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# Financial Crisis, Trade, and Fragmentation

Alan V. Deardorff
University of Michigan

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# ABSTRACT

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Motivated by the Asian financial crises that began in 1997, this paper adds money to a Ricardian model of international trade in order to explore the role of financing costs in general-equilibrium trade. The purpose is to show not only that financing costs matter, but to argue a potentially important effect of a financial crisis. If financial markets suddenly come to expect a country's currency to depreciate, as might happen if it has attempted an unsustainable peg, then that expectation will itself force a depreciation. The depreciation will in turn make it impossible for international traders to repay their financing, and their default will increase the costs of financing trade in subsequent periods. Finally, this crisis-induced increase in costs of trade financing then undermines both trade itself and the gains from trade. The paper also goes on to argue that fragmentation – the splitting of production processes across countries – contributes to both trade and the gains from trade, but in doing so it makes countries more vulnerable to these effects of a financial crisis.

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**Correspondence:**

Alan V. Deardorff
Department of Economics
University of Michigan
Ann Arbor, MI 48109-1220

Tel. 734-764-6817
Fax. 734-763-9181
E-mail: alandear@umich.ed
http://www.econ.lsa.umich.edu/~alandear/

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# Financial Crisis, Trade, and Fragmentation [*]

**Alan V. Deardorff**
**The University of Michigan**

## I. Introduction

Trade economists like myself routinely ignore events in exchange markets, financial markets, and the macroeconomy, but recent events have made that difficult. The Asian financial crisis that began in 1997 caused large contractions in the countries' trade. As documented in Table 1, both exports and imports fell between 1997 and 1998 in most of countries that were hit by the crisis.[1] In most cases, these changes represent not just the effects of exchange rates on trade balances through prices of domestic versus foreign goods, which might have been expected to reduce imports but to increase exports. Instead, both exports and imports fell. Thus these countries experienced declines in their overall trade, as well as in their terms of trade, and this suggests that they lost much of the gains from trade as well. Of course, the trauma to their economies included other effects as well, many of them macroeconomic, but these effects on trade suggest that trade theory ought to have something to say about both the causes and the effects of what occurred.

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[*] I have benefited greatly from conversations about the topic of this paper with Bob Stern. I also got a very useful and informative taste of cash-in-advance models from a seminar in Ann Arbor by Patrick Kehoe, whose presentation showed me, when I was nearly done with this paper, how it probably should have been done. I also received many useful comments from participants at the Hong Kong conference.

[1] Table 1 excludes one other country that was hit hard by the crisis, Malaysia, because its balance of payments data in *International Financial Statistics* stop in 1997. *IFS* also does not report any data for Taiwan, or balance of payments data for Hong Kong, two other countries that were impacted by the crisis.

My purpose in this paper is therefore to say what I can about financial crisis in the context of a simple Ricardian model of international trade. To do this I need to include some sort of financial assets in the Ricardian model, and my choice for these is simply national currencies. A financial crisis will be modeled as a change in expectations about the exchange rate between these currencies, and I will explore the effects of such a change on international trade. I will also examine briefly a possible cause of such crisis, arising naturally from an attempt to peg an exchange rate at an unsustainable level with insufficient reserves.

All of this is pretty primitive stuff. But remember, I'm a trade theorist, not (anymore) a scholar of international macro or finance. My approach to the problem is therefore to make it as simple as I can manage and hope that I can learn something.

The paper also includes a final section on fragmentation – the splitting of production processes into parts that can be done in different locations. This is included primarily because fragmentation is something I have been working on recently in other papers,[2] and partly because the conference for which this paper was written had that as its topic. The inclusion of fragmentation does indeed add a somewhat interesting dimension to my model here, but it is admittedly not central to its message.

## II. A Ricardian Model with Money

Like any Ricardian trade model, mine has goods produced with labor alone and constant unit labor requirements that differ across countries. First, however, let me lay out the closed economy version of the model, since that will clarify the role of money.

[2] See Deardorff (1998a,b).

*Autarky*

The country is endowed with labor, $L$, which is the only factor of production, and it produces two goods, 1 and 2, the outputs of which are $Q_1$ and $Q_2$. Their production requires $a_1$ and $a_2$ units respectively of labor per unit of output. They are demanded by consumers, the owners of the labor, who have identical homothetic preferences over the goods only (their labor supply is fixed), described by their common utility function $U(C_1,C_2)$. This can equivalently be written in its indirect form, $V(p,E)$, where $p=(p_1,p_2)$ is the vector of prices and $E$ the level of expenditure, measured in domestic currency. Demand is therefore the function $D(p,E)=V_p(p,E)$.

All transactions in this economy require money, a domestic currency that has been printed by a government that for the moment plays no active role. Instead, a quantity of money $M$ exists in the economy and must be used for transactions. It will pass back and forth between firms and workers/consumers over time as firms pay workers to produce, then sell the product to consumers. I will assume that these transactions occur in orderly fashion over a period of time, with workers first being hired and paid, product then being produced, and finally the product sold to consumers. Firms must therefore have money on hand to pay workers before they can employ them, and consumers must have money before they can consume. Neither can exchange goods directly for labor or vice versa. Nor can a unit of currency be used for multiple transactions at the same time.

We could think of starting this process with the firms holding the entire quantity of money $M$ and using it to hire workers. However, I will add another step because it will be useful later. Consumers/workers own the existing money stock, and it is they who start with it. Firms must borrow money from them at the start of a period in order to have money to pay their workers. At the end of the period, after production has been completed, firms sell the goods to workers and get money back, which they use, finally, to repay their loans. This arrangement has the advantage that we are assured of the existence of those who own the money, since they are the people who populate the economy, participating as both workers and consumers. Firms, on the other hand, can pass into and out of existence in response profit opportunities, borrowing the money needed to start up, and repaying it out of revenues. In any case, the quantity of money plays a crucial role in this model, since it imposes a strict limit on the total value of, first, the labor that is hired and, at the end of the period, the goods that can be purchased.

The money wage is therefore determined immediately as $w=M/L$. These workers, employed by firms (which could include self-employment) produce either or both of the goods in quantities that they expect will sell. The firms then sell these goods to consumers for whatever prices $p$ will clear the market, in exchange for the money, $M$, that the consumers earlier were paid as workers. Then the process begins again in the next period. I gather that this is in the spirit of the "cash-in-advance" economy that was introduced by Lucas (1982) and that is now commonplace in macroeconomic theory, although I am familiar with little more than the name.

It is customary to assume perfect competition in a Ricardian model, and I will do so here. But I will not necessarily assume zero profits or that equilibrium prices necessarily equal average costs, for it is possible that such prices will not clear the market. This will happen if firms incorrectly anticipate demand, or if, as it will shortly, the government injects more money into the system. Perfect competition here therefore means that firms are atomistic price takers maximizing profit as best they can, and that they all expect to earn the same profit on each unit of currency spent on labor, regardless of what it produces. It will be left to the market equilibrium to determine whether either anticipated or actual profit is equal to zero.

Equilibrium in this closed economy therefore consists of a wage *w*, a vector of prices *p*, and a vector of outputs $Q=(Q_1,Q_2)$ such that the following equations hold:

$$wL = M \tag{1}$$

$$p_j = (1+\mu)wa_j \qquad j=1,2 \tag{2}$$

$$\sum_j a_j Q_j = L \tag{3}$$

$$D_j(p, M) = Q_j \qquad j=1,2 \tag{4}$$

The markup rate, μ, is also endogenous, so that this is a system of six equations and six unknowns, although the budget constraint underlying the demand function assures that in equilibrium the markup is zero. That is, using (1), (3), (2), and (4) followed by the budget constraint, we get

$$M = wL = \sum_j wa_j Q_j = \sum_j \frac{1}{1+\mu} p_j Q_j = \frac{1}{1+\mu} \sum_j p_j D_j(p, M) = \frac{1}{1+\mu} M \tag{5}$$

which implies μ=0. Thus the equilibrium is the usual Ricardian one with the variables determined recursively:

$$w = \frac{M}{L} \tag{6}$$

$$p_j = \frac{Ma_j}{L} \qquad j=1,2 \tag{7}$$

$$Q_j = D_j\left(a_1, a_2, L\right) \qquad j=1,2 \tag{8}$$

where $M$ has dropped out of (8) because of the zero-degree homogeneity of $D(\cdot)$.

Money does not really matter in this model, so far, as it should not, except for nominal prices and the nominal wage. However it may seem to matter if we now allow the money supply to change. Whether it matters or not then depends on how that change is accomplished. Suppose, for example, that the government injects additional money into the system by printing it and giving it as a transfer payment to worker/consumers sometime during the period, after they were hired as workers but before they spend their wages on consumption. At their first opportunity they will spend all of the transfer, since there is no benefit here from saving, and this will bid up prices above the costs that firms have already incurred. The above solution will still hold, except that

$$p_j = \frac{(M + \Delta M)a_j}{L} \qquad j=1,2 \tag{9}$$

for any period within which additional money, ? $M$, has been transferred to consumers. If however the money had been transferred to consumers at the beginning of the period instead, before they lent to firms, then the original solution would be unchanged, except that $M$ in each period would be the quantity of money including the transfer.

More interesting, perhaps, is a monetary expansion that is spent by the government on real goods, since that may be a more plausible motive for the expansion in the first place. Suppose that government decides to purchase quantities $G=(G_1,G_2)$ of the two goods at the end of the current period, paying for them with newly printed money. If firms do not anticipate this purchase, then they will produce based on other expectations – perhaps of the demand levels that would have obtained without the government intervention. In that case, the same quantities $Q=(Q_1,Q_2)$ defined in (8) will be produced.

However, the market will clear at whatever prices induce consumers to spend their labor income *M* on the smaller quantities *Q- G*. These prices will be higher, in nominal terms, since the same money *M* is spread over fewer goods, and they will be tilted toward a higher relative price for whichever good the government purchases in higher proportion than consumers.

Of course it is not really money that is mattering here for real variables, but only the fact that the money is being injected by means of real government purchases that differ proportionally from private purchases. Nonetheless, it serves to remind us that while money itself may be neutral, the reasons for its expansion may not be.

With prices rising here over time, consumers would perhaps prefer to move their consumption to an earlier date. But they cannot do this, under the assumptions of the model, since they are constrained, both in the aggregate and individually, to consume no more than the fixed money supply will purchase. However, suppose that prices were falling rather than rising. Then consumers might want to postpone consumption. I will consider this possibility briefly here.

To handle intertemporal substitution, I must first make some assumption about time preference. I make the simplest one possible, that consumers discount consumption in future periods at a constant rate d per period. This is a dangerous assumption, of course, since it seems to invite consumers to postpone consumption indefinitely if the circumstances permit it. However, most of the circumstances I consider will not.[3]

[3] With these consumers lending money to firms to use throughout the period of production, you might think that they should be paid an interest rate equal to the rate of time preference on the loans. That will indeed be the case when we allow them to lend across periods. However, within the period the consumers have nothing else they can do with the money, since newly produced goods are not yet available for

Suppose, then, that the government reduces the money supply at a constant rate –*d* per period by what we have seen to be the simplest means available: taxing consumers *d* percent of their money holdings at the start of each period, before they lend it to firms who use it to hire labor. And suppose that the government destroys the tax proceeds. The above solution then holds, with the money supply *M* falling at the rate *d* per period, and both prices and the wage also falling over time at that rate.

Or at least, this holds so long as *d*<d, for in this case it will continue to be true that the extra consumption that a consumer could get by waiting – the percentage *d* permitted by the lower price – is too small to compensate the impatient consumer for consuming less than their wage.

But suppose that *d*>d, meaning that the government deflates money and prices at a rate faster than the rate of time preference. Then it would seem that we are in exactly the situation alluded to above, where consumers will want to postpone consumption indefinitely. Indeed we are, except for one thing: If consumers don't buy the goods that have just been produced, firms will be unable to hire labor for production during the next period, and a shortage will emerge, raising prices after all.

That is, if prices were expected to be lower next period than they are this period by a fraction greater than the rate of time preference, then consumers would choose to buy nothing in the current period, and the goods market would not clear. Therefore, if it is known in this period that the government will tax away the fraction *d* of the money supply next period, then prices this period must already fall below the levels that otherwise would have been appropriate for the current money supply. How much below? Enough so that

consumption, and the markets for last period's goods have closed. So the equilibrium interest rate is zero, consumers become indifferent between buying today and waiting. At these lower prices, they cannot spend all of $M$ on current goods, since that would more than exhaust supply of goods. But that may be manageable, since they can simply hold on to part of $M$ to spend next period.

However, this means that firms no longer get all of $M$ as revenues with which to pay back their loans from consumers. And consumers therefore have less to re-lend to firms at the start of next period for them to use to hire labor next period. It follows that next period's wage must fall even more than it might have due to the tax alone. This in turn causes next period's prices to be lower as well, complicating matters further. To allow for all of this, we would need to look further ahead and find a time path for both prices and wages that is consistent with the path of the money supply, taking into account the constraint on the rate of deflation and its effects on demands for goods.

To solve for such a path would take me too far afield (and out of my field, as well). But I conjecture that the following results would hold: An attempt to reduce the money supply at a constant rate $d$>d indefinitely will, under my assumptions, cause the economy to implode, as consumers will indeed attempt to postpone consumption indefinitely. In contrast, an attempt to reduce the money supply at such a rate only temporarily, with it then settling at a new lower level from then on, may be workable. However, the price level in that case will not simply follow the same path as the money supply. Instead it will drop immediately much closer to its long-run level as soon as information about the new path is first obtained. Consumers will hoard a fraction of the money supply in anticipation of the further decline in prices that they know will occur.

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at which consumers are indifferent between lending the money to firms and not.

And finally, I suspect that if such a path to a lower money supply is traversed too quickly, the bottom may fall out of prices anyway. This will happen in spite of the fact that an ultimately stationary money supply is in the works. For hoarding holds back money from firms, lowering wages and therefore prices, and causing a sort of speculative deflationary bubble.

*Trade*

I turn now to an economy that trades. The model that I have in mind in principle is a two-country model, with each country modeled like the one above, but with different relative productivities and therefore comparative advantage, and also with different currencies. Like any Ricardian model, this one would admit of two kinds of equilibrium, one in which both countries specialize and another in which one does not. In addition, finding which solution obtains for particular parameters, and even specifying the equilibrium would get a bit messy, because of the need to distinguish notationally both two countries and two goods. I therefore opt to avoid many of these complications here using instead the familiar trade theorist's assumption of a small open economy. That is, in the two country model that is in the background, the foreign country is so large that it necessarily must produce both goods, and its prices, both nominal and relative, are only imperceptibly sensitive to any changes in its trade with the small country that we study explicitly.

Thus I continue to examine a country with labor force $L$, unit labor requirements $a_1$ and $a_2$, consumer demand function $D(p,E)$, and money supply $M$. But this money is now its own currency, and while it (and only it) is required for all domestic transactions, it is not acceptable abroad. The larger world, therefore, has its own prices $p^* = (p_1^*, p_2^*)$ expressed in the different "world" currency, and we take $p^*$ as given and impervious to the home country's trade or other transactions.

Trade could now be introduced by simply allowing domestic firms to sell abroad as well as, and at the same time as, at home. They would use their foreign-currency revenues to buy foreign goods and then bring them home to sell to domestic consumers. I will not do that, however, because my objective is to model financial crisis, and I think that requires someone to take an open position across currencies. Therefore, to allow for this in a simple way, I will assume that it takes time, one period, to complete an export or an import. This time-cost of trade could arise most obviously from transportation, but one could think of it equally as arising from other requirements of trade, such as negotiating the deal with the foreign customer, or dealing with bureaucratic red tape. The point is that, while I will not allow for any explicit resource cost of getting goods from one country's market to the other, I will assume that it takes one period of time. This will be true for trade in both directions.

For exports, then, the story is as follows. Firms borrow domestic money from consumers and hire labor as before to produce either or both of the two goods. Once produced, they can sell these goods in the current period to domestic consumers. Or alternatively, they can ship them abroad at zero resource cost and sell them there in the next period for next period's foreign price in foreign currency. At that time they can instantly exchange that foreign currency with others who wish to convert in the other direction on a global and costless foreign exchange market. This leaves exporters with domestic currency with which to pay back their loan. The result of all of this is that, by exporting, firms get access to the foreign market, but this delays by one period their receipt of the domestic currency they need in order to pay back their original loan. At the same time, exporting also subjects them to the potential uncertainty of both next period's prices and next period's exchange rate.

The delay itself is costly, because of the rate of time preference of consumers, and perhaps for reasons of risk as well. Consumers will not be willing to postpone consumption to the next period unless they can get at least that fraction, d, as a real rate of interest on the loan to firms. In addition, the uncertainty of trade may add a risk premium to what lenders require. To allow for this, I will simply assume a domestic real interest rate, $r$ per period, that is at least as great as d. Firms, therefore, must pay back in real terms $(1+r)$ times what they borrow to produce for export. They will therefore not choose to export at all unless they expect to get a (real) price that is at least that much higher than they could get by selling their product at home in the current period. On the other hand, if they could get even more than this, then they would decline to sell at all in the domestic market. Thus for exporting to happen at all, along with serving the domestic market, the expected foreign price of an exported good, converted at the expected exchange rate, must be exactly $r$ percent higher than its domestic price next period. If domestic prices are rising at a rate of inflation p per period, then the expected foreign price next period must be higher than the current domestic price by the nominal interest rate, $i=r+p$.

The story for imports is a little different. I could assume that foreign producers behave in exactly the same way as domestic exporters – borrowing from foreign consumers, producing and shipping their product to the home country where they sell it a period later, and exchanging the revenues for their own currency at that time to repay their financiers. However, since I wish to model a small country that may be even more unfamiliar to the world than the world is to it, I will assume instead that the perceived risk on such a transaction is prohibitively high. Instead, for our country to import, it is domestic firms that must undertake the transaction, and to do so they must borrow foreign currency from lenders abroad. The real interest rate for doing so, which I will call $r^*$, is not simply the foreign real rate of conventional interest, but instead includes a perhaps substantial risk premium that is also motivated by the unfamiliarity of foreign lenders with the credit-worthiness of domestic borrowers.

Thus, like $r$ for exporters, $r^*$ for importers is an extra real cost that they must expect to cover in order to import. They will import only if the expected domestic price next period of the imported good, converted to foreign currency at the expected exchange rate next period, is $(1+r^*)$ times next period's foreign currency price of the imported good abroad. Of course, if the expected price were even higher than this, then competition among potential importers would bring it down. If there is foreign inflation at rate p* per period, so that the foreign nominal interest rate is $i^*=r^*+$p*, then imports will require the expected foreign-currency-converted domestic price to equal $(1+i^*)$ times the current foreign price.

Together, then, the needs of both exporters and importers therefore require that relative costs at home differ from exogenous foreign relative prices by $(1+r)(1+r^*)=$(1+f ) in order for trade to take place. If they do not, then the small home country will not trade. We can think of f as the total financing costs of trade. To get an equilibrium in which trade occurs, I therefore assume that

$$\frac{a_1}{a_2}(1+\varphi) < \frac{p_1^*}{p_2^*} \tag{10}$$

Thus the small economy has a comparative advantage in good 1, of sufficient size for it to overcome these financing costs of trade, and indeed to specialize completely in good 1.[4]

With this assumption fully determining the pattern of specialization and trade, the rest of a trading equilibrium can be specified fairly simply, although it is now necessary to take careful account of time. In general, let $x(t)$ be the value of any variable $x$ in period $t$, including those already introduced, and let any variable with a star be that of the world. Specifically, let $X_j$ be the quantity of good $j$ exported by the home country, and $X_j$* the quantity exported by the foreign country and thus imported at home. Finally, let $e$ be the exchange rate, defined as the home country's domestic currency price of foreign currency.

A trading equilibrium then consists of a domestic wage $w$ and prices $p=(p_1,p_2)$, in domestic currency, levels of output $Q_1$, exports $X_1$, and imports $X_2$*, and the exchange rate $e$, all of these indexed by time $t$, such that the following equations (11-18) all hold:

$$w(t)L(t) = M(t) \tag{11}$$

$$a_1 Q_1(t) = L(t) \tag{12}$$

$$p_1(t) = (1+\mu(t))w(t)a_1 \tag{13}$$

$$[1+i(t)]p_1(t) = e(t+1)p_1^*(t+1) \tag{14}$$

$$p_2(t+1) = [1+i^*(t)]e(t+1)p_2^*(t) \tag{15}$$

$$e(t)p_1^*(t)X_1(t-1) = p_2(t)X_2^*(t-1) \tag{16}$$

$$D_1(p(t), M(t)) = Q_1(t) - X_1(t) \tag{17}$$

[4] If (10) were to hold with equality, then the pattern of trade would be determinate, but the volume of trade would not be.

$$D_2(p(t), M(t)) = X_2^*(t-1) \quad (18)$$

The first three of these equations represent the cash constraint on wages, the full employment condition, and the markup of price over cost, exactly as in the closed economy except that here they are simplified by specialization. Equation (14) reflects the requirement discussed above, that exports yield an *i* percent higher price next period than domestic sales this period, expressed in the same currency exchanged next period. (15) does the same for imports, using the foreign nominal interest rate on domestic borrowing from abroad, $i^*$. (16) is the exchange market equilibrium condition, or balance of payments constraint. The left side is this period's demand for domestic currency by last period's exporters, while the right side is this period's supply of domestic currency by last period's importers. Finally, equations (17) and (18) equate domestic demand to supply, the latter originating last period as foreign exports in the case of good 2, which the home country does not produce.

This system of equations is not particularly simple, largely because current values depend both on last period's decisions to trade and on expectations about next period's prices and exchange rates. I will therefore not attempt to characterize the solution for arbitrary time paths of exogenous variables. Instead I will look primarily only at steady state solutions and then use the structure of the model to discuss, more loosely I'm afraid, the subject of financial crisis.

Consider first the stationary solution. That is, suppose that $M$, $L$, $p^*$, $i$, and $i^*$ are all constant over time. Then other variables will be constant as well, and there will be no inflation, so that $r=i$ and $r^*=i^*$. A stationary solution will satisfy all of the above equations with their time indices removed, as follows:

$$wL = M \tag{11'}$$

$$a_1 Q_1 = L \tag{12'}$$

$$p_1 = (1+\mu) w a_1 \tag{13'}$$

$$(1+r) p_1 = e p_1^* \tag{14'}$$

$$p_2 = (1+r^*) e p_2^* \tag{15'}$$

$$e p_1^* X_1 = p_2 X_2^* \tag{16'}$$

$$D_1(p, M) = Q_1 - X_1 \tag{17'}$$

$$D_2(p, M) = X_2^* \tag{18'}$$

The solution to this is relatively straightforward. First, domestic relative prices are fully determined by (14') and (15'):

$$\rho \equiv \frac{p_1}{p_2} = \frac{1}{(1+\varphi)} \frac{p_1^*}{p_2^*} \tag{19}$$

With homothetic preferences, this relative price determines the ratio of the goods consumed domestically, $C_1/C_2$,

$$\frac{C_1}{C_2} = \frac{D_1(p, M)}{D_2(p, M)} = f\left(\frac{p_1}{p_2}\right) = f(\rho) \tag{20}$$

as well as the consumption shares, $\beta_j$,

$$\beta_j = \frac{p_j C_j}{M} = \frac{p_j D_j(p, M)}{M} = \beta_j(\rho) \tag{21}$$

Then, again using the budget constraint that underlies the demand functions, we note that

$$
\begin{aligned}
M &= wL = wa_1Q_1 = \frac{p_1}{1+\mu}Q_1 = \frac{1}{1+\mu}p_1(C_1+X_1) \\
&= \frac{1}{1+\mu}\left[p_1C_1 + \frac{1}{1+r}ep_1^*X_1\right] = \frac{1}{1+\mu}\left[p_1C_1 + \frac{1}{1+r}p_2X_2^*\right] \\
&= \frac{1}{1+\mu}\left[p_1C_1 + \frac{1}{1+r}p_2C_2\right] = \frac{1}{1+\mu}\left[\beta_1M + \frac{1}{1+r}(1-\beta_1)M\right] \\
&= \frac{1+\beta_1 r}{(1+\mu)(1+r)}M
\end{aligned} \tag{22}
$$

Eliminating $M$ from (22) and solving for the markup, μ, we find that it is no longer zero:

$$
\mu = -\frac{\beta_2(\rho)i}{(1+r)} = \mu(\rho) \tag{23}
$$

This is negative, meaning that producers get a price for their good in the current period that is below current cost. This is as it should be, since they get a higher price for exports to compensate them for the delay, and its interest cost, and their total revenue must equal total cost, due to the consumers' budget constraint.

This markup (or markdown, as it turns out), would be fully determined by parameters if preferences were Cobb-Douglas, but otherwise it depends on the relative prices determined in (19) as shown in (23). With the markup known, it is straightforward to characterize the rest of the solution. For example:[5]

$$
w = \frac{M}{L} \tag{24}
$$

$$
p_1 = (1+\mu(\rho))\frac{a_1}{L}M \tag{25}
$$

$$
e = \frac{(1+r)p_1}{p_1^*} = \frac{(1+r)(1+\mu(\rho))a_1M}{p_1^*L} = \frac{(1+\beta_1(\rho)r)a_1M}{p_1^*L} \tag{26}
$$

[5] (24) comes from (11'). (25) comes from (13') and (24). (26) comes from (14'), (25), (23) and the property that $ß_1$+ $ß_2$=1.

As for levels of output and consumption, these are determined essentially as in the standard real Ricardian model. With specialization in good 1, the home country produces $Q_1=L/a_1$. It then trades, in order to consume the ratio of the goods demanded at domestic relative price ?. The only slight twist is that trade is balanced neither at foreign prices $p^*$ nor at domestic prices $p$, but rather at the mixture indicated in the foreign exchange market clearing condition (16'), which mixes the foreign price of the export good with the domestic price of the import good. This is illustrated in Figure 1, where consumption occurs at point $C$, a tangency of an indifference curve with a price line whose slope is the ratio of domestic prices, $p_1/p_2$, since these are what consumers face in the domestic market. However, trade must be balanced at the domestic-currency prices received by exporters, $ep_1^*$, and by importers, $p_2$, and thus at the higher ratio $ep_1^*/p_2=(1+r)(p_1/p_2)$. Therefore consumption must lie on a price line with slope given by this ratio, connecting it to the production point at $Q_1$. This is possible because consumers have extra income at domestic prices beyond what would be needed to purchase $Q_1$. This extra income takes the form of interest on their loans to exporters.

One could put this model through the same sorts of paces as the standard Ricardian model, changing the parameters of labor endowment, technology, foreign prices, and tastes to find out what would happen, but I doubt that anything new would be learned. More interesting would be to consider more complex dynamics, allowing exogenous variables to change over time, and also to explore the dynamic approach to steady state. I do not have time to do any of this, except only to note how the model will behave with constant rates of monetary expansion.

Suppose, contrary to the above, that the two money supplies grow at constant rates p and p * per period. To minimize the effects on the real economy, let this growth be accomplished by governments that print money and give it to consumers, in proportion to what they already have, at the start of each period (before they lend it to firms to pay workers).

In the rest of the world, which is effectively the closed economy of Section 1, this monetary growth will simply cause prices to grow at the rate p *. In a steady state for the domestic economy, prices and money will both grow at the rate p, while the exchange rate will rise (depreciate) at the rate p – p *. This depreciation will hold all relative prices constant over time, at the same levels that clear the markets in the stationary state seen above.

## IV. Crisis

I will model a financial crisis as a loss of confidence in a currency. That means that market participants suddenly come to expect the currency to fall in value. They may or may not have good reason to think this, but I will start with the assumption that nothing else has happened, and therefore they perhaps do not.

Suppose then that we begin in the stationary equilibrium discussed above, with variables now labeled with a superscript *S*, for stationary. Then suddenly, within the current period after firms have borrowed money and hired labor, but before they have sold their output, expectations change. The public comes to believe that the exchange rate *next* period (not necessarily this period – that will be determined) will be some number, $\vec{e}$, that is larger than the equilibrium that has prevailed in the past in the stationary state: $\vec{e} > e^S$.

Since $e$ is the price of foreign currency, this means that the domestic currency is expected to depreciate.

What will happen now, in response to this expectation? Firms have already borrowed the available domestic money stock and paid all of it to their employees, so they can do nothing about that, even if they want to. However, some firms are also traders, and they have goods in transit in both directions between the countries. Exporters shipped a portion of their output to the foreign market in the preceding period, and they are waiting to sell it there and bring the proceeds home. Likewise, importers have bought foreign goods and have brought them to the domestic market for sale here. Both groups have the option, if they choose, of delaying either the sale of their good or the sale of the proceeds on the foreign exchange market until next period, when they expect the exchange rate to be $\vec{e}$. Will they do this? If today's exchange rate were to remain unchanged at its previous equilibrium value, then importers – firms that have brought products to the domestic market – would have an even greater incentive to sell now, since they will lose not only time but money if they wait. But exporters – domestic firms that have taken their product abroad – will have a strong incentive to delay the return of their proceeds to the domestic economy. Recall that in equilibrium these exporters were indifferent between selling in the domestic market and exporting, since the slightly higher price abroad was just enough to pay the interest on their loan. Now, however, if today's exchange rate remains $e^S$, they can add to their profit the full percentage of the expected depreciation simply by waiting one more period to return their funds at the expected exchange rate $\vec{e}$. If this depreciation is greater than the time cost of waiting – the interest cost $r$ of extending their loan one more period, as I now assume it is – then they will wait.

Therefore the previous equilibrium exchange rate $e^S$ can no longer clear the exchange market *this period*, because at $e^S$ there would be supply of domestic currency from importers but no demand from exporters. Indeed, this would be true for any exchange rate below $\vec{e}/(1+r)$. At that point, the expected depreciation is only $r$, which still adds to the profit of exporters, but only enough to compensate them for the interest cost of waiting an extra period. Therefore the effect of the expectation that next period's exchange rate will be $\vec{e}$ is to drive this period's exchange rate to $e^C$ ($C$ is for crisis), where $e^C = \vec{e}/(1+r)$.

Is this the end of the story? It can't be, since the new exchange rate is higher than would clear the market in equation (16). That is, we know that in the previous stationary equilibrium

$$e^S p_1^* X_1^S = p_2^S X_2^{*S} \tag{27}$$

Now the foreign price $p_1^*$ is unchanged, and the quantity of imported good 2, $X_2^{*S}$, does not change since its importers, as just noted, want to sell as quickly as they can. Domestic consumers have the same money to spend as before, and they also have no incentive not to spend it since they too face a depreciation in its value. Therefore the same domestic prices $p_1^S$ and $p_2^S$ must clear the domestic market. That leaves only $X_1^S$ to adjust in equation (27) when the currency depreciates to $e^C > e^S$, and that is what happens. Exporters of good 1, who are indifferent at $e^C$ between selling now and selling next period because $e^C = \vec{e}/(1+r)$, postpone a portion of their sales equal to the depreciation. That is, they repatriate their earnings from sales abroad of only $X_1^C < X_1^S$, such that the exchange market now clears at the new exchange rate $e^C$:

$$e^{C} p_1^{*} X_1^{C} = p_2^{S} X_2^{*S} \tag{28}$$

Does this matter? Not right away. Since the home country is small, the fact that its exporters are either selling less abroad or are holding onto foreign currency for an extra period will not matter for the world. And because of the depreciation, these exporters acquire the same amount of domestic currency from their sale of foreign currency as they would have gotten before. So they are able to repay their loans and re-borrow as they enter the next period, thus starting again with the same amount of money, *M*, available to hire labor, which they do. The only difference for them is that they still have either some unsold goods or some unconverted currency sitting abroad, waiting to be exchanged next period.[6]

However, importers have taken a hit. The currency they earn from selling their imports on the domestic market is now worth less than they expected on the exchange market, and it is no longer enough to pay off the loans they obtained abroad last period. If the model included a better cushion in the form of some sort of wealth, they might be able to repay their loan out of that, with subsequent effects on wealth and whatever these imply. But in the current model this is not possible, and I assume that importers simply default on their loans. This has no further effects that I can see, in the current period.

But in the next period, it will have what I take to be the main adverse effect of such a crisis: borrowers find their access to credit either cut off entirely, or made available only on much less attractive terms. If credit is cut off entirely, then there is not much to

[6] In the stationary world I am looking at here, it doesn't matter whether they wait to sell goods or wait to sell currency. With inflation it might, depending on where and at what interest rate they refinance their loan.

say. Without credit, countries cannot import, and without imports trade will break down completely. The country will return to autarky, and give up its gains from trade.

Less drastically, I will assume that credit remains available, but that the default in the crisis causes the risk premium on foreign loans to rise substantially. Thus $r^*$ goes up, raising the domestic price at which imports must sell in order to cover the increased cost of financing. Since world relative prices are fixed, this means that the domestic relative price of the export good falls, as does the hybrid price ratio ($ep_1^*/p_2$) at which trade is balanced. This is illustrated in Figure 2. Starting from the initial equilibrium at *C*, the foreign interest rate that is charged to domestic borrowers rises from $r^*$ to $r^{*\prime}$. This lowers the relative price of the country's export good at which trade must balance from $(p_1^*/p_2^*)/(1+r^*)$ to $(p_1^*/p_2^*)/(1+r^{*\prime})$, and it lowers the domestic price faced by consumers correspondingly, moving the equilibrium to *C*'.

This, then, is my story of a financial crisis. When all is said and done, it does not really amount to much. Expectation of a currency depreciation undermines an otherwise satisfactory and stationary equilibrium, forcing a depreciation even before it is expected. This causes those who have financed their trade by borrowing abroad expecting to repay with domestic currency – in my model, these are importers – to default on their loans. And this raises the financing costs for borrowing in the next period. Because financing costs enter the model in a manner analogous to other costs of trade, this increase in the risk premium on foreign borrowing worsens the country's terms of trade and causes a drop in its welfare.

Obviously, this is a simple story, and it captures at best only a small part of what really goes on in a financial crisis. One extension that comes immediately to mind would be to include a banking sector as an intermediary between firms and both domestic and foreign lenders. If these banks were to be the ones that either default on loans or suffer the adverse effects of such default, their costs might rise on loans in both foreign and domestic currencies, increasing the cost of exports as well as imports. Qualitatively, the effect would be the same as above, but this might be more plausible, and quantitatively it could be even larger.

## V. One Cause of Crisis: A Pegged Exchange Rate

My story above did not attempt to explain why the crisis occurs, except to say that there is an unexplained loss of confidence in the country's currency. Many reasons for such a loss of confidence exist, but the one that is perhaps the most common arises in the presence of an attempt to peg an exchange rate by exchange market intervention. In this section I explore that possibility.

Suppose, then, that the government/central bank of a country attempts to peg its exchange rate at a rate, $\bar{e}$. It could easily do this by setting its money supply appropriately, but I will assume that it does not, and that instead it finds itself with an overvalued currency. To make this happen, I will start in a stationary equilibrium like those above without intervention, based upon an initially fixed money supply $M^S$ and other variables that correspond to it. Then in the current period, the government expands the money supply by a one-time percentage $p_1$ (which will turn out to be the domestic rate of inflation in the current period $t$=1) to $M_1=(1+ p_1)M^S$ that would yield, if there were no exchange-market intervention, an equilibrium exchange rate $e_1 = (1+\pi_1)e^S > e^S$. Yet rather than letting the currency depreciate, the central bank chooses to intervene, pegging at $\bar{e} = e^S$.

How can the central bank enforce its pegged rate $\bar{e}$? I will assume that it has reserves of foreign currency, *R*, perhaps accumulated during past exchange-market intervention or perhaps acquired from a swap or a bail-out from a foreign institution. It now uses these reserves to peg its exchange rate. That is, it stands ready to buy its own currency at the price $\bar{e}$ in whatever amounts are forthcoming from the market.

Thus we start the current period with quantities of both goods in transit, $X_1^S$ and $X_2^{*S}$, that were shipped in the previous period as exports and imports respectively. The world price to be received for exports, $p_1$*, remains the same, but the domestic price that will clear the domestic market for good 2 in the current period *t*=1, is increased by the monetary expansion to $p_2(1) = (1+\pi_1)p_2^S$.[7] Since it was previously true that

$$e^S p_1^* X_1^S = p_2^S X_2^{*S} \quad , \tag{29}$$

the equilibrium exchange rate in the current period without intervention would indeed be $e_1 = (1+\pi_1)e^S > e^S$, since this would increase both sides of the equation by $(1+p_1)$. Pegging the exchange rate instead at $\bar{e} = e^S < e_1$ will therefore leave the left-hand-side of equation (29), which is the demand for domestic currency on the foreign exchange market arising from (last period's) exports, unchanged. But there is still an increase in the right-hand-side, the supply of domestic currency arising from imports, by the fraction $p_1$. The central bank will have to buy this excess domestic currency, using up a part of its reserves.

[7] Similar to the argument above, this occurs because consumers have been paid $(1+p_1)M^S$, and they are offered the two goods in the same quantities as before, so that both equilibrium prices rise by the same proportion.

The change in reserves, ? $R=R_2-R_1$, will therefore be

$$\Delta R = p_1^* X_1^S - \frac{p_2(1) X_2^{*S}}{\bar{e}} = p_1^* X_1^S - \frac{(1+\pi_1) p_2^S X_2^{*S}}{e^S}$$
$$= \frac{1}{e^S}\left[e^S p_1^* X_1^S - p_2^S X_2^{*S} - \pi_1 p_2^S X_2^{*S}\right] = -\pi_1 p_2^S X_2^{*S} / e^S \tag{30}$$

That is, the central bank loses reserves during the current period in proportion to the value of imports and the extent of the over-valuation of domestic currency.

Now it is well-known in international finance that this sort of problem solves itself eventually if the central bank lets that happen, and this is true here as well. When the central bank sells foreign currency out of its reserves, it does this in exchange for domestic currency which it buys and therefore retires from circulation. That is, the domestic currency value of (30) equals the change in the domestic money supply from period 1 to period 2:

$$\Delta M = M_2 - M_1 = \bar{e}\left(-\pi_1 p_2^S X_2^{*S} / e^S\right) = -\pi_1 p_2^S X_2^{*S} \tag{31}$$

If this decline in the domestic money supply is allowed to occur, then it will gradually, over time, cause domestic prices to fall and the overvaluation to be corrected.

There are two problems with this, however. One is that the central bank may resist this deflationary change, offsetting (sterilizing) it with an additional monetary infusion to keep the money supply at its new level. Not knowing why the money supply was increased in the first place, we cannot know whether this will be done, but we also cannot rule it out. If that happens, then next period's equilibrium will be just like this one, with the same loss of reserves repeated.

The other problem is simply that there may not be enough reserves. Even without sterilization, the overvaluation will be fully corrected only when the money supply has fallen to the original level at which it began in the old stationary state. That is, we need the money supply to fall by the amount that it recently increased, $p_1M^S$, and the value of this at $\bar{e}$ may be greater than $R$. Note in particular that the central bank's ability to defend the peg during the first period is not enough, since first-period non-sterilized intervention cannot be enough to bring the money supply back to its old level. This is so because the intervention in (30) is $p_1$ times the level of imports only, while the money supply has grown by $p_1$ times the level of total income per period.

Therefore it is quite possible that the central bank will run out of reserves eventually. This will happen either necessarily if it sterilizes the effects of its intervention on the domestic money supply, or it may happen if it does not sterilize, if the value at the pegged exchange rate of the initial monetary expansion was greater than the level of reserves. Furthermore, if we can know this, then the market can know it too. Suppose we know that, in some time period down the road, the remaining reserves will be insufficient to finance the necessary intervention. The intervention will then have to stop, and the exchange rate will be determined by the market, at a level that is depreciated relative to $\bar{e}$. But in the period before that, market participants will know it is coming, and therefore we will be in the situation of the previous section, with a depreciated exchange rate expected during the next period.

Of course, there is now no reason for this expectation to arrive only in the period just before the central bank would run out of reserves without that expectation. As seen in the previous section, the expectation of a depreciation will induce those who have already exported to delay buying domestic currency until the next period. In the previous section, this caused the current exchange rate to depreciate. With a pegged rate, on the other hand, this will instead cause the central bank to have to intervene more heavily. The excess demand for foreign currency will now, in the period before the peg collapses, be the whole value of imports, not just $p_1$ times it as in (30). This in turn means that the peg will actually collapse earlier.

The point of this discussion, however, is not just to flag the unsustainability of a pegged exchange rate. Rather, it is to connect that with the adverse real effects of a financial crisis that were seen in section IV. Whenever the expectation of a depreciation first arrives, it will cause an actual depreciation then or shortly thereafter as the peg collapses, and this in turn will cause defaults on loans and an increase in the financing costs of trade that deprive the country of part or all of the gains from trade. Thus a financial crisis that originates in nominal misbehavior by the central bank can have significant adverse real effects.

## VI. Fragmentation

The point I wish to make in this section about fragmentation is simply this: Fragmentation can enhance the gains from trade, but it does so by increasing also the volume of trade that must be financed. This increases the vulnerability of a country to financial crisis, both because there is more trade being financed, and because there are greater gains from trade to be lost if a crisis undermines that financing.

To illustrate that point, I will work through just one example. Starting from the model considered so far in this paper, suppose that fragmentation becomes possible in the technology for producing good 1. That is, in addition to the unified technique of producing good 1 using $a_1$ units of labor per unit of output, it now becomes possible, everywhere in the world, to produce good 1 in two stages. In the home country, the first stage uses $a_{11}$ units of labor to produce a unit of an intermediate input, while the second stage uses one unit of the intermediate input (call it good 11) together with $a_{12}$ units of labor to produce a unit of final good 1. I assume that the fragmented technology would actually be inferior to the unified technology if both stages were done at home, in the sense that $a_{11}+a_{12}>a_1$. These two stages can be carried out in different locations, and the intermediate good 11 is freely tradable, subject only to the same requirements of financing assumed above for goods 1 and 2. Both stages can therefore be undertaken abroad, but because this is a Ricardian model, their unit labor requirements abroad are different. All that matters for the home country, however, is the prices abroad of the intermediate input, $p_{11}^*$, and of the final goods $p_1^*$ and $p_2^*$.

With these assumptions, the home country may specialize in one or the other fragment of production, or it may not, depending on how the labor requirements of both stages compare to world prices and financing costs. For my example, I will assume that $a_{11}$ is small enough relative to other parameters that the country specializes in fragment 11, producing only the intermediate input and exporting all of it in return for imports of both final goods, 1 and 2. It turns out that what is needed for this to be the outcome is the following pair of conditions:

$$\frac{a_{11}}{a_1} < \frac{1}{1+\varphi}\frac{p_{11}^*}{p_1^*} \tag{32}$$

$$\frac{a_{11}}{a_2} < \frac{1}{1+\varphi}\frac{p_{11}^*}{p_2^*} \tag{33}$$

where as before, (1+f )=(1+$r$)(1+$r$*). These say, in effect, that it must be possible to produce fragment 11, and to export it in exchange for final goods 1 and 2 respectively, cheaper than those goods can be produced at home.

With these conditions satisfied, the situation is as shown in Figure 3. The stationary equilibrium from Figure 1, without fragmentation, is shown with lightly shaded lines and output and consumption levels $Q_1^0$ and $C^0$. With fragmentation, the relevant restrictions on stationary equilibrium prices and trade are given by the following equations:

$$(1+r)p_{11} = ep_{11}^* \tag{34}$$

$$p_1 = (1+r^*)ep_1^* \tag{35}$$

$$p_2 = (1+r^*)ep_2^* \tag{36}$$

$$p_1 X_1^* + p_2 X_2^* = ep_{11}^* X_{11} \tag{37}$$

Equation (34) requires that the foreign price of exports of fragment 11 be enough to pay the domestic interest on its financing. Equations (35) and (36) do the same for imports of final goods, 1 and 2, both of which must now be financed by borrowing abroad. Equation (37) is the balance-of-payments or exchange-market-equilibrium condition, requiring that the domestic currency receipts of importers (with which they must buy foreign currency in order to repay their loans) equal the domestic currency value of exports of the fragment 11.

It is still technologically possible for the country to produce goods 1 and 2 on the transformation curve of Figure 1, and thus to produce an output $Q_1^0$ of good 1. However, with the assumed comparative advantage in fragment 11, it can do better by producing the fragment and trading it for good 1. Setting $X_2$*=0 in (37) we can solve for maximum obtainable import of good 1,

$$Q_1^F = \frac{ep_{11}^* X_{11}}{p_1} = \frac{1}{1+r^*} \frac{p_{11}^*}{p_1^*} \frac{L}{a_{11}} \tag{38}$$

which from (32) is larger than the maximum output of final good 1 produced directly:

$$Q_1^0 = \frac{L}{a_1} < \frac{L}{a_{11}} \frac{1}{1+\varphi} \frac{p_{11}^*}{p_1^*} < \frac{1}{1+r^*} \frac{p_{11}^*}{p_1^*} \frac{L}{a_{11}} = Q_1^F \tag{39}$$

Therefore, in Figure 3, the consumer's budget line starts from $Q_1^F$ to the right of $Q_1^0$. Dividing (35) by (36), the ratio of domestic prices is now the same as the ratio of foreign prices of the final goods, $p_1^*/p_2^*$. The consumption point with fragmentation, $C^F$, is therefore shown as a tangency to a budget line with this slope extending from $Q_1^F$.

It is notable that fragmentation has permitted a considerable increase in economic welfare compared to the original equilibrium $C^0$. In effect, fragmentation permits a country to expand its consumption possibilities outward, in addition to giving it access to an imported good at lower price, tilting these possibilities in its favor. Of course, this is all still just the effects of comparative advantage, but fragmentation seems to focus comparative advantage more narrowly and thus permit greater gains from specialization and trade.

But like other trade in this model, fragmentation-based trade requires financing, and the costs of financing (like other trading costs not considered here) can reduce these gains from trade. In particular, following the argument of the preceding sections, if a financial crisis raises the risk premium on borrowing from abroad and thus raises $r^*$, then the gains from fragmentation and trade will be reduced or even eliminated.

This is shown in Figure 3, where the effect of a crisis that increases $r^*$ is shown as reducing the intercept of the budget line from $Q_1^F$ to $Q_1^C$, as we know it must from equation (37). Consumption and welfare are therefore reduced, as is the volume of trade. However, if $r^*$ were to increase by even more, then this would raise f in (32), and might eliminate the country's comparative advantage in fragment 11 completely. If so, then the economy will return to the equilibrium we had without fragmentation at $C^0$, and the welfare loss will be that much greater.

Thus, although fragmentation-based trade is not intrinsically any different from any other trade that is based on comparative advantage, it does appear to make an economy more sensitive to trade costs at the same time that it expands the gains from trade. Therefore a financial crisis that increases these trade costs can have a more devastating impact.

## VII. Conclusion

The purpose of this paper has been to point out and model one link between the international financial performance of a country and its international trade. Economists have not routinely paid much attention to such links, in part because the difficulty of the subject has led most of us to specialize in studying either trade or finance, not both. But the links between trade and finance have become painfully evident to residents of several Asian economies in the last three years, as a financial crisis has caused real suffering there, at least some of which seems to have been transmitted to them by trade. This paper has tried to show one simple mechanism by which this may have happened, working through the need to finance international trade in international credit markets.

Recent research has also directed attention to international fragmentation as a means by which the world economy has become more integrated. It seems plausible in particular that the most successful of the Asian economies may have achieved their success in part by exploiting opportunities for fragmentation. This paper has suggested, however, that by doing so they may also have made themselves more vulnerable to financial crisis, with repercussions that have only recently been felt.

The message should not, however, be that increased trade and fragmentation was a mistake, in spite of that vulnerability. For what has been lost, according to this analysis, has been primarily only the gains from trade and fragmentation themselves, or a portion of them. The message should instead be that the world economy needs to find better ways to prevent crises like these. And that is a task that I will gladly outsource to my colleagues in international finance.

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Table 1
Effects of the Asian Crisis on Trade
Exports and Imports of Goods
f.o.b., Millions of U.S. $

| | | 1997 | 1998 | Percent Change |
|---|---|---|---|---|
| Indonesia | Exports | 56,298 | 50,371 | –10.5% |
| | Imports | 46,223 | 31,942 | –30.9% |
| Philippines | Exports | 25,228 | 29,496 | +16.9% |
| | Imports | 36,355 | 29,524 | –18.8% |
| Singapore | Exports | 125,746 | 110,379 | –12.2% |
| | Imports | 124,628 | 95,702 | –23.2% |
| South Korea | Exports | 138,619 | 132,122 | –4.7% |
| | Imports | 141,798 | 90,495 | –36.2% |
| Thailand | Exports | 56,652 | 55,000 | –2.9% |
| | Imports | 52,747 | 36,513 | –30.8% |

Source: IMF, *International Financial Statistics*

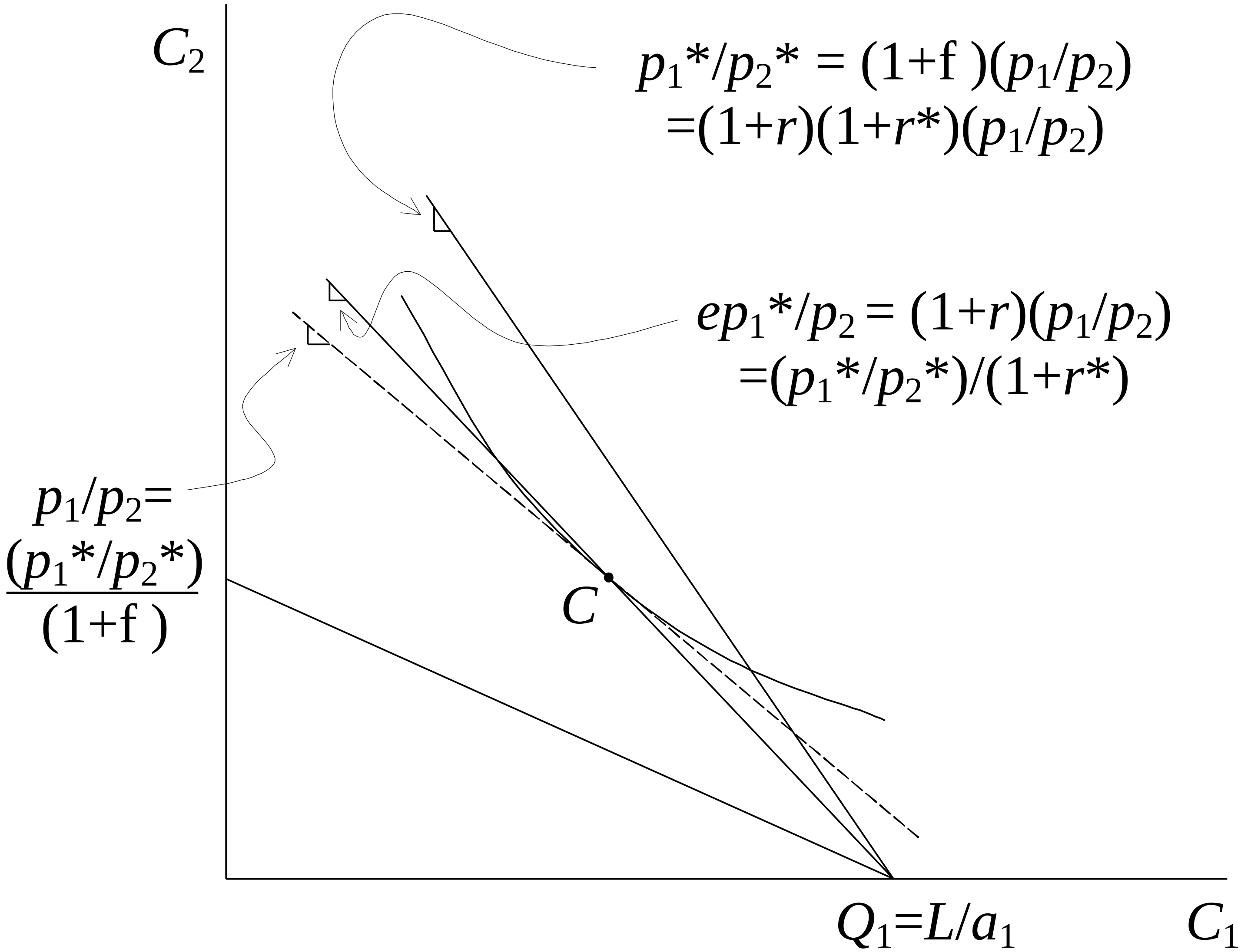


Figure 1
Trading Equilibrium with
Financing Costs of Trade

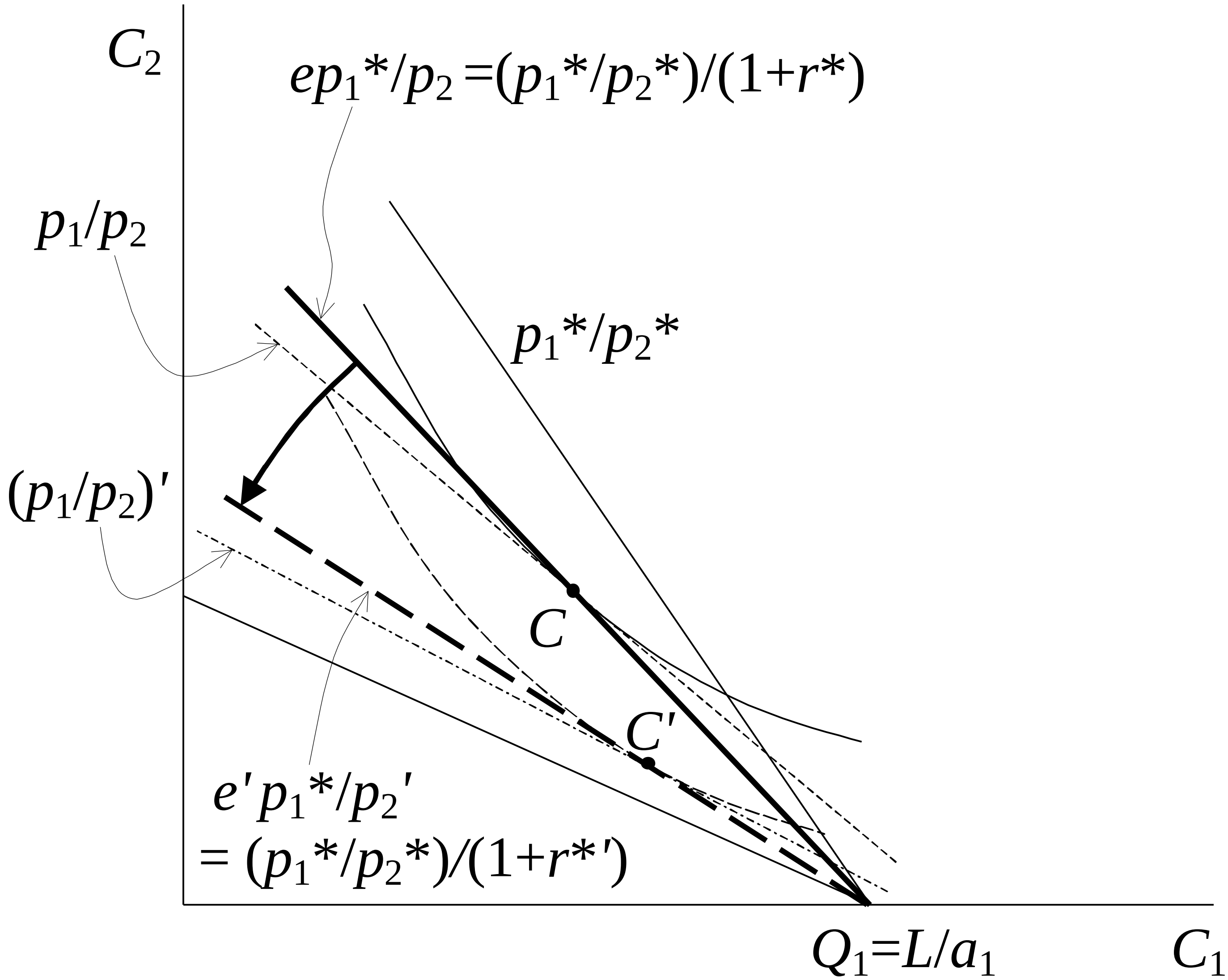


Figure 2
Effects of a Crisis that
Raises Financing Costs

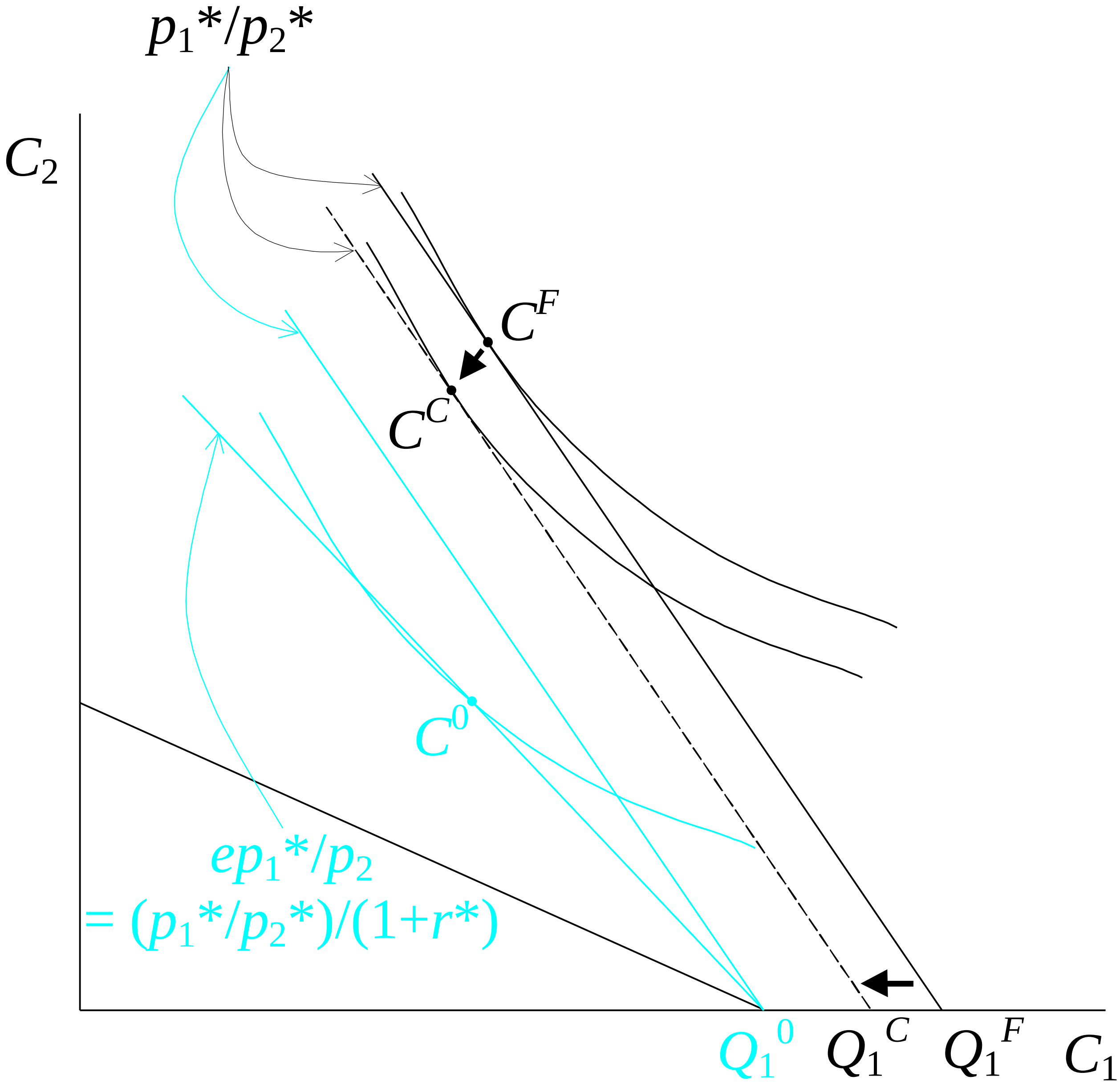


Figure 3
Trade with Fragmentation and
Effects of a Financial Crisis