Trade Integration, Competition, and the Decline in Exchange-Rate Pass-Through*

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Abstract

Over the past twenty years, U.S. import prices have become less responsive to the exchange rate. We propose that this decline is a result of increased trade integration. To illustrate this effect, we develop an open economy DGE model in which there is strategic complementarity in price setting so that a firm's pricing decision depends on the prices set by its competitors. Because of the complementarity in price setting, a foreign exporter finds it optimal to vary its markup over cost in response to shocks that change the exchange rate, which insulates import prices from exchange rate movements. With increased trade integration, exporters have become more responsive to the prices of their competitors and this change in pricing behavior accounts for a significant portion of the observed decline in the sensitivity of U.S import prices to the exchange rate. Our environment of low pass-through also has important implications for the welfare benefits of trade integration: we find that the benefits are substantially reduced compared to an environment with complete pass-through.

JEL classification: F15, F41

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1 Introduction

An important factor influencing the transmission of external shocks to the domestic economy is the responsiveness of import prices to exchange-rate movements. To the extent that exchange-rate pass-through is high, exchange-rate movements will be accompanied by similar changes in import prices, inducing relatively large movements in trade flows and consumer prices. As a consequence, pass-through can be particularly relevant to monetary policymakers seeking to maintain a low and stable rate of inflation.

What is the extent of exchange-rate pass-through to import prices (pass-through herein)? Summarizing empirical results from research on pass-through in the 1980s, Goldberg and Knetter (1997) report a range of pass-through estimates between 50 and 60 percent for the United States. Such estimates imply that, following a 10 percent depreciation of the dollar, a foreign exporter selling to the U.S. market would raise its price in the United States by 5-6 percent, absorbing the remainder of the dollar depreciation via lower markups. Recent evidence by Campa and Goldberg (2004) documents that pass-through to U.S. import prices is even lower ranging between 25 and 40 percent. Olivei (2002) and Marazzi, Sheets, and Vigfusson (2005) report that pass-through has fallen considerably since the early 1990s. Although roughly 50 percent in the 1980s, they estimate that pass-through is significantly lower today and centers around 20-25 percent. Over a similar sample period, Ihrig, Marazzi, and Rothenberg (2005) document a fall in pass-through in the other G-7 economies, and Otani, Shiratsuka, and Shirota (2003) find a large decline in pass-through in Japan.

Different explanations have been advanced to account for the fall in pass-through. Taylor (2000) proposes that improved monetary policy performance underlies this decline. Campa and Goldberg (2004), on the other hand, estimate that it is partly due to a change in the composition of imports towards manufactured products. In this paper, we develop a new approach by linking the fall in pass-through to an increase in trade integration spurred by lower tariffs, transport costs, and increases in productivity. Our environment broadly captures the view that pass-through has fallen because of increased foreign competition. To support our theoretical findings, we also provide empirical evidence linking the fall in pass-through to lower trade costs. Using industry specific measures of pass-through and trade costs, we show that industries in which the decline in trade costs has been relatively large have also experienced relatively large declines in pass-through.

We model incomplete pass-through building on the work of Kimball (1995) and more recently, Dotsey and King (2005). These papers allow for strategic complementarity in price setting using demand curves for which (the absolute value) of the demand elasticity is increasing in a firm's price relative to the price of its competitors.[1] This feature implies that a firm's pricing decisions depend not only on its marginal cost but also on the prices of its competitors. Because a foreign exporter does not want its price to deviate too far from its competitors, it is optimal for the exporter to increase its markup in response to a dollar appreciation that lowers its costs in dollars. Accordingly, pass-through of exchange-rate changes to import prices is incomplete in an environment with strategic complementarity in price setting.

It is well known that models with strategic complementarity have incomplete pass-through. Our main contribution is to show that, in a model with strategic complementarity, lower trade costs reduce pass-through. In such a model, lower trade costs improve the relative competitiveness of a foreign exporter in the domestic market – allowing the foreign firm to increase its relative markup over costs.[2] With strategic complementarity, the foreign exporter's price becomes more responsive to the prices of its competitors as its markup increases, and the firm finds it optimal to vary its markup more and its price less in response to an exchange rate movement, i.e., lower pass-through. In our model, strategic complementarity thus induces an exporter to set a relatively high and variable markup when its costs are lower than its com-

[1]We follow Woodford (2003) and define pricing decisions to be *strategic complements* if an increase in the prices charged for other goods increases a firm's own optimal price. For a similar approach to modelling the strategic complementarity in an open economy, see Bergin and Feenstra (2001). The strategic complementarity in price setting also arises in models with monopolistic competition and distribution services such as Corsetti and Dedola (2005) and Corsetti, Dedola, and Leduc (2005). In these models, an increase in the price of nontradeables induces a firm in the tradeable sector to increase its price. For a game-theoretic approach, see, for example, Atkeson and Burstein (2005) or Bodnar, Dumas, and Marston (2002).

[2]In contrast, markups would be constant for a CES demand curves where there is no strategic complementarity.

petitors and a low and unresponsive markup when its costs are relatively high. We show that this mechanism has a significant impact on the pricing behavior of exporting firms. In our benchmark calibration, trade integration accounts for about 40 percent of the observed decline in pass-through since the early 1990s.

Low pass-through also has important implications for the welfare benefits of trade integration. We find that the welfare benefits of trade integration are substantially lower than an environment with complete pass-through. By lowering trade costs, trade integration directly raises welfare. However, given the strategic complementarity, foreign exporters raise their markups and pass less of the reduction in costs to domestic consumers. These higher markups by reducing the increase in trade can substantially reduce the benefits of trade integration to the domestic economy.

Finally, our model implies that trade integration induces an economy to become more competitive. Because lower trade costs reduce the prices of foreign exports relative to domestic producers, domestic producers lose market share. Strategic complementarity in price setting induces these producers to reduce their markups in response to the decline in the prices of foreign exporters.[3] The approach developed in this paper is thus in line with the view that trade integration has reduced the market power of domestic producers in developed economies and squeezed their profit margins.

2 U.S. Import Prices and the Real Exchange Rate

We first examine the statistical relationship between import prices and the exchange rate and the increasing disconnect between these variables.

In our analysis, we focus on imports that are included in the end-use categories of automotive products, consumer goods, and capital goods, excluding computers and semiconductors. We will refer to these categories as finished goods, which roughly account for 45 percent of the

[3]This result is consistent with the evidence of Chen, Imbs, and Scott (2004) who estimate that markups have fallen in the European Union since 1990.

nominal value of total imports since 1987.

We concentrate on this more narrowly defined measure of import prices for two reasons. First, we exclude import prices of services, computers, and semiconductors because of concerns about price measurement. Prices for services are notoriously hard to measure. In addition, over time, different kinds of services have been added to the measured series and thus their composition is particularly unstable. We also exclude computers and semiconductors since their hedonic prices are heavily influenced by rapid increases in technology.

Second, our preferred measure excludes import prices of foods, feeds, beverages, and industrial supplies, because we view our model as less applicable to these categories.[4] In particular, we model the determination of import prices as arising from the decisions of firms that are monopolistic competitors and have the ability to price discriminate across countries. In the context of our model, excluding these goods is sensible since many of these goods are homogeneous and are traded on organized exchanges, so that the extent of monopolistic behavior and price discrimination is limited.

We argue that the decline in pass-through can be understood using a real model and thus focus on real import prices and real exchange rates. Accordingly, we define the real price of imports as the ratio of the finished goods import price deflator to the U.S. CPI deflator. Henceforth we will refer to our relative price index of finished goods as the relative price of imports. For our measure of the real exchange rate, we use the Federal Reserve's real effective exchange rate, which is constructed from data on nominal exchange rates and consumer price indices for 39 countries.

The top panel of Figure 1 plots the relative price of imports and the real exchange rate (as the inverse of the Federal Reserve's real effective exchange rate) so that a rise in the real exchange rate denotes a real depreciation of the dollar. Our relative import price index has fallen over time, reflecting in part that goods' prices have declined relative to the prices of services. To abstract from this trend, the solid line shows the ratio of the price of imported

[4] Industrial supplies include oil, natural gas, non-fuel primary commodities, such as copper, and more processed items, such as chemicals.

goods to a consumption price index that excludes services.[5] Using this series, it is apparent that real import prices and the real exchange rate in the 1980-2004 period have tended to move closely together, although movements in import prices tend to be dampened relative to the exchange rate. This series also suggests that in the 1990s movements in relative import prices have become more disconnected from movements in real exchange rates. Import prices rose in the 1970s with the dollar's depreciation and also rose sharply in the late 1980s with the large dollar depreciation beginning in 1985. In contrast, import price movements have been much more subdued in the 1990s: even though the dollar depreciated in the early 1990s and then appreciated in the latter half of the decade, import prices remained relatively unchanged.

Although the levels data are useful in examining trends in relative import prices and the real exchange rate, our emphasis is on understanding the relationship between these series at business cycle frequencies. Accordingly, the middle panel of Figure 1 plots the relative price of imports and the real exchange rate after HP-filtering these series. The same basic pattern emerges for the HP-filtered data: relative import prices and the real exchange rate are highly correlated and import prices tend to be less volatile than exchange rates. Moreover, fluctuations in import prices have moderated relative to exchange rate fluctuations since the early 1990s.

Table 1 summarizes these findings by comparing the volatility and correlation of the relative import price and the real exchange rate over different subsamples. The top panel shows the results for the data in differences and the bottom panel for the HP-filtered data. Both the HP-filtered and differenced data show a marked decline in the ratio of the standard deviation of import prices, σ_{p_m}, to the standard deviation of the exchange rate, σ_q, in the latter half of our sample. The correlation of the relative import price with the real exchange rate has declined noticeably as well for both the HP-filtered and differenced data.

Another important statistic summarizing the relationship between these two series is:

$$\beta_{p_m,q} = \frac{\text{cov}(p_m, q)}{\sigma_q^2} = \text{corr}(p_m, q)\frac{\sigma_{p_m}}{\sigma_q}, \tag{1}$$

where p_m denotes the relative price of imports and q denotes the real exchange rate. This

[5] We use NIPA data to apply standard chain-aggregation routines to construct both our deflator for imported finished goods and our deflator of U.S. consumption goods that excludes services.

statistic takes into account the correlation between the two series as well as their relative volatility and can be derived as the estimate from a univariate least squares regression of the real exchange rate on the relative import price. As shown in Table 1, our estimate of $\beta_{p_m,q}$ has declined in the 1990s both for the HP-filtered and differenced data, reflecting both the decline in the relative volatility of import prices and the lower correlation between the two series. We view the decline in $\beta_{p_m,q}$ as a useful way of summarizing the increasing disconnect between the relative import price and the real exchange rate.

Our summary statistic, $\beta_{p_m,q}$, is closely related to estimates of pass-through in empirical studies. One notable difference is that these studies typically estimate a specification for import prices with the exchange rate as one of a number of other factors influencing import prices. An important paper from our perspective that follows this approach is Marazzi, Sheets, and Vigfusson (2005), who argue that pass-through of exchange rate changes to import prices has fallen from about 0.5 in the 1980s to a current estimate of 0.2. It is interesting to note that despite the different approach taken here, we get comparable estimates regarding the change in the relationship between import prices and the exchange rate.

Further evidence of the increasing disconnect between these variable is shown in the bottom panel of Figure 1 which plots estimates of $\beta_{p_m,q}$ for the HP-filtered data based on 10-year, rolling windows (The line with stars indicates the point estimate and the shaded region denotes the 95 percent confidence region.) There is a sharp drop in $\beta_{p_m,q}$ occurring around 1990, as the 1980s leave the sample. We also found evidence of a structural break in the relationship between import prices and the real exchange rate using the supremum F-test of Andrews.[6] In particular, based on this methodology and using HP-filtered data, there is a statistically significant break in the relationship between relative import prices and the real exchange rate

[6] For a given K, we defined the following regression:

$$p_t = \beta_1 q_t + \beta_2 d_t^K q_t + u_t,$$

where d_t^K is a dummy variable that takes on the value of 0 if $t < K$ and 1 if $K \leq t$. Defining K over the recommended range suggested by Andrews, we computed the supremum of the F-tests of the significance of β_2 and compared it against the critical values of Andrews.

that occurs in 1989q2.

For further evidence regarding the relationship between import prices and the exchange rate, we also examined more disaggregated data. For industry i, the upper left panel of Figure 2 reports our summary statistics, $\beta^i_{pm,q}$, using data in log-differences on prices for each of 16 finished goods industries (two digit SITC) and our real exchange rate measure defined earlier. This statistic is computed for two sample periods: pre- and post-1990. As can be seen in the upper left panel of Figure 2, most industries have seen a sizeable decline in $\beta^i_{pm,q}$. Taking a simple average across industries, the mean value of $\beta^i_{pm,q}$ declined almost 30 percentage points, from an industry-average value of 0.48 pre-1990 to a value of 0.19 post-1990.

Overall, the evidence suggests that there has been an increasing disconnect between the price of imported finished goods and the exchange rate. We now turn to documenting the decline in trade costs and the rise in productivity outside the United States, which we argue are two important factors underlying the decline in pass-through.

3 Trade Costs and Productivity

Barriers to international trade take many forms, some less tangible than others. Typically, tariffs and transport costs come to mind as factors impeding the free flow of goods across countries. However, international trade can also be hindered by the presence of legal and regulatory costs, distribution costs, and institutional and cultural barriers. Although tariffs and transport costs have the advantage of being relatively easier to quantify, it is more difficult to precisely measure other forms of trade costs, since they are often not directly observable. As a result, researchers infer these costs by estimating gravity models of international trade.[7] This literature finds mixed evidence regarding a possible decline in overall trade costs. Using different datasets and methodologies, Rauch (1999), Coe, Subramanian, Tamirisa, and Bhavnani (2002), and Brun, Carrere, Guillaumont, and de Melo (2002) find that trade costs have fallen continuously since the 1970s. On the other hand, Frankel (1997) and Berthelon and Freund (2004) find no evidence

[7]See Anderson and van Wincoop (2004) for a survey of gravity models.

of a significant decline in trade costs.

The evidence regarding the fall in tariffs and transport costs is more conclusive. For the Unites States, we calculate changes in tariffs and transport costs using highly disaggregated import data (see Feenstra 1996 and 2002 for details). For each available finished-goods industry, we measure these costs as the share of freight expenditure and duties paid in terms of customs value of the goods (which is the value on which duties are assessed). We then compute an average trade cost measure by weighting an industry's trade cost measure by that industry's share of total customs value of finished goods. The upper right panel of Figure 2 reports that, between 1980 and 2001, the average trade costs across industries fell from 16 percent of the custom value of the goods to 9 percent.[8]

We now report additional evidence on the global fall in tariffs and transport costs. Tables 2 and 3 show that the decline in tariff rates initiated in the 1950s has continued over the last 25 years in both developed and developing economies. The average weighted tariffs, in developed economies, applied to products coming from the rest of the world declined roughly three percentage points since the late 1980s. Moreover, a more pronounced decline occurred in developing economies over approximately the same period. Overall, tariffs in developing economies fell 11 percentage points and more than 20 percentage point in South American economies.

Alternative measures of transport costs also tend to show a decline. Transport costs are often measured using the fact that exporting countries measure trade flows exclusive of freight and insurance (*fob*), while importing countries measure flows inclusive of freight and insurance (*cif*). Comparing the valuation of the same aggregate flow reported by the importer and the exporter provides a measure of transport costs.[9] Bernard, Jensen, and Schott (2003) use this

[8]There are a few caveats to these numbers. First, these calculations are the realized average trade cost rather than the marginal trade cost. An increase of imports from a distant country may lead to higher average trade cost even though the cost of importing from that distant country may not have changed. Second, failing to control for possible quality improvements may bias the measure of trade costs.

[9]This measure should be interpreted with some caution. In addition to changes in transport costs, differences in valuations may change because of other factors, such as improved reporting by exporters.

strategy to study the impact of falling trade costs on industry productivity in the United States. Of the U.S. industries they examine, 44 percent experienced a decline in transport costs between 1982 and 1987, while the percentage rose to 66 percent for the period 1987-1992. Similarly, Hummels (1999) finds that ocean freight rates have declined steadily since the mid-1980s, in part because of the introduction of containerization in ocean transport, which increased shipping efficiency.[10] Hummels (1999) also finds a steady decline in air freight rates since the 1970s.

Although tariffs and transport costs make up only a fraction of overall trade costs, they remain an important factor underlying the movement towards greater trade integration. For instance, Baier and Bergstrand (2001) find that the decline in tariff rates and transport costs (measured using *fob* and *cif* trade data) played an important role in post-World-War-II expansion in international trade. They estimate that, between the late 1950s and the late 1980s, tariff-reductions and declining transport costs explain respectively 25 percent and 8 percent of the growth in world trade.

In sum, our reading of the literature suggests that trade costs have continued to fall in the past twenty-five years. Although the gravity models are inconclusive with respect to the magnitude of the decline in overall trade barriers, more tangible measures of trade costs – tariff rates and transport costs – have clearly declined over the past twenty-five years.

Since trade integration can also be triggered by improved productivity of exporting firms, we consider changes in relative productivities across countries. The top panel of Figure 3 displays the annualized percentage change in GDP per employee for the United States ('US'), its foreign counterpart ('ROW'), and other regions around the world for the 1980-2003 period.[11] These indices are constructed using data on GDP per employee, and the ROW index is based on data for OECD and major developing countries.[12] Growth in GDP per employee outside

[10] Although containerization was introduced in the 1960s, ocean freight rates started to decline only in the mid-1980s. Hummels (1999) argues that the increase in rates in the 1970s and early 1980s were driven in part by adverse cost shocks. Moreover, containerization on shipping routes to and from developing countries occurred primarily after 1980.

[11] Although we would prefer a more disaggregated measure, we focus on productivity at the aggregate level due to data limitations for developing countries.

[12] The productivity indices are constructed using GDP in 1990 U.S. dollars at purchasing power parity. We

the United States outpaced U.S. growth largely due to faster productivity growth in developing Asia ('DA'), which includes a number of rapidly-developing countries such as China and South Korea. Productivity growth in Europe ('EU') was roughly on par with growth in the United States, while Japanese ('JA') productivity growth was somewhat faster than in the United States, despite a marked deceleration in Japanese productivity in the 1990s.

With foreign labor productivity growth higher than U.S. productivity growth over the last two decades, there has been considerable convergence of foreign productivity to the level of U.S. productivity. The bottom panel of Figure 3 shows that GDP per employee outside the United States roughly doubled over the 1980-2003 period, while U.S. GDP per employee rose about 40 percent over this period. As a consequence, the level of foreign productivity has increased by 40 percent relative to U.S. productivity over the past twenty-five years.[13]

4 The Model

Our model consists of a home and a foreign economy. These two economies have isomorphic structures so in our exposition we focus on describing only the domestic economy. The domestic economy consists of two types of agents: households and firms. Households have utility that depends on the consumption of both domestically-produced goods and imported goods. These goods are purchased from monopolistically competitive firms, who sell their goods to both domestic and foreign households. The key element we introduce into this environment is that a firm's demand curve has a non-constant elasticity so that exchange-rate pass-through to import prices may be incomplete.

define labor productivity based on GDP per employee rather than GDP per hour, since the former index allows for greater country coverage. This aggregate is constructed using data on Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, China, India, Indonesia, Malaysia, South Korea, Taiwan, Thailand, Argentina, Brazil, and Mexico. All data are from the Groningen Growth and Development Centre (http://www.ggdc.net).

[13]We arrived a slightly larger differential using GDP per hour worked and fewer countries for our foreign aggregate.

4.1 Households

The utility function of the representative household in the home country is

$$E_t \sum_{j=0}^{\infty} \beta^j \{\log (C_{t+j}) - \chi_0 \frac{L_{t+j}^{1+\chi}}{1+\chi}\}, \tag{2}$$

where the discount factor β satisfies $0 < \beta < 1$ and E_t is the expectation operator conditional on information available at time t. The period utility function depends on consumption C_t and labor L_t. A household also purchases state-contingent assets b_{t+1} that are traded internationally so that asset markets are complete.[14]

Household's receive income from working and an aliquot share of profits of all the domestic firms, Ω_t. In choosing its contingency plans for C_t, L_t, b_t, a household takes into account its budget constraint at each date:

$$C_t + \int_s p_{bt,t+1} b_{t+1} - b_t = w_t L_t + \Omega_t. \tag{3}$$

In equation (3), $p_{bt,t+1}$ denotes the price of an asset that pays one unit of the domestic consumption good in a particular state of nature at date $t+1$ (For convenience, we have suppressed that variables depend on the state of nature.)

4.2 Demand Aggregator

Household consumption is made up of a continuum of domestically-produced goods, $C_{dt}(i)$, indexed by $i \in [0, 1]$, and a continuum of imported goods, $C_{mt}(j)$, $j \in [0, \omega]$. Household choose $C_{dt}(i)$ and $C_{mt}(j)$ to minimize their total expenditures:

$$\left[\int_0^1 P_{dt}(i) C_{dt}(i) di + \int_0^{\omega} P_{mt}(j) C_{mt}(j) dj\right], \tag{4}$$

subject to $D\left(\frac{C_{dt}(i)}{C_t}, \frac{C_{mt}(j)}{C_t}\right) = 1$. In the above, the parameter, ω, may be interpreted as determining the degree of home bias in a household's consumption expenditures, as we assume

[14] We discuss the incomplete markets case below in our sensitivity analysis.

that domestic household's purchase a greater variety of home goods than foreign goods since $\omega < 1$.[15] The function, $D\left(\frac{C_{dt}(i)}{C_t}, \frac{C_{mt}(j)}{C_t}\right)$, is a household's demand aggregator defined as:

$$D\left(\frac{C_{dt}(i)}{C_t}, \frac{C_{mt}(j)}{C_t}\right) = V_{dt} + V_{mt} - \frac{1}{(1+\eta)\gamma} + 1, \tag{5}$$

In this expression, V_{dt} is an aggregator for domestic goods given by:

$$V_{dt} = \int_0^1 \frac{1}{(1+\eta)\gamma}\left[(1+\eta)\frac{C_{dt}(i)}{C_t} - \eta\right]^\gamma di, \tag{6}$$

and V_{mt} is a similarly defined aggregator for imported goods except that its limits of integration are 0 and ω.

Our demand aggregator adapts the one discussed in Dotsey and King (2005) to an international environment. It shares the central feature that the elasticity of demand is nonconstant with $\eta \neq 0$, and the (absolute value of the) demand elasticity can be expressed as an increasing function of a firm's relative price when $\eta < 0$.[16] This feature has proven useful in the sticky price literature, because it helps mitigate a firm's incentive to raise its price after an expansionary monetary shock in the context of a model in which other firms have already preset their prices. It is also consistent with the evidence that firms tend to change their prices more in response to cost increases than decreases (see, for instance, Peltzman (2000)). Another important implication of this aggregator, more relevant for us, is that exchange-rate pass-through to import prices will be incomplete when the elasticity of demand is increasing in a firm's relative price.[17]

Our aggregator differs from Dotsey and King (2005) by aggregating over foreign goods, and allowing for home bias in consumption expenditures. Accordingly, the aggregator of Dotsey and King (2005) can be viewed as a special case of equations (4) and (5) with $\omega = 0$.

[15]While we assume that the degree of home bias in each country is exogenous, a natural extension would allow ω and ω^* to be endogenous variables. In that case, a change in trade costs would affect the number of exporters in each market (extensive margin) in addition to the demand for a foreign exporter's good (intensive margin).

[16]Alternatively, one can express the NCES demand curve as a decreasing function of a firm's market share, as in Kimball (1995). See Woodford (2003) and Eichenbaum and Fisher (2003) who also pursue this approach.

[17]See, for example, Bergin and Feenstra (2001) who demonstrate that the interaction of their NCES demand curve with sticky prices-local currency pricing is useful in accounting for the observed volatility and persistence of the exchange rate.

Expenditure minimization by a domestic household implies that demand for import good j is given by:

$$\frac{C_{mt}(j)}{C_t} = \frac{1}{1+\eta}\left[\left(\frac{P_{mt}(j)}{\Gamma_t}\right)^{\frac{1}{\gamma-1}} + \eta\right]. \tag{7}$$

In equation (7), Γ_t is a price index consisting of the prices of a firm's competitors and is given by:

$$\Gamma_t = \left[\left(\int_0^1 P_{dt}(i)^{\frac{\gamma}{\gamma-1}} di\right) + \left(\int_0^\omega P_{mt}(j)^{\frac{\gamma}{\gamma-1}} dj\right)\right]^{\frac{\gamma-1}{\gamma}}. \tag{8}$$

According to equation (7), the demand curve is the sum of a Dixit-Stiglitz term and a linear term in which the parameters γ and η govern the elasticity and curvature of the demand curve. Expenditure minimization also implies a similar expression for the demand of $C_{dt}(i)$ expressed as a function of $\frac{P_{dt}(i)}{\Gamma_t}$.

The aggregate consumer price level is given by

$$P_t = \frac{1}{1+\eta}\Gamma_t + \frac{\eta}{1+\eta}\left[\int_0^1 P_{dt}(i)di + \int_0^\omega P_{dt}(j)dj\right]. \tag{9}$$

From this expression, it is clear that the consumer price level is equal to the competitive pricing bundle, Γ_t, when $\eta = 0$. In general, the consumer price level is the sum of Γ_t with a linear aggregator of prices for individual goods.[18]

4.3 Firms

The production function for firm i is linear in labor so that

$$Y_t(i) = Z_t L_t(i). \tag{10}$$

In the above, Z_t is an aggregate technology shock that affects the production function for all firms in the home country and evolves according to:

$$\log(Z_t) = (1-\rho_z)\log(Z) + \rho_z \log(Z_{t-1}) + \sigma_z \epsilon_{zt}. \tag{11}$$

[18]The consumer price level is derived from equating equation (4) to $P_t C_t$ and substituting in the relative demand curves. The price Γ_t is derived from substituting the relative demand curves into equation (5).

A firm hires labor in a competitive labor market in which labor is completely mobile within a country but immobile across countries. Marginal cost is therefore the same for all firms in the home country so that real marginal cost of firm i is given by

$$\psi_t = \frac{w_t}{Z_t}, \tag{12}$$

where w_t is the real wage in the domestic economy.

Firms in each country are monopolistically competitive and each firm sells their good to households located in their country. Consistent with our assumption about home bias, only a fraction of firms sell their goods to households located in the other country. Specifically, firms indexed by $i \in [0, \omega^*]$, where ω^* denotes the home-bias parameter of the foreign country, sell their goods both in the home and foreign country, while the remaining fraction of firms sell their goods only in the home market (We use an asterisk to denote a variable in the foreign country).

A firm chooses to set its price as a markup over marginal cost, taking the demand curve of the representative household as given. As a result, the price of good i in the domestic market satisfies:

$$\frac{P_{dt}(i)}{P_t} = \mu_{dt}(i)\psi_t, \tag{13}$$

with $\mu_{dt}(i) \geq 1$. The markup $\mu_{dt}(i)$ can be expressed as:

$$\mu_{dt}(i) = \left[1 - \frac{1}{|\epsilon_{dt}(i)|}\right]^{-1} = \left[\gamma + \eta(\gamma - 1)\left(\frac{P_{dt}(i)}{\Gamma_t}\right)^{\frac{1}{1-\gamma}}\right]^{-1}, \tag{14}$$

where $|\epsilon_{dt}(i)|$, is the absolute value of the elasticity of good i given by:

$$\epsilon_{dt}(i) = \left[(\gamma - 1)\left(1 + \eta\left(\frac{P_{dt}(i)}{\Gamma_t}\right)^{\frac{1}{1-\gamma}}\right)\right]^{-1}. \tag{15}$$

We restrict our attention to a symmetric equilibrium in which all domestic firms set the same price in the domestic market so that $P_{dt}(i) = P_{dt}$, $\epsilon_{dt}(i) = \epsilon_{dt}$, and $\mu_{dt}(i) = \mu_{dt}$.

Equation (14) shows that firm i's markup depends on the price it sets relative to its competitors price Γ_t. When the (absolute value of) the demand elasticity is increasing in $\frac{P_{dt}(i)}{\Gamma_t}$, the markup will be a decreasing function of this relative price. Consequently, a firm will respond to a fall in the price of its competitors by lowering its price and accepting a lower markup. A firm finds it desirable to do so, because otherwise it will experience a large fall in its market share. An important exception to this pricing behavior is the CES demand curve in which $\eta = 0$. In this case, firm i does not experience a fall in demand when Γ_t decreases and therefore decides to leave its markup unchanged.

We view our setup with variable markups as a tractable way to capture the strategic complementarity amongst price-setting firms. Although we do not explicitly model strategic behavior using a game-theoretic framework, our setup has similar implications to those of Bodnar, Dumas, and Marston (2002) and Atkeson and Burstein (2005) who model the strategic complementarity that arises between firms through Cournot or Bertrand competition and show that exchange-rate pass-through is incomplete. Their setup, like ours, also give rise to a markup that is increasing in a firm's market share or decreasing in its price relative to those of its competitors.

While all domestic firms set their price according to equation (13), some of these firms also choose a price for the foreign market. For these firms, we assume that they incur an iceberg shipping cost D_t, which evolves according to:

$$\log(D_t) = (1-\rho_d)\log(D) + \rho_d \log(D_{t-1}) + \sigma_d \epsilon_{dt}. \tag{16}$$

Accordingly, the real marginal costs inclusive of the shipping cost for a domestic exporter is $D_t\psi_t$ and the price of good i in the foreign market is given by:

$$\frac{P^*_{mt}(i)}{P^*_t} = \mu^*_{mt}(i)\frac{D_t\psi_t}{q_t}, \tag{17}$$

where $\mu^*_{mt}(i) \geq 1$, $P^*_{mt}(i)$ denotes the foreign currency price of good i and q_t denotes the real exchange rate expressed in units of the home consumption bundle per units of foreign consumption.

In a symmetric equilibrium (i.e., $P^*_{mt}(i) = P^*_{mt}$), the markup of a domestic firm in the foreign market is given by:

$$\mu^*_{mt} = \left[\gamma + \eta(\gamma-1)\left(\frac{P^*_{mt}}{\Gamma^*_t}\right)^{\frac{1}{1-\gamma}}\right]^{-1}. \tag{18}$$

Comparing equations (13) and (17), we note that the law of one price (i.e., $\frac{P^*_{mt}(i)}{P^*_t}q_t = \frac{P_{dt}(i)}{P_t}$) will not hold when $D_t > 1$. In addition, because the demand elasticity can differ across markets, a firm will optimally decide to price discriminate. It will be able to set different markups in the domestic and foreign markets as long as the difference between a firm's price in the two markets (expressed in the same currency unit) is less than the cost of shipping the good:

$$\frac{D_t P_{dt}(i)}{P_t} \geq \frac{P_{mt}(i)}{P_t} q_t \ \text{ and } \ \frac{P_{dt}(i)}{P_t} \leq \frac{D^*_t P_{mt}(i)}{P_t} q_t. \tag{19}$$

The first condition ensures that a foreign household can not buy the good for less in the domestic market inclusive of the cost of shipping the good. The second condition ensures that a domestic household can not buy the good for less abroad. Later, we show that these conditions and their counterparts for the prices set by foreign firms are satisfied.

4.4 Market Clearing

The home economy's aggregate resource constraint is given by:

$$Y_t = C_{dt} + \omega^* n D_t C^*_{mt}, \tag{20}$$

where Y_t denotes the output of all domestic firms expressed on a per capita basis and n denotes the population of the foreign economy scaled by the population of the home economy. The foreign economy has an isomorphic structure to the home economy and differs only in its level of trade costs, technology, and population size.

5 Defining Pass-Through

We define pass-through from the perspective of an individual exporter who views the exchange rate as exogenous (see also Bodnar, Dumas, and Marston (2002)). It is defined as how much an individual exporter changes his price in response to a one percent change in the exchange rate, holding constant the other factors a firm takes as given: its marginal cost and the prices of other firms. Letting $p_{mt}(h) = \frac{P_{mt}(j)}{P_t}$ and $\xi_t = \frac{\Gamma_t}{P_t}$ denote the relative price of exporter j and the relative price of its competitors, respectively, a foreign exporter's pricing equation can be written as:

$$p_{mt}(j) = \mu_{mt}(j) D_t^* \psi_t^* q_t, \tag{21}$$

where $\mu_{mt}(j)$ is given by the foreign exporter's version of equation (14). The direct effect of an exchange rate change on the price of foreign exporter j is given by $\kappa_{mt}(j) = \frac{\partial \ln(p_{mt}(j))}{\partial \ln(q_t)}$:

$$\kappa_{mt}(j) = \frac{1}{1 - \frac{\mu'_{mt}(j)\left(\frac{p_{mt}(i)}{\xi_t}\right)}{\mu_{mt}}} = \frac{1}{1 - \eta \mu_{mt}(j) \left(\frac{p_{mt}(j)}{\xi_t}\right)^{\frac{1}{1-\gamma}}}, \tag{22}$$

where $\mu'_{mt}(j) = \frac{d\mu_{mt}(j)}{d(\frac{p_{mt}(j)}{\xi_t})}$. Because $\kappa_{mt}(j)$ measures only the direct effect of an exchange rate change on an exporter's price, we refer to it as the direct pass-through measure.

From the above expression, we can see that if $\eta < 0$ so that $\mu'_{mt}(j) < 0$ then direct pass-through will be incomplete.[19] In this case, a one percent increase in q_t drives up a foreign exporter's cost when denominated in dollars; however, a firm does not raise its price a full one percent because as the exporter's price rises relative to its competitors, it induces the exporter to accept a lower markup rather than give up market share. In contrast, in the CES case in which $\eta = 0$ so that $\mu'_{mt}(j) = 0$, direct pass-through is complete, as an exporter's pricing decision does not depend on the prices set by other firms.

To facilitate comparisons of our model with the data, in addition to our direct pass-through measure, we also examine our model's implications for the second moment $\beta_{p_m,q}$ previously defined (in log-differences) as:

$$\beta_{p_m,q} = \frac{\text{cov}(\Delta p_{mt}, \Delta q_t)}{\text{var}(\Delta q_t)}. \tag{23}$$

The relationship between $\beta_{p_m,q}$ and $\kappa_{mt}(j)$ can be seen by log-linearizing equation (21) around the non-stochastic steady state to write a foreign exporter's pricing decision as:

$$\hat{p}_{mt} = \kappa_m \left(\hat{D}_t^* + \hat{\psi}_t^* + \hat{q}_t\right) + (1 - \kappa_m)\,\hat{\xi}_t. \tag{24}$$

[19]With $\eta < 0$, the demand curve is less convex than the CES case.

The symbol '^' denotes the log-deviation of a variable from its steady state value and $\kappa_m = \kappa_m(j)$ evaluated at nonstochastic steady state. Using this equation, we can relate β_{q,p_m} and κ_m via:

$$\beta_{p_m,q} = \kappa_m + \kappa_m \left(\frac{\text{cov}(\Delta\psi_t^*, \Delta q_t)}{\text{var}\,(\Delta q_t)} + \frac{\text{cov}(\Delta D_t^*, \Delta q_t)}{\text{var}\,(\Delta q_t)} \right) + (1 - \kappa_m) \frac{\text{cov}(\Delta\xi_t, \Delta q_t)}{\text{var}\,(\Delta q_t)}. \tag{25}$$

According to equation (25), the univariate regression statistic, $\beta_{p_m,q}$, is related to κ_m except that $\beta_{p_m,q}$ takes into account any correlation of the real exchange rate with an exporter's costs and the pricing index of an exporter's competitors that occurs in general equilibrium. Thus, $\beta_{p_m,q}$ takes into account both direct and indirect effects of an exchange rate change on an exporter's price.

In our analysis, we focus on comparing our model results to the data for $\beta_{p_m,q}$ rather than κ_m. This reflects that $\beta_{p_m,q}$ is a second moment that is easily measured in the data. In contrast, measuring κ_m is complicated by finding good measures of marginal costs and the prices of a firm's competitors as well as correctly specifying the equations for estimating κ_m and dealing with the endogeneity of the exchange rate and the prices of other firms.

6 Calibration

In order to investigate the role of trade costs and productivity differentials on pass-through, we log-linearize and solve the model for two different cases. In the first case, the steady state trade costs, D and D^*, are high and the level of productivity in the United States is higher than in the rest of the world. We call this the strategic complementarity (SC) calibration. In the second case, trade costs are low and the level of productivity in steady state is the same in the two countries.[20] We call this the 2004 SC calibration, whose only differences from the SC calibration are the parameters governing the level of trade costs and productivity in each country.

As discussed above, η, which governs the curvature of the demand curve is a crucial parameter for our analysis. Faced with sparse independent evidence regarding this parameter,

[20] While the level of foreign productivity in 2004 is lower than U.S. productivity, we focus only on the change in relative productivity, as it is the change that is important for our results.

we calibrate it as a part of a simulated method of moments procedure. Specifically, we choose η, $\sigma_z = \sigma_z^*$, and $\sigma_D = \sigma_{D^*}$ so that the model's implications for the volatility of output, the ratio of the volatility of relative import prices to the real exchange rate, and the correlation between relative import prices and the real exchange rate match those observed in the 1980-1989 period. By construction, our model therefore matches the observed value of $\beta_{p_m,q}$, our benchmark measure of pass-through, for the 1980s. With η pinned down based on the pre-1990s data, we then examine and compare the fall in $\beta_{p_m,q}$ arising from falling trade costs and rising foreign productivity to the observed fall in the data.

Tables 4 and 5 show our calibrated value of η as well as the calibrated values of other important parameters of the model. For the other parameter governing the demand curve, γ, we choose a value so that the price markup $\mu_d - 1$ is about 20 percent in the non-stochastic steady state of the SC calibration. With $D^* > 1$, the markup set by foreign firms in the domestic market is even smaller, as $\mu_m - 1$ is about 10 percent. Since this has the implication that the elasticity of import demand with respect to the relative price of imports is above 10, later in our sensitivity analysis we consider an alternative calibration with a lower trade-price elasticity.

We calibrate the model at a quarterly frequency so that $\beta = 1.03^{-0.25}$. The utility function parameter χ is set to 1.5 so as to imply a Frisch elasticity of labor supply of 2/3, an elasticity well within the range of most empirical estimates.[21] We choose χ_0 and χ_0^* so that $L = L^* = 1$ in the SC calibration.

The model is calibrated so that the two economies are identical except for country size. The parameter $\omega = \omega^*$ is chosen so that model matches the import to GDP ratio in the United States in the early 1980s of about 10 percent. We choose the relative population sizes of the two countries so that the United States comprises about 33 percent of world output. Since we choose an initial level of assets that is consistent with balanced trade in the steady state of the SC calibration, the import share of output of the foreign economy is about 5 percent.

We calibrate our model to be consistent with the change in relative productivity and trade

[21]See, for example, Pencavel (1986), Killingsworth and Heckman (1986), and Pencavel (2002).

costs observed over the 1980-2004 period. As discussed above, the level of foreign productivity is about 40 percent higher vis-à-vis U.S. productivity in 2004 than in 1980. We choose a more conservative 30 percent increase in the level of foreign to U.S. productivity. In particular, we normalized $Z = 1$ in both the SC and 2004 SC calibrations and set $Z^* = 0.7143$ in the SC calibration and $Z^* = 0.9289$ in the 2004 SC calibration.

For our benchmark case, we set the decline in D and D^* to 7 percentage points, consistent with the evidence presented in the upper right panel of Figure 2 and discussed in Section3.[22] However, since this estimate is potentially fraught with uncertainty, we also consider alternative calibrations for the decline in trade costs in our sensitivity analysis. In all of these cases, we set $D = D^* = 1.25$ for the initial level of trade costs.

Table 6 compares selected moments for our benchmark SC calibration to the data as well as a calibration with CES demand curves. For the CES calibration, we set $\eta = 0$ and $\gamma = 1/1.1027$. This value of γ is chosen so that the markup of a foreign exporter and thus the demand elasticity of imports with respect to price are the same as in the SC calibration.

For both the SC and CES calibrations, the technology and trade-cost shocks in the foreign economy are calibrated to have the same persistence and volatility as the shocks in the home economy. Also, we set the AR(1) coefficient for each shock equal to 0.95 and assumed that the shocks are uncorrelated with each other.

As shown in Table 6, both the CES and SC calibration (by construction) match the observed volatility of output and correlation between import prices and the exchange rate in the 1980s. However, only the SC calibration with $\eta \neq 0$ has the flexibility to match the observed value of $\beta_{p_m,q}$ in the 1980s. Although the SC calibration implies slightly less exchange rate volatility than the CES calibration, both versions of the model understate the amount of exchange rate volatility and persistence relative to the data. Thus, while the NCES demand

[22]Alternatively, we also calibrated the decline in D and D^* to be consistent with the evidence of Baier and Bergstrand (2001) that falling trade costs accounted for one third of the growth in world trade after World War II. More specifically, we set the fall in D and D^* such that it induces a 1.7 percentage point increase in the U.S. import share, roughly a third of the rise in the U.S. import share observed over the 1980-2004 period. The required fall in D and D^* turned out to also be 7 percentage points.

curves better account for the observed relationship between the relative import price and the real exchange rate, they do not by themselves explain other important aspects of the data emphasized in the international business cycle literature.

7 Results

To gain intuition for our main results, we first illustrate the implications of our setup for pass-through in partial equilibrium. We then look at the impact of different shocks for our measures of pass-through. Finally, we report our general equilibrium findings regarding the impact of a rise in trade integration on pass-through and consider the effects of trade integration on welfare in a environment of low pass-through.

7.1 A Partial Equilibrium Explanation for Declining Pass-Through

The upper left panel of Figure 4 plots the demand curve of import good j for our SC parameterization of η and γ and compares it to a CES demand curve.[23] The absolute value of the demand elasticity for good j, $|\epsilon_{mt}(j)|$, is shown in the upper right panel. Our calibrated demand curve is consistent with strategic complementarity in price setting. The absolute value of the elasticity is increasing in an exporter's relative price. Therefore, an exporter finds it optimal to reduce its markup rather than increase its prices, and, hence, direct pass-through, $\kappa_{mt}(j)$, is incomplete.

Another important implication of our demand curve is that pass-through will fall with a decline in the cost of exporting. Thus, our model will be able to account for a declining pass-through via either a fall in trade costs or a rise in foreign productivity relative to U.S. productivity. We now discuss the intuition for this result.

[23]For convenience, we have focused on a case in which $\frac{P_{mt}(j)}{\Gamma_t} = \frac{P_{dt}(i)}{\Gamma_t}$ $\forall i, j$. In our calibrated model, this equality does not hold in part because $D_t > 1$. As a result, the markup and pass-through in this example are different from the value reported in Table 5.

We begin by noting that foreign exporter j's marginal revenue satisfies:

$$MR_{mt}(j) = \frac{P_{mt}(j)}{\mu_{mt}(j)} = P_{mt}(j)\left[1 - \frac{1}{|\epsilon_{mt}(j)|}\right]. \tag{26}$$

The lower left panel of Figure 4 displays marginal revenue (in logs and scaled by Γ_t) as a function of the relative price $\frac{P_{mt}(j)}{\Gamma_t}$. As a firm increases its price relative to the price of its competitors, marginal revenue exhibits diminishing returns. At a low relative price, the demand elasticity is also low and an increase in exporter j's relative price boosts marginal revenue because of a) the direct effect of the rise in the firm's price and b) the increase in the demand elasticity as an exporter's price rises relative to its competitors. However, as the exporter's relative price increases and the demand elasticity becomes high enough, the latter effect becomes negligible and the increase in marginal revenue is limited to only the direct effect of the increase in price. (As the demand elasticity approaches infinity, a firm is essentially setting its price equal to marginal cost.) Thus, the effect of strategic complementarity in price setting diminishes as the elasticity rises, and, as displayed in the lower right panel of Figure 4, an exporter's markup is more responsive to $\frac{P_{mt}(j)}{\Gamma_t}$ at a low elasticity (i.e., high markup) and less responsive to $\frac{P_{mt}(j)}{\Gamma_t}$ at a high elasticity (i.e., low markup).

A consequence of the concavity of the marginal revenue schedule is that a fall in an exporter's costs will result in a decline in direct pass-through.[24] To illustrate this point, consider the dashed blue line, labelled mc_H, of the lower left panel, which shows the logarithm of the exporter's marginal cost denominated in domestic currency units (also scaled by Γ_t). At this portion of the marginal revenue schedule, a real (exogenous) depreciation of the domestic currency that results in a 2 percent increase in firm j's marginal cost (mc'_H) only results in about a 0.8 percent increase in a firm's relative price, so that direct pass-through is roughly

[24]Because of this concavity, pass-through $\kappa_{mt}(j)$ is an increasing function in a firm's relative price or a decreasing function in a firm's market share for our calibrated demand curve. Using data from the automobile industry, Feenstra, Gagnon, and Knetter (1996) find a more complicated U-shaped relationship between pass-through and the market share of automobile exporters. In particular, for automobile exporters with a low market share (between 0 and 40 percent) in a destination market, pass-through falls as the exporters' market share increases, as our model predicts. By contrast, they estimate that the opposite relationship occurs for exporters with a higher market share.

40 percent. Now, suppose a fall in trade costs shifts the firm's marginal costs down to mc_L. In this case, a two percent real depreciation of the domestic currency increases the exporter's costs from mc_L to mc'_L and results in only about a 0.4 percent increase in relative price, so that direct pass-through is roughly 20 percent. Pass through is lower for a low-cost producer because a cost increase requires a smaller increase in price, since the associated rise in the demand elasticity provides an extra boost to marginal revenue.

In comparison, under CES demand curves direct pass-through of exchange-rate changes will be complete: A two percent home currency depreciation results in a two percent increase in price regardless of an exporter's costs. This reflects the fact that the demand elasticity, and thus the markup, do not vary with a monopolist's relative price.

7.2 The Effects of Different Shocks on Pass-Through

Using impulse responses, we show that productivity and trade-cost shocks have different effects on our two measures of pass-through. An important difference between the two measures is that κ_m is independent of the economy's shocks, while $\beta_{p_m,q}$ is not. To illustrate this, Figure 5 shows the effects of a one standard deviation increase in home technology for the SC calibration. Home technology shocks induce a real depreciation of the home currency (i.e., a rise in q_t) and put upward pressure on the real marginal cost of foreign firms, as foreign labor supply contracts and real wages rise abroad. Accordingly, the correlation of ψ_t^* and q_t is positive and $\beta_{p_m,q} > \kappa_m$ in response to technology shocks ($\beta_{p_m,q} = 0.6$ and $\kappa_m = 0.35$).

Figure 5 also displays the effects of a one standard deviation increase in a foreign exporter's trade cost, D_t^*. An increase in D_t^* raises the price of foreign goods for home households, thereby lowering the demand for foreign goods on the world market and inducing a real depreciation of the foreign currency. With only trade cost shocks, there is a negative correlation between D_t^* and q_t, and $\beta_{p_m,q}$ is roughly zero while $\kappa_m = 0.35$.

Overall, our calibration procedure implies that the bulk of the variation in the real exchange rate and the relative import price are driven primarily by technology shocks. As a consequence, the values of $\beta_{p_m,q}$ reported in Table 6 for the SC calibration mainly reflect the influence of technology shocks.[25]

7.3 Trade Integration and Declining Pass-Through

Table 7 shows the effects of lowering trade costs and higher foreign productivity on pass-through and important steady state prices and quantities. The table shows the value of the variables in steady state except for $\beta_{p_m,q}$, which is obtained from log-linearizing the model and computing the population moments of the model's variables given the shock processes of the SC calibration. We start by looking at the effects of changing one variable at a time (columns 2-4), before analyzing their combined impacts (last column). As shown in the second column, a seven percentage points fall in the trade costs of foreign exporters reduces the real cost of exporting in home currency by 4.3 percent. Note that the fall in foreign exporters' real marginal cost, $D^*\psi^*q$, is less than the decline in D^* as increased demand for the foreign good puts upward pressure on the real exchange rate, q, and on the marginal cost of production, ψ^*. With lower costs, foreign exporters reduce their prices and the home country's import share rises 1.3 percentage points. Because foreign exporters' prices falls relative to their competitors - the domestic firms, they are able to increase their markups and still gain market share. Conversely, the prices for domestic goods rise relative to their competitors, and domestic firms are forced to cut their markups in reaction to stiffer competition from abroad.

With higher markups on foreign goods, the strategic complementarity intensifies and foreign exporters become more willing to vary their markups in response to cost shocks (recall the lower left panel of Figure 4). Thus, the 7 percentage points decline in trade costs causes the pass-through measure κ_m to fall from 0.36 to 0.332, or 2.8 percentage points. This fall in κ_m also leads to a reduction in our statistical measure of pass-through, $\beta_{p_m,q}$, of more than 5.5 percentage points, from 0.55 to 0.495. As indicated by equation (25, reproduced below), a fall

[25] It is interesting to note that the cyclicality of the domestic producers' markups in the home market depends on the source of the shock. Domestic markups are countercyclical conditional on changes in trade costs faced by home exporters and procyclical with respect to the other shocks. The domestic markup is procyclical unconditionally, reflecting the importance of technology shocks. Of course, incorporating nominal rigidities in domestic prices would imply a countercyclical markup.

in κ_m directly lowers $\beta_{p_m,q}$:

$$\beta_{p_m,q} = \kappa_m + \kappa_m \left[\frac{\mathrm{cov}(\Delta\psi_t^*, \Delta q_t)}{\mathrm{var}\,(\Delta q_t)} + \frac{\mathrm{cov}(\Delta D_t^*, \Delta q_t)}{\mathrm{var}\,(\Delta q_t)} \right] + (1-\kappa_m) \left[\frac{\mathrm{cov}(\Delta\xi_t, \Delta q_t)}{\mathrm{var}\,(\Delta q_t)} \right].$$

Moreover, the decline in κ_m implies that $\beta_{p_m,q}$ places less weight on the marginal cost term (the first term in square brackets) and more weight on the price competitiveness term (the second term in square brackets). The marginal cost term is larger than the price competitiveness term because ξ_t has little variation (See Figure 5). As a result, a fall in κ_m, by shifting a firm's emphasis in pricing away from cost considerations to considerations of price competitiveness, induces an even larger decline in $\beta_{p_m,q}$.

A fall in D, the trade cost on domestic goods sold to the foreign economy, also lowers pass-through (third column of Table 7). In general equilibrium, increased foreign demand for home goods causes an appreciation of the home currency that reduces the cost of foreign exporters and leads to a fall in pass-through. Because of the larger size of the foreign economy, the appreciation is substantial and results in the real cost of foreign exporters (in home currency) falling by 1.5 percent. This decline in costs triggers a fall in foreign exporters' prices relative to prices of domestic goods in the home market. As a result, exporters increase their markups and prices of foreign goods decline only 0.6 percent. At these higher markups, κ_m declines 1 percentage point and $\beta_{p_m,q}$ declines 3.7 percentage points.

The fourth column of Table 7 shows the combined effects of lowering trade costs in the home and foreign economies. In this case, foreign exporters' share of the domestic market expands by 1.7 percentage points and our statistical measure of pass-through declines about 7 percentage points.

The fifth column of Table 7 displays the effects of raising the level of foreign productivity by 30 percent. Although there is a substantial increase in foreign real wages in response to the higher level of productivity, marginal costs in foreign currency fall. The foreign currency also depreciates; so, an exporter's marginal cost in home currency falls almost 12 percent. This large decline in foreign costs allows foreign exporters to both substantially reduce prices and expand their markups at the expense of their domestic competitors. Consequently, the decline in $\beta_{p_m,q}$ is a sizeable 9.1 percentage points.

The last column of Table 7 displays the decline in pass-through from the SC to the 2004 SC calibration in which the increase in foreign productivity is combined with the decline in D and D^*. Higher productivity and lower trade costs have a substantial impact on pass-through. Overall, $\beta_{p_m,q}$ falls almost 16 percentage points, which accounts for about 40 percent of the observed decline. The fall in pass-through occurs even though the home market is simultaneously becoming more competitive: markups on domestic goods fall 3 percentage points following the rise in trade integration (see Table 5 for a more detailed comparison of the properties of the SC and 2004 SC calibrations). These results broadly capture the view that pass-through has fallen in the United States because of increased foreign competition, which in turn has reduced profit margins of domestic producers in the U.S. market.

The positive theoretical relationship between trade costs and pass-through emphasized in our model is broadly in line with US industry-level data since the early 1980s. In the lower left panel of Figure 2, we relate the changes in industry-specific pass-through (reported in Section 2) to the changes in industry-specific trade cost (discussed in Section 3). The figure indicates that declines in trade costs are correlated with declines in pass-through. In particular, a 1 percentage point decline in trade costs is associated with a 0.8 percentage point decline in pass-through, about the same magnitude as in our benchmark calibration. While we view this correlation as suggestive of our theory, one important caveat is that we only have a limited number of industries for assessing this relationship.[26]

Finally, we note that with producers engaging in price discrimination, a household might find it profitable to exploit deviations in the law of one price. However, we verified that households have no incentive to do so because deviations from the law of one price are smaller than the costs of trading goods across countries: for instance, in the 2004 SC calibration, the deviations in the law of one price for the home good as measured by $|p_d - p_m^* q|$ are less than 5 percent.[27] Deviations from the law of one price are small because a monopolist must take into

[26]The limited number of industries makes the magnitude (though not the sign) sensitive to outliers. For instance, when we remove the footware industry, the postive relationship between trade costs and pass-through becomes stronger, with a slope coefficient of roughly 3.

[27]We also checked that the counterparts to equations (19) for the foreign good also hold. In addition, these

account the influence of its competitors' prices on its own price setting behavior: in the market where its costs are low, a producer sets a high markup, while in the market where its costs are high, it sets a low markup. Thus, the strategic complementarity in price setting acts to limit deviations from the law of one price.

The strategic complementarity also implies that the degree of price discrimination declines in response to a fall in trade costs. Given lower trade costs, a firm increases its markup abroad and lowers it in its own market and as such markups converge. These changes in markup, however, do mute the degree to which prices change in response to the fall in trade costs. For example, the 7 percentage point fall in D and D^* only results in about a 1 percentage point convergence in prices. This result is consistent with the evidence that notwithstanding an increase in trade integration, price convergence remained muted in comparison.[28] In comparison, in the CES economy, deviations from the law of one price would decline one-for-one with the fall in trade costs.

7.4 Trade Integration and Welfare

So far, we have documented that trade integration helps account for declining pass-through in an environment with strategic complementarity in price setting. We now show that the strategic complementarity in price setting has important implications for the welfare benefits of trade integration.

Table 8 reports the welfare effects of trade integration under alternative scenarios. In each scenario, we calculate the home and foreign welfare gains by comparing household utility in the initial steady state and the steady state associated with greater trade integration. The welfare gain is expressed in consumption equivalent units as the percentage of consumption in

conditions held for all cases in Tables 7 and 9 as well as our stochastic simulations in which technology and trade costs vary.

[28]See Engel and Rogers (2004) and Bergin and Glick (2005). Bergin and Glick (2005) also find puzzling instances in which price dispersion increased over time as barriers to trade fell. They model trade along the extensive margin to account for this observation and show that in some cases trade integration can indeed lead to greater price dispersion. In contrast, our approach predicts that prices always converge as trade costs decline.

the initial steady state a household would give up in order to be in a world with greater trade integration. We also report world welfare, which weights each country's welfare according to its population. For each scenario, we report the welfare gains for two versions of our model: the strategic complementarity (SC) calibration and the CES calibration.

The second column of Table 8 reports the welfare gains from lowering D^*. In both the SC and CES economies, a fall in D^* directly raises home welfare, though by substantially less in the SC case. This difference reflects how the fall in D^* affects the distortion arising from monopolistic competition. Because the markups of foreign exporters increases in the SC economy, a decline in D^* leads to a less pronounced fall in import prices in the SC economy than in the CES economy. The smaller price decline implies a smaller increase in import consumption. The relatively lower consumption of imports in the SC economy is partially compensated by a reduction in the markups of domestic firms, which has a stimulative effect on consumption and hours worked. Overall, however, home welfare increases only about half as much as it does in the CES economy.

Surprisingly, a fall in D^* leads to a decline in foreign welfare. This decline mainly reflects international risk-sharing. In our economy, asset markets are complete so that $c_t = \nu_0 q_t c_t^*$ where ν_0 is a constant determined in the initial steady state. With complete asset markets, a fall in D^* induces relatively large increases in both c and q, and a foreign household is willing to work harder without much compensation in terms of higher c^*. Of course, a foreign household expects a domestic household to behave similarly following a fall in D as shown in the third column of Table 8.

In response to the fall in D^*, foreign welfare is about 60 percent lower in the CES economy than the SC economy. There are two channels affecting foreign welfare in opposite directions that help explain this result. First, because pass-through is complete in the CES case, there is a larger increase in import demand by domestic households than in the SC case. This larger increase in demand induces a more pronounced rise in foreign hours worked and in turn tends to lower welfare more in the CES economy. Second, there is an appreciation of the foreign currency (see Table 7 for the SC case) that leads to higher foreign import demand. To the extent that pass-through is higher in the CES economy, foreign import demands expands more, providing a bigger boost to overall consumption and welfare. The effect of the first channel dominates the second channel in part because the foreign economy is relatively closed with an import share of about 5 percent.

In general, the qualitative effects of a fall in D are similar to those for the decline in D^* except that the roles of the home and foreign economies are reversed. Note that there is a larger fall in home welfare in the SC economy than in the CES economy in response to the fall in D. This reflects the increased relative importance of the second channel for the home economy due to two factors. First, the larger size of the foreign economy leads to a greater appreciation of the home currency. Second, the home economy is relatively more open so that the appreciation provides a bigger boost to home import demand, aggregate consumption, and welfare.

The fourth column of Table 8 combines the effects of lower trade costs in both markets and demonstrates the importance of pass-through for the welfare benefits of lower trade costs. Although world welfare rises by nearly as much in the SC economy than the CES economy, home welfare falls over 1 percent in the SC economy compared to a rise of 0.6 percent in the CES economy. This fall in home welfare in the SC case in part reflects that the fall in D has a larger effect on demand for domestic exports, since the foreign economy is more than twice as large as the home economy. Since it also is driven by our assumption of perfect risk-sharing between foreign and domestic households, we consider an alternative with imperfect risk-sharing in our sensitivity analysis.

We also consider the welfare effects of trade integration driven by an increase in foreign productivity. As shown in the fifth column of Table 8, the increase in home welfare following an improvement in foreign productivity is only somewhat smaller in the SC economy than the CES economy. Although home consumption of imports, and in turn aggregate consumption, does not rise as much in the low pass-through SC environment, this effect is secondary to the large efficiency gains of the foreign economy that a domestic household gets to share with its foreign counterparts. Consequently, home welfare rises about 21.4 percent in the CES economy and only about 1.2 percentage points less in the SC economy.

With higher foreign productivity and lower trade costs, trade integration improves world welfare by about 20 percent of steady state consumption in the CES economy and a little more in the SC economy. Although the difference of the low or high pass-through environment for world welfare is not large, the difference in terms of the welfare of the home country is sizeable. The improvement in home welfare from trade integration is one-third lower in the low pass-through SC environment than in the complete pass-through CES environment.

We emphasize that our goal in this section was simply to illustrate how incomplete pass-through can alter the welfare benefits of trade integration. In our model, trade occurs solely along the intensive margin. Although a more realistic model for examining the welfare benefits of trade integration would also allow for an endogenous firm entry and exit decision, the incomplete pass-through associated with the strategic complementarity would likely have important consequences for these models. In general, models that allow for an extensive trade margin assume constant markups of prices over marginal costs and therefore pass-through is complete.[29] An important exception is the work of Ottaviano and Melitz (2005), which studies the welfare benefits of trade reforms when firms face entry and exit decisions and have variable markups.[30] While they do not focus on the welfare differences of their variable markup environment with a constant markup environment, their framework also implies that lower trade costs lead to a rise in the markups of exporting firms and to a fall in the markups of domestic producers.

7.5 Sensitivity Analysis

We derived our main results by calibrating the fall in D and D^* to be consistent with the evidence of Baier and Bergstrand (2001) that falling trade costs accounted for one third of the growth in world trade after World War II. In our alternative calibration, we choose the fall in D

[29]See, for instance, Bernard, Eaton, Jensen, and Kortum (2003), Melitz (2003), Ghironi and Melitz (2005), Bergin and Glick (2005), and Choi and Alessandria (2005).

[30]As in our model, markups are variable because demand curves exhibit non-constant elasticity of substitution between goods.

and D^* solely based on tariff data. In particular, we set the fall in D^* to 2.7 percentage points, which according to Table 2 is equivalent to the decline in average tariff rates in developed countries since the late 1980s. For the decline in tariff in the rest of the world, we set the fall in D to 5.6 percentage points by using U.S. export shares to average the tariff decline in developing countries (11 percentage points) and in developed countries (2.7 percentage points) presented in Tables 2 and 3.[31] The top panel of Table 9 reports the results from this alternative calibration. Abstracting from a rise in foreign productivity, we find that pass-through falls 5 percentage points in this alternative scenario, compared to almost 7 percentage points in our benchmark calibration. When both trade costs decline and foreign productivity increases, pass-through falls more than 12 percentage points, which accounts for almost 30 percent of the decline in pass-through observed in the data.

Throughout our analysis, our calibration of steady-state markups also implied a relatively high trade-price elasticity of imports. Since there is considerable uncertainty regarding estimates of this elasticity, it is natural to consider whether lowering the trade-price elasticity has a significant impact on our results. To do this while roughly preserving the same level of markups in our benchmark calibration, we modified our demand aggregator as follows:

$$D\left(\frac{C_{dt}(i)}{C_t}, \frac{C_{mt}(j)}{C_t}\right) = \left[V_d\left(\frac{C_{dt}(i)}{C_t}\right)^{1/\rho} + V_m\left(\frac{C_{mt}(j)}{C_t}\right)^{1/\rho}\right]^{\rho} - \frac{1}{(1+\eta)\gamma} + 1 = 1. \tag{27}$$

Note that setting $\rho = 1$ yields our benchmark demand aggregator. In our alternative calibration, we set ρ and γ so that the elasticity of aggregate imports with respect to the relative import price is 6.5 (compared to 10.7 in the SC calibration) and the level of the steady-state markup of the foreign exporter is 13.5% (compared to 10.2% in the SC calibration). As before, we set η based on the observed value of $\beta_{p_m,q}$ in the pre-1990 period.[32]

Results from this alternative are reported in Table 9 under the label "Lower Elasticity Calibration". Our first experiment shows that when the fall in trade costs remains at 7

[31] We used a weight of 65% for industrial countries based on 1992 data from the IFS DOTS database.

[32] We set $\rho = 0.97$, $\eta = -2.32$, $\gamma = 1.135$, and $\omega = \omega^* = 0.1281$. As in the SC calibration, we set $\sigma_z = \sigma_z^* = 0.0113$ and $\sigma_D = \sigma_D^* = 0.0034$ in order to match the volatility of output and the correlation of the real exchange rate and the relative import price. We also used the same parameter values given in Table 4.

percentage points and the level of foreign productivity is 30 percent higher than in the initial steady state, the fall in pass-through is a bit larger than in the SC calibration. Not surprisingly, with a lower elasticity the model has more difficulty accounting for the 5 percentage point rise in the U.S. import share that has occurred over the last twenty five years: the overall trade share rises only 2.4 percentage points in this case compared to 4.2 percentage points in the SC calibration. Thus, our model is no different than other international real business cycle models in that it needs a counterfactually high trade price elasticity to account for the growth in U.S. trade experienced over the last twenty-five years.[33]

Table 9 also reports the effects of calibrating the trade costs so that trade costs account for 1/3 of the observed 5 percentage point increase in the U.S. trade share. In this case, D and D^* fall by 15 percentage points and pass-through falls by about 24 percentage points.

Our results so far have been derived under the assumption of complete international risk-sharing. Table 10 displays the effects of lower trade costs and higher foreign productivity on pass-through and welfare when asset markets are incomplete internationally but complete at the national level. In this case, there is a single, internationally-traded asset that is non-state contingent. We also assume that there is a small "portfolio adjustment cost" associated with purchases/sales of this international asset so that the level of net foreign assets in a country is stationary.[34]

As shown in Table 10, a decrease in D and D^* of 7 percentage points results in $\beta_{p_m,q}$ falling 10 percentage points, compared to 7 percentage points in the complete asset market case. The larger increase in the incomplete market economy reflects that the larger appreciation of the home currency and thus a larger decline in foreign export costs (denominated in home currency) in response to a decline in D. This larger appreciation occurs because a fall in D does not stimulate domestic production as much as in the complete market economy in which a household is willing to work more due to risk-sharing considerations.

[33]See Yi (2003) for an extended discussion of this point.

[34]Specifically, we assume that a household pays a quadratic adjustment cost, $\frac{\zeta}{2}(b_{ft+1})^2$ for changing its level of the international asset, b_{ft+1}. For the experiments reported in Table 10, we set $\zeta = 1e^{-05}$. See Schmitt-Grohé and Uribe (2001) for a comparison of this way of imposing stationarity with other alternatives.

In contrast, there is a much smaller increase in $\beta_{p_m,q}$ following the rise in foreign technology in the incomplete market economy than in the complete market economy. In the incomplete market case, foreign export costs denominated in home currency do not fall as sharply, limiting the associated increase in the markup of a foreign exporter. This smaller rise in costs reflects a more subdued appreciation of the home currency.

Table 10 also displays the welfare benefits from trade integration under incomplete markets. Similar to the complete market case, the benefits of trade integration are significantly reduced in the SC economy relative to the CES economy. Home welfare rises about 1 percent in the CES economy in response to both a fall in trade costs and a rise in foreign technology compared to only 0.3 percent in the SC economy.

While the welfare benefits of trade integration to the home economy are much lower in the SC economy than in the CES economy regardless of the asset market structure, there is a considerable difference in the home welfare gains in the SC economy depending on the asset market assumption. A fall in trade costs results in an increase in home welfare under the incomplete markets, while home welfare declines in the complete markets economy. Also, a fall in foreign technology results in a slight fall in home welfare in the incomplete market economy compared to a substantial increase in the complete market economy. This fall in home welfare in the incomplete market case reflects an increase in hours worked induced by a fall in the domestic markups of home firms. Furthermore, home consumption no longer rises much when risk-sharing is limited.

Overall, our sensitivity analysis supports our main finding that increased trade integration has been an important factor behind the decline in pass-through. A fall in trade costs induces a substantial decline in pass-through both in a version of our model with a lower trade-price elasticity and in a version in which asset markets are incomplete. In contrast, the fall in pass-through resulting from higher foreign productivity is sensitive to the asset market assumption, as the decline in pass-through is much greater in the case of complete asset markets. Our analysis also shows that low pass-through alters the welfare benefits of trade integration regardless of the asset market structure.

8 Conclusion

In this paper, we proposed a new explanation for the decline in pass-through that emphasized the role of trade integration and strategic complementarity. When firms face strategic complementarity in setting prices, a fall in exporters' marginal costs, driven by trade integration, leads to lower pass-through. This effect is quantitatively important since a fall in trade costs leads to roughly a one-for-one reduction in pass-through in our benchmark calibration and accounts for roughly 40 percent of the observed decline in pass-through since the early 1990s.

We also showed that pass-through is an important factor for the welfare benefits of trade integration. Because foreign exporters raise their markups and pass-through less of the reduction in their costs to domestic households, the welfare benefits of trade integration can be substantially reduced relative to an environment with complete pass-through.

In our analysis, we chose to model strategic complementarity via monopolistic competition and non-CES demand curves. Although this approach broadly captures the complementarity in price setting by firms in a tractable manner, directly modelling the strategic interaction amongst firms in a richer, game-theoretic framework may yield additional insights. Finally, in our environment, the impact of trade integration on pass-through and welfare occurred solely along the intensive margin. An important extension is to investigate the entry and exit decision of firms into the export market, especially since our model requires a high elasticity of substitution between home and foreign goods to match the observed rise in U.S. trade shares. We leave these extensions for future research.

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Table 1: Volatility and Correlation of Relative Import Price and Real Exchange Rate[a]

Moment (Differenced)	Full Sample	1980:1-1989:4	1990:1-2004:4
a. $\beta_{p_m,q}$	0.35	0.55	0.13
(a = b*c)			
b. σ_{p_m}/σ_q	0.47	0.60	0.25
c. corr(q, p_m)	0.75	0.92	0.51
Moment (HP-Filtered)			
a. $\beta_{p_m,q}$	0.46	0.59	0.17
(a = b*c)			
b. σ_{p_m}/σ_q	0.54	0.61	0.29
c. corr(q, p_m)	0.85	0.95	0.60

[a] $\beta_{p_m,q}$ denotes the regression coefficient from a univariate least squares regression of the real exchange rate on the relative import price. Differenced refers to data that has been log-differenced. HP-filtered series were computed by transforming the log of the variables (with $\lambda = 1600$).

Table 2: Weighted-Average Tariffs on Products in Developing Countries[a]

Region	1984-1987	1988-1990	2000-01	Decline from 1984-2001[b]
Developing Countries	22.2	17.9	11	11.2
Asia[c]	20.9	17.1	9.7	11.2
South America	36.4	24.9	11.2	23.2

[a]Weighted-average tariffs are calculated as simple averages across product categories, weighting by each country's import share. Source: Unctad (http://globstat.unctad.org/html/index.html).
[b]Decline refers to the difference between columns 2 and 4.
[c]Asia including Japan.

Table 3: Weighted-Average Tariffs on Products in Developed Countries[a]

Tariffs on Products from:	1989-1992	1996	2001	Decline from 1989-2001[b]
Developing Countries	7.2	4.9	3.9	3.3
Asia[c]	7.8	4.8	3.9	3.7
Developed Countries	5.1	3.5	2.5	2.6
World	5.8	4.0	3.1	2.7

[a]Weighted-average tariffs are calculated as simple averages across non-fuel and non-agricultural products, weighting by each country's import share. Source: Unctad (http://globstat.unctad.org/html/index.html).
[b]Decline refers to the difference between columns 2 and 4.
[c]Asia including Japan.

Table 4: Common Parameter Values Across Calibrations

n = 2.8	$Z = 1$
$\beta = (1.03)^{-0.25}$	$\chi = 1.5$
$\rho_Z = \rho_Z^* = 0.95$	$\rho_D = \rho_D^* = 0.95$

Table 5: Additional Parameter Values and Properties of Calibrated Models

	NCES Demand		
	SC Calibration	2004 SC Calibration	CES Calibration
η	-1.87	-1.87	0
γ	1.15	1.15	1/1.024
$D = D^*$	1.25	1.19	1.25
Z^*	0.7143	0.9289	0.7143
$\omega = \omega^*$	0.15	0.15	0.68
χ_0	0.83	0.83	0.91
χ_0^*	0.80	0.80	0.91
$\sigma_Z = \sigma_Z^*$	0.01075	0.01075	0.0103
$\sigma_D = \sigma_D^*$	0.0024	0.0024	0.0021
Home Trade Share	9.9%	14.2%	9.9%
Home Firms' Domestic Markup (μ_d)	1.22	1.19	1.1024
Foreign Exporters' Markup (μ_m)	1.1024	1.26	1.1024
Direct Pass-Through (κ_m)	0.36	0.25	1

Table 6: Selected Moments and Parameter Values of Calibrated Models[a]

Moment	Data		Model	
	1980-1989	1990-2004	SC Calibration	CES Calibration
a. $\text{cov}(\Delta q, \Delta p_m)/\text{var}(\Delta q)$ (a = b*c)	0.55	0.13	0.55	1
b. $\sigma(\Delta p_m)/\sigma(\Delta q)$	0.60	0.25	0.60	1.09
c. $\text{corr}(\Delta q, \Delta p_m)$	0.92	0.51	0.92	0.92
$\sigma(y^{hp})$	1.74	0.98	1.74	1.74
$\sigma(q^{hp})$	4.98	2.70	0.60	0.61
$\sigma(\Delta q)$	2.89	1.45	0.47	0.49
$\text{corr}(y^{hp}, y^{hp}_{-1})$	0.90	0.88	0.71	0.71
$\text{corr}(q^{hp}, q^{hp}_{-1})$	0.87	0.81	0.71	0.70
$\text{corr}(p^{hp}_m, p^{hp}_{m,-1})$	0.92	0.92	0.66	0.64

[a]The subscript 'hp' denotes that a variable was transformed using the HP-filter (with $\lambda = 1600$).

Table 7: The Effect of Lower Trade Costs and Higher Foreign Productivity[a,b]

	Lower D^*	Lower D	Lower D^*, D	Higher Z^*	Higher Z^* Lower D^*, D
Foreign Exporter Trade Cost (D^*)	-7	0	-7	0	-7
Home Exporter Trade Cost (D)	0	-7	-7	0	-7
Foreign Productivity (Z^*)	0	0	0	30	30
Home Trade Share	1.3	0.5	1.7	3.0	4.2
Home Firm Markup at Home (μ_d)	-0.8	-0.3	-1.0	-1.8	-2.5
a. Home Import Price (p_m)	-1.6	-0.6	-2.1	-3.9	-5.8
(a = b+c)					
b. Foreign Firm Markup at Home (μ_m)	2.8	1.0	3.8	7.8	13.2
c. Foreign Marginal Cost ($qD^*\psi^*$)	-4.3	-1.5	-5.9	-11.7	-19.0
Real Exchange Rate (q)	1.3	-2.6	-1.3	-6.6	-9.7
Direct Pass-Through (κ_m)	-2.8	-1.0	-3.8	-7.1	-10.8
Pass-Through ($\beta_{p_m,q}$)	-5.5	-3.7	-6.9	-9.1	-15.8

[a] Entry refers to the log-difference for a variable with the exceptions of the trade costs, home trade share, κ_m, and $\beta_{p_m,q}$. For these variables, the entries refer to the percentage point difference from its initial steady state value. For the increase in Z^*, we report the arithmetic percentage change instead of the log-difference.
[b] Row a equals row b plus row c with any discrepancy due to rounding.

Table 8: The Welfare Effects of Lower Trade Costs and Higher Foreign Productivity[a,b]

	Lower D^*	Lower D	Lower D^*, D	Higher Z^*	Higher Z^* Lower D^*, D
Foreign Exporter Trade Cost (D^*)	-7	0	-7	0	-7
Home Exporter Trade Cost (D)	0	-7	-7	0	-7
Foreign Productivity (Z^*)	0	0	0	30	30
SC Calibration:					
Home Welfare	1.18	-2.26	-1.12	20.17	16.81
Foreign Welfare	-0.35	1.36	1.04	20.47	22.36
World Welfare	0.05	0.40	0.48	20.39	20.90
CES Calibration:					
Home Welfare	2.48	-1.87	0.61	21.40	25.35
Foreign Welfare	-0.91	1.34	0.46	19.02	18.14
World Welfare	-0.02	0.50	0.50	19.65	20.04

[a]Change in steady state calculated in consumption equivalent units.
[b]World welfare is calculated by weighting home and foreign welfare using the population sizes of the two economies.

Table 9: The Decline in Pass-Through For Alternative Calibrations[a]

	Foreign Exporter Trade Cost (D^*)	Home Exporter Trade Cost (D)	Foreign Productivity (Z^*)	Home Trade Share	$\beta_{p_m,q}$
SC Calibration					
Tariff Data Only	-2.7	-5	0	0.9	-5.0
Tariff Data Only, Higher Z^*	-2.7	-5	30	3.6	-12.4
Lower Elasticity Calibration					
$\Delta D = \Delta D^* = -7$, Higher Z^*	-7	-7	30	2.4	-18.3
$\Delta D = \Delta D^* = -17$, Higher Z^*	-15	-15	30	2.9	-24.4

[a]Entry refers to the percentage point difference between a variable and its initial steady state value.

Table 10: The Decline in Pass-Through and Welfare Benefits Under Incomplete Markets[a,b]

	Lower D^*	Lower D	Lower D^*, D	Higher Z^*	Higher Z^* Lower D^*, D
Foreign Exporter Trade Cost (D^*)	-7	0	-7	0	-7
Home Exporter Trade Cost (D)	0	-7	-7	0	-7
Foreign Productivity (Z^*)	0	0	0	30	30
SC Calibration:					
Real Exchange Rate (q)	1.7	-3.7	-2.1	-1.1	-3.8
Pass-Through ($\beta_{p_m,q}$)	-5.3	-4.9	-9.8	-1.90	-11.6
Home Welfare	0.15	0.16	0.34	-0.04	0.30
Foreign Welfare	0.14	0.13	0.31	30.11	30.47
World Welfare	0.14	0.14	0.32	22.17	22.53
CES Calibration:					
Home Welfare	0.35	0.31	0.77	0.15	1.03
Foreign Welfare	0.15	0.17	0.37	29.96	30.38
World Welfare	0.21	0.21	0.48	22.11	22.65

[a]Entries for change in trade costs and $\beta_{p_m,q}$ refer to percentage point change from initial steady state values. Entries for change in q and Z^* refer to percent change. Change in steady state welfare calculated in consumption equivalent units.
[b]World welfare is calculated by weighting home and foreign welfare using the population sizes of the two economies.

Figure 1: The Real Exchange Rate and Relative Import Prices

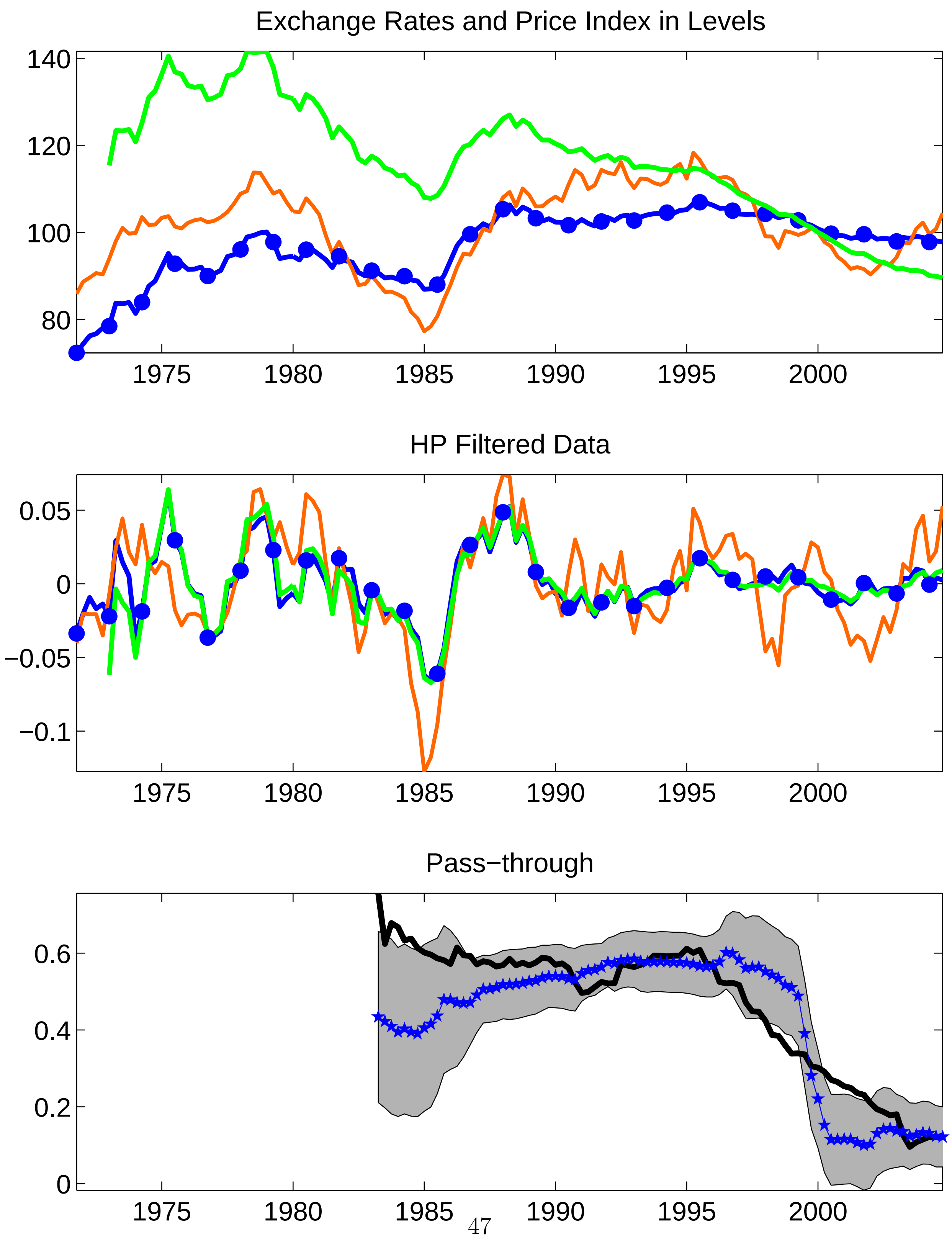


Figure 2: Pass-through and Trade Costs

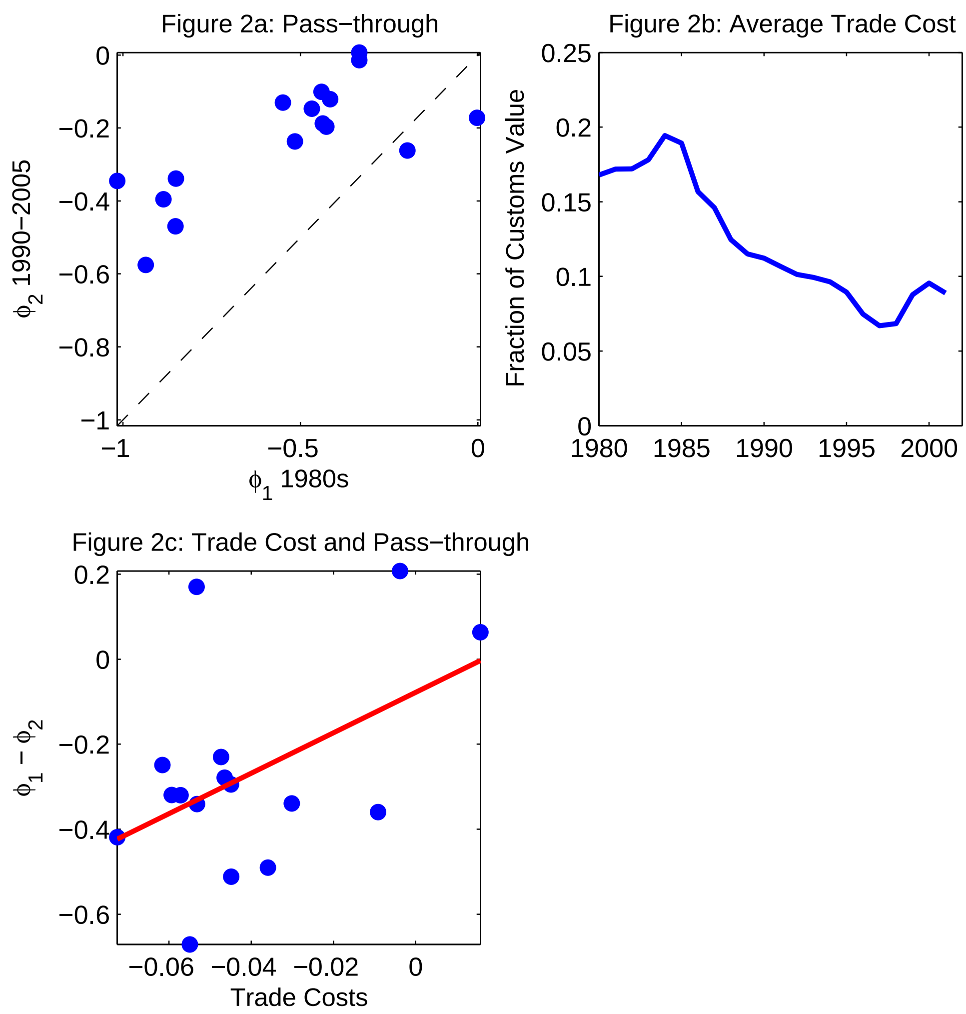
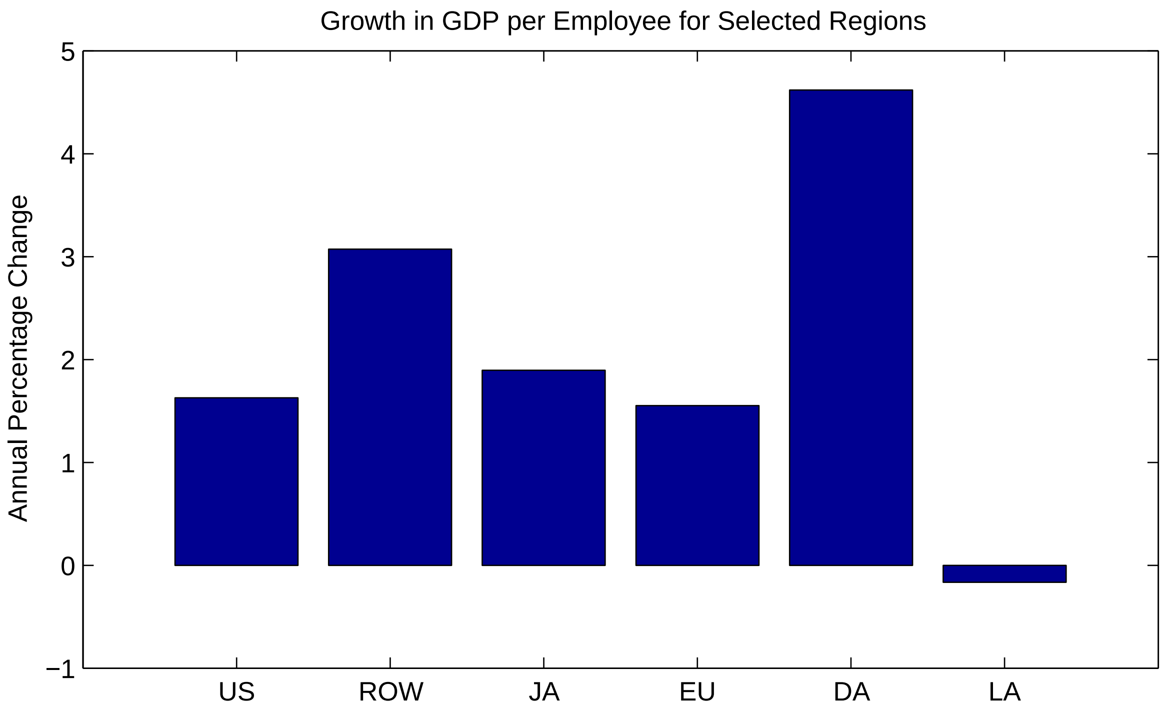


Figure 3: Growth in GDP per Employee in the United States and the Rest of the World



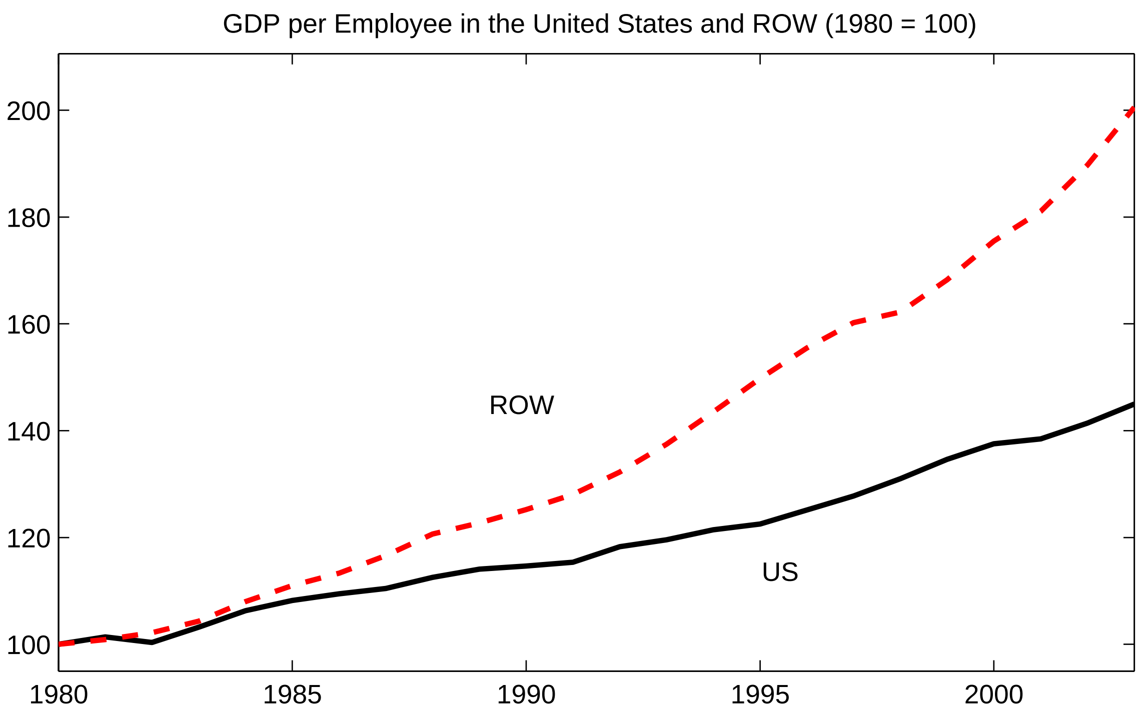


Figure 4: Import Demand and an Exporter's Marginal Revenue Schedule

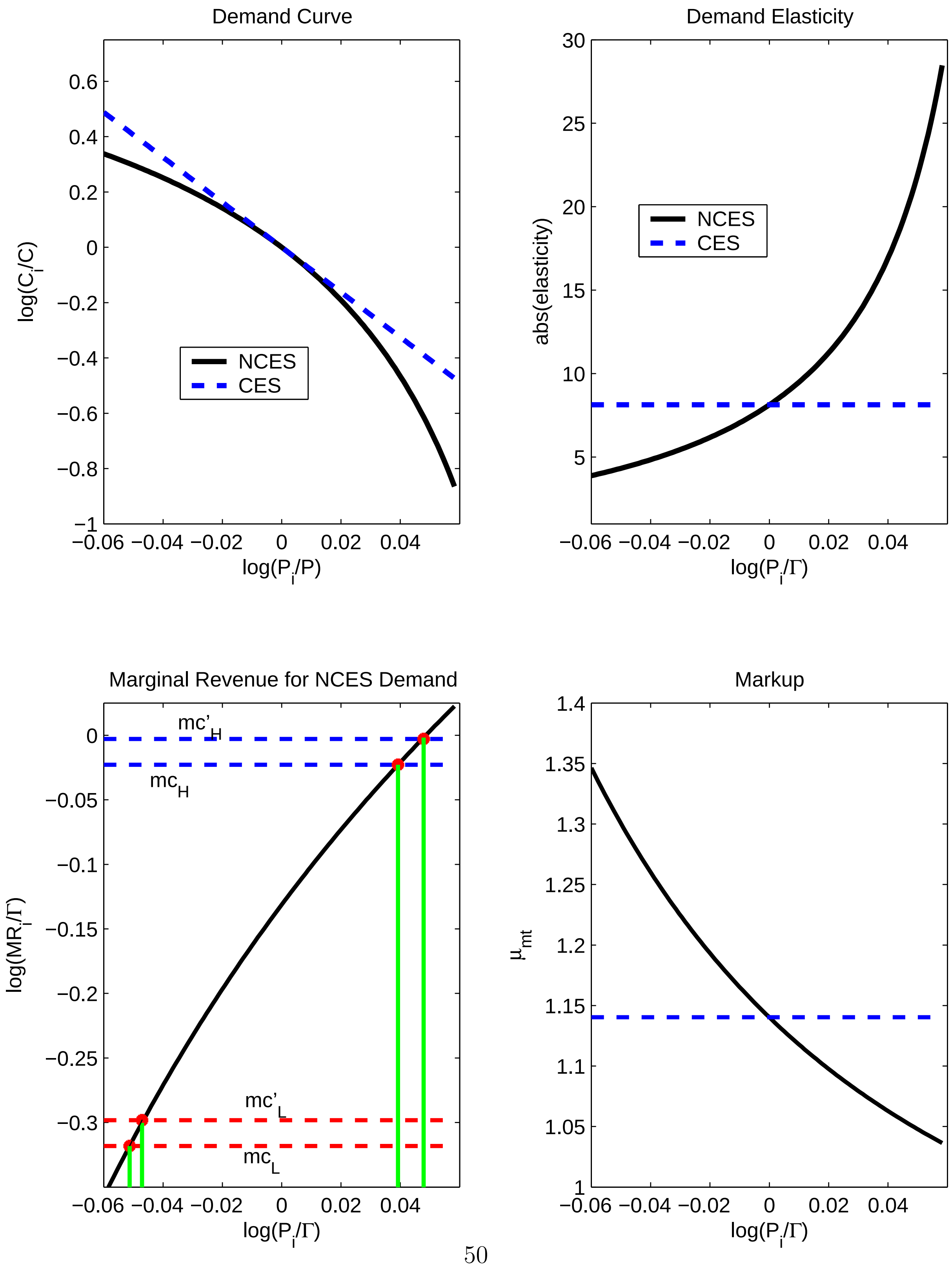


Figure 5: The Effects of Home Technology and Foreign Exporter Trade Cost Shocks