

The Division and Size of Gains from Liberalization in Service Networks*

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Abstract

If two disjoint country service networks involving a small and large country are connected as part of international liberalization in the presence of network externalities, the per capita gain for the small country from access to a large network will be large, and the per capita gain for the large country will be small. In contrast to goods, the benefits of liberalization in network-related services are more likely to be approximately equally divided between large and small countries than is true of trade in goods, where benefits accrue disproportionately to the small country. We also argue that non-cooperation in network-related services trade may involve more extreme retaliation than suggested for trade in goods by the optimal tariff literature, so that relative to a non-cooperative outcome, gains from liberalization in network-related services become larger than from liberalization in goods. We develop simple models which we use for numerical examples showing these points, along with an empirical implementation for global telecoms liberalization for the US, Europe, Canada, and the rest of the world using the framework developed in the paper. This shows similar proportional gains to regions, consistent with the theme of the paper that goods and services liberalization differ.

1. Introduction

We discuss cross-border liberalization in flows of network-related services, such as telecoms, suggesting that both the division of the gains from liberalization between countries and the size of such gains is likely to differ from the case of trade in goods when tariff barriers are removed at the border. For network-related services, no cross-border payment is made since senders (callers) pay fully for services (messages). Cross-border welfare effects of liberalization still occur since when prices for international calls are lowered both senders and receivers of messages (calls) benefit. Since callers pay the full cost of calls, the addition of a new subscriber to a network confers an externality on existing subscribers who potentially receive calls at no charge. We model such effects as generated by preferences in which individual utility is a function not only of own consumption of network-related services (i.e. calls made), but also the consumption of similar services by others within the network (i.e. calls received). We then examine the effects of liberalization across country networks,¹ making reference to the sharp reductions in international call rates in recent years which have occurred under deregulation.²

We first consider a simple two-good, two-country case involving network-related services and other goods, in which the two countries have different numbers of consumers. We model liberalization as the joining of two previously disjoint country networks into

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one combined cross-country network. When this occurs, consumers in the smaller country receive a larger per capita gain than those in the larger country due to the network externalities since these arise from gaining access to a larger network yielding incoming messages (calls). Country size and the per capita benefit of access to the other country's network tend to offset each other in determining the division of the gains from liberalization, suggesting that the country gains from cross-border network service liberalization can be of similar (absolute) size even where countries differ in size. This is different from the case of trade in goods where the benefits of liberalization accrue disproportionately to the smaller country.

We first examine a case in which the country's gains from liberalization are of equal absolute size in the two countries independently of relative country size (in money metric terms), and then show how it is possible to change preferences and other model parameters in such a way that larger gains accrue to the larger (rather than the smaller) country, or vice versa. In an alternative formulation with two types of network-related services (international and domestic), we also show how it is possible to capture price-based substitution effects between service categories. This allows us to model network-related service trade liberalization as the removal of barriers to international services (which have cross-country network externality effects), rather than simply the joining of two disjoint networks. Using this alternative formulation, we again show that the absolute size of gains can be larger or smaller for the large (or small) country, depending upon the parameter specification used in the model.

We then turn to the relative size of the aggregate gains from liberalization of network-related services compared to goods trade liberalization. We characterize inter-country network service interactions as involving service delivery along a joined network, but in ways which, in principle, give each of the two governments in the origin and destination countries the power to tax the same transaction.³ Phone calls made from, say, the US to India can be regulated or taxed by both governments as messages are either sent or delivered. We evaluate non-cooperative international retaliatory outcomes involving service barrier retaliation in this case, measuring the gains from liberalization by comparing free trade and non-cooperative Nash policy outcomes.

A cross-country policy game in a service network reveals three key differences relative to the traditional Nash equilibrium tariff policy game in goods. One is the use of instruments (taxes) by both countries on each bilateral service flow; another is the absence of any restriction that two-way service flows be balanced in value terms as the services do not involve any cross-country payment (unless taxed by the other government). The third is that inter-country flows along networks can be, and frequently are, unbalanced (more calls from the US to India, than from India to the US). As a result, both governments can have an incentive to charge high taxes in the Nash equilibrium if they can make the first charge on the appropriate bilateral service flow. We find that relative to a non-cooperative Nash outcome, gains from liberalization of network-related services are typically larger than gains from liberalization in goods trade in models made comparable in the sense that the service flow parameter values used for trade barriers now apply to similar flows of goods instead of services.

Finally, we apply our framework to the analysis of global telecom liberalization in a model of the EU, the US, Canada, and the rest of the world, and calibrated to 1999 data. Data on call volumes and pricing are drawn from the *World Telecommunications Development Report*, and are supplemented by GDP and other data from the *World Development Report*. Liberalization yields gains similar in proportional size for large and small regions; consistent with the theme of the paper of the differences in liberalization between goods and services.

We suggest that our analysis has three main implications. The first is that the benefits of liberalization in network-related services, in contrast to goods, are more likely to be approximately equally divided between countries than is true of trade in goods, and this can occur independently of the size of the countries and the number of residents in each. The second is that non-cooperation in network-related services trade may involve extremes of retaliation which go beyond even those suggested for goods trade in the optimal tariff literature, and so the gains from liberalization may be larger in network-related services than in goods. The third is the large potential size of welfare gains from transborder liberalization where network externality effects rather than conventional gains from trade apply. The broader implication is the seemingly different nature of cross-border liberalization in network-related services compared to liberalization in goods.

2. Network Externalities and the Division of Gains from Liberalization in a Simple Network Service Model

We first consider a world consisting of N countries, each of which has a fixed endowment of resources which, in turn, can be used for producing goods or network-related services. Services are consumed via a network, and involve no cross-border payment, since services are purchased and consumed by senders of messages along the network.⁴ They directly enter the sender's utility function; but also provide utility to the receiver; hence messages sent by others also appear in the utility function of the receiver. It is this feature which generates network externalities, since service recipients make no payment for incoming messages (calls) even though they receive a welfare benefit. The word externality in such situations denotes a consumption-to-consumption externality in the sense of Meade; here the physical interdependence via message flows to recipients is not appropriately priced.

We use a transformation frontier to describe the technology which allows goods and network services in each country to be produced from resource endowments:

$$Y_n = F_n(G_n, S_n) \quad (n = 1, 2), \quad (1)$$

where Y_n is the fixed resource endowment, G_n is goods production, and S_n is network services production in country n , and W_n , the value of production of goods and network services in country n is given by

$$W_n = P_n^g G_n + P_n^s S_n, \quad (2)$$

where P_n^g is the country n price of goods, and P_n^s is the price of network-related services in country n . These prices are denominated relative to the country-specific resource Y_n (effectively a composite of G_n and S_n) where price is unity. Thus $Y_n = W_n$. For simplicity, we assume that no direct international trade in either goods or network services occurs. Senders pay for such services in their country of origin, and the prices of the services can differ between the countries. Y_n can also be thought of as the value of the production frontier, where a unit of a composite of G_n and S_n is taken as the *numéraire*, and has a price of unity. Optimizing behavior on the production side of the model implies

$$\frac{\partial F_n}{\partial G_n} \bigg/ \frac{\partial F_n}{\partial S_n} = \frac{P_n^g}{P_n^s}. \quad (3)$$

The transformation frontier (1), along with (2), thus yields an implicit supply function for goods and network services in each country.

We assume that there are T_1 households in country 1, and T_2 in country 2. Each household in each country derives utility directly from consumption of goods and from sending messages along the network (services). When connected to a service network, households also receive additional utility benefits from the services consumed by others in home and foreign countries, since they are the recipients of messages. We assume such benefits are proportional to the total volume of messages sent along the network; as the total message volume expands so does the potential number of callers who could be in contact with any particular recipient.

We use a utility function to represent the preferences of each household in which, ST , the total number of calls made along the relevant network, enters multiplicatively with a constant λ ,⁵ which we, for now, take to be common to all individuals:

$$U_n^h = \lambda \cdot ST \cdot U_n^h(G_n^h, S_n^h), \tag{4}$$

where the subscript n refers to countries and the superscript h to households in a country; U is utility, G is consumption of goods, and S is consumption of network-related services. ST is total consumption of network-related services by all the households in the relevant network; the domestic network when networks are disjoint, or the international network when they are linked. In this formulation, the network externality impacts directly on household utility when there is an expansion in the size of the service network to include both home and foreign countries.

We assume, for simplicity, that each household in each country receives a fixed share of the economy-wide income:

$$I_n^h = \theta_n^h W_n, \tag{5}$$

where I_n^h denotes income for household h in country n , and $\sum_h \theta_n^h = 1$; $\theta_n^h \geq 0$. This income is spent on purchasing goods and network-related services. Each household budget constraint implies that

$$I_n^h = P_n^g G_n^h + P_n^s S_n^h. \tag{6}$$

Demands for goods and services by each household are obtained from maximization of the utility function (4) subject to the household budget constraint (6).

As no direct trade in network services takes place in this model, in equilibrium the market for goods and services clears in each country; i.e.

$$G_n = \sum_h G_n^h \tag{7}$$

$$S_n = \sum_h S_n^h. \tag{8}$$

In equilibrium, goods and services prices are thus such that country demands for services match their domestic supply.

We can consider the effects of liberalization involving a joining of the two previously disjoint country service networks using this framework. In this case, the ST term in preferences refers to the combined service consumption across the two countries, rather than the two separate country service consumptions. As only the externality term in preferences changes, when liberalization occurs in this simple case there are no real effects from liberalization; prices and quantities of both goods and services within countries remain the same; only utility changes.

Since any homothetic utility function can be represented as a linear homogeneous function with special ordinal properties,⁶ the welfare implications of liberalization in

this case are especially easy to analyze. As noted in Shoven and Whalley (1992), with linear homogeneous preferences the Hicksian compensating variation measure of welfare change between equilibria is given by

$$CV^h = \frac{U_N^h - U_0^h}{U_N^h} \cdot I_N^h, \quad (9)$$

where U_N^h and U_0^h refer to the old and new utility levels for household h , and I_N^h is the income of household h in the new (post-change) equilibrium.⁷

Because price and quantities do not change between equilibria, and because the term ST is multiplicative in utility from goods and own services, each household's compensating variation in this case can be written as

$$CV^h = \frac{ST^N - ST^0}{ST^N} \cdot I_N^h, \quad (10)$$

where the λ terms cancel, and ST^N and ST^0 denote the aggregate service consumption values relevant for household h in the new and base period (original) equilibria. I_N^h is household h new period equilibrium income.

If preferences are identical across the households in each country, the total welfare impact in the two countries, TCV^1 and TCV^2 , can be written as

$$TCV^1 = I_1 \frac{(ST^N - ST_1^0)}{ST^N} \quad (11)$$

$$TCV^2 = I_2 \frac{(ST^N - ST_2^0)}{ST^N}, \quad (12)$$

where ST_1^0 and ST_2^0 refer to the base case aggregate service consumption in countries 1 and 2, I_1 and I_2 are economy-wide incomes in countries 1 and 2 from (2), and again the λ terms cancel.

The ratio of the welfare gains in the two countries from liberalization is given by

$$\frac{TCV^1}{TCV^2} = \frac{I_1}{I_2} \left(\frac{ST^N - ST_1^0}{ST^N - ST_2^0} \right). \quad (13)$$

Noting that in this special case $ST^N = ST_1^0 + ST_2^0$, since there is no quantity response under liberalization, (11) implies that

$$\frac{TCV^1}{TCV^2} = 1 \quad \text{if} \quad \frac{I_1}{I_2} = \frac{ST_1^0}{ST_2^0}, \quad (14)$$

i.e. the two countries will receive a welfare gain under liberalization of equal size if the ratio of national income and service consumption are the same across the countries.

Thus in this simple case it is possible to construct parameterizations in which both countries will receive benefits from network-related service liberalization of equal absolute size, even if one country is smaller or larger than the other and has more or less households. The widely accepted propositions concerning the division of gains and country relative size involving liberalization of trade in goods thus seem not to apply to this case in the same way.

3. The Gains from Liberalization in a Two-service-type Model

While illustrating a case where the gains from network-related service trade liberalization between countries can be of equal absolute size, the discussion in the previous section nonetheless embodies some important simplifying model features which need further investigation. Liberalization is simply treated as a connection of two separate country networks, and so unchanged relative services to goods prices in each country characterize a liberalization scenario. Also, because the network externality effect is multiplicative in utility, no real effects accompany liberalization; consumption and production of network-related services remain unchanged in the new integrated network equilibrium, while household utility changes due to expanded network size.

One can relax these assumptions and extend the framework used above to see if similar results can still be obtained by numerical simulation. Numerical simulation is needed because the model solutions are no longer analytic. To do this, we separately consider two different types of services; one assumed to relate only to domestic and one assumed to relate only to internationally transmitted services (message communications). In this model extension we also give governments the power to tax these two types of services differently when purchased in their own country. A higher tax rate on international rather than on domestic communications can be thought of as reflecting regulation of internationally linked network service transactions. Liberalization in this case involves lowering barriers to international communication, and is reflected in reduced tax rates in all countries on purchases of international network-related services. This form of services liberalization, unlike that considered in the previous section, generates relative price effects and, hence, quantity responses.

We use a constant elasticity of transformation (CET) function to describe the transformation of endowments into goods and services, but now one which incorporates two service types, S^1 and S^2 , one of which is supplied domestically and the other internationally, i.e.

$$Y_n = \left(\eta_n^1 G_n^{\frac{\sigma_n-1}{\sigma_n}} + \eta_n^2 S_n^1^{\frac{\sigma_n-1}{\sigma_n}} + \eta_n^3 S_n^2^{\frac{\sigma_n-1}{\sigma_n}} \right)^{\frac{\sigma_n}{\sigma_n-1}}, \tag{15}$$

where Y_n is the fixed resource endowment of country n , G_n is goods production in country n , S_n^1 is production of network service type 1 in country n , and S_n^2 is production of network service type 2 in country n . η_n^1 , η_n^2 , and η_n^3 are share parameters in production, and σ_n is the country n elasticity of transformation.

The value of production of goods and network services in country n is given by

$$W_n = P_n^g G_n + P_n^{s1} S_n^1 + P_n^{s2} S_n^2, \tag{16}$$

and maximizing the value of production subject to the CET function (15) implies supply functions for country n for the two types of services:

$$S_n^1 = G_n \left(\frac{\eta_n^2 P_n^g}{\eta_n^1 P_n^{s1}} \right)^{\sigma_n} \tag{17}$$

$$S_n^2 = G_n \left(\frac{\eta_n^3 P_n^g}{\eta_n^1 P_n^{s2}} \right)^{\sigma_n}. \tag{18}$$

Each household in each country again derives utility from consumption of goods, but now also from the two types of network services. These households also receive

externality benefits from the consumption of network-related services by other households along both the home and international networks.

We use Cobb–Douglas preferences for each household of the form⁸

$$U_n^h = G_n^{\alpha_g^h} \left(S_n^{1,h} \left(\sum_h S_n^{1,h} \right) \right)^{\alpha_1^h} \left(S_n^{2,h} \left(\sum_n \sum_h S_n^{2,h} \right) \right)^{\alpha_2^h}, \quad (19)$$

where the n subscripts refer to countries, and h superscripts refer to households within country n . U is utility, G is consumption of goods, and S^1 and S^2 are consumption of the two service types (domestic and international). As before, household utility increases when country service networks are more fully joined, but these effects now operate differently in the home and international markets.

Each household again receives a fixed share of country income

$$I_n^h = \theta_n^h W_n, \quad (20)$$

and this income is spent on purchasing goods and services. Household budget constraints now imply that

$$I_n^h = P_n^g G_n^h + P_n^{S_1} S_n^{1,h} + P_n^{S_2} S_n^{2,h}, \quad (21)$$

and demands for goods and services by each household are derived from maximization of Cobb–Douglas household utility functions subject to the household budget constraints (19).

These give goods demands as:

$$G_n^h = \frac{\alpha_{g,n}^h \cdot I_n^h}{P_n^g}, \quad (22)$$

and demands for the two types of services as

$$S_n^{1,h} = \frac{\alpha_{1,n}^h \cdot I_n^h}{P_n^{S_1}} \quad (23)$$

$$S_n^{2,h} = \frac{\alpha_{2,n}^h \cdot I_n^h}{P_n^{S_2}}. \quad (24)$$

Markets for goods and network services again clear at country level in equilibrium, i.e.

$$G_n = \sum_h G_n^h \quad (25)$$

$$S_n^1 = \sum_h S_n^{1,h} \quad (26)$$

$$S_n^2 = \sum_h S_n^{2,h}. \quad (27)$$

Taxes charged by national governments on S^2 purchased at home can be incorporated into this framework, and distort the relative prices of both network services and goods and also among services, reducing purchases of externality-generating international services.

Table 1 reports parameterizations used in a numerical example showing the impacts of network-related services liberalization in this two-service-type model. To capture differences in country size, we assume country 2 has double the resources of country

Table 1. Model Specifications of the Two-service-type Model Yielding Country Gains from Liberalization of Similar Relative Size across Countries, and Larger or Smaller Gains for the Larger Country

	Specification yielding gains to both small and large countries	Specification yielding larger gains to a small country and a loss to the larger country	Specification yielding the majority of the gains to the larger country and loss to the smaller country
Production			
Resources	Country 1: $Y_1 = 500$ Country 2: $Y_2 = 1000$	Country 1: $Y_1 = 500$ Country 2: $Y_2 = 1000$	Country 1: $Y_1 = 500$ Country 2: $Y_2 = 1000$
Transformation frontier shares and elasticities (G, S^1, S^2)	$\eta_1 = 0.4; \eta_2 = 0.2;$ $\eta_3 = 0.4; \sigma = -0.75$	$\eta_1 = 0.5; \eta_2 = 0.25;$ $\eta_3 = 0.25; \sigma = -0.75$	$\eta_1 = 0.5; \eta_2 = 0.25;$ $\eta_3 = 0.25; \sigma = -0.75$
Demand (three households in country 1 and five in country 2, with identical preferences within countries)	Country 1: $\alpha_g = 0.4;$ $\alpha_1 = 0.4; \alpha_2 = 0.4$	Country 1: $\alpha_g = 0.2;$ $\alpha_1 = 0.2; \alpha_2 = 0.6$	Country 1: $\alpha_g = 0.2;$ $\alpha_1 = 0.2; \alpha_2 = 0.6$
Demand-side shares (G, S^1, S^2)	Country 2: $\alpha_g = 0.4;$ $\alpha_1 = 0.4; \alpha_2 = 0.2$	Country 2: $\alpha_g = 0.3;$ $\alpha_1 = 0.4; \alpha_2 = 0.3$	Country 2: $\alpha_g = 0.3;$ $\alpha_1 = 0.4; \alpha_2 = 0.3$
Taxes	$t_1^1 = 3.01; t_1^2 = 0.67;$ $t_2^1 = -0.83; t_2^2 = -0.49$	$t_1^1 = 0.49; t_1^2 = 47.1;$ $t_2^1 = -0.448; t_2^2 = 0.97$	$t_1^1 = 76.5; t_1^2 = 0.57;$ $t_2^1 = -0.57; t_2^2 = -0.44$
Pre-liberalization (country tax rates on S^2)	$EV_1 = 0.605$	$EV_1 = 4.42$	$EV_1 = -0.24$
Post-liberalization (country tax rates on S^2)	$EV_2 = 1.006$	$EV_2 = -0.93$	$EV_2 = 1.79$
Money-metric welfare gains from liberalization (Hicksian EV as percentage of national income)			

1 at 1000 rather than 500. We consider two households in country 1 and five in country 2, with identical preferences within countries. We consider liberalization to be the creation of a link between two disjoint networks.

Results in Table 1 show that, while the absolute value of the gains from liberalization in network-related services differ across the two countries, the proportional effects are similar. It is also possible with further changes in specification beyond these used to report results in Table 1 to construct a case where the gains to the two countries go mainly to the small country (as with trade in goods), as in the second specification, or vice versa all in the third specification.

Thus, in this more realistic but slightly more complex world the theme is the same as above; namely that with network externalities and cross-country service liberalization, there is no presumption (as with goods) that the benefits of liberalization will accrue disproportionately to the small country. Per capita effects and country size seemingly once again operate in opposite directions.

4. The Size of the Gains from Liberalization in Service Networks

Having argued that the country division of gains from international liberalization in network-related services will typically differ from that for trade in goods, we finally proceed to a discussion of the size of the gains from such liberalization.

We analyze the size of the gains from liberalization in a cross-country policy game by comparing Nash equilibria and free-trade outcomes. The network-related service policy game differs from a conventional tariff game in which both countries apply tariffs to their own imports. In this game, both countries have the ability to tax service flows between countries; the origin country through regulation of the service flow as it leaves its own border, and the destination country through regulation of flows from its own border onward within the country of the eventual recipient of the network-related service.⁹ Thus, in the two-country case four tax rates t_j^i (the tax rates charged by country j on services originating in country i) are involved in the game.

To provide a point of comparison to tariff games in goods trade, we can compute Nash equilibria in a two-country tariff game in which S , instead of being a network-related service, is treated as a conventional commodity, much like G , and international trade takes place in G and S . In this calculation, all share and elasticity parameters are as in the two-service-type model calculations reported in Table 1, and in a Nash equilibrium tariff rates on imports are determined by commodity and by the country of source. In this case, levels of only two instruments (tariffs on imports by each country) are endogenously determined, rather than four instruments as in the network service case.

We use the two-service-type model set out in section 3 above, with the further difference that tax rates charged by the two countries on network-related services are endogenously determined in a Nash equilibrium rather than set exogenously. In the process, we determine the two-country, two-tax-rate reaction functions.

Table 2 reports results from these calculations, and compares Nash-equilibrium outcomes to those under no intervention (free trade in the goods trade model). Because of the network externality accruing to own-country residents, origin countries have an incentive to subsidize own consumption of internationally traded services, but destination countries have an incentive to apply a significant tax due to revenues transferred from abroad under the tax. Results in Table 2 suggest that the welfare gains as a percentage of national income, from moving to no intervention (the analogue of free trade) are larger in the two-service-type model than in the trade model.

Table 2. Differences in the Welfare Gains from Liberalization in a Service Networks Model and a Tradable Goods Model Relative to a Nash Equilibrium

	<i>Services-related network model (two-service type)</i>	<i>Trade in goods model</i>
Production	Country 1: $Y_1 = 500$	Country 1: $Y_1 = 500$
Resources endowment	$\eta_1 = 0.5; \eta_2 = 0.25; \eta_3 = 0.25$	$\eta_1 = 0.5; \eta_2 = 0.25; \eta_3 = 0.25$
Transformation elasticities	Country 2: $Y_2 = 1000$	Country 2: $Y_2 = 1000$
Transformation shares (G, S^1, S^2)	$\eta_1 = 0.5; \eta_2 = 0.25; \eta_3 = 0.25$	$\eta_1 = 0.5; \eta_2 = 0.25; \eta_3 = 0.25$
Demand	Country 1: $\alpha_g = 0.4;$	Country 1: $\alpha_g = 0.4;$
Demand-side shares (G, S^1, S^2)	$\alpha_1 = 0.4; \alpha_2 = 0.2$	$\alpha_1 = 0.4; \alpha_2 = 0.2$
	Country 2: $\alpha_g = 0.4;$	Country 2: $\alpha_g = 0.2;$
	$\alpha_1 = 0.4; \alpha_2 = 0.2$	$\alpha_1 = 0.2; \alpha_2 = 0.6$
Nash-equilibrium tariff rates (Tariff rates on goods and tax rates on services)	$t_1^1 = 240\%; t_1^2 = 107\%;$ $t_2^1 = 210\%; t_2^2 = 99\%$	$t_1^1 = 235\%; t_1^2 = 1008\%;$ $t_2^1 = 183\%; t_2^2 = 28\%$
Money-metric welfare from unilateral liberalization (Hicksian EV or CV as a percentage of national income)	$EV_1 = 3.56\%$ $EV_2 = -3.81\%$	$EV_1 = -0.03\%$ $EV_2 = -0.07\%$

5. Empirical Analysis of Global Telecom Liberalization

Finally we use the two-service-type model set out above to analyze the implications of global liberalization in telecoms using an empirically-based version of the modeling approach set out above. For these purposes, we consider a global four-region telephone service network model consisting of Canada, Europe, the USA, and the rest of the world (ROW). We use this to compute the global welfare gains from telecom liberalization using the network-related service model presented above. We also analyze the role played by the relative sizes of domestic and global networks in determining the division of gains, using data on the volume of cross-border telephone calls, and the relative size of caller and recipient regions. The size of the domestic network in Canada, for instance, is smaller than that of the USA, even though both countries have interconnected domestic and international networks. European countries have a well-developed domestic network, while networks elsewhere in the world are, on average, not as developed as in the three other regional blocs in the model.

To parameterize the model, we specify estimates of preference and technology parameters for each of the regions in the model. In the absence of literature estimates on the relevant elasticities, we have used a value of unity for the transformation elasticities in each region, which we then vary in subsequent sensitivity analysis. The λ parameters in preferences determine the strength of the network externality effects and are important; we have assumed them to be 0.1 in all countries. Using these values, we calibrate share parameters of preference functions and production frontiers using 1999 data on call volumes, implied call prices, and GDP published in the *World Telecommunication Development Report (WTDR)* (ITU, 1999) and the *World Development Report (WDR)* (World Bank, 2001).

The 1999 *WTDR* gives detailed information on the use of telephone networks by country and region, reporting volumes of both international and domestic calls, and

Table 3. Base Year (1999) Data Used for Calibration of Empirically-based Telecom Services Model

	GDP ^a	VS1 ^b	VS2 ^b	PS1 ^c	PS2 ^d	S ^{1e}	S ^{2f}	M ^g	E ^g	GE ^g
Canada	618	12	5	0.09	1.18	132	4	205	214	-9
Europe	9,613	180	42	0.07	1.23	2566	34	31	249	-218
USA	8,083	170	76	0.09	3.35	1889	23	945	683	262
ROW	11,014	159	79	0.03	3.49	5312	23	5415	5359	56

^a GDP, gross domestic product (in billions of US\$) is from Table 1 of *WTDR* (1999).

^b VS1 value of service type 1, VS2 value of service type 2, are derived from Table 14 of *WTDR* (1999), and the split between the two is based on information in Table 4 of *WTDR* (1994).

^c PS1 are prices of domestic calls reported in Table 7 of *WTDR* (1999).

^d PS2 are prices of foreign calls obtained by dividing VS2 by S².

^e S¹ is number of domestic calls obtained by dividing VS1 by PS1.

^f S² is number of international calls, reported in Table 12, p. A-59, *WTDR* (1999), in million minutes.

^g M and E are values of merchandise imports and exports obtained from the *World Development Report*, in millions (World Bank, 2001, Table 20, pp. 268–9). GE is balance of merchandise trade, M – E. Notice that there is a surplus of US\$91 billion in merchandise trade at the global level.

Source: *World Telecommunication Union Development Report* (1999).

revenues generated by the telephone sector in each country, again broken down by domestic and international calls. It also reports total and per capita GDP, as well as other information such as the telephone density and major telephone operating companies in 202 countries and autonomous territories.

We construct base case data on prices and quantities for our model by dividing *WTDR* revenues by volumes, using the assumption that calls within each group for each country are the same. We use country-specific information for Canada and the USA, and use summary statistics for Europe and derive data on the rest of the world (ROW) as a residual from world totals minus Canada, the USA, and Europe. In order to produce a benchmark equilibrium dataset for use in calibration, we use merchandise trade data published in the 2001 *WDR*.

Table 3 (and accompanying notes) set out how we have manipulated basic data to obtain a model admissible benchmark equilibrium dataset for model calibration.¹⁰ We use this for counterfactual equilibrium analysis in which we reduce the differential pricing in all regions between international and domestic calls by one-half, and then perform sensitivity tests in order to assess the robustness of model results to alternative values of elasticity parameters in production.

Calibrating our two-service model to the data in Table 3 yields the calibrated model parameters reported in Table 4. The share parameters in the demand functions are computed using income and price information applied to Cobb–Douglas demand functions, with the sum of share parameters constrained to equal one. Share parameters in the production possibility frontier are computed using information on the value of goods and two types of services produced, and the elasticities of transformation by region. Both sets of share parameters are dominated in their first component by GNP, which is large relative to the service categories.

Table 5 reports regional welfare benefits from liberalization in international network-related services using this model specification, where the price differential in all regions between domestic and international phone rates is halved. Results show gains for all regions but in proportional terms these are comparable across the

Table 4. Calibrated Share Parameters in the Empirically-based Telecom Model

	Canada	Europe	USA	ROW
α_g	0.619	0.547	0.426	0.196
α_1	0.200	0.246	0.437	0.626
α_2	0.043	0.030	0.101	0.159
η_2	0.005	0.005	0.006	0.004
η_3	0.002	0.0007	0.002	0.001

Note: α 's refer to consumption, η 's refer to production shares. Subscripts 1, 2, and 3 denote non-telecom GDP, domestic phone calls, and international phone calls, respectively.

Table 5. Regional Welfare Gains from Global Liberalization of Telecom Services

Canada	Europe	USA	ROW
0.0408	0.0539	0.0549	-0.3398

Note: Hicksian EV as percentage of GDP (based on 1999 data).

Table 6. Sensitivity Analysis of Regional Welfare Results for International Telecom Service Liberalization

Countries	Base case	Doubling ^a transformation elasticities in all regions	Tripling ^a transformation elasticities in all regions
Canada	0.0408	0.0450	0.0453
Europe	0.0539	-0.0001	-0.0005
USA	0.0549	0.0061	0.0058
ROW	-0.3398	0.00004	-0.0001

Notes: Welfare effects of Hicksian EV as percentage of GDP.

^aBase case values are -0.75.

smallest and largest regions, confirming the conjecture we offered earlier regarding the country division of the gains from liberalization in services and the difference relative to goods liberalization.

We have also performed some limited sensitivity analysis using this model to explore ranges of welfare estimates by region as we vary production-side transformation elasticities (the model demand side is Cobb–Douglas). Results are reported in Table 6; money-metric welfare effects by region are affected, as one might expect. Model was Solved using the GAMS Software.

6. Conclusion

This paper explores international liberalization of network-related services, such as telecoms. We argue that in the presence of network externalities, larger per capita

benefits accrue to residents of smaller countries when expanding international networks, and this can roughly offset differences in numbers of residents (country size). Hence, unlike for trade in goods, gains from liberalization can be of approximately equal absolute size across small and large countries.

We first show this for a simple case and explore this numerically for more complex structures, including for an empirical model implementation to global telecoms liberalization for the US, Europe, Canada, and the rest of the world. This theme that the division of gains does not relate to country size in the same way as for the case of liberalization of goods trade prevails across all model calculations. We also show larger gains from liberalization relative to a Nash equilibrium in a network-related service model than in a comparable goods model.

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Notes

1. Katz and Shapiro (1985, 1986) analyze network externalities in an industrial organization structure, and stress the incentives to capture markets in the design of the network. Later contributions include Choi (1994), Liebowitz and Margolis (1994), Economides (1996a,b), Garrone (1996), Bousquet and Ivaldi (1997), and Binmore (1999). Harris (1995) discusses application to trade, but in a different framework from that used here. Kikuchi and Ichikawa (2002) evaluate the influence of congestion in network services on comparative advantage in services trade for larger and smaller countries.
2. See the discussion of this in Cairncross's (1997) book *The Death of Distance*.
3. In practice, various sharing agreements between origin and destination countries operate. See ITU (1994, pp. 27–9) for a discussion on how these apply.
4. Much of service activity, as Melvin (1989) pointed out, is concerned with intermediation through time and/or space. Network-related services not only capture activity in telecommunications, but also transportation services where recipients of shipments receive benefits while shipment costs are fully paid by the shipper. They seem not to cover intertemporal intermediation, such as financial services, which involves intermediaries bringing together agents in order to transact. See Laffront and Tirole (2000) and Foros and Bjorn 2001.
5. The value of λ determines the strength of the network externality effect. Having ST enter multiplicatively in this way also indicates that it is the potential number of other households in the network that might contact an individual household, rather than the expected number of calls actually received, that yields the external effect. A treatment based on the expected number of calls can also be accommodated within this framework.
6. We are grateful to the referee for correcting our drafting on this part.
7. Alternatively, Hicksian-equivalent variation measures can be used, which in this case are:

$$EV^h = \frac{U_N^h - U_0^h}{U_0^h} I_0^h.$$

8. The λ term from the previous section does not appear here. The externality summation term multiplies the separate S^1 and S^2 terms rather than all utility.
9. A non-cooperative outcome can thus be thought to correspond to a breakdown of present inter-country telecom revenue-sharing arrangement discussed in ITU (1999).
10. Several features of this dataset are important for our experiments and results. One is that prices for international calls are sharply above prices for domestic calls (this situation has changed since 1999). Another is that domestic calls are higher in North America than in Europe and ROW, reflecting the higher share of intra-continental (e.g. LA/NY) calls to local calls in this region.