Essays in International Economics

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Abstract

The first chapter of this dissertation investigates the impact of globalization on inflation in the context of a two-country New Keynesian model. Three questions have been raised in the recent literature: Has globalization lowered long-run inflation? Has globalization affected short-run dynamics of inflation? Has globalization been a source of shocks for the inflation process? Here, these questions are framed in terms of the effects of increased openness on different aspects of open-economy Phillips curves, considering different scenarios for the measure of inflation, and for the assumed export-pricing behavior of firms. The main qualitative prediction of the model is that globalization makes Phillips curves flatter. Quantitatively, the effects of globalization on inflation are modest: increased openness only slightly decreases the slope of Phillips curves, domestic factors are still the main determinants of inflation, and globalization does not lead to a substantial increase in the volatility of shocks to the inflation process.

The second chapter explores another angle for the impact of openness. Many studies have estimated the so-called New Keynesian Phillips curve (NKPC), with mixed results. This chapter thus investigates whether several dimensions of openness to international trade, in particular the distinction between traded and nontraded goods, affect the specification of the NKPC that can be brought to the data. More specifically, which additional control variables should be included in estimating the NKPC, relative to its closed-economy counterpart? We ask this question for both domestically produced goods’ and consumption expenditure’s inflation, considering different scenarios for nontradability, in final goods and intermediate inputs, and for the assumed export-pricing behavior of firms, namely Producer Currency Pricing.
and Local Currency Pricing. We find that nontradability matters: estimation of the NKPC not accounting for these aspects is likely to produce biased results.

The third and last chapter, co-authored with Alexis Antoniades, studies exchange rate pass-through and its determinants using scanner data on about 85% of the fast moving consumer goods (FMCGs) sold by 1,041 outlets in the United Arab Emirates between January of 2005 and December of 2010. The data, reported at the barcode level at each outlet, are augmented with Country-of-Origin (COO) information that was collected from the products’ labels. At the aggregate level, we find exchange rate pass-through on imported consumer goods to be 3% in the short-run and 20% in the long-run. We then show that exchange rate pass-through is correlated positively with retailer market share, negatively with product quality, and negatively with the elasticity of substitution of the products within specific FMCGs categories.
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Chapter 1

Globalization and the Phillips curve†

1.1 Introduction

The globalization and inflation debate has become very lively, and not without controversy. From a policymaker’s standpoint, if we are to accept the notion that the world is becoming more globalized, it is of course important to understand in which ways inflation is affected, and how (or whether) the conduct of monetary policy has to be adjusted. These issues have received much attention in recent policy discussions. Bernanke (2007) broadly identifies two channels for globalization to potentially impact monetary policy: directly, affecting its ability to influence domestic financial market conditions through short and long term interest rates, and indirectly, modifying the determinants of inflation, which is a key policy variable. This chapter focuses on the latter and, in particular, on the effect of increased trade openness.¹

From a reading of the recent literature on the effects of globalization on inflation, three questions emerge:

1. Has globalization lowered long-run inflation? One argument supporting this

¹Material from an earlier version of this chapter was presented at the 2009 annual meeting of the LACEA/LAMES conference.

¹It’s worth noting that the definition of globalization employed here, namely an increase in the share of foreign produced goods in aggregate consumption (or share of imports in GDP, as shown later - see Figure 1.1), is by no means exhaustive. There are several other dimensions of globalization, including cross border factor mobility and financial integration, that can be relevant for inflation and are beyond the scope of this analysis.
view relies on the idea that increased competition due to globalization makes wages and prices more flexible, which in turn steepens the inflation/output relation. Central banks have less incentive to exploit this worse trade-off and equilibrium inflation is lower as a result (Rogoff (2003, 2006)).

2. Has globalization affected short-run dynamics of inflation? More specifically: has it affected the output/inflation trade-off, and does it imply that foreign factors matter in addition to (or more so than) domestic ones?

3. Has globalization been a source of shocks to the inflation process? More specifically: has globalization made inflation more volatile, beyond its effects through domestic and global measures of slack?

This chapter informs the debate, providing a theoretical investigation of these claims. Specifically, the model we study implies Phillips curves of the following general form

\[ \pi_t = \beta E_t \pi_{t+1} + \alpha(\gamma)\tilde{y}_t + \alpha^*(\gamma)\tilde{y}^*_t + \chi_t(\gamma) \]  

relating inflation \( \pi_t \) to expected inflation next period, measures of domestic and foreign output gaps (\( \tilde{y}_t \) and \( \tilde{y}^*_t \) respectively), with coefficients that depend on some openness parameter \( \gamma \), and an endogenous shift term \( \chi_t \) (also affected by openness).

The above questions can then be framed in terms of the effect of increased openness (as measured by \( \gamma \)) on different aspects of these Phillips curves: the argument in the first hypothesis rests on a positive relationship between the slope and openness (\( \frac{\partial \alpha}{\partial \gamma} > 0 \)). The second hypothesis states that the slope and the coefficient on the foreign output gap might be changing with openness (\( \frac{\partial \alpha}{\partial \gamma} \neq 0 \) and \( \frac{\partial \alpha^*}{\partial \gamma} \neq 0 \)). The
third hypothesis predicts that the variance of the shifter is increasing with openness \( \left( \frac{\partial \text{Var}(\chi_t)}{\partial \gamma} > 0 \right) \).

The analytical framework is an open-economy, two-country New Keynesian model with sticky prices. We allow for pricing-to-market (PTM), whereby firms are potentially able to set different prices for the domestic and export market.\(^2\) We consider three different scenarios for the assumed export-pricing behavior of firms, defined by the currency in which exports’ prices are sticky. Let us illustrate this with an example that uses the US Dollar (\$) and the Japanese Yen (¥): with *Producer-Currency Pricing* (PCP), US firms price their exports in $, whereas Japanese firms set export prices in ¥. With *Local-Currency Pricing* (LCP), US firms use ¥, while Japanese firms use $. Finally, with *Dollar-Dominant Pricing* (DDP), exports from both countries are invoiced in $ (so that the Yen is only used to price Japanese goods sold in the Japanese market). These assumptions have different implications for the degree of *exchange rate pass-through*, broadly defined as the sensitivity of import and consumer prices to fluctuations in exchange rates. We also assess whether they have implications for the effects of globalization on inflation. Moreover, the distinction between domestic good-inflation and CPI-inflation is explicitly introduced to highlight the role of import prices.

There is a growing body of empirical literature that explores the globalization and inflation hypothesis. These empirical studies provide conflicting evidence regarding the three questions outlined above. First, there is general consensus that the estimated sensitivity of inflation to domestic output gaps has declined (see for example

\(^2\)The introduction of PTM is motivated by work in the New Open-Economy Macro literature (e.g. Betts and Devereux (2000), Chari et al. (2002) and Devereux and Engel (2003)) that recognizes its importance in affecting exchange rate dynamics and the international transmission of monetary policy.
Roberts (2006) for the US, and Pain et al. (2006) for a group of OECD countries). The issue is how much, if any, of this decline is due to globalization. The IMF (2006) finds a significant negative relation between trade openness and the slope of Phillips curves for some industrial economies. On the other hand, Wynne and Kersting (2007) and Ihrig et al. (2007) report weak or no relation at all. Second, and on a related note, if global as well as domestic markets now matter for firms’ price-setting decisions, we should expect global measures of resource utilization to be increasingly important in determining inflation. Evidence is once again mixed: Gamber and Hung (2001) and Borio and Filardo (2007) find a significant role for foreign output gaps, while Ihrig et al. (2007) argue that the result is not robust, and there is little support for the “globe-centric” approach once domestic factors are controlled for. Milani (2009) performs Bayesian estimation of a structural open-economy model for G-7 countries and points to weak evidence for a direct effect of global measures of slack on national inflation rates. Bianchi and Civelli (2010) use VARs with time varying coefficients and stochastic volatilities and report reduced-form results that are consistent with those in Ihrig et al. (2007). They argue, however, that the lack of significant effects of foreign output gaps in this form might be because the observed increase in openness hasn’t been large enough, and they employ structural VAR analysis to argue for their potential importance in affecting inflation dynamics. Third, recent studies have explored the role of increased shares of low-cost imports in generating downward pressure on inflation. That is, even if globalization hasn’t affected the structural determinants of inflation, it might have acted as a source of shocks through this channel. Kamin et al. (2006) specifically study whether there is a “China effect” on global inflation, and conclude that it has been quantitatively modest. Aside from the inherent
difficulties in measuring such effects, it might also be argued that such developments can lead to offsetting price increases in other categories of goods, so that the overall impact is unclear.\(^3\)

More generally, a number of policy contributions (e.g. Kohn (2008, 2006), Bean (2006), Yellen (2006)) share a common message: globalization is a phenomenon to be reckoned with, but its effects on inflation and monetary policy have yet to be adequately assessed and should not be overstated. Ball (2006) and Mishkin (2008) go further and argue that globalization has had very little role in changing the determinants of inflation, and the low and stable inflation rates observed in the US during the 1990s are a consequence of better policy and well-anchored inflation expectations. The overall picture is that evidence so far is too scattered to be conclusive.

The main qualitative prediction of the model in this chapter is that increased openness makes Phillips curves flatter. This result holds for a broad range of parameter configurations and is true both for domestic good-inflation and CPI-inflation. The basic mechanism works through firms’ marginal costs, which are affected by changes in output to a lesser extent. This is because the required terms of trade adjustment following an output change is smaller the more open the economy. Quantitatively, however, the effects of globalization on inflation are modest, especially in the case that we consider empirically relevant for the US: First, increased openness only slightly decreases the structural slope of Phillips curves. Second, while foreign measures of output gap are increasingly important, domestic factors are still the main determinants of inflation. Third, globalization amplifies the volatility of shocks to the inflation process, but the increase is not substantial. This set of results is confirmed

\(^3\)For example, as noted in Bean (2006), the rapid growth of the same emerging countries that provide low-cost imports is putting upward pressure on commodity prices.
when we look at “empirical” regressions that use data generated by the model, and are intended to mimic the analysis of earlier studies.

Another implication of this model is that the different export-pricing scenarios don’t change the way openness impacts the structural slope of Phillips curves: more specifically, the elasticity of marginal cost with respect to domestic output is not affected by the exporters’ currency of choice. The same is true for the coefficient on the foreign output gap. Different assumptions about currency choice do imply, however, different endogenous shift terms in the Phillips curves. These terms reflect differential degrees of exchange rate pass-through into import prices, and affect the way globalization impacts inflation through this channel. We also check the model’s implication for pass-through at the aggregate level, across the three pricing assumptions. To do this, we compute the implied short-run elasticity of import prices with respect to the exchange rate, and find it is in line with empirical estimates for the US.

There are some relatively close predecessors to this analysis in terms of modeling: Clarida, Gali and Gertler (2002), and Gali and Monacelli (2005), for example, employ similar New Keynesian open-economy models to study how openness affects properties of optimal monetary policy. Monacelli (2005) introduces imperfect pass-through in the analysis. Steinsson (2008) looks at the volatility and persistence properties of the real exchange rate in a two-country model with LCP. Corsetti and Pesenti (2005a, 2005b) allow for partial indexation of prices to fluctuations of the exchange rate for a simpler form of price stickiness, and regard PCP, LCP and DDP as special cases. There is some recent theoretical work that focuses more explicitly on the effects of globalization. Razin and Yuen (2002) look at Phillips curves in the context of a small
open economy model with prices set one period in advance, and find that the open-
economy case implies a flatter Phillips curve than closed-economy. Woodford (2007)
has a slightly different focus: his analysis builds on Clarida, Gali and Gertler (2002)
to study several channels through which globalization might affect the impact of mon-
etary policy on domestic variables. His conclusion is that globalization is not likely to
impair monetary policy’s ability to control domestic inflation. Finally, other papers
use a New Keynesian framework to study the theoretical link between the slope of
Phillips curves and developments related to globalization other than increased trade
openness: Binyamini and Razin (2007) allow for international labor flows and cap-
ital mobility and find they make inflation less responsive to domestic real activity.
Sbordone (2007) considers the effect of increased competition (modeled through an
increase in varieties of traded goods) on the elasticity of demand faced by firms and
argues that the impact on the slope of the Phillips curve is not quantitatively rele-
vant. Guerrieri et al. (2010) follow a similar approach to estimate a Phillips curve
in the context of an explicit open-economy model, and find that foreign competition
has contributed to lowering the level of inflation. We view the results in this strand
of the literature as complementary to those in this chapter.

The rest of the chapter is organized as follows: Section 1.2 describes the main
features of the model, while Section 1.3 analyzes Phillips curves in detail, establishing
the role of open economy aspects. Section 1.4 presents the main results and provides
a qualitative and quantitative assessment of the effects of globalization on the Phillips
curves. Section 1.5 evaluates the model’s implications for exchange rate pass-through
and Section 1.6 concludes.
1.2 The Model

The world economy consists of two large countries, Home (H) and Foreign (F), with representative optimizing households and symmetric preferences. There is a competitive, economy-wide labor market, and financial markets are complete both domestically and across borders, in that agents have access to a complete set of state contingent assets which can be traded internationally. Both countries have monopolistically competitive intermediate-good producers who set nominal prices in a staggered fashion (following Calvo (1983)), and a perfectly competitive final-good producer.

As for the more specific open-economy aspects, we abstract from non tradable goods, so that fluctuations of the real exchange rate are only due to deviations from the Law of One Price (LOP) for tradables and movements of the terms of trade in the presence of consumption home bias. Intermediate-good producers are potentially able to price discriminate across markets.

1.2.1 Households

The representative household chooses consumption $C_t$ and labor $N_t$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}}{1+\phi} \right]$$

subject to a flow budget constraint that reflects market completeness:

$$P_t C_t + E_t \{ \rho_{t,t+1} D_{t+1} \} = W_t N_t + D_t + \Upsilon_t$$

(1.3)
where $D_{t+1}$ is the state-contingent payoff of the portfolio at the beginning of period $t + 1$ and $\rho_{t,t+1}$ is the relevant stochastic discount factor. $W_t$ is nominal wage and $\Upsilon_t$ denotes profits from firms. $\sigma$ is the inverse of the intertemporal elasticity of substitution and $\phi$ is the inverse of the Frisch elasticity of labor supply.\footnote{The Appendix to this chapter provides details and derivations of the model.}

The index $C_t$ is defined as:

$$
C_t \equiv \left[ (1 - \gamma)\frac{1}{\varepsilon} C_{H,t}^{\frac{\varepsilon - 1}{\varepsilon}} + \gamma^{\frac{1}{\varepsilon}} C_{F,t}^{\frac{\varepsilon - 1}{\varepsilon}} \right]^{\frac{\eta}{\eta - 1}} \tag{1.4}
$$

where $C_H$ and $C_F$ are consumption bundles of domestic and foreign varieties, respectively:

$$
C_{H,t} \equiv \left[ \int_0^1 C_{H,t}(i)^{\frac{1}{\varepsilon}} \, di \right]^{\frac{\varepsilon}{\varepsilon - 1}} \tag{1.5}
$$

$$
C_{F,t} \equiv \left[ \int_0^1 C_{F,t}(i)^{\frac{1}{\varepsilon}} \, di \right]^{\frac{\varepsilon}{\varepsilon - 1}}
$$

Accordingly, $\varepsilon > 1$ is the elasticity of substitution between varieties and $\eta$ denotes the elasticity of substitution between Home and Foreign goods.

The corresponding price index is:

$$
P_t = \left[ (1 - \gamma)P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}. \tag{1.6}
$$

with

$$
P_{H,t} = \left[ \int_0^1 P_{H,t}(i)^{1-\varepsilon} \, di \right]^{\frac{1}{1-\varepsilon}} \tag{1.7}
$$
and

\[ P_{F,t} = \left[ \int_0^1 P_{F,t}(i)^{1-\epsilon} \, di \right]^{\frac{1}{1-\epsilon}} \]  

(1.8)

\( P_t \) is the Consumer Price Index (CPI) in the model. We denote \( P_{H,t} \) and \( P_{F,t} \) as the domestic price index and import price index, respectively. The corresponding inflation rates are analogously defined as CPI, domestic and import inflation.

The parameter \( \gamma \) represents the relative preference for foreign vs. domestic goods. Note that \( \gamma \in (0, \frac{1}{2}) \) implies there is home bias in preferences. We assume the same degree of bias in both countries, so that the aggregate consumption index for country F is given by

\[ C^*_t \equiv \left[ (1 - \gamma)^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta-1}{\eta}} \right]^{-\frac{\eta}{\eta-1}}. \]

As \( \gamma \) increases, both countries become more “open”, in that they are less biased towards domestically produced goods.\(^5\) Corresponding price indices for country F are derived accordingly.\(^6\)

Optimal consumption allocation between the domestic and foreign goods implies

\[ \frac{C_{H,t}}{C_{F,t}} = \frac{1 - \gamma}{\gamma} \left( \frac{P_{H,t}}{P_{F,t}} \right)^{-\eta} \]  

(1.9)

The steady state satisfies \( P_H = P_F \) (\( P_H^* = P_F^* \) for the foreign country) and \( C = C^* = \)

---

\(^5\)In this respect, the setup is different from Clarida, Gali and Gertler (2002), who regard \( \gamma \) as the size of the foreign country (the variables are thus in per capita terms). We can still interpret their \( \gamma \) as an openness parameter, but as one country becomes larger, the other becomes smaller in this instance.

\(^6\)A note on notation: subscripts H and F, both for consumption and price variables, define production location, i.e. “home-” and “foreign-” produced goods, respectively. As for the star superscript, \( C \) vs. \( C^* \) define the identity of the consumer (H vs. F resident), while \( P \) vs. \( P^* \) will denote the currency in which prices are expressed (H-currency vs. F-currency).
$Y = Y^*$, so combining (1.9) and (1.4) shows that $\gamma = \frac{C_F}{Y}$ is the ratio of imports to GDP. This is the measure of openness we employ in the analysis that follows.

1.2.2 Firms

Each economy comprises a continuum of monopolistically competitive firms, producing with a linear technology that uses labor as the sole input. We assume Calvo-style nominal price stickiness: each period, any firm is able to optimally update its price with probability $1 - \theta$ (independent of the time elapsed since the last adjustment). $\theta$ is the same in H and F. With the assumed technology, domestic firms’ real marginal cost is

$$MC_t = \frac{(W_t/P_{H,t})}{A_t}$$

(1.10)

where $A_t$ is exogenous productivity. The pricing-to-market assumption implies that there are two separate pricing problems, one for the domestic and one for the export market. Accordingly, expected profits for an optimizing firm in period $t$ are:

$$E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} (X_{H,t} - MC_{t+j}P_{H,t+j})C_{H,t+j}(i)$$

$$+ E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} (P_{H,t+j}^*(i)E_{t+j} - MC_{t+j}P_{H,t+j})C_{H,t+j}^*(i)$$

where $C_{H}(i)$ and $C_{H}^*(i)$ are domestic and foreign demand for good $i$, and $E$ is the nominal exchange rate (defined as the price of one unit of Foreign currency in terms of Home currency).
Choice of Domestic Price  The domestic firm chooses the reset price $X_{H,t}$ to maximize the above profit function. The first order condition for this problem reads
\[ E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} (X_{H,t} - \frac{\varepsilon}{\varepsilon - 1} MC_{t+j} P_{H,t+j}) C_{H,t+j}(i) = 0 \] (1.11)
where $\frac{\varepsilon}{\varepsilon - 1}$ is the usual expression for the constant (gross) markup over marginal costs. This equation is combined with the evolution of the domestic price index
\[ P_{H,t} = \left[ \theta P_{H,t-1}^{1-\varepsilon} + (1 - \theta) X_{H,t}^{1-\varepsilon} \right]^{1/\varepsilon} \] (1.12)
to give rise to the familiar (log-linear) New Keynesian Phillips curve for domestic inflation
\[ \pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda m c_t \] (1.13)
where $\lambda = \frac{(1-\theta)(1-\theta\beta)}{\theta}$.

Choice of Export Price  We now turn to the price setting problem for the export market. Since we are ultimately interested in the impact of export pricing behavior on inflation dynamics in the domestic country, we consider a firm in country F exporting its produced good to country H.\(^7\) This producer solves:
\[ \max E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( \frac{P_{F,t+j}(i)}{\varepsilon_{t+j}} - MC_{t+j}^{*} P_{F,t+j}^{*} \right) C_{F,t+j}(i) \]
The actual choice variable depends on the assumed pricing scenario. Under \textit{Producer-Currency Pricing (PCP)}, exporters in both countries set prices in their own cur-
\[^7\text{Exporters in country H face an analogous problem, as exemplified by their profit function.}\]
rency: producers in F pick $X^*_F,t$ and producers in H symmetrically pick $X^*_{H,t}$. Under *Local-Currency Pricing (LCP)*, exports are priced using the destination market’s currency: producers in F pick $X_{F,t}$ and producers in H pick $X^*_{H,t}$. Finally, under *Dollar-Dominant Pricing (DDP)*, H-currency is used to price exports from both countries: producers in F pick $X_{F,t}$, whereas producers in H pick $X_{H,t}$. We argue that this asymmetric case is empirically relevant for the US, where most of imports and exports are priced in dollars (hence the denomination).\footnote{Gopinath and Rigobon (2008) use unpublished US micro data on import and export prices (collected by the Bureau of Labor Statistics in 1994-2005) and report that 90\% (97\%) of imports (exports) are priced in dollars.}

The term $P_{F,t+j}(i)$ in the profit function is the H-currency price of the exported good (that is, the import price from the standpoint of country H) in $t+j$, conditional on no further adjustment. It is then converted to F-currency using the nominal exchange rate. The different assumptions about currency choice have implications for the pass-through of exchange rate fluctuations into this price.

- *Producer-Currency Pricing:* $P_{F,t+j}(i) = \mathcal{E}_{t+j}X^*_{F,t}$

The expected profits can be written as

$$E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( X^*_{F,t} - MC^*_{t+j} P^*_{F,t+j} \right) C_{F,t+j}(i)$$

This shows that fluctuations of the exchange rate are fully passed into $P_{F,t+j}(i)$. On the other hand, of course, the price received by the exporter is completely insulated from such fluctuations. Similarly, producers in country H choose $X^*_H$, so that $P^*_H_{t+j}(i) = \frac{X^*_{H,t}}{\mathcal{E}^*_{t+j}}$. The LOP holds in this instance for both the Home and Foreign composite good.
• **Local-Currency Pricing:** \( P_{F,t+j}(i) = X_{F,t} \)

Expected profits now become

\[
E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( \frac{X_{F,t}}{e_{t+j}^*} - MC_{t+j}^* P_{F,t+j}^* \right) C_{F,t+j}(i)
\]

which makes clear that the implications at the single product level are the polar opposite of the PCP assumption: the importing country doesn’t see any price change as the exchange rate moves, and the exporter fully bears its fluctuations. Similarly, producers in country \( H \) choose \( P_{H,t+j}^*(i) = \frac{X_{H,t}}{e_{t+j}^*} \), which makes the LOP only hold for the Home good.

• **Dollar-Dominant Pricing:** \( P_{F,t+j}(i) = X_{F,t} \)

This case is asymmetric and combines the previous two assumptions. Exporters in country \( F \) behave as in the LCP case, while exporters in country \( H \) choose \( P_{H,t+j}^*(i) = \frac{X_{H,t}}{e_{t+j}^*} \). The LOP only holds for the Home good.

1.2.3 Solving for the Equilibrium

The model (in its three versions) is log-linearized around a zero-inflation steady state. In what follows, all lower case letters denote logarithmic deviations from this steady state. For both countries \( H \) and \( F \), the model is characterized by an IS-type relation, which is derived from the household’s problem and links output to the real interest rates, and Phillips curves for domestic and CPI inflation. To close the model, we need to specify the determination of the nominal interest rate and the evolution of the exogenous shocks in each country. We assume that monetary policy is conducted
according to a Taylor-type rule:

\[ r_t = \phi_\pi \pi_t + \phi_y y_t + u_t \]  

(1.14)

The shock to technology \( a_t \) and the monetary shock \( u_t \) both follow AR(1) processes:

\[ a_t = \rho_a a_{t-1} + \epsilon_t \]  

(1.15)

\[ u_t = \rho_u u_{t-1} + \mu_t \]  

(1.16)

where \( \epsilon_t \) and \( \mu_t \) are zero-mean i.i.d. random variables with variance \( \sigma^2_\epsilon \) and \( \sigma^2_\mu \), respectively. The shocks are assumed to be uncorrelated across countries.

### 1.3 Phillips Curves

We now look more in detail at the Phillips curves implied by the model, highlighting the channels through which they are affected by open economy aspects. It is useful at this point to define the following variables:

\[ z_t \equiv p_{F,t}^* + e_t - p_{F,t} \]  

(1.17)

\[ z_t^* \equiv p_{H,t} - e_t - p_{H,t}^* \]  

(1.18)

which represent deviations from LOP for Foreign and Home goods.
With the assumed form of price stickiness, we find:

\[ z_t = e_t - (1 - \theta) \sum_{i=0}^{\infty} \theta^i e_{t-i} \]  
\[ z_t^* = (1 - \theta) \sum_{i=0}^{\infty} \theta^i e_{t-i} - e_t \]

where \( e_t^W \equiv (1 - \theta \beta) E_t \sum_{j=0}^{\infty} (\theta \beta)^j e_{t+j} \). A couple of observations are in order. First, the pricing assumptions have an impact on \( z_t \) and \( z_t^* \). Under PCP, \( z_t = z_t^* = 0 \), as the LOP holds for both types of goods. Under LCP, both \( z_t \) and \( z_t^* \) are different from zero and they are related by \( z_t = -z_t^* \), given that \( \theta \) is the same in H and F. Under DDP, \( z_t \neq 0 \) and \( z_t^* = 0 \). We also note that if prices are flexible (i.e. \( \theta \to 0 \)), \( z_t = z_t^* = 0 \), which shows that currency choice makes a difference only insofar as there is nominal stickiness. Second, the pricing assumptions have different implications for import inflation \( \pi_F \). Under PCP, foreign inflation \( \pi_F^* \) and import inflation \( \pi_F \) are simply related by

\[ \pi_{F,t} = \pi_{F,t}^* + \Delta e_t \]  

where \( \pi_{F,t}^* = \beta E_t \pi_{F,t+1}^* + \lambda m c_t^* \). The Phillips curve for \( \pi_F \) can be written as

\[ \pi_{F,t} = \beta E_t \pi_{F,t+1} + \lambda m c_t^* + (\Delta e_t - \beta E_t \Delta e_{t+1}) \]

For both LCP and DDP, the corresponding Phillips curve is the result of exporters in country F directly pricing in H currency, which yields

\[ \pi_{F,t} = \beta E_t \pi_{F,t+1} + \lambda m c_t^* + \lambda z_t \]
1.3.1 The Inflation - Marginal Cost Relation

We can now combine domestic inflation as given in (1.13), with import inflation (1.22) or (1.23) to state the following:

**Proposition 1.1.** CPI inflation is given by \( \pi_t = (1 - \gamma)\pi_{H,t} + \gamma \pi_{F,t} \) and can be written in terms of real marginal costs as:

- **PCP:**
  \[
  \pi_t = \beta E_t \pi_{t+1} + (1 - \gamma)\lambda mc_t + \gamma \lambda mc_t^* + \gamma (\Delta e_t - \beta E_t \Delta e_{t+1})
  \] (1.24)

- **LCP & DDP:**
  \[
  \pi_t = \beta E_t \pi_{t+1} + (1 - \gamma)\lambda mc_t + \gamma \lambda mc_t^* + \gamma \lambda z_t
  \] (1.25)

Inflation is affected here by foreign marginal costs \( mc_t^* \), because of their role in the pricing problem of foreign exporters. Currency choice plays a role through its effects on the prices of imports: the different shift terms reflect full or partial pass-through of exchange rate fluctuations. In this instance, LCP and DDP are equivalent. This representation of inflation is conditional on marginal costs. We now examine how they are related to output, and assess whether this provides additional channels for openness to affect inflation.

1.3.2 Linking Marginal Cost and Output

As shown in the Appendix to this chapter, real marginal cost can be written as a function of the output gap and deviations from the LOP for foreign and domestic
where $\kappa = \phi + \sigma_0$, and in turn $\sigma_0 = \frac{\sigma(1+2\omega)}{1+4\omega}$, $\omega = \gamma(1-\gamma)(\sigma\eta - 1)$. The output gap is defined as the deviation of output from its flexible-price level. Thus, $\tilde{y}_t \equiv y_t - \bar{y}_t$ with

$$\bar{y}_t = \frac{1}{\phi + \sigma_0}[(1 + \phi)a_t - (\sigma - \sigma_0)y_t^*]$$

(1.27)

Open-economy aspects enter (1.26) through $z_t (z_t^*)$, and by affecting natural output $\tilde{y}_t$ and the elasticity of marginal cost with respect to the domestic output gap $\kappa$. 

Note how the above relations are affected by the openness parameter $\gamma$: when $\gamma = 0$, we have $\omega = 0$ and $\sigma_0 = \sigma$, so that the model is equivalent to its closed economy version. We then ask whether openness increases or decreases the elasticity $\kappa$ relative to closed economy. This in turn depends on the value of $\sigma_0$ relative to $\sigma$, which also determines the impact of foreign output $y_t^*$ on $\tilde{y}_t$ (see (1.27)). It’s clear from inspection that the elasticity of $mc_t$ with respect to $\tilde{y}_t$ is smaller (larger) than in closed economy when $\sigma\eta$ is larger (smaller) than 1. In the special case $\sigma\eta = 1$, neither $\kappa$ nor $\tilde{y}_t$ are affected by open economy considerations, regardless of the value of $\gamma$.

What are the channels at work? To gain some intuition, we go back a few steps and use labor supply along with the aggregate production function to express real marginal costs as:

$$mc_t = \phi n_t + \sigma c_t + \gamma s_t - a_t$$

(1.28)

where $s_t$ denotes the terms of trade for country H, defined as $s_t \equiv p_{F,t} - p_{H,t}$. They
can be written as a function of relative output:

\[
s_t = \frac{\sigma}{1 + 4\omega}(y_t - y^*_t) - \frac{2\omega + (1 - \gamma)}{1 + 4\omega}z_t - \frac{2\omega + \gamma}{1 + 4\omega}z^*_t
\]  

(1.29)

Moreover, consumption \( c_t \) is a function of domestic and foreign output, as follows:

\[
c_t = \frac{2\omega + (1 - \gamma)}{1 + 4\omega}y_t + \frac{2\omega + \gamma}{1 + 4\omega}y^*_t + \frac{\omega + \gamma(1 - \gamma)}{\sigma(1 + 4\omega)}(z_t - z^*_t)
\]  

(1.30)

Openness \((\gamma > 0)\) changes the effect of an output change on marginal costs in two ways. Consider an output increase: First, relative to the closed economy version of the model, the corresponding increase in \( c_t \) is smaller because of international risk sharing, as (1.30) makes clear. This curbs the increase of real wages that works through the marginal rate of substitution between consumption and leisure, thus dampening the effect of \( y_t \) on \( mc_t \). Second, in order to ensure market clearing, the terms of trade depreciate when domestic output rises relative to foreign output (see (1.29)), which leads to an increase in marginal costs (see (1.28)). This additional channel works towards amplifying the effect of \( y_t \) on \( mc_t \). The overall effect depends on the magnitude of \( \sigma \eta \), and the first channel is more likely to dominate with larger values of the parameters \((\sigma \eta > 1)\). Recall that \( \sigma \) is the inverse of the elasticity of intertemporal substitution and \( \eta \) is the elasticity of substitution between domestic and foreign goods: for given \( \eta \), a larger \( \sigma \) implies that the muted consumption response has a stronger (wealth) effect in limiting the change in real wages. For given \( \sigma \), a larger elasticity \( \eta \) implies a smaller required relative-price adjustment following an output change, so the terms of trade effect is not strong enough to counteract the dampening due to risk sharing. We regard \( \sigma \eta > 1 \) as the relevant case. Hence, the
Table 1.1: Domestic and CPI inflation Phillips curves

<table>
<thead>
<tr>
<th>Domestic Inflation</th>
<th>CPI Inflation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PCP:</strong></td>
<td></td>
</tr>
<tr>
<td>$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda \kappa \bar{y}_t$</td>
<td>$\pi_t = \beta E_t \pi_{t+1} + (1 - \gamma) \lambda \kappa \bar{y}_t + \gamma \lambda \kappa \bar{y}<em>t^* + \gamma (\Delta e_t - \beta E_t \Delta e</em>{t+1})$</td>
</tr>
<tr>
<td><strong>LCP:</strong></td>
<td></td>
</tr>
<tr>
<td>$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda \kappa \bar{y}_t + \lambda \left( \frac{\gamma + 2}{1 + 4\omega} \right) z_t$</td>
<td>$\pi_t = \beta E_t \pi_{t+1} + (1 - \gamma) \lambda \kappa \bar{y}_t + \gamma \lambda \kappa \bar{y}_t^* + 2\lambda \left( \frac{\gamma (1 - \gamma) + \omega}{1 + 4\omega} \right) z_t$</td>
</tr>
<tr>
<td><strong>DDP:</strong></td>
<td></td>
</tr>
<tr>
<td>$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda \kappa \bar{y}_t + \lambda \left( \frac{(1 - 2) / \omega}{1 + 4\omega} \right) z_t$</td>
<td>$\pi_t = \beta E_t \pi_{t+1} + (1 - \gamma) \lambda \kappa \bar{y}_t + \gamma \lambda \kappa \bar{y}_t^* + \lambda \left( \frac{\gamma (1 - \gamma) + \omega}{1 + 4\omega} \right) z_t$</td>
</tr>
</tbody>
</table>

open-economy elasticity of marginal cost with respect to the domestic output gap, $\kappa$, is smaller than in closed economy.

1.3.3 The Inflation - Output Relation

We are now ready to state the following:

**Proposition 1.2.** Using equation (1.26) linking domestic marginal costs to output (and an analogous one for foreign marginal costs), Phillips curves for domestic and CPI inflation can be written in terms of output gaps, and are reported in Table 1.1 for the three pricing assumptions.

Importantly, Table 1.1 shows that the structural slope of Phillips curves (that is, the coefficient on the domestic output gap) doesn’t change across the different pricing assumptions: the slope is determined by $\lambda$, which depends on the degree of price stickiness, and the elasticity $\kappa$, which is invariant to the export-pricing scenarios. For CPI inflation, openness additionally matters through $1 - \gamma$.

As is apparent from equation (1.26), $z_t$ generates endogenous deviations from the
simple proportional relation between $mc_t$ and $\tilde{y}_t$, which in turn implies shift terms in the Phillips curves that are different across pricing assumptions.\footnote{Under the LCP assumption, we exploit the fact that $z^*_t = -z_t$ to write everything in terms of $z_t$ only.} Looking at domestic inflation, we observe that deviations from the LOP matter solely through their role in marginal costs. Indeed, with PCP, we just have $mc_t = \kappa \tilde{y}_t$, and the Phillips curve is isomorphic to closed economy\footnote{See Clarida, Gali and Gertler (2002).}: openness enters the picture only by affecting $\kappa$ and $\tilde{y}_t$. Also note that, with DDP, $z_t$ only matters as long as preferences are biased ($\gamma \neq \frac{1}{2}$). As for CPI inflation, deviations from LOP now matter both because they affect marginal costs and because of the direct impact on import prices. Moreover, the effect of $z_t$ on CPI inflation is always larger with LCP than DDP for any value of $\gamma$.

1.3.4 “Empirical” Phillips Curves

We also consider alternative specifications of Phillips curves and broadly group them under the “empirical” header, as opposed to the theoretical relationships explored above. We do this in the spirit of recent studies on the globalization-inflation hypothesis (e.g. Ball (2006) and Wynne and Kersting (2007)), and compare the findings to the model’s predictions. In particular, we first look at a “New” Keynesian specification:

$$\pi_t - \beta E_t \pi_{t+1} = \alpha(\gamma) \tilde{y}_t + \xi_t$$  \hspace{1cm} (1.31)

This relation uses model-consistent measures of inflation expectations and output gap and is the closest to the theoretical one. We then specify a backward looking (“Old”
Keynesian) Phillips curve as
\[ \Delta \pi_t = \alpha(\gamma) y_t + \xi_t \]  
(1.32)

where we use lagged inflation as a more naive measure of inflation expectations. This specification corresponds to a simple regression of the change in inflation on output. Finally, we consider a similar equation where we also include foreign output:
\[ \Delta \pi_t = \alpha(\gamma) y_t + \alpha^*(\gamma) y^*_t + \xi_t \]  
(1.33)

For these three specifications, we will study the effects of openness on the slopes by looking at the regression coefficients \( \alpha (\alpha^*) \) as predicted by the model, over a range of values of \( \gamma \). The openness parameter affects the slope through its effect on simulated data.

1.4 The Effects of Globalization

Figure 1.1 reports the ratio of US imports of goods and services to GDP for the last fifty years. We regard this measure as the data counterpart of the parameter \( \gamma \) in the model, given the steady state interpretation of the latter. In the analysis that follows, we define globalization as an increase in \( \gamma \).\(^{11} \) We take the year 1990 as the starting point of the wave of globalization that is at the center of the recent debate, and note that imports have since then increased from 10 to 18% of GDP, approximately. Thus, a little more loosely, we take \( \gamma \in (0.1, 0.2) \) as the relevant range for the parameter in the quantitative exercises.

\(^{11}\)More precisely, we will be comparing the model’s predictions for different, and increasing, steady state values of the import/GDP ratio.
1.4.1 Calibration

The parameter values are reported in Table 1.2. Most are relatively non-controversial: we set $\beta = 0.99$, which is consistent with quarterly data, implying a steady-state annualized riskless return of about 4%. We assume $\phi = 3$, so that the elasticity of labor supply is $\frac{1}{3}$. The Calvo parameter is $\theta = 0.75$, which gives an average duration of price spells of one year. This represents a widely used standard, albeit perhaps a little higher than the values implied by recent empirical studies (e.g. Bils and Klenow (2004)). Finally, the coefficients of the interest rate rule are set to $\phi_{\pi} = 1.5$ and $\phi_{y} = 0.5/4 = 0.125$ (Taylor (1993)).

As we have seen, the parameters $\sigma$ and $\eta$ play an important role in the model. Typical values for the risk aversion parameter $\sigma$ are in the range of 1 (log-utility) to 5. The elasticity $\eta$ is hard to pin down, as exemplified by the very wide range of estimates available in the literature. Obstfeld and Rogoff (2000) report estimates from trade studies between 5 and 6. As noted in Adolfson et al. (2007), $\eta$ has been estimated in the 5 to 20 range using micro data, and much lower (between 1 and 2) using macro data (see also Chari et al. (2002)). Lubik and Schorfheide (2005) estimate a value as low as 0.5. We use $\sigma = 5$ and $\eta = 1$ as the preferred values.\textsuperscript{12}

The value of $\sigma$ is on the high end, but it is often used in calibrations of open economy models (e.g. McCallum and Nelson (2000), Chari et al. (2002) and Steinsson (2008)). Our results are robust to changes in the values of those parameters.

\textsuperscript{12}$\eta = 1$ is an interesting special case used, among others, by Corsetti and Pesenti (2005a). It leads to a Cobb-Douglas formulation of the consumption index of Home and Foreign goods. One rationale for this value (or, more generally, for a value that is not larger than 1) is that the elasticity of substitution between varieties ($\varepsilon$ in the model) is assumed to be strictly greater than 1, and is presumably higher than the elasticity between Home and Foreign goods. So, without having to take a stand on the exact value of $\varepsilon$, setting $\eta = 1$ “loosely” satisfies the above condition.
Table 1.2: Parameter values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta = 0.99$</td>
</tr>
<tr>
<td>Inverse of EIS</td>
<td>$\sigma = 5$</td>
</tr>
<tr>
<td>Inverse of Frisch elasticity</td>
<td>$\phi = 3$</td>
</tr>
<tr>
<td>Calvo probability</td>
<td>$\theta = 0.75$</td>
</tr>
<tr>
<td>Elasticity of subs. H/F</td>
<td>$\eta = 1$</td>
</tr>
<tr>
<td>Taylor rule</td>
<td>$\phi_{\pi} = 1.5$</td>
</tr>
<tr>
<td></td>
<td>$\phi_y = 0.5/4$</td>
</tr>
<tr>
<td>Tech. shock AR(1)</td>
<td>$\rho_a = 0.89$</td>
</tr>
<tr>
<td>Monetary shock AR(1)</td>
<td>$\rho_u = 0.82$</td>
</tr>
<tr>
<td>Relative variance</td>
<td>$\frac{\sigma_x}{\sigma_\mu} = 0.66$</td>
</tr>
</tbody>
</table>

There is less clear-cut guidance in the literature regarding the parameters of the shock processes. We calibrate $\rho_a$, $\rho_u$ and $\frac{\sigma_x}{\sigma_\mu}$ (i.e. the relative variability of the shocks) to match three moments in US data, namely the first order autocorrelation of output and inflation, and the variance of inflation relative to output. For this calibration exercise, we use the DDP version of the model. The openness parameter $\gamma$ is set to 0.10, the average value of the import to GDP ratio in the period 1975:1 - 1989:4.\footnote{Output is the HP-filtered quarterly real GDP series, while inflation is given by $400 \times (\ln CPI_t / \ln CPI_{t-1})$. Data is taken from the FRED Economic database maintained by the Federal Reserve Bank of St. Louis. The sample is 1975:1 - 2004:4.}

1.4.2 Structural Slopes

Recall the general formulation (1.1) for the Phillips curves in the model, $\pi_t = \beta E_t \pi_{t+1} + \alpha(\gamma) \ddot{y}_t + \alpha^*(\gamma) \ddot{y}_t^* + \chi_t(\gamma)$. We now look at the effects of globalization on the slope parameter $\alpha$ and state the following:

Proposition 1.3. If $\sigma_\eta > 1$, the slope of the Phillips curve (both for domestic and $CPI$ inflation) is monotonically decreasing in $\gamma$ (with $\gamma \in (0; \frac{1}{2})$). The result holds...
with PCP, LCP and DDP.

This is the main qualitative result. Figures 1.2 and 1.3 plot the structural slopes of the domestic and CPI Phillips curves, \( \alpha = \lambda \kappa \) and \( \alpha = (1 - \gamma) \lambda \kappa \) respectively, as a function of the openness parameter \( \gamma \). For domestic inflation, all the action takes place in \( \kappa \). Globalization makes the slope smaller through its effects on the sensitivity of marginal costs with respect to output. The intuition is similar as before: as \( \gamma \) increases, the required terms of trade adjustment following an output change gets smaller and smaller (in equation (1.29), the elasticity of \( s_t \) with respect to relative output is decreasing in \( \gamma \)). With this configuration of parameters (\( \sigma \eta > 1 \)), this implies a decreasing response of marginal costs to output. The Phillips curve thus becomes flatter. For CPI inflation, the slope includes an additional term \( 1 - \gamma \), which reflects the “CPI weight” and is obviously decreasing in \( \gamma \). The \( \sigma \eta > 1 \) condition is now sufficient but not necessary for the slope to be decreasing in \( \gamma \). Indeed, the result is robust to different reasonable parametrizations.

When \( \gamma \) ranges from 0.1 to 0.2, the slope of the domestic Phillips curve ranges from 0.56 to 0.53, while the slope of the CPI Phillips curve decreases from 0.5 to 0.43. To have a sense of how these changes translate into differences in the dynamics of the model, Figure 1.4 compares the responses of inflation and output to a domestic (one standard deviation) monetary shock for \( \gamma = 0.1 \) and \( \gamma = 0.2 \). The responses are virtually indistinguishable, and this is true for all three pricing assumptions. Thus, in this range, the impact of increased openness is quantitatively very modest. Note by comparing Figures 1.2 and 1.3 that this is mostly because of the limited effect of \( \gamma \) on \( \kappa \), which is captured by the relation between \( \gamma \) and the slope of the domestic Phillips curve. Indeed, this slope hardly changes with \( \gamma \) even for larger values of the
1.4.3 The Role of Foreign Output Gap

We now turn to the effects of globalization on the foreign output gap coefficient.

**Proposition 1.4.** If \( \sigma \eta < 1 \) the structural coefficient on the foreign country’s output gap is increasing in \( \gamma \). Under the chosen parametrization the coefficient is increasing in \( \gamma \) with \( \sigma \eta > 1 \) too. The result holds with PCP, LCP and DDP.

Figure 1.5 shows the coefficient \( \alpha^* = \gamma \lambda \kappa \) as a function of \( \gamma \). When \( \sigma \eta \) is less than 1, the elasticity \( \kappa \) increases with \( \gamma \), and so does \( \alpha^* \). However, this positive association is also preserved with \( \sigma \eta > 1 \) (which we argued is the relevant case) given the chosen values for the other parameters. Importantly, this qualitative result is once again robust to different calibrations.\(^{14}\) Given that \( \kappa \) is decreasing in \( \gamma \) for \( \sigma \eta < 1 \), the result is mostly driven by the direct impact of \( \gamma \) on \( \alpha^* \).

In the (0.1, 0.2) range for \( \gamma \), \( \alpha^* \) changes from 0.06 to 0.11. The model thus predict an increased role for foreign measures of slack as a consequence of increased openness (and according to Proposition 1.3, this is happening at the expense of the domestic output gap, at least qualitatively). However, domestic factors still remain the main determinants of inflation.

As a check on the robustness of these results, Figure 1.6 plots the slopes of domestic and CPI Phillips curves and the coefficients on the foreign output gaps as a function of openness, for alternative values of \( \sigma \) and \( \eta \). The basic qualitative and quantitative conclusions are confirmed under these different calibrations.

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\(^{14}\)It can be shown that, if \( \sigma \geq 1 \), the derivative of \( \alpha^* \) with respect to \( \gamma \) is positive regardless of the value \( \eta \) and the other parameters.
1.4.4 Shift Terms

Going back again to the general specification $\pi_t = \beta E_t \pi_{t+1} + \alpha(\gamma)\tilde{y}_t + \alpha^*(\gamma)\tilde{y}_t^* + \chi_t(\gamma)$, we now look at how globalization affects the volatility of the $\chi_t$ terms and state the following:

**Proposition 1.5.** The variance of the Phillips curves’ shift terms is increasing in $\gamma$. The result holds with PCP, LCP and DDP.

We recall that this is the aspect of the model’s Phillips curves where the export-pricing scenarios make a difference. Depending on the assumption, CPI Phillips curves have endogenous shifters that depend on fluctuations of the exchange rate and/or the domestic-currency relative to foreign-currency prices of imports. Figure 1.7 plots $\text{Var}(\chi_t)$ as a function of $\gamma$ for the PCP, LCP and DDP assumptions. The positive relation between the variance of endogenous shocks to the Phillips curves and openness holds in all cases, but while the increase is comparable for PCP and LCP in the relevant range, it is notably less pronounced for DDP: an increase in $\gamma$ amplifies the implied variance of $z_t$ to a smaller extent in the DDP vs. the LCP version of the model. Moreover, as reported in Table 1.1, the coefficient on $z_t$ is always larger in the former case.

As a further assessment of the quantitative relevance of globalization, Figure 1.8 plots the responses of inflation and output to a foreign monetary shock, again for $\gamma = 0.1$ and $\gamma = 0.2$. The effects on the dynamic responses are not substantial, especially for inflation. This is particularly true with DDP.
1.4.5 Empirical Phillips curves

Figure 1.9 reports the coefficient $\alpha(\gamma)$ in the “New” Keynesian specification (1.31) for the three pricing assumptions, along with the structural slope $(1 - \gamma)\lambda\kappa$. The coefficient results from an OLS regression of $\pi_t - \beta E_t \pi_{t+1}$ (where $E_t \pi_{t+1}$ are model-consistent expectations) on $\tilde{y}_t$, the theoretical measure for the domestic output gap. This exercise thus compares the model’s predictions to those of an (intentionally) misspecified relation, showing the results we would obtain if we had available the “correct” measures of output gap and inflation expectations and were to run this simpler regression with the model as the “true” data generating process. The regression coefficient is computed using the relevant variables’ covariances and variances, which vary across the three different versions of the model. The qualitative findings are by and large confirmed. We observe some difference in the level of the estimated slopes relative to the structural coefficient, especially for PCP and DDP, and this is due to the correlation of the domestic output gap with the variables we are omitting. The negative but weak relationship between openness and the slope in the relevant range for $\gamma$, however, continues to hold with this specification in all cases (with DDP, $\alpha$ decreases from 0.58 to 0.53).

We then ask the same question when the Phillips curve is as in (1.32). Now, the relation is further misspecified in that we are not using the correct measurements of the variables. Figure 1.10 plots the coefficients $\alpha(\gamma)$ we obtain when we run this regression: the effect of globalization on the slope is now harder to detect, especially for LCP and DDP. The value of the coefficient in the latter case is basically constant at just below 0.2. Interestingly, this is in line with the estimated value in Ball (2006), who uses an analogous specification. Figure 1.11 reports the mean value of the co-
efficient, along with the 5\textsuperscript{th} and 95\textsuperscript{th} percentile, over several simulated economies for the DDP version of the model: small sample uncertainty is substantial and dominates any detected change of the slope as a function of $\gamma$.\textsuperscript{15} If DDP is a reasonable assumption for US data, this result would lead to conclude that increased openness played a very little role (or no role at all) in flattening US Phillips curves. Given the model’s prediction, this implies that, if anything, a specification like (1.32) tends to understate the effects of globalization. These effects, however, are small to start with and thus hard to uncover in a limited sample.

Finally, Figure 1.12 reports the coefficients $\alpha(\gamma)$ and $\alpha^*(\gamma)$ for the specification in (1.33). Recall that the way the foreign output gap $\tilde{y}_t^*$ affects inflation in the model’s Phillips curve is rather mechanical, and mainly depends on the direct impact of $\gamma$. However, foreign output $y_t^*$ has an effect on inflation also through the domestic output gap. Here, we run a more “reduced-form” regression on domestic and foreign output and assess whether the resulting implications are similar. We still find a positive relationship between openness and the coefficient on $y_t^*$ especially for DDP. On the other hand, the coefficient on $y_t$ is not greatly affected by the inclusion of foreign output (compare the upper panel of Figure 1.12 to Figure 1.10). In the relevant range for $\gamma$, the coefficients look similar across the three versions of the model.\textsuperscript{16} Overall, the empirical specification confirms the increased role of foreign output and the prevalence of domestic factors in explaining inflation dynamics.

\textsuperscript{15}The 95\% bands are based on 1000 simulations of the model with sample size $T=120$.

\textsuperscript{16}One possible exception is the coefficient on $y_t^*$ with LCP, which is predicted to be considerably lower in this range.
1.4.6 The Contribution to the Debate

We conclude the discussion of the results by relating these findings to the three questions outlined earlier. The questions were framed in terms of different aspects of the model’s Phillips curves, generally written as

\[ \pi_t = \beta E_t \pi_{t+1} + \alpha(\gamma) \tilde{y}_t + \alpha^*(\gamma) \tilde{y}_t^* + \chi_t(\gamma). \]

1. Has globalization lowered long-run inflation?

We find \( \frac{\partial \alpha}{\partial \gamma} < 0 \). Rogoff’s political-economy argument for a lower equilibrium inflation rests on the premise that globalization should make Phillips curves steeper. The model instead predicts the globalization makes Phillips curves flatter. Recall that the slope parameter \( \alpha \) has three components: First, one that is directly related to openness \( (1 - \gamma) \). Second, a factor that depends on the degree of price stickiness \( (\lambda) \). Third, a component that relates marginal costs to output \( (\kappa) \). Rogoff’s argument relies on increased competition making wages and prices more flexible: that is, globalization affects the slope of Phillips curve by affecting \( \lambda \). The model in this paper has nothing to say about this channel, but argues that openness lowers marginal costs’ sensitivity to domestic output: globalization affects the slope by affecting \( \kappa \).

In this sense, the analysis in Sbordone (2007) can be regarded as complementary to ours and looks at a channel that is more directly related to the argument above. Her paper studies the slope-openness relation in a model with non-constant elasticity of demand. More specifically, increased openness is related to an increase in the variety of traded goods, which impacts the degree of competition. In turn, this affects the demand elasticity and ultimately the firms’ markups. This feature introduces real rigidities in pricing and has an effect on the relation between inflation and marginal costs (i.e. the parameter \( \lambda \) in our model). Sbordone argues that it’s not clear whether
globalization increases or decreases the slope through this mechanism and finds that the effect is not quantitatively relevant in either direction.

2. Has globalization affected the short-run dynamics of inflation?

We find $\frac{\partial \alpha}{\partial \gamma} < 0$ and $\frac{\partial \alpha^*}{\partial \gamma} > 0$. The qualitative prediction of the model is that more openness leads to an increased role for global factors at the expense of domestic factors. This prediction parallels the results in Borio and Filardo (2007). Differently from their analysis, though, we have shown that, quantitatively, globalization has a modest role in the flattening of Phillips curves. Moreover, and importantly, domestic conditions still retain the lion’s share in determining inflation. Overall, globalization only slightly impacts the structural short-run dynamics of inflation as summarized by open-economy Phillips curves.

3. Has globalization been a source of shocks to inflation?

We find $\frac{\partial \text{Var}(\chi_t)}{\partial \gamma} > 0$. Globalization magnifies the volatility of the endogenous shift terms to the model’s Phillips curves, though the increase is less evident with DDP. Under PCP, when the LOP holds for both domestic and foreign goods, these terms reflect the impact on inflation of full pass-through of exchange rate fluctuations into import prices. Under LCP and DDP, the short run pass-through is partial, and this is reflected in deviations from the LOP that enter both import prices and the marginal costs of firms. Interestingly, the DDP scenario limits the effects of globalization through this channel. This is a relevant result for the US and, for that matter, any country whose currency is used to price most imports and exports.
1.5 Exchange rate pass-through

It’s a well established empirical observation that exchange rate fluctuations are not fully passed through into import and consumer prices. For example, Campa and Goldberg (2005) estimate short-run (within one quarter) pass-through elasticities into aggregate import prices for 23 OECD countries and find an average value of about 46%. The US in particular ranks among the lowest, with a value around 25%. Pass-through increases with the time horizon, but it is in general still far from complete: long(er) run elasticities (cumulated over four quarters) for the same set of countries have an average value of about 64% (40% for the US). Moreover, there is some work that documents a substantial decline in pass-through for the US and other industrialized countries, comparing the 70s and 80s to the last decade. Olivei (2002) and Marazzi and Sheets (2007) explore some potential explanations for this development, such as shifting composition of imports and changes in the pricing behavior of exporters. More related to the questions in this paper, Gust et al. (2010) link declining pass-through to increased trade integration: strategic complementarities, lower trade costs and more competition interact to lower the sensitivity of prices to exchange rate fluctuations.

In our model, imperfect pass-through is a consequence of sticky prices and local-currency pricing. Hence, it is solely a consequence of the behavior of exporters.\textsuperscript{17} We abstract from any distribution sector or other intermediate steps between the dock

\textsuperscript{17}As an example of a different approach, Smets and Wouters (2002) and Monacelli (2005) (for a small open economy) introduce to a similar effect importing firms (local distributors) that set the domestic price of foreign goods in a staggered fashion, thus generating short run deviations from the LOP. In Monacelli (2005), the LOP is assumed to hold at the dock, which might be a good approximation for commodities (see e.g. Nakamura and Zerom (2010) on the coffee industry) but not for most traded goods.
and the final consumer, which would introduce local cost components into the price of imported goods. These have been shown to be potentially important explanations for imperfect exchange rate pass-through.\footnote{See for example Corsetti and Dedola (2005), Hellerstein (2008) and Goldberg and Hellerstein (2011).}

We now turn to assessing the implications of the model for the short-run pass-through of exchange rate movements into aggregate import prices. While exchange rate pass-through is not a main focus of this paper, it is arguably an important check for the model, given its emphasis on export-pricing behavior. Moreover, it is interesting to look at pass-through magnitudes in a general equilibrium context. Figure 1.13 reports the coefficient of an OLS regression of $\pi_{F,t}$ on $\Delta e_t$ as a function of $\gamma$, for the PCP, LCP and DDP versions of the model. While regressions in the empirical pass-through literature usually control for additional variables, mainly proxying for exporters’ costs, we follow Gust et al. (2010), who find that results are similar with this simpler specification.\footnote{Gust et al. (2010) actually use relative import prices and the real exchange rate to be consistent with their model. We instead use nominal variables in keeping with the cited empirical literature.} First, as expected, the degree of pass-through is much higher with PCP across the entire range of values for $\gamma$. Clearly, though, it is unrealistically high for the United States. Second, focusing on the DDP case, the values are line with empirical evidence for the US, being just above 20% when $\gamma \in (0.1, 0.2)$. Third, this pass-through measure is roughly constant as a function of $\gamma$ (if anything, it is slightly increasing): increased openness doesn’t seem to play a role, which is not consistent with the findings cited earlier. Note, however, that this model abstracts from the channels highlighted in Gust et al. (2010), which involve non-constant elasticities of demand that give rise to variable desired markups. Hence, in a way, this observation can be regarded as complementary to their results.
1.6 Conclusion

We have examined the role of globalization in affecting the determinants of inflation as described by open-economy Phillips curves in the context of a two-country New Keynesian model. Overall, we find support for the claims that the effects of globalization are quantitatively modest: increased openness only slightly decreases the slope of Phillips curves and while foreign factors have an increased role, domestic factors are still relatively more important. Globalization increases the volatility of shocks to the Phillips curves, but not to a large extent. This set of result is robust to different measures of inflation and different assumptions for the exporters’ currency of choice.

The Dollar-dominant version of the model, which we argue is empirically relevant for the US, provides a reasonable approximation to empirical measures of short-run exchange rate pass-through into import prices, although LCP gives similar results. Moreover, we show that this peculiar position in terms of “vehicle currency” suggests a more muted impact of globalization on inflation beyond its effects through measures of slack: while the structural slopes of Phillips curves are invariant to currency choice assumptions, the variance of shocks to inflation (as measured by the Phillips curves’ shift terms) is less sensitive to increased openness in the DDP version of the model.

Obvious caveats apply for the generality of these results. This study is purposely specific in isolating a potential channel for openness to affect inflation, and assessing its importance in the context of a stylized general equilibrium model which is widely used for policy analysis. Moreover, this is done taking into account the possibility of imperfect exchange rate pass-through, which is very much at the center of the debate in current open-macroeconomy research. There are sensible extensions that
are worth pursuing: for example, introducing imported intermediate goods in pro-
duction\(^\text{20}\) would likely allow for a richer interaction between the output-marginal cost
cchannel and the determinants of imperfect pass-through, and thus between inflation
and openness. More generally, it would be interesting to disentangle the concepts of
openness and size of the countries, allowing for an element of asymmetry. This would
likely matter in the discussion about currency choice.

\(^{20}\)We pursue this aspect in the next chapter, in a different context.
Figure 1.1: Imports of goods and services (%GDP) (Source: IMF)
Figure 1.2: Structural slope of domestic inflation Phillips curve
Figure 1.3: Structural slope of CPI inflation Phillips curve
Figure 1.4: Responses of inflation and output to a domestic monetary shock

Note: $\gamma = 0.1$ (Dashed line), $\gamma = 0.2$ (Solid line)
Figure 1.5: Structural coefficient on foreign output gap
Figure 1.6: Sensitivity of the relation between $\gamma$ and the slopes of domestic/CPI Phillips curves and the coefficient on foreign output gap, for different parameterizations of $\sigma$ and $\eta$
Figure 1.7: Variance of CPI Phillips curve shifters
Figure 1.8: Responses of inflation and output to a foreign monetary shock

Note: $\gamma = 0.1$ (Dashed line), $\gamma = 0.2$ (Solid line)
Figure 1.9: Slopes of “New” Keynesian Phillips curves
Figure 1.10: Slopes of backward looking Phillips curves
Figure 1.11: Slope of backward looking Phillips curve (under DDP assumption), with 5\textsuperscript{th} and 95\textsuperscript{th} percentiles
Figure 1.12: Backward looking Phillips curves with domestic and foreign output
Figure 1.13: Regression of import prices on exchange rate
Chapter 2

Openness and the New Keynesian Phillips Curve: The role of nontradables

2.1 Introduction

A common specification of the so-called New Keynesian Phillips curve (NKPC henceforth) in closed economy relates current inflation to expected next period’s inflation and the labor income share (as a measure of real marginal costs). Studies of the NKPC in an open economy context (see for example Balakrishnan and Lopez-Salido (2002), Leith and Malley (2003) and Rumler (2005)) argue that inflation dynamics might be additionally affected by external factors like the price of imported materials, as they become a relevant portion of the cost of production. While various versions of the NKPC have been extensively taken to the data and put to the test using different estimation methods, their empirical success has been mixed. This chapter aims to inform the empirical literature on the NKPC by providing a systematic and over-

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21 The New Keynesian Phillips curve denomination is generally attributed to Roberts (1995), who explicitly showed how different models of incomplete price adjustment lead to equations for inflation dynamics that resembled traditional Phillips curves in spirit, but with features that reflected optimizing microfoundations.

22 Estimation in this literature is mostly carried out by means of linear GMM/Instrumental variables, but there are examples of full information Maximum Likelihood too, as in Linde’ (2005) and Kurmann (2004).

arching analysis of the implications of several open economy aspects, in particular the distinction between traded and nontraded goods, for the control variables that should be included in the estimation of Phillips curves.

To this end, we study the following general representation of the NKPC:

\[ \pi_t = \beta E_t \pi_{t+1} + \delta x_t + \xi_t \]  

(2.1)

which relates (some measure of) inflation \( \pi_t \) to expected inflation next period, the labor income share \( x_t \), and (potentially) an extra set of variables collected in \( \xi_t \). In this context, we think of openness as (i) implying additional controls in the specification of the NKPC, as summarized by the \( \xi_t \) term, and (ii) impacting the slope \( \delta \). Our main focus is on the former point, although we do highlight the implications for \( \delta \) as well. We are specifically interested in the role of traded vs. nontraded goods because this is a dimension of openness that is typically neglected in the analysis of open-economy Phillips curves. We derive NKCPs in the general form of equation (2.1) for two measures of inflation: One pertaining to domestically produced goods only (which we label “GDP deflator” inflation), and another that includes goods imported from abroad (which we label “Personal Consumption Expenditure (PCE)” inflation). We first do this in a model economy with final goods only, and then analyze the role of nontradability for intermediate inputs that are used in the production of final goods. Moreover, we consider whether different assumptions about the export-pricing behavior of firms (specifically, Producer Currency Pricing vs. Local Currency Pricing) matter in the context of this analysis.

The nature of the exercise underlying (2.1) is to start from the marginal cost
representation of the NKPC that arises from the assumed form of price stickiness (and forms the basis for the empirical specifications in the literature), and then express it as conditional on the labor income share across the different assumptions and scenarios described above. The question is then whether these scenarios imply additional controls in this labor share representation. As such, our approach doesn’t entail refinements to the labor income share itself to obtain better proxies for real marginal costs.

Generally, we find that nontradability does matter, both for final goods and intermediate inputs and across the scenarios outlined earlier: with the exception of very special cases, it consistently implies that specifications of open-economy NKPCs for estimation should include controls that reflect this dimension of openness. The model predicts that the slope of the NKPC might be affected too. Interestingly, in the cases where this happens, the direction of the effect is ambiguous, as it crucially depends on parameters that are not easily calibrated. We also show that the robustness of the results to the assumption of Producer vs. Local Currency Pricing depends on the type of representation we adopt.

**Literature review**

The theoretical and empirical literature on the NKPC is vast. Since the seminal work of Gali and Gertler (1999), one of the central questions regarding its specification is about the appropriate real “driving” variable of inflation. The optimal price setting problem implies this variable should be a measure of real marginal costs. Under certain assumptions, there is a simple, proportional relationship between real marginal costs and the output gap defined as the deviation of output from the level arising
with flexible prices. Unfortunately, the performance of estimated Phillips curves of this kind has been poor, as the coefficient on the gap variable tends to be statistically insignificant and/or of the “wrong” sign.

One of the insights in Gali and Gertler (1999) is that empirical measures of the output gap (such as detrended output) don’t seem to validate the above relationship with marginal costs, thus producing counterfactual results when used in the estimation of the NKPC. There are potential issues with the proxies for the output gap, with the assumed output gap/marginal costs relationship, or (likely) both. The proposed approach is then to step back and try to measure real marginal costs directly. Under standard assumptions about the production technology, they can be well approximated by the labor income share (equivalently, real unit labor costs). Subsequent literature provides variations on this theme (see for example Sbordone (2002) and Gali, et al. (2001, 2005), who have somewhat less restrictive assumptions regarding the structure of factor markets) and claim that the labor-share specification of the NKPC yields significant improvement in the fit of the dynamics of inflation for the US and other developed countries. This is especially true for “hybrid” specifications of the NKPC that include lagged inflation terms, although forward looking behavior is argued to be predominant. The consensus on this conclusion is however far from complete, as argued for example in Rudd and Whelan (2005, 2007). In fact, the literature on the shortcomings and counterfactual implications (both theoretical and empirical) of the NKPC in its different incarnations is, too, very extensive.\footnote{Some early examples include Ball (1994), Mankiw (2001), and Mankiw and Reis (2002).}

Within this framework, from an empirical standpoint, the mixed performance of the estimated labor-share NKPC can be attributed to both the labor share being a
poor proxy of real marginal cost and relevant control variables being omitted from
the specification. In this regard, and more related to the present paper, one source
of criticism is the NKPC’s inability to properly fit observed inflation especially as
the economies under study are more open to trade (e.g. Balakrishnan and Lopez-
Salido (2002) for the UK). As argued above, the idea is that when open-economy
considerations become more important, marginal costs are potentially affected by
factors beyond domestic labor. Moreover, the ability of firms to substitute between
domestic and external factors of production might change the way both types of
factors impact inflation, by mitigating the effects of changes in their prices and by
potentially affecting firms’ frequency of price adjustment.

Examples of work on estimation of open-economy Phillips curves include Leith and
Malley (2003) and Rumler (2005), who find that accounting for imported intermediate
inputs in production seems to matter for the estimated degree of price stickiness in
several G7/Euro Area countries. Mihailov et al. (2011) is closer in spirit to this
paper: building on the model of Gali and Monacelli (2005), they empirically assess
the role of a “terms of trade” term (vs. the traditional labor share/output gap term)
and find it is significant for several European countries.

We view the results in this chapter as useful in informing the empirical literature
on the estimation of the NKPC. Using the framework of Clarida et al. (2002) and
Gali and Monacelli (2005), Monacelli (2007) shows that the open-economy Phillips
curve for domestic inflation, written in terms of marginal costs, is identical to its
closed-economy version, and argues that the result follows from assuming that there
are only final consumption goods and exchange rate fluctuations are fully passed
through into import prices.\footnote{Monacelli’s point is more specifically related to the observation that, under these assumptions, open-economy aspects are not a source of real rigidity (i.e. they don’t have any effect on $\delta$, according to our notation). This is true regardless of whether we consider domestic inflation or consumer prices’ inflation.} Here we argue that even under these assumptions, once the nontradability dimension is taken into account, the same open-economy labor share NKPC is no longer equivalent to its closed-economy counterpart, as it includes controls that account for relative output and prices in the traded and nontraded sectors (in other words, using the notation in (2.1), $\xi_t$ is a non-empty set of variables).

While our set up is very simple, we view this insight as a note of caution when specifying open-economy NKPCs, even under relatively basic assumptions. More generally, estimation of open-economy Phillips curves is especially challenging because of the host of additional assumptions that potentially come into play (some of which we explore here). Moreover, the additional layer of endogeneity associated with open-economy variables (e.g. the exchange rate) might make econometric identification harder.\footnote{Although it could also be argued that, in certain instances, open economy aspects are themselves potential sources of identification. This is for example true in the case of small open economies, where “foreign” variables can be more realistically considered exogenous.}

The rest of the chapter is organized as follows: Section 2.2 studies the implications of nontraded goods for Phillips curves in a version of the model with final goods only. Section 2.3 discusses the robustness of these implications to the assumption of Producer Currency Pricing versus Local Currency Pricing. Section 2.4 evaluates the role of intermediate inputs in production, both when they are imported only and when there is a share that is domestically produced. Section 2.5 systematically summarizes our findings in terms of the types of additional control variables included in the Phillips curves, across the different scenarios. Section 2.6 concludes.
2.2 The role of nontraded final goods

In this section we derive open-economy Phillips curves in the context of a model where production and trade occur only at the level of final goods. The domestic economy produces two categories of goods, traded and nontraded. For each category, there is a continuum of monopolistically competitive firms producing with a linear technology that uses labor as the sole input. We assume Calvo (1983)-style price stickiness, whereby firms set their price to maximize future discounted profits taking into account that every period there is a fixed probability (i.e. independent of the time elapsed since the last adjustment) they can optimally update their price. There is a competitive, economy-wide labor market.\(^{27}\)

Consumers in the domestic economy derive utility from a consumption bundle that includes domestically produced \((C_H)\) and imported \((C_F)\) goods:

\[
C_t = \left(1 - \gamma\right)^{\frac{1}{\eta}} C_{H,t}^{\frac{\eta - 1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{F,t}^{\frac{\eta - 1}{\eta}}
\]

where \(\gamma\) represents the weight of foreign goods and can be thought of as an index of openness (it is the share of imports in GDP in a symmetric steady state), and \(\eta\) is the elasticity of substitution between Home and Foreign goods. Focusing on \(C_H\), we express it as a Cobb-Douglas composite of traded (T) and nontraded (N) goods: \(^{28}\)

\[
C_{H,t} = C_{T,t}^{1-\alpha} C_{N,t}^\alpha
\]

\(^{27}\)Since we want to focus on the impact of open-economy aspects on the specification of the Phillips curves, we abstract from other mechanisms commonly used in the literature, such as rule of thumb price setters, to give rise to inertial inflation behavior.

\(^{28}\)The T and N subscripts will identify all subsequent variables/parameters as pertaining to the traded or nontraded sector, respectively.
where $\alpha$ is the share of the nontraded sector in the economy and $C_T$ and $C_N$ are in turn Dixit-Stiglitz aggregates of individual varieties:

$$C_{T,t} = \left[ \int_0^1 C_{T,t}(i)^{\frac{1}{\epsilon}} di \right]^{\frac{1}{\epsilon-1}}$$

$$C_{N,t} = \left[ \int_0^1 C_{N,t}(i)^{\frac{1}{\epsilon}} di \right]^{\frac{1}{\epsilon-1}}$$

where $\epsilon > 1$ is the elasticity of substitution between varieties (assumed to be the same for T and N).

The corresponding price indices are then given by:

$$P_t = \left[ (1 - \gamma)P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \quad (2.2)$$

with

$$P_{H,t} = \frac{1}{(1 - \alpha)^{1-\alpha} \alpha^\alpha P_{T,t}^{1-\alpha} P_{N,t}^{\alpha}} \quad (2.3)$$

and

$$P_{T,t} = \left[ \int_0^1 P_{T,t}(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}$$

$$P_{N,t} = \left[ \int_0^1 P_{N,t}(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}$$

In what follows we will refer to $P_H$, the price index for domestically produced final goods, as the model’s GDP deflator. $P_F$ is an index for import prices, expressed in domestic currency. $P$ can be thought of as a Personal Consumption Expenditure (PCE) deflator.\textsuperscript{29} We now turn to deriving Phillips curves for these price indices,

\textsuperscript{29}These denominations are shorthands to distinguish a price index that has to do with domestic production from a price index that pertains to consumption, and thus includes prices of imported
starting with $P_H$. 

### 2.2.1 Open-economy NKPC for $\pi_H$

We approximate (2.3) with

$$p_{H,t} = (1 - \alpha)p_{T,t} + \alpha p_{N,t} = p_{T,t} + \alpha (p_{N,t} - p_{T,t}) \quad (2.4)$$

so we can write

$$\pi_{H,t} = (1 - \alpha)\pi_{T,t} + \alpha \pi_{N,t} = \pi_{T,t} + \alpha (\pi_{N,t} - \pi_{T,t}) \quad (2.5)$$

We then have to determine the pricing behavior of producers in the traded and nontraded sector. With the assumed form of price stickiness, the pricing problem of an optimizing firm producing the variety $i$ of traded goods for the domestic market\(^{30}\) is to choose the reset price $\bar{P}_{T,t}$ to maximize its expected profits, given by:

$$E_t \sum_{j=0}^{\infty} \theta_T^j \rho_{t,t+j} (\bar{P}_{T,t} - MC_{T,t+j}^n) C_{T,t+j}(i)$$

where $\theta_T$ is the Calvo probability of non adjustment in any period (in the traded sector), $\rho$ is an appropriate stochastic discount factor, $C_{T,t+j}(i) = \left( \frac{\bar{P}_{T,t}}{P_{T,t+j}} \right)^{-\epsilon} C_{T,t+j}$ is demand faced by the firm, and $MC_{T,t+j}$ denotes nominal marginal costs (which, under the assumed structure of factor markets, are the same for all firms).

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\(^{30}\)The same firm would face a similar problem for its export market, as discussed in Chapter 1.
As is standard in the literature\(^{31}\), the first order conditions for this problem, combined with the evolution of the price index for traded goods \(P_T\), and log-linearized around the zero-inflation steady state, yield the following equation for traded goods’ inflation, \(\pi_{T,t} = p_{T,t} - p_{T,t-1}\):

\[
\pi_{T,t} = \beta E_t \pi_{T,t+1} + \lambda_T (m c_{T,t}^n - p_{T,t})
\] (2.6)

where \(\lambda_T = \frac{(1-\theta_T)(1-\theta_T \beta)}{\theta_T}\) and \(\beta\) is the steady state value of the discount factor. Note that here and in what follows, lower case letters denote logarithmic deviations from the steady state.

The next step is to write (2.6) in terms of the labor income share, defined by

\[x_t = w_t + l_t - (p_{H,t} + y_t),\]

where \(w_t\) is the economy-wide wage, \(l_t\) is total labor, and \(y_t\) is real output. With the assumed production technology, we can write marginal costs as:

\[
m c_{T,t}^n - p_{T,t} = w_t - a_t - p_{T,t}
\]

\[= w_t - (y_{T,t} - l_{T,t}) - p_{T,t}
\]

\[= w_t + l_{T,t} - p_{H,t} - y_t + \alpha[(p_{N,t} - p_{T,t}) + (y_{N,t} - y_{T,t})]
\]

\[= x_{T,t} + \alpha[(p_{N,t} - p_{T,t}) + (y_{N,t} - y_{T,t})]
\] (2.7)

where the third equality uses equation (2.4) and \(y_t = (1 - \alpha)y_{T,t} + \alpha y_{N,t} = y_{T,t} + \alpha(y_{N,t} - y_{T,t})\). The variable \(x_{T,t} = w_t + l_{T,t} - p_{H,t} - y_t\) is the labor income share.

\(^{31}\)See for example Walsh (2003) or Woodford (2003) for a detailed derivation.
the traded goods sector. We can then express (2.6) as:

\[ \pi_{T,t} = \beta E_t \pi_{T,t+1} + \lambda_T x_{T,t} + \lambda_T \alpha \left[ (p_{N,t} - p_{T,t}) + (y_{N,t} - y_{T,t}) \right] \]  

(2.8)

We further use \( L_t = L_{T,t} + L_{N,t} \) or \( l_t = (1 - \alpha) l_{T,t} + \alpha l_{N,t} \) to obtain

\[ \pi_{T,t} = \beta E_t \pi_{T,t+1} + \lambda_T x_t + \lambda_T \alpha \Gamma_t \]  

(2.9)

where \( \Gamma_t = (p_{N,t} - p_{T,t}) + (y_{N,t} - y_{T,t}) - (l_{N,t} - l_{T,t}) \) is a term in the relative prices, output and labor in the nontraded and traded sectors, which will generally be different from zero. Going from the real marginal cost representation (2.6) (which is in terms of the price index and output in the traded sector) to the labor share equation (2.9), we need to account for prices and output in the nontraded sector, since the labor share \( x_t \) is in terms of overall nominal GDP, \( p_{H,t} + y_t \). Moreover, total labor \( l_t \) is the relevant variable in \( x_t \), explaining the presence of the relative labor term \( l_{N,t} - l_{T,t} \) in deriving (2.9) from equation (2.8), which is conditional on the labor share in the traded sector \( x_{T,t} \).

Intuitively, as the relative price of nontraded goods \( p_{N,t} - p_{T,t} \) rises, demand will shift towards traded goods, exerting pressure on their inflation rate. Similarly, when relative output in the nontraded sector \( y_{N,t} - y_{T,t} \) rises, prices in the traded sector accordingly increase to ensure market clearing, thus affecting \( \pi_T \) positively. Also note
that we can equivalently write $\Gamma_t$ as:

$$
\Gamma_t = [p_{N,t} + y_{N,t} - (w_t + l_{N,t})] - [p_{T,t} + y_{T,t} - (w_t + l_{T,t})]
$$

(2.10)

which can be interpreted as relative profits (nominal output minus the wage bill) in the two sectors.

Turning to the nontraded goods sector, we follow analogous steps to first obtain:

$$
\pi_{N,t} = \beta E_t \pi_{N,t+1} + \lambda_N (mc^N_{N,t} - p_{N,t})
$$

(2.11)

where $\lambda_N = \frac{(1-\theta_N)(1-\theta_N/\beta)}{\theta_N}$, and then get to the labor share representation:

$$
\pi_{N,t} = \beta E_t \pi_{T,t+1} + \lambda_N x_t - \lambda_N (1 - \alpha) \Gamma_t
$$

(2.12)

Finally, using (2.5) with (2.9) and (2.12) yields the following:

**Proposition 2.1.** With final goods only, the NKPC for GDP deflator inflation $\pi_H$ is given by:

$$
\pi_{H,t} = \beta E_t \pi_{H,t+1} + [(1 - \alpha) \lambda_T + \alpha \lambda_N] x_t + (\lambda_T - \lambda_N) \alpha (1 - \alpha) \Gamma_t
$$

(2.13)

Thus, with the notation of representation (2.1):

$$
\xi_t = (\lambda_T - \lambda_N) \alpha (1 - \alpha) \Gamma_t
$$

$$
\delta = (1 - \alpha) \lambda_T + \alpha \lambda_N
$$
The slope $\delta$ is a weighted average of the slopes of the NKPCs for the traded and nontraded sector, with weights given by their relative importance in the economy. The value of $\delta$ predicted by the model is smaller (larger) than in its traded goods-only/closed economy version if the degree of price stickiness in the nontraded sector is higher (smaller), as $\theta_N > \theta_T$ ($\theta_N < \theta_T$) implies $\lambda_N < \lambda_T$ ($\lambda_N > \lambda_T$). Note that the comparison of $\lambda_T$ and $\lambda_N$ also determines the sign of the coefficient on $\Gamma_t$.

From the result in Proposition 2.1 we can then state the following:

**Corollary.** If and only if $\alpha = 0$ and/or $\lambda_T = \lambda_N$ is $\xi_t = 0$ and $\delta = \lambda$, i.e. the NKPC is equivalent to its closed economy counterpart.

Note that we can already see from the traded goods inflation equation (2.9) that if $\alpha = 0$ (so that the model collapses to its traded goods-only version), $\pi_{H,t} = \pi_{T,t}$ and the resulting NKPC for GDP deflator inflation is the same as the one we would obtain for a closed economy, as observed in Monacelli (2007). On the other hand, if $\alpha > 0$ and we neglected $\Gamma_t$, we would be estimating a misspecified Phillips curve even if we were to use an appropriate measure of inflation for traded goods.

Equation (2.13) highlights the fact that $\alpha = 0$ is not in itself a necessary condition for $\xi_t$ in (2.1) to be equal to zero. If the traded and nontraded sector are characterized by the same degree of price stickiness ($\theta_T = \theta_N$ so that $\lambda_T = \lambda_N$), the result holds even with a nonzero share of the nontraded sector in the economy.

To get a sense of the bias we would incur if we were to omit the variable $\Gamma_t$ from equation (2.13), we construct a very crude empirical counterpart and compute its correlation with the labor income share $x_t$. Following Engel (1999), we use deflators for personal consumption expenditure on services and goods to proxy for $p_N$ and $p_T$, respectively. We use a similar characterization for the output (real GDP in services...
and goods) and labor (employment in services and manufacturing) variables.\textsuperscript{32} We obtain a negative and relatively low correlation of about -0.10. Moreover, if we are willing to assume $\lambda_N < \lambda_T$, so that the nontraded sector is “stickier” than the traded sector, the coefficient on $\Gamma_t$ is positive. Thus, in this case, omitting $\Gamma_t$ would lead to underestimation of the slope of the NKPC. Although this exercise is clearly for illustrative purposes only, it does suggest the potential for a bias.

\section*{2.2.2 Open-economy NKPC for $\pi$}

Approximating (2.2) yields:

$$p_t = (1 - \gamma)p_{H,t} + \gamma p_{F,t} = p_{H,t} + \gamma(p_{F,t} - p_{H,t}) \tag{2.14}$$

Using (2.4) we can write:

$$p_{F,t} - p_{H,t} = s_t - \alpha(p_{N,t} - p_{T,t}) \tag{2.15}$$

where $s_t = p_{F,t} - p_{T,t}$ represents the terms of trade, that is the price of the domestic country’s imports relative to its tradables. In the absence of a nontraded sector ($\alpha = 0$), the terms of trade simply correspond to $p_{F,t} - p_{H,t}$. From (2.14) and (2.15) we obtain:

$$\pi_t = \pi_{H,t} + \gamma \Delta s_t - \alpha \gamma (\pi_{N,t} - \pi_{T,t}) \tag{2.16}$$

Then, combining (2.16) with (2.13), (2.9) and (2.12), one gets the following:

\footnotesize
\textsuperscript{32}We use US data from the National Income and Product Accounts maintained by the Bureau of Economic Analysis. Data is at the annual frequency, based on the availability of the employment measures. The sample is 1970-2011. We replicate $\Gamma_t$ using log differences of Hodrick-Prescott (HP)-filtered series.
Proposition 2.2. With final goods only, the NKCP for PCE inflation $\pi$ is given by:

$$
\pi_t = \beta E_t \pi_{t+1} + [\lambda_T + \alpha(1 - \gamma)(\lambda_N - \lambda_T)] x_t + \gamma(\Delta s_t - \beta E_t \Delta s_{t+1}) \\
+ \alpha[\gamma \lambda_N + (1 - (1 - \gamma))(\lambda_T - \lambda_N)] \Gamma_t
$$

Thus, with the notation of representation (2.1):

$$
\xi_t = \gamma(\Delta s_t - \beta E_t \Delta s_{t+1}) + \alpha[\gamma \lambda_N + (1 - \alpha(1 - \gamma))(\lambda_T - \lambda_N)] \Gamma_t
$$

$$
\delta = \lambda_T + \alpha(1 - \gamma)(\lambda_N - \lambda_T)
$$

The slope $\delta$ now additionally depends on the degree of openness $\gamma$. Similarly to GDP deflator inflation, the sign of $\lambda_N - \lambda_T$ determines whether the slope is smaller or larger than in closed economy. Note that the slope of the PCE NKPC is always smaller (larger) than the slope of the GDP NKPC when $\lambda_N > \lambda_T$ ($\lambda_N < \lambda_T$), more so the more open the economy. The sign of the coefficient on $\Gamma_t$ is now more difficult to predict, as it doesn’t exclusively depend on the relative degree of price stickiness in the nontraded and traded sectors.

We can then state the following:

**Corollary.** If $\alpha = 0$, the NKPC reduces to:

$$
\pi_t = \beta E_t \pi_{t+1} + \lambda_T x_t + \gamma(\Delta s_t - \beta E_t \Delta s_{t+1})
$$

which we regard as the baseline case for PCE inflation.

With $\alpha > 0$, if the traded and nontraded sector have the same degree of price stickiness in the nontraded and traded sectors.

---

33 The slope in equation (2.13) can be expressed as $\delta = \lambda_T + \alpha(\lambda_N - \lambda_T)$
stickiness ($\lambda_T = \lambda_N = \lambda$), the NKPC is not equivalent to the baseline case and it reads:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t + \gamma (\Delta s_t - \beta E_t \Delta s_{t+1}) + \alpha \gamma \lambda T$$

Equation (2.18) shows that PCE inflation is directly affected by import prices through a terms of trade channel (which is more important the more open the economy, as measured by $\gamma$), regardless of any consideration about nontraded goods. This baseline case is the foundation for the empirical study in Mihailov et al. (2011). As argued in their analysis, the intuition behind the term in leads and lags of the terms of trade, $\Delta s_t - \beta E_t \Delta s_{t+1}$, has to do with how the expected change in the relative price of imports compares to the current one: for example, if there is an expected relative appreciation of the terms of trade (so that $\Delta s_t > \beta E_t \Delta s_{t+1}$), demand would tend to shift towards domestic goods, thus pushing inflation up.$^{34}$

Relative to the GDP deflator case, as long as there is a nontraded sector (i.e. $\alpha > 0$), the relative nontraded/traded term $\Gamma_t$ is included even when $\lambda_T = \lambda_N$ because it matters in the definition of PCE inflation (see (2.16)), beyond its role in the labor share (see equations (2.7) and (2.9)). In the general case of Proposition 2.2, the sign of the coefficient on $\Gamma_t$ is now more difficult to predict, as it doesn’t exclusively depend on the relative degree of price stickiness in the nontraded and traded sectors.

---

$^{34}$Note that, based on the definition of $s_t$, an appreciation corresponds to a decrease. The latter is in turn viewed as an improvement of the terms of trade.
2.3 Producer vs. Local Currency Pricing and the real exchange rate

Recent research in open-economy macroeconomics has put significant emphasis on the impact of different assumptions about export pricing behavior on issues such as international transmission of shocks and optimal monetary policy. More specifically, in models with nominal rigidities in prices, it is natural to ask in which currency exporters’ prices are sticky: the Producer-Currency pricing (PCP) assumption states that exporters set prices in their own currency, while the Local-Currency Pricing (LCP) assumption maintains that prices are sticky in the destination market’s currency.\textsuperscript{35}

Chapter 1 explored the implications of these different assumptions in the context of Phillips curves. Here, the question is more specifically whether the labor-share representations of the NKPC we have derived thus far depend on the above assumptions on export pricing. If the goal is to inform the empirical literature on the open-economy NKPC, it is useful to assess the robustness of these representation (and the variables involved) to this dimension of openness. To this end, note that nowhere in deriving equations (2.13) and (2.17) have we used the PCP vs. LCP assumption. In other words, the choice of the empirical counterparts of the variables in the relevant NKPC doesn’t depend on this assumption.

It is worth mentioning at this stage that open-economy Phillips curves often include the \textit{real exchange rate} as an additional explanatory variable (see also Monacelli

\textsuperscript{35}See for example, among many others, the theoretical work of Betts and Devereux (2000), Devereux and Engel (2003) and Engel (2011). Gopinath and Rigobon (2008) provide empirical evidence on LCP behavior for exports to the US. Antoniades (2012) investigates the PCP vs. LCP hypothesis for Eurozone countries.
(2007)). To show what this entails in the present model, we derive a relationship between the terms of trade and the real exchange rate. We assume the foreign country F is a large country, and everything is symmetric relative to the domestic economy. The superscript * for price variables denotes that they are denominated in foreign currency. The (log-linear) real exchange rate between H and F is defined as:

$$q_t = p_t^* + e_t - p_t$$

(2.19)

where $e_t$ is the nominal exchange rate (price of one unit of F-currency in terms of H-currency). We also define country F’s terms of trade as $s_t^* = p_{H,t}^* - p_{T,t}^*$ and express its relevant price indices as:

$$p_{F,t}^* = p_{T,t}^* + \alpha (p_{N,t}^* - p_{T,t}^*)$$

$$p_t^* = p_{F,t}^* + \gamma s_t^* - \gamma \alpha (p_{N,t}^* - p_{T,t}^*)$$

(2.20)

It is also useful to introduce the following variables:

$$z_t = p_{T,t}^* + e_t - p_{F,t}$$

$$z_t^* = p_{T,t} - e_t - p_{H,t}^*$$

(2.21)

which represent deviations from the law of one price for Home and Foreign tradable goods. As shown in Chapter 1, under PCP, $z_t = z_t^* = 0$. Under LCP, both $z_t$ and $z_t^*$ are different from zero.\(^{36}\) Moreover, under the assumption that the degree of price stickiness is the same in H and F, $z_t = -z_t^*$.

\(^{36}\)Of course, LCP is only one of many possible reasons why the LOP does not hold
The definitions for \( s_t \) and \( s_t^* \) together with (2.21) yield:

\[
s_t = -s_t^* - (z_t + z_t^*)
\]  
(2.22)

In an exercise that is similar in spirit to Engel (1999), we use the expression for the appropriate price indices, together with (2.21) and (2.22), in (2.19) to obtain:

\[
q_t = (1 - 2\gamma)s_t + z_t + (1 - \gamma)[\alpha^*(p_{N,t}^* - p_{T,t}^*) - \alpha(p_{N,t} - p_{T,t})]
\]  
(2.23)

This can be solved for \( s_t \):

\[
s_t = \frac{q_t - z_t}{1 - 2\gamma} + \frac{1 - \gamma}{1 - 2\gamma}[\alpha^*(p_{N,t}^* - p_{T,t}^*) - \alpha(p_{N,t} - p_{T,t})]
\]

and substituted in equation (2.17) to yield the following:

**Proposition 2.3.** The NKPC for PCE inflation as a function of the real exchange rate \( q_t \) is:

\[
\pi_t = \beta E_t \pi_{t+1} + [\lambda_T + \alpha(1 - \gamma)(\lambda_N - \lambda_T)]x_t + \alpha[\gamma \lambda_N + (1 - (1 - \gamma))(\lambda_T - \lambda_N)]\Gamma_t
\]

\[
+ \frac{\gamma}{1 - 2\gamma}(\Delta q_t - \beta E_t \Delta q_{t+1}) + \frac{\gamma}{1 - 2\gamma}(\Delta z_t - \beta E_t \Delta z_{t+1})
\]

\[
+ \frac{\gamma(1 - \gamma)}{1 - 2\gamma} \Psi_t
\]  
(2.24)

where \( \Psi_t \) is a term in the relative (current and expected) inflation rate for nontradables in the domestic and foreign country.\(^{38}\)

\(^{37}\)We also use \( z_t = -z_t^* \) to express everything in terms of \( z_t \).

\(^{38}\)\( \Psi_t \) is equal to zero if the share of nontraded goods is equal to zero in both countries.
The NKPC in Propositions 2.1 and 2.2 is robust to deviations from the law of one price for tradables, and specifically to assuming PCP vs. LCP. The PCE NKPC conditional on the real exchange rate is not robust to this assumption, as neglecting to take the $z_t$ terms into account implicitly assumes that PCP holds.

2.4 The role of intermediate inputs

We now explore the implications of a richer production structure, whereby the production of final goods requires intermediate inputs in addition to labor. This layer allows us to study another dimension of openness, as all or part of the intermediate inputs are imported from abroad. We now abstract from the traded/nontraded distinction in final goods.

We assume the following CES production technology:

$$\begin{align*}
Y_t &= \left[ (1 - \alpha_m)^{\frac{1}{\psi}} L_t^{\frac{\psi-1}{\psi}} + \alpha_m^{\frac{1}{\psi}} M_t^{\frac{\psi-1}{\psi}} \right]^{\frac{1}{\psi-1}} \\
&= (2.25)
\end{align*}$$

where $M$ represents intermediate inputs ($\alpha_m$ being the corresponding share in production) and $\psi$ is the elasticity of substitution between labor and intermediate inputs.

We now turn to deriving the GDP deflator NKPC under two alternative assumptions about $M$: First, we assume it only consists of imported inputs (i.e. there are no non-tradables in the intermediate sector). Then, we will allow for domestically produced intermediate inputs as well.
2.4.1 Imported inputs-only

The analysis in this section follows Balakrishnan and Lopez-Salido (2002). With freely adjustable labor, marginal costs deflated by $P_H$ can generally be expressed as:

$$MC_t = \frac{MC_n}{P_H,t} = \frac{W_t}{P_H,t} \frac{\partial Y_t}{\partial L_t}$$

where $X_t = \frac{W_t L_t}{P_H,t Y_t}$ is the usual labor income share and $\chi_t$ is the elasticity of output with respect to labor $\left(\frac{\partial Y_t}{\partial L_t} L_t Y_t\right)$. Using (2.25), we have:

$$\chi_t = (1 - \alpha_m) \left( \frac{Y_t}{L_t} \right)^{\frac{1}{1-\psi}}$$

or, in terms of the relative price of the factors of production $\frac{P_{m,t}}{W_t}$:

$$\chi_t = \frac{1}{1 + \frac{\alpha_m}{1-\alpha_m} \frac{P_{m,t}}{W_t}}$$

where $P_m$ is the price of imported inputs. The marginal cost expression can then be log-linearized around the flexible-price equilibrium (characterized by $MC = \frac{1}{\mu} = \frac{LSH}{\chi}$, where $\mu$ is the steady state markup) to obtain:

$$mc_t = mc_t^H - p_{h,t} = x_t + \kappa (p_{m,t} - w_t)$$  \hspace{1cm} (2.26)
where $\kappa = (1 - \psi)(1 - \chi)$. This can be used in the equation for GDP deflator inflation $\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda mc_t$ to obtain the following:

**Proposition 2.4.** With imported-only intermediate inputs, the NKPC for GDP deflator inflation $\pi_H$ is given by:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda x_t + \lambda \kappa(p_m,t - w_t)$$

Thus, with the notation of representation (2.1):

$$\xi_t = \lambda \kappa(p_m,t - w_t)$$

Thus, with the notation of representation (2.1):

$$\delta = \lambda$$

The above result leads to the following:

**Corollary.** If the elasticity of substitution $\psi$ between labor and imported inputs is equal to 1, $\xi_t = 0$ and the NKPC is equivalent to closed economy. If $\psi \neq 1$, even in the absence of nontraded intermediate inputs, $\xi_t$ is not zero.

This shows that, except in the special case where the production technology (2.25) is Cobb-Douglas, the NKPC includes an additional term in the relative price of the factors. The way the relative price $(p_m,t - w_t)$ term affects inflation depends on the sign of $\kappa$, which is positive or negative depending on whether the elasticity of substitution $\psi$ is smaller or larger than 1, respectively. For example, with high substitutability

\[39\] $\chi$ is the steady state value of the elasticity of output with respect to labor, which is also equal to $LSH \times \mu$, i.e. the product of the steady state values of the labor income share and markup. This can be useful for calibration purposes.

\[40\] This is true for values of the steady state labor share ($LSH$) and gross markup ($\mu$) such that $1 - LSH \times \mu$ is greater than zero.
between imported inputs and labor ($\psi > 1$), an increase of imported prices relative to wages will tend to reduce marginal costs and thus inflation. The slope $\delta$, on the other hand, is not affected by the introduction of imported intermediate inputs.

2.4.2 The role of nontraded intermediate inputs

We now allow for a share of the intermediate inputs to be domestically produced. Specifically, we assume that $M_t$ is as follows:

$$M_t = \left[ (1 - \gamma_m)^{\frac{1}{\psi}} M_{H,t}^{\frac{1}{\psi}} + \gamma_m^{\frac{1}{\psi}} M_{F,t}^{\frac{1}{\psi}} \right]^{\psi}$$  \hspace{1cm} (2.28)

where $\psi$ is the elasticity of substitution between domestic and imported intermediate inputs, and $\gamma_m$ is the share of intermediate imports. We can then think of $1 - \gamma_m$ as the corresponding share of nontradables. The corresponding price index is:

$$P_{m,t} = \left[ (1 - \gamma_m) P_{mH,t}^{1-\psi} + \gamma_m P_{mF,t}^{1-\psi} \right]^{\frac{1}{1-\psi}}$$  \hspace{1cm} (2.29)

We assume that domestic intermediate inputs are produced with a linear technology with labor as the sole factor. Importantly, we now need to distinguish between the labor employed in final (consumption) goods’ production (which we denote $L_c$) and labor used in intermediate inputs’ domestic production ($L_m$). We then have $L_t = L_c + L_m$ or, in log deviations from the steady state:

$$l_t = \frac{1 - \alpha_m}{1 - \alpha_m \gamma_m} l_{c,t} + \frac{\alpha_m (1 - \gamma_m)}{1 - \alpha_m \gamma_m} l_{m,t}$$  \hspace{1cm} (2.30)

where $\frac{1 - \alpha_m}{1 - \alpha_m \gamma_m}$ and $\frac{\alpha_m (1 - \gamma_m)}{1 - \alpha_m \gamma_m}$ are the steady state shares of $L_c$ and $L_m$, respectively, in
total labor $L$. This implies the following:

$$x_t = x_{c,t} + \frac{\alpha_m (1 - \gamma_m)}{1 - \alpha_m \gamma_m} (l_{m,t} - l_{c,t})$$  \hspace{1cm} (2.31)$$

where $x_{c,t} = w_t + l_{c,t} - p_{H,t} - y_t$ is the labor income share in the final goods sector.

The GDP deflator NKPC under these assumptions can thus be written as:

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda x_{c,t} + \lambda \kappa (p_{m,t} - w_t)$$

$$= \beta E_t \pi_{H,t+1} + \lambda x_t + \lambda \kappa (p_{m,t} - w_t) + \lambda \frac{\alpha_m (1 - \gamma_m)}{1 - \alpha_m \gamma_m} (l_{c,t} - l_{m,t})$$  \hspace{1cm} (2.32)$$

The NKPC has now an additional term that depends on relative labor in the intermediate and final good sectors. Equation (2.32) is of course equivalent to the NKPC of Proposition 2.4 if the share of domestically produced inputs is equal to zero (that is, $\gamma_m = 1$). Note that this term can be equivalently expressed in terms of the relative labor shares in the two sectors, $x_{c,t} - x_{m,t}$. Without taking a stand on the determinants of the domestic and foreign price indexes underlying $p_{m,t}$, the NKPC in the form of equation (2.32) could be plausibly implemented empirically, proxying $p_m$ with a Producer Price Index (PPI), as it includes both domestic and imported inputs.

Going a step further, we approximate (2.29) and write:

$$p_{mt} = (1 - \gamma_m) p_{H,t} + \gamma_m p_{mF,t} = p_{mH,t} + \gamma_m s_{m,t}$$  \hspace{1cm} (2.33)$$

where $s_{m,t} = p_{mF,t} - p_{mH,t}$ is the price of imported inputs relative to domestically produced ones. To determine $p_{mH,t}$, we assume the intermediate sector is characterized
by Calvo-style price stickiness, with parameter $\theta_m$. In this case we can write:

$$p_{mH,t} = \frac{1}{1 + \beta} [p_{mH,t-1} + \beta E_t p_{mH,t+1} + \lambda_m (mc_{m,t}^n - p_{mH,t})] \quad (2.34)$$

where $\lambda_m = \frac{(1 - \theta_m)(1 - \theta_m \beta)}{\theta_m}$. Using approximations of (2.25) and (2.28), together with (2.30) and (2.33), we can express $mc_{m,t}^n - p_{mH,t}$ in terms of the usual labor share $x_t$:

$$mc_{m,t}^n - p_{mH,t} = x_t + \frac{1 - \alpha_m}{1 - \alpha_m \gamma_m} (l_{m,t} - l_{c,t}) + (1 - \alpha_m)(l_{c,t} - m_t) + \gamma_m (m_{F,t} - m_{H,t}) + (p_{H,t} - p_{mH,t}) \quad (2.35)$$

In addition to the term in relative labor $l_{m,t} - l_{c,t}$, we now have to account for foreign inputs relative to domestic, $m_{F,t} - m_{H,t}$, and labor relative to intermediate inputs, $l_{c,t} - m_t$, when we express output in the domestic intermediate sector $m_{H,t}$ in terms of real GDP $y_t$. The $p_{H,t} - p_{mH,t}$ term is included as we need to use the GDP deflator for the overall labor share.

Equation (2.35) can then combined with (2.34) and (2.33), and substituted in (2.32) to finally obtain the following:

**Proposition 2.5.** *With imported and domestically produced intermediate inputs, the*
NKPC for GDP deflator inflation $\pi_H$ is given by:

$$
\pi_{H,t} = \beta E_t \pi_{H,t+1} + \lambda \left[ 1 + \frac{\lambda m \kappa}{1 + \beta} \right] x_t
$$

$$
+ \frac{\lambda \kappa}{1 + \beta} (p_{mH,t-1} + \beta E_t p_{mH,t+1}) + \lambda \kappa (\gamma m s_{m,t} - w_t)
$$

$$
+ \frac{\lambda \lambda m \kappa}{1 + \beta} [(1 - \alpha_m)(l_{c,t} - m_t) + \gamma m (m_{F,t} - m_{H,t}) + (p_{H,t} - p_{mH,t})]
$$

$$
+ \frac{\lambda}{1 - \alpha_m \gamma m} \left[ \alpha_m (1 - \gamma_m) - \frac{\lambda m (1 - \alpha_m) \kappa}{1 + \beta} \right] (l_{c,t} - l_{m,t})
$$

(2.36)

Thus, with the notation of representation (2.1):

$$
\xi_t = \frac{\lambda \kappa}{1 + \beta} (p_{mH,t-1} + \beta E_t p_{mH,t+1}) + \lambda \kappa (\gamma m s_{m,t} - w_t)
$$

$$
+ \frac{\lambda \lambda m \kappa}{1 + \beta} [(1 - \alpha_m)(l_{c,t} - m_t) + \gamma m (m_{F,t} - m_{H,t}) + (p_{H,t} - p_{mH,t})]
$$

$$
+ \frac{\lambda}{1 - \alpha_m \gamma m} \left[ \alpha_m (1 - \gamma_m) - \frac{\lambda m (1 - \alpha_m) \kappa}{1 + \beta} \right] (l_{c,t} - l_{m,t})
$$

$$
\delta = \lambda \left[ 1 + \frac{\lambda m \kappa}{1 + \beta} \right]
$$

Similarly to Proposition 2.4, NKPC (2.36) has a term in the relative prices of factors, $\gamma m s_{m,t} - w_t$, where $s_{m,t}$ reflects the fact that intermediate inputs are now both imported and domestically produced. The presence of nontradability in intermediate inputs impacts the specification of the NKPC in a rather complex way, and it implies an additional set of variables which depend on relative prices and quantities in different sectors (final vs. intermediate goods) and markets (domestic vs. foreign).

The slope $\delta$ now depends also on the degree of price stickiness in the intermediate sector (via $\lambda_m$) and the elasticity of substitution $\psi$ between labor and intermediate
inputs (via $\kappa$). Whether $\delta$ is larger or smaller than in the imports-only case (which in turn is the same as closed economy) depends on whether $\psi$ is smaller or larger than 1, respectively: relatively high substitutability is predicted to reduce the impact of given movements in the labor income share on inflation.

Finally, we note that our focus in this section has been on GDP deflator inflation. Analogously to the baseline case in section 2.2.2, the PCE version of the NKPC includes an additional term in leads and lags of the terms of trade (which in this instance are just given by $s_t = p_{F,t} - p_{H,t}$, since we did away with the traded/nontraded distinction for final goods). In this regard, similar considerations apply.

2.5 What have we learned?

The ultimate purpose of this analysis is to offer some guidance on the implications of open economy aspects for empirical specifications of the NKPC. We then provide a systematic summary of our results as a list of candidate control variables implied by the scenarios we examined. Accordingly, “robust” estimation of the labor income share NKPC as in representation (2.1) should include the following:

- $\left( p_{N,t} - p_{T,t} \right) + \left( y_{N,t} - y_{T,t} \right) - \left( l_{N,t} - l_{T,t} \right)$: This control is a term in relative prices, output and employment in the nontraded versus the traded sector. It accounts for the proper definition of the labor income share variable when both sectors are present. It is predicted to matter for both GDP and PCE inflation, as long as there is a nonzero share of nontradables.

- $\Delta s_t - \beta E_t \Delta s_{t+1}$: This control is a term in lags and leads of the terms of trade $s_t$, i.e. the price of the country’s imports relative to the price of its tradables.
It is predicted to be an additional determinant of PCE inflation, accounting for
the direct effect of import prices, as long as the economy is open to trade in
final goods.

- \( s_{m,t} - w_t \): This control is a term in the relative prices of intermediate inputs,
  \( s_{m,t} \), and domestic labor, \( w_t \). It is predicted to matter for both measures of
  inflation and it reflects the presence of intermediate inputs as an additional
  factor of production. The variable \( s_{m,t} \) is itself a relative price, of imported over
domestic intermediate goods, in the general case where intermediate inputs
include a share of nontradables (i.e. they are both imported and domestically
produced).\(^{41}\)

- \( l_{c,t} - m_t, m_{F,t} - m_{H,t}, p_{H,t} - p_{mH,t}, l_{c,t} - l_{m,t} \): These controls are terms in
  relative prices, quantities and employment that account for the proper defini-
tion of the labor income share when (i) both final and intermediate goods are
  present, and (ii) the latter have a nonzero share of nontradables. The relative
  amount of labor and intermediate inputs, \( l_{c,t} - m_t \), reflects the assumption on
  the production technology for final goods. The relative price \( p_{H,t} - p_{mH,t} \) and
  employment \( l_{c,t} - l_{m,t} \) terms capture the two layers of domestic production, i.e.
  final and intermediate goods. Finally, the relative quantities of intermediate in-
  puts, \( m_{F,t} - m_{H,t} \), reflect the presence of both a foreign and a domestic market
  for these factors.

This list suggests variables that are potentially relevant for the dynamics of inflation,
once open economy considerations are taken into account. Empirical implementation
\(^{41}\)Under the assumption of imported-only intermediate inputs, of course, the relevant variable
would be an appropriate import price index, as shown in equation (2.27).
is the natural next step, to verify whether these variables indeed belong to the NKPC specification as suggested by theory and, if so, whether they significantly improve the fit of the estimated equation.\footnote{A related question is whether the estimation of the slope would be affected by the inclusion of the additional controls, as discussed in Section 2.2.1.} One obvious challenge in taking these specifications to the data is to be able to generate appropriate empirical counterparts to the theoretical constructs for price indexes, output and employment measures. This is particularly true when it comes to traded versus nontraded goods, as the data does not provide the same clear-cut distinction we have in theory.\footnote{There is work on real exchange rate fluctuations that provides some guidance on this. See for example Engel (1999), Burstein et al. (2005), Betts and Kehoe (2008) and Corsetti et al. (2011).} The construction of proxies for the variables that pertain to domestic versus foreign intermediate inputs, as well as final goods versus intermediate inputs, would also require particular care.

To conclude, another perspective on the above results is that such a wide range of potential controls in our NKPC specification in fact suggests that perhaps we should move away from the labor share representation. One possible direction would then be to search for an alternative measure, in a similar spirit, of the real driving variable for inflation that is more suitable to account for open economy aspects. We do not have a proposal for such a variable here, and from the analysis in this paper it is not obvious that a simple one exists. This does, however, at the very least challenge the notion that the labor share is a robust measure of the driving process for inflation.

\section{Conclusion}

We have provided a systematic overview of the impact of openness to trade, in particular the role of different scenarios for nontradability, on the specification of New Keynesian Phillips curves. The purpose is to try and inform the empirical literature
on the NKPC by examining the potential implications for additional control variables to be included in its estimation. We also considered how the slope of the NKPC is affected.

Overall we find that the presence of nontraded goods matters in relating open-economy aspects to the estimation of the NKPC: collecting the propositions in this chapter reveals that, except for very special cases, additional variables enter the NKPC specification. We show that even under relatively basic scenarios (for example, where we consider only final goods), using the labor share representation and failing to account for nontradability is likely to lead to biased results. Moreover, we concluded that our representations are robust to assuming Producer versus Local Currency Pricing. This is not true of typical representations conditional on the real exchange rate, as we showed they might be implicitly assuming PCP.

Slopes of the NKPC are relatively “resilient” to the different scenarios under study: they are either equivalent to their closed economy counterpart, or they are affected in a relatively straightforward way reflecting the presence of more than one sector. As for the additional controls, several candidates emerge, depending on the scenario for nontradability that we consider and the measure of inflation we employ. Once we condition the representation on the overall labor income share, our results show that it is important to take into account variables that reflect relative prices and quantities for different sectors in the economy and for the domestic versus the foreign market.

The results in this chapter do suggest that empirical specifications of the NKPC should include additional controls to account for the open economy aspects that we have discussed. The natural and obvious next step is to take these specifications to the data. This task presents specific challenges, especially in finding appropriate
empirical counterparts to the theoretical variables, and it is worth pursuing in future research.
Chapter 3

Retailer pass-through and its determinants using scanner data

(Joint with Alexis Antoniades)

3.1 Introduction

A key issue in international macroeconomics is the degree to which movements in exchange rates affect prices of imported goods. Whether the exchange rate pass-through into consumer prices is small or large has important implications for a range of theoretical and policy issues, such as the dynamics of inflation, adjustment of trade imbalances, selection of the appropriate exchange rate regime, and the choice of optimal monetary policy.\(^{44}\)

Of equal importance to policymakers is knowledge on the determinants of exchange rate pass-through. Possible contributors to the observed variation in pass-through levels across countries and across time are macro-economic factors (such as inflation) and micro-economic factors (such as product differentiation and market structure). These factors affect the pricing behavior of producers in the exporting

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\(^{44}\)Several studies examine how the degree of exchange rate pass-through is related to these issues. See for example Betts and Devereux (2000), Devereux and Engel (2003), Devereux, Engel and Tille (2003), Engel (2000, 2002, 2011), Corsetti and Dedola (2005), Gust et al. (2009). Chapter 1 briefly investigated how exporters’ currency choice affects pass-through.
country, but also of wholesalers and retailers in the importing country.\textsuperscript{45} Knowledge on the pricing behavior of exporters is required to explain exchange rate pass-through into the price of goods at the dock, while knowledge of the pricing behavior of retailers further contributes to explaining pass-through into consumer prices.

In this chapter we study retailer pass-through and its determinants using micro data on about 85\% of the fast moving consumer goods (FMCGs) sold across 1,041 outlets in the United Arab Emirates between January of 2005 and December of 2010. The data, reported at the barcode level at each outlet, are augmented with Country-of-Origin (COO) information that is collected from the products’ labels. Furthermore, for each outlet there is information on its type, the region it belongs to, and whether the outlet is part of a chain. Each outlet’s market share is also retrieved. By exploiting the uniqueness of the compiled dataset we are able to provide a more accurate measure of exchange rate pass-through on imported goods at the point of consumption. Most importantly, we are able to provide new insights on the importance of the cross-border transmission process in explaining incomplete pass-through.\textsuperscript{46}

The United Arab Emirates (UAE), where expatriates make up more than 80\% of the population, is a good place to study exchange rate pass-through. It is a developing country with a currency pegged to the US dollar; the majority of the FMCGs are imported; there are no price controls; and data are available at the finest level of disaggregation and across hundreds of outlets. While most studies on pass-through are done in the context of advanced economies, there has been little work on pas-

\textsuperscript{45}For a review of the literature on the determinants of pass-through, see Yang (1997), Taylor (2000), Campa and Goldberg (2006), and Marazzi and Sheets (2007) and references therein.

\textsuperscript{46}For comparison purposes, we attempted, and failed, to obtain scanner-level data at the outlet level in Europe. Stricter regulations on confidentiality of information prevent sharing outlet-level data.
through in developing countries, where the issue is most relevant. For developing and emerging markets committed to dollar pegs, the degree of exchange rate pass-through into consumer goods prices determines how much inflation these countries import from abroad whenever the US dollar depreciates. Fears of importing inflation make some policy makers, especially those in the Arabian Gulf, ponder a move away from the dollar peg.

Our investigation proceeds in three steps. First, we apply the standard methodology proposed in the literature to measure the degree of cross-border exchange rate pass-through on imported FMCGs. Second, we provide new stylized facts on the determinants of exchange rate pass-through in relation to retailers’ market share, product quality, and the elasticity of substitution of product categories. Third, we discuss how our findings relate to existing theories of firm behavior.

At the aggregate level we find exchange rate pass-through is low and delayed. In the short-run, defined as a quarter, we find that only 3% of the movement in the exchange rate is passed through to consumer prices. In the long-run, defined as four quarters, we find the degree of pass-through rises to 20%.

Our estimates fall in the middle of the range of estimates obtained in previous studies that used aggregate price data for developed countries. Studies that looked at import prices at the dock found long-run pass-through to be around 40% to 60% (e.g. Campa and Goldberg (2006), Marazzi and Sheets (2007)), whereas studies that looked at consumer prices found pass-through between 0% and 17%, depending on the sample and specification considered, and in most cases statistically insignificant (e.g. Goldberg and Campa (2010), Ihrig et al. (2006)).

Measuring exchange rate pass-through at the dock or at the consumer level is of
interest for different reasons. On one hand, studies that measure exchange rate pass-through into import prices at the dock shed light on how exporters adjust output, prices and markups in response to movements in exchange rates. More recent work has looked at these issues using data at a high level of disaggregation (e.g. Gopinath et al. (2010)). On the other hand, studies that use aggregate consumer price data are relevant in their contribution to investigate important macroeconomic questions, such as the impact of exchange rate fluctuations on inflation.

While the studies above provide great insights on the micro-determinants of exchange rate pass-through by generating a wealth of information on the behavior of exporters, and they give recommendations on the macro-implications, they provide little information on the cross-border transmission process.

Local non-traded costs, along with markups at the wholesale and retail level generate a distribution wedge between dock and retail prices. Berger et al. (2009) and Anderson and van Wincoop (2004) show that the distribution wedge can account for as much as 40% to 60% of the final retail price. Consequently, as wholesalers and retailers might absorb some of the price fluctuations, to properly account for incomplete pass-through one needs to take into account changes in distribution costs (Burnstein et al. (2003), Goldberg and Campa (2010), Choudri et al. (2005), Corsetti and Dedola (2005)) and variations in markups at the wholesale and retail level (Atkeson and Burnstein (2008), Goldberg and Hellerstein (2011), Nakamura and Zerom (2010)).

Given the importance of the distribution wedge, estimates of exchange rate on imports data at the dock “overstate” pass-through on traded goods at the retail level in that they fail to account for how wholesalers and retailers may respond to
fluctuations in exchange rates. Similarly, studies based on consumer prices “under-state” pass-through, for these studies use price indexes of baskets that also include non-traded goods.

A more recent literature has taken advantage of increased data availability at the product level to study micro-determinants of exchange rate pass-through at the consumption level for specific industries (Hellerstein (2008), Goldberg and Hellerstein (2011), Nakamura and Zerom (2010)). We contribute to this literature, drawing on the strengths of our dataset, by providing new stylized facts on the microeconomic determinants of the cross-border transmission mechanism.

First, we find that exchange rate pass-through is positively correlated with retailer market share; exchange rate pass-through is highest for supermarkets, and lowest for mini-markets, with groceries in between. To control for any differences in business models across types of outlets, we repeat the analysis only considering supermarkets. We find that exchange rate pass-through in supermarkets with high market share is almost double that of supermarkets with low market share. The results hold true at the country, and at the regional level.

Second, we find that exchange rate pass-through is negatively correlated with product quality. We follow Auer and Chaney (2009) and use variation in price within specific product category-weight-package type triplet as evidence of variation in quality. By sorting traded goods into three quality bins we find high pass-through for products in the low-quality bin, but almost no pass-through for products in the medium- and high-quality bins.

Third, we find that exchange rate pass-through is negatively correlated with the elasticity of substitution of the FMCGs categories. While product quality is a proxy
for markups, the elasticity is a proxy for the degree of product heterogeneity and substitutability of the available varieties within a product group. Product quality varies across products in a specific group, but the elasticity of substitution is constant within a group. We find that categories with low elasticity of substitution exhibit high exchange rate pass-through. For the medium and high-elasticity bins, exchange rate pass-through is low.

Our result on retailer behavior gives support to models of market competition that relate market power to exchange rate pass-through, such as in Feenstra et al (1996). While the emphasis of such models is on exporter market share and pass-through, our data reveals that the relation also holds true for retailers.

Our evidence on market “toughness” and product quality on exchange rate pass-through is suggestive of a new link between globalization and pass-through. Much attention has been paid on the effects of globalization on trade diversification.\textsuperscript{47} To the extent that globalization affects market competition in the host country and the share of high-quality goods consumed, it also affects the level of exchange rate pass-through on traded goods at the consumption level, and ultimately its impact on domestic inflation.

In addition, the result that pass-through is low for high quality goods is consistent with recent work on firm heterogeneity and pricing to market.\textsuperscript{48} Recent theoretical work on heterogeneous firms and quality choice links quality choice to firm productivity.\textsuperscript{49} High-productivity firms produce high quality goods. But these same high-productivity firms are documented to absorb more exchange rate pass-through

\textsuperscript{47}See Gust, Leduc, and Vigfusson (2010).
\textsuperscript{48}For an empirical investigation of firm heterogeneity and pricing to market and a thorough review of theoretical models that support this, see Berman et al. (2012).
\textsuperscript{49}See Antoniades (2008), Johnson (2012), Baldwin and Harrigan (2008).
in their markups (Berman et al. (2012)). Therefore, low pass-through should be expected for high quality goods, which is exactly what we see in the data.\textsuperscript{50, 51}

Finally, we contribute to understanding the impact of product differentiation on exchange rate pass-through. As Bussiere and Peltonen (2008) remark,

"the role of product differentiation is actually ambiguous as two different effects may cancel out: on the one hand, more differentiated goods may be characterised by higher market power and therefore higher pass-through (which is consistent with Yang, 1997, and Bacchetta and van Wincoop, 2005); on the other hand, more differentiated products may be characterised by higher markups, hence higher scope for pricing-to-market and therefore lower pass-through (consistent with the finding of Campa and Goldberg, 2005, that pass-through is higher for commodities than for manufacturing goods)."

Our framework enables us to tackle this ambiguity by considering these effects separately: quality is used a proxy for markup, and the elasticity of substitution is used as a proxy for “market power/product differentiation.” The elasticity of substitution characterizes the interchangeability among products within a particular category, and is constant within that category. Quality, on the other hand, is specific to each product and therefore varies both across and within product categories. Consistently with Bussiere and Peltonen, we find that exchange rate pass-through is high for product

\textsuperscript{50}In Auer and Chaney (2009) the mechanism linking quality to pass-through is different from the one argued here. We elaborate more on this later in the paper.

\textsuperscript{51}Since in these models high-productivity exporters are also the ones with higher market shares, our results are consistent with Atkeson and Burnstein (2008) and Amiti et. al. (2012) who show that exchange rate pass-through is negatively related to the market share of the exporter.
categories with low elasticity of substitution, but low for categories with high elasticity of substitution.

The rest of the chapter is organized as follows: In Section 3.2 we describe the data in more detail. In Section 3.3 we establish the methodology used to measure exchange rate pass-through, and we present evidence on pass-through at the aggregate level. In Section 3.4 we discuss how micro-economic factors affect pass-through by focusing on retailer market share, product quality, and demand elasticity. We also discuss how the results relate to existing work. We conclude in Section 3.5.

3.2 Data

We use micro data on more than 25,000 fast-moving consumer goods (FMCGs) sold across 1,042 outlets in the United Arab Emirates (UAE). The data, recorded at the scanner (barcode) level, comes from Nielsen and cover sales in thirty product categories between 2006 and 2010.\textsuperscript{52}

The data frequency is either monthly or bi-monthly and varies by product category. In the subsequent analysis, bi-monthly data is used by converting all monthly series to bi-monthly.\textsuperscript{53}

The dataset contains price and quantity information for all products sold by each outlet, along with information on the brand, manufacturer, weight, package type, etc.

\textsuperscript{52}The categories are: beans, blades, bullion, cereals, cheese, chewing gum, chocolate, cigarettes, cooking oil, carbonated soft drinks, deodorants, detergents, dish wash, energy drinks, fabric conditioners, insecticides, juices, liquid cordials, male grooming, milk, milk powder, powder soft drink, shampoo, skincare, skin cleansing, sun care, tea, toothbrush, toothpaste, water.

\textsuperscript{53}We only consider odd months in the analysis: January, March, May, July, September, and November. For the series available at a monthly frequency, we just remove observations for the even months. For the series available at a bi-monthly frequency, we divide quantities in half and keep prices the same.
and whether the item was under non-sales promotion.\textsuperscript{54}

Each barcode corresponds to a product, unless otherwise specified. In addition, there is information on the location of each outlet, its type, and its chain code, if it belongs to a chain. Location covers three regions in the UAE: Dubai and Sharjah, Abu Dhabi and Al Ain, and Northern Emirates. Type classifies outlets as supermarkets, groceries, self-service, mini-markets, pharmacies, eateries, and convenience stores. The market share of each outlet can be retrieved since total sales by each outlet are known.

Descriptive statistics for the dataset are provided in Table 3.1. In 2010, 25,899 unique products were sold by 1,042 outlets in the UAE. These products were produced by 1,144 manufacturers, and belonged to 2,828 different brands. Some outlets are part of chains, with a total of 15 different chains listed in the dataset. The Nielsen dataset was augmented with Country-of-Origin (COO) information for a subset of the products. To collect COO information, we sent a team of researchers to the biggest hypermarket in the UAE. The researchers were equipped with hand-held scanners, enabling them to scan each barcode and then to enter the COO information listed on the label. To minimize errors, the team was sent back to the same outlet for a second round of scanning. Any barcodes that appeared to have come from two different countries were dropped. This occurred in less than 1% of the scanned products.

A couple of important points are worth making here. The COO information was collected in 2011. Because of the high rate at which new products are introduced and old products are dropped, we can’t attribute COO to many products from ear-

\textsuperscript{54}Non-sale promotions are classified as promotion bundle, promotion free, promotion gift, promotion same, promotion unit, and promotion volume.
In earlier years, about half of the scanned barcodes come from countries with currencies pegged to the US dollar, including other Gulf Cooperation Council (GCC) countries. Since we care about exchange rate pass-through, we exclude these observations from the regressions.

The euro dominates foreign currency transactions in our sample. This can be seen from Figure 3.1, which shows countries of origin ranked by number of products and value of products sold in the UAE. More than half the products in our sample come from the Eurozone. In addition, three other EU countries, namely the UK, Poland, and Switzerland account for about 20%, whether measured by value or by number of products sold.

### 3.3 Analysis: Aggregate Level

In this section we lay out the methodology and present standard pass-through regression results for the UAE. We also show aggregate pass-through estimates for goods imported from the Eurozone.

#### 3.3.1 Methodology

Our methodology follows standard specifications in the empirical pass-through literature (see for example Gopinath et al. (2010) for a recent application). Specifically, we estimate the following (pooled) regression:

$$
\Delta p_{c,t} = \mu_c + \sum_{j=1}^{k} \beta_j \Delta e_{c,t-j} + \sum_{j=1}^{k} \alpha_j \Delta p_{c,t-j}^* + \sum_{j=1}^{k} \gamma_j \Delta y_{t-j} + u_{c,t}
$$

55 Our analysis shows that in a two-year period, product entry rates were between 40% and 90%, depending on the category. To put this in perspective, using similar data for the US, Broda and Weinstein (2010) find that it takes four years to get 40% of new products.
where $\Delta p_c$ is the average bi-monthly change in the (log) price of products imported from country $c$, $e_c$ is the bilateral exchange rate between UAE and country $c$ (UAE Dirhams per unit of foreign currency), $\Delta p^*_c,t$ measures the bi-monthly change in the log price level in country $c$, and $\Delta y$ measures bi-monthly changes in demand conditions in the UAE.

To obtain $\Delta p_c$ we proceed in two steps: First, we compute the average price $P_{ic}$ for each product $i$ across all outlets. A sales promotion at an outlet is accompanied by a substantial surge in the quantity sold at that outlet. A price that is a *volume-weighted* average across outlets would be driven down substantially by the reduced price of the product from the outlet that had it on a sales promotion, and this decline would not be caused by movements in the exchange rate or changes in demand and supply conditions. Therefore, we use a *simple* average to ensure that sales promotions at an outlet do not drive changes in $P_{ic}$. Second, we compute $\Delta p_c$ as the weighted average price change for all products $i$ from country $c$. Weights are based on sales volumes and are used to minimize measurement error that can arise when an item with very low sales volume experiences a sharp fluctuation in price.

Exchange rates come from the International Financial Statistics (IFS) database. For robustness, three alternative timing conventions are used: average daily exchange rates over the current bi-monthly period, average daily exchange rate over the previous bi-monthly period and exchange rates quoted at the last day of the previous period. We use the first convention for our baseline specification. As we show below,

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56 Because many outlets enter and exit from the sample, in the baseline regressions we restrict the panel to include outlets that exist in all periods. This ensures that changes in the average price of product $i$ are not driven by changes in outlet composition.

57 For robustness, we consider a more disaggregated definition of products, where we do not average prices of the same barcode across outlets. Results are not affected, as we report in our robustness checks.
though, results are robust to these different conventions.

We use foreign CPI data to control for shifts in prices that are not driven by changes in exchange rates. Shifts in foreign prices affect marginal costs and, subsequently, they have potential effects on the prices of imported products. For the case of the Eurozone countries, we use country-specific CPI measures unless the product label states EU. In such cases, we use an EU-based CPI measure.\textsuperscript{58}

Finally, to capture shifts in domestic demand conditions, we compute an output measure based on the value of total sales of FMCG products in our sample. Such measure is a much better proxy than conventional GDP for changes in demand of the products under study, for three main reasons: (i) measures of GDP in developing countries are not as accurate as measures in advanced economies, (ii) GDP changes in the UAE are mainly driven by changes in the price of oil and of natural gas and as a result, they do not reliably reflect changes in demand conditions, and (iii) the data are not available at a bi-monthly frequency. An advantage of the detailed dataset we have is that we can construct a market-specific measure of GDP that better tracks changes in the demand conditions for FMCGs.

3.3.2 Aggregate Pass-through

The parameter of interest is $\beta(k) = \sum_{j=1}^{k} \beta_j$, i.e. the sum of the coefficients on the lagged exchange rate as estimated from regression (3.1), for different values of the maximum number of lags $k$. We are thus interested in the cumulative effect of movements in the exchange rate on the change in consumer prices, at different horizons.

\textsuperscript{58}For robustness, we re-ran the regressions using PPI data for the countries that such data are available (mainly EU). The results are almost identical and available upon request.
Figure 3.2 plots the values of $\beta(k)$, along with 95% confidence bands. Pass-through is estimated to be statistically different from zero at the 5% level, at all horizons. We find that in the short-run (corresponding to a quarter\textsuperscript{59}), exchange rate pass-through into consumer prices is around 3%. This measure of pass-through steadily increases to reach 20% after one year (which we regard as the long run). Table 3.2 reports variations on the baseline specification (which is also included, for comparison purposes, in column 1), with different timing conventions for the exchange rates and a more disaggregated definition for the price series (as discussed above). Across these different specifications, we also ran regressions that use data on supermarkets only. These results are by and large robust to the different specifications, in that we consistently estimate low and delayed pass-through.

Because there is a large presence of Eurozone products in our dataset, we find it worthwhile to compare overall pass-through to Euro pass-through. That is, we use specification (3.1) to estimate pass-through for all products and for products originating from the Eurozone only. To control for compositional effects, stemming from the fact that supermarkets are more likely to carry European brands than groceries and mini-markets, we restrict the analysis to supermarket data. The results are reported in Figure 3.3. We find that Eurozone pass-through is higher. In the long run, pass-through for goods from the Eurozone is twice the size of overall pass-through.

While this finding deserves further investigation, two plausible explanations are worth mentioning. First, it may be the case that supermarkets that carry a larger share of Eurozone products also have a larger market share, thus using this market power to pass more of the exchange rate movements to the consumers. We explore

\textsuperscript{59}Note that in our specification one lag corresponds to a two-month period. Consequently, we define pass-through for the first quarter as the simple average of $\beta(1)$ and $\beta(2)$.
the relation between retailers’ market share and pass-through in the next section and find that it is indeed positive. Second, we might be observing third currency pricing behavior. Exporters in countries with currencies that have been more volatile than the Euro during the 2006-2010 period (such as Poland and Turkey) may have chosen to set prices in US Dollars. Since the UAE Dinar is pegged to the US Dollar, exchange rate pass-through for the products originating from these countries is therefore expected to be substantially lower than pass-through for products from the Eurozone.\footnote{For empirical evidence of Producer Currency Pricing behavior among Eurozone firms, see Antoniades (2012).}

To complete our aggregate analysis, we run regression (3.1) for the different regions in the UAE. If pricing to market characterizes pass-through, we should not expect to see substantial variation in pass-through across regions. The regression coefficients for each region are reported in Figure 3.4. Indeed, we observe similar overall pass-through behavior across the regions.\footnote{A higher pass-through in Dubai and Sharjah may be due to the fact that their population is mostly comprised of expats, who are more likely to stay in the region for shorter periods, whereas in the other two regions the population is mostly comprised of nationals. Retailers in these regions may be less willing to pass the burden of exchange rate movements to the consumers as they try to build loyalty with the local population.} However, we should not interpret this finding as evidence that pricing to market is the sole explanation for pass-through. As we show in the next section, while there is very little variation across regions, there is substantial variation within regions.

At the aggregate level, our results contribute to a growing body of work that measures the degree of exchange rate pass-through. Using aggregate import price indices for OECD countries, Campa and Goldberg (2005) find evidence of partial, but relatively large pass-through, with an average value of 46\% in the short run and 64\% in the long run. Olivei (2002) and Marazzi and Sheets (2007) find evidence...
of relatively low, and declining, pass-through for the US. These studies estimate aggregate long run pass-through to be around 50% during the 1980s and 20% in the 1990s. They also find that there is heterogeneity in the degree of pass-through across aggregate product categories. At a more disaggregated level, Gopinath et al. (2010) and Gopinath and Itskhoki (2010) study exchange rate pass-through into US prices “at the dock”, using unpublished data on prices of individual imported goods collected by the Bureau of Labor Statistics. The data allow for a careful analysis of how pass-through is related to issues such as currency choice of exporters and the frequency of price adjustment. Aggregate pass-through is slightly above 20% in the short run, but increasing to about 30% after two years.

Differently from this evidence, where most of the action is within six months, in our estimates for consumer prices in the UAE only about half of the long run pass-through takes place in the first two quarters. This seems to suggest a more delayed response of prices at the consumer level.

Import price data, no matter how disaggregated, fail to account for additional sources of incomplete price adjustment in response to exchange rate movements. These include the presence of local, non-traded cost components during distribution, and the fact that some of the imported goods are used as intermediate inputs by domestic final good producers that directly compete with a domestic non-traded sector. In addition, imperfectly competitive wholesalers and retailers might use profit margins as a buffer to movements in the exchange rates, thus further muting the response of consumer prices.

While empirical work on the degree of exchange rate pass-through into consumer prices is less extensive, available evidence indeed shows that consumer prices are much
less sensitive to exchange rate movements than prices at the border. Using CPI data, Goldberg and Campa (2010) estimate an average long run pass-through of 17% for advanced economies. Studying a similar group of countries, Ihrig et al. (2006) also find low and mostly non-significant consumer price pass-through, which moreover appears to be declining to around 0% in the latter part of their sample (covering the years between 1990 and 2004).

One potential caveat in interpreting these numbers is that, because of data limitations, the above studies use aggregate consumer price data on bundles that include non-traded goods. Those estimates would then also include the effects of exchange rate movements on the prices of non-traded goods, or the share of those goods in the overall basket.

A series of recent studies takes advantage of newly available disaggregated data on wholesale and retail prices for specific industries and documents a higher degree of exchange rate pass-through at the consumption level than the degree suggested by work on aggregate price indexes. Hellerstein (2008) and Goldberg and Hellerstein (2011) study the beer market in Chicago in the mid 90s and report average pass-through of 11% and 7%, respectively. Similarly, Nakamura and Zerom (2010) report 30% pass-through on coffee prices after six quarters. What is attractive in these studies is their ability to provide insights on the relative importance of local non-traded costs, markup adjustments, and price adjustment costs in explaining incomplete pass-through cross the border.

Our estimates of the degree of exchange rate pass-through into retail prices of imported FMCGs are in line with these results and fall in between the upper bound provided by studies on pass-through at the dock and the lower bound provided by
the studies on pass-through into prices of aggregate bundles of consumer goods. In relation to the available evidence on consumer prices, our estimates seem to suggest that using data at the highest level of disaggregation, as opposed to aggregate indices, avoids the potential understatement of pass-through into consumer prices that we have discussed. In relation to import prices, our estimates confirm that there are important effects past the border that make consumer prices insensitive to the exchange rate. Understanding the sources of this local price stability is what we turn to next.

3.4 Analysis: Micro Level

In this section we examine micro-economic factors that determine the degree to which movements in the exchange rate affect the price that consumers pay for imported goods. The following factors are examined: (i) retailer market share, (ii) quality differentiation across products, used as proxy for markups, and (iii) product homogeneity within product categories as measured by the elasticity of substitution of each product category. The first is an outlet-specific attribute, the second is product-specific, and the third is category-specific.

3.4.1 Retailer Market Share

Retailer market share may determine exchange rate pass-through. A retailer with higher market share faces less competition, and is thus better able to pass to the consumer any increase in cost related to exchange rate movement.\footnote{An interesting issue is whether cross-border pass-through is symmetric to a depreciation or an appreciation of the currency. We explore this issue and its implications on retailer behavior in a separate paper.}
hand, a retailer with small market share may be forced to absorb most of the cost increase.

We test this hypothesis by examining how exchange rate pass-through varies across outlet type. Outlets in our sample are supermarkets, groceries, mini-markets, self-services, pharmacies, convenience stores, cafeterias, and eateries. Table 3.3 provides the number of outlets and outlet types across the three regions in UAE. Supermarkets in each region are few, but as the high concentration ratios show, they account for the majority of sales.\(^{63}\) Most of the outlets are located in the Dubai and Sharjah region. For purposes of the analysis, we will only focus on the three main outlet types, namely supermarkets, groceries, and self-service stores.

We run regression (3.1) for each outlet type. To account for changes in demand across regions, we replicate the analysis for each region. The results are presented in Figures 3.5 and 3.6. Two striking results stand out. Exchange rate pass-through is higher in supermarkets than in groceries and self-service stores, and within-variation in pass-through in each region is substantially higher than between-variation (see Figure 3.4).

The finding that exchange rate pass-through is higher for supermarkets than groceries and self-service stores suggests that market share is positively correlated with pass-through. However, there may be other differences across outlet types that affect pass-through without being related to market share. For example, the composition of imported goods can vary across outlet types, as well as management pricing behavior and clientele.

\(^{63}\)Outlet market shares and concentration ratios do not change over the sample period. The results, along with additional robustness analysis performed on the degree of exchange rate pass-through and its determinants, are available upon request.
To control for such variation not linked to market share, we replicate the analysis focusing only on supermarkets. In each region, we allocate supermarkets into two bins based on their market share, with equal number of outlets in each bin.\(^\text{64}\) We then estimate pass-through for each market share bin. Figures 3.7 and 3.8 report these coefficients for the country and for each region, respectively. Again, we find that exchange rate pass-through is positively correlated with market share and that relation is robust across regions.

### 3.4.2 Quality

Next we investigate how product quality affects exchange rate pass-through. Following Auer and Chaney (2009), we use variation in price within specific product category-weight-packaging type triplets as evidence of variation in quality. Examples of such triplets are water-0.33L-glass, water-0.33L-tins, and water-0.33L-pet. In total, 413 such triplets are considered. The deviation between the price of a product and the average price of all products within that same triplet is used to make inferences about quality.\(^\text{65}\)

We allocate products into three quality bins by sorting the price deviations and setting the 33\(^{rd}\) and 67\(^{th}\) percentile as the cutoff points. We then estimate pass-

\(^{64}\)In the country-wide analysis, outlets in the low-share bin have less than 1% market share in their region, while outlets in the high-share bin have from 1% to 12% share.

\(^{65}\)Arguably, price may not always be a good proxy for quality. If a Perrier and a San Pellegrino 1-Liter, glass bottles of water both sell for a price premium over other goods, but Perrier sells 1,000 units per month, while San Pellegrino only sells 1, it can be deduced that consumers perceive Perrier as a product of higher quality than San Pellegrino. However, for the purpose of the analysis in this paper, what matters is the perception that suppliers have on the quality of their products as it determines the markups charged. So, if both products have high price, regardless of the quantity sold, we make the assumption here that both exhibit high markups. For a discussion on how quantity and price can be used to extract quality using constant markups, see Broda and Weinstein (2010) and Feenstra and Romalis (2012).
through for each bin. We run a regression across the entire country, and then for robustness, we repeat the analysis for each region. The national and regional results are presented in Figures 3.9 and 3.10, respectively. Exchange rate pass-through is high for low quality goods, but low for medium- and high-quality goods. The results suggest that a certain markup threshold exists, beyond which retailers are able to absorb most of the movement in the exchange rate.

While this study is among the first to confirm empirically this strong negative relation, possible channels by which product quality affects exchange rate pass-through have been discussed in previous work.\textsuperscript{66} Bussiere and Peltonen (2008) emphasized the role of markups, while Auer and Chaney (2009) considered changes in the quality- and quantity- mix of goods produced and consumed in response to movements in exchange rates.

Yet, the result suggests a couple new directions where more investigation could be fruitful. First, if globalization affects the share of quality goods produced and consumed and if it affects market concentration across wholesalers and retailers then one may expect that two sources of variation in pass-through across time and space may be variations in the average quality of the consumption basket and/or changes in cross-border market toughness.\textsuperscript{67}

Second, our results confirm a hypothesis generated by two distinct literatures that link firm heterogeneity and pricing to market, on one hand, and firm heterogeneity and endogenous quality choice on the other hand. One set of studies documents that

\textsuperscript{66} In a working paper, Auer et al. (2012) use European car data to show that pass-through is larger for low than for high quality cars.

\textsuperscript{67} For studies that link trade liberalization and quality, see Hummels (2005), Verhoogen (2008), and Goldberg et al. (2012). For studies that consider how trade liberalization affects retailers, see Raff and Schmitt (2009).
high-productivity exporters (Berman et al. (2012)) and exporters with high market share (Atkeson and Burnstein (2008)) absorb more exchange rate pass-through in their markups. Another set of studies, which endogenize quality choice (see Antoniades (2008), Johnson (2012), Baldwin and Harrigan (2008)), theorize that high-productivity firms have higher market shares and export higher-quality goods. By putting together the predictions of these two literatures, we can formulate the hypothesis that exchange rate pass-through must be lower for high-quality goods. This is because high-quality goods are produced by high-productivity firms that exhibit with high market shares and absorb more pass-through in their markups. Our analysis finds strong support for the aforementioned hypothesis.

3.4.3 Elasticity of Substitution

Our third exercise is motivated by the conjecture that product differentiation can have both a positive and negative effect on pass-through, as noted in Bussiere and Peltonen (2008).

Since highly differentiated products command higher markups, exporters and retailers may use markups to absorb fluctuations in exchange rates. This notion suggests a negative relation between product differentiation and exchange rate pass-through. Yet, highly differentiated products are associated with high market power (less competition), which may encourage exporters and retailers to pass more of the fluctuations in exchange rates to the consumers. Hence, this channel suggests a positive relation between product differentiation and exchange rate pass-through. Overall, the impact of product differentiation on exchange rate pass-through is ambiguous.

Our interpretation of the discussion is that product differentiation has two dimen-
sions: a product-specific dimension and a product-group (category) dimension. The product-specific dimension reflects product quality. And as we showed in the previous section, our results confirm the prediction that higher quality (markup) goods exhibit lower pass-through.

The product-group dimension is captured by the elasticity of substitution of each product-group, which is constant within the group. For example, the juice and water product-groups have two different elasticities of substitution. These elasticities characterize the substitutability among products in a given category. In categories with high elasticity of substitution, there is more substitutability among products and hence, exporters and retailers have less desire to pass the extra cost to the consumers. In contrast, in categories with low elasticity of substitution, consumers are more likely to absorb most of the burden.

By realizing this very important but subtle point, we can now formulate a second hypothesis: exchange rate pass-through and the elasticity of substitution are negatively related.

To test this hypothesis, we first compute the elasticity of substitution for each product category in the sample using a methodology proposed by Broda and Weinstein (2006) and Broda et al. (2006). We then allocate categories to bins as shown in Table 3.4. The elasticity of substitution is the highest in the Liquid Cordials, Sun-care, and Blades categories, and the lowest in the Chewing Gum, Power Soft Drinks, and Dish Wash. Finally, we run the pass-through regression for each bin.

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68 Indeed, in models such as Melitz and Ottaviano (2008), and Antoniades (2008) there is a product-specific elasticity and an elasticity that characterizes the degree of product differentiation among all available varieties.

69 We would like to thank David Weinstein for sharing the code for the estimation of the elasticities.
The regression results by elasticity bin are reported in Figure 3.11 and confirm the hypothesis above. Exchange rate pass-through is the highest for the low elasticity bin, which suggests that the higher the degree of product heterogeneity within a particular product group, the higher the degree of exchange rate pass-through into consumer prices.

3.5 Conclusion

We have documented substantial variation in the degree of exchange rate pass-through on imported consumer goods across retailers in the United Arab Emirates. Retailers with higher market share pass more of the movement in the exchange rate to the consumer, while retailers with small market shares end up passing less. Furthermore, we have documented that pass-through is lower for high-quality goods, and for product categories with high elasticity of substitution.

The strength of the analysis comes from our ability to link prices and quantities of products sold across hundreds of outlets with country-of-origin information extracted from the product labels. In addition, the information is provided for thirty product categories that cover more than 85% of the fast moving consumer goods sold, at the highest level of disaggregation, and at the point of consumption. Finally, our data come from a developing country with a committed dollar peg, where we believe information on cross-border pass-through is most relevant. This is true more generally for economies where gross trade flows constitute a large portion of GDP.

At the same time, because of the peculiarity of the UAE as a developing country, with its high GDP per capita and the preponderance of its energy sector, concerns might be raised about how much these findings can be generalized. Specifically, given
the questions we ask in our analysis, it is important to consider whether we expect this peculiarity to impact retailing models and practices or, from the consumer’s standpoint, purchasing patterns.

As we have mentioned, the vast majority of the population is made up by expatriates, whose origin is from developed and developing countries alike. Many of the retailing chains in the UAE, along with their management, are international. Moreover, we recall that we have excluded from our sample goods that are imported from other GCC countries, which have fixed exchange rates relative to the UAE, since the question of interest is exchange rate pass-through. We believe these observations address some of the concerns above, as we expect bundles of consumption goods and invoicing practices to be generally comparable to (or at least not systematically different from) those of other countries.\footnote{As shown in section 3.2, a large portion of the FMCGs in our sample is imported from the Eurozone. We have anecdotal evidence from informal discussions with sourcing managers that pricing is predominantly in the currency of the producer.}

Our analysis further explores variation within the UAE, across its regions. The latter display notable differences along several dimensions, including the degree of urbanization, infrastructure and demographics, from the “Western-like” Dubai to the more “traditional” Northern Emirates, where UAE citizens make up the majority of the population. Yet, our findings on aggregate pass-through and its potential determinants show remarkable robustness to regional differences. This seems to suggest that the basic insights are relatively general.

Overall, while the question of the “external validity” of these results warrants further research (including studying additional GCC countries), we have some confidence in claiming they can help shed light on the determinants of exchange rate pass
through. We are further reassured by noting that our findings on the elasticity of substitution and quality are broadly consistent with the intuition in models that are calibrated and estimated for advanced economies.

To conclude, our findings point us to two directions for further investigation. First, whether some variations in pass-through observed over time and across countries can be attributed to changes in market competition across wholesalers and retailers, and to changes in the quality mix of imported products. Second, whether retailers respond symmetrically to an appreciation or a depreciation of the currency, and whether the response in non-linear. We are currently pursuing both directions.
### Table 3.1: Descriptive statistics for the United Arab Emirates

<table>
<thead>
<tr>
<th>Year</th>
<th>Products</th>
<th>Categories</th>
<th>Brands</th>
<th>Manufacturers</th>
<th>Outlets</th>
<th>Chains</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>25,462</td>
<td>30</td>
<td>3,158</td>
<td>974</td>
<td>840</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>2007</td>
<td>24,360</td>
<td>30</td>
<td>2,949</td>
<td>946</td>
<td>912</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>2008</td>
<td>23,908</td>
<td>30</td>
<td>2,820</td>
<td>976</td>
<td>915</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>2009</td>
<td>23,988</td>
<td>30</td>
<td>2,756</td>
<td>1,002</td>
<td>1,031</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>2010</td>
<td>25,889</td>
<td>29</td>
<td>2,828</td>
<td>1,144</td>
<td>1,042</td>
<td>15</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 3.2: Robustness for aggregate pass-through

<table>
<thead>
<tr>
<th>Month (k)</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
<th>(12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
<td>0.02</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>4</td>
<td>0.04</td>
<td>0.05</td>
<td>0.06</td>
<td>0.06</td>
<td>0.05</td>
<td>0.05</td>
<td>0.02</td>
<td>0.03</td>
<td>0.02</td>
<td>0.04</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>6</td>
<td>0.10</td>
<td>0.10</td>
<td>0.14</td>
<td>0.13</td>
<td>0.12</td>
<td>0.05</td>
<td>0.08</td>
<td>0.08</td>
<td>0.12</td>
<td>0.07</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>8</td>
<td>0.15</td>
<td>0.15</td>
<td>0.14</td>
<td>0.13</td>
<td>0.12</td>
<td>0.10</td>
<td>0.11</td>
<td>0.14</td>
<td>0.10</td>
<td>0.14</td>
<td>0.10</td>
<td>0.13</td>
</tr>
<tr>
<td>10</td>
<td>0.17</td>
<td>0.17</td>
<td>0.18</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.17</td>
<td>0.17</td>
<td>0.15</td>
<td>0.14</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>12</td>
<td>0.20</td>
<td>0.18</td>
<td>0.14</td>
<td>0.13</td>
<td>0.16</td>
<td>0.14</td>
<td>0.19</td>
<td>0.18</td>
<td>0.21</td>
<td>0.17</td>
<td>0.19</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Supermarkets only: NO YES NO YES NO YES NO YES NO YES NO YES

Exchange Rate
- Average t: * * * *
- Average (t-1): * * * *
- End period: * * * *

Disaggregated: NO NO NO NO NO YES YES YES YES YES YES

Notes: The main entries are the cumulative pass-through coefficients $\sum_{j=1}^{k} \beta_j$ as in specification (3.1). We consider three timing conventions for the exchange rate ((i) the average daily value in the current month, (ii) the average daily value in the previous month and (iii) the end-of-period value for the previous month. The Disaggregated version considers the price of each product-outlet combination as a separate data entry (i.e. it doesn’t compute the average price for a given product across outlets)
Table 3.3: Outlet information by region

<table>
<thead>
<tr>
<th>Region</th>
<th>All</th>
<th>Supermarkets</th>
<th>Groceries</th>
<th>Self-Service</th>
<th>Other*</th>
<th>Mkt Concentration Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Top-4</td>
</tr>
<tr>
<td>Dubai - Sharjah</td>
<td>599</td>
<td>50</td>
<td>129</td>
<td>36</td>
<td>384</td>
<td>0.72</td>
</tr>
<tr>
<td>Abu Dhabi - Al Ain</td>
<td>277</td>
<td>25</td>
<td>135</td>
<td>21</td>
<td>96</td>
<td>0.83</td>
</tr>
<tr>
<td>Northern Emirates</td>
<td>165</td>
<td>10</td>
<td>67</td>
<td>6</td>
<td>82</td>
<td>0.87</td>
</tr>
<tr>
<td>Total UAE</td>
<td>1,041</td>
<td>85</td>
<td>331</td>
<td>63</td>
<td>562</td>
<td>0.28</td>
</tr>
</tbody>
</table>

* Includes cafeterias, eateries, pharmacies and convenience stores
Table 3.4: Elasticities of substitution by product category

<table>
<thead>
<tr>
<th>Group</th>
<th>Category</th>
<th>Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Low</td>
<td>Liquid cordials</td>
<td>4.13</td>
</tr>
<tr>
<td></td>
<td>Suncare</td>
<td>4.88</td>
</tr>
<tr>
<td></td>
<td>Blades</td>
<td>5.80</td>
</tr>
<tr>
<td></td>
<td>Skin cleansing</td>
<td>6.88</td>
</tr>
<tr>
<td></td>
<td>Milk powder</td>
<td>8.65</td>
</tr>
<tr>
<td></td>
<td>Male grooming</td>
<td>9.89</td>
</tr>
<tr>
<td></td>
<td>Skincare</td>
<td>10.92</td>
</tr>
<tr>
<td></td>
<td>Toothbrush</td>
<td>12.61</td>
</tr>
<tr>
<td></td>
<td>Cooking oil</td>
<td>13.60</td>
</tr>
<tr>
<td>ii. Medium</td>
<td>Toothpaste</td>
<td>14.01</td>
</tr>
<tr>
<td></td>
<td>Deodorant</td>
<td>19.75</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>20.85</td>
</tr>
<tr>
<td></td>
<td>Csd</td>
<td>21.14</td>
</tr>
<tr>
<td></td>
<td>Juices</td>
<td>23.19</td>
</tr>
<tr>
<td></td>
<td>Shampoo</td>
<td>23.80</td>
</tr>
<tr>
<td>iii. High</td>
<td>Energy drinks</td>
<td>24.11</td>
</tr>
<tr>
<td></td>
<td>Cereals</td>
<td>24.37</td>
</tr>
<tr>
<td></td>
<td>Fabric conditioner</td>
<td>25.10</td>
</tr>
<tr>
<td></td>
<td>Beans</td>
<td>25.53</td>
</tr>
<tr>
<td></td>
<td>Insecticides</td>
<td>32.91</td>
</tr>
<tr>
<td></td>
<td>Detergents</td>
<td>35.33</td>
</tr>
<tr>
<td></td>
<td>Cheese</td>
<td>35.70</td>
</tr>
<tr>
<td></td>
<td>Dishwash</td>
<td>38.55</td>
</tr>
<tr>
<td></td>
<td>Powder soft drink</td>
<td>39.92</td>
</tr>
<tr>
<td></td>
<td>Chewing gum</td>
<td>86.80</td>
</tr>
</tbody>
</table>

Notes: For more information regarding the methodology used to estimate elasticities, please refer to Broda and Weinstein (2006) and Broda et al. (2006)
Figure 3.1: Country of origin information (based on 2010 data)

* Turkey 2.24%, China 1.92%, Egypt 1.92%, Thailand 1.88%, Philippines 1.42% South Africa 1.10%, Indonesia 1.10%, Argentina 0.92%, Denmark 0.87%, South Korea 0.82%, Morocco 0.59%, Singapore 0.50%, Japan 0.37%, Tunisia 0.32%, Brazil 0.32%, Canada 0.32%, Vietnam 0.27%, Russia 0.23%, Sweden 0.05%.

** Turkey 2.65%, Japan 1.70%, Thailand 1.63%, Egypt 1.30%, South Africa 1.11%, Argentina 1.08%, Korea 0.98%, Philippines 0.62%, Denmark 0.63%, China 0.54%, Singapore 0.42%, Indonesia 0.39%, Morocco 0.33%, Canada 0.23%, Brazil 0.21%, Russia 0.17%, Vietnam 0.15%, Tunisia 0.06%, Sweden 0.01%.
Figure 3.2: Exchange rate pass-through in UAE

Figure 3.3: Euro pass-through to UAE

Notes: This figure uses supermarket data only
Figure 3.4: Exchange rate pass-through by region

Figure 3.5: Exchange rate pass-through by outlet type, UAE
Figure 3.6: Exchange rate pass-through by outlet type, Regional
Figure 3.7: Exchange rate pass-through by supermarket market share, UAE
Figure 3.8: Exchange rate pass-through by supermarket market share, Regional
Figure 3.9: Exchange rate pass-through and product quality, UAE
Figure 3.10: Exchange rate pass-through and product quality, Regional
Figure 3.11: Exchange rate pass-through and elasticity of substitution of FMCG category, UAE
References


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A Appendix to Chapter 1

This appendix provides additional derivations for Chapter 1.

A.1 Aggregate Demand and Output

The representative household in country H maximizes (1.2) subject to (1.3). First order conditions with respect to consumption and assets give:

\[ \rho_{t,t+1} = \beta \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \left( \frac{P_t}{P_{t+1}} \right) \]  

(A.1)

for each state or, taking expectations:

\[ \frac{1}{R_t} = \beta E_t \left\{ \left( \frac{C_{t+1}}{C_t} \right)^{-\sigma} \left( \frac{P_t}{P_{t+1}} \right) \right\} \]  

(A.2)

where \( R_t \) is the (gross) nominal interest rate, i.e. the return on the one-period discount bond. Labor supply is:

\[ \frac{W_t}{P_t} = N_t^\phi C_t^\sigma \]  

(A.3)

Similarly for the representative household in country F, given that the state-contingent assets are denominated in Home currency, the budget constraint reads:

\[ P_t^* C_t^* + E_t \left\{ \rho_{t,t+1} D_{t+1} \frac{\tilde{E}_{t+1}}{\tilde{E}_{t+1}} \right\} = W_t^* N_t^* + D_t \frac{\tilde{E}_t}{\tilde{E}_t} + \Upsilon_t^* \]

First order conditions imply:

\[ \rho_{t,t+1} = \beta \left( \frac{C_{t+1}^*}{C_t^*} \right)^{-\sigma} \left( \frac{P_t^*}{P_{t+1}^*} \right) \left( \frac{\tilde{E}_t}{\tilde{E}_{t+1}} \right) \]
which, with (A.1), lead to

\[ C_t = C_t^* Q_t^{\frac{1}{2}} \]  \hspace{1cm} (A.4)

where \( Q = \frac{E P^*}{F} \) is the real exchange rate, and we have assumed without loss of generality that the constant \( \mathcal{E}_0 \left( \frac{C_0^*}{C_0} \right) \left( \frac{P_0^*}{P_0} \right) \) is equal to 1. This is a typical international risk sharing condition, which predicts that relative consumption moves proportionally with the real exchange rate.

The model is log-linearized around a steady state where \( P_H = P_F \) (and \( P_H^* = P_F^* \)) holds. Recall that the terms of trade in both countries are defined as

\[ s_t \equiv p_{F,t} - p_{H,t} \]
\[ s_t^* \equiv p_{H,t}^* - p_{F,t}^* \]

Using the definitions (1.17) and (1.18), we can relate Home and Foreign terms of trade as

\[ s_t = -s_t^* - (z_t + z_t^*) \]  \hspace{1cm} (A.5)

which shows that if the LoP holds for both type of goods (so that \( z_t = z_t^* = 0 \)), Home and Foreign terms of trade are just the inverse of one another.

The log-linear versions of the Home country CPI (1.6) and the Foreign counterpart are written as:

\[ p_t = (1 - \gamma)p_{H,t} + \gamma p_{F,t} = p_{H,t} + \gamma s_t \]  \hspace{1cm} (A.6)
\[ p_t^* = (1 - \gamma)p_{F,t}^* + \gamma p_{H,t}^* = p_{F,t}^* + \gamma s_t^* \]  \hspace{1cm} (A.7)

Defining inflation rates as the first differences of the relevant price indices, it follows
that:

$$\pi_t = (1 - \gamma)\pi_{H,t} + \gamma\pi_{F,t} = \pi_{H,t} + \gamma \Delta s_t \quad (A.8)$$

$$\pi^*_t = (1 - \gamma)\pi^*_{F,t} + \gamma\pi^*_{H,t} = \pi^*_{F,t} + \gamma \Delta s^*_t \quad (A.9)$$

The log real exchange rate is then

$$q_t \equiv p_t^* + e_t - p_t$$

$$= (1 - 2\gamma) s_t + (1 - \gamma) z_t - \gamma z^*_t \quad (A.10)$$

where we have used (A.6) and (A.7) with (A.5). Note that for Purchasing Power Parity (PPP) to hold in the model (so that $q_t = 0$), the LOP has to hold for both types of goods and the consumption baskets must be the same in H and F (i.e. $\gamma = \frac{1}{2}$, so that there is no home bias in preferences). The international risk sharing condition (A.4) then becomes

$$c_t = c_t^* + \frac{1}{\sigma} q_t$$

$$= c_t^* + \frac{1}{\sigma} [(1 - 2\gamma) s_t + (1 - \gamma) z_t - \gamma z^*_t] \quad (A.11)$$

Log-linearizing the Home demand functions $C_{H,t} = (1 - \gamma) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t$ and $C_{F,t} = \gamma \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} C_t$, and the Foreign counterparts yields:

$$c_{H,t} = -\eta(p_{H,t} - p_t) + c_t$$

$$c_{F,t} = -\eta(p_{F,t} - p_t) + c_t$$
\[ c^*_{F,t} = -\eta(p^*_{F,t} - p^*_t) + c^*_t \quad c^*_{H,t} = -\eta(p^*_{H,t} - p^*_t) + c^*_t \]

The (log-linearized) market clearing conditions in the two countries are given by:

\[ y_t = (1 - \gamma)c_{H,t} + \gamma c^*_{H,t} \tag{A.12} \]
\[ y^*_t = \gamma c_{F,t} + (1 - \gamma) c^*_{F,t} \tag{A.13} \]

Substituting in the demand functions (along with equations (A.6) and (A.7)), and using (A.11), we can write output in each country as a function of respective domestic aggregate consumption, the terms of trade and the deviations from the LOP, that is

\[ y_t = c_t + \frac{2\omega + \gamma}{\sigma} s_t + \frac{\omega + \gamma}{\sigma} z_t^* \tag{A.14} \]
\[ y^*_t = c^*_t - \frac{2\omega + \gamma}{\sigma} s_t - \frac{\omega + \gamma}{\sigma} z_t^* \tag{A.15} \]

We can subtract (A.15) from (A.14) (after using (A.11) again to eliminate \( c^*_t \)) to solve for the terms of trade as a function of relative output:

\[ s_t = \frac{\sigma}{1 + 4\omega}(y_t - y^*_t) - \frac{2\omega + (1 - \gamma)}{1 + 4\omega} z_t - \frac{2\omega + \gamma}{1 + 4\omega} z_t^* \]

which is equation (1.29) in the text. We can now write an aggregate demand equation for country H, combining (A.14) and (1.29):

\[ c_t = \frac{2\omega + (1 - \gamma)}{1 + 4\omega} y_t + \frac{2\omega + \gamma}{1 + 4\omega} y^*_t + \frac{\omega + \gamma(1 - \gamma)}{\sigma(1 + 4\omega)}(z_t - z_t^*) \]

which is equation (1.30) in the text. The log-linearized Home Euler equation (A.2)
reads
\[ c_t = E_t c_{t+1} - \frac{1}{\sigma} (r_t - E_t \pi_{t+1}) \]

Using (1.30), (A.8) and (1.29), we can write an IS-type relation in terms of output and domestic inflation:

\[
y_t = E_t y_{t+1} - \frac{1}{\sigma_0} (r_t - E_t \pi_{t+1}) + \frac{2\omega}{1 + 2\omega} E_t \Delta y^*_t + \frac{(1 - 2\gamma)\omega}{\sigma(1 + 2\omega)} E_t \Delta z_{t+1} - \frac{(1 + 2\gamma)\omega + \gamma}{\sigma(1 + 2\omega)} E_t \Delta z^*_t + 2\omega E_t \Delta y^*_t \]

(A.16)

where we recall that \( \sigma_0 = \frac{\sigma(1+2\omega)}{1+4\omega} \) and \( \omega = \gamma(1 - \gamma)(\sigma \eta - 1) \).

A corresponding IS curve is derived for country F, following similar steps. Here we just highlight that we can write the log-linear consumption Euler equation as

\[ c^*_t = E_t c^*_{t+1} - \frac{1}{\sigma} (r^*_t - E_t \pi^*_{t+1}) \]

where we have used \( r^*_t = r_t - E_t \Delta e_{t+1} \), an approximate version of the uncovered interest parity (UIP). The resulting Foreign IS curve is

\[
y^*_t = E_t y^*_{t+1} - \frac{1}{\sigma_0} (r^*_t - E_t \pi^*_{t+1}) + \frac{2\omega}{1 + 2\omega} E_t \Delta y^*_t + \frac{(1 - 2\gamma)\omega}{\sigma(1 + 2\omega)} E_t \Delta z^*_{t+1} - \frac{(1 + 2\gamma)\omega + \gamma}{\sigma(1 + 2\omega)} E_t \Delta z^*_t + 2\omega E_t \Delta y^*_t \]

(A.17)
A.2 Phillips Curves and Marginal Costs

With PCP, the exporter in country F solves

\[ \text{Max}_{X^*_F} \quad E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( X^*_F - MC^*_t \cdot P^*_F,t+j \right) C_{F,t+j}(i) \]

where \( MC^*_t = \frac{(W^*_t/P^*_F,t)}{A_t} \). The first order conditions for this problem are:

\[ E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( X^*_F,t - \frac{\varepsilon}{\varepsilon - 1} \cdot MC^*_t \cdot P^*_F,t+j \right) C_{F,t+j}(i) = 0 \quad (A.18) \]

The log-linear optimal reset price in Foreign currency is thus given by:

\[ x^*_F,t = (1 - \theta \beta) \cdot E_t \sum_{i=0}^{\infty} \theta^i (p^*_F,t+i + mc^*_t,i) \quad (A.19) \]

The aggregate \( p^*_F,t \) can be written as:

\[ p^*_F,t = (1 - \theta) \sum_{i=0}^{\infty} \theta^i x^*_{F,t-i} \]

What is the relation between \( p^*_F,t \) and \( p_{F,t} \)? At time \( t \), each \( x^*_{F,t-i} \) is converted to Home currency by \( x^*_{F,t-i} + e_t \), so

\[ p_{F,t} = (1 - \theta) \sum_{i=0}^{\infty} \theta^i (x^*_{F,t-i} + e_t) \]

\[ = p^*_F,t + e_t \]

and \( \pi_{F,t} = \pi^*_F,t + \Delta e_t \), as in (1.21).
With LCP, the exporter in country F solves

\[
\max_{X_F} E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( \frac{X_{F,t}}{\epsilon_{t+j}} - MC^*_t P^*_F t \right) C_{F,t+j}(i)
\]

The first order conditions read:

\[
E_t \sum_{j=0}^{\infty} \theta^j \rho_{t,t+j} \left( \frac{X_{F,t}}{\epsilon_{t+j}} - \frac{\varepsilon}{\varepsilon - 1} MC^*_t P^*_F t \right) C_{F,t+j}(i) = 0 \tag{A.20}
\]

Log-linearization of (A.20) gives:

\[
x_{F,t} = (1 - \theta \beta) E_t \sum_{j=0}^{\infty} (\theta \beta)^j (p_{F,t+j}^* + mc_{t+j}^* + e_{t+j})
\]

\[
= (1 - \theta \beta) E_t \sum_{j=0}^{\infty} (\theta \beta)^j (p_{F,t+j}^* + mc_{t+j}^* + z_{t+j}) \tag{A.21}
\]

where we have used the definition of \( z_t \) in (1.17). Combining (A.21) with \( p_{F,t} = \theta p_{F,t-1} + (1 - \theta) x_{F,t} \) yields the following:

\[
\pi_{F,t} = \beta E_t \pi_{F,t+1} + \lambda mc_{t}^* + \lambda z_t
\]

which is country H’s import inflation Phillips curve under LCP and DDP (equation (1.23) in the text).

Note that using (A.19) and (A.21) gives:\(^71\)

\[
x_{F,t} = x_{F,t}^* + (1 - \theta \beta) E_t \sum_{j=0}^{\infty} (\theta \beta)^j e_{t+j}
\]

\(^71\)This replicates the result in Gopinath et al. (2010) when the exchange rate is a random walk, as is assumed there.
which implies that the following relationship now holds between \( p_{F,t}^* \) and \( p_{F,t} \):

\[
p_{F,t} = p_{F,t}^* + (1 - \theta) \sum_{i=0}^{\infty} \theta^i e_t^W
\]

where \( e_t^W \equiv (1 - \theta \beta) E_t \sum_{j=0}^{\infty} (\theta \beta)^j e_{t+j} \) (Note that when \( \theta \to 0 \), \( e_t^W = e_t \) and the above reduces to \( p_{F,t} = p_{F,t}^* + e_t \)). The expression for \( z_t \) implied by this model of pricing is thus:

\[
z_t = e_t - (1 - \theta) \sum_{i=0}^{\infty} \theta^i e_{t-i}^W
\]

as in equation (1.20) in the text (an analogous equation for \( z_t^* \) is derived solving the pricing problem of exporters in country H).

We now derive real marginal costs as a function of output. We have:

\[
mc_t = w_t - p_{H,t} - a_t
\]

\[
= w_t - p_t + \gamma s_t - a_t
\]

\[
= \phi n_t + \sigma c_t + \gamma s_t - a_t
\]

where we have used (A.6) and the linearized version of (A.3). To substitute for \( n_t \), we approximate the aggregate production function with \( y_t = a_t + n_t \), which holds up to first order. Thus, real marginal costs can generally be written as

\[
mc_t = -(1 + \phi)a_t + \phi y_t + \sigma c_t + \gamma s_t
\]
and we eliminate \( c_t \) and \( s_t \) using (1.30) and (1.29) to obtain:

\[
mc_t = -(1 + \phi)a_t + (\phi + \sigma_0)y_t + (\sigma - \sigma_0)y_t^* + \frac{(1 - 2\gamma)\omega}{1 + 4\omega} z_t - \frac{(1 + 2\gamma)\omega + \gamma}{1 + 4\omega} z_t^* \tag{A.22}
\]

In the equilibrium under flexible prices, \( z_t = z_t^* = 0 \) and prices chosen by firms in each period are the usual markup over the relevant marginal cost. This implies that real marginal cost is \textit{constant} and equal to the inverse of the markup. In log-linear terms we then have

\[
mc = -(1 + \phi)a_t + (\phi + \sigma_0)y_t + (\sigma - \sigma_0)y_t^* = 0
\]

which can be solved for \( y_t \) to obtain the \textit{flexible-price (natural) level of output} (equation (1.27)):

\[
\bar{y}_t = \frac{1}{\phi + \sigma_0} [(1 + \phi)a_t - (\sigma - \sigma_0)y_t^*]
\]

Finally, we define the domestic output gap \( \tilde{y}_t \equiv y_t - \bar{y}_t \) and derive the general expression for real marginal costs as a function of \( \tilde{y}_t \) (equation (1.26)):

\[
mc_t = \kappa \tilde{y}_t + \frac{(1 - 2\gamma)\omega}{1 + 4\omega} z_t - \frac{(1 + 2\gamma)\omega + \gamma}{1 + 4\omega} z_t^*
\]

where \( \kappa = \phi + \sigma_0 \). This general formulation is then specialized according to the pricing assumption. Under PCP, \( z_t = z_t^* = 0 \), so:

\[
m_c_t = \kappa \tilde{y}_t \tag{A.23}
\]
Under LCP, \( z_t^* = -z_t \), so we write everything in terms of \( z_t \) only:

\[
mc_t = \kappa \tilde{y}_t + \frac{2\omega + \gamma}{1 + 4\omega} z_t
\]  

(A.24)

Finally, under DDP, \( z_t^* = 0 \), so:

\[
mc_t = \kappa \tilde{y}_t + \frac{(1 - 2\gamma)\omega}{1 + 4\omega} z_t
\]  

(A.25)

These expressions for domestic marginal costs (and analogous ones for the foreign counterparts) are combined with the relevant Phillips curves to obtain the equations reported in Table 1.

**A.3 Solving the model**

In solving the model, we use the following equations (appropriately specialized for the different pricing assumptions, when applicable): the IS curves (A.16) and (A.17); the Taylor rules determining \( r \) and \( r^* \); the Phillips curves for \( \pi_H \) and \( \pi_F^* \) written in terms of output; the corresponding equations for \( \pi \) and \( \pi^* \), using (A.8) and (A.9); the Phillips curve for \( \pi_F \); an equation that links \( \pi_H \) and \( \pi_F \) using the expression for the terms of trade (1.29); finally, for LCP and DDP, the definition of \( z \). Given initial conditions, these equations and the specifications for the exogenous shocks determine a fully specified model that can be solved for the endogenous variables \( \pi_{H,t}, \pi_{t}, y_t, r_t, \pi_{F,t}^{*}, \pi_{F,t}^{*}, \pi_t^{*}, y_t^{*}, r_t^{*} \), \( e_t \) (and \( z_t \) in the relevant cases). We do so following Sims (2001).