Export shares, import shares and exchange rate pass-through*.

(Incomplete: theory section only)

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Abstract

Trade in intermediate goods has gained importance in recent years. Typically, in markets for those types of goods, there is a limited number of firms, both on the sellers’ and the buyers’ sides. We build a two country model in which trade in intermediate goods is characterized by the “bilateral oligopoly” model of Hendricks and McAfee (2010). Prices of inputs into the production of those goods, as well as those of final goods produced with those goods, are sticky in their domestic currency units. The model implies the following:

1. In the benchmark case in which the two countries are completely symmetric, the exchange rate pass-through rate is 50%. This prediction is in stark contrast with that of the standard model with a monopolistically competitive market, which states that the long-run pass-through rate should be 100%. Thus, the pass-through puzzle --- empirical estimates for the pass-through rate are typically far below 100% (actually often around 50%) --- may not really be a puzzle, after all.

2. Overall market share of a country matters, not only on the exporter’s side but also on the importer’s side. On both sides, a higher share implies a lower pass-through.

3. Firm sizes matter. Holding constant the overall market share for a country, the pass-through rate is lower when the individual market share for each firm is larger. This is true about both exporter’s and importer’s shares.

4. The model also points to a number of other determinants of the pass-through rate, such as the elasticities of the marginal cost curve (on the seller side) and the marginal valuation curve (on the buyer side), degrees of stickiness of input prices as well as final goods prices.

In the empirical section (to be added), we study a data set on unit values of US imports from Japan at a detailed industry level (the HS 6 digit level). We ask how those import prices are affected by the exchange rate between the two countries as well as Japan’s rival countries’ exchange rates. We investigate how magnitudes of those effects are correlated with Japan’s and rival countries’ market shares on both the exporter’s and the importer’s sides.
I. Introduction

In this paper, we develop a new theoretical framework for understanding the issue of exchange rate pass-through. Our two country model is centered around a market for intermediate goods, which is characterized by “bilateral oligopoly”. That is, number of market participants is finite both on the seller and the buyer sides. We find that, in a case in which the two countries are symmetric, the predicted pass-through rate is 50%, as opposed to 100% implied by the standard model. We also find that market shares matter. A higher overall market share of a country, not only on the seller side but also on the buyer side, leads to lower pass-through. On the other hand, a country with larger shares for individual firms, holding constant the overall share of all the firms, tends to experience higher pass-through.

This paper is motivated by an observation that trade in intermediate goods has gained importance in recent years. For example, in Japan, the share of those types of goods in total exports is about 60%\(^1\). Transactions of intermediate goods are often characterized by a limited number of participants, not only on the seller’s side but also on the buyer’s side. This casts doubts on the usefulness of the workhorse of modern open economy macroeconomics, namely the model of monopolistic competition. In such a model, there are infinitely many sellers and buyers, and, importantly, only the sellers are given monopoly power. In this paper, we propose an alternative theoretical framework which we believe captures the reality of today’s trade better. It is based on the “bilateral oligopoly” model of Hendricks and McAfee (2010), extended to a two country situation. In this model, there are limited numbers of both sellers and buyers. As a consequence, both sides possess certain degrees of monopoly power. We investigate how firms react to a change in the exchange rate under such a circumstance, and study responses of prices.

One notable conclusion from our model is that, in a symmetric equilibrium (which will be exactly defined below), the rate of response of the price of internationally traded intermediate goods to a change in the exchange rate is exactly 50%. This is in a sharp contrast with a prediction of the conventional model with monopolistic competition (and the assumption of constant price elasticities) that the “pass-through rate”, in the absence of

\(^1\) The share of capital goods, whose transaction also tend to be characterized by a limited number of participants, is slightly over 20%. Taken together, they make up as much as 80% of Japan’s exports. Their combined share in the country’s imports is around 50%.
nominal price stickiness, should be 100%. The intuition behind our result is that, in our model, monopoly powers are distributed between the seller side and the buyer side. When there is a force that tries to stabilize a price of a good measured in the units of one country’s currency, and another force that tries to keep the price denominated in the other country’s currency stable, and if the two forces happen to be of equal strength, we naturally obtain the “50%” result. We will see that the same intuition carries over to the short run when prices of domestically traded inputs and goods are sticky.

In the empirical literature on the exchange rate pass-through, authors have repeatedly found evidence for an incomplete pass-through, both for the long run and the short run estimates (Campa and Goldberg (2005) for example). Those estimates are often scattered around 50%, and this fact has been regarded as a big puzzle, from the viewpoint of the above conventional theories. Our results suggest that it might not be so puzzling, after all.

In our model, market shares play important roles as well. We find that a country whose firms, taken as a group, make up a larger overall share of a market, tends to experience lower pass-through. This is true not only of the market share on the seller side but also on the buyer side. Holding constant those overall shares, we find that a country with larger market shares for individual firms (i.e., a country with fewer firms) tends to experience higher pass-through. Again, this statement applies to market shares on the seller side as well as on the buyer side.

Our model in this regard is closely related to existing studies on the relationship between market shares and exchange rate pass-through. Dornbusch (1987) was an early advocate of using oligopolistic models, as opposed to models of monopolistic competition, to understand reactions of prices to exchange rate movements. Feenstra, Gagnon and Knetter (1996) develop a model characterized by a Bertrand competition among sellers and a demand function with a reservation price (and thus deviates from the standard Dixit-Stiglitz formulation). They show that the pass-through rate depends on relative market shares between domestic and foreign firms. Sbordone (2007) introduces a demand structure in which the price elasticity varies with market shares. This model is used to study implications of globalization on inflation dynamics. Benigno and Faia (2010) extends the model of Dornbusch (1987) into an open economy New Keynesian type model in which firms derive monopoly power not through product differentiation but from non-zero market shares. They also study implications of globalization (which causes changes in relative market shares) on inflation dynamics.
This paper is a companion paper of Shioji and Uchino (2011). In the previous paper, we introduced nominal price stickiness in trade in intermediate goods. In contrast, in the model of this paper, there is no pricing friction in the intermediate goods market. Instead, producers of intermediate goods face sticky nominal prices of domestically supplied inputs. Also, buyers of those goods are supposed to use them to produce final goods, whose prices are also sticky.

The remainder of the paper is structured as follows. In the next section, we provide a brief overview of our three types of models, namely models 1, 2 and 3. In section III, we present our model 1, which is a simple extension of the original model of Hendricks and McAfee (2010) to a two country world. Section IV develops model 2, which adds suppliers of inputs to the intermediate goods producers, as well as the demand for final goods produced with those goods. In section V (to be added), we study determinants of US import prices from Japan. Section VI concludes.

II. How we proceed

This section offers an overview of our modeling strategy. In this paper, we start from a simple model, called “Model 1” or the “Industry Equilibrium”, with only one industry and two types of firms. The first type of firms, called type-A firms, are sellers of intermediate goods. They employ inputs, whose prices are assumed to be exogenously given, to produce intermediate goods. Those goods are sold to the second type of firms, called type-B firms, which are buyers of those goods. They use those intermediate goods to produce final goods. Prices of those final goods are also taken as given in this analysis. In “Model 2” or the “Sector Equilibrium” model, we introduce nominal price stickiness in prices of both inputs and final goods. For that purpose, we introduce pricing decisions by both the suppliers of inputs and by the suppliers of final goods (namely type-B firms). In “Model 3” or the “General Equilibrium” model, we introduce another, more conventional sector of production, dynamic optimization by the representative household, and a monetary policy rule.

II-1 Intermediate goods market: prototype bilateral oligopoly model of Hendricks and McAfee (2010)

In this sub-section, we overview the bilateral oligopoly model developed by Hendricks and
McAfee (2010) (though our exposition is slightly different from theirs). This model will provide a foundation for our own analysis.

The basic idea is presented in Figure 1-0. Consider a market for a single type of intermediate goods within a country. Within this market, all the intermediate goods are homogeneous: there is no product differentiation. There are finite numbers of sellers of intermediate goods, called “type-A firms”, and buyers of those goods, called “type-B firms”. type-A firms employ inputs, whose prices are treated as given here, to produce intermediate goods. Type-B firms purchase the intermediate goods from them and produce final goods, called “F goods”, whose prices are also taken as exogenous. Type-A firms and type-B firms cannot engage in direct negotiations. It is assumed that there is an auctioneer in the middle of the market, and each type-A firm reports to her its desired seller price, or “ask price”, while each type-B firm expresses its desired buyer price, or a “bid price”. Those reported prices do not have to be a representation of each firm’s “true” desired price, namely the marginal cost of producing a unit of intermediate goods for a type-A firm or the marginal valuation of a unit of intermediate goods for a type-B firm. The auctioneer aggregates all the ask and bid prices and determines the transaction price for the intermediate good, allocates an amount of sales to each type-A firm and an amount of purchase for each type-B firm. She will assign a smaller amount of sales to a type-A firm who posted a higher ask price, and a larger amount of purchase to a type-B firm who placed a higher bid price. As a consequence, each type-A firm faces a downward sloping demand curve. That is, by posting a higher ask price, the firm can raise the equilibrium transaction price. But, as it raises its ask price, it will be permitted to sell smaller amount of goods. Each type-A firm takes as given the auctioneer’s rule, the other type-A firms’ ask prices, as well as all the type-B firms’ bid prices, and chooses its own ask price optimally. If the firm has a greater monopoly power, it will be more willing to post a higher ask price, i.e., it will try to charge a higher markup. On the other hand, the above rule also implies that a type-B firm faces an upward sloping supply curve. By reporting a lower bid price, it can lower the equilibrium transaction price, but will be assigned a smaller quantity of intermediate goods. Each type-B firm takes as given the auctioneer’s rule, the other type-B firms’ bid prices, as well as all the type-A firms’ ask prices, and chooses its own bid price optimally. When a type-B firm faces a less severe competition, it will have a greater incentive to post a lower bid price, i.e., it will try to force a larger markdown.
II-2 Model 1: Industry equilibrium
In Model 1, in which we consider a single industry, we simply extend the above prototype model into a two country environment. Suppose that there are two countries, home and foreign. The nominal exchange rate between them is taken as given until it is endogenized in Model 3. Consider an industry in which there are finite numbers of type-A firms and type-B firms in both of the countries. As in the original one country model, type-A firms in both countries submit their respective ask prices, while type-B firms in both countries post their bid prices. Home firms quote their ask or bid prices in home currency units, while foreign firms express their ask or bid prices in foreign currency units. Only intermediate goods are traded: inputs are all domestically supplied, and final goods (F goods) are all domestically consumed. In this analysis, home prices of both inputs and F goods are treated as fixed in the home currency units. Their foreign prices, on the other hand, are exogenously given in foreign currency units. The auctioneer translates ask and bid prices posted by foreign firms into home currency units, and determines the transaction price of the intermediate goods as well as allocation of sales and purchase to each of type-A and type-B firms. The idea of this model is sketched in Figure 1-1.

II-3 Model 2: Sector equilibrium
We then extend the model to consider an equilibrium in the entire intermediate goods sector. The main idea is sketched in Figure 1-2. In Model 2, we assume that the intermediate goods “sector” consists of infinitely many “industries”. Each industry is characterized by Model 1 above. In each of those industries, only type-B firms in that industry have the technology to make use of intermediate goods supplied by type-A firms of the same industry, and those type-B firms have no technology to utilize intermediate goods supplied by type-A firms that belong to different industries.
Hence, in the input market, there are infinitely many type-A firms competing for inputs. We assume that, in this market, each type-A firm acts as a price taker. On the other hand, inputs are differentiated and each input supplier has a monopoly right to supply a single type of inputs to all the type-A firms. Thus, the input market is characterized by monopolistic competition.
Final goods (F goods) are also differentiated. Each type-B firm produces its own type of F goods; they are imperfect substitutes both for F goods produced by the other type-B firms in the same industry, and for F goods produced by type-B firms in the other industries. In
the F goods market, each type-B firm faces a downward sloping demand curve, and the market is characterized by monopolistic competition.

We assume that an input supplier has to pay a Rotemberg style adjustment cost when changing the price of inputs (quoted in its own country’s currency units) it supplies to type-A firms. We also assume that each type-B firm has to pay a similar adjustment cost when changing the price of F goods it produces (also quoted in its own country’s currency unit).

In the intermediate goods market, type-A firms and type-B firms are free to choose their ask and bid prices, that is, there is no nominal price stickiness in the market. However, as discussed above, each type-A firm faces input prices that are sticky in its own currency units. Also, each type-B firm sells products whose prices are sticky in its own currency units. This creates an incentive for each of the type-A firms to try to stabilize the transaction price of intermediate goods in the units of its own country’s currency. A similar incentive also arises for each of the type-B firms. Thus, a change in the exchange rate will create opposing incentives between home firms and foreign firms.

III. Model 1: “Industry equilibrium”

Consider a world economy that consists of two countries, home and foreign. The structure of the two countries is basically the same, although specific parameter values might differ between them. In what follows, the superscript “*” denotes foreign variables, while those variables without the superscript are either associated with the home country or variables that are common to the two countries. For the moment, we omit the time subscript t for the sake of exposition.

In this section, we focus on a single industry which is centered around a market for intermediate goods. We denote the number of type-A firms (sellers of intermediate goods) by $N_A$ and the number of type-B firms (buyers of intermediate goods) as $N_B$, respectively.

Corresponding foreign variables will be denoted as $N_A^*$ and $N_B^*$.

III-1 type-A firms (sellers of intermediate goods)

Consider the $i$th type-A firm at home ($i=1, 2, \ldots, N_A$). Its production of intermediate goods and employment of inputs will be denoted as $q_{Ai}$ and $x_{Ai}$, respectively. The production
function is assumed to take the following form:

\[ q_{Ai} = A_i^{1-\alpha_A} \cdot x_{Ai}^{\alpha_A}, \quad \text{where} \quad 0 < \alpha_A < 1 \]  

(1)

Here, \( A_i \) denotes the productivity which can potentially differ across firms, while \( \alpha_A \) is assumed to be common across the two countries. The intermediate good is homogeneous within an industry. Its price measured in the home currency units is denoted as \( P_M \). Denote the nominal price of an input at home as \( P_I \). Then this firm’s nominal profit is given by

\[ \pi_{Ai} = P_M \cdot q_{Ai} - P_I \cdot x_{Ai} = P_M \cdot q_{Ai} - P_I \cdot A_i^{-(1-\alpha_A)/\alpha_A} \cdot q_{Ai}^{1/\alpha_A}. \]  

(2)

By differentiating the second term on the right hand side of equation (2), namely the nominal cost, by output \( q_{Ai} \), we obtain the nominal marginal cost function:

\[ MC_{Ai} = P_I \cdot A_i^{-a_A} \cdot (1/\alpha_A) \cdot q_{Ai}^{a_A}, \]

where \( a_A \equiv \frac{1-\alpha_A}{\alpha_A} \).  

(3)

Here, introduce a new variable:

\[ P_{Ai} = P_I \cdot A_i^{-a_A} \]  

(4)

which governs the height of the nominal marginal cost function in (3). We can use this to rewrite the nominal marginal cost in the form of the following function:

\[ MC_{Ai}(P_{Ai}, q_{Ai}) = P_{Ai} \cdot (1/\alpha_A) \cdot q_{Ai}^{a_A}. \]  

(5)

III-2 type-B firms (buyers of intermediate goods)

Consider next the \( j \)th type-B firm \( (j=1, 2, \ldots, N_B) \). Its production of \( F \) goods is denoted as \( y_{Fj} \), while the amount of intermediate goods it purchases is \( q_{Bj} \). Then the production function is written as:

\[ y_{Fj} = B_j^{1-\alpha_B} \cdot q_{Bj}^{\alpha_B}, \quad \text{where} \quad 0 < \alpha_B < 1. \]  

(6)

Again, \( B_j \) denotes the productivity, while the parameter \( \alpha_B \) is common across the countries. Let the price of \( F \) goods be \( P_F \), which is taken as fixed in this section. Then the nominal profit of this firm is:
\[ \pi_{ Bj} = P_{ Bj} \cdot y_{ Bj} - P_{ M} \cdot q_{ Bj} = \left[ P_{ Bj} \cdot \left( B_{ j} \right)^{(1-\alpha_{ P})} \right] \cdot \left( q_{ Bj} \right)^{\alpha_{ P}} - P_{ M} \cdot q_{ Bj}. \]  
(7)

Again, define a new variable:
\[ P_{ Bj} = P_{ Bj} \cdot \left( B_{ j} \right)^{\alpha_{ P}} \]
where \( a_{ P} = 1 - \alpha_{ P} \)

which governs the magnitude of marginal valuation of intermediate goods purchases for this firm, i.e., by how much its nominal revenue increases from purchasing an extra unit of intermediate goods. Differentiate the first term on the right hand side of (7) by \( q_{ Bj} \) to get:
\[ MV_{ Bj} (P_{ Bj}, q_{ Bj}) = P_{ Bj} \cdot \alpha_{ P} \cdot q_{ Bj}^{-\alpha_{ P}} \]
where \( MV \) stands for “marginal valuation”.

III-3 Foreign firms

Problems that foreign firms face are similar to the above. Let the nominal exchange rate be denoted as \( e \) (an increase in \( e \) means a depreciation of the home country). Let the \( i \)th foreign type-A firm’s nominal marginal cost, evaluated in the home currency units, as
\[ MC_{ Ai}^{*} (eP_{ Ai}^{*}, q_{ Ai}^{*}) = eP_{ Ai}^{*} \cdot \left( 1 / \alpha_{ A} \right) \cdot q_{ Ai}^{* \cdot \alpha_{ A}}. \]
(10)

Also, we denote the \( j \)th foreign type-B firm’s nominal marginal valuation, evaluated in home currency units, as
\[ MV_{ Bj}^{*} (eP_{ Bj}^{*}, q_{ Bj}^{*}) = eP_{ Bj}^{*} \cdot \alpha_{ B} \cdot q_{ Bj}^{* \cdot -\alpha_{ B}}. \]
(11)

III-4 Equilibrium in a bilaterally oligopolistic market

As intermediate goods within an industry are assumed to be homogeneous, the law of one price holds. That is,
\[ P_{ M}^{*} = e \cdot P_{ M}^{*}. \]
(12)

In the market, firms report their evaluation of their own \( P_{ Ai}^{*} \), \( P_{ Ai}^{*} \), \( P_{ Bj}^{*} \), or \( P_{ Bj}^{*} \) to the auctioneer. They do not have to be their true values. Those submitted numbers (or the “ask
prices” and the “bid prices”) will be denoted ˆ\( P_{Ai} \), ˆ\( P_{Ai}^* \), ˆ\( P_{Bj} \), and ˆ\( P_{Bj}^* \). The auctioneer solves the following two sets of conditions to determine the price of an intermediate good \( P_M \), total amount of intermediate goods produces, \( Q \), and assigns the amount of transaction to each firm.

\[
Q = \sum_{i=1}^{N_A} q_{Ai} + \sum_{i=N_A+1}^{N_A+N_B} q_{Ai}^* = \sum_{j=1}^{N_B} q_{Bj} + \sum_{j=N_B+1}^{N_B+N_A} q_{Bj}^*, \quad (13)
\]

and

\[
P_M = MC_A(\hat{P}_{Ai}, q_{Ai}) = MC_A^*(e\hat{P}_{Ai}^*, q_{Ai}^*) = MV_{Bj}(\hat{P}_{Bj}, q_{Bj}) = MV_{Bj}^*(e\hat{P}_{Bj}^*, q_{Bj}^*)
\]

(for all \( i \) and \( j \)). \( (14) \)

The auctioneer’s allocation rule in (14) implies that an type-A firm that posts a higher ask price tends to be allocated a smaller quantity of sales, while a type-B firm that posts a higher bid price tends to be allocated a larger quantity of purchases.

Now we solve for the equilibrium under the assumption that both type-A and type-B firms are symmetric within each country. Given the auctioneer’s pricing and allocation rules, each firm solves its profit maximization problem. Defining

\[
b_A = \frac{a_A^{-1}}{a_A^{-1} + a_B^{-1}}, b_B = 1 - b_A,
\]

we obtain:

\[
\frac{P_A}{P_{A}^*} = 1 - a_A \cdot \frac{b_A \cdot s_A}{1 - b_A \cdot s_A}, \quad (15-1), \quad \frac{P_{A}^*}{P_A} = 1 - a_A \cdot \frac{b_A \cdot s_A^*}{1 - b_A \cdot s_A^*} \quad (15-2)
\]

\[
\frac{P_B}{P_{B}^*} = 1 + a_B \cdot \frac{b_B \cdot s_B}{1 - b_B \cdot s_B}, \quad (16-1), \quad \frac{P_{B}^*}{P_B} = 1 + a_B \cdot \frac{b_B \cdot s_B^*}{1 - b_B \cdot s_B^*} \quad (16-2)
\]

where \( s_A \) etc. are individual market shares:

\[
s_A = \frac{q_{Ai}}{Q} \quad (i=1, \ldots, N_A), \quad s_A^* = \frac{q_{Ai}^*}{Q} \quad (i=N_A+1, \ldots, N_A+N_B),
\]

\[
s_B = \frac{q_{Bj}}{Q} \quad (j=1, \ldots, N_B), \quad s_B^* = \frac{q_{Bj}^*}{Q} \quad (j=N_B+1, \ldots, N_B+N_A),
\]

and thus \( N_A s_A + N_A s_A^* = 1, \quad N_B s_B + N_B s_B^* = 1 \). \( (17-3) \)
Equations (15) state that type-A firms charge a markup over its true marginal cost. The markup rate is an increasing function of each firm’s market share. Equations (16) state that type-B firms gain a markdown under its true marginal valuation. The markdown rate is a decreasing function of each firm’s market share.

Under the auctioneer’s allocation rule, those shares have to satisfy the following relationships:

\[
\left( \frac{s_A}{s_A^*} \right)^{\alpha_A} = \frac{\hat{P}_A'(e)}{eP_A^*} \quad (18)
\]
\[
\left( \frac{s_B}{s_B^*} \right)^{\alpha_B} = \frac{\hat{P}_B'(e)}{eP_B^*} \quad (19)
\]

Equations (15-1), (15-2) and (18) together determine the two ask prices and the relative market share between the home type-A firms and the foreign type-A firms. Equations (16-1), (16-2) and (19) together determine the two bid prices and the relative market share between the home type-B firms and the foreign type-B firms. Once we have solved for the ask and bid prices, the transaction price, \( P_M \), can be derived as:

\[
P_M^{1/a_A+1/a_B} = \left[ N_B \left( \frac{\hat{P}_B}{\alpha_B} \right)^{1/a_B} + N_B^* \left( \frac{eP_B^*}{\alpha_B} \right)^{1/a_B} \right] / \left[ N_A \left( \frac{\hat{P}_A}{\alpha_A} \right)^{-1/a_A} + N_A^* \left( \frac{eP_A^*}{\alpha_A} \right)^{-1/a_A} \right] \quad (20)
\]

III-5 Effects of the exchange rate

Suppose that the exchange rate \( e \) increased, that is, the home currency depreciated, by 1%. How would that affect the pricing behaviors of the firms? First, for home type-A firms, we can show:

\[
\frac{d \ln \hat{P}_A}{d \ln e} = \frac{g(s_A)/S_A}{a_A(1/S_A + 1/S_A^*) + g(s_A^*)/S_A + g(s_A^*)/S_A} > 0 \quad (21-1)
\]

where \( S_A = N_A s_A, S_A^* = N_A^* s_A^* \), and thus \( S_A + S_A^* = 1 \)

The function \( g(.) \) on the right hand side is the “elasticity of gross markup with respect to market share” and satisfies:

\[
g(s) = \frac{a_A b_s s}{(1-b_s s/\alpha_A)(1-b_s s)} , \quad g'(s) > 0
\]

Equation (21-1) states that a currency depreciation leads to a greater market share for each
type-A firm at home, and thus they can now charge greater markups. Its right hand side is a decreasing function of $S_A$. That is, if the overall presence of home type-A firms was as a group large from the beginning, the impact of a depreciation tends to be smaller. As $g^* > 0$, holding constant $S_A$, the right hand side is an increasing function of $s_A$. That is, if each home type-A firm is larger, in response to a currency depreciation, it reacts more aggressively by raising the markup rate further. Likewise, we can show:

$$\frac{d \ln \hat{P}_d^*}{d \ln e} = -\frac{g(s_d^*) / S_d^*}{a_d(1 / S_d + 1 / S_d^*) + g(s_d) / S_d + g(s_d^*) / S_d^*} < 0$$  \hspace{1cm} (21-2)$$

$$\frac{d \ln \hat{P}_d^*}{d \ln e} = \frac{h(s_b) / S_b}{a_b(1 / S_b + 1 / S_b^*) + h(s_b) / S_b + h(s_b^*) / S_b^*} > 0$$  \hspace{1cm} (22-1)$$

$$\frac{d \ln \hat{P}_d^*}{d \ln e} = -\frac{h(s_b^*) / S_b^*}{a_b(1 / S_b + 1 / S_b^*) + h(s_b) / S_b + h(s_b^*) / S_b^*} < 0$$  \hspace{1cm} (22-2)$$

$$h(s) = \frac{a_d b_a s}{1 + a_d b_a s / (1 - b_a s)}, \quad h'(s) > 0$$

Finally, the effect on the transaction price is:

$$\frac{d \ln P_M}{d \ln e} = b_d S_d^* + b_b S_b^* + b_a \frac{g(s_d) - g(s_d^*)}{a_d(1 / S_d + 1 / S_d^*) + g(s_d) / S_d + g(s_d^*) / S_d^*}$$

$$+ b_b \frac{h(s_b) - h(s_b^*)}{a_b(1 / S_b + 1 / S_b^*) + h(s_b) / S_b + h(s_b^*) / S_b^*}$$  \hspace{1cm} (23)$$

The first term on the right hand side implies that the response of $P_M$ is an increasing function of overall market shares of both foreign type-A and foreign type-B firms. The remaining terms indicate that market shares of individual firms matter. For example, in response to a home currency depreciation, home type-A firms will start charging higher markups while foreign type-A firms lower them. If each home type-A firm has a larger market share than its foreign competitor, holding constant their overall market share as a group, the former effect will dominate and $P_M$ will increase. However, as we shall see later, numerical examples suggest that the roles of those individual firms’ market shares are quantitatively small.
III-6 Two benchmark cases
To see some of the implications of equation (23), consider the following two different
benchmark cases.

(Benchmark 1) There are equal number of sellers and equal number of buyers in each
country \((N_A = N_A^* \text{ and } N_B = N_B^*)\), and all the productivity terms \((A \text{ and } B)\) are the same
between the two countries.

(Benchmark 2) All the type-A firms are in one country, and all the type-B firms are in the
other country. In addition, the elasticities of the marginal cost (for the type-A firms) and the
marginal valuation (for the type-B firms) are the same: \(a_A = a_B\), which implies \(b_A = 0.5\).

In both of the benchmark cases, \(P_M\), the price of intermediate goods in the home currency
unit, increases by 0.5% in response to a 1% home currency depreciation. That is, the
exchange rate pass-through is 50%.

III-7 Numerical results

In this sub-section, we compute responses of the ask and bid prices as well as the
transaction price to a home currency depreciation. The purpose is to see how the shapes of
those responses change when we alter one (or some) of the underlying parameter values. In
every exercise that follows, we start from the above benchmark case 1, namely the situation
of a complete symmetry. Underlying parameter values in the benchmark case are as
follows:
\[ \alpha_A = 2/3, \alpha_B = 1/2, \ e = 1, \ N_A = N_A^* = N_B = N_B^* = 2. \]

Other parameter values are determined so that
\[ P_A = P_A^* = P_B = P_B^* = 1 \]
will be satisfied. In all the panels in Figure 2, the vertical axis measures the percentages
responses of the transaction price as well as the ask and bid prices.

(i) Changing country shares
In Figure 2(1), we compute responses of ask, bid and transaction prices under different
assumptions about the number of home type-A firms \((N_A)\). When we change \(N_A\), we adjust
the values of $P^*_A$ and $P^*_B$ at the same time, so that the initial market shares of individual type-A firms will be the same across the countries all the time. That is, as we move further to the right, the overall share of home type-A firms as a group increases. Note, from the figure, that, as $N_A$ increases, each home type-A firm becomes less aggressive in demanding a higher markup. This is because the market share per firm is reduced. The response of the transaction price measured in the home currency unit, $P_M$, is reduced as the overall market share of foreign firms, that wish to pass the exchange rate change onto the transaction price, is reduced.

In Figure 2(2), we change the number of home type-B firms ($N_B$) instead in a similar manner. The effects on $P_M$ turn out to be similar.

(ii) Changing home firm sizes

In Figure 2(3) we again change the number of home type-A firms, but this time, we keep the overall share of those firms as a group at 0.5 at all times. This means that, as we move to the right along the horizontal axis, each home type-A firm becomes smaller in size. As a consequence, they become less aggressive in demanding higher markups in response to a currency depreciation which favors them. The other groups of firms do not change their behaviors concerning the ask and bid prices. As a result of all this, the response of the transaction price, $P_M$, is weakened, but only to a negligible extent.

In Figure 2(4), we change the number of home type-B firms, and the basic results are the same: those firms that lose individual market shares will react less aggressively, but that has only a limited influence on the response of $P_M$.

(iii) Changing the elasticities of the marginal cost or the marginal valuation

In Figure 2(5), we study what happens when we change the value of $\alpha_A$. As we move to the right along the horizontal axis, the marginal cost curves for type-A firms become flatter. Intuitively, between the sellers side and buyers side, the “flatter side” can react more aggressively to cost changes. As $\alpha_A$ becomes larger, type-A firms react more aggressively. The transaction price, $P_M$, is unchanged, as the entire market structure always remains symmetric in this experiment.

In Figure 2(6), we change $\alpha_B$ instead. As we move to the right, the marginal valuation curves for type-B firms become flatter, and the responses of those firms are strengthened.
Again, as the symmetry of the market structure is always preserved, $P_M$ is unchanged.

IV. Model 2: “Sector equilibrium”

In this section, we consider equilibrium in the entire intermediate goods sector. It is assumed that there is a continuum of intermediate goods industries, and they are all identical. The number of industries is normalized to equal 1. Thus, the numbers of type-A and type-B firms at home are equal to $N_A \cdot 1 = N_A$ and $N_B \cdot 1 = N_B$, respectively. This also means that, as each type-B firm produces a unique type of F goods, there are $N_B$ types of F goods in total at home. Now we consider input suppliers’ pricing and the type-B firms’ pricing decisions. In the below, we shall only explain the case of home input suppliers and the home type-B firms, but the foreign cases are completely symmetric.

IV-1 Input suppliers’ pricing

Suppose that there are infinitely many input suppliers and their total number is equal to 1. We index them by $k \ (0 \leq k \leq 1)$. Each supplier has the monopoly right to supply one brand of inputs. Its marginal cost for supplying inputs to type-A firms is given by:

$$MC_{lAk} = \left( \frac{\omega_l x_k}{x_{ak}} \right)^{\frac{1}{\psi_l}} W \frac{1}{A_l}, \quad 0 < \omega_l < 1, \psi_l < 0$$

(24)

where $x_k$ is the total amount of inputs this firm supplies, $W$ is the nominal wage (taken as exogenous in this section) and $A_l$ is the productivity parameter. The meaning of $x_k$ will be clarified in the general equilibrium analysis, but, for the moment, it suffices to know that, in equilibrium, it will be equal to $X$, aggregate supply of inputs, which we could think of it as an exogenous parameter in the current analysis: $x_k=X$ for $k$. The firm faces a downward sloping demand curve:

$$x_{ak} = \left( \frac{P_{lAk}}{P_{lA}} \right)^{-\theta_l} X_A, \quad 0 < \theta_l$$

(25)

where $P_{lAk}$ is the nominal input price this firm charges to type-A firms, $P_{lA}$ is the average input price across all the input suppliers, and $X_A$ is the total demand for inputs from type-A firms. Each input supplier has to pay a Rotemberg-style price adjustment cost when it wants to change $P_{lAk}$. 

16
\[
\Psi_{j,t} = \frac{\psi_{j,t}}{2} \left[ \frac{P_{j,t} - P_{j,t-1}}{P_{j,t-1}} \right]^2. 
\]  

Each input supplier’s objective is to maximize the discounted sum of profits, where the discount factor \( \beta \) is treated as exogenous in this section. We omit the optimization condition to save space, but the solution is a standard one.

IV-2 Pricing of final goods

Suppose that each type-B firm faces the following demand curve for its own brand of F goods:

\[
y_{jF} = \left( \frac{P_{jF}}{P_F} \right)^{-\theta_F} \cdot y_F \Rightarrow \frac{P_{jF}}{P_F} = \left( \frac{y_{jF}}{y_F} \right)^{-1/\theta_F} \quad \text{where} \quad \theta_F > 1. \tag{27}
\]

In the above, \( P_F \) is the average price of F goods at home, and \( y_F \) is the total output of final goods, \( Y_F \), divided by \( N_B \). This means that we need to modify the nominal profit of this type-B firm as:

\[
\pi_{jB} = P_F \cdot \left( \frac{y_{jF}}{y_F} \right)^{-1/\theta_F} \cdot y_{jF} - P_M \cdot q_{jB} \\
= \left[ P_F \cdot y_F^{-1/\theta_F} \cdot (B_j)^{(1-\alpha_g)(1-1/\theta_F)} \right] \left( q_{jB} \right)^{\alpha_g(1-1/\theta_F)} - P_M \cdot q_{jB} \tag{28}
\]

We also need to modify the definition of the true marginal valuation parameter as:

\[
P_{jB} \equiv P_F \cdot y_F^{-1/\theta_F} \cdot (B_j)^{(1-\alpha_g)(1-1/\theta_F)} \tag{29}
\]

Also, the marginal valuation function is modified to:

\[
MV_{jB}(P_{jB}, q_{jB}) = P_{jB} \cdot \alpha_g(1-1/\theta_F)q_{jB}^{\alpha_g(1-1/\theta_F)-1}. \tag{30}
\]

The remaining conditions for type-B firms that we went through in the previous section all need to be modified accordingly.

This firm also faces a Rotemberg style price adjustment cost:

\[
\Psi_{jF} = \frac{\psi_{jF}}{2} \left[ \frac{P_{jF,t} - P_{jF,t-1}}{P_{jF,t-1}} \right]^2. \tag{31}
\]

Finally, total demand for final goods is given by:
\[ Y_F = \omega \left( \frac{P_F}{P} \right)^{-\rho} \cdot C, \quad 0 < \omega < 1, \ 0 < \rho \]  

(32)

Here, \( \omega \) is an expenditure share parameter, and \( \rho \) signifies the price elasticity of demand. The variable \( C \) is total consumption of the country and is treated as given in this section.

IV-3 Impulse response analysis

In this sub-section we present some results from our impulse response analyses. In all the exercises, we suppose that the nominal exchange rate initially increases by 0.1 percent above its steady state value (that is, the home currency depreciates), and then reverts back to the original position, following an AR(1) process with the persistence parameter of 0.95. The rest of the benchmark parameter values are summarized in Table 1.

(1) Changing country shares

In Figure 3-1, we compute impulse responses under different assumptions about the value of \( N_A \), namely the number of type-A firms at home. Within each panel, different plots correspond to the value of \( N_A \) of 2, 3, 4 and 5, respectively. We always maintain the number of foreign type-A firms, \( N_A^* \), at 2. In every exercise, we adjust the productivity parameters so that the individual firms’ market shares will be equalized across all the type-A firms in two countries. Thus, differences between \( N_A \) and \( N_A^* \) imply differences in overall market shares between the two countries. In the first panel, we plot the responses of the transaction price. We also plot the response of the exchange rate itself, for the sake of comparison. Again, in the benchmark case in which the overall market shares are 50% for both countries, the response of \( P_M \) to the exchange rate is 50%. As \( N_A \) increases, that is, as the market share of home type-A firms as a whole increases, the transaction price measured in home currency units becomes less responsive to the exchange rate. In the second panel, we depict the responses of home type-A firms’ ask price, \( \hat{P}_A \). Comparing the different plots within the panel, we see that, as \( N_A \) increases, the response becomes more muted. This is because a higher \( N_A \) means that each home type-A firm’s market share is lower. As a consequence,
they become less aggressive in raising their markups in reaction to a favorable exchange rate movement. This result is consistent with our finding from Model 2.

(2) Changing other parameter values
In Figure 3-2, we investigate how the shapes of the impulse responses change as we vary some of the other parameter values. In panel 1, we experiment with different values of \( \rho_i \), which governs the elasticity of input supply to type-A firms. In panel 2, we see what happens when we change \( \rho \), the demand elasticity for F goods produced by type-B firms. In panel 3, we study consequences of different assumptions on \( \psi_f \), the adjustment cost parameter for input prices. In panel 4, different plots correspond to different values of \( \psi_f \), the adjustment cost parameter for F goods prices.

In every experiment, the initial condition is the symmetric steady state. In all the panels, we only present responses of home ask or bid prices, because responses of the corresponding foreign variables are their exact mirror images. In panels 1 and 3, we show only responses of \( \hat{A}_P \), as those of \( \hat{B}_P \) are unaffected by the changes in the parameters in question. In panels 2 and 4, we omit responses of \( \hat{A}_P \), and only show those of \( \hat{B}_P \), for similar reasons. In all the cases, we omit the response of \( P_M \), as it never changes: as long as the economy starts from the symmetric steady state, the response is always exactly half of that of the exchange rate.

The results presented in panels 1 through 3 in Figure 3-2 are intuitive. In panel 1, as the input supply becomes more elastic, home type-A firms become less willing to charge higher markups even if the exchange rate moves in their favor. In panel 2, as demand for F goods becomes more price sensitive, home type-B firms find it more difficult to pass the increase in the price of intermediate goods on to households: they are thus less willing to allow the price to go up. In panel 3, as \( \psi_f \) becomes higher, production costs for home type-A firms become stickier in their own currency units, and thus they have a greater incentive to try to stabilize \( P_M \) measured in the same currency unit. Results in panel 4 require more explanation. As nominal prices of F goods become stickier (i.e., as \( \psi_f \) becomes larger), on the one hand, home type-B firms have a greater incentive to stabilize \( P_M \) in home currency units: this effect will weaken the response of their bid prices. On the other hand, as home type-B firms become less capable of raising prices of their products, they will end
up selling more of them. This effect will cause them to bid up the price of intermediate goods. It turns out that the latter effect dominates in this numerical example: as $\psi_F$ becomes larger, the response of their bid price becomes stronger.

(3) Asymmetric case: example
In Figure 3-3, we allow $\rho_I$, the elasticity of input supply, to be different between the two countries. We study how shapes of the impulse responses change when we vary the value of $\rho_I$ for the foreign country only. Starting with the third panel, as input supply becomes more elastic in the foreign country, the reaction of the ask price by its type-A firms becomes more attenuated. In the second panel, we see that this allows type-A firms at home to respond more aggressively to take advantage of a favorable exchange rate. Combining those two effects, the response of $P_M$ becomes larger, as we see in the first panel.

V. Empirical studies on prices of US imports from Japan

(To be added)

VI. Conclusions and remaining tasks

In this paper, we have argued that, in today’s international transactions, trade in intermediate goods plays an important role and that its market is typically characterized by limited numbers of participants on both sellers and buyers sides. We have developed a new theoretical framework which we believe is suitable for analyzing such a situation. In two benchmark cases --- one in which both monopoly and monopsony powers are equally distributed between the two countries, and the other in which the sellers are all located in one country and the buyers are located in the other country and the slopes of the “supply” and “demand” curves are the same --- the response of prices of intermediate goods to the exchange rate is exactly 50%. We have also investigated how the initial market shares of the firms, parameters that govern the slopes of those “curves” and other conditions affect this rate of the response.

An obvious next step would be to quantify the model. The numerical analyses conducted in this paper have been mere examples, designed to highlight certain aspects of the model. It would be interesting to calibrate the model to an economy which is heavily involved in
trade in intermediate goods, such as Japan. On the theoretical aspect, the bilateral oligopoly model utilized in this paper fails to take into account aspects of bargaining in international negotiations between sellers and buyers. Realistically, one would expect that, for example, if there are only two sellers of a certain type of intermediate goods in the world, while there are ten buyers, the former firms would have a much stronger bargaining power over goods prices. To develop a framework that can incorporate such a viewpoint would be a challenging but worthy task.

References


Table 1: Model 2, underlying parameters for the impulse response analysis (benchmark case)

(1) Parameters whose values are given directly

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>Exchange rate</td>
<td>1</td>
</tr>
<tr>
<td>( N_A, N_A^<em>, N_B, N_B^</em> )</td>
<td>Number of firms</td>
<td>2</td>
</tr>
<tr>
<td>( \alpha_A )</td>
<td>Type-A firm parameter</td>
<td>2/3</td>
</tr>
<tr>
<td>( \alpha_B )</td>
<td>Type-B firm parameter</td>
<td>0.5/0.9</td>
</tr>
<tr>
<td>( P, P^* )</td>
<td>Average price level</td>
<td>1</td>
</tr>
<tr>
<td>( W, W^* )</td>
<td>Nominal wage</td>
<td>1</td>
</tr>
<tr>
<td>( \omega_f, \omega )</td>
<td>Share parameter</td>
<td>0.5</td>
</tr>
<tr>
<td>( \rho )</td>
<td>Price elasticity of demand for F goods</td>
<td>2</td>
</tr>
<tr>
<td>( \psi_f )</td>
<td>- (Elasticity of input transformation)</td>
<td>-2</td>
</tr>
<tr>
<td>( \psi_{IA}, \psi_F )</td>
<td>Price adjustment cost parameter</td>
<td>100</td>
</tr>
<tr>
<td>( \theta_f )</td>
<td>Within goods-type substitution elasticity</td>
<td>10</td>
</tr>
<tr>
<td>( \beta )</td>
<td>Subjective discount factor</td>
<td>0.99</td>
</tr>
<tr>
<td>( A_I )</td>
<td>Input supplier productivity</td>
<td>1</td>
</tr>
</tbody>
</table>

(2) Parameters whose values are adjusted so that steady states satisfy certain conditions.

Parameters: \( A, A^*, B, B^* \) (productivity parameters), \( C, C^* \) (aggregate consumption), \( X \) and \( X^* \) (aggregate supply of inputs)

Steady state conditions: \( \hat{P}_A = \hat{P}_A^* = \hat{P}_B = \hat{P}_B^* = 1 \) (ask and bid prices), \( P_F = P_F^* = 1 \) (final goods prices), \( P_{IA} = P_{IA}^* = 1 \) (input prices for type-A firms)
Figure 1-0: Industry equilibrium, closed economy version

Figure 1-1: Industry equilibrium: two country version
Figure 1-2 Sector Equilibrium

HOME

INPUTS

…

A

A

A

A

A

A

A

A

A

…

FOREIGN

Input suppliers

Households

Input suppliers

Households

auctioneer

F GOODS

…

B

B

B

B

B

B

B

B

B

…
Figure 2: Industry Equilibrium, Response to home currency depreciation
(1) Under different number of Home type-A firms: market share per firm is equal across two countries (number of Foreign type-A firms = 2)

(2) Under different number of Home type-B firms: market share per firm is equal across two countries (number of Foreign type-B firms = 2)
(3) Under different number of Home type-A firms: total market share is equalized across two countries (number of Foreign type-A firms = 2)

(4) Under different number of Home type-B firms: total market share is equalized across two countries (number of Foreign type-B firms = 2)
(5) Under different values of $\alpha_A$

(6) Under different values of $\alpha_B$
Figure 3-1: Model 2, Impulse responses to an exchange rate shock
Under different number of Home type-A firms (market share per firm is equalized across two countries)
Figure 3-2: Model 2, Impulse responses to an exchange rate shock

(1) Under different values of $\rho_i$

(2) Under different values of $\rho$

(3) Under different values of $\psi_i$

(4) Under different values of $\psi_F$

(Note: In all the four cases, the response of the corresponding “Phat” variable in foreign country is a simple mirror image of the home responses shown above. As we always start from the symmetric steady state, the response of the transaction price, $P_M$, is zero.)
Figure 3-3: Model 2, Impulse responses to an exchange rate shock
When only the foreign value of \( \rho_f \) is changed.