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Evaluating the Market and Welfare Impacts of Agricultural Policies in Developed Countries: Comparison of Partial and General Equilibrium Measures

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We revisit the question of choosing partial equilibrium or general equilibrium modeling in applied policy analysis in the context of evaluating the effects of a complete phase-out of the Common Agricultural Policy (CAP) of the European Union. We compare the results of three models—two three-sector general equilibrium models (one with an additional major distortion in the nonagricultural sector) and a two-sector partial equilibrium model. We find that the market effects of a complete phase-out of the CAP are quite comparable across these models. On the other hand, the measured welfare impacts may depend on the modeling choice.

Agriculture continues to be a major bone of contention in the negotiations of regional trade agreements, as well as in the ongoing multilateral trade negotiations conducted by the World Trade Organization (WTO). It is widely acknowledged that the difficulties in making some progress in the agricultural dossiers significantly contributed to the failure of the fifth WTO Ministerial Conference in Cancun in September 2003. Indeed, there remains disagreement and confusion as to the true extent of global farm support. Perhaps most important, there is still considerable debate over the impacts of these agricultural policies.

Numerous quantitative analyses have been performed. But the attributes of the models used differ, and so do the derived results. The diversity of modeling approaches is understandable: there are many unresolved modeling challenges and no model can serve all purposes (Westhoff et al.). Whereas economists may

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accept and even welcome the discrepancies among the results of alternative models purporting to address the same question, policy makers and the public are often baffled by the seeming inconclusiveness of applied policy analysis.

The main purpose of this paper is to revisit the roots of such discrepancies. Among the various modeling factors that may contribute to differing conclusions, we focus on the comparison between partial equilibrium (PE) and general equilibrium (GE) estimates, for two main reasons. First, it is quite common to distinguish between PE and GE models for agricultural policy analysis (e.g., van Tongeren, van Meijl, and Surry). Second, it has long been observed empirically that these two frameworks lead to different outcomes, with GE models typically yielding larger welfare gains and lower world price impacts than PE models (e.g., Winters; Johnson; Sharma, Konandreas, and Greenfield). To date, there have been few attempts to compare PE and GE models while controlling for other modeling factors. Moreover, such studies offer a mixed picture, some concluding that GE and PE estimates are very different and others finding the opposite. In that context, this article reports a new empirical comparison of GE/PE estimates of a significant agricultural liberalization scenario. Compared to previous comparative studies, our analysis is not restricted to either the market or welfare impacts but considers both types of effects. Our analysis also emphasizes the nonagricultural sectors, which are, arguably, what critically differentiates the GE and PE frameworks.

We review a number of studies that compare PE and GE analysis of agricultural policies and try to sort out the main reasons for diverging conclusions. Next, we present our analytical framework, which nests the two modeling approaches and emphasizes their differences. We analyze a radical policy experiment designed to maximize the economic impacts, thus making it as difficult as possible to choose between the two modeling approaches. This experiment focuses on the Common Agricultural Policy (CAP) of the European Union (EU), widely regarded as the epitome of a distorted sector.

PE versus GE Estimates of Farm Policy: Review of Empirical Comparisons

A GE model can be viewed as a consistent sum of PE models, with the explicit structural representation of all good and factor markets, as well as the specification of macroeconomic equilibrium conditions. *Ceteris paribus*, therefore, a GE approach is bound to be more general and the results are more appealing on theoretical grounds. But often there is a meaningful trade-off between a GE and a PE approach. Generally speaking, PE models can provide a detailed analysis of some sectors, while ignoring interactions with other sectors of the economy. In contrast, GE models can take these interactions into account, often at the cost of relying on a more aggregated level of analysis.

Agriculture's typically small (and declining) share of the economy in developed countries, however, suggests that there may be a limited scope for capturing economy-wide effects in agricultural policy analysis. This is clearly recognized by some GE studies. Hertel (1990), for instance, provides a formal argument of why a GE model is not needed to assess accurately the farm sector impacts of most farm policy changes when (as in developed countries) agriculture accounts for a small fraction of the economy.

There are a number of reasons why a GE framework may still be attractive in such cases, including accounting consistency, the explicit treatment of interindustry linkages, theoretical consistency with the powerful check offered by Walras's Law, and the possibility of conducting household-based welfare analysis (Hertel, 2002). On this last point, since Harberger, it is well known that a GE approach is theoretically preferable for the assessment of welfare effects when there are distortions in the economy under consideration.[1] These theoretical arguments, however, remain of little help in understanding whether PE and GE models should lead to different outcomes when contemplating farm policy reforms in developed countries.

Review of Studies Explaining Differences

Gylfason, Tokarick, and Bautista et al. attempt to explain the differences between PE and GE estimates. Gylfason reviews fourteen studies measuring the cost of EU agricultural support in the 1980s. Nine of them were based on PE models and, on average, they estimate that the cost of the CAP represents 0.7% of the EU Gross Domestic Product (GDP) (with a minimum of 0.3 and a maximum of 1.3). In contrast, the five studies relying on GE models found an average cost equivalent to 2.2% of the GDP (with a minimum of 1.4 and a maximum of 3.3). Thus, on average, GE estimates are about three times higher than PE estimates. According to Gylfason, this huge difference is mostly explained by the larger price elasticities of agricultural supply typically assumed in GE models.

On the other hand, the existence of other distortions that may interact is seldom acknowledged. To illustrate, Gylfason derives a synthetic formula that expresses static output gains from agricultural trade liberalization as a function of only three elements: the level of agricultural protection, the agricultural productivity growth, and the price elasticity of industrial supply. The higher the price elasticities of industrial supply and agricultural supply, the greater the static output gains. For instance, assume initial domestic farm prices are 80% above world market prices, and agricultural productivity growth is at an average rate. Under these assumptions, static output gains from complete agricultural liberalization would range from 0.7% of GDP when the price elasticity of industrial supply equals 0.05 to 2.8% when this elasticity reaches 0.2.

Gylfason's rationale is that the GE approach accounts for the response of non-agricultural output to farm trade liberalization and explicitly assumes a time horizon long enough for all farm inputs to be gainfully re-employed outside agriculture. In contrast, PE estimates do not reflect the other side of the coin, namely, the loss of producer surplus and the gain in consumer surplus resulting from depressed industrial prices relative to agriculture.

Tokarick offers estimates of the distortionary impacts of farm policies using both PE and GE models. More precisely, Tokarick's PE model has ten commodities and is structurally very similar to other PE models currently used to assess the impact of agricultural support (such as the Organisation for Economic Co-operation and Development [OECD], Food and Agricultural Policy Research Institute [FAPRI],

Table 1. Welfare change effects of agricultural liberalization in developed countries: Partial versus general equilibrium estimates (millions of US dollars)

	USA	EU	Japan
Partial equilibrium			
Total welfare change[a]	11,303	10,716	3,420
General equilibrium			
Equivalent variation	6,182	31,788	22,333

Source: Tokarick.
[a]Sum over all commodities of producer surplus, consumer surplus, and government net revenue.

U.S. Department of Agriculture, and United Nations Conference on Trade and Development [UNCTAD] models). He also uses the standard Global Trade Analysis Project (GTAP) model calibrated with data for 1997 (Hertel, 1997), which is currently the most widely used GE model. Both models are used to assess the market and welfare impacts of a complete removal of agricultural policies of developed countries.

Table 1 reports the welfare effects of this experiment for three developed countries.[2] While both frameworks yield positive welfare effects, the quantitative estimates vary substantially. According to the PE results, the United States and the EU are the main winners from agricultural liberalization, whereas Japan has less incentive to pursue such a policy. In contrast, the GE results show that the EU will gain the most from an agricultural liberalization, followed by Japan. The United States will receive very limited benefits. The results appear even more differentiated in a per-country comparison. As in the prior results mentioned earlier, welfare gains computed with the GE model are higher than with the PE model for both the EU and Japan (by a factor of three and six, respectively). But for the United States, the GE welfare impact is only half the amount of the PE estimate (table 1). The discussion in Tokarick, while admittedly mostly focused on developing countries, suggests that these important differences are primarily explained by the displacement of resources (labor and capital) from agriculture to other economic sectors (manufacturing and services), which only the GE model takes into account.

Although our focus is on developed countries, it is worthwhile to conduct a quick review of the literature assessing farm policies in developing countries.[3] Agriculture in developing countries represents a larger share of the economy and is generally perceived as taxed relative to the industrial sectors. Recently, Bautista et al. compared PE and GE evaluations of the policy bias against agriculture with a "stylized" version of a Tanzania-like economy. This economy is clearly dominated by agriculture, which accounts for 42% of total gross production and 56% in value-added at market prices.

Bautista et al. find that PE measures miss much of the action operating through indirect product and factor market linkages while overstating the strength of the linkages between the changes in the exchange rate and price of traded goods on the agricultural terms of trade. This study then supports the use of GE models.

However, close inspection of the results reveals that differences between the two approaches mainly come from different assumptions concerning the degree of tradability of all commodities. "Large" second-best effects are not relevant because the starting point of the policy simulations is a distortion-free base solution. More precisely, their PE model assumes perfect substitutability between domestic and traded goods, while the GE model adopts imperfect substitutability between domestically produced and imported goods, as well as between domestic products for exports and for internal use (the so-called Armington specification, with finite elasticity of substitution and/or transformation). Thus, like previous studies on developed countries that find significant differences between PE and GE estimates, this study reveals that, to a large extent, the specification of price elasticities is what really matters.

Review of Studies Revealing No Differences

Whereas previous papers stress the significant differences between PE and GE estimates, other studies conclude the opposite. Hertel (1992), for example, finds that the market effects of CAP removal on agricultural markets are very similar, regardless of whether estimates are derived from a PE or a GE model. For instance, his experiment yields a 10.9% decrease in EU agricultural production with the GE model, and an 11.9% decrease with the PE model.

Contrary to previous authors, Hertel starts from a highly aggregated GE model (the SALTER model with three commodities and nine regions), and generates the PE specification by assuming that (i) nonfood output levels and prices are exogenous, (ii) income is exogenous, and (iii) nonland primary factor rental rates are exogenous. Differences between the two approaches are kept to a minimum (in particular, same database, sectoral and regional disaggregation, price specifications, and market structures).

The fact that results are similar between GE and PE specifications reveals that the exogenously specified variables in PE are marginally affected by the experiment. For instance, there is only a slight increase of EU manufacturing and services outputs of 1.5% and 0.5%, respectively. Hertel argues that, in this case, the PE model performs very well and the major benefit of a GE analysis is its ability to draw the link between agricultural and nonagricultural interests in farm policy, and by extension to find new advocates of policy reform.

At this juncture, it is worth mentioning that Hertel performs another experiment and contemplates full removal of all policies, excluding the CAP.[4] In that case, differences between PE and GE estimates of production impacts are more pronounced (they reach 8%), mainly because the shock is greater and competition for fixed factor endowments becomes more severe. The main message of this second experiment is to reveal the inadequacy of PE models for handling simultaneous shocks to both agriculture and nonagriculture.

Peterson, Hertel, and Stout also provide empirical comparisons between PE and GE estimates of agricultural liberalization. In this paper, a variant of the Static World Policy Simulation (SWOPSIM) Modeling Framework, the well-known PE model with three regions and twenty-three agriculturally related commodities, is the starting modeling framework. Peterson, Hertel, and Stout add one nonagricultural commodity to the model and close it with an income equation to get the GE version. These two models are used to examine the impacts of complete agricultural liberalization in the United States and the EU. World price impacts are very similar, with the main difference reaching only 0.5%. Percentage changes in agricultural factor returns are also comparable. These authors conclude that if one is only interested in the farm sector effects of farm policies, it is sufficient to treat the nonfood sector as exogenous. On the other hand, complete coverage of the agricultural sector is very important to account for otherwise significant leakages.

Finally, Nielsen investigates the effects of the EU enlargement to the east with GTAP as the core of the modeling framework. Six different closures are imposed on this GE model, leading to five PE versions as well as the standard GTAP version. The first version assumes there are ten completely independent agricultural commodity markets (cross-price elasticities are put to zero). The second version takes into account cross-price elasticities between these markets. Version three generalizes the previous one by introducing the land market, whereas version four introduces all primary factor markets. Version five adds five food markets, and, finally, the GE model includes other commodity markets and makes regional incomes endogenous.

It appears that the first two PE versions give estimates far different from the four others. For instance, following integration, EU-15 wheat production declines by 10.2% and 13.2% according to the first two PE versions, compared to 4.4%, 3.5%, 5.1%, and 4.2% in the four subsequent versions. These results suggest that GE modeling reveals only minor new effects compared with a PE model that includes a land market-clearing mechanism, mainly because these added effects pull in opposite directions.

Interim Summary

From the foregoing literature review, it is tempting to dismiss the PE versus GE modeling question as simply one of choosing appropriate parameters and/or exogeneity assumptions. But two points warrant further consideration. First, the studies that find significant differences between PE/GE estimates exclusively focus on welfare effects, while the other studies concentrate mostly on market effects. So are the results really conflicting?

To address this first issue, market and welfare effects must be jointly evaluated, a perspective that appears to have been somewhat neglected in previous studies. Therefore the first objective of our empirical analysis is the joint evaluation of market and welfare effects in the context of an explicit agricultural trade liberalization framework. Second, at least since Harberger, we know that welfare change measured in one market is inappropriate if distortions exist in other markets. The aforementioned studies either fail to account for these other distortions or seem to suggest that distortions marginally interact.

The second question that remains to be pursued, then, concerns the implications of such possible distortions on a particular GE analysis. Of course, many possible distortions could be relevant and warrant explicit analysis (e.g., public goods, tax and income policies, scale economies, capital market imperfections).

Labor market regulations are the domestic distortions that probably receive the most attention. For instance, Goulder and Williams argue that the traditional measure of the excess burden of commodity taxes, which ignores labor market regulations, underestimates the true cost (in some cases by a factor of 10 or more). It is thus highly desirable to correctly specify this labor market in GE models. As an illustration of a prototypical distorted economy, therefore, our empirical application considers the existence of labor market rigidities leading to involuntary unemployment.

Empirical Framework

We use the GTAP model version 4, and its associated database, as the core of our empirical framework.[5] Three different versions of the model are developed to address this paper's two main concerns. The first model version, hereafter labeled the standard GE specification, is a slight modification of the standard GTAP model described in Harrison, Rutherford, and Tarr. Our modifications are meant to introduce more realistic price/income elasticities.

The second one, hereafter labeled the PE version, treats nonagricultural components as exogenous. Finally, the third scenario, the distorted GE version, introduces one labor market regulation. We first detail the main characteristics of the standard GE version before mentioning only differences between it and the two others.

The Standard GE Model

Our first version is a relatively simple multiregion, multisector computable GE model, which is static and perfectly competitive. The aggregation retains only three mono-product sectors—crop, animal, and other activities (hereafter labeled services for simplicity); two regions, the EU and the Rest of the World (RoW); and three primary factors of production (labor, capital, and land).[6]

Bilateral trade between the two regions is modeled with an "Armington" specification (Armington). Because of the crude commodity aggregation, we assume that substitution elasticities on the import side equal 2 (half of usual values) but maintain perfect tradability on the export side. Each region has a single representative consumer who allocates income across commodities so as to maximize welfare. To capture the characteristics of food demand in developed countries, which is typically found to be both price and income inelastic (e.g., Moschini), we adopt a latent separability specification (Gohin). Elasticity of substitution is assumed to be 0.5 for the pair crop/animal and 0.1 for the two other pairs. Income elasticities are set to 0.2 for the crop commodity, and to 0.3 for the animal commodity. The income elasticity for services (1.05) is derived from the budget constraint (Engel condition). Tables 2 and 3 reports all EU final demand elasticities.

As for the production side, the technologies of profit-maximizing producers exhibit constant returns to scale. With a medium-term horizon in mind, we assume that capital is fixed in each sector, whereas both labor and land are perfectly mobile between activities and are in fixed supply. Substitution between intermediate inputs and primary factors is assumed to be zero (still because of the crude commodity aggregation) while the substitution between primary factors is

Table 2. Assumed EU final demand elasticities (Marshallian demands)

	Crop	Animal	Services	Income
Crop	−0.121	0.014	−0.093	0.200
Animal	0.004	−0.117	−0.187	0.300
Services	−0.019	−0.044	−0.989	1.052

Table 3. Assumed EU final demand elasticities (Hicksian demands)

	Crop	Animal	Services
Crop	−0.116	0.023	0.093
Animal	0.010	−0.103	0.093
Services	0.002	0.005	−0.007

governed by a constant elasticity of substitution (CES) function. The value of the substitution elasticity is calibrated at 0.2 in the crop and animal sectors, so that price elasticities of supply are around 0.7 in the base. For the services sector, the substitution elasticity is 0.5, which leads to a price elasticity of supply of 0.35.

Production taxes (on intermediate inputs and volume of production), consumption taxes, and trade taxes (export and import) are the distortions included in this standard GE version. All these distortions are represented as ad valorem price wedges.[7] Finally, we choose the EU consumer price of services as our *numéraire* so as to minimize the inevitable difference between the compensating and equivalent variation measures of welfare (Hausman), and to facilitate the comparison with the PE results.

The PE Model

To obtain our PE version, we follow Hertel (1992) by first adopting the standard GE model and assuming that (i) the prices of services, (ii) regional incomes, and (iii) wages are now exogenous variables.[8] Accordingly, the equations defining these variables are dropped. At this stage, two remarks are in order. First, we maintain the land market equilibrium equation because this procedure has progressively become the norm in PE models focused on agriculture. Moreover, Nielsen already stresses the substantial effect that the modeling of this market has on-farm policy estimates. Second, we also maintain the specification of the complete final demand system used in the GE model (because we only have one good in the rest of the economy, the price of which is presumed fixed in the PE analysis).[9]

The Distorted GE Model

Our last version still starts from the standard GE model and removes its labor market closure for the EU. We now assume that there are considerable rigidities in the labor market, as suggested by the existence of severe unemployment rates in the EU countries (averaging 9% in the 1990s). Practically, we introduce the constraint that the EU nominal wage not be allowed to fall from its benchmark value, with the labor supply assumed perfectly elastic. It follows that any changes in labor demand are automatically matched by changes in labor supply. This is obviously a highly simplified representation of the complex rigidities in EU labor markets. Nevertheless, this rather simple modeling of the effects of unemployment follows previous approaches, for instance, Harrison, Rutherford, and Wooton in the context of the evaluation of the CAP or Mercenier in the context of the evaluation of the creation of the EU single market.

Simulation Results

We simulate complete removal of the CAP in order to maximize the resulting economic impacts. This specification also allows us to circumvent the question of how particular instruments operate at the margin (especially given our level of commodity aggregation). Practically, we remove export and production subsidies and import tariffs on the two agricultural commodities but maintain all taxes on services as well as consumption taxes on all products. Before interpreting the simulation results, it is worth noting some features of the base (table 4). The crop sector represents 1.5% of total EU gross production and the animal sector, 3.0%. The crop and animal sectors represent 1.7 and 1.9% in total value-added, respectively. These two sectors benefit from significant support compared to the services sector, which faces production and export taxes. It also appears that the animal sector is highly insulated from world market prices, as reflected by the high export subsidy and import tariff rates, while the crop sector benefits relatively more from direct subsidies and to a lesser extent from price support instruments.[10]

Results from the Standard GE Model

Table 5 reports the market effects of our policy experiment under the three modeling specifications and table 6 shows the welfare effects. For completeness

Table 4. Features of the EU economy in the initial situation (in billion U.S. dollars or %)

	Crop	Animal	Services	Total
Production	240.5	491.7	15,544.2	16,276.4
Share	1.5%	3.0%	95.5%	100%
Value added	126.9	141.8	7,367.8	7,636.5
Share	1.7%	1.9%	96.4%	100%
Output subsidies	25.0	23.2	−358.9	−310.7
Output subsidy rate	10.4%	4.7%	−2.3%	
Export subsidies	2.6	9.8	−3.8	8.6
Export subsidy rate	15.8%	42.9%	−0.4%	
Import tariff revenue	5.2	5.3	23.1	33.5
Import tariff rate	12.9%	52.1%	2.7%	

Source: GTAP version 4 database.

Table 5. Market impacts of CAP removal (percentage differences with respect to the base)

	Standard GE	PE	Distorted GE
EU production			
Crop	−8.1	−8.7	−8.4
Animal	−14.9	−15.2	−15.2
Services	+0.3	–	+0.01
EU producer prices			
Crop	−1.1	−1.2	−0.9
Animal	−7.7	−7.7	−7.6
Services	−0.02	–	−0.02
EU final consumption			
Crop	+0.0	+0.1	−0.1
Animal	+1.0	+1.1	+0.8
Services	+0.1	+0.4	−0.4
EU final prices			
Crop	−1.5	−1.6	−1.3
Animal	−8.9	−8.9	−8.8
Services	0	–	0
EU imports			
Crop	+11.0	+12.6	+11.3
Animal	+208.2	+215.5	+209.2
Services	−2.8	–	−3.0
EU import prices			
Crop	−2.6	−3.0	−2.6
Animal	−15.1	−15.3	−15.0
Services	+0.2	–	+0.2
EU exports			
Crop	−39.4	−41.3	−40.0
Animal	−90.8	−91.2	−90.8
Services	+3.3	–	+3.1
RoW import prices			
Crop	+9.1	+8.6	+9.2
Animal	+18.3	+17.7	+18.4
Services	+0.4	–	+0.3
EU land market			
Price	−58.4	−59.6	−59.0
Demand by crop sector	+4.7	+4.5	+4.6
Demand by animal sector	−6.0	−5.8	−5.9
EU labor market			
Price	−1.0	–	0
Demand by crop sector	−12.0	−12.8	−12.5
Demand by animal sector	−21.0	−21.4	−21.3
Demand by services	+0.9	–	+0.03
EU capital market			
Shadow price in crop sector	−47.8	−49.7	−48.6
Shadow price in animal sector	−69.5	−70.0	−69.8
Shadow price in services	+0.7	–	+0.1

Table 6. Welfare impacts of CAP removal (differences from the baseline, in billions of U.S. dollars)

	Standard GE	PE	Distorted GE
Value added	−64.7	–	−90.0
Crop	−34.2	−35.0	−34.2
Animal	−59.3	−59.4	−59.2
Services	+28.7	–	+3.4
Returns to land	−12.9	−13.2	−13.0
Returns to labor	−31.7	–	−26.1
Returns to capital	−20.1	–	−50.8
Crop	−17.0	−17.7	−17.3
Animal	−35.9	−36.2	−36.1
Services	+32.8	–	+2.5
Agricultural producer surplus[a]	−65.8	−67.1	−66.4
Crop	−24.0	−24.9	−24.4
Animal	−41.8	−42.2	−42.0
Taxpayer surplus[b]	+51.0	+50.1	+49.7
Output subsidies	−49.4	−48.2	−48.2
Crop	−25.0	−25.0	−25.0
Animal	−23.2	−23.2	−23.2
Services	−1.2	–	0.0
Export subsidies	−12.6	−12.4	−12.6
Crop	−2.6	−2.6	−2.6
Animal	−9.8	−9.8	−9.8
Services	−0.2	–	−0.2
Import tariff revenue	−11.0	−10.5	−11.1
Crop	−5.2	−5.2	−5.2
Animal	−5.3	−5.3	−5.3
Services	−0.5	–	−0.6
Aggregate welfare	+8.9	+5.5	−19.1
Disposable income	−13.4	–	−40.8
Household welfare (EV)	+8.9	–	−19.1
Consumer welfare (EV)	–	+22.5	–

[a]Returns to capital and land.
[b]Net sum of all taxes and subsidies.

and transparency, we provide the impacts on all main EU variables. Consider first the estimated impacts in the standard GE specification (second column of both tables). As expected, the removal of the CAP leads to a significant decline of EU agricultural production, which is more pronounced for the animal sector (14.9%) than for the crop sector (8.1%). Hence, we again find that price support instruments have more coupling impacts on production than do direct subsidies. European producer and consumer prices of the animal commodity decrease by nearly 8%, leading to a rather limited increase of that commodity's final demand (1.0%) due to the assumed price inelasticity of demand.

On the other hand, crop price decreases are very limited and crop consumption is essentially unchanged. Larger animal imports (208.2% increase) and smaller exports (90.8% less) compensate for the production declines. These trade effects lead to substantial world price increases, explaining the traditional external pressure for CAP reform.

Regarding production technologies, land allocation shifts toward crop production (4.7%) to the detriment of the animal sector (6.0%), while land return decreases 58.4%. The "extensification" process with respect to land accounts for most of the agricultural production decreases. But these come with a 17.4% reduction of farm labor. By assumption, capital is fixed in each sector and capital returns in the agricultural sectors substantially decrease.

European farmers are hurt in this experiment, which is consistent with their continuing resistance to CAP reforms. In contrast, services production increases (0.3%), mainly thanks to the flow of labor to this sector (0.9%) and the wage decline (1.0%). This supplementary production translates into more domestic consumption and exports and conversely to less imports. This experiment then benefits the European services sector (a slight increase of the shadow price of capital) but percentage figures here are low because of the small share of the agricultural sectors.

Farm value-added decreases by $93.5 billion while the services sector value-added increases by $28.7 billion (table 6). Net taxpayer surplus increases by $51 billion, mainly because of the budgetary effects of the removal of agricultural output/export subsidies. Disposable income decreases by $13.4 billion. But aggregate welfare, computed as the equivalent variation (EV) measure, increases by $8.9 billion. This aggregate welfare is computed for the representative household, which owns all primary factors of production, and reflects both the impact of price changes (food prices decrease) and the change in disposable income.

Results from the PE Model

The foregoing GE results are not especially surprising. In particular, we obtain very limited impacts on the nonagricultural (i.e., services) sector, wages and disposable income, which raises the question of whether it is important to account for them explicitly. In fact, once we compare these first GE results with those derived from the PE specification, we observe that food market impacts are very similar. The differences are almost within the 1% range. Agricultural production decreases slightly more, because price declines are more pronounced. For the same reason, final consumption marginally increases, so that trade effects are magnified.

The surpluses that accrue to producers, consumers, and taxpayers are the typical welfare measures in PE models. Producer surplus is computed as the returns to capital and land. Land returns, of course, matter because there are no nonfarm uses of this factor, so that the land market-clearing condition can be maintained within the agricultural sector. Returns to capital are also relevant because we have assumed rigidities in the movement of capital across sectors.[11]

Using this definition, it appears that European farmers lose $67.1 billion, compared to $65.8 billion with the standard GE specification. The expected overestimation of European farmers' benefits from the CAP (Chambers) is actually very limited. Taxpayer surplus, in the PE framework, only includes food subsidies and tariffs. The taxpayers' gain amounts to $50.1 billion, slightly less than with the standard GE version because increasing taxes on services production and consumption are not taken into account.

Finally, consumer welfare, computed as the EV measure, increases by $22.5 billion (table 6).[12] This measure is much larger than the EV estimate obtained from the GE model, but, in fact, these two measures are not directly comparable because the PE measure that we report, following standard practice, does not account for variations in the disposable income. The change in disposable income, in the PE approach, could be estimated by the sum of the changes in producer surplus and taxpayer surplus. Indeed, it is common practice in PE analyses to simply sum producers' surplus, taxpayers' surplus, and consumer welfare to get a PE measure of aggregate welfare (e.g., Tokarick). Carrying out this summation yields an aggregate welfare gain of $5.5 billion, which is quite comparable to the EV welfare estimate obtained from the standard GE model. Similar to some previous studies, therefore, the PE model leads to welfare gains lower than those of the GE model. However, the differences in estimated welfare effects are minimal in our PE model (which retains an integrable demand system and explicitly accounts for the exogenously given land resource base). Our welfare results also contrast with those reported by Gylfason because our estimates never exceed 0.2% of initial GDP of the EU.

Results from the Distorted GE Model

How is this picture affected when the existence of European labor market rigidities is taken into account? Comparing the distorted/standard GE results again reveals marginal changes in terms of market effects. Obviously, given the nature of the distortion that we model, the main difference is the reduction in labor use (about 0.8%). Assuming a 9% unemployment rate in the initial solution would mean an 8.1% increase in unemployment to 9.7%. Practically, this would represent the presumption that European farmers may not easily find jobs in the rest of the economy. This effect translates into a large decrease in disposable income ($40.8 billion) and a welfare loss of $19.1 billion. Quite clearly, the differences in terms of welfare effects between the models are much more severe.

As emphasized earlier, many empirical studies already reveal the potential crucial role of labor market modeling. For instance, Harrison, Rutherford, and Wooton found that the welfare impact of a CAP elimination scenario in 1974 ranges from a decrease of 0.2% of initial GDP to an increase of 0.5%, depending on the introduction/absence of unemployment (a reflection of the familiar theory of the second best).

Sensitivity Analysis

All previous results are obviously contingent on other modeling assumptions, as well as the definition of our experiment. Tables 7 and 8 provide the results of a (limited) sensitivity analysis for the elasticities used in the models. Because of space reasons, we focus on one market variable (the EU crop production) and one welfare measure (aggregate welfare). We first examine the robustness of these results to the value of Armington elasticities and successively cut by half and double the base value. In the same manner, we test the sensitivity to the income elasticities[13] and to the substitution elasticities in the production technologies.

Table 7. Sensitivity analysis of EU crop production (percent differences with respect to the base)

	Standard GE	PE	Distorted GE
Baseline results	−8.1	−8.7	−8.4
Armington elasticities			
Low values	−8.0	−8.7	−8.4
High values	−8.1	−8.8	−8.5
Income elasticities			
Low values	−8.2	−8.8	−8.5
High values	−8.1	−8.9	−8.5
Production elasticities			
Low values	−4.8	−5.4	−5.1
High values	−12.5	−13.3	−13.0

Table 8. Sensitivity analysis of aggregate welfare (billions of U.S. dollars)

	Standard GE	PE	Distorted GE
Baseline results	8.9	5.5	−19.1
Armington elasticities			
Low values	8.8	5.8	−18.7
High values	9.0	5.1	−19.8
Income elasticities			
Low values	9.0	5.5	−19.1
High values	8.9	5.6	−19.2
Production elasticities			
Low values	5.9	0.3	−12.7
High values	12.9	12.6	−28.1

It appears that the results are not very sensitive to the values of Armington and income elasticities. On the other hand, they are more sensitive to production elasticities. For instance, according to the standard GE model, EU crop production decreases by 8.1% in the base case, by 4.8% in the low case, and as much as 12.5% in the high case. This is not surprising because our experiment (CAP removal) is mainly directed at the production side of the farm sector. Most interestingly, the pattern of the comparisons among all frameworks is not sensitive to the value of these elasticities: production impacts remain similar across all frameworks, whereas the welfare effects obtained with the distorted GE model are quite different from those of the two other models.

Concluding Comments

We have revisited the question of choosing between PE and GE modeling in the context of evaluating the effects of agricultural policies. The motivation for this analysis is rooted in two observations: (1) the continuing challenges that agriculture poses for domestic policy reform in developed countries and the enduring critical role that agriculture plays in the ongoing WTO efforts at international trade liberalization; and (2) the fact that PE and GE analyses often provide widely differing conclusions on the economic effects of interest. Our simulation exercise specifically addresses estimation of the economic effects of a complete phase-out of the CAP, probably the most significant farm policy reform that can be contemplated. In this context, we compare and contrast the effects predicted by three models: a GE model built on the standard GTAP framework, and allowing for tax/subsidy distortions (in the form of ad valorem price wedges); a PE model obtained by restricting this GE model (the main variables of the nonagricultural sector are exogenous); and a GE model that allows for one additional major distortion in the nonagricultural sector, namely, that the labor market does not clear (there is unemployment).

The results show that the market effects of a complete CAP phase-out obtained from all these models are quite similar, i.e., there are no major differences between PE and GE results (with the exception of labor employed in the nonagricultural sector in the distorted GE model). On the other hand, the measures of welfare impacts are more sensitive to the modeling choice. More precisely, the total welfare effects are similar between the standard GE model and the corresponding PE model, but such measures differ considerably from those yielded by the distorted GE model.

We are reluctant to draw too general a conclusion from our limited exercise. But it seems that, when analyzing the agricultural sector of developed economies (where agriculture constitutes a small fraction of economic activities), and when no other major distortions exist in the rest of the economy, GE and PE models yield comparable implications. The predicted market effects are in fact very similar, and indeed the magnitudes of aggregate welfare effects are also similar.

This latter observation may provide some comfort to users of existing mainstream PE models for the agricultural sector. But it also suggests that these models' reluctance to engage in welfare evaluations is difficult to justify on the grounds that this is the province of GE models. In our experiment, for example, a properly constructed PE model yields welfare effects very similar to those of a GE model that makes the same assumptions on the rest of the economy (i.e., no distortions).

The advantage of GE models in our context is the ability to model explicitly the nonagricultural sectors. But this is a "double-edged" sword. On the one hand, it offers the potential to account explicitly for distortions in the rest of the economy that may have nonnegligible interactions with the effects of agricultural liberalization. On the other hand, it requires the analyst to identify and represent correctly the relevant distortions in the rest of the economy. As our example suggests, the effects of using the wrong GE model could be disastrous in terms of welfare measures. Thus, the very reasons that would advise the use of a GE approach for modeling the effects of agricultural liberalization policies, despite the fact that agriculture represents a small and decreasing portion of the economy in developed countries, also make the undertaking challenging and problematic.

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Endnotes

[1]For a more recent formal demonstration, see Blackorby.

[2]The "total welfare" measures for the PE results is our sum, over all commodities, of the disaggregated welfare effects reported by Tokarick (this is admissible because there are no cross-price effects between markets).

[3]Schiff and Valdés provide a recent survey of this literature.

[4]This includes the removal of farm policies in non-EU regions.

[5]This database version captures economic flows in 1995.

[6]Our crop activity is the aggregate of the following original sectors: paddy rice, wheat, grains, vegetables, oilseeds, sugarcane and sugar beet, plant-based fibers, other crops, vegetable oils, sugar, and processed rice. The animal activity includes bovine cattle, other animal products, raw milk, wool, bovine cattle meat, other meat products, and dairy products. The services sector aggregates all other sectors of the GTAP version 4 database. Skilled labor and natural resources are aggregated with capital.

[7]Thus, CAP policy instruments are represented in a very simplified manner, but this simplification is consistently maintained across the three models that we consider.

[8]The demand for agricultural products used as intermediate inputs for the nonagricultural sector is also held constant in the PE model.

[9]Thus, we need not be concerned by the downward bias of welfare measures from partial demand systems (Hanemann and Morey).

[10]This mainly results from the 1992 CAP reform, which places great emphasis on the arable crop sector and preserves the milk policy.

[11]But there are no meaningful labor returns to be accounted for in this PE framework, because labor is assumed perfectly mobile across sectors.

[12]We can compute household welfare as the EV because, as noted earlier, we still maintain the full demand system (with the price of the nonagricultural good, as well as income, held constant).

[13]We only modify the income elasticity of crop and animal final demands, as the income elasticity of services is determined from the adding-up condition implied by the budget constraint.

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