Incorporating Transportation Costs into International Trade Models: Theory and Application

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Is transportation a relevant variable? That's probably not a relevant question for this audience, but certainly if you've taken a number of theory courses, like I have, you'll recall that transportation didn't come up very often. I recall in one of my early courses as an undergraduate, the professor, as usual, assumed zero transportation cost. A student asked how could that be true and what was meant by that. The professor replied that he meant exactly what he said, transportation costs are assumed to be zero. The student got up and walked out of the classroom and was never heard from again. We can sometimes get away by assuming transportation costs do not exist, but it depends on the context in which we make the assumption. Although I've spent a lot of time on transportation data for modeling purposes, because I think it's important, if I were to go back to the classroom and teach trade, I don't think I would dwell too much on transportation costs. It's not necessary when trying to teach the essence of comparative advantage in trade. In fact, it can unnecessarily complicate things. In the classroom, we can teach a lot of good trade theory without real world complications regarding international transactions cost. Of course transportation is important; that's why we are here today. The problem is that some teachers assume too often students will recognize why it's not important in some circumstances but important in others.

Various trade models are used to explain or predict trade. When it comes to applied trade models, transportation can be an important variable. But I would say that just taking into account transportation costs in a model will not necessarily enable us to better predict evolving trade patterns. I'm not completely convinced that transport costs add much in explaining overall trade pattern changes, which can be very complex. But where I think the transportation variable is important is in policy simulation models, and that's how we use a lot of our trade models in ERS. This year we have a large modeling project working on upcoming WTO issues. For these models, we take trade as a given without having to explain why it occurs. We then simulate outcomes by changing policy variables, such as tariffs or other policy variables. Now, if we introduce the transportation variable, we can get different outcomes than if it were excluded. Transport costs affect how prices are transmitted between countries. So the transportation variable, I think, is important in that type of application.

This afternoon Zhi Wang and I are giving a briefing at the International Trade Commission. Not all of their staff are trained as economists, and they ask different questions than might be asked in a university seminar. They're going to be grilling us on the model for a project we are working on for the Commission. If we're asked about transportation costs we can look them in the eye and say, "Yes, we've taken into account transportation costs in this model." For some this is important and makes a model more realistic. Having realistic assumptions and detailed data raises the confidence level for people who are the end consumers of model results. Sometimes what comes across as an unimportant detail to modelers is of great importance to someone else.

Let's start by defining how we measure transportation costs. For any transaction involving transport cost, there's obviously a quantity or physical unit of trade. Then we have an exporter's price valued at fob prices, and an importer's price valued at cif prices. The difference between the two prices is the unit transport cost. Another measure of transportation costs is the transportation margin. A transport margin is the share of transport cost in the total cost of the good. So the two cost measures do not measure the same thing. The change in the margin across time can be confusing because if the cost of the good falls relative to the unit transport cost, the margin increases even while the transportation cost falls. We can observe changes in the margin over time but they do not directly reflect transport cost changes.

Next I'll try to walk you through some theory as painlessly as possible. In a spatial equilibrium model, we can represent two regions and clearly see that there's a higher price in region B than in A (figure 1). In the diagram, we see that the excess supply from region A and the excess demand from region B determine an equilibrium price and quantity in the world market. So, if there are transportation costs, clearly there's going to be less trade. Transportation costs act like a tariff.

Now that we see how transport cost fits into the world market, I'm going to derive the demand for shipping services. If you're good with geometry, you can see graphically that there's a relationship between transport costs and the quantity shipped in the world market. If the shipper or carrier decides to raise the transportation costs above a certain level, they can at some point choke off world trade. If they want to provide a free service, then trade expands out to the maximum equilibrium level of trade, the intersection of the excess supply and excess demand curve. The derived demand for services relates volume of traded goods with the price of the shipping service. It is an inverse relationship like all demand curves (fig. 2).

We can now link the derived demand for shipping services with the market for shipping services. Now to illustrate some things we've been talking about in the workshop, like technological change, I want to perform some experiments using this framework. A technological change in the shipping services industry is represented by a shift to the right in the supply curve for services (fig. 3). In other words, a higher level of services is supplied at the same unit cost. How might that occur? Well just as Bill Hall was describing, you now have faster turnaround times in ports. This is what I was thinking when he was talking about that. Lower rates and higher volumes of trade are the result. We see here this will increase world trade, decrease cif prices and increase fob prices. Unit transport costs fall and the margin falls. As shown here, if the fob price increases but the transport costs fall, then unequivocally we can say that the transportation margin falls.

We can do another experiment. Let's say if we liberalize trade, the excess demand curve shifts to the right as consumers in the protected region increase the quantity demanded, but at the same time, the demand for services increases, which then bids up unit transport costs (figure 4). Both unit transportation costs and fob prices increase. In that case, the change in the margin is ambiguous. The change in the margin depends on the supply response of services. We don't really know very much about the supply of services. We can't estimate it very easily. Perhaps if we had some detailed data we might be able to do so. In the model, a simple assumption is just to use a fixed margin. That's what has been done in the model I'm currently working with.

Madeleine is going to talk about a single-commodity model, and I'm going to talk about the transport services in an economy-wide CGE (Computable General Equilibrium) model. In the single-commodity model, unit transport costs are determined outside the model. In the CGE model, there is a price in the model representing transportation services.

The model I'm referring to here is known as GTAP, which stands for Global Trade Analysis Project. It's a project that I became actively involved with at Purdue University and that is now being used throughout the world for performing trade policy simulations and other applications.

In this model, we have a shipping industry where there's both a supply and demand for shipping services and what is assumed is that goods and transport services are in fixed proportion when trade occurs. You have to have a fixed quantity of services for each unit of traded goods. We can see from the equation that if there's a zero transport margin, a given percentage change in the cif price will give you exactly the same percentage change in the fob price. The higher the margin, the less of a percent change in the cif-fob price differential. This is why the relative size of the margin is important in a simulation.

Transport margins in the model vary by partner and by sector. So next we'll look at some estimates of margins. There's no complete source for global transport margins. Some of them have to be estimated. One thing I've taken into account is a problem associated with aggregation bias that I avoid by using very detailed margin data before aggregating to the sector level.

You might think the margins would increase with greater distances. Well, here are some margins from the GTAP model for an aggregate sector (table 1). The transportation margin for shipping from Mexico to the United States is higher than the margin for shipping from India to the United States. For this particular aggregate--fruits, vegetables, and nuts--the shipping margin is very low. The reason for this can only be understood after examining the detailed data and noting what the United States is actually importing from India. The trade consists primarily of cashew nuts, which have less than a 4 percent transportation margin, whereas fresh fruit has a margin of closer to 25 percent. When I was doing some econometric work, I would get frustrated working with aggregate data because many times the margins are not positively related to distance. It is common to find low margins on long-distance routes because of compositional shifts in the trade. It becomes prohibitively expensive to ship certain fresh products long distances. Having detailed data is important in this area of work.

If we look at U.S. trade with the same partners shipping to and from the United States, you'll notice that the margins are different. Margins for imports from Central America are higher than for exports to these countries. The distance is exactly the same and possibly the same ports are being used, so why are the margins different? Again, the answer lies in the type of product being shipped. Exports to these countries consist primarily of dried goods such as beans and legumes, whereas imports are fresh products requiring high per unit transport costs.

This next figure (table 2), which shows trade in fresh tomatoes, gives you an idea how unit costs and transportation margins vary. Comparing Mexico with Canada, we see that there is a higher margin for Mexican imports. But it's partly because higher-priced tomatoes are being imported from Canada not because it costs more to ship to Canada than Mexico. So, there's not always a positive correlation between the high unit transport cost and the transport margin for the same product. This illustrates the importance of the unit cost of goods and how it varies by trading partner.

Something now being explored for this model is incorporating different types of shipping services. The market for transportation is becoming more fragmented by type of service. Basically there are three modes of transportation--ocean, ground, and air. The next figure (figure 5) shows the share of fresh fruits and vegetables shipped by air. Tomatoes are coming by air from the Netherlands and this share is rising. A greater share of fresh stone fruits are flown from Chile. So, we are seeing growth in air shipments for fresh produce.

So far, we have examined transportation margins in the model. In the next experiment, I ask what the impact is if these margins were reduced as a result of technical change in the shipping industry. In this case specifically, I'm asking what would happen if we had a 20 percent reduction in all transport margins. It turns out that this would have an effect nearly equivalent to complete trade liberalization in world trade. In other words, reducing barriers to trade would provide welfare gains of the same magnitude as reducing transport costs by 20 percent. The question came up yesterday, "How should we allocate our resources: to reducing transportation costs or to reducing levels of protection?" Well, if you can get a 20 percent reduction in transport costs, it is equivalent to complete worldwide trade liberalization and U.S. households would be better off by about $9 billion (tables 3 and 4). However, I'm not sure if anyone knows exactly how we might achieve this kind of transport cost reduction. We know how to support and negotiate trade agreements, but as economists we are less sure about how to achieve a 20 percent reduction in transportation margins. This is at least one way to put trade barriers, which include transport costs, into broader perspective.

It turns out that because U.S. food imports have a higher margin than exports, imports would grow more than exports from a reduction in transport costs. The margins are actually higher for U.S. imports than U.S. exports. The reverse is true, by removing tariff barriers, food exports would increase more than imports since the United States is a relatively more open market than the rest of the world.

In summary, both producer and consumer welfare need to be considered when it comes to the problem of transportation costs. U.S. consumers stand to gain from cost reducing technologies. Cost reduction is not important solely for the benefit of exporters.