Time and Trade: The Role of Time in Determining the Structure and Effects of International Trade, with an Application to Japan

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ABSTRACT

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This paper explores the importance of time in international trade. The framework for the discussion is a model in which products "depreciate" over time, perhaps because the characteristics of goods that consumers desire change randomly over time. On the supply side, production and trade also take time, but producers can choose to produce and trade faster at higher cost. Faster production is also assumed to be more intensive in the use of physical and/or human capital. Together, these assumptions have several implications about which countries will have comparative advantage in which goods, and also about how distances between countries interact with comparative advantage and the speed of trade. The paper includes observations about the roles of infrastructure and government regulations in influencing the time costs of trade, and it concludes with speculation about how Japanese producers have managed to deal with time in their trade.

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I. Introduction

It was Japanese exporters who taught us something about the increasing importance of time in international trade. Supplying the United States market from a distance and seeking to be competitive in a range of high-end, heavy products such as automobiles, they had no choice but to master the logistics of getting their products to market in a timely fashion. And master it they certainly did, pioneering innovations in production, transportation, and marketing that became the pattern for world industry. The lesson was that just as important as what you produce is *when* you produce it, or more specifically when you are able to deliver it to market or to the next stage of production. Managing time is now an essential part of productive activity. It may also be an essential part of understanding international trade, which is what this paper seeks to explore.

That is, I will examine how time may matter for trade. As always in trade theory, I will simplify this topic considerably, ignoring for example all of the ways that time enters economic processes through the need to coordinate different activities – issues of

[*] I owe an obvious debt to David Hummels whose work (in Hummels (2000) and whose comments prior to that work alerted me to the potential importance of time in international trade. I also thank my discussants at the Tokyo conference, K.C. Fung and Masahiro Kawai, as well as other conference participants.

timing rather than time, if you like – and focus instead on what to me is the simplest aspect of time in economics: speed. Why is speed important in both production and trade? And what does it take for an economy to become adept at producing and delivering products speedily to other markets? In a world where speed is increasingly important, who stands to gain and who to lose from this change? What role does and should government play in speeding up or slowing down production and trade? These are some of the questions that I will touch on in this paper.

I will do this very informally. My purpose here is not to provide a formal economic model of the role of time in trade, although I will sketch what such a model might look like and draw upon it to speculate on what it might be able to tell us. Nor is my purpose to document the facts of how time has in fact mattered in international trade. My closest brush with reality is the first paragraph above, and I will do no better than that below, in bringing in detail from the real world. Rather, my purpose is to explore in intuitive terms how time might matter, largely as a guide to myself and others who might want to examine this topic further in the future. But I also hope that these thoughts may be suggestive for those who must deal with the real world without waiting for economists like myself to provide formal analysis. It seems to me that there are some rather simple lessons that emerge from thinking about time and trade, and these lessons can be useful immediately.

In section II, I will discuss why it is that time seems to matter more today than it used to. There are several reasons for this, each of which suggests its own complicated formulation of how time should enter into an economic model. But I suggest that a simple starting point for moving ahead with conceptualizing time in production and trade is just to assume that some goods depreciate rather rapidly over time, in both their market value and their usefulness. I will sketch a very simple formal model that would lead to this formulation.

If goods lose value quickly over time, then those who produce these goods must also move quickly, in both producing them and in delivering them to their users. How they are to do this is their problem, not mine, but how they solve that problem may matter for the economies in which they operate, and for trade. In sections III and IV I will examine some possibilities here, leading to theoretical predictions about how patterns of production and trade may arise in a world where time is increasingly important.

Based loosely on the conceptual framework laid out in sections II through IV, I will move in section V to consider several specific issues that may arise when time depends on the institutions and policies of an economy. I conclude in section VI with a brief discussion of how these issues have been handled by Japan, and what they may imply for the future of the Japanese economy and Japanese trade.

II. Why Time Matters, and How

To some extent, time matters more today than it used to, simply because it can. Changes in technology have increased the speed of transportation and communication so much that we no longer need to wait for many things to happen. Therefore we have also learned to be impatient with delays that in previous times were inevitable and therefore acceptable. I suppose that human beings have always "wanted it now," but the difference is that today we can get it now, and before we could not.

But immediate gratification is not the whole story here, for our needs as consumers could be (and are) satisfied more quickly without necessarily requiring that the whole productive process move more quickly. As long as our needs can be anticipated in the aggregate, production of the goods to fill those needs can take place at a leisurely pace and the goods placed on conveniently located shelves for us to choose from when the need arises. In fact, that is very much the way that many of our needs are served in today's economy. Huge stores maintain large and diverse inventories, which we can access either in person or electronically to get exactly what we want with a minimum of delay.

But catering to our needs through inventories is expensive, in two ways. Most obviously, goods in inventory are costly to acquire and costly store, draining businesses of substantial amounts of money in interest, storage, insurance, security, etc. Less obviously – but quantitatively more important in some industries, as I understand it – are costs that stem from changing market conditions. Over time and with surprising speed, consumers change what they want, and so, therefore, do the producers who seek to serve them. Goods that might have been just what they wanted one day become unwanted – or at least less than ideal – the next. Those who hold them in inventories lose not just the cost of holding them, but the value of the goods themselves. Excess inventories are necessary so as not to disappoint a customer who wants a product when it is in demand, but the cost of unsold inventories can be very large if they must later be sold for scrap.

This seems to be the main basis for "just in time" production, wherever along the production chain it occurs. If you can wait until the demand for a good appears and then produce it instantly to order, your customer gets what they want and you do not run the risk of producing something that you will never sell. It is this that makes the speed of production and trade important, with implications that I will discuss in the next section.

Here, however, let me dwell further on how we might best conceptualize this need for speed. An explicit model of inventory control in a dynamic and stochastic world is probably what is needed, but I have neither the stomach nor the brain for such a model in this paper. My suggestion is therefore much simpler: depreciation. That is, let us assume that goods depreciate over time, becoming worth less the longer the time that elapses after their production. What something is "worth" is of course up to the market, so to simplify even further, I would assume that it is the actual quantity of a good that declines. It may strain credulity to think of a refrigerator, say, as shrinking from one refrigerator down to 0.9 refrigerators over some period of time, and then to 0.8 some time later, and so forth. But in terms of the services that a good provides, this might not be a bad representation. In any case this makes the valuation of the depreciated good simple and unambiguous: it is worth the same as a newer version of the good, just multiplied by the appropriate fraction. And this simple formulation easily provides the incentive for producers and traders to move fast: The longer they wait, the less they will get for what they have to sell.

In practice I have in mind using this product depreciation as shorthand for all sorts of more complicated processes that may make delay costly. But just to be sure that there is at least one story that could underpin this formulation, let me imagine a simple model of consumer behavior that serves the purpose.

Suppose that goods possess a long list of characteristics, each of which can take on many distinct values that producers could build into the goods if they knew what was needed. Consumers have in mind an ideal value for each of these characteristics, and goods enter their utility functions with each unit of the good multiplied by the fraction of these characteristics that have their ideal values in that unit. Therefore, for example, if a refrigerator is associated with 100 characteristics (color, door placement, energy use, etc.), and if a particular refrigerator has a consumer's ideal values for 90 of these characteristics, then that consumer will get the same utility from this machine as from a 0.9 share of one refrigerator that has all of the characteristics exactly right.

Next, suppose that consumers exogenously change these lists of ideal characteristics randomly and unpredictably over time. In each period of time, they replace some fraction of their ideal characteristics with new ones that they choose at random from the sets of possible values. I will not try to explain why this happens, in part because I do not begin to understand it in the world itself, and in part because the importance of this process is its unpredictability. For it means that producers must build characteristics into products knowing that some of these characteristics – but they don't know which – will at some point in time become obsolete.

Of course, some of these changes in ideal characteristics do make good sense in response to market changes that we observe, and these changes in characteristics would therefore be predictable if those market changes were themselves predictable. The desire for energy-saving characteristics, for example, is obviously related to the ups and downs of oil prices. But other characteristics, such as the particular colors and shapes that are fashionable, really do seem to me to be random and without any rationale at all.

In reality, most goods are not consumer goods, and this conception may seem therefore not to apply to intermediate goods. In many cases, this is probably true, especially at early stages in the production process where inputs have little in the way of their own characteristics to provide. More realistically, changes in fashion among consumers are more likely to change the quantities of various inputs that are needed than the characteristics of those inputs, something that this formulation does not deal with quite correctly. But the uncertainty about what is to be needed really does carry over into input markets in that sense, and for some inputs it will take exactly this form of produced characteristics becoming obsolete.

Another drawback of this model is that it treats ideal characteristics as being satisfied or not, all or nothing, instead of being more or less closely approximated by characteristics that are similar but not the same. The latter would be more realistic, but it surely would not change the sense of the model.

What all of this leads me to, then, is a simple modification in any economic model of trade that you might choose, assuming that goods each have their own specific rate at which they depreciate. This depreciation takes place at a constant percentage rate per unit time, and it takes the form of the quantity of the good continuously diminishing. Different goods have different rates of depreciation, depending perhaps on the importance of fashion and fad for their consumption. One question of interest will be which countries are likely to have a comparative advantage in supplying these high-depreciation goods, and do they gain from supplying them any more than producers of more conventional products.

When does this depreciation begin? The more conventional depreciation that we expect of capital goods is a result of use, and it begins only when the good has been produced, sold, and has begun to be used. But this product depreciation has nothing to do with use, and it will instead start earlier, whenever the characteristics of the good are locked into place. Realistically that does not happen at a single moment in time for all characteristics, some being added at final stages of production (painting the finish), others at the design stage well before production (shape). For simplicity I would assume that product depreciation begins when the production of a unit commences. This can be important if production takes a long time, since it means that by the time production of a unit is completed, it will already be worth less than one unit to consumers.

I will assume, then, that product depreciation does occur, for some goods more rapidly than for others, and that for some goods this depreciation is fast enough to matter. This may seem implausible to some readers, as I think it would have to me not long ago. In support, let me cite a preliminary result of Hummels (2000), who has used data on the costs of different forms of shipping in international trade to try to get a handle on how important these trade costs can be. One fact that he reports is immediately suggestive: transport by air is about seven times the cost of transport by ship, and yet air is nonetheless used for a great deal of international trade. Speed must evidently be important to somebody. Using facts like this within a much more formal and careful econometric analysis, Hummels has estimated that the cost of time in trade is comparable to a 2.9% *ad valorem* tariff *per day*. The version that I have of his paper is preliminary, and perhaps I should not be quoting it. But the result is too striking, and relevant to my argument here, for me to ignore.

III. The Speed of Production

Our customary specifications of technology do not say anything about how quickly things are done, but if time matters, especially in the form just introduced, then we need to include that. The usual formulation of technology is $X = F(V)$, where X is output per unit time, V is a vector of inputs (or the services of inputs) also per unit time, and F is a production function, which may have various properties such as constant returns to scale. Although both X and V are defined per unit of time, the function does not really specify whether the output and associated inputs occur at the same time. Used in a static model, they need not be simultaneous, since what is happening implicitly is an ongoing flow of factor inputs and output, with no temporal connection between the two. Used alternatively in a dynamic model, the timing becomes explicit through the dating of the variables, perhaps with the output at time t being a function of the inputs at time $t-1$. In any case, the speed of production is not a subject of endogenous choice within the model.

To allow for such choice without unduly complicating things, let us introduce a second variable into the production function, D. Let D be the time delay between the moment when production of a unit of the good is initiated – the decision being made then to build into it various characteristics – and the moment when production of that unit is completed. The production function is then $X = F(V;D)$. This still does not specify the exact timing of the inputs relative to the output, but for my purposes the explicit timing is not needed. The point is simply that, having selected a delay D, the producer will build characteristics into the good that will be somewhat obsolete by the time that production of the good is completed. I do not necessarily expect that, for most traded goods, the amount of depreciation that occurs during production will be significant. Rather, I am introducing this formulation here, where it is otherwise familiar, and then I will use the same formulation for the technology of trade later on.

For any given value of D, the function of inputs V can be conventional. But what role should D itself play? It seems plausible that there may be a tradeoff, with larger D and therefore slower production requiring a smaller total amount of inputs, so that D becomes somewhat like a factor input itself. That is true, but the shape of that function may be different from what we usually assume for factors of production.

Suppose for example that production of a good requires that ten operations be performed, each of which requires a day's labor by a worker. One unit therefore requires ten units (person-days) of labor, and the delay in production is ten days. Right? Well, not necessarily. If these ten separate operations can be performed simultaneously and achieve the same result, then ten workers could produce the same unit of the good in just one day. The labor requirement per unit of the good would still be the same ten units, but the delay would now be only one day. In this case, reducing the delay does not require any increased input of factors at all. Indeed, one might even imagine that by having each worker specialize in one operation, they would be more productive and achieve the result in somewhat less than a day, actually reducing total labor requirements and reducing the delay still further.

Of course, this is not always possible. The operations may need to be performed in order. The point is only that reduced delay is not always costly in terms of production, and therefore increased delay is not always "productive," in the sense of reducing the total inputs needed to produce a given output.

But when delay is not costly in terms of inputs, since by assumption delay *is* costly in terms of the value of the output produced, firms will reduce the delay at least to the point where further reduction does require increased resources. Therefore, while the function $F(V;D)$ may not be assumed to be strictly increasing in D throughout, the D's that are actually chosen will be small enough that the function will have this property locally. Thus, it is reasonable to assume that, like any productive factor, the marginal product of delay is positive and declines as the size of the delay increases, perhaps to zero.

More interesting and important, for trade at least, is the effect that D may have on the needed inputs of various factors. While it is possible, I suppose, that an increase in speed of production (a fall in the delay D) for a given output could increase all required factor inputs in the same proportion, I think that is quite unlikely. Instead, methods to speed up the pace of production, in most industries that I can think of, rely on machinery, and the machinery may in turn require inputs of human capital to maintain or operate it. Therefore I would expect increased speed to be intensive in the use of physical and/or human capital.

That is, I will assume that for any given level of D, the isoquant map of factor inputs is conventional, and that it shifts inward with an increase in D, rather in the manner of technological progress (except that this process could more readily be reversed). But the inward shift is not neutral, in any sense; rather it is biased in favor of using relatively more physical and/or human capital and relatively less unskilled labor.

Competitive firms, then, face given prices of factors, as usual, and they also face a given rate of depreciation of their output during the delay in production. For any given level of delay, they will choose factor inputs in the usual way to minimize their costs of production, but they will also select the size of the delay itself by equating the marginal product of delay to its cost. Its marginal product is the amount by which cost per unit falls with increased delay, while the marginal cost is the given rate of depreciation. Under the stated assumption that speed is capital intensive, firms facing the same factor prices and same technologies but having different rates of product depreciation will behave differently. Those firms with higher rates of depreciation will choose shorter delays and will use more capital-intensive techniques of production.

Some implications of all this for trade are straightforward, and are most easily seen if trade itself is costless and instantaneous. Suppose the world consists of two countries, and one of them has a more rapid pace of changing preferences than the other, so that goods in general depreciate for its consumers more rapidly than goods for the other country. The country with the faster pace of change will have a greater incentive for industries to speed up production, and by selecting lower values of D, their technologies will make more intensive use of physical and human capital. This in turn will alter factor prices, raising the relative returns to capital and skill in the faster paced country, and affecting also the patterns of production and trade. If, as seems plausible, the faster paced country is also the more developed, its more capital-intensive techniques will tend to offset the incentives to trade that would be predicted by the Heckscher-Ohlin Theorem. Indeed, this difference in pace of production could account in part for a smaller volume of trade between the developed and developing world than is predicted by the Heckscher-Ohlin model, as has been observed by Trefler (1995), among others.

Suppose alternatively that industries, rather than countries, differ in the extent to which their products depreciate, some industries experiencing a faster pace of change than others. Other things equal, such industries will, in response to this need for speed in production, be more capital and skill intensive than others. This in turn means that developed countries are likely to have comparative advantage in these industries. Unlike the previous case, which predicted behavior at variance with the Heckscher-Ohlin benchmark, this one is simply an example of Heckscher-Ohlin forces at work. But the pace of change in consumer preferences now becomes a reason for some sectors to be more capital/skill intensive than others, providing a layer of explanation for what would normally be taken as given in the Heckscher-Ohlin model, the relative factor intensity of different sectors.

IV. The Speed of Trade

So far I have focused only on the time required for production, not trade, and my implications at the end of the previous section applied standard Heckscher-Ohlin theory ignoring costs of trade. But in fact, trade is costly not just in resources but also in time, and this is very much the point of this paper. What happens, then, when we take the time costs of trade into account?

If these costs are given, then allowing for them is not much different from allowing for other costs of trade. Those goods that depreciate over time in consumers' estimation will also depreciate during whatever time elapses getting them from one country to another. This is important primarily because it is not a cost that is normally identified in efforts to measure costs of trade, and yet in some industries it could be quite important. It too may account in part for the lower than expected level of trade in the world, including the large "border effects" that McCallum (1995) and others have identified. If crossing a border involves delay, then in some industries where time is most important, this could well be more costly than a formally levied tariff or explicit transportation cost in reducing the volume of international trade. This possibility may be particularly important for policy, as I will discuss below.

However, the time costs of trade are not all given; many are chosen deliberately by traders selecting among alternative methods of accomplishing their trade. This is most obvious in the case of transportation costs, for which the tradeoff between resource cost and speed is evident. The more important is speed, as captured here by the rate of depreciation, the more money will traders be willing to spend on faster means of transportation. In such cases, the actual time used up in trade may be rather small, but it will be partially made up for by the cost of faster transportation. In general, the actual monetary cost of transportation may not be a good measure of the cost of trade, which should also include the time delay and its market importance, which varies across industries.

Two implications of this analysis come to mind. First, considering only a two-country world where differences in costs of trade can play only a very limited role, I can nonetheless make a prediction if I combine the importance of time with my assumptions about technology of production. Suppose there are two countries in the world, differing in their relative abundance of capital, and also that there are two goods differing in the rate at which they depreciate, for all consumers in both countries. If the technologies for producing the goods are otherwise the same, then by the argument above producers everywhere will choose faster and hence more capital-intensive techniques of production for the more rapidly depreciating good. It will therefore be exported by the more capital-abundant country. That higher rate of product depreciation, however, will imply a greater need for speed in the trade of that good, and thus the capital-abundant country will also spend more resources on shipping the good in order to achieve this higher speed. The implication, then, is that developed countries will on average choose higher-cost methods of transporting their exports than will developing countries, in order to get their products to market more quickly.[1]

A second implication arises in a world of many countries, where some countries are more distant from world markets than others. Since transporting over distance takes time, this implies immediately that countries at greater distance are less likely, other things being equal, to have a comparative advantage in goods that depreciate rapidly. This is completely analogous to the disadvantage that such countries also face in products that are expensive to transport, due to weight perhaps, and indeed it may appear to be exactly that, to the extent that rapidly depreciating goods are transported by more rapid and therefore more expensive means. This is also an example of the role of trade costs in influencing the pattern of trade, as discussed in Deardorff (2001).

[1] In a two-country world, this seems to imply that the developed countries will use different modes of transport for their exports than for their imports, which raises the problem of what to do with vessels on their return trips. However, if the need to use ships and planes in both directions were accounted for, this implication could still have some meaning, as a prediction of how rapidly vessels of either kind would move in the two directions. That is, ships will move faster from "North" to "South" than from "South" to "North."

V. Other Determinants of Speed of Production and Trade

The speed of production and trade is also influenced by various institutional factors and government policies. Together these suggest that government may play a much larger role in both facilitating and discouraging trade than we learn from looking at easily measurable trade taxes and subsidies.

Infrastructure

The importance of infrastructure for trade – most obviously the networks of communication and transportation within a country, and between it and the rest of the world – is obvious even before we consider issues of time. But time magnifies its importance. The resource costs of moving goods between the interior of a country and its border may not be that much larger with a primitive transportation system than a modern one, but the time required to move the goods is likely to be much shorter with the latter. In a poor country, the labor costs of loading a ship by hand are small, but it cannot be done nearly as quickly as by a modern piece of capital – is it called a crane? – that can do the job in hours instead of days. Not incidentally, the modern technology also moves goods in large "containers" that speed up the process of unloading and further transport at the destination. I am sure that if I knew more about the technology of moving goods, there would be many more examples of the benefits of installed infrastructure that facilitate trade, not so much by lowering the out-of-pocket costs, but by making everything happen faster.

But infrastructure is not something that can easily be provided without at least a role for government. In many cases, governments themselves are responsible for building infrastructure, and without the profit motive to push them along, these projects can drag on for years. Once completed, if the government then administers the infrastructure facility, it is likely to instill within it the same sluggish responses that governments display in other functions.

If instead the infrastructure is built by the private sector, then the incentives may be right for more efficient and quick response. But infrastructure projects tend to be natural monopolies, and this presents the unhappy choice between an unfettered monopolist and government regulation. The monopolist can extract its rents by charging high prices, and then presumably its customers move quickly but at high cost. If government regulation tries to limit those charges, then a natural response of the monopolist is to move slowly, and perhaps even to delay its services artificially, in order to elicit under-the-table payments in addition to the officially permitted charges.

Government Regulations

Government regulations are certainly not confined to monopolists. Governments intervene in all manner of activities, and especially so in international trade. Some of this intervention is merely for the purpose of monitoring activity and collecting data – something that we economists are all in favor of. But the process of monitoring inevitably adds a time cost to transactions, and, if it is not done carefully, this time cost can be considerable. There usually is no incentive for government employees to move quickly, and again there may instead be the opposite incentive if delays can elicit bribes.

Like other barriers to trade, time costs are subject to the forces of political economy. WTO commitments may prevent a country from protecting its domestic industry with tariffs or other explicit charges. But domestic interests are also likely to play a role in determining how imports are processed at the border. By pressing for as many delays as possible, they can effectively undermine the competitive pressure from imports.

VI. Japanese Experience

As alluded to in my introduction, the country that seems to have been most adept, early on, in turning issues of timing in trade to its advantage, has been Japan. When Japan turned in the 1970s and 80s to exporting high-end manufactures to the United States, its exporters had no choice but to deal with the delays that were inherent in its long distance from U.S. markets.

Forced to attend to time, Japanese manufacturers did better than simply make up for what might have been a disadvantage. They developed new techniques for organizing production, inventories, and trade that were designed to minimize the delays in getting their products to market and responding to market changes. The innovation of "just-in-time" production methods gave them an advantage that, together with other innovations, permitted them to serve distant markets with both a speed and a quality that were unparalleled.

Speed and quality, here, are not necessarily substitutes. The Japanese reputation for quality, in automobiles for example, was partly the result of their ability to respond quickly to feedback from their customers, designing cars that met the desires of their customers rather than of their engineers. (I speak not as an authority on cars, but as a four-time purchaser of a Honda.) These skills served them even better later, when the handicap of distance was reduced by their moves of manufacturing to the United States.

Thus, Japan seems to have been a case study of a country that did *not* let time determine its trade pattern in the way that my earlier discussion would have predicted. If it had, then Japan would not have exported in sectors where time was important, or where in my formulation products could depreciate rapidly. Instead, Japanese manufacturers were able to break the law of comparative advantage, in a sense, by changing the technology. That is, by pioneering just-in-time production and other production and marketing tools, they gave themselves comparative advantage in sectors where, due to their distance from markets and the associated time-costs of trade, they would have lacked comparative advantage otherwise.

This raises a problem, however. What happens when a country bases its trade on what is essentially a single technological advance? Over time, the new technology diffuses, as it is copied by producers elsewhere. Over time, therefore, the comparative advantage disappears. If one innovation is followed by another, time after time as in the Vernon (1966) product cycle, then one lost comparative advantage will be replaced by another. But if the change is not based on a country's underlying ability to innovative, but rather on a one-time accomplishment that will not be repeated, then the implications for the country are less sanguine.

What I am suggesting, then, is that Japan's success as an exporter in the 1980s, say, may have been based primarily on a single innovation in managing the time costs of production and trade. If this innovation has now been copied by producers in other countries (or taken to those countries via FDI by Japanese producers themselves), then it no longer may provide the basis for comparative advantage. If so, one would expect Japan's trade pattern to revert to what it was before, with distance from markets once again playing an important role. I would hesitate even to believe that this story is correct, let alone claim that it accounts for much of what we see in the real world. But I have to wonder whether the stagnation that has characterized the Japanese economy during the last decade is entirely a coincidence.

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