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The economic cost of the CAP revisited

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Abstract

This paper reports estimates of the domestic economic cost of the common agricultural policy (CAP) from computable general equilibrium simulations which incorporate imperfect competition in the non-primary sectors, as well as explicit modelling of agricultural protection. Imperfect competition is characterised to include hierarchical preferences, addressing the notion of varietal diversity as an important decision variable in consumer behaviour. Results indicate that repeal of the CAP would reduce varietal diversity in food processing in the EU, causing utility losses. However, these would be countered by positive varietal effects in other sectors and by strong allocative effects. The net cost of the CAP to the EU is estimated at 0.2% of gross domestic product (GDP). For an individual member state the cost can be considerably larger, as with the UK where the estimate is above 0.5% of GDP.

JEL classification: D12; D58; F12; Q18

Keywords: CAP; CGE; GTAP; Imperfect competition; Varietal effects

1. Introduction

The costs of the EU's common agricultural policy (CAP) on internal and world markets have long been subjects of debate amongst academics and policy makers. Throughout the 1980s most cost estimates were based on partial equilibrium studies, but recognition of the limitations of this approach and the advent of improved software brought computable general equilibrium (CGE[1]) to the fore in the 1990s. Heightened interest in global trade liberalisation and the development of database syndicates advanced the use of CGE applications, with greater attention given to the modelling of policy instruments and to the incorporation of imperfectly competitive market structures. The latter means that CGE models now typically characterise not only the standard efficiency gains associated with resource reallocations in perfectly competitive markets, but also the additional welfare effects emanating from internal firm economies of scale[2] and increased levels of varietal diversity.[3]

Whilst a range of imperfectly competitive market structures has been employed in CGE applications pertaining to the effects of global trade liberalisation (Francois et al., 1995; Harrison et al., 1995b), enlarge-

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[1] Applied general equilibrium (AGE).

[2] Internal scale effects emanate from movements down the average total cost curve with increases in firm output. Pro-competitive effects, which we address subsequently, include this effect but also examine the simultaneous reduction of the mark-up price distortion.

[3] Varietal diversity relates to product differentiation associated with perceived differences by consumers, either in the form of 'love of variety' (Dixit and Stiglitz, 1977) or 'preferred variety' (Lancaster, 1979).

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ment of the EU (Baldwin and Francois, 1996) and European market segmentation (Mercenier, 1992), the literature has largely ignored the effects of less than perfectly competitive markets on the cost of the CAP. Furthermore, of the CGE applications that incorporate imperfect competition, few have examined consumers' preferences and choice patterns. We address these two considerations by using CGE simulations which highlight the impact on the cost of the CAP of strategic conjecture and pro-competitive effects in imperfectly competitive non-primary production sectors, and of consumers' preferences, based on region of origin. We also employ an explicit representation of CAP instruments. Our simulations utilise version 4 of the GTAP global database (McDougall et al., 1998), but focus on the internal economic cost to the EU, with the UK separately identified to illustrate that the impact on an individual member state can differ significantly. Before outlining features of the model (Section 3), our characterisation of the CAP (Section 4) and simulation results (Section 5), Section 2 briefly reviews estimates of the cost of the CAP published in the literature over the past 20 years.

2. The cost of the CAP — a review [4]

The domestic economic cost of the CAP to the EU, or a member state, is typically reported as a forgone percentage of gross domestic product (GDP), illustrating the inefficiency of the policy. Estimates published during the 1980s ranged from 0.27 to 2.70% of GDP [5] (Table 1), where the larger estimates were associated with the early CGE models, although as Atkin (1993) notes, even the smallest estimate represents a significant cost. In the 1990s, political and economic developments prompted a change of direction in the literature on CAP costs. In addition to estimating the *potential* gains from complete abolition of CAP support (i.e. the full cost), studies focused on the impact of *actual* reform and compatibility with GATT/WTO requirements (e.g. Folmer et al., 1995; Blake et al., 1998; Weyerbrock, 1998). Most of these estimates are less than 0.5% of GDP, in part reflecting this emphasis on partial rather than full liberalisation of EU agriculture (Table 1).

The cost estimates in Table 1 fall within a wide range. This is due in part to differences in liberalisation scenarios, model structure, country and commodity coverage, level of aggregation and base year, but also to the way in which the CAP is represented in the models. During the latter part of the 1990s, CGE model structures evolved to better characterise the intricacies of specific CAP regimes. Hitherto, modellers had been content to approximate protection, insulation and distortive effects through exogenous ad valorem tariff equivalents. However, they increasingly began introducing endogenous behaviour through the explicit modelling of policy instruments. Consequently, the more recent cost estimates tend to be smaller due to the treatment of, for example, set-aside and headage payments which, because of their (partially) de-coupled nature, are now modelled not as output subsidies but rather as lump sum transfers (Folmer et al., 1995; Weyerbrock, 1998) or input subsidies (Blake et al., 1998). Likewise, the incorporation of features such as farm-specific factors (Blake et al., 1999) dampens the supply response of agriculture and thereby lessens the allocative efficiency gains from liberalisation.

3. Market structure and hierarchical preferences

Our model incorporates a demand structure which exhibits endogenous hierarchical consumer preferences, based on region of origin. This extends the treatment of endogenous product differentiation in CGE models and adds an extra dimension to the exogenous, region-of-origin approach maintained under the Armington assumption. Endogenous product differentiation has important implications for the treatment of costs within productive sectors. Moreover, it allows for utility effects resulting from varietal diversity in consumption. Our approach is based on the work of Lancaster (1979, 1980, 1984) in which varieties, differentiated explicitly in terms of their characteristics or attributes, are ranked with respect to an 'ideal', where varieties which are closer to the ideal are more preferred.

[4] For fuller coverage of earlier empirical studies on CAP costs, see Buckwell et al. (1982), Winters (1987), Demekas et al. (1988), and Atkin (1993).

[5] Estimates in the order of 0.5% of GDP were more usual (see Winters, 1987).

Table 1
Review of estimates of the domestic economic cost of the CAP[a]

	Model structure	Market structure	EU coverage	GDP (%)
1980s				
Morris (1980)	PE	PC	EC9	0.50
Harvey and Thomson (1981)	PE	PC	EC9	0.50
Buckwell et al. (1982)	PE	PC	EC9	0.50
Tyers (1985)	PE	PC	EC9	1.10
Roberts (1985)	PE	PC	EC10	0.30
Spencer (1985)	GE	PC	EC9	0.90
Burniaux and Waelbroeck (1985)	GE	PC	EC9	2.70
Tyers and Anderson (1987)	PE	PC	EC12	0.27
Stoeckel and Breckling (1989)	GE	PC	EC4[b]	1.50
1990s				
European Commission (1994)	PE	PC	EU9	0.22
Harrison et al. (1995a)	GE	PC	EU10	0.10
Hubbard (1995a)	GE	PC	EU12	0.80
Hubbard (1995b)	GE	PC	EU12	0.14–1.3
Folmer et al. (1995)[c]	GE	PC	EU9	0.30
Blake et al. (1998)[d]	GE	PC	EU12	0.42
	GE	IC	EU12	0.44–0.53[e]
Weyerbrock (1998)	GE	PC	EU12	0.20[f]
	GE	PC	EU12	0.40[g]
	GE	PC	EU12	0.10[h]
Blake et al. (1999)	GE	PC	EU15	0.12–0.28

[a] PE: partial equilibrium; GE: general equilibrium; PC: perfect competition; IC: imperfect competition.
[b] This application models the four largest economies of the EU (Federal Republic of Germany, France, Italy and the UK).
[c] Based on the MacSharry CAP reform.
[d] CAP reform including the full Uruguay Round reform package.
[e] This study employs a Cournot oligopolistic structure similar to that used by Harrison et al. (1995b).
[f] CAP reform only.
[g] CAP and GATT reform, plus further reductions in intervention prices for sugar and dairy to meet GATT commitments.
[h] CAP and GATT reform, plus quantity controls required to meet GATT commitments.

On the production side, we incorporate an increasing returns-to-scale characterisation of the non-primary sectors. This follows a recent theme in the literature (Horn, 1984; Brown, 1987; Hertel, 1994; Harrison et al., 1995b; Francois, 1998) which employs standard assumptions of product differentiation and freedom of entry/exit, stemming from the work of Spence (1976), and Dixit and Stiglitz (1977), and combines these with oligopolistic strategic (Cournot) conjecture (i.e. endogenous mark-ups). This gives rise to 'pro-competitive' effects associated with reductions in the mark-up distortion, as well as scale effects associated with changes in the level of firm output.

Each region is assumed to produce a single 'representative variety' of a given differentiated product, and each imperfectly competitive firm is assumed to produce a unique variant of its region's representative variety.[6] Proliferation in the number of firms (product variants) in a given region results in that region's representative variety moving closer to the ideal (Vousden, 1990). This improves the position (and possibly the ranking) of the representative variety in the hierarchical preference structure. It is this process that characterises the 'variety effect' (see Appendix A).

[6] There are two reasons for this approach. First, from an economic point of view, a new firm is more likely to succeed in the industry by producing a new variant instead of duplicating an existing one (i.e. firms are trying to capture a niche in the product space). Secondly, a firm producing more than one variant would imply a different mark-up pricing rule for each, significantly enhancing model complexity.

In modelling the demand structure, an important parameter is that which characterises the degree of preference heterogeneity (γ). The larger the γ is, the more strongly the consumer identifies with varietal choice, and the more marked will be increases (decreases) in purchasing behaviour following proliferation (reduction) in product variants of a given representative variety. Larger values of γ will also result in larger differences in hierarchical utilities between higher and lower ranked representative varieties. If $\gamma = 0$, all representative varieties have the same hierarchical utility value which implies preference homogeneity. It is plausible to assume that marginal hierarchical utility falls as a representative variety moves closer to the ideal. This implies $0 < \gamma < 1$.

Market research on food product preferences has shown that respondents typically favour the domestic variety over foreign substitutes (Quagrainie et al., 1998; Juric et al., 1996). In our modelling of hierarchical preferences, we capture this patriotic purchasing behaviour by characterising the domestic representative variety as being the most favoured. Benchmark preference values are calibrated from expenditure shares on each representative variety. Expenditure shares are probably not the best measure to characterise preference hierarchies. Values could be based on stated preference choice experiments, a method that has been used to identify country of origin effects (see for example, Unterschultz et al., 1998; Kim et al., 2001). However, in the absence of appropriate, readily available estimates, we use expenditure shares as indicative of consumers' purchasing predilections.

4. Modelling the CAP

4.1. Milk and sugar

In CGE data sets it is common practice to characterise a quantitative restriction, e.g. an output quota, as a sectoral ad valorem tax equivalent or 'wedge'. However, this 'equivalence' only exists in the benchmark data set, and subsequent endogenous changes in market conditions will render the tax a poor approximation of the quota. To overcome this, milk and sugar quotas in the EU are modelled by holding output from these sectors constant and allowing two wedges — one to capture quota rent, the other to capture any output tax or subsidy — to adjust endogenously.[7] Furthermore, given the self-financing principle operated for sugar, co-responsibility levy revenue is determined endogenously to offset exactly the budget cost of surplus disposal.

4.2. Arable sectors

An important development in the 1992 MacSharry reform of the CAP was the 'de-coupling' of support payments. Strictly, this term is used to describe a compensatory payment which has no effect on output and, being non-distortive from a trade point of view, is not subject to GATT/WTO reforms. However, the concept of cross-compliance[8] leaves such compensatory payments more often recognised as only partially de-coupled, since to qualify for the payment, the farmer is implicitly making decisions which would be different if the cross-compliance were not in place, and which therefore are likely to affect output level. The modelling approach we employ is closer to the latter concept of partially de-coupled support. To characterise the nature of de-coupled support, area compensation and set-aside payments are removed from the output subsidy wedge in the cereals and oilseeds sectors in the GTAP database. Area-compensation is re-calibrated as an input subsidy to the land factor in these EU arable sectors, driving a wedge (i.e. rent) between the market price of land and the price farmers pay for land. Hence, support is no longer directly linked to output. Set-aside compensation is re-introduced as a totally de-coupled lump-sum payment from the CAP budget to the agricultural household in each EU region, and thus is allocated to land-owners rather than to the productive sector. The combined value of the area and set-aside payments is less than the output subsidy value in the benchmark data set; the residual amount now provides a more accurate measure of direct (coupled) support.

To qualify for area payments, farmers must register a base acreage. Land previously unregistered but moved into the cereals sectors does not qualify,

[7] A caveat of this approach is that, by definition, the quota is always binding, although this is arguably the case for EU milk and sugar.

[8] For example, where land must be set-aside to qualify for the payment.

effectively deterring such movements. Moreover, much of the EU's livestock land area is unsuitable for cereals. Thus, we segregate the land endowment in the EU into cereals land and non-cereals land, with the degree of mobility within each determined by a constant elasticity of transformation function. In the benchmark data set, 14% of the total cereals land is in set-aside;[9] with repeal of the CAP, this land returns to cereals use.

4.3. Headage payments

In the GTAP database all of the support to the livestock sector is captured in an output subsidy wedge. As with area and set-aside payments in the cereals sectors, modelling headage premia in the livestock sector as input subsidies more accurately characterises their partially de-coupled nature. Thus, they are re-assigned as input subsidies to suckler cows which are treated as reproductive capital.

4.4. Intervention purchases

No attempt is made to include inventory demand within the model framework because, in the long run, "the importance of stocks is diminished, since continued stock accumulation or decumulation quickly becomes infeasible ... [Moreover, the deterministic, comparative static, analysis] ... abstracts from commodity stockpiling, assuming that the associated price effects will only be transitory" (Mekki et al., 2000, p. 116).

4.5. Brussels household

In order to calculate budgetary contributions to the CAP budget, a 'Brussels household' is included in the model. This collects revenues from the member states by way of GDP and VAT contributions, agricultural levies and import tariffs, and meets expenditures on export and output subsidies, area and set-aside payments and headage premia.[10] Whilst the budget is unlikely to balance for individual member states, by definition it must balance for the EU. For a member state that is a net contributor (beneficiary), regional income in the benchmark data will be less (greater) than the sum of domestic expenditure and savings. This discrepancy is accommodated by changing the member state's level of savings. Since the overall CAP budget is in balance, the level of EU15 savings is unaffected, such that further modifications are not necessary.

4.6. Re-balancing the database

It is not possible to simply alter subsidy wedges in the database and leave the rest unchanged, as this destroys internal consistency. Hence, following Malcolm (1998), a separate model structure is used solely to prepare a consistent benchmark data set, complete with input subsidies and adjusted output subsidy flows. The input subsidy wedges are calibrated into the benchmark data by simultaneously shocking the exogenous input subsidy and output subsidy variables, to remove that part of the latter now treated as input subsidy. As with any simulation, the model calculates the impact of these shocks on the endogenous variables. However, the difference between a normal experiment and this procedure is that whereas in the former case, model structure, closure and parameter values are chosen to represent economic reality as accurately as possible, in the latter case they are chosen to minimise disturbances in the database resulting from the exogenous shocks, such that the adjusted benchmark data are as close as possible to the original data. Having conducted experiments using an array of model variants proposed by Malcolm (1998), it was found that disturbances in the database were minimised by allowing all factors to be perfectly mobile, keeping the trade balance exogenous and characterising all substitution possibilities as Cobb–Douglas. Other changes were made on an empirical basis, where sensitivity testing revealed that such additions were beneficial to minimising changes from the original benchmark data.

5. Simulations and results

Within our aggregation of the GTAP database, the UK is separately identified from the rest of the EU (EU14), to illustrate that the cost of the CAP to an individual member state can differ significantly from

[9] Authors own calculations.

[10] Sugar does not feature in the budget in the model, since the sector is treated as self-financing.

the EU average.[11] All other countries and regions are combined in a rest-of-the-world aggregate. Industry sectors are aggregated to 17, focusing on agriculture and food processing.[12]

Some CAP-related CGE studies have imposed a specific time horizon to more realistically quantify the impacts of liberalisation. Frandsen et al. (1996), in studying EU expansion to the East, project their benchmark dataset through to 2010 and then measure liberalisation scenarios against this base. We adopt this approach, choosing 2005 as our projected base, the first year in which all Uruguay Round (UR) GATT/WTO commitments will be fully implemented. Thus, the GTAP database is projected 10 years beyond its base year of 1995, using forecasted growth rates in capital, skilled and unskilled labour endowments,[13] real GDP growth and agricultural total factor productivity, following Frandsen et al. (1998).

We model the UR commitments as 36% (24% for less developed countries) reductions in tariffs and export subsidy expenditures, 21% (14%) reductions in export subsidy volumes, and 20% (13.3%) reductions in output subsidies. We follow Jensen et al. (1998), and Blake et al. (1998) in incorporating endogenous behaviour in the modelling of these UR commitments. Specifically, compatibility between export subsidy expenditure and volume constraints is ensured by imposing complementary slack conditions (Bach and Pearson, 1996). An allowance has also been made within the tariff rate reductions for a degree of 'dirty tariffication', based on Blake et al. (1999).

We report estimates of the economic impact of the CAP by making a comparison between the projected database for 2005 including full implementation of the UR commitments, and this same projected database base with additional shocks to simulate the removal of all CAP protection. This provides a measure of the cost of the CAP in 2005, post-UR. The simulations are evaluated under conditions of imperfect competition in the food processing, manufacturing and services sectors, with remaining sectors (agriculture and other primary) characterised as perfectly competitive. Mark-ups are calibrated, inter alia, to the number of firms in each sector and adjust endogenously according to the seller's market (i.e. domestic versus export). Given the sizes of the EU14 and the rest of world, and the level of sectoral aggregation, the number of firms in each sector in these regions is set initially to 100. For the UK, the number of firms is set to two in sugar processing, 10 in milk processing and 100 elsewhere.[14] Results are presented for two arbitrary values of the preference heterogeneity parameter (γ), 0 and 0.95, the latter value imposed to assess the importance of varietal diversity under strongly patriotic preferences.

Table 2
The impact of CAP abolition on composite hierarchical utility under preference heterogeneity in 2005 (change (%))

Sector	EU14	UK
Meat processing	−7.31	−4.75
Other meat processing	−0.26	−0.42
Vegetable oils and fats	−0.57	−0.10
Milk processing	−1.18	−7.65
Sugar processing	−3.43	−1.88
Other food processing	−1.16	−0.44
Manufacturing	0.28	0.10
Services	0.06	0.11

An illustration of the varietal effect under preference heterogeneity is provided in Table 2, which shows percentage changes in hierarchical utility, in the EU14 and UK, resulting from changes in varietal diversity with removal of the CAP. These changes in composite hierarchical utility are weighted averages of changes in hierarchical utility from each of the (three) regional

[11] Other EU member states separately identified in the full GTAP database are Germany, Denmark, Sweden and Finland. All member states will be separately identified in version 5 of the GTAP database, due for release in 2001.

[12] The sectors are wheat, other grains, oilseeds, sugar, milk, cattle and sheep, pigs and poultry, other agriculture, other primary, meat processing, other meat processing, vegetable oils and fats, milk processing, sugar processing, other food processing, manufacturing and services.

[13] Land and natural resource endowments remain unchanged under the projections.

[14] The UK sugar processing market is dominated by two firms (British Sugar and Tate & Lyle). In milk processing, the five-firm concentration ratio in liquid milk production is 84% (Mintel, 1999) and the five-firm concentration ratio in the dairy sector is 55% (Strak and Morgan, 1995). In the remaining UK sectors, the available data do not suggest particularly high levels of concentration (meat processing, other meat processing), or the model aggregates are too broad for any sensible approximation (manufacturing, services). In these cases we have chosen 100 as an arbitrary number of firms in the benchmark data set.

Table 3
Impact on the EU and UK of CAP abolition in 2005

	Preference homogeneity ($\gamma = 0$)			Preference heterogeneity ($\gamma = 0.95$)		
	EU14	UK	EU15	EU14	UK	EU15
Net gain						
US$ (1995, million)[a]	10560	6480	17040	10570	7038	17608
GDP (%)	0.14	0.54	0.19	0.13	0.56	0.19
Decomposition of net gain (contribution (%))						
Allocative effect	217	88	168	255	93	190
Terms of trade	−73	−15	−51	−81	−17	−56
Varietal effect:						
Food processing	0	0	0	−101	−22	−70
Manufacturing	0	0	0	38	4	24
Services	0	0	0	34	18	28
Pro-competitive effect	1	−4	−1	1	−4	−1
CAP budget effect	−23	38	0	−23	35	0
Other[b]	−22	−7	−16	−22	−6	−16

[a] Equivalent variation.
[b] Principally endowment effect and technical change.

varieties, with weights based on preference ratings, which favour the domestic variety. In the food processing sectors all changes are negative, because varietal diversity decreases. This is due largely to a reduction in the number of variants of the domestic varieties, resulting from contraction of the upstream agricultural sectors following CAP abolition. However, there are concurrent increases in composite hierarchical utility in manufactures and services, because of expansion and improvements in varietal diversity in these sectors.

The economic cost of the CAP is shown in Table 3, for the EU15 and separately for the EU14 and UK, under preference homogeneity ($\gamma = 0$) and preference heterogeneity ($\gamma = 0.95$). Preference heterogeneity has only a negligible effect on the net cost, which for the EU15 is estimated at 0.19% of GDP. The cost to the UK, at 0.54–0.56%, is markedly higher, but comparable to estimates for the EU reported in the literature and reviewed in Section 2.

A decomposition of the net gain from abolition of the CAP shows resource reallocation to be the largest of the positive impacts and of overriding importance. Under preference homogeneity, the allocative effect for the EU15 is 168% of the overall net gain; preference heterogeneity increases this to 190% (Table 3). For the UK, the positive budgetary effect (35–38%) is also important, and explains in part the higher cost of the CAP to the UK economy. Of the negative impacts that lessen the net gain from CAP abolition, the largest under preference heterogeneity are the varietal effects in food processing. For the EU14, this loss is of equal magnitude to the net gain (101%). However, the negative varietal effects in food processing are offset, in part for the EU and in full for the UK, by positive varietal effects in manufactures and services. Throughout the EU, the allocative effect is shown to be enhanced by the varietal effects under preference heterogeneity.

6. Summary and conclusions

In this paper we seek to provide greater insight into the importance of imperfectly competitive markets in analysing the general equilibrium effects of full liberalisation of the CAP. More specifically, we characterise imperfect competition to include hierarchical preferences, addressing the notion of varietal diversity as an important decision variable in consumer behaviour. We examine the impact of preference heterogeneity, where product proliferation results in increases in hierarchical utility.

Results indicate that the CAP may have a marked effect on increasing varietal diversity in the EU, primarily through expansion of the domestic food processing sectors. Removal of the CAP reverses this effect, causing hierarchical utility losses. However, these are offset by positive varietal effects in manufactures and services and by stronger allocative effects than under preference homogeneity. Overall, preference heterogeneity has a negligible impact on the net cost of the CAP, which for the EU is estimated at 0.19% of GDP. For the UK, the cost is considerably larger at around 0.5% of GDP, partly as a result of the budgetary effect.

In the modelling framework we have presented, varietal impacts are conditional on the level of consumers' preference heterogeneity (i.e. the extent to which consumers identify with variety and varietal changes) and on the strength of country of origin preferences. We have specified a value of preference heterogeneity close to an imposed upper bound, so as to highlight the contrast with preference homogeneity. In choosing to model patriotic purchasing behaviour we have calibrated benchmark preference values to expenditure shares, but there is scope for using alternative criteria and for research to derive estimated values.

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Appendix A. Hierarchical preferences within a linearised CGE framework

Following Lancaster (1984, 1991), cardinal hierarchical utility from the consumption of a representative variety 'i' from region 'r' to the consumer in 's', $Z_{i,r,s}$, is given as:

$$Z_{i,r,s} = [1 + V_{i,r,s}]^{\gamma_{i,s}}, \quad \gamma_{i,s} > 0 \tag{A.1}$$

where $V_{i,r,s}$ is the preference value or rating of the variety measured in relation to the ideal and γ is the preference heterogeneity parameter (see main text). Eq. (A.1) is strictly increasing in V and "the effect of distance increases as products differ more and more from the ideal" (Lancaster, 1991, p. 3). Thus, varieties with higher preference values ($V_{i,r,s}$), yield higher amounts of hierarchical utility ($Z_{i,r,s}$) compared to less favoured varieties. Linearising Eq. (A.1) gives (where lowercase letters are percentage change variables of their uppercase counterparts):

$$z_{i,r,s} = \left[\frac{\gamma_{i,s} V_{i,r,s}}{[1 + V_{i,r,s}]}\right] n_{i,r} \tag{A.2}$$

where increases (decreases) in the number of regional firms, or product variants ($n_{i,r}$), serve as a proxy for improvements (deteriorations) in that region's representative variety's preference value ($V_{i,r,s}$).

Consumers' preferences are approximated in an Armington structure using a CES cost minimisation procedure. However, in the case of the imperfectly competitive sectors, modified hierarchical Hicksian demands are based on a non-nested Armington structure, where domestic and foreign varieties compete *directly* with one another (Swaminathan and Hertel, 1996; Francois et al., 1995). The choice of non-nested preferences supports the notion that consumers are making direct comparisons between varieties from each region. [15] Moreover, a nested Armington structure effectively dampens the imperfectly competitive tie between regions, since firms compete only through composite goods such that variety and scale effects are limited to the regional level. The non-nested specification allows domestic and foreign firms to compete directly which enlarges the size of the market and therefore the gains from specialisation, i.e. imperfect competition is 'global' (Francois et al., 1995).

To incorporate hierarchical preferences within this model framework, minimise expenditure on all representative varieties ($r = s, r \neq s$), subject to a modified non-nested CES sub-utility function (see Lancaster, 1984):

$$U_{i,s} = A_{i,s}\left[\sum_r \delta_{i,r,s} Q_{i,r,s}^{-\rho_i} Z_{i,r,s}\right]^{-1/\rho_i} \tag{A.3}$$

where $U_{i,s}$ is the level of sub-utility from the consumption of differentiated commodity 'i' in region 's', $Q_{i,r,s}$ the consumer demand in region 's' for representative variety 'i' from region 'r', $Z_{i,r,s}$ bilateral hierarchical utility associated with the consumption of the representative variety (Eq. (A.1)), $\delta_{i,r,s}$ a CES

[15] All perfectly competitive sectors in the model retain the standard nested Armington framework, where regional varieties compete through a composite foreign variety.

share parameter, $A_{i,s}$ a scale parameter, and ρ_i is an elasticity parameter. Linearising gives:

$$q_{i,r,s} = u_{i,s} - \sigma_i[p_{i,r,s} - p_{i,s}] + \sigma_i z_{i,r,s} \quad \text{(A.4)}$$

$$p_{i,s} = \sum_r S_{i,r,s} p_{i,r,s} + \frac{1}{\rho_i} z_{i,s} \quad \text{(A.5)}$$

$$z_{i,s} = \sum_r S_{i,r,s} z_{i,r,s} \quad \text{(A.6)}$$

$$\rho_i = \frac{1}{\sigma_i} - 1 \quad \text{(A.7)}$$

Linearised bilateral differentiated Hicksian demands ($q_{i,r,s}$) in Eq. (A.4) are a function of total sub-utility ($u_{i,s}$), representative variety prices ($p_{i,r,s}$), the composite price ($p_{i,s}$) and bilateral hierarchical utility ($z_{i,r,s}$). In this formulation, the composite price is an average of representative variety prices weighted by expenditure shares ($S_{i,r,s}$) but modified by the composite hierarchical utility ($z_{i,s}$) (Eq. (A.5)). The composite hierarchical utility is itself an expenditure share weighted average (Eq. (A.6)), and hence changes in bilateral hierarchical utility of the more preferred representative varieties in region '*s*' have larger effects on the composite. Finally, the elasticity parameter, ρ_i, is defined in Eq. (A.7) in relation to the elasticity of substitution (σ_i).[16] Thus, Eqs. (A.2) and (A.4)–(A.7) encapsulate our treatment of hierarchical preferences within a linearised CGE model framework. With preference *homogeneity* (i.e. $\gamma_{i,s} = 0$, $Z_{i,r,s} = 1$, $z_{i,r,s} = 0$), Eqs. (A.2) and (A.6) drop out and Eqs. (A.3)–(A.5) revert to their standard Hicksian forms.

Varietal effects can be discussed in the context of this framework. In region '*s*', the effect of an increase in bilateral hierarchical utility ($z_{i,r,s}$) due to increases in product variants (firms) in region '*r*', will always have a positive effect ceteris paribus on the demand for that representative variety, $q_{i,r,s}$. Varietal effects may also occur at constant prices ($p_{i,r,s}$) with increases in composite hierarchical utility. Thus, reference to the composite price Eq. (A.5) shows that an increase in composite hierarchical utility ($z_{i,s}$) has the effect of reducing the per unit expenditure ($p_{i,s}$) necessary to acquire an extra unit of sub-utility ($u_{i,s}$) (Swaminathan and Hertel, 1996). This is because increases in the level of aggregate varietal diversity enable consumers to purchase higher utility-yielding varieties with the same per unit cost, which is equivalent to accruing equal amounts of utility at lower cost.

Price effects are captured through relative movements in representative variety prices ($p_{i,r,s}$) and composite price ($p_{i,s}$) determining movements in demand ($q_{i,r,s}$). Thus, in this structure there are varietal and price effects contained within the Hicksian demands. Moreover, following Lancaster (1984), it is possible to have the same level of demand for two representative varieties, where one variety has a lower preference value ($V_{i,r,s}$), but also a lower price ($p_{i,r,s}$).

Finally, in the imperfectly competitive sectors, the number of firms, or product variants ($n_{i,r}$), is determined by changes in output per firm ($qofm_{i,r}$) and industry output ($qo_{i,r}$), which are related by the linearised condition:

$$qo_{i,r} = qofm_{i,r} + n_{i,r} \quad \text{(A.8)}$$

Given a change in industry output, the change in output per firm is determined by the change in mark-up (i.e. pro-competitive effect), with the number of firms changing to ensure that condition (A.8) is satisfied. Moreover, any change in the number of firms is used as a proxy for the change in consumer preference value ($V_{i,r,s}$), see Eq. (A.2).

[16] The elasticity of substitution (σ_i) in Eq. (A.7) must be greater than 1, implying that ρ_i is negative. If $\sigma_i \leq 1$, then ρ_i is zero or positive. In the former case, $1/\rho_i$ in the composite price, Eq. (A.5) prevents a model solution. The latter case would be counter-intuitive with respect to changes in composite hierarchical utility on the right hand side of Eq. (A.5). Moreover, values of σ_i less than 2 yield foreign mark-ups which are much larger than the domestic mark-up, implying that firms always have a better 'foothold' abroad than at home, which is also counter intuitive.

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