, the exchange rate, the interest rate and the industrial price; Γ_j is a matrix of short-run parameters and Π is a matrix of long-run parameters. When the matrix Π has a reduced ranked, there is a factorization $\Pi = \alpha\beta'$ of $0 < r < p$, where the matrix β contains the r cointegrating equations and the matrix α contains the adjustment parameters in the vector error correction model (VECM). The adjustment parameters will be used to assess the speed of adjustment for the different variables following a shock to the equilibrium. Within the SRM framework, the adjustment parameters capture the speed of adjustment of the tropical commodity price relative to manufactured good price after a monetary shock.

Since estimates from VAR models are often sensitive to the number of lags included in the model, the optimal lag order was determined using the following criteria: the final prediction error, the SC, the sequential modified likelihood ratio test, the AIC criterion, and the Hannan-Quinn information criterion (HQ). The lag order two was generally identified by two out of five multivariate diagnostic statistics applied to the VAR model specified in first differences form (Tables 3 and 4). The SC tended to indicate a lag order of zero, but residual diagnostic tests point to a high level of autocorrelation when no lag is included for each VAR model. Johansen's likelihood ratio tests for cointegration rank are applied to verify the existence of cointegrated relationships in each of the two systems. In the absence of a generally accepted method for the best specification to utilize when testing for cointegration relationships, it is assumed that the data generating process of each time series contains two lags and a constant term in the cointegrated equations. At the 5% significance level, the trace statistic and the maximal eigenvalue tests indicate one cointegrated equation exists in the system with cocoa as the agricultural commodity price. In the system containing coffee, the trace statistic indicates the existence of two cointegrating equations at the 5% significance level and one cointegrating equation at the 1% significance level. The maximal eigenvalue test (λ-max) indicates the existence of one cointegrating equation for coffee. We conclude that each system contains only one cointegrated vector[6]. Johansen's likelihood ratio test results are shown for the system containing cocoa and coffee price, respectively in Tables 5 and 6.

[6] No cointegrated relationships were found with deterministic trend assumption

Table 3. Lag Order selection for cocoa, money supply, industrial, interest rate and exchange

Lag	LR	FPE	AIC	SC	HQ
0	NA	2.59E-17	-24.00	-23.89*	-23.96
1	86.95	1.93E-17	-24.30	-23.66	-24.04*
2	72.70	1.57E-17*	-24.51*	-23.34	-24.03
3	31.12	1.75E-17	-24.40	-22.71	-23.71
4	17.16	2.19E-17	-24.18	-21.97	-23.28
5	20.88	2.63E-17	-24.01	-21.27	-22.89
6	29.20	2.92E-17	-23.92	-20.65	-22.59
7	26.00	3.33E-17	-23.81	-20.01	-22.27
8	21.02	3.96E-17	-23.67	-19.34	-21.91
9	29.20	4.31E-17	-23.62	-18.77	-21.65
10	34.35	4.40E-17	-23.65	-18.27	-21.46
11	32.67	4.53E-17	-23.69	-17.78	-21.28
12	64.13*	3.08E-17	-24.15	-17.71	-21.53

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4. Lag Order selection for coffee, money supply, industrial, interest rate and exchange

Lag	LR	FPE	AIC	SC	HQ
0		4.29E-17	-23.50	-23.39*	-23.46
1	84.07	3.3E-17	-23.76	-23.14	-23.51
2	74.98*	2.65E-17*	-23.98*	-22.84	-23.52*
3	37.38	2.81E-17	-23.93	-22.27	-23.25
4	16.78	3.5E-17	-23.71	-21.54	-22.83
5	28.27	3.93E17	-23.61	-20.91	-22.51
6	24.46	4.55E-17	-23.47	-20.26	-22.17

Table 5. Cointegration test with the trace statistic

Ho	Cocoa system	Coffee system	5% Critical Value
r = 0	86.24*	96.76*	76.07
r ≤ 1	50.63	58.36*	53.12
r ≤ 2	29.00	33.54	34.91
r ≤ 3	13.92	17.17	19.96
r ≤ 4	4.75	3.81	9.24

* denotes significance at 5%

Table 6. Cointegration test with the maximal eigenvalue

Ho	Cocoa system	Coffee system	5% Critical Value
r = 0	35.62*	38.40*	34.4
r = 1	21.63	24.82	28.14
r = 2	15.08	16.37	22
r = 3	9.18	13.35	15.67
r = 4	4.75	3.81	9.24

Vector Error Ccorrection Model Estimations

Two types of experiments are carried out in the empirical investigation with the vector error correction models. First, the SRM model is utilized to investigate the linkage among the macroeconomic variables and the agricultural good and industrial good prices. The second experiment complements the empirical estimation of the SRM model by imposing restrictions based upon the long-run property of money supply. All long run estimates are normalized with respect to the agricultural commodity price. The unique cointegrating vector is interpreted as the long-run equilibrium relationship (Engle and Granger, 1987) between the agricultural commodity price and the macroeconomic variables. The estimates for the speed of adjustment coefficients for the agricultural commodity and the industrial good are used to assess the flexibility of agricultural prices relative to industrial prices. The speed of adjustment coefficients for agricultural price, industrial price, exchange rate and money supply are conjectured to be negative. In contrast, the speed of adjustment for interest rate is expected to the positive. The variable ordering was: tropical agricultural price, the industrial price, the exchange rate, the interest rate and the money supply.

In the first experiment, the 5 x 1 cointegrating vector is restricted to the SRM framework such that $\beta = (1 \quad 0 \quad 0 \quad x_4 \quad x_5)$. It is expected that the coefficient estimated for the long-run impact of interest rate on commodity price is negative (x_4) while the parameter capturing the long-run impact of money supply change on commodity price (x_5) is positive. At the 5% significance level, the likelihood ratio tests yield $\chi^2(3)$ = 5.34 (p =0.06) and $\chi^2(3)$ = 3.42 (p =0.18) for the system containing cocoa and coffee, respectively. Consequently the LR tests fail to the reject the restriction imposed by the SRM model for both systems. The long-run linear equilibrium relationships with the SRM model, which allows money to be non-neutral each system, are:

Coffee price = 2.12 + 0.005 Interest rate + 0.40Money Supply
7.51 (0.16) (1.05)

Cocoa price = -4.94 - 0.71Interest rate + 1.94Money Supply
-12.13 (-0.26) (-1.69)

The long-run parameter estimates for the impact of U.S. money supply on coffee price and cocoa price imply that a unit increase in money supply leads to a long-run increase of cocoa price and coffee price of 1.94 units and 0.40 units, respectively. However, neither of these parameter estimates is significantly different from zero at the 5% level. In the long-run, the impact of an interest rate increase on cocoa price is negative (-0.71) and significantly different from zero. In the coffee system, the interest rate is not found to be significantly different from zero at the 5% level.

Tables 7 and 8 present the results with the SRM model for the systems containing cocoa and coffee, respectively. The adjustment parameter for each variable in the cointegrating vector is the overshooting parameter and represents the variable's movement toward the long-run equilibrium relationship after the occurrence of economic shocks. In the short-run, the agricultural price is more flexible than the industrial price if the absolute value of its adjustment parameter is greater than the adjustment parameter for the industrial good, which is true in both cases. This suggests that coffee and cocoa prices react faster to macroeconomic disturbances than industrial good prices. In the cocoa system, for example, the coefficient for the adjustment parameter for cocoa is 1.07% and the adjustment coefficient for the industrial good price is -0.26%. The negative value of the adjustment parameters for good prices and money is consistent with the results of SRM. Furthermore, the degree of flexibility for industrial prices is the lowest in both systems. The speed of adjustment coefficient for agricultural commodity in each case is greater than that of industrial good price, but it is not statistically different from zero in the two systems. In contrast, the adjustment coefficients for industrial good price are statistically different from zero.

Table 7. VECM estimates for the system with cocoa using the SRM model

Variables	?$P_{cc,t}$	?$P_{i,t}$	?$E_{,t}$	?$R_{,t}$	$\Delta m,t$
Adjust coef	-0.011	-0.002	0.003*	-0.002	-0.004
?$P_{cc,t-1}$	0.145	-0.002	-0.001	-0.073	-0.025
?$P_{cc,t-2}$	-0.159	0.001	0.024	-0.133	-0.017
?$P_{i,t-1}$	-0.355	0.070	0.288	0.960	0.011
?$P_{i,t-2}$	-1.246	-0.261*	0.236	0.788	-0.341*
?$E_{,t-1}$	-0.052	-0.010	0.368*	0.434	-0.052
?$E_{,t-2}$	0.025	0.020	-0.174*	-0.402	-0.109
?$R_{,t-1}$	-0.126	0.029*	-0.030	0.381*	0.005
?$R_{,t-2}$	-0.012	0.003	-0.012	0.150	-0.034
?$M_{,t-1}$	-0.798*	-0.015	0.007	-0.522	-0.277*
?$M_{,t-2}$	0.015	0.012	0.004	0.180	-0.509*
R-squared	0.114	0.137	0.187	0.329	0.322
F-statistic	1.769	2.199	3.179	6.770	6.549
Log likelihood	220.674	552.159	423.786	235.071	456.976
Akaike AIC	-2.814	-7.264	-5.541	-3.008	-5.986
Schwarz SC	-2.593	-7.042	-5.319	-2.786	-5.764

Table 8. VECM estimates for the system with coffee using the SRM model

Variables	$\Delta P_{cf,t}$	$\Delta P_{i,t}$	$\Delta E_{,t}$	$\Delta R_{,t}$	$\Delta m,t$
Adjust coef	-0.011	-0.004	0.006*	0.012	-0.006
$\Delta P_{cf,t-1}$	0.185*	-0.007	-0.009	-0.079	0.029*
$\Delta P_{cf,t-2}$	-0.043	-0.010	0.003	0.044	0.000
$\Delta P_{i,t-1}$	1.252	0.035	0.328	1.267	-0.003
$\Delta P_{i,t-2}$	-1.665	-0.263*	0.286	1.100	-0.372*
$\Delta E_{,t-1}$	0.683	-0.011	0.365*	0.415	-0.034
$\Delta E_{,t-2}$	-0.550	0.022	-0.176*	-0.328	-0.119
$\Delta R_{,t-1}$	0.117	0.033*	-0.037	0.410*	0.004
$\Delta R_{,t-2}$	-0.044	0.010	-0.018	0.103	-0.022
$\Delta M_{,t-1}$	0.602	-0.009	0.003	-0.461	-0.261*
$\Delta M_{,t-2}$	0.470	0.020	0.008	0.356	-0.493*
R-squared	0.084	0.173	0.194	0.327	0.324
F-statistic	1.257	2.891	3.330	6.699	6.619
Log likelihood	171.483	555.312	424.447	234.816	457.231
Akaike AIC	-2.154	-7.306	-5.550	-3.004	-5.990
Schwarz SC	-1.932	-7.084	-5.328	-2.782	-5.768

The second experiment attempts to further revisit, within the SRM framework, the linkage between monetary supply and tropical prices when the assumption of money supply homogeneity with respect to prices is imposed such that a one percent increase in money supply will lead in the long run to an equivalent one percent increase in all prices. This is equivalent to setting $\beta = (1 \quad -1 \quad 0 \quad x_4 \quad -1)$. We expect x_4 to be negative. By imposing money neutrality we attempt to verify whether the empirical results will be consistent with economic theory. The LR tests for the system with cocoa and coffee are, respectively, $\chi^2(4)$ = 4.94 (p =0.17) and $\chi^2(4)$ = 4.23 (p =0.23), so the assumption of money neutrality is not rejected at the 5% significance level. The long-run stable linear equilibrium relationships with money neutrality are:

Coffee price = -6.62 - 0.19Interest rate +Industrial price + Money Supply*
(-0.28) (-0.21)

Cocoa price = -3.26 - 0.71 Interest rate* + Industrial price + Money Supply*
(-0.30) (-0.22)

Following the imposition of money neutrality, the long-run impact of the interest rate on cocoa is negative and statistically significant at the 5% level. The magnitude of the coefficient for interest rate is similar in the SRM model and the model imposing the money supply homogeneity. In the two systems containing cocoa price, the long-run model results indicate that for each unit increase in the interest rate, the nominal prices of cocoa and coffee decrease by 0.71 and 0.19 units, respectively. As in the SRM case, the parameter capturing the long-run impact of interest rate on the tropical commodity is significant at the 5% level for cocoa and not for coffee. With the imposition of money neutrality, though, the interest rate has a negative impact on both commodities in the long-run.

The adjustment parameter results with money neutrality are presented in tables 9 and 10. When long-run money neutrality is imposed; the adjustment parameters still indicate that the prices of cocoa and coffee are highly flexible. The magnitudes of the adjustment parameters for cocoa and coffee prices are greater than those of industrial price. Therefore, cocoa price and coffee prices return to their long-run equilibrium faster than the industrial good prices. In both cases the adjustment parameter for coffee and cocoa is higher than that of the exchange rate, which suggests these agricultural commodity prices are highly flexible.

Table 9. VECM estimates for the system with cocoa and long run money neutrality restriction

Variables	$\Delta P_{cc,t}$	$\Delta P_{i,t}$	$\Delta E_{,t}$	$\Delta R_{,t}$	$\Delta m,t$
Adjust coef	-0.011	-0.002	0.003*	-0.001	-0.005
$\Delta P_{cc,t-1}$	0.144	-0.002	-0.001	-0.074	-0.025
$\Delta P_{cc,t-2}$	-0.159	0.001	0.024	-0.133	-0.017
$\Delta P_{i,t-1}$	-0.366	0.070	0.290	0.977	0.005
$\Delta P_{i,t-2}$	-1.257	-0.262*	0.238	0.802	-0.348*
$\Delta E_{,t-1}$	-0.053	-0.010	0.369*	0.432	-0.052
$\Delta E_{,t-2}$	0.021	0.019	-0.173*	-0.403	-0.111
$\Delta R_{,t-1}$	-0.124	0.029*	-0.030	0.381*	0.006
$\Delta R_{,t-2}$	-0.010	0.003	-0.013	0.150	-0.033
$\Delta M_{,t-1}$	-0.795*	-0.013	0.006	-0.515	-0.276*
$\Delta M_{,t-2}$	0.016	0.013	0.003	0.187	-0.509*
R-squared	0.114	0.135	0.187	0.329	0.326
F-statistic	1.779	2.153	3.180	6.763	6.664
Log likelihood	220.723	551.942	423.792	235.045	457.394
Akaike AIC	-2.815	-7.261	-5.541	-3.007	-5.992
Schwarz SC	-2.593	-7.039	-5.319	-2.786	-5.770

Table 10. VECM estimates for the system with coffee and long run money neutrality restriction

Variables	$\Delta P_{cf,t}$	$\Delta P_{i,t}$	$\Delta E_{,t}$	$\Delta R_{,t}$	$\Delta m,t$
Adjust coef	-0.009	-0.002	0.004*	0.005	-0.005*
$\Delta P_{cf,t-1}$	0.1831*	-0.008	-0.007	-0.076	0.028*
$\Delta P_{cf,t-2}$	-0.046	-0.011	0.006	0.047	-0.002
$\Delta P_{i,t-1}$	1.222	0.033	0.343	1.158	-0.007
$\Delta P_{i,t-2}$	-1.680	-0.262	0.293	0.998	-0.370
$\Delta E_{,t-1}$	0.693	-0.008	0.359*	0.422	-0.029
$\Delta E_{,t-2}$	-0.536	0.026	-0.184*	-0.335	-0.112
$\Delta R_{,t-1}$	0.110	0.031*	-0.034	0.417*	0.000
$\Delta R_{,t-2}$	-0.045	0.009	-0.017	0.115	-0.024
$\Delta M_{,t-1}$	0.593	-0.010	0.007	-0.492	-0.263*
$\Delta M_{,t-2}$	0.454	0.017	0.016	0.333	-0.499*
R-squared	0.084	0.173	0.201	0.320	0.324
F-statistic	1.273	2.891	3.465	6.501	6.628
Log likelihood	171.558	555.313	425.030	234.092	457.262
Akaike AIC	-2.155	-7.306	-5.557	-2.995	-5.990
Schwarz SC	-1.933	-7.084	-5.336	-2.773	-5.768

Impulse Response Functions

The impact of monetary policy on the variability of good prices and exchange rate is further investigated using impulse response functions measuring the effect of one variable's shock on another variable for a number of periods ahead (other variables held constant). The response functions are obtained using the generalized impulse response technique of Pesaran and Shin (1998), which is available in the E-views software. Pesaran and Shin adapted the Cholesky orthogonalization technique to obtain impulse response functions that are independent of the variable ordering. The dynamic responses of the agricultural and industrial good prices to a one standard deviation monetary shock are presented in Figures 1 and 2. An exogenous one standard deviation increase in monetary supply has a negative, volatile impact on each of the tropical commodity prices. Moreover, the impact of the monetary shock on agricultural prices is substantially higher than on the industrial price. In the case of cocoa, the initial impact of a money supply change is a sharp negative effect that stretches over two months. The negative effect in price indicates that tropical crop prices undershoot relative to their long-run equilibrium value after a monetary shock. After undershooting, the impulse response functions reveal that prices tend to converge quickly toward a long-run equilibrium for cocoa and coffee that is close to zero. The longer-term impact of the money supply shock on tropical commodity prices is quite small (around 0.1%) but it has a long lasting effect on commodity price. The responses of the industrial good prices to a monetary shock are negligible in the two systems. Thus, the agricultural commodity prices respond faster to money supply shocks than do industrial good prices.

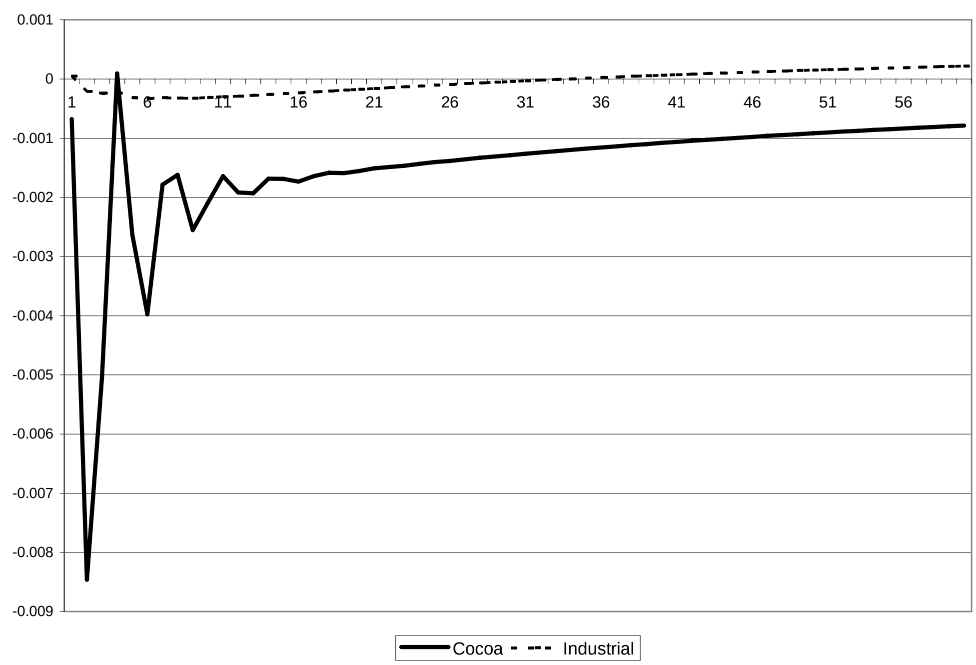

Figure 1. Impulse response of cocoa price to one standard deviation of M1 shock.

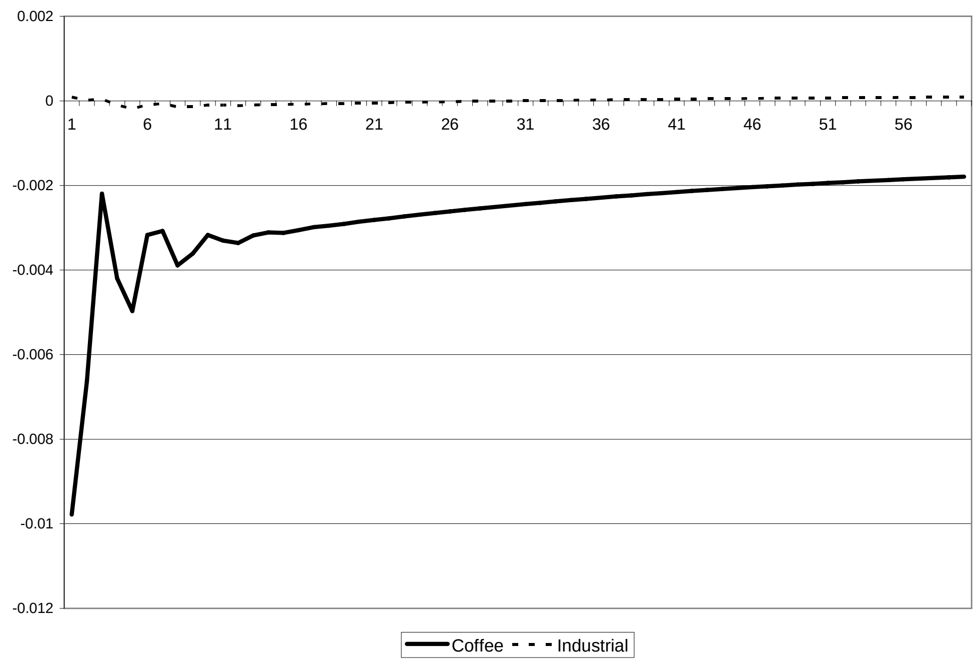

Figure 2. Impulse response of coffee price to one standard deviation of M1 shock.

In their theoretical model, SRM recognized that commodity prices could undershoot if the exchange rate bears all the burden of adjustments to monetary shocks. Undershooting is also conceptually possible when the interest rate response to money demand is sluggish. Lai et al. (1996) and Dorfman and Lastrapes (1996) also recognized that undershooting of commodity price was possible. Reviewing the theoretical literature on the overshooting hypothesis, Kitchen and Denbaly (1987) suggested that wealth effects (through changes in output or the trade balance), sluggish financial adjustments, restrictions on capital mobility, or imperfect substitutability between domestic and foreign bonds could mitigate the response of flexible good prices to monetary shocks and even lead to undershooting. In this model the response of the exchange rate to a money supply shock was investigated and no evidence of exchange rate overshooting was found. Thus, the best explanation of the undershooting for tropical goods prices is the sluggish response of the interest rate to changes in the money market, which is possible if the uncovered interest rate parity condition does not hold.

Summary and Conclusions

A VECM is used in this paper to analyze the impacts of U. S. monetary policy on coffee and cocoa prices using a modification of the conceptual and analytical framework developed by Saghaian, Reed, and Marchant (2002). The results of this analysis shed light on the linkages between monetary policy and the instability of the prices for two important crops for developing countries, cocoa and coffee. The econometric evidence points toward the high flexibility of cocoa and coffee prices in the short-run. Those prices respond faster to money supply shocks than do industrial good prices. Furthermore, the results indicate that tropical crop prices are more flexible than the exchange rate, which is traded in transparent exchange markets. The impulse response functions of coffee and cocoa prices to money supply change indicate that tropical crop prices undershoot in the short-run following a money supply shock. The impulse responses functions also indicate that the long-run impacts of money supply shocks on the tropical crop prices are long lasting and negative, though small. The high flexibility and undershooting of the tropical crops prices have important implications for developing countries.

For Andrews and Rausser (1986) the undershooting of agricultural prices from a money supply increase represents a form of tax from macroeconomic disturbances. This undershooting of the tropical crop prices following a monetary shock can be viewed as a redistribution of income that adversely affects producing countries and favorably affects consumers in the consuming countries. Offsetting the welfare loss due to price variability was the driving force behind various domestic and international intervention policies for cocoa and coffee.

With the collapse of these intervention policies, market-based instruments such futures and options hedging have been advocated as efficient and effective alternatives to mitigate the price instability of these tropical crops. This adds exchange rate risk and basis risk to the challenges from transactions costs, information costs, and credit constraints that already face coffee and cocoa growers. If cocoa and coffee prices undershoot following monetary shocks, it is important to determine the duration of the transitory effects of overshooting or undershooting. In the case of undershooting, hedging during the downward phase might not be optimal.

For the large number of developing countries that rely on the trade of coffee and cocoa for export earnings, the instability of those crop prices jeopardizes their development goals by deterring investment and economic growth. It is possible that a strategy results in direct intervention into the market can help insulate against the instability arising from the macroeconomic sector. Agricultural policies may need to be flexible enough to adapt to changing macroeconomic environments and its resulting instability. With the collapse and decline in popularity of international commodity agreements and parastatal agencies controlling the internal and external marketing of cocoa and coffee, development economists seem hard-pressed for intervention instruments that will tackle price variability and the challenges associated with the downward trend in real price.

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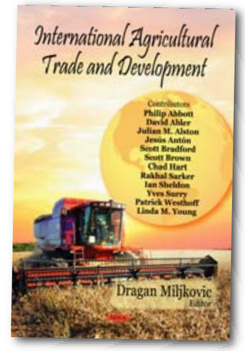

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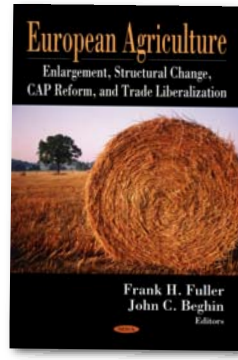

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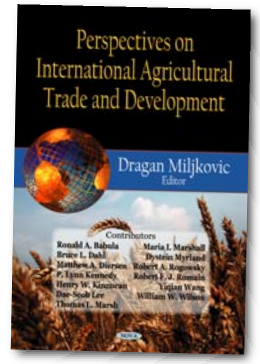

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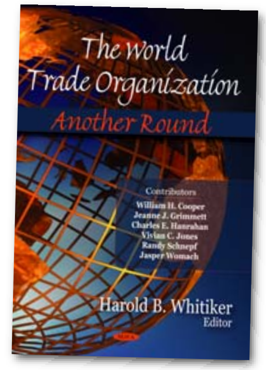

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