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Transportation Infrastructure Investments and Regional Trade Liberalization

Eric W. Bond

This model predicts that without cooperative infrastructure agreements between countries, there will be underinvestment in those forms of infrastructure in which the investments will have spillover effects to other countries. For a relatively small country, for example, there would tend to be more underinvestment in railroad and highway infrastructure to neighboring countries than there would be in airport and harbor infrastructure (carrying goods to the whole world).

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Summary findings

Bond examines whether trade liberalization should create a greater incentive for countries to invest in transportation infrastructure. He pays special attention to the case of preferential trade liberalization between neighboring countries, where investments in roads or railroads are specific to the partner country and will thus have spillover effects. The existence of spillovers will lead to gains from cooperative agreements about investment levels.

Bond shows that in a small country the incentive to invest in infrastructure depends on the level of the tariff when demand is linear. If protection is in the form of a quota, on the other hand, trade liberalization will increase the optimal infrastructure investment.

He shows that in a two-country model with spillovers between countries, the cooperative equilibrium may involve either more or less investment than the noncooperative equilibrium, depending on the pattern of trade between the two countries and the degree of substitutability between investments in the two countries.

For a relatively small country, for example, there would be more underinvestment in railroad and highway infrastructure to neighboring countries than there would be in airport and harbor infrastructure. The first type of investment is specific to certain markets and is likely to affect the relative price of goods in those markets. The second type of investment, on the other hand, will send goods to world markets generally, where prices are likely to be relatively unaffected by the investments.

Bond also examines the desirability of linking regional trade and infrastructure agreements. The prediction generated by his model is that in the absence of cooperative agreements between countries, there will be underinvestment in those forms of transportation in which the investments will have spillover effects to other countries.

Bond identifies two forms of gains from infrastructure agreements:

- Internalizing the terms-of-trade effects and thus avoiding the inefficient investment levels that arise in noncooperative choices of investment levels.
- Internalizing the effects of the infrastructure investment in the tariff negotiation process, in cases where countries cannot commit to future tariff rates.

This paper — a product of the Development Research Group — is part of a larger effort in the group to understand regionalism and development. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Jennifer Ngaine, room N5-060, telephone 202-473-7947, fax 202-522-1159, Internet address trade@worldbank.org. November 1997. (29 pages)

Transportation Infrastructure Investments and Regional Trade Liberalization*

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Foreword

As regional trading arrangements (RTAs) have spread, enlarged and deepened over the last decade, they have posed challenges to economists on both intellectual and policy levels. On the former, do RTAs stimulate growth and investment, facilitate technology transfer, shift comparative advantage towards high value-added activities, provide credibility to reform programs, or induce political stability and cooperation? Or do they, on the other hand, divert trade in inefficient directions and undermine the multilateral trading system?

The answer is probably "all of these things, in different proportions according to the particular circumstances of each RTA." This then poses the policy challenge of how best to manage RTAs in order to get the best balance of benefits and costs. For example, should technical standards be harmonized and, if so, how; do direct or indirect taxes need to be equalized; how should RTAs manage their international trade policies in an outward-looking fashion?

Addressing these issues is one important focus of the international trade research program of the Development Research Group of the World Bank. It has produced a number of methodological innovations in the traditional area of trade effects of RTAs and tackled four new areas of research: the dynamics of regionalism (e.g., convergence, growth, investment, industrial location and migration), deep integration (standards, tax harmonization), regionalism and the rest of the world (including its effects on the multilateral trading system), and certain political economy dimensions of regionalism (e.g., credibility and the use of RTAs as tools of diplomacy).

In addition to thematic work, the program includes a number of studies of specific regional arrangements, conducted in collaboration with the Regional Vice Presidencies of the Bank. Several EU-Mediterranean Association Agreements have been studied and a joint program with the staff of the Latin American and Caribbean Region entitled "**Making the Most of Mercosur**" is under way. Future work is planned on African and Asian regional integration schemes.

Regionalism and Development findings have been and will, in future, be released in a number of outlets. Recent World Bank Policy Research Working Papers concerning these issues include:

Glenn Harrison, Tom Rutherford and David Tarr, "Economic Implications for Turkey of a Customs Union with the European Union," (WPS 1599, May 1996).

Maurice Schiff, "Small is Beautiful, Preferential Trade Agreements and the Impact of Country Size, Market Share, Efficiency and Trade Policy," (WPS 1668, October 1996).

L. Alan Winters, "Regionalism versus Multilateralism," (WPS 1687, November 1996).

Magnus Blomström and Ari Kokko, "How Foreign Investment Affects Host Countries" (WPS1745, March 1997)

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Eric Bond, "Using Tariff Indices to Evaluate Preferential Trading Arrangements: An Application to Chile" (WPS1751, April 1997)

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Planned future issues in this series include:

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Other papers on regionalism produced by DECRG include:

Ahmed Galal and Bernard Hoekman (eds), Regional Partners in Global Markets: Limits and Possibilities of the Euro-Med Initiative. CEPR 1997.

Bernard Hoekman and Simeon Djankov, "Imports of Inputs, Foreign Investment and Reorientation of East European Trade," World Bank Economic Review (forthcoming)

Bernard Hoekman and Simeon Djankov, "The EU's Mediterranean Free Trade Initiative," World Economy

Bernard Hoekman and Simeon Djankov, "Effective Protection in Jordan and Egypt in the Transition to Free Trade with Europe," World Development.

Bartlomiej Kaminski, "Establishing Economic Foundations for a Viable State of Bosnia and Hercegovina: Issues and Policies".

In addition, **Making the Most of Mercosur** issued the following papers:

Alexander J. Yeats, "Does Mercosur's Trade Performance Raise Concerns About the Effects of Regional Trade Arrangements?" (WPS1729, February 1997))

Azita Amjadi and L. Alan Winters, "Transport Costs and 'Natural' Integration in Mercosur" (WPS1742, March 1997)

Claudio Frischtak, Danny M. Leipziger and John F. Normand, "Industrial Policy in Mercosur: Issues and Lessons"

Sam Laird (WTO), "Mercosur Trade Policy: Towards Greater Integration"

Margaret Miller and Jerry Caprio, "Empirical Evidence on the Role of Credit for SME Exports in Mercosur"

Malcom Rowat, "Competition Policy within Mercosur"

For copies of these papers or information about these programs contact Maurice Schiff, The World Bank, 1818 H Street NW, Washington, D.C. 20433.

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I. Introduction

One of the salient features of the preferential trading arrangements (PTAs) that have proliferated in recent years is that the member countries tend to be located in the same geographic region. The European Union, NAFTA, and Mercosur, which are among the most prominent examples of PTAs that have initiated or expanded market integration in recent years, all consist of countries that are located in the same geographic region. It has become common to refer to countries that are close in geographic proximity as being "natural trading partners," because the lower costs of transporting goods to nearby countries would reduce the amount of cost difference required to generate trade between the countries.[1]

A common feature of the models of natural trading partners is that the level of transportation costs is taken to be exogenously given, with transport costs being lower between nearby countries.[2] However, it may in fact be quite costly to transport goods between two nearby countries if the transportation infrastructure between the countries is not well developed, a problem which is frequently

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[1]The concept of natural trading partners was first used by Wonnacott and Lutz (1979), and has been popularized recently by Krugman (1991). A somewhat stronger statement is frequently made, which is that there is a presumption that preferential agreements between natural trading partners are welfare improving. Frankel, Stein and Wei (1995) provide a systematic simulation analysis of this issue in a model that allows for intra-continental transport costs that are lower than inter-continental transport costs. They find evidence that "unnatural" trading blocs between countries on different continents typically reduce welfare, whereas "natural" trading blocs between countries in the same continent will raise welfare if intercontinental transport costs are not too low. If intercontinental transport costs are very low, then continental blocs may also be welfare reducing. It should be noted that the usefulness of the concept of natural trading partners to characterize trading blocs that are welfare-improving is not without controversy. Bhagwati and Panagariya (1996) argue that these results are highly sensitive to functional forms, and provide examples in which it is more desirable to form a link with more distant country.

[2]Frankel, Stein, and Wei (1995)) use a gravity model to explain trade patterns and find evidence that the volume of trade between countries is negatively related to the distance between them, which is consistent with a role for transport costs. Furthermore, they include dummy variables for regional groupings as a proxy for the effect of preferences, and find some significant coefficients. In contrast, Amjadi and Winters (1997) construct a direct measure of transport cost from trade data for Mercosur countries. They find that transport costs average approximately 6% of intra-Mercosur trade for Brazil and Argentina and 12% of trade with the rest of the world (excluding Chile). They point out that the differential of approximately 6% between within bloc and outside bloc trade is well below the differential found by Frankel, Stein and Wei to represent natural trading blocs in their simulations.

encountered in developing countries. This has been particularly noticeable in the case of the Mercosur countries, where cross-border transportation links have been quite poor. For example, three-quarters of the overland trade between Brazil and its western neighbors travels over a single bridge over the Uruguay river.[3] Also, railway transport between Brazil and Argentina is hampered by the fact that the respective countries' railroads were built with different gauges of rail. The formation of Mercosur has created pressure to expand the infrastructure investments between the member countries, as evidenced by the fact that Chile's free trade agreement with Mercosur commits Chile and Argentina to each spend $150 million on improving transportation infrastructure (The Economist (1996)). Similarly, the entry of Greece, Portugal and Spain into the European Union has resulted in substantial investment in transportation infrastructure investment in these countries. In addition, an Infrastructure Committee was created as part of the single market initiative to coordinate transportation investments across countries.

These examples suggest that the degree to which countries are "natural" trading partners is to an important sense endogenous. The purpose of this paper is to examine the incentives for investment in transport infrastructure between geographically proximate countries, and to examine how these incentives are affected by trade liberalization. A main feature of this analysis is to focus on the fact that transport investments between nearby countries are frequently country-specific, such as roads or railroads, which lower transport costs between those countries but have little impact on transport costs with the rest of the world. These types of infrastructure investments differ from investments in seaports and airports, which typically reduce transport costs to many different locations. Coordination of investments is likely to be particularly important in the former type of investment, where the productivity of investment by one country is likely to be significantly affected by investments in the other country (e.g. adopting the same

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[3] The lack of cross-border transportation links in South America reflects both the difficulties brought on by difficult terrain, such as the Andes, but also by the historical mistrust between the countries. Since good transportation links are potentially a route for invading armies, countries tended to develop their domestic transportation links while neglecting connections with neighboring countries.

gauge of railroad track).[4] Therefore, we will examine how the level of investment is affected by coordination between the countries, and whether coordination in infrastructure investments is enhanced by preferential trade liberalization between the countries. This question is important for policy purposes, because it will help to answer whether cooperative agreements on infrastructure levels are complementary with trade agreements and should be tied to preferential trading arrangements or whether investment coordination can be undertaken independently of trade liberalization.

Section II of the paper analyzes the optimal degree of infrastructure investment for a small open economy, and examines how the incentives to invest in infrastructure are related to trade policy in the absence of coordination issues. One's intuition might suggest that since trade liberalization is associated with an increase in the volume of trade, the return to trade-related infrastructure investments should rise with the volume of trade. This intuition is incorrect in the case where trade is restricted by tariffs and the government chooses transport levels to maximize national welfare. In the case where demands are linear, the optimal level of transport cost investment is independent of the level of the tariff because governments have an offsetting incentive to invest in infrastructure when tariffs are high in order to expand the volume of trade and alleviate the effects of the tariff distortion. However, if trade is restricted by quotas, infrastructure investments will be higher when trade is liberalized.

Section III extends the analysis to consider the case of a customs union between two countries that are small relative to the rest of the world. It is shown that the question of whether the non-cooperative equilibrium results in underinvestment relative to the cooperative outcome depends on the pattern of trade between the countries. It is shown that in a customs union in which trade continues with

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[4]A good example is provided by transportation costs for Uganda, a landlocked country. A World Bank (1997) evaluation of transportation cited 8 causes of inefficiency in the road transport of imports, 5 of which related to inefficiencies in Kenya. These included a slow weight bridge system and convoy system in Kenya, lack of properly operating cranes at the port of Mombasa, and slow evaluation of transit cargo. Similar issues arose for rail transport through Kenya.

the rest of the world, the benefits of transport cost reduction will not be symmetrically distributed between the countries. The country experiencing an improvement in its terms of trade will have an incentive to overinvest relative to the cooperative level, while the other country will have an incentive to under invest. The overall level of investment in the non-cooperative equilibrium may be higher or lower than in the cooperative equilibrium, depending on the degree of substitutability between the investments by the two countries. In contrast, in the case where the formation of the union eliminates trade with the rest of the world, the non-cooperative equilibrium will involve lower levels of investment by both countries than the cooperative equilibrium. This follows because the effects of each country's infrastructure investments spills over to affect the other country through changes in the terms of trade. In each of these cases, the overall benefit to the union of transport cost reduction is independent of the level of the tariff when demands are linear.

Section IV examines the linkage between trade and infrastructure investments between nearby countries. It is shown that there is a basic independence between trade and infrastructure agreements when demands are linear, because the efficient level of one variable (tariff levels or investments) is independent of the level of the other variable. It is also shown that when negotiations over tariff rates take place after infrastructure investments have been made, countries will use investments strategically to influence tariff negotiations. Infrastructure agreements can be used to internalize these effects, which leads to efficient choices of infrastructure. This represents a second form of benefit from cooperative infrastructure investments. Section V offers some concluding remarks on the relationship between infrastructure investments and other forms of public goods in customs unions that have been studied.

I. Infrastructure Investments in a Small Country

In this section we examine how the benefits of reductions in transport costs are related to the level of tariffs and the volume of trade for a small country. We analyze a simple partial equilibrium model in which there are two traded goods, with the numbering of goods chosen such that good 1(2) is the home country import (export).[5] We begin by deriving the effect of reductions in transport costs on national welfare. These results are then used to derive the optimal level of infrastructure investment, and to examine how the optimal investment level is affected by trade liberalization.

The home country import demand schedule is denote $M_1(p_1)$ and the export supply schedule is $X_2(p_2)$, where p_i is the domestic price of good i in the home country. Units are chosen such that the transport cost per unit of each good is v. Letting t_1 (t_2^*) be the home (foreign) tariff per unit of imports of good 1 (2) and p_i^* the domestic price of good i in the foreign country, commodity arbitrage ensures $p_1 = p_1^* + t_1 + v$ and $p_2 = p_2^* - t_2^* - v$. Foreign prices p_i^* are exogenously given by the small country assumption. Welfare for the home country can be expressed as the sum of tariff revenue and consumer and producer surplus in each market,

$$W(t_1, v) = \int_{p_1}^{\infty} M_1(u)du + \int_{0}^{p_2} X_2(u)du + t_1 M_1(p_1) \tag{1}$$

Differentiating (1) yields

$$-\frac{\partial W}{\partial t_1} = -t_1 M_1' > 0; \qquad -\frac{\partial W}{\partial v} = M(p_1) + X(p_2) - t_1 M_1' > 0 \tag{2}$$

[5]The partial equilibrium model is chosen to simplify two aspects of the problem: the existence of income effects in demand and the effect of infrastructure investments on the outputs of the two goods. This partial equilibrium model can be interpreted as a general equilibrium model in which there is a traded good 0 with zero tariffs and transport costs. The production side is assumed to have goods 1 and 2 produced using sector-specific capital and mobile labor, while good 0 and transport infrastructure investments require only labor. With this production structure, changes in infrastructure investment will change only output of good 0, and not that of 1 or 2. Preferences for the goods are assumed to be represented by a utility function $U_1(D_1) + U_2(D_2) + D_0$, where D_i denotes consumption of good i and U_i is a strictly concave function, so that all income effects are absorbed by good 0. The absence of income effects allows good 0 to be used to make transfers between countries for the case of a customs union considered later.

A tariff reduction must be welfare-increasing for a small open economy when $t_i > 0$. When domestic price is above world price, the increase in trade volume created by a tariff reduction is welfare increasing. A reduction in transport costs has two favorable effects on welfare: (i) it improves the terms of trade for the small importing country by reducing the costs of imports and raising the return per unit of exports (at given prices in the rest of the world) and (ii) it has a favorable effect on the volume of imports. The favorable terms of trade effect is proportional to the volume of trade, indicating that reductions in transport costs are more beneficial when the volume of trade with the rest of the world is large.

A. Optimal Transportation Infrastructure in the Small Country Case

Now suppose that domestic resources can be devoted to investments in infrastructure that reduce transport costs. These investments could include projects to upgrade roads and railroads, port facilities, and airports. Our analysis will focus on the case in which these investments are public goods, so it is natural to think of the government as making the decisions on the level of investment to undertake. We will treat this as a two period model, with r denoting the amount of investment in transport cost reduction made in the first period. The level of unit transport costs in the second period is $v = \phi(r)$, where $\phi' < 0$, $\phi'' > 0$ reflects increasing marginal infrastructure costs of reducing unit transport costs. The present value of second period welfare for the country, given an investment of r in the first period, is $\beta W(t_i, \phi(r))$, where β is the discount factor on second period payoffs. Note that the second period here should be interpreted as being the life of the investment.[6]

If the choice of transportation infrastructure is being made by the government, then r will be

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[6] For example, if the project is completed in one year and has a life of T years, then $\beta = \sum_{t=1}^{T} \left(\frac{1}{1+i} \right)^t$ when i is the market rate of interest. The assumption of separability between transport investments and period 0 outputs of goods 1 and 2 (see footnote 6) thus implies no distorting effect of the investment on period 0 trade flows.

chosen to maximize net national welfare, $\beta W(t_1, \phi(r)) - r$. The optimal level of investment in transport costs occurs where

$$M_1(p_1) + X_2(p_2) - t_1 M_1' = -\frac{1}{\beta\phi'(r)} \tag{3}$$

which requires equating the marginal social benefit of transport reduction to the marginal cost.[7]

If the tariff level is being set to maximize national welfare, then the tariff will be zero independently of the level of transport costs. However, suppose that the government is constrained in its ability to change tariff levels, so that the level of the tariff is viewed as exogenously given by the government. We could then consider a second best exercise of examining the optimal level of r given the tariff, in order establish how the incentive to invest in infrastructure varies with the level of the tariff. Totally differentiating (3) yields

$$\frac{\partial r}{\partial t_1} = \frac{-\,tM_1''\phi'}{\left(\frac{\partial^2 W}{\partial v^2}(\phi')^2 + \frac{\partial W}{\partial v}\phi''\right)} \tag{4}$$

There are two offsetting effects of an increase in the tariff rate on the optimal level of transport cost reduction. The first is that an increase in the tariff reduces the volume of trade, which reduces the cost-savings resulting from an increase in r. The second is that a higher tariff raises the distortion on imports, which raises the amount of tariff revenue gained by a reduction in transport costs. In the case of a linear demand curve, these two effects exactly offset (i.e. the numerator in (4) is 0) and the tariff has no

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[7]The sufficient condition for a maximum is that $(\partial^2 W/\partial v^2)(\phi')^2 \;\; \partial W/\partial v)\phi''<0$. From (3) it can be seen that $\partial^2 W/\partial v^2 > 0$ as long as the home import demand schedule is not too concave in p_1. Since benefits depend on the volume of trade and the volume of trade rises as transport costs fall, this creates a tendency toward increasing marginal benefits of transport cost reduction. Therefore, satisfaction of this condition requires that ϕ be sufficiently convex. An interior solution with $r > 0$ and $v > 0$ can be guaranteed by assuming $\lim_{r\to 0}\phi'(r) = -\infty$ and that $\lim_{r\to\infty}\phi(r) > 0$.

effect on the optimal r. If the home import demand curve for imports is convex (concave) in p, then an increase in t_1 will increase (decrease) the optimal r. A convex import demand schedule has a smaller trade volume effect when the tariff is high, which raises the benefits of transport cost reduction.

The analysis in this section has been made under the assumption of a specific tariff to simplify the presentation. This result will also hold in the case of an ad valorem tariff as long as the tariff is imposed on the fob price of the import. Letting τ_1 (τ_2^*) denote the ad valorem import tariff imposed in the home (foreign) country, home country prices will be $p_1 = v + p_1^*(1+\tau_1)$ and $p_2 = (p_2^* - v)/(1+\tau_2^*)$ and the benefit of transport cost reduction will be $-\partial W/\partial v = M(p_1) + X(p_2) - \tau_1 p_1^* M_1'$. This yields $\partial^2 W/\partial\tau\partial v = 0$ when the import demand curve is linear, so the level of transport cost investment will be independent of the tariff rate when demand is linear.[8]

B. Quantitative Restrictions

The effect of trade liberalization on the benefits of transport cost reduction will differ when protection is by quotas, however, because there is no trade volume effect of transport cost reduction with quantitative restrictions. With an import quota set at $\bar{Q}_1$, the domestic price of the importable is determined by the market-clearing condition $M_1(p_1) = \bar{Q}_1$. Assuming that the rents from the quota accumulate to home country residents, home welfare will be

$W(\bar{Q}_1, v) = \int_{p_1}^{\infty} M_1(u)du + \int_0^{p_2} X_2 du + (p_1 - p_1^*)\bar{Q}_1$. The benefit of transport cost reduction in this case is

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[8] If the tariff is imposed on the c.i.f. price, we have $p_1 = (v + p_1^*)(1+\tau_1)$, $p_2 = \left(p_2^*/(1+\tau_2^*)\right) - v$, and $-\partial W/\partial v = M(p_1) + X(p_2) - \tau_1(1+\tau_1)(v + p_1^*)M_1'$ With linear demand, $-\partial^2 W/\partial v \partial\tau_1 = -2(p_1^* + v)\tau_1 M' > 0$. When the tariff is imposed on the transportation cost component of the price, an increase in the tariff raises rate makes the benefits of transport cost reduction larger because the trade volume effect is larger. It then follows that the optimal infrastructure investment will be increasing in the tariff rate with linear demand.

simply the reduction in the cost of trade,

$$-\frac{\partial W(\bar{Q}_1,v)}{\partial v} = \bar{Q}_1 + X(p_2) > 0 \tag{5}$$

The difference between (5) and (2) is that with a quota in place, a reduction in transport costs will not increase the volume of trade. The optimal level of r in the presence of a quota will be determined by the condition $\frac{\partial W(\bar{Q}_1,v)}{\partial v} = \frac{1}{\beta\phi'}$. This yields two results on the differences between optimal transport cost investments under quotas and those under tariffs. First, the level of transport investment will be greater under a tariff than under the equivalent quota, because the tariff creates an additional benefit of transport cost reduction due to the impact on trade volume.[9] Second, an expansion of the quota must result in an increase in the optimal level of r, regardless of the shape of the import demand schedule. Thus, trade liberalization should result in an incentive to increase the amount of investment in transportation infrastructure.

Note that the level of infrastructure investment chosen with the quota is the same level that would be chosen if protection was provided by tariffs and the infrastructure investment were being made by the private sector with projects being evaluated at domestic (rather than world) prices. It is also the level of investment which minimizes the present value of transport-related costs for a given trade volume, $\beta\phi(r)(M_1+X_2) + r$, which includes both infrastructure costs and unit costs.

The results of this section for the small country case can be summarized in the following result:

Proposition 1: For a small country,

(a) The optimal level of infrastructure investment exceeds that which minimizes transport costs (for the

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[9] Note that with endogenous transportation costs, the equivalent tariff for a quota of $\bar{Q}_1$ is determined by the condition $M_1(p_1^* + \phi(\tilde{r}(t_1)) + t_1) = \bar{Q}_1$, where $\tilde{r}(t_1)$ is the optimal level of investment for the tariff t_1.

given trade volume) in the presence of a positive tariff (either specific or ad valorem tariff) because of the favorable trade volume effects of transport cost reductions.

(b) If demand is linear, the optimal level of transport cost investment will be independent of the level of a specific tariff or an ad valorem tariff imposed on the f.o.b. price.

(c) If imports are restricted by quotas, the optimal level of investment is the one that minimizes transport costs. Investment will increase with quota liberalization in all cases.

These results will serve as a useful benchmark, because they yield the linkage between trade policy and infrastructure in the absence of spillovers between countries.

III. Infrastructure Investment in a Customs Union

In this section we analyze the case in which there are two small countries, **A** and **B**, trading with the rest of the world. Countries **A** and **B** are assumed to be located next to each other, so that infrastructure investments in one country have an effect on the productivity of investments in the other. In this section we will analyze the effect of cooperative infrastructure agreements between the two countries by comparing the investment levels that arise when the countries behave non-cooperatively. In particular, we will examine how this comparison depends on the pattern of trade between the two countries and on the existence of a preferential trading arrangement between the two countries.

We analyze a two good model, as in the small country case, with the pattern of comparative advantage will be chosen such that country **A (B)** imports 1 (2) and exports good 2 (1) at the initial world prices and tariff rates. The rest of the world, denoted by *, assumed to be sufficiently large that world prices p_1^* and p_2^* are unaffected by trade of either **A** or **B**. The transport costs between countries **A** and **B** are v per unit for either product, while transport costs between the rest of the world and either country are v^*. t_k^{ij} denotes the tariff imposed by country i on imports of good k from country j, where i, j = A, B, * , i $\neq$ j; k = 1,2, and p_k^i is the internal price of good k in country i. It will be assumed that in the initial

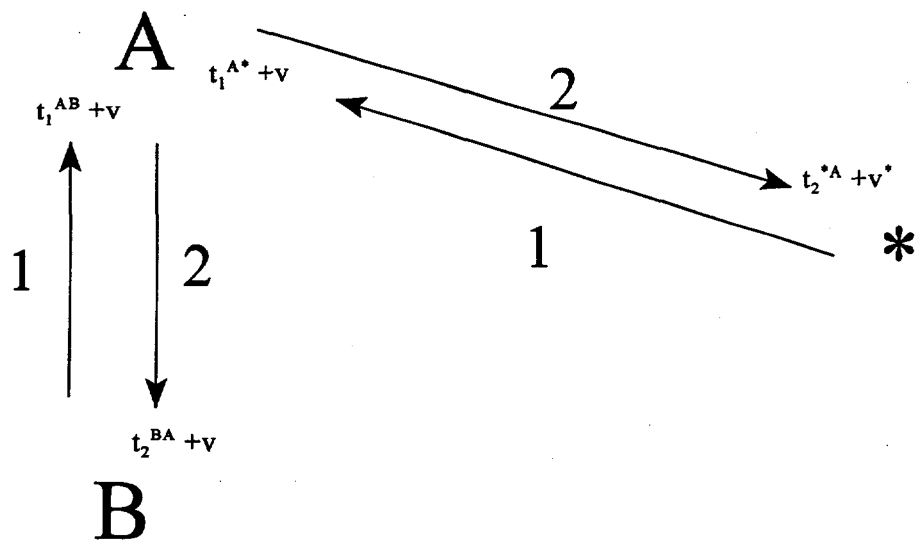

Figure 1a Case I: Country **A** Imports 1 from **B** and * and Exports 2 to **B** and *

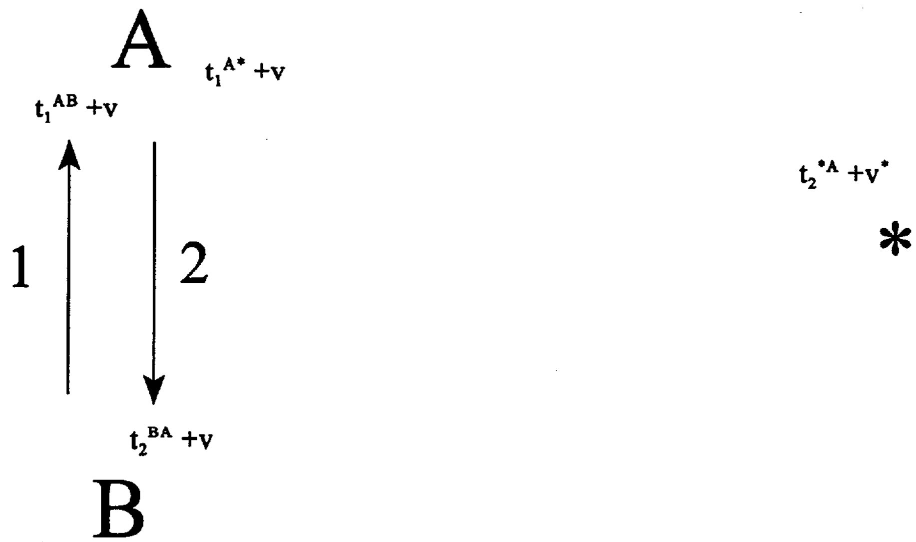

Figure 1b: Case II: Preferential Tariff Reductions Eliminate Trade with *

situation with non-discriminatory tariffs (i.e. $t_1^{AB} = t_1^{A*}$ and $t_2^{BA} = t_2^{B*}$) country **A** imports good 1 from both **B** and * and exports good 2 to both **B** and *. Figure 1a illustrates the initial trade pattern, with the costs of moving goods (transport costs plus import tariffs) between the markets indicated next to the respective arrows.[10]

The transportation cost assumptions in this section are intended to capture the returns to transport cost investments that are specific to trade between **A** and **B**, and have no effect on the cost of trading with the rest of the world. One might interpret these as being overland transportation routes between **A** and **B**, such as railroads or roads, which serve to move goods only between the two countries. Specifically, unit transport costs between countries **A** and **B** are $v = \phi(r^A, r^B)$, where r^i is the investment of country i in infrastructure. It is assumed that the transport costs are decreasing in each country's investment level, $\phi_{r^i} < 0$, and that ϕ is convex in (r^A, r^B). The cross effect $\phi_{r^A r^B}$ captures the substitutability/ complementarity between infrastructure investments in the two countries. Investments in the two countries will be substitutes (complements) if $\phi_{r^A r^B} > (<) 0$, because an increase in the level of country **B** investment reduces (raises) the cost reduction generated by country **A** investment. Investment in the two countries might be substitutes in the case of investment in a bridge over a river on the border between two countries, where the investment in the bridge could be made by either country. The case of perfect substitutability would arise if the quality of the bridge depends only on the sum of expenditures by the two countries in constructing the bridge. Complementarity, on the other hand, case might arise in the case of a road connecting the two countries, with each country investing in the section of the road that lies within its borders. If the size of trucks that can be run along the road (and hence the level of unit transport costs) is determined by the lowest quality section of the road, then we have the case of perfect

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[10] Letting q_1^i denote the autarky price in country i, the assumption on comparative advantage is that $q_1^A < q_1^i$ for $i \neq$ **A**. The initial trade pattern illustrated in Figure 1a implies the following restrictions on tariffs and transport costs: (i) **A** will import good 1 from B and * if $q^A > q_1^i + v^i + t_1^{Ai}$ for i = B, *. (ii) B will export to A (rather than *) if $v + t_1^{AB} < 2v^* + t_2^{*A} + t_2^{B*}$.

complementarity, with $v = \phi(\min(r, r^*))$. Transport costs between either country and the rest of the world will be an exogenously given at v^*. These transport cost links can be thought of as seaports or airports, which are not specific to transport costs with a particular country and are thus less subject to coordination problems in investment level.

Reductions in transport costs or preferential trade liberalization between **A** and **B** will lead to an increase in the volume of trade between **A** and **B**. Two cases will be considered in the analysis below. In case I, shown in Figure 1a, country **A** continues to trade goods 1 and 2 with the rest of the world after the formation of the union. The linkage between prices in the two countries is then given by the following relationship:

$$\text{Case I:} \quad p_1^A = p_1^* + v^* + t_1^{A*} = p_1^B + v + t_1^{AB}; \quad p_2^A = p_2^* - v^* - t_2^{*A} = p_2^B - v - t_2^{BA} \qquad (6)$$

In case I prices in country **A** and the domestic price of **B**'s importable are determined by the exogenously given prices in the foreign country, while country B's export price is determined by trade/transport barriers between **A** and **B**. In case II, the supply of good 2 and demand for good 1 in country **B** are sufficiently large that a preferential tariff reduction results in the elimination of trade between the union and the outside world. Prices in **A** and **B** are thus given by

$$\text{Case II:} \quad p_1^A = p_1^B + v + t_1^{AB} < p_1^* + v^* + t_1^{A*}; \quad p_2^A = p_2^B - v - t_2^{BA} > p_2^* - v^* - t_2^{*A} \qquad (7)$$

In case II, domestic prices in both countries are endogenously determined as in the case of two large countries.

In this section we will emphasize two types of spillovers that occur between the member countries of the customs union as a result of infrastructure investments. The first spillover is the impact of investments by one country on the level of transport costs and the profitability of investments for the other country as captured by the $\phi(r^A, r^B)$ function. The second spillover is the impact of transport costs on the terms of trade between the two union members. The trade patterns illustrated in Figure 1 are not intended to be exhaustive, but are chosen to illustrate two quite different implications for the distribution of terms of trade effects between the two countries. In case I, **A**'s terms of trade are locked in to the world market and all of the effects of changes in transport costs will be reflected in changes in **B**'s domestic prices. In case II, the reductions will be distributed more symmetrically across countries, with prices in both countries changing as a result of reductions in transport costs. We will show that in the former case the gains are captured exclusively by country **B** and the non-cooperative infrastructure level may be either higher or lower than the cooperative level. In the former case, in contrast, both countries experience the benefits of one country's infrastructure investment. This leads to a prisoner's dilemma in which the non-cooperative level will be less than the cooperative level.

A. Case I: Customs Union with Trade with the Foreign Country

In Case I, country **A** trades with both **B** and *, so the welfare of the respective countries can then be written as

$$W^A(t_1^{AB},v) = \int_{p_2^A}^{\infty} M_1^A(u)du + \int_0^{p_2^A} X_2^A(u)du + t_1^{AC}\left(M_1^A(p_1^A)-X_1^B(p_1^B)\right) + t_1^{AB}X_1^B(p_1^B)$$

$$W^B(t_1^{AB},t_2^{BA},v) = \int_0^{p_1^B} X_1^B(u)du + \int_{p_2^B}^{\infty} M_2^B(u)du + t_2^{BA}M_2^B(p_2^B) \tag{8}$$

where the domestic prices are determined by (6). Domestic prices in **A** will be unaffected by changes in either tariffs or transport costs, but for country **B** we have $dp_1^B = -dv - dt_1^{AB}$ and $dp_2^B = dv + dt_2^{BA}$. The effects of transport cost and tariff reductions on A's welfare, assuming $t_1^{AB} \le t_1^{A*}$, are given by

$$-\frac{\partial W^A}{\partial t_1^{AB}} = -X_1^B + (t_1^{AB} - t_1^{A*})X_1^{B\prime} < 0; \qquad -\frac{\partial W^A}{\partial v} = (t_1^{AB} - t_1^{A*})X_1^{B\prime} \le 0 \tag{9}$$

A preferential tariff reduction by **A** has two negative effects on **A**: it worsens the terms of trade by increasing the price of imports from **B** and it also diverts trade from the lower cost non-member country when $t_1^{AB} < t_1^{A*}$. A transport cost reduction also has a negative effect for **A** when $t_1^{AB} < t_1^{A*}$ because of the expansion of trade with the partner country.

For country **B**, welfare effects are

$$-\frac{\partial W^B}{\partial t_1^{AB}} = X_1^B > 0; \qquad -\frac{\partial W^B}{\partial t_2^{BA}} = -t_2^{BA} M_2^{B'} > 0; \qquad -\frac{\partial W^B}{\partial v} = X_1^B + M_2^B - t_2^{BA} M_2^{B'} > 0 \quad (10)$$

The preferential tariff reduction by **A** raises **B**'s welfare because it improves **B**'s terms of trade, and a preferential reduction by **B** raises **B**'s welfare because it has a favorable effect on trade volume. **B** also benefits from a reduction in transport costs. Note the similarity of the effect of reductions in t_2^{BA} and v for country **B** and those obtained in the small country case.

In the case where countries choose infrastructure investment levels non-cooperatively, country i will choose r^i to maximize $W^i(t_1^{AB}, t_2^{BA}, \phi(r^A, r^B)) - r^i$, given r^j (i, j = A, B and i ≠ j). Since **A** experiences a welfare reduction from infrastructure investments, $r^A = 0$. **B** will choose its level of infrastructure investment such that the marginal benefit of transport cost reductions equals the marginal cost,

$$X_1^B + M_2^B - t_2^{BA} M_2^{B'} = -\frac{1}{\beta \phi_{r^B}(0, r^B)} \quad (11)$$

The non-cooperative investment level can be contrasted with the level undertaken if the two countries behave cooperatively, which would arise if countries are able to write a binding contract that specifies the investment levels of the two countries. Assuming that it is possible to make transfers between countries, the cooperative level would involve choosing r^A and r^B to maximize $W^A + W^B$. This yields the necessary condition for optimal choice of investment

$$X_1^B + M_2^B - t_2^{BA} M_2^{B'} + (t_1^{AB} - t_1^{A*}) X_1^{B'} = - \frac{1}{\beta \phi_{r^A}(r^A, r^B)} = - \frac{1}{\beta \phi_{r^B}(r^A, r^B)} \tag{12}$$

(12) requires that the marginal benefit of transport cost reduction to the union as a whole equal the marginal cost of transport cost reduction in each location.

(11) and (12) can be used to compare the level of cost reduction in the non-cooperative equilibrium investment in the non-cooperative equilibrium with that in the cooperative equilibrium, which is shown in Figure 2. The MB^B curve in Figure 2 is the marginal benefit to **B** of transport cost reductions (the left hand side of (11)) which will be upward sloping for the case of linear demand. The $MC^B(0)$ curve is the marginal cost of reducing v for country **B** when $r^A = 0$. The equilibrium investment level for the non-cooperative case, v^N, is determined by the intersection of the MB^B and $MC^B(0)$ curves, with the second order condition requiring that MC^B be steeper at the intersection. The MB^U curve is the marginal benefit to the union as a whole of transport cost reductions, which will lie below the MB^B locus for $t_1^{AB} < t_1^{A*}$. The MC^U curve is the marginal cost of transport cost reduction for the union when r^A and r^B are chosen to minimize the cost of achieving a given v, which requires $MC^U = -\left[\phi_{r^B}(r^A, r^B)\right]^{-1} = -\left[\phi_{r^A}(r^A, r^B)\right]^{-1}$. It can be shown that a sufficient condition for the MC^U curve to lie below the $MC^B(0)$ curve is that r^A be a "normal" input, in the sense that the cost-minimizing choice of r^A is an increasing function of the overall level of infrastructure investment (i.e. a lower level of v).[11] The level of unit transport costs for the cooperative case, v^U, is determined by the intersection of the MC^U and MB^U curves.

Figure 2 illustrates that both the marginal benefit and the marginal cost of transport cost

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[11] Totally differentiating $-\left[\phi_{r_B}(r^A, r^B)\right]^{-1}$ subject to $dv = \phi_{r^B} dr^B + \phi_{r^A} dr^A = 0$, we obtain the result that $-\left[\phi_{r_B}(r^A, r^B)\right]^{-1}$ is decreasing in r^A iff $\phi_{r^B r^B} \phi_{r^A} - \phi_{r^B r^A} \phi_{r^B} < 0$. It is straightforward to show that this condition is satisfied if the solutions $\{r^A(v, \alpha), r^B(v, \alpha)\}$ to the problem :

$$\min \alpha r^A + r^B \text{ subject to } \phi(r^A, r^B) \geq v$$

$\alpha \in (0, \infty)$, have the property $dr^A/dv < 0$.

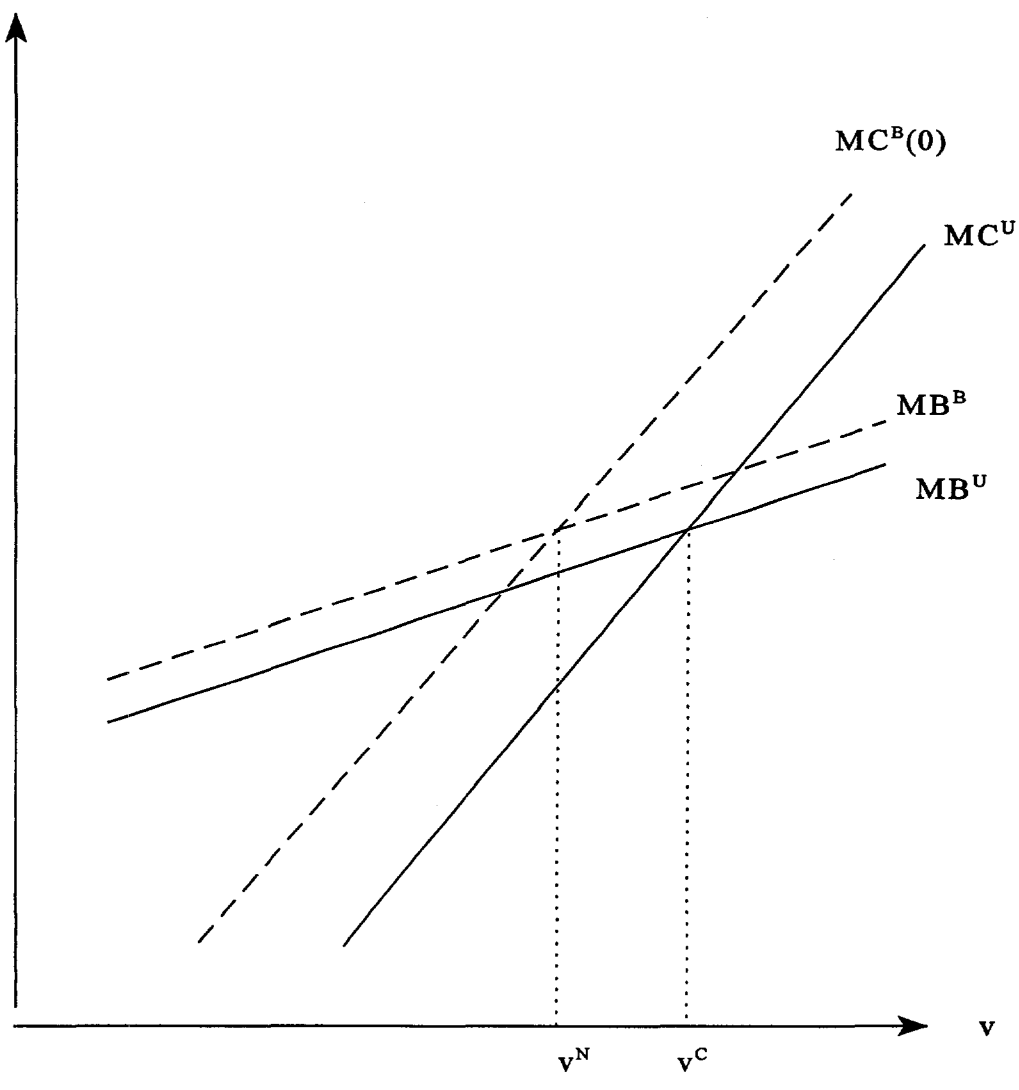

Figure 2 Comparison of Transport Cost levels in the Non-Cooperative Case (v^N) and the Cooperative Case (v^C)

reductions are higher in the non-cooperative case. Two examples can be used to illustrate that v^N may be either greater or less than v^C. First, suppose that investments by **A** and **B** are perfect substitutes, with $v = \phi(r^A + r^B)$. In this case $MC^B(0) = MC^U$ and the investment by **B** in the non-cooperative equilibrium must exceed that in the cooperative equilibrium as long as $t_1^{AB} < t_1^{A*}$. If the investments are perfect complements, on the other hand, then $r^A = r^B = 0$ in the non-cooperative equilibrium. Since **A** does not invest, the marginal cost of reducing v is arbitrarily high in **B** and no investment will take place. In this case, the cooperative equilibrium must lead to higher investment than in the cooperative equilibrium.

Conditions (11) and (12) can also be used to identify the effect of preferential trade liberalization on the benefits of transport cost reduction. For **B**, the effect of a reduction in t_2^{BA} is identical to that for the small country case, which means that $dr^B/dt_2^{BA} = 0$ when demands are linear. However, a reduction in country **A**'s tariff will raise the return to infrastructure investment by country **B**, because it expands the volume of exports of good 1, $\partial^2 W^B/\partial v \partial t_1^{BA} = -X_1^{B\prime} < 0$. Note however that for country **A** we have $\partial^2 W^A/\partial v \partial t_1^{BA} = X_1^{B\prime} + (t_1^{AB} - t_1^{A*})X_1^{B\prime\prime}$. Summing these two terms, it can be seen that there is no effect of trade liberalization on optimal investments for the union as a whole when demand and supply curves are linear.

These results can be summarized as:

Proposition 2: (a) In the non-cooperative equilibrium for infrastructure investments in case I, the country (A) whose internal prices remain constant will make no infrastructure investments. The country whose terms of trade improve (B) earns a higher marginal benefit from infrastructure benefit than for the union as a whole when it has preferential access to the partner's market. The level of unit transport costs in the cooperative equilibrium may be higher or lower than in the non-cooperative equilibrium.

(b) Trade liberalization has no effect on the incentives to invest for the union as a whole when demand/supply curves are linear, but will increase the transport cost investment of B in the non-cooperative equilibrium.

This suggests that when the trade pattern takes this form, there is no reason to tie cooperative agreements on transport costs to trade liberalization agreements.

B. Case II: Customs Union with No Trade with Non-members

We next consider Case II, where the preferential tariff reduction eliminates trade with the foreign country. Note that this is an example of the cases discussed by Wonnacott and Wonnacott (1981) in which a customs union can achieve gains that cannot be obtained from unilateral liberalization, due to the endogeneity of the terms of trade for each country. When two large countries are negotiating tariff reductions, individual countries will not have an incentive to unilaterally reduce their tariffs from the Nash equilibrium level because the benefits of tariff reduction spill over to affect the other country. This creates a prisoner's dilemma, which requires simultaneous trade liberalization by the two countries. In this section we show that a similar prisoner's dilemma will arise with regard to infrastructure investments, because countries fail to internalize the full effects of transport cost reductions on the other country. In this case, the investment levels in the non-cooperative equilibrium will be too low.

Using (7), the prices in country B can be determined by the market-clearing conditions in the respective markets, $M_1^A(p_1^B+t_1^{AB}+v) = X_1^B(p_1^B)$ and $M_2^B(p_2^B) = X_2^A(p_2^B-t_2^{BA}-v)$, where X_1^B (M_2^B) is B's export supply (import demand) function. Differentiating these conditions yields

$$0 > \frac{\partial p_1^B}{\partial t_1^{AB}} = \frac{\partial p_1^B}{\partial v} = \frac{-M_1^{A\prime}}{M_1^{A\prime}-X_1^{B\prime}} > -1$$

$$1 > \frac{\partial p_2^B}{\partial t_2^{BA}} = \frac{\partial p_2^B}{\partial v} = \frac{-X_2^{A\prime}}{M_2^{B\prime}-X_2^{A\prime}} > 0 \qquad (13)$$

The impact on B market prices is greater in absolute value the less elastic are the B demand/supply schedules relative to those of country A.

Since all trade is between A and B in this case, the welfare expressions for the respective countries are

$$\begin{aligned} W^A(t_1^{AB},t_2^{BA},v) &= \int_{p_1^A}^{\infty} M_1^A(u)du + \int_0^{p_2^A} X_2^A(u)du + t_1^{AB}M_1^A(p_1^A) \\ W^B(t_1^{AB},t_2^{BA},v) &= \int_0^{p_1^B} X_1^B(u)du + \int_{p_2^B}^{\infty} M_2^B(u)du + t_2^{BA}M_2^B(p_2^B) \end{aligned} \tag{14}$$

Using (7) and the market clearing prices $p_1^B(t_1^{AB},v)$ and $p_2^B(t_2^{BA},v)$ in (13), we obtain the effect of reductions in transport costs to be welfare to be

$$\begin{aligned} -\frac{\partial W^A}{\partial v} &= M_1^A(p_1^A)\left(1+\frac{\partial p_1^B}{\partial v}\right) + X_2^A(p_2^A)\left(1-\frac{\partial p_2^B}{\partial v}\right) - t_1^{AB}M_1^{A\prime}\left(1+\frac{\partial p_1^B}{\partial v}\right) > 0 \\ -\frac{\partial W^B}{\partial v} &= -X_1^B(p_1^B)\frac{\partial p_1^B}{\partial v} + M_2^B(p_2^B)\frac{\partial p_2^B}{\partial v} - t_2^{BA}M_2^{B\prime}\frac{\partial p_2^B}{\partial v} > 0 \end{aligned} \tag{15}$$

A reduction in transport costs must raise A's welfare, just as it did in the small country case. However, A does not obtain the full benefit of transportation cost investments it undertakes because part of the benefits spill over to B through changes in the terms of trade. A similar spillover is associated with investments by **B**. The gain to **A** (**B**) is smaller (larger) the greater is the impact on **B** prices, $\left|\frac{\partial p_i^B}{\partial v}\right|$.

The necessary condition for optimal choice of infrastructure investment in the non-cooperative case, where each country chooses its level of investment to maximize its national welfare taking the policy of the other country as given, will be

$$\frac{\partial W^i(t_1^{AB},t_2^{BA},\phi(r^A,r^B))}{\partial v} = \frac{1}{\beta\phi_r^i(r^A,r^B)} \qquad i = A,B \tag{16}$$

(16) defines the reaction function for country i, $r^i = \psi^i(r^j, t_1^{AB}, t_2^{BA})$. The Nash equilibrium values for infrastructure investment are the values $\{r^{AN}, r^{BN}\}$ such that (16) is satisfied for both countries.

We can now use (15) and (16) to establish the following result:

Proposition 3: (a) If demands are linear and $\phi_{r^i r^j} < 0$, then infrastructure investments in A and B are strategic complements (i.e. $\partial\psi^i/\partial r^j > 0$).

(b) In the non-cooperative equilibrium in infrastructure investments in Case II, where trade with the rest of the world has been eliminated, the welfare of both countries can be increased by a simultaneous increase in investment levels in both countries.

Proof: (a) The second order condition for choice of r^i requires $(\partial^2 W/\partial v^2)(\phi_{r^i})^2+(\partial W/\partial v)\phi_{r^i r^i}<0$. Therefore, $\partial\psi^i/\partial r^j > 0$ iff $(\partial^2 W/\partial v^2)\phi_{r^i}\phi_{r^j} + (\partial W/\partial v)\phi_{r^i r^j} > 0$. It can be established from (2) that $\partial W/\partial v < 0$ and $\partial^2 W/\partial v^2 > 0$ if the demand supply schedules are linear. Since $\phi_{r^i}, \phi_{r^j}<0$, it follows that $\phi_{r^i r^j} < 0$ is sufficient for HH to be upward sloping.

(b) Let $\hat{W}^i(r^j) = \max_{r^i} \; W^i(t_1^{AB},t_2^{BA},\phi(r^A,r^B)) - r^i$. It follows from (15) and (16) that $\partial\hat{W}^i/\partial r^j = (\partial W^i/\partial v)\phi_{r^j} > 0$. ||

Figure 3 illustrates Proposition 3 for the case where $\phi_{r^A r^B} < 0$. By part a of the Proposition, the reaction functions of each country will be upward sloping in this case, with the locus AA (BB) denoting the reaction function of country A (B). The W_N^i contour represents the welfare level for country i in the Nash equilibrium, which will be horizontal (vertical) at the intersection point for country A (B). Part b of the Proposition reflects the fact that the values of (r^A, r^B) that improve welfare of both countries lie in the lens created by the respective iso-welfare contours of the two countries. This underinvestment result does not depend on the sign of $\phi_{r^A r^B}$, because it will continue to hold when the reaction functions are downward sloping. The results of this case contrast with those in case I, where a general underinvestment result was not available because of the fact that $\partial\hat{W}^A/\partial r^B = (\partial W^A/\partial v)\phi_{r^B} < 0$ by (9). Furthermore, the sign of $\phi_{r^A r^B}$ played a role in determining whether the non-cooperative equilibrium

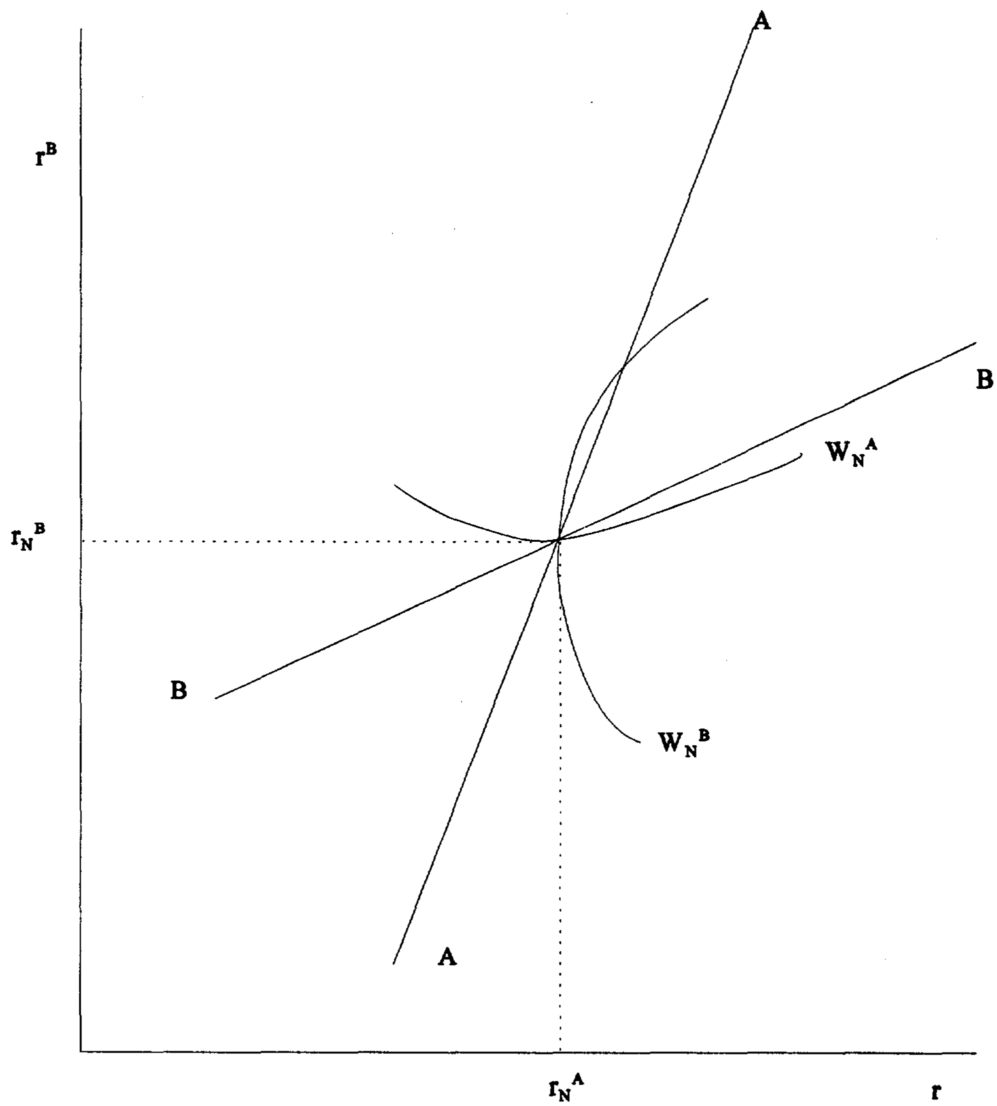

Figure 3: Nash Equilibrium for Infrastructure Investments in Case II

exhibited underinvestment or overinvestment in the examples in case I.

The efficient investment level is the one that maximizes the sum of the welfare levels of the two countries. Using (16), the necessary condition for optimal investment in the cooperative case is

$$M_1^A + X_2^A - t_1^{AB} M_1^{A\prime}\left(\frac{\partial p_1^A}{\partial v}\right) - t_2^{BA} M_2^{B\prime}\left(\frac{\partial p_2^B}{\partial v}\right) = \frac{-1}{\beta\phi_{r^A}(r^A, r^B)} = \frac{-1}{\beta\phi_{r^B}(r^A, r^B)} \tag{17}$$

The cooperative investment levels will internalize the effects of each country's investment on the other's welfare level.

These results can be used to obtain the relationship between trade liberalization and the returns to infrastructure in each country. We will establish the following result for the large country case:

Proposition 4: If import demand and export supply curves are linear, then

(a) the benefit of infrastructure investment is increasing in the country's own tariff, $-\dfrac{\partial^2 W^A}{\partial v \partial t_1^{AB}}$, $-\dfrac{\partial^2 W^B}{\partial v \partial t_2^{BA}} > 0$, *and decreasing in the other country's tariff,* $-\dfrac{\partial^2 W^A}{\partial v \partial t_2^{BA}} < 0$, $-\dfrac{\partial^2 W^B}{\partial v \partial t_1^{AB}} < 0$.

(b) the optimal infrastructure investment for the union as a whole is independent of either country's tariff.

Proof: To establish (a), we differentiate (15) to obtain

$$-\frac{\partial^2 W^A}{\partial v \partial t_1^{AB}} = M_1^{A\prime}\frac{\partial p_1^A}{\partial v}\frac{\partial p_1^B}{\partial t_1^{AB}} - \left(\frac{\partial p_1^A}{\partial v}\right)^2 M_1^{A\prime\prime} + M_1^A\frac{\partial^2 p_1^B}{\partial v \partial t_1^{AB}} - t_1^{AB} M_1^{A\prime}\frac{\partial^2 p_1^A}{\partial v \partial t_1^{AB}}$$

$$\frac{\partial^2 W^B}{\partial v \partial t_1^{AB}} = -X_1^{B\prime}\frac{\partial p_1^B}{\partial v}\frac{\partial p_1^B}{\partial t_1^{AB}} - X_1^B\left(\frac{\partial^2 p_1^B}{\partial v \partial t_1^{AB}}\right) \tag{18}$$

In the case where demand/supply curves are linear, $\partial^2 p_1^B/\partial v \partial t_1^{AB} = \partial^2 p_1^A/\partial v \partial t_1^{AB} = 0$ by (13) and only the first term in each expression will be non-zero. Since $\partial p_1^A/\partial v < 0$ and $\partial p_1^B/\partial t_1^{AB} = \partial p_1^B/\partial v > 0$, we obtain $-\partial^2 W^A/\partial v \partial t_1^{AB} > 0$ and $-\partial^2 W^B/\partial v \partial t_1^{AB} < 0$ for the linear case. A similar argument for changes in t_2^{BA} establishes part a of the Proposition. To establish b, note that we can use (13) to show that $M_1^{A\prime}\left(\partial p_1^A/\partial v\right) = M_1^{A\prime}\left(1 - (\partial p_1^B/\partial v)\right) = X_1^{B\prime}\left(\partial p_1^B/\partial v\right)$. It then follows that $-\partial^2 W^A/\partial v \partial t_1^{AB} + -\partial^2 W^B/\partial v \partial t_1^{AB} = 0$.‖

In the small country case, the impact of a tariff on the volume of trade exactly offsets the impact of the tariff on the distortion on imports when demands are linear. Proposition 4 shows that a similar result holds for the large country case, in that the sum of trade volume effects across the two countries equals the impact on the tariff distortion when the tariff is increased. This results in no impact of a tariff change on the incentive to invest in infrastructure at the union level.[12] However, the fact that the trade volume effect is shared between the two countries due to changes in the terms of trade means that the tariff will alter the incentive of the individual countries to invest in infrastructure.

It should be noted that this conclusion will not necessarily hold when countries are adopting a criterion that is other than one of maximizing national welfare. Suppose that the level of infrastructure investment is being chosen to minimize the cost of transportation expenditures, $\beta\phi(r^A, r^B)(M_1^A + M_1^B) + r^A + r^B$, given the level of trade. The necessary condition for optimal infrastructure investment in this case would be

$$M_1^A(p_1^A) + M_2^B(p_2^B) = \frac{-1}{\beta\phi_{r^A}(r^A, r^B)} = \frac{-1}{\beta\phi_{r^B}(r^A, r^B)} \tag{19}$$

[12]Note that an additional implication of the result that $-\partial^2 W^A/\partial v \partial t_1^{AB} + -\partial^2 W^B/\partial v \partial t_1^{AB} = 0$ is that the benefit of tariff reduction is independent of the level of transportation cost. Thus, trade agreements with nearby countries are not more attractive than agreements with distant countries when demand is linear in this model.

Note that this necessary condition would arise if trade restrictions are in the form of country-specific quotas, as in (5) for the small open economy case, or if effects on tariff revenues are being ignored. Since the volume of trade increases when trade is liberalized, trade liberalization will result in an increase in the returns to infrastructure investment and typically to a reduction in unit transport cost in the cooperative equilibrium.

IV. Tying Together Infrastructure Agreements and Preferential Trading Arrangements

The analysis so far has concentrated on optimal choice of infrastructure, under either a cooperative or non-cooperative choice of investments by the two countries, treating the tariff as exogenously chosen. We conclude by discussing the implications of these results for an environment in which countries have the option of negotiating both tariff rate reductions and infrastructure investments as part of their preferential trade arrangement. We will analyze two cases: one in which countries simultaneously choose infrastructure levels and tariff rates, and one in which infrastructure investments are made in the first period and tariff rates are chosen in the second period. The second case is intended to capture the notion that once transport cost investments have been sunk, they may influence subsequent trade negotiations between the countries.

We begin with the case in which the countries can write a contract in the first period that commits them to infrastructure investments and second period tariff rates. If we assume that lump sum transfers are possible between countries, then the values $\{t_1^{AB},t_2^{BA},r^A,r^B\}$ will be chosen to maximize the sum of payoffs to the union as a whole. The countries will then bargain over lump sum transfers that determine the split of the union payoff between the two countries. The sum of payoffs to the union as a whole is denoted $V^U(t_1^{AB},t_2^{BA},t_1^{A*},r^A,r^B)=\sum_{i=A,B}\beta W^i(t_1^{AB},t_2^{BA},t_1^{A*},\phi(r^A,r^B))-r^i$. The efficient trade and infrastructure agreement is defined to be the one that maximizes union welfare,

$$\left\{\hat{t}_1^{AB},\hat{t}_2^{BA},\hat{r}^A,\hat{r}^B\right\} = \text{argmax } V^U(t_1^{AB},t_2^{BA},t_1^{A*},r^A,r^B) \qquad \textbf{(20)}$$

First consider the case I, where **A**'s domestic prices are equal to those of the rest of the world. By summing the benefits of countries **A** and **B** from (9) and (10), it can be seen that the optimal policy is $\hat{t}_1^{AB} = t_1^{A*}$ and $\hat{t}_2^{BA} = 0$. Greater benefits (for the union as a whole) can be achieved by a unilateral cut in **B**'s external tariff than by a customs union, because the preferential reduction by **A** leads to an inefficient diversion of trade from the rest of the world. Welfare can be increased further if **A** unilaterally reduces its external tariff so that $t_1^{A*} = 0$. In case II we have a situation with two large countries, so the negotiated tariff reduction that maximizes the sum of their welfare is $\hat{t}_1^{AB} = \hat{t}_2^{BA} = 0$. The values of optimal infrastructure investments for case I [II] is then given by (12) [(17)] evaluated at the optimal tariffs.

Note that in either case, the efficient trade agreement between the two countries is independent of the level of transport costs between the two countries. Thus, the level of tariffs that is chosen by the simultaneous negotiation over tariffs and infrastructure is the same as the one that would be obtained when only tariffs are being negotiated. Similarly, Propositions 2b and 4b established that in the case where demand curves are linear, the infrastructure investment levels obtained in a cooperative agreement will be independent of the level of tariff rates negotiated between the two countries. Combining these results yields an independence between efficient trade agreements and infrastructure agreements in the linear case, since the value chosen in either efficient agreement for the union would be independent of the levels chosen in the other agreement. In particular, there would be no incentive for a country to sign a trade agreement that is inefficient (e.g. an agreement that gives **B** preferential access to **A**'s market in case I) with a cooperative infrastructure agreement, because there are no spillovers of the trade agreement to the infrastructure agreement.

It should be noted however that the fact that the efficient trade agreements are independent of the level of infrastructure investments is not sufficient to guarantee that independent negotiations for infrastructure and tariffs will reach the same solution as joint negotiations. If negotiations are constructed sequentially, then it is possible that countries will use their first round negotiations to influence their bargaining position in the future round. For example, consider the case in which countries choose infrastructure investments in period 1, and then negotiate tariff rates in period 2. This problem would arise if countries cannot commit to future tariff rates, so that any tariffs in period 1 would be renegotiated in period 2.[13] Assume that lump sum transfers between the countries are possible and that the negotiation process can be modeled using the generalized Nash bargaining solution. The negotiated tariff rates and the lump sum transfer paid by country A to country B, T^{AB}, will be the solutions to the problem

$$\max_{T^{AB},t_1^{AB},t_2^{AB}} \left(W^A(t_1^{AB},t_2^{BA},v) - T^{AB} - \tilde{W}^A(v)\right)^{\alpha}\left(W^B(t_1^{AB},t_2^{BA},v) + T^{AB} - \tilde{W}^B(v)\right)^{1-\alpha} \tag{21}$$

where $\alpha \in (0,1)$ reflects the relative bargaining power of country A and $\tilde{W}^i(v)$ is the threat point of country i. The threat point could be chosen to be the payoff in the "tariff war"(i.e. non-cooperative Nash equilibrium) between the two countries, or it could be payoffs obtained under an existing trade agreement. The essential point for the argument here is that for either of these examples, the payoff in the absence of the trade agreement will be affected by the infrastructure investment of country i. Solving the necessary conditions for (21) yields:

$$\begin{gathered} t_1^{AB} = \hat{t}_1^{AB} \qquad t_2^{BA} = \hat{t}_2^{BA} \\ T^{AB}(v) = (1-\alpha)(W^A(\hat{t}_1^{AB},\hat{t}_2^{BA},v) - \tilde{W}^A(v)) - \alpha(W^B(\hat{t}_1^{AB},\hat{t}_2^{BA},v) - \tilde{W}^B(v)) \end{gathered} \tag{22}$$

The use of the Nash bargaining solution with lump sum transfers ensures that the tariff rates will maximize the sum member country welfare, $W^A + W^B$, so that the tariff rates chosen will be the efficient ones defined in (20). The transfer paid by country A is a decreasing function of its threat point and an increasing function of B's threat point.

[13] This sequence of negotiations is the natural one because of the sunk nature of infrastructure investments. Once made, these investments are likely to be irreversible. In contrast, tariff rates can be changed at relatively low cost.

The present value payoff to country **A** in period 1, given tariff negotiations in period 2 characterized by (21), will be $V^A(\hat{t}_1^{AB},\hat{t}_2^{BA},r^A,r^B) - \beta T^{AB}(\phi(r^A,r^B))$. The benefit to country **A** of infrastructure investment will thus be $\frac{\partial V^A}{\partial r^A} - \beta\frac{\partial T^{AB}}{\partial v}\phi_{r^A}$. The first term is the net benefit from infrastructure investment at given tariffs as analyzed in the previous section. The second term is the impact of the investment on the second period negotiation process. The tariff negotiation process will raise the benefits of infrastructure investment to country **A** iff $\frac{\partial T^{AB}}{\partial v} > 0$. Utilizing (22), this is more likely to occur the greater the benefits of reduction in v at the threat point relative to the agreement for country **A** (i.e. larger values of $-\frac{\partial(\tilde{W}^A - W^A)}{\partial v}$), and the greater the benefits of reduction in v at the agreement relative to the threat point for **B** (larger values of $-\frac{\partial(W^B - \tilde{W}^B)}{\partial v}$). In the case considered by McLaren (1997) where the tariff war is the threat point, there is a presumption that a small country will be harmed in tariff negotiations by infrastructure investment. We can capture this case in the present model (Case II of the previous section) by letting $M_2^{B'} \to -\infty$ and $X_1^{B'} \to \infty$, which yields $\frac{\partial p_i^B}{\partial v} = 0$ for i = 1, 2. All of the gains from infrastructure accrue to the small country under the agreement (i.e. $\frac{\partial W^B}{\partial v} = 0$ from (15)), but the small country will not capture all of the gains from transport cost reductions in the tariff war because the large country's tariff is decreasing in v. It can be shown that increases in the r^A will raise T^{AB} when **A** is a small country, so that **A** will underinvest in infrastructure relative to the results obtained in (3). [14]

The present value payoff to country **B** in period 1 is $V^B(\hat{t}_1^{AB},\hat{t}_2^{BA},r^A,r^B) + \beta T^{AB}(\phi(r^A,r^B))$. Since the only effect of the infrastructure investment on the tariff negotiation process occurs through

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[14]Using (14), it can be shown that the optimal tariff for country i is $\dot{t} = M^i(p^j)/X^{j'}$, which yields $t^A = 0$ and $t^B > 0$ when **A** is small. Differentiating with respect to v in the linear case and using (13) yields $dt^i/dv = M^{i'}/(X^{j'}-2M^{i'})$ and $dt^B/dv = -\frac{1}{2}$. This result can be used to show that $-\frac{\partial(\tilde{W}^A - W^A)}{\partial v}) > 0$ and $-\frac{\partial(W^B - \tilde{W}^B)}{\partial v}) = 0$, so that $\frac{\partial T^{AB}}{\partial v} > 0$.

changes in the transfer, the tariff negotiation process raises the benefits of infrastructure to **B** iff it reduces the benefits of infrastructure to **A** (i.e. $\frac{\partial T^{AB}}{\partial v} < 0$). This yields the conclusion that in the case where infrastructure levels are chosen non-cooperatively, the tariff negotiation process will create an incentive for the two countries to alter their investment levels in order to influence the period 2 tariff negotiations. Note however that if the negotiation process creates an incentive to increase its investment, it will also create an incentive for the other country to reduce its incentive.

The strategic use of infrastructure investments to influence tariff negotiations by the two countries can be eliminated if the countries choose to negotiate an infrastructure agreement in period 1. If **A** and **B** negotiate the level of infrastructure investment at time 1 and can make lump sum transfers between the countries, then the resulting negotiation process will maximize the sum of payoffs to the two countries, $V^{U}(\hat{t}_1^{AB}, \hat{t}_2^{BA}, r^{A}, r^{B})$. Comparing with (20) for the case of simultaneous tariff and infrastructure negotiations, it can be seen that the outcome with sequential negotiations be $\{\hat{r}^{A}, \hat{r}^{B}\}$, which is the same as in the simulatneous negotiations. The existence of negotiations in period 1 allows firms to internalize the effects of investments on the future negotiation process and to obtain efficient investment levels.

V. Conclusions

This paper has shown that the linkage between infrastructure investments and trade liberalization depends critically on the degree of terms of trade spillovers between countries. The prediction generated by this model is that in the absence of cooperative agreements between countries, there will be under investment in those forms of transportation in which the investments have spillover effects to other countries. This would suggest, for example, that for a relatively small country there should be under investment in railroad and highway infrastructure to neighboring countries relative to airport and harbor infrastructure. The former types of investments are specific to certain markets, and are likely to have an impact on the relative prices of the goods in those markets. The latter type of investment, on the other hand, will send goods to world markets generally, whose prices are likely to be relatively unaffected by the investments. Two forms of gains from infrastructure agreements have also been identified. The first is the role of these agreements in internalizing the terms of trade effects and thus avoiding the inefficient investment levels that arise in non-cooperative choice of investment levels. The second is to internalize the effects of the infrastructure investment on the tariff negotiation process in cases where countries cannot commit to future tariff rates.

The infrastructure investments analyzed in this paper can be compared with other work which has analyzed the role of coordination of public goods investments within a customs union. The key feature of the transportation infrastructure investments analyzed in this paper is that the benefits of these investments is related to the volume of trade between the two countries. The results of this paper might then be applied to other types of public goods investments whose benefits are tied to trade with a particular country. For example, harmonization of standards or market rules that reduce the cost of selling goods in a particular trading partner's market would yield similar results.

The infrastructure investments analyzed in this paper contrast with public goods analyzed by Clarida and Findlay (1994) and Chiu (1997), who consider the case in which public goods investment raise the productivity of all resources within a country. Clarida and Findlay (1994) obtain an underinvestment result when public goods investments in one country raise productivity of resources in the other country, and analyze how capital mobility within the customs union may create a public investment boom. The underinvestment result does not necessarily arise in the case of transport infrastructure investments because the spillovers between countries depend on the pattern of trade. Chiu (1997) considers the possibility that public goods investments also affect non-member countries, and examines the incentives to form trading blocs which coordinate investment levels when non-member countries can free ride on union public goods investments. The analysis in the current paper has abstracted from spillover effects of infrastructure investments on the rest of the world. The approach taken in this paper would suggest that the spillovers to outside countries would differ depending on whether investments are general transport investments that reduce costs with all trading partners or investments that are tied to costs of trading with a particular partner.

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