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Hanna Freystätter

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Abstract

This paper investigates price setting of internationally traded goods. We develop a theoretical model that incorporates sticky prices in the currency of both the buyer (local currency pricing) and seller (producer currency pricing). The nature of price setting is thus forward looking and the exchange rate effect depends on the relative share of local currency and producer currency pricing firms in the economy. The model is estimated with Finnish foreign trade price data for the period 1980–1998. The estimation results seem to support the model. The estimated share of local currency pricing is 40 percent in the export sector and 60 percent in the import sector implying that there is limited pass-through from exchange rate to destination-country prices in both sectors.

Keywords: local currency pricing, producer currency pricing, GMM, Finnish foreign trade prices

Tiivistelmä

Tässä työssä tutkitaan kansainvälisesti kaupattavien hyödykkeiden hintojen asetantaa. Tutkimuksessa kehitetty malli lähtee hintajäykkyyden oletuksesta niin, että hinnat voivat olla jäykkiä joko ostajan (hinnoittelu paikallisessa valuutassa) tai myyjän (hinnoittelu tuottajan valuutassa) valuutassa. Hintojen asetanta on siten luonteeltaan eteenpäinkatsovaa, ja valuuttakurssin vaikutus riippuu ostajan ja myyjän valuutassa hinnoittelevien yritysten suhteellisesta osuudesta taloudessa. Malli estimoidaan käyttäen Suomen dataa (1980–1998). Estimointitulokset näyttävät antavan tukea teoreettiselle mallille. Ostajan valuutassa hinnoittelevien yritysten estimoitu osuus on 40 % vientisektorilla ja 60 % tuontisektorilla. Näin ollen valuuttakurssin läpimeno kohdemaan tuontihintoihin on epätäydellinen.

Avainsanat: hinnoittelu ostajan valuutassa, hinnoittelu myyjän valuutassa, GMM, Suomen ulkomaankauppahinnat

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1 Introduction

This study investigates price setting behavior in an open economy context. The importance of understanding pricing behavior is underlined by the vast empirical literature on international pricing. One of the key issues is the evidence of systematic failures of the law of one price among internationally traded goods (see eg surveys by Rogoff 1996 and Goldberg and Knetter 1997). Instead of the traditional assumption of price-taking, it is often argued that these findings are best understood within a framework that incorporates imperfect competition, nominal rigidities, and international market segmentation. Krugman (1987) introduced the term "Pricing to Market" to describe monopolistic firms that choose to set different prices in different national markets because of different market conditions.¹ The idea of pricing to market has been adopted in the new open economy literature (see discussion below) in the form of local currency pricing (LCP), which refers to sticky prices in the currency of buyer. This approach is also followed in this study.

A number of recent papers examine price setting, nominal rigidities and the nature of inflation dynamics. For example, Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) have recently studied inflation dynamics in the United States and euro area. They estimate a structural equation for inflation (also known as a New Phillips Curve) that evolves from a model of staggered nominal price setting by monopolistically competitive firms. The estimation results of Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) seem to support the forward looking nature of price setting behavior. They argue that the model captures the pattern of both euro area and US inflation measured by the GDP deflator (although some signs of inertia can be found). However, these papers, although very insightful, ignore the open economy aspect of price setting.

Many important questions concerning the exact form of price setting and their implications for an open economy have been raised

¹The same idea is found in Dornbusch (1987).

in the new literature on the "new open economy macroeconomics" (see Lane 1999 for a survey). The new open economy literature was initiated by Maurice Obstfeld and Kenneth Rogoff in their 1995 article, "Exchange Rate Dynamics Redux."² This growing body of literature addresses open economy issues in a micro-founded general equilibrium framework. An important role also in this new approach is played by imperfect competition and nominal rigidities. In particular, there is an ongoing discussion on two pricing conventions and their implications for the economy, namely those of producer currency pricing (PCP) and local currency pricing (LCP).

The Obstfeld and Rogoff model is based on the conventional price setting assumption of producer currency pricing. In this case, prices are set in the seller's currency and the law of one price holds. Under producer currency pricing, because the producer sets prices in home currency but does not change them frequently (prices are sticky), prices faced by consumers in the export market fluctuate with changes in the nominal exchange rate, so that there is complete pass-through of exchange rates to destination-country prices.

The Obstfeld and Rogoff model has been modified in many aspects in the recent literature. One of the first modifications was by Betts and Devereux (1996) who incorporate local currency pricing into the Obstfeld and Rogoff framework. The alternative convention of local currency pricing means that prices are set and sticky in the buyer's currency. In this case, changes in nominal exchange rates do not affect goods prices in the local market of sale, ie there is zero pass-through of exchange rate changes to import prices (in the short run). In this case, deviations from the law of one price are possible, as exchange rate fluctuations have no impact on destination-country customer prices. Such rigid price levels mean that nominal exchange rate shocks pass through into real exchange rates.

It is important to note that local currency pricing limits the pass-through from exchange rate changes to import prices. Thus, it reduces the traditional expenditure-switching role of exchange rate changes. For example, in the case of currency depreciation, the shift of domestic demand away from imports and the shift of global demand towards domestic tradables is reduced. For this reason, Obstfeld and Rogoff (2000a) argue in favor of producer currency pricing which they

²The paper by Svensson and van Wijnbergen (1989) is commonly acknowledged as a precursor of Obstfeld and Rogoff (1995).

feel is a better approximation to reality. However, Obstfeld and Rogoff (2000a) and Obstfeld (2000) stress the difference between responses of consumer prices vs firm level export and import prices, which are likely to be less sticky than consumer prices. It is thus possible that, at the same time when the consumer price level remains insulated from exchange rate fluctuation, the expenditure switching effect is at work in foreign trade conducted between firms. In this paper, the focus is on foreign trade prices, which may indeed exhibit different properties from consumer prices. The characteristics of Finnish foreign trade prices are presented and discussed in section 4.1.

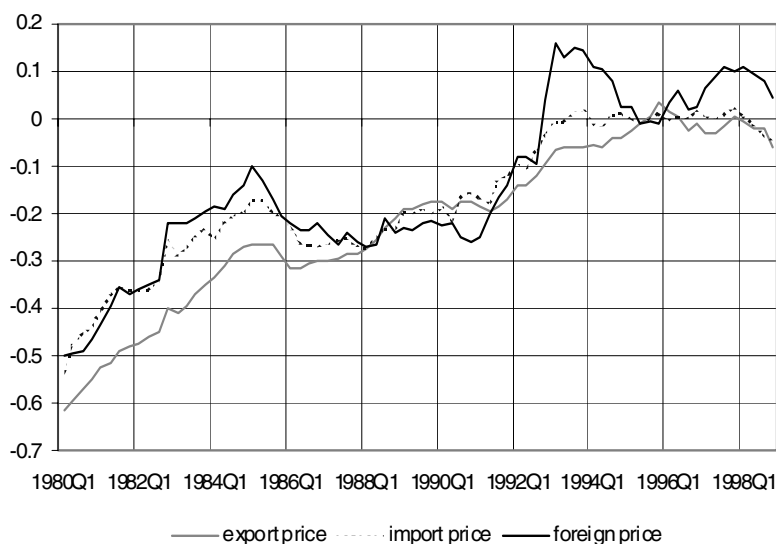


Figure 1. Logarithms of export price, import price and foreign price level in Finnish currency.

This study combines the recent important advances in the theoretical modeling of inflation dynamics and the open economy aspects of price setting debated in the new open economy macroeconomics literature. Our aim is to reconsider the modeling of export and import price determination in the light of the recent literature. The starting point here is similar to what is typical for derivation of the New Phillips Curve, namely an environment of monopolistically competitive firms that face some type of constraints on price adjustment. Here, we focus on modeling the behavior of forward-looking export and import firms.

Instead of trying to determine whether PCP or LCP is closer to reality, we assume that there are two types of price setters in an open economy: those who set prices in home currency and those who set prices in foreign currency. As a result, in an open economy setting, there are two sources of variation for trade price inflation: Firstly, changes in the exchange rate may lead to changes in trade price inflation. The size of the impact is the greater, the larger the fraction of firms that set their price in foreign currency. Secondly, variations in the real marginal cost lead to variation in trade price inflation – a property reflected also in Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001).

The model developed in this study differs fundamentally from the traditional model of export and import price determination in a small open economy. Traditionally, small open economy export and import prices were assumed to follow exogenously given world market prices, due to a lack of pricing power. The lack of pricing power stems from perfect competition and homogeneity of goods. Figure 1 shows the relationship between Finnish trade prices (both export and import prices measured by corresponding deflators) and a measure of foreign prices, all in Finnish currency. Finnish import prices and foreign prices were apparently closely connected prior to the 1990s, after which the connection seems to have broken down. A similar pattern may also be seen for export prices, although the link before the 1990s was less stable than for import prices. We argue in this study that the "anomalous" behavior of Finnish foreign trade prices in the 1990s is easy to understand in the context of our model of trade price determination, which rejects the idea of price-taking behavior and instead assumes forward-looking optimizing behavior in the foreign trade sector. In addition to pricing power, we assume nationally segmented markets that allow exporters to set the price according to the currency of sale.

The structure of the study is as follows. Chapter 2 introduces the analytical framework and reviews the new open economy and recent inflation dynamics literature. Empirical research on the relationship between exchange rates and goods prices is also briefly reviewed. Chapter 3 presents our model of export and import price determination. In chapter 4, we provide evidence on the fit of the model for Finnish data over the period 1980–1988. In particular, the empirical part of the study sheds light on the price-setting

behavior of Finnish exporters and importers by estimating the relative share of PCP and LCP firms in the economy. We apply the generalized method of moments (GMM) in estimating the parameters of the export and import pricing equations. Chapter 5 presents the conclusions.

2 A review of price setting in the recent (open economy) literature

This chapter presents the key concepts and basic framework used throughout the paper. A similar framework can nowadays be found in most articles in the field of new open economy macroeconomics and in the inflation dynamics literature. However, as this study is concerned with open economy issues, we present the framework largely by discussing some important articles in the new open economy macroeconomics genre. The focus is thus on investigation of the treatment of foreign trade in the new open economy macroeconomic models. Particular interest is paid to different price setting regimes and their implications for the response of the economy to monetary shocks. Many other interesting aspects of these new models are thus left out, to keep the focus on trade issues. Empirical studies on exchange rates and goods prices are also briefly reviewed.

As already mentioned, the article that initiated the new open economy macroeconomics literature is "Exchange Rate Dynamics Redux" by Obstfeld and Rogoff (1995). The literature has been growing rapidly, as more and more researchers are seeking a superior alternative to the Mundell-Fleming-Dornbusch model. There are at least two survey articles available (Lane 1999 and Sarno 2000), which give one a good idea of this new modeling approach for open economies. The main characteristic of the recent literature is that the models are dynamic general equilibrium models with well-specified microfoundations. Furthermore, sticky prices and imperfect competition play a crucial role in these models. In chapter 2 we discuss some of the features of these models that are relevant for our model of trade price determination presented in chapter 3.³

³Since the literature of new open economy macroeconomics is vast, chapter 2 discusses mainly Obstfeld and Rogoff (1995, 1996 Chapter 10), and Betts and Devereux (1996 and 2000), all of which consider the case of two large open economies.

The two key features of our model of chapter 3 are sticky prices and imperfect competition. Firstly, in an open economy, nominal price rigidities can take a variety of forms since producers can choose to preset product prices in domestic or foreign currency. In the Betts-Devereux setup (1996, 2000), some producers preset export prices in foreign currency (referred to as local currency pricing in Devereux (1997)). This is an important extension of Obstfeld and Rogoff (1995) that assumes complete pass-through of exchange rates to import prices. Section 2.1. presents and discusses the two pricing conventions of LCP and PCP and the debate over these conventions in the new open economy macroeconomics literature.

Secondly, a central element in these models (and ours) is the presence of a monopolistic supply sector. The behavior of monopolistic firms is discussed in section 2.2. The standard approach is to assume that the world is inhabited by a continuum of individual monopolistic producers (indexed by $z \in (0, 1)$) each of whom produces a single differentiated good (also indexed by z). Before turning to the behavior of firms and optimal price setting, section 2.1. considers consumer preferences and the demand curve that the monopolists face. In this paper, we assume that each firm faces a conventional constant-price-elasticity-demand curve for its product. This is a standard assumption also present in the inflation dynamics papers by Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001), which are also discussed in section 2.2.

2.1 The basic setup

2.1.1 Preferences and price indices

In the Obstfeld and Rogoff model (1995, 1996 Chapter 10), the world is inhabited by a continuum of individual producer-consumers, of which $(0, n)$ are located in the home country and $(n, 1)$ in the foreign country. Furthermore, the Redux model builds on the assumption that all individuals in home and foreign country have identical preferences and constraints. This assumption allows us to examine the maximization problem of a representative national consumer-producer and to derive his first order optimality conditions.

In the Redux model, households maximize intertemporal utility, which depends positively on consumption and real money balances and negatively on work effort, which is positively related to output. For the purposes of this study, we only need analyze one component of the utility function, namely the real consumption index

$$C = \left[\int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} \quad (2.1)$$

where $c(z)$ is the representative home individual's consumption of good z . The real consumption index is of the constant-elasticity-of-substitution (CES) form where θ (a constant) is the elasticity of substitution between different goods. Equation (2.1) is thus a CES aggregator of the quantities of different goods consumed.

Specifying household preferences is a key decision in any microfounded model. For our purposes the critical parameters to be selected are the elasticities of substitution between different varieties of a given class of goods, and between home and foreign goods. Since, in our model presented in chapter 3, all goods are assumed to be traded goods, the substitution between traded and nontraded goods is outside the scope of the analysis.

In this paper, as in the Redux model, it is assumed that there are only traded goods in the economy and that all varieties enter symmetrically into the aggregate CES index. In other words, there is no distinction between home- and foreign-produced goods in specifying preferences.

The parameter θ will turn out to be the price elasticity of demand faced by each monopolist. θ is required to be greater than one since marginal revenue is negative when the elasticity of demand is less than one.

The home price index P solves the problem

$$\min Z = \int_0^1 p(z)c(z)dz$$

subject to

$$\left[\int_0^1 c(z)^{\frac{\theta-1}{\theta}} dz \right]^{\frac{\theta}{\theta-1}} = 1.$$

The solution gives the consumption-based price index (see Obstfeld and Rogoff 1996 chapter 4)

$$P = \left[\int_0^1 p(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \quad (2.2)$$

where P is the aggregate price index and $p(z)$ denotes the price of good z in home currency. A foreign individual's real consumption index is completely analogous to that of a home agent and the foreign price level (in foreign currency) is

$$P^* = \left[\int_0^1 p^*(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} . \quad (2.3)$$

We denote foreign country variables with an asterisk. $p^*(z)$ is thus the foreign-currency price of good z produced in the foreign country whereas $p(z)$ is the home-currency price of good z produced in the home country. For consumers it does not matter where goods are produced, as they enter preferences symmetrically. However, later on when we consider pricing decisions, there will be two more prices to consider: the price set by a home producer in foreign currency, $q(z)$, and the price set by a foreign producer in home country currency, $q^*(z)$.

2.1.2 Consumption-based purchasing power parity and the law of one price

Obstfeld and Rogoff (1995, 1996 Chapter 10) assume that there are no impediments to trade, so that the law of one price holds for each individual good. Let us denote by e the nominal exchange rate (home-currency price of foreign currency). The law of one price says that identical products should sell for the same common-currency price in different countries

$$p(z) = ep^*(z). \quad (2.4)$$

Under the law of one price, we can rewrite the home price index, equation (2.2), as

$$\begin{aligned}
P &= \left[\int_0^1 p(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \\
&= \left[\int_0^n p(z)^{1-\theta} dz + \int_n^1 [ep^*(z)]^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \tag{2.5}
\end{aligned}$$

since 0 to n goods are made in the home country and the rest are produced abroad and imported. Similarly, the foreign price index can be written as

$$\begin{aligned}
P^* &= \left[\int_0^1 p^*(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \\
&= \left[\int_0^n [p(z)/e]^{1-\theta} dz + \int_n^1 p^*(z)^{1-\theta} dz \right]^{\frac{1}{1-\theta}}. \tag{2.6}
\end{aligned}$$

Comparing equations (2.5) and (2.6) we see that the home and foreign consumer price indices are related by purchasing power parity (PPP):⁴

$$P = eP^*. \tag{2.7}$$

PPP holds here because preferences are identical across countries and because there are no deviations from the law of one price.⁵

The basic building block of the PPP theory is the law of one price (LOOP). The mechanism enforcing the law of one price is arbitrage: If the home-currency price of a commodity is cheaper in another country, there should be increasing demand for the commodity in the foreign

⁴The basics of PPP can be found in almost any macroeconomics textbook (see eg Obstfeld and Rogoff 1996, p. 200–202). According to the (absolute) purchasing power parity theory, national price levels should be equal once converted into a common currency. Thus, the theory of purchasing power parity predicts that real exchange rates (eP^*/P) should equal one or at least return quickly to one after short-run fluctuation. The relative purchasing power parity theory states that changes in national price levels are always equal or at least tend to equality. The relative PPP prevails if the ratio of price indices stays constant when corrected for changes in the exchange rate, ie if the ratio (eP^*/P) is constant.

⁵Extensive empirical evidence has shown that PPP often fails dramatically as real exchange rates display large and persistent deviations from PPP. See Rogoff (1996) for a review of the theory and evidence of PPP. See also a recent paper by Engel and Morley (2001) on the PPP puzzle.

country market until its price rises. However, several empirical studies document large deviations from the law of one price (see eg Goldberg and Knetter 1997, Engel 1993, Engel and Rogers 1995). It has been documented eg by Engel (1993) that consumer prices are not very responsive to exchange rate changes, which leads to deviations from the law of one price. According to Engel and Rogers (1996), prices of similar goods sold in a US and a Canadian city systematically differ by more than prices in two cities equally far apart in the same country.

Engel (2001) moves on from documenting what he calls the "border effect" to examining the sources of the failure of the law of one price. According to Engel (2001) potential sources include tariffs and nontariff barriers to trade, transportation costs, non-traded inputs such as marketing and other distribution services that are a part of final goods prices, and variable nominal exchange rates under sticky prices. His principle focus is the role of local currency pricing and floating exchange rates in accounting for deviations from PPP. According to his paper, the empirical results indicate that the main source of failures of the LOOP across European cities over the period 1981–1997 is local currency pricing, although other barriers are also important explanatory factors.

Engel's (2001) results thus support the importance of local currency pricing, which is also emphasized in this paper and several recent theoretical papers. Local currency pricing is discussed in more detail in the following section. At the empirical level, one should also note the differences between different goods and between consumer prices and trading prices. Firstly, it is likely that there is more pass-through for simple, homogeneous goods than for complex goods produced by monopolistic competitors. Secondly, evidence from Goldberg and Knetter (1997) seems to indicate that there is more pass-through directly to export prices than there is to prices of finished goods sold to consumers.

With the vast empirical literature that does not seem to support the law of one price, there is a growing literature raising questions of how firms actually set their export prices and what the implications are of different price setting regimes. The next section discusses this issue further.

2.1.3 Nominal rigidities and price setting behavior in an open economy

Betts and Devereux (1996, 2000) offer an explanation for the empirical failure of the law of one price discussed in the previous section: prices are sticky but not in the seller's currency. Instead, exporters set prices in the currencies of destination markets. This would lead prices of most goods to exhibit local currency price stability. As prices are set in the currency of buyers and do not adjust at high frequencies, real exchange rate movements are driven primarily by fluctuations in the nominal exchange rate. Furthermore, Betts and Devereux (2000) argue that if prices are sticky in local currency, and there is no possibility for arbitrage (markets are segmented), there may be permanent deviations from the law of one price.

The often used label for this phenomenon is pricing to market (PTM) also used in Betts and Devereux (1996 and 2000). Pricing to market, originally introduced by Krugman (1987), refers to third-degree price discrimination by an exporter: price is based on an observable signal as to consumer type, namely national location.⁶ Furthermore, it refers to a monopolistic firm that intentionally chooses different prices for different markets, because of differing market conditions in the destination markets. Local currency pricing, on the other hand, refers simply to sticky prices in the currency of the buyer and does not assume differences in the market conditions across countries.

Betts and Devereux (1996, 2000) extend the Obstfeld and Rogoff theoretical framework to allow for local currency pricing. They do this by assuming that a fraction s of firms in each country can set prices in the local currency of sale (price discriminate across countries). These are what they call the PTM goods. At the same time, the fraction $1 - s$ of goods can be freely traded by consumers, so that firms must set a unified price across countries.

The home country consumer price index (CPI) thus has an additional component, $q^*(z)$:

⁶Obstfeld 2000, p. 19.

$$\begin{aligned}
P = & \left[\int_0^n p(z)^{1-\theta} dz + \int_n^{n+(1-n)s} q^*(z)^{1-\theta} dz \right. \\
& \left. + \int_{n+(1-n)s}^1 [ep^*(z)]^{1-\theta} dz \right]^{\frac{1}{1-\theta}}. \tag{2.8}
\end{aligned}$$

The second integral represents the foreign firms setting their prices in the currency of the buyer (LCP).

The same applies for the foreign country CPI:

$$\begin{aligned}
P^* = & \left[\int_0^n p^*(z)^{1-\theta} dz + \int_n^{n+(1-n)s} q(z)^{1-\theta} dz \right. \\
& \left. + \int_{n+(1-n)s}^1 [p(z)/e]^{1-\theta} dz \right]^{\frac{1}{1-\theta}} \tag{2.9}
\end{aligned}$$

where $q(z)$ is the additional element consisting of imported goods prices set directly in foreign currency.

Home country export prices in home currency consist of both eq and p , while foreign country export prices in foreign currency consist of q^*/e and p^* . Accordingly, home country import prices in home currency consist of $q^*(z)$ and ep^* , while foreign country import prices in foreign currency consist of $q(z)$ and $p(z)/e$.

Before considering the case of local currency pricing any further, let us first discuss producer currency pricing and its implications for the terms of trade along the lines of Obstfeld and Rogoff (2000a). Assume there are two countries – home and foreign – and define the home terms of trade as the relative price of exports in terms of imports:

$$\frac{eP_h^*}{P_f} \tag{2.10}$$

where P_f is the home-currency price of goods imported from the foreign country, P_h^* is the foreign-currency price of home goods exported to the foreign country and e is the exchange rate (home-currency price of foreign currency).⁷

⁷The notation is the same as that in Obstfeld and Rogoff (2000a).

The assumption under producer currency pricing concerning the nomination of price stickiness is the following: Import prices are sticky in foreign currency and domestic export prices are sticky in domestic currency. In other words, prices are sticky in the seller's currency. Therefore, if the home currency depreciates (e increases), and import prices are sticky in foreign currency, P_f rises proportionally to the exchange rate. In other words, there is full pass-through of the exchange rate to import prices.

As the depreciation of the home currency means that if the foreign price of exports P_h^* remains the same, once converted to home currency, the price has risen. Therefore, in the case of depreciation, the home producers lower the price P_h^* so that the home-currency price remains unchanged as we assumed export prices to be sticky in home currency. This kind of price setting behavior leaves price-cost markups unchanged and the home exporting firms do not experience fluctuation in the markups no matter how the exchange rate fluctuates as long as the exchange rate fluctuation does not affect their marginal costs. Due to the mechanism described above, the law of one price holds – adjusted for exchange rates, the same good sells for the same price in home and foreign country.

In this case, the terms of trade deteriorate, as eP_h^* remains unchanged but P_f rises proportionally to the exchange rate. This leads to a shift in demand towards domestically produced tradables. This mechanism, called expenditure switching, is a crucial property of the Mundell-Fleming-Dornbusch model. One of the main arguments against local currency pricing is in fact that it would reduce expenditure switching, as explained below.

Before introducing local currency pricing, let us briefly go through what happens when the exchange rate appreciates. Firstly, appreciation of the home currency leads to lower import prices, P_f . As we consider export prices, we once again notice that the price in foreign currency, P_h^* , has to change in order for the export price to remain sticky in the home currency. If the currency appreciates, the exporters have to raise their price in foreign currency, P_h^* , in order to get the same income in home-currency for each unit sold.

As we can see, the terms of trade improve in this case, and demand is shifted away from domestically produced tradables. However, what we actually assume is that home producers selling abroad change immediately the foreign-currency price of the good they are selling, to

the full extent of the exchange rate appreciation or depreciation (full pass-through of exchange rate). Especially under a floating exchange rate, one might suspect that the price that the foreign buyer faces cannot fully reflect exchange rate fluctuation. Furthermore, at least in the case of exchange rate appreciation, most producers would hesitate to raise the price of their good in the foreign market for fear of losing some customers (especially if the change is temporary). Instead, the home firm might find it optimal to lower its foreign country markup in the case of appreciation of the home currency. Furthermore, it is not obvious that exchange rate depreciation should lead to a decrease in the price that foreign consumers face. At least, if the exchange rate movement is expected to be only temporary, there is little reason for not letting the markup vary in response to exchange rate fluctuations.

Let us now turn to the case of local currency pricing and look again at the expression for the terms of trade. Local currency pricing means that P_h^* and P_f are predetermined, so it is easy to see that in this case we get exactly the opposite reaction to changes in the exchange rate. When the home-country exchange rate depreciates, the terms of trade actually improve. This is due to the following. Import prices are expected to be sticky in the home currency and export prices are sticky in the foreign currency, so that in both cases the destination-country consumer does not see any rise in import prices due to exchange rate depreciation. With import prices preset in the importer's, rather than the exporter's, currency, the (short-run) pass through to import prices is exactly zero.

The home country terms of trade improve because the import prices remain unchanged, but the price of exports converted to home currency now reacts fully to changes in the exchange rate. It also means that the exporting firms will see their markups fluctuating according to the nominal exchange rate. Furthermore, it means that under this form of price stickiness for tradables, exchange rate changes lead to proportional (short-run) deviations from the law of one price.

The two pricing conventions are debated in several of the recent new open economy articles. Obstfeld and Rogoff (2000a) evaluate the plausibility of local currency pricing by calculating correlations between changes in exchange rate and changes in terms of trade for a large sample of industrial countries. The correlations they obtain are

generally large and negative⁸ giving support to producer currency pricing. Obstfeld and Rogoff (2000a) thus argue that producer currency pricing (and full exchange rate pass-through) is a reasonable approximation to reality. Furthermore, Obstfeld and Rogoff argue that local currency pricing is not plausible for the reason that it shuts down the mechanism by which exchange rate changes redirect expenditure internationally. It is however possible, they continue, that the expenditure switching effect is strong while consumer prices are stable in the local currency if retailers set prices in local currency, while at the same time prices paid by the retailers for the imported goods react to fluctuations in the exchange rate, as wholesale prices are set in the producer's currency. Local currency pricing could thus be seen as capturing the apparent zero pass-through of exchange rates to retail prices.

Naturally, it is possible that one cannot find pure producer currency pricing or local currency pricing at the empirical level. Betts and Devereux (1996 and 2000) assume in their theoretical model that only a fraction of firms are LCP firms while the rest are PCP firms. This approach is also used in our model presented in chapter 3. At the aggregate level, this approach produces positive but partial exchange rate pass-through. Another possibility would be to assume that the firm behaves in a manner that allows for partial pass-through of the exchange rate at the firm level.⁹ Moreover, there is some evidence that the response of the price setting firms might be asymmetric as regards exchange rate depreciation vs appreciation. This paper, however, considers only full and symmetric LCP and PCP and leaves the other approaches for further research. Furthermore, the endogeneity of the denomination currency is not investigated in this study.

Another important question beyond the scope of our analysis is the adoption of the single currency in the euro area and its implications for price setting behavior. According to Devereux, Engel and Tille (1999), in 1995 there was still an asymmetry such that US exports to Europe were heavily invoiced in dollars, but European exports to the US were also invoiced in dollars. Since 1999, it is more likely that US exports will be invoiced in euros and that multinational marketers, in general, are more likely to view the euro area as a single marketing

⁸Obstfeld and Rogoff actually define terms of trade as import price relative to export price, so that the correlations they obtain are positive.

⁹Corsetti and Pesenti (2001) model imperfect pass-through directly.

area and will develop pricing plans in terms of euros. This means that import prices and consumer price inflation might become less sensitive, in the short run, to US dollar exchange rate movements.

2.1.4 Demand curve facing each monopolist

Under monopolistic competition, each firm faces a demand curve that is at least slightly downward sloping. Given a constant-elasticity-of-substitution consumption index (preferences over the continuum of goods), it can be shown that a home individual's demand for z is given by¹⁰

$$c(z) = \left(\frac{p(z)}{P} \right)^{-\theta} C. \quad (2.11)$$

The demand curve shows the relation between the price of a given good, $p(z)$, and its consumption, $c(z)$. P is the home price level (home price index), C is aggregate consumption (a scale factor) and θ is the price elasticity of demand. In this study, demand elasticities are assumed to be the same at home and abroad. The elasticity of a downward sloping demand curve is negative (an increase in price means a decrease in quantity). If a good has a large number of substitutes, price elasticity θ is high and demand curve is relatively flat. Product differentiation implies less substitutability and lower price elasticity than in the case of perfect substitution, but still we expect monopolistic competitors to face quite elastic demand curves.

Correspondingly, we have for the foreign country

$$c^*(z) = \left(\frac{p^*(z)}{P^*} \right)^{-\theta} C^*. \quad (2.12)$$

In general, the demand for a good is proportional to real consumption (or some other scale factor), with a proportionality coefficient that is an isoelastic function of the ratio of the good's price (in terms of the numeraire) to the price index (calculated in the same numeraire). For the model in chapter 3 one should keep in mind that the price of a single good may originally be set in either home or foreign currency. For example, foreign demand is a function of the home producer's

¹⁰This is the solution to the consumer's cost minimization problem.

price in foreign currency, meaning that for a PCP firm the price set in home currency has to be divided by the exchange rate $(p(z)/e)$ in order to get the relevant price in terms of the numeraire. For LCP goods, on the other hand, the price is already set in foreign currency.

In the two-country general equilibrium models, we can explicitly derive price indices for both countries. These price indices were discussed in sections 2.1.1–2.1.3. The difference in the model presented in chapter 3 is that it describes a small open economy that trades with the rest of the world (ie the foreign country). In this case, the small economy assumption implies that the export prices of the small economy do not enter the price level of the rest of the world since the amount of the home country exports is assumed to be negligible in the rest-of-world imports.

As we have seen, the equations for trade volumes in the models we consider are demand equations, as usual; the volume of imports and exports depends on the relative price and the demand for the good (scale factor). Next we turn to the question of how the firm actually sets the price for the good that it produces.

2.2 Behavior of firms

In this section, we turn to the monopolistic supply sector and analyze the behavior of a monopolistic firm, a firm that is the only producer of a good. Monopolistic competition is a standard assumption in recent macroeconomic models. This assumption has some important implications for export and import pricing equations. The traditional approach for modeling small open economy trade was to assume perfect competition, which basically means that trade prices are exogenously given in the world market. In contrast, monopolistic competition allows one to examine price setting.

After discussing the key characteristics of a monopolistic production structure in section 2.2.1, we turn to optimal price setting under flexible prices. In this section we show that with identical CES preferences across countries, even PTM firms (which are able to segment their markets by country and set the price in the local currency of sale) will optimally select home and foreign currency prices that are a constant markup over marginal cost and hence the

LOOP is satisfied in the steady state. Section 2.2.3 discusses different ways to incorporate price rigidities into the model and presents key features of some inflation dynamics models.

2.2.1 Production structure and monopolistic competition

As already mentioned, the latest macroeconomic models incorporate imperfect competition, usually in the form of monopolistic competition. Typically, as in Obstfeld and Rogoff (1995), there is monopolistic competition in product markets. An alternative assumption would be imperfect competition in factor markets. Our model in chapter 3 is also based on the assumption of monopolistic competition in product markets.

The new open economy models thus build on the assumption that there is a large number of producers in the economy – one per good. In fact, there is a continuum of goods and a continuum of producer-consumers, who are located either in home country or foreign country. Furthermore, the Obstfeld and Rogoff (1995) model assumes that all goods produced are final consumer goods. However, there are also models that consider intermediate goods production and trade.

The underlying assumption of monopolistic competition is product differentiation. Each firm produces a product that is slightly different from any other good, so that each good is unique but has many close substitutes. As is well known, a producer in a competitive market must take the market price as given and cannot announce a price in advance. However, due to product differentiation, monopolistic producers are able to set prices for their products, and may not change those preset prices in response to supply and demand shocks if there are menu costs and the size of the shock is sufficiently small. An additional assumption characterizing monopolistic competition is that market power is accompanied by only a low level of strategic interaction, so that the strategies of any particular firm do not affect the payoff of any other firm.¹¹

Since the producers are monopolistic, they set prices above

¹¹See Mas-Colell, Whinston and Green (1995, p. 400).

marginal costs. Put differently, profit maximization in monopolistic competition implies that prices are set as a markup over marginal costs. If there is an increase of demand for the product, the producer is willing to increase output to satisfy demand at preset prices as long as the increase in demand does not push into a region where marginal cost exceeds price. Thus, monopolistic price setting offers a rationale for demand-determined output.

2.2.2 Optimal price setting under flexible prices

Let us start with the definition of markup¹²,

$$1 + \mu_t = \frac{P_t}{MC_t^n} = \frac{1}{MC_t}. \quad (2.13)$$

$1 + \mu_t$ is the gross markup and μ_t is the net markup, which is zero under perfect competition. P_t is the price of the good (in home currency). MC_t^n is the nominal marginal cost, while MC_t is the real marginal cost. Markup is thus defined as the ratio of price to nominal marginal cost.

Measuring markup is problematic since it is difficult to obtain an empirical counterpart for nominal marginal cost. Theoretically, the concept of nominal marginal cost is clear: In this paper, we do not specify a production technology but instead assume a (total) cost function (here denoted by TC , later by $c(x^d)$). Throughout the paper we will take factor prices to be fixed so that the cost is a function of output alone. Nominal marginal cost is obtained by taking the first derivative of the total cost function (MC^n or $c'(x^d)$). The marginal cost curve thus measures the change in cost for a given change in output. Alternatively, we could derive an expression for marginal costs based on an assumption on production technology (as eg in Galí and Gertler 1999, p. 205).

The optimal or desired level of markup is obtained by solving the problem of the representative firm under flexible prices. The monopolist's decision problem consists of choosing its price $P_t(z)$ so as to maximize its profit, ie revenue minus total cost (prices are denominated in home currency):

¹²This Section draws on Galí (2000).

$$P_t(z)Y_t(z) - TC_t(Y_t(z)) \quad (2.14)$$

subject to the downward sloping demand curve

$$Y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\theta} Y_t. \quad (2.15)$$

Solving the problem gives us the optimal price setting rule under flexible prices,

$$P_t(z) = \left(\frac{\theta}{\theta - 1} \right) MC_t^n. \quad (2.16)$$

The assumption of isoelastic demand implies that the firm chooses a markup equal to $\frac{\theta}{\theta-1}$ (the optimal gross markup). That markup will thus be common across firms, and constant over time. The constancy of the optimal (desired) markup (due to the assumption of constant price elasticity) is also a key characteristic of our model presented in chapter 3.

In logarithms, we have (small letters denote logarithms)

$$p_t(z) = \log \left(\frac{\theta}{\theta - 1} \right) + mc_t^n \quad (2.17)$$

where $\log \left(\frac{\theta}{\theta-1} \right) \approx \mu$ is the net markup. The higher the price elasticity, the closer the gross markup $\left(\frac{\theta}{\theta-1} \right)$ to one (one in perfect competition) and the closer the net markup to zero.

In optimum, characterized by $p_t(z) = \mu + mc_t^n$, we have

$$mc_t = -\mu. \quad (2.18)$$

Hence, it follows that the real marginal cost (ie the inverse of the markup) will also be constant, and given by $mc_t = -\mu$ for all t, where $\mu = \log \left(\frac{\theta}{\theta-1} \right)$. If, for some reason (eg price stickiness) firms do not adjust prices optimally each period, real marginal cost will no longer be constant. In fact, the variation in the real marginal cost (which implies variation in markup) is a source of changes in aggregate inflation in the latest inflation dynamics equations (see eg Galí and Gertler 1999 and Galí, Gertler and López-Salido 2001).

Betts and Devereux (1996 and 2000) consider a two country setting where so-called PTM firms are able to segment their markets by

country and set the price in the local currency of sale. A firm sells the good that it produces both to home and foreign market, and may set the price according to the market. However, it is easy to show that under flexible prices PTM firms will choose to set prices in the two markets as a markup over marginal cost such that

$$P_t(z) = e_t Q_t(z) = \left(\frac{\theta}{\theta - 1} \right) MC_t^n \quad (2.19)$$

where $Q_t(z)$ is the price of the same good set in the foreign currency. As we can see, even if the firm can price discriminate, under flexible prices and identical CES preferences across countries, it is not optimal to do so. Since the price elasticities of demand are same in each market (identical CES preferences across countries), even PTM firms will optimally select home and foreign currency prices as a constant markup over marginal costs. Hence the law of one price will be satisfied. This result will reappear in the model of chapter 3.

2.2.3 Nominal rigidities and forward looking behavior

A simple way of introducing price stickiness into the model is to assume simultaneous one-period-ahead price setting (as eg in Betts and Devereux 1996, 2000). As discussed above, under flexible prices when firms set prices after the exchange rate and costs are known, the law of one price must hold even for goods that are priced in foreign currency. If, however, firms set prices simultaneously one period in advance so that prices cannot respond to shocks within the period, the law of one price holds only ex ante. For PTM goods whose prices are set in foreign currency, unanticipated changes in the exchange rate lead to deviations from the law of one price.

Thus after a shock is realized, the home and foreign prices of the good can diverge widely as the exchange rate moves, with international market segmentation preventing arbitrage by consumers. However, in this case, the deviation from the LOOP is only a short-term phenomenon. As soon as firms have the possibility, they will change the price, and the LOOP will hold again, so that in the absence of shocks prices are set at a level so as to achieve the optimal markup, which is the same as in the flexible price case.

It should also be noted that in an open economy, the firm's profits are exposed to exchange rate fluctuations. In the case of one-period-ahead local currency pricing, exchange rate fluctuations lead to short-run fluctuations in the markup. To demonstrate, let us assume that the price of an export good Q_t is fixed in foreign currency for one period. The markup of the firm is thus

$$1 + \mu_t = \frac{e_t Q_t}{MC_t^n}. \quad (2.20)$$

Now, if there is any change in the exchange rate, e_t , the markup has to adjust. Assuming that the good is produced with domestic inputs only, so that there is no impact from the exchange rate on nominal marginal cost, an exchange rate depreciation will increase the markup, while an appreciation will decrease it. However, if imported goods are used in the production of export goods, the impact on the markup is not as straightforward. Furthermore, even if the price is set in home currency, exchange rate movement may lead to fluctuation in the markup for the same reason that the nominal marginal cost is influenced by the exchange rate. To summarize, markups are independent of exchange rate movements, for instance, when goods are produced with domestic inputs only and are priced in the producer's currency.¹³

Instead of assuming that prices are sticky for one period ahead, there are other ways of incorporating price stickiness into the theoretical model. In general, most formal derivations of price determination take as given either the cost of adjusting price or the fixed or random interval for setting the price. Subject to this constraint, an optimal price for maximizing profits can be found. Because it will be costly or difficult to change prices in the future, the future affects the current pricing decision. This dependence of current prices on the future is, of course, common to all models in which rational firms have rigid prices.

From the set of alternative approaches we follow the cost-of-changing-prices approach of Rotemberg (1982). Rotemberg assumed that firms face an explicit cost of adjusting prices, which depends on the size of the price change. Alternatively, we could have chosen Calvo (1983) price setting. For Calvo price setting, firms

¹³The markup might also be independent of exchange rate movements if exporters are fully insured against currency volatility.

are not allowed to change their prices unless they receive a random price-change signal. However, it has been demonstrated in Rotemberg (1987) that dynamic adjustment costs, although simple to specify and work with, generate price dynamics identical to those of Calvo random price staggering.¹⁴

In general, a sticky price model leads to a supply function that can be written in a form in which current inflation depends on the expected next-period inflation, possibly lagged inflation and on a demand factor such as output (or marginal cost). Recently, Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001), who derive their model assuming Calvo price setting, obtain the following model for inflation (often referred to as the New Phillips curve):

$$\pi_t = \beta E_t\{\pi_{t+1}\} + \lambda mc_t \quad (2.21)$$

where mc_t is real marginal cost (in percent deviation from its steady state level), β is a subjective discount factor, and λ is a slope coefficient that depends on the primitive parameters of the model. In this model, the firm sets price as a markup over a discounted stream of expected future nominal marginal costs. As the degree of price rigidity increases, the firm places more weight on expected future marginal costs in setting the current price.

In this model, inflation is an entirely forward looking phenomenon. However, Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) also consider a hybrid model that allows for a fraction of firms that use a backward-looking rule to set prices. Naturally, the model nests the purely forward-looking New Keynesian Phillips curve as a particular case. They argue that while statistically significant, backward-looking price setting is not quantitatively important. The forward-looking model thus provides a good first approximation to the dynamics of inflation, both in the euro area and in the United States.

Furthermore, they argue that since in its primitive form, the New Phillips curve relates inflation to movements in real marginal costs, real marginal cost is the theoretically appropriate measure of real sector inflationary pressures. Therefore, they use real unit labor cost as a measure of real marginal cost in the estimations and conclude

¹⁴Note that theory-based modeling of price rigidities is in stark contrast with the data-based methods that are widely used to develop error correction models.

that real marginal costs are a significant and quantitatively important determinant of inflation. Moreover, they argue that the sluggishness of real marginal cost, in turn, appears to help the model account for the high degree of persistence in inflation.

In modeling firm's behavior in the following chapter, we also start with the assumption that prices are somewhat sticky. However, as our model deals with an open economy, we have to take into account that prices can be sticky in either home or foreign currency. Otherwise, our modeling approach and results resemble those of Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) discussed above.

3 A model of price setting in the foreign trade sector

In this chapter, we present our model of export and import price determination. Section 3.1. describes the monopolistic competitor's profit maximization in the export sector, while section 3.2. considers the import sector. The corresponding pricing decisions evolve explicitly from the optimization problem subject to the constraint on price adjustment.

As already mentioned, the dynamic general equilibrium models typically consider two large economies. In this chapter, we examine a small open economy that produces export goods for the rest of the world (referred to as the foreign country) and imports goods from the rest of the world. The analysis is partial in nature.

Small economies have been studied, for example, by Kollman (1997) and Bergin (2001). We follow Bergin (2001) and assume that there are two types of monopolistically competitive goods suppliers in the small open economy. The first type produces goods for export whereas the second type of firm imports foreign goods to resell in the domestic market. Both types of firms are owned by domestic households and maximize their discounted profits. Furthermore, both export and import firms can set their prices either in home or foreign currency. Note that when an exporting firm sets its price in the home currency, this is referred to as producer currency pricing (PCP). However, an importing firm setting its price in home currency is exercising local currency pricing (LCP), since the imported goods are produced abroad.

After considering the optimization problem in both the LCP and PCP cases, we derive an estimable equation that incorporates both of the pricing conventions.¹⁵ This is done by assuming that an exogenously given share of firms are LCP firms, while the rest are PCP firms.

To keep things simple, we assume that all goods produced in the home country are exported. Furthermore, we do not specify the

¹⁵Bergin (2001) studies the cases of LCP and PCP separately, but does not derive a model for aggregate trade price inflation that incorporates both LCP and PCP firms.

production technology of the exporting firms but instead use a general form of cost function denoted by $c_t(x_t^d)$.¹⁶

The problem of the monopolistic firm in this paper is similar to the problem considered in the papers by Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) who study inflation dynamics in a closed economy. The log-linearized price setting equations for LCP and PCP firms separately even resemble the equation for national inflation (measured by GDP deflator) obtained in Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) and presented in section 2.2.3., equation (2.21). In fact, the New Phillips curve applies to exporting firms that set their prices in the producer currency but not to local currency pricing. However, it is important to note that the separate LCP firm and PCP firm pricing equations derived in this study are given in different currencies.

Thus, modeling of the aggregate export and import prices requires that LCP and PCP price setting be combined. As a result, we get a model that allows for less than perfect exchange rate pass-through at the aggregate level. We argue that this is important since it is unlikely that the pass-through is either zero, as under LCP, or one, as under PCP. On the other hand, we assume that initially the price has to be set either in home or foreign currency, ie, a firm has to make a choice. Overall, the model developed here emphasizes the external sector and combines both producer and local currency pricing, whereas Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) abstract from the existence of an external sector in the economy.

3.1 The problem of the exporting firm

This section deals with the profit maximization of a representative exporting firm in two extreme cases: under local currency pricing and under producer currency pricing. Further, a model that combines the two cases is derived. Section 3.2. turns to the problem of the importing firm. We do not discuss the demand side (ie household behavior) explicitly in this chapter, since that was done earlier in chapter 2.

¹⁶Bergin (2001) specifies a production technology and allows firms to sell products to both to home and foreign markets.

3.1.1 Case 1: Local currency pricing

The exporting firm chooses the price ($p_{xt}^f(z)$) for sale of its good z in the foreign market to maximize its profits ($\pi_{xt}(z)$) in home currency, knowing that the choice of price will determine the level of demand for the good ($x_t^d(z)$). The exporting firm faces production costs $c_t(x_t^d(z))$ that depend on the price it sets as well. Markets are assumed to be segmented, and the foreign sale price ($p_{xt}^f(z)$) is in terms of the foreign currency (case 1: LCP). Superscript f is associated with foreign currency denomination. The foreign aggregate price level denoted by P_t^* is also denominated in foreign currency. Note that because prices are denominated in foreign currency, they must be multiplied by the exchange rate, e_t , to get the corresponding price in home currency. The nominal exchange rate, e_t , is the home currency price of one unit of foreign currency.

We assume that it is costly to reset prices because of quadratic menu costs, $AC_{xt}^f(z)$, where ψ_x is the adjustment cost parameter. This assumption is important for obtaining forward looking behavior. $\rho_{t,t+n}$ is the pricing kernel (stochastic discount factor) used to value random date $t+n$ payoffs. Since each firm is assumed to be owned by a representative household, it is assumed that firms value future payoffs according to the household's intertemporal marginal rate of substitution in consumption.¹⁷

The dynamic problem can thus be formulated as follows. The exporting firm maximizes discounted profits:

$$\max E_t \sum_{n=0}^{\infty} \rho_{t,t+n} \pi_{xt+n}(z) \quad (3.1)$$

where

$$\pi_{xt}(z) = e_t p_{xt}^f(z) x_t^d(z) - c_t(x_t^d(z)) - e_t AC_{xt}^f(z) \quad (3.2)$$

subject to adjustment costs defined as

$$AC_{xt}^f(z) = \frac{\psi_x}{2} \frac{\left(p_{xt}^f(z) - p_{xt-1}^f(z) \right)^2}{p_{xt-1}^f(z)} x_t^d(z) \quad (3.3)$$

and to the downward sloping demand curve that was derived earlier:

¹⁷ $\rho_{t,t+n} = \beta^n U'_{C,t+n} / U'_{C,t}$, where $U'_{C,t+n}$ is the household's marginal utility of consumption in period $t+n$.

$$x_t^d(z) = \left(\frac{p_{xt}^f(z)}{P_t^*} \right)^{-\theta} X_t \quad (3.4)$$

where P_t^* is the aggregate foreign price level and X_t is the aggregate demand for exports. If we were to specify production technology, there would be an additional production technology constraint.

The steady state solution to the problem is¹⁸

$$p_x^f(z) = \left(\frac{\theta}{\theta - 1} \right) \frac{c'(x^d(z))}{e}. \quad (3.5)$$

The steady state equilibrium is thus characterized by a constant optimal (desired) markup. This property is due to the isoelastic demand curve.

The solution to the dynamic problem giving the optimal price setting rule for exports is¹⁹

$$\begin{aligned} & E_t \left\{ \frac{\rho_{t,t+1}}{\rho_{t,t}} \left(\frac{\psi_x}{2} \right) \frac{e_{t+1}}{e_t} \left[\left(\frac{p_{x_{t+1}}^f(z)}{p_{x_t}^f(z)} \right)^2 - 1 \right] \frac{x_{t+1}^d(z)}{x_t^d(z)} \right\} \\ & - \psi_x \left(\frac{p_{xt}^f(z)}{p_{x_{t-1}}^f(z)} - 1 \right) \\ & + \theta \left(\frac{\psi_x}{2} \right) \left(\frac{p_{x_{t-1}}^f(z)}{p_{x_t}^f(z)} \right) \left[\frac{p_{xt}^f(z)}{p_{x_{t-1}}^f(z)} - 1 \right]^2 \\ & + (1 - \theta) \left[1 - \left(\frac{\theta}{\theta - 1} \right) \frac{c'_t(x_t^d(z))}{e_t p_{xt}^f(z)} \right] = 0. \quad (3.6) \end{aligned}$$

¹⁸To get the steady state solution, consider a static version of the dynamic problem above by dropping the adjustment costs and time subscripts: $\max_e p_x^f(z) x^d(z) - c(x^d(z)) = \max_e p_x^f(z)^{1-\theta} P^{*\theta} X - c(p_x^f(z)^{-\theta} P^{*\theta} X)$. The first order condition is $\frac{\partial}{\partial p_x^f(z)} = (1 - \theta) e x(z)^d + c'(x(z)^d) \frac{-\theta}{p_x^f(z)} x^d(z) = 0$, which yields equation (3.5).

¹⁹The dynamic problem is solved by considering two periods: $\max_e e_t p_{xt}^f(z) x_t^d(z) - c_t(x_t^d(z)) - e_t AC_{xt}^f(z) + \rho_{t,t+1} E_t \{ e_{t+1} p_{x_{t+1}}^f(z) x_{t+1}^d(z) - c_{t+1}(x_{t+1}^d(z)) - e_{t+1} AC_{x_{t+1}}^f(z) \}$ and taking the first derivative with respect to p_{xt}^f , which yields equation (3.6).

Letting lower case letters denote percent deviations from the steady state and denoting the log difference of variable p_t by Δp_t , we obtain the following log-linearized version of the first order condition above²⁰:

$$\left(\frac{\psi_x}{1+r}\right) E_t\{\Delta p_{xt+1}^f\} - \psi_x \Delta p_{xt}^f + (\theta-1) \left[c_t'(x_t^d) - e_t - p_{xt}^f \right] = 0 \quad (3.7)$$

where r is the real interest rate, which is assumed constant throughout the study.²¹ Note that the index z is left out because all LCP firms set the same price since they face an identical problem, ie, $p_{xt}^f(z) = p_{xt}^f$ for all z .

Rearranging yields

$$\Delta p_{xt}^f = \left(\frac{1}{1+r}\right) E_t\{\Delta p_{xt+1}^f\} + \left(\frac{\theta-1}{\psi_x}\right) mc_t \quad (3.8)$$

where mc_t denotes the percent deviation of the firm's real marginal cost from its steady state value. Comparing this equation with equation (2.21) in section 2.2.3, we notice the similarity of our model to Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001).

3.1.2 Case 2: Producer currency pricing

In the case of producer currency pricing, we assume that the price set for exported home goods, p_{xt}^h , is denominated in home currency (previously: foreign currency). The superscript h refers to home currency. The profit of the representative exporting firm (in home currency) must be redefined as follows, since multiplication by the exchange rate is not needed in this case:

$$\max E_t \sum_{n=0}^{\infty} \rho_{t,t+n} \pi_{xt+n}(z) \quad (3.9)$$

where

$$\pi_{xt}(z) = p_{xt}^h(z) x_t^d(z) - c_t(x_t^d(z)) - AC_{xt}^h(z). \quad (3.10)$$

²⁰Log-linearization is discussed eg in Uhlig (1999).

²¹We know from the consumer Euler equation for the representative consumer that the stochastic discount factor equals $\frac{1}{1+r}$ where r is the constant real interest rate.

Thus, the firm maximizes profits as defined above, subject to the adjustment costs

$$AC_{xt}^h(z) = \frac{\psi_x}{2} \frac{(p_{xt}^h(z) - p_{xt-1}^h(z))^2}{p_{xt-1}^h(z)} x_t^d(z) \quad (3.11)$$

and to the downward sloping demand curve, which is now modified to producer currency pricing:

$$x_t^d(z) = \left(\frac{p_{xt}^h(z)/e_t}{P_t^*} \right)^{-\theta} X_t. \quad (3.12)$$

The steady state solution in this case is

$$p_x^h(z) = \left(\frac{\theta}{\theta - 1} \right) c'(x^d(z)). \quad (3.13)$$

With the same denomination currency, one obtains the same steady state solution as for local currency pricing. In other words, equation (3.5) times the exchange rate yields the same solution as in the equation above (equation (3.13)).

The optimal price setting rule for exports in the case of producer currency pricing is

$$\begin{aligned} E_t \left\{ \frac{\rho_{t,t+1}}{\rho_{t,t}} \left(\frac{\psi_x}{2} \right) \left[\left(\frac{p_{xt+1}^h(z)}{p_{xt}^h(z)} \right)^2 - 1 \right] \frac{x_{t+1}^d(z)}{x_t^d(z)} \right\} - \psi_x \left(\frac{p_{xt}^h(z)}{p_{xt-1}^h(z)} - 1 \right) \\ + \theta \left(\frac{\psi_x}{2} \right) \left(\frac{p_{xt-1}^h(z)}{p_{xt}^h(z)} \right) \left[\frac{p_{xt}^h(z)}{p_{xt-1}^h(z)} - 1 \right]^2 \\ + (1 - \theta) \left[1 - \left(\frac{\theta}{\theta - 1} \right) \frac{c'_t(x_t^d(z))}{p_{xt}^h(z)} \right] = 0. \end{aligned} \quad (3.14)$$

Log-linearization yields

$$\left(\frac{\psi_x}{1+r} \right) E_t \{ \Delta p_{xt+1}^h \} - \psi_x \Delta p_{xt}^h + (\theta - 1) [c'_t(x_t^d) - p_{xt}^h] = 0. \quad (3.15)$$

After rearranging we get

$$\Delta p_{xt}^h = \left(\frac{1}{1+r} \right) E_t \{ \Delta p_{xt+1}^h \} + \left(\frac{\theta - 1}{\psi_x} \right) m c_t. \quad (3.16)$$

3.1.3 Combining case 1 & case 2

The two log-linearized price setting equations (3.8) and (3.16) are rewritten here: (3.17) is the equation for PCP firms and (3.18) for LCP firms. The two equations are now in different currencies since Δp_{xt}^h is denominated in home currency, while Δp_{xt}^f is denominated in foreign currency. Here, we denote as $\left(\frac{1}{1+r}\right) \equiv \beta$ the subjective discount factor and as $\left(\frac{\theta-1}{\psi_x}\right) \equiv \delta^{22}$ the slope coefficient for the real marginal cost, so that we have the following two price setting equations:

$$\Delta p_{xt}^h = \beta E_t \{ \Delta p_{xt+1}^h \} + \delta \left[c_t'(x_t^d) - p_{xt}^h \right] \quad (3.17)$$

and

$$\Delta p_{xt}^f = \beta E_t \{ \Delta p_{xt+1}^f \} + \delta \left[c_t'(x_t^d) - e_t - p_{xt}^f \right]. \quad (3.18)$$

Let us assume there are both LCP and PCP firms in the country and combine the two log-linearized first-order conditions above. In order to combine the two equations above, we must convert the LCP firms' price setting rule, Δp_{xt}^f , into home currency by multiplying it by the exchange rate e_t . The aggregate price, p_t^x , can be written as a geometric average of the LCP and PCP price setting rules. Thus in logarithms we use

$$p_t^x \equiv \omega p_{xt}^h + (1 - \omega) p_{xt}^f + (1 - \omega) e_t \quad (3.19)$$

where the weight ω captures the share of exports priced in home currency, namely the share of PCP firms in the export sector. In this model, the relative shares of LCP and PCP firms are assumed to be exogenously given and constant. This assumption will be further discussed later.

The result of the combination is the equation

²² δ is higher, the higher the price elasticity, θ , (the more substitutable the goods) and the smaller the adjustment cost parameter, ψ_x . The less costly it is to reset prices, the more sensitive export price inflation is to movements in marginal cost.

$$\begin{aligned} \Delta p_t^x &= \beta E_t \{ \Delta p_{t+1}^x \} + (1 - \omega) [\Delta e_t - \beta E_t \{ \Delta e_{t+1} \}] \\ &\quad + \delta \left[c_t'(x_t^d) - p_t^x \right] \end{aligned} \quad (3.20)$$

where $c_t'(x_t^d) - p_t^x$ is the real marginal cost (in percent deviation from its steady state level). ω is the share of exports priced in home currency, ie, the fraction of PCP firms. δ is a slope coefficient, which depends on the primitive parameters of the model, namely on ψ_x , which is the parameter that governs the degree of price stickiness, and on price elasticity, θ . Given constant export price inflation expectations, we see that short-run fluctuations in export price inflation are due to either exchange rate fluctuation (the impact of which is the greater, the greater the share of exporters that price in foreign currency, ie the lower the value of ω) or variation in the real marginal costs. The latter source of variation can also be found in the model of Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001).

Iterating equation (3.20) forward yields

$$\Delta p_t^x = (1 - \omega) \Delta e_t + \delta \int_{k=0}^{\infty} \beta^k E_t \{ mc_{t+k} \}. \quad (3.21)$$

Because the firm's markup price over marginal cost is forward looking due to price adjustment costs, the firm bases its pricing decision on the expected future behavior of marginal costs. Here, we see that fluctuation in the exchange rate leads to short-run variation in export price inflation, while expected changes in the path of real marginal costs lead to permanent changes in export price inflation. Marginal cost is thus the driving force of the model. We will estimate this model with Finnish data and present the results in chapter 4.

3.2 The problem of the importing firm

3.2.1 Case 1: Local currency pricing

The importing firms choose the resale price to maximize their profits, where they too are subject to quadratic menu costs. The price in this case is set in the currency of the small open economy and denoted by $p_{mt}^h(z)$, where the superscript h refers to the home currency of the small country. Since production of the goods actually takes place in the foreign country, pricing in home currency is in this case associated with local currency pricing.

The problem of the representative import firm may be summarized as follows. The importing firm maximizes discounted profits (in home currency):

$$\max E_t \sum_{n=0}^{\infty} \rho_{t,t+n} \pi_{mt+n}(z) \quad (3.22)$$

where

$$\pi_{mt}(z) = (p_{mt}^h(z) - e_t P_t^*) y_{mt}^d(z) - AC_{mt}^h(z) \quad (3.23)$$

subject to adjustment costs defined as

$$AC_{mt}^h(z) = \frac{\psi_m}{2} \frac{(p_{mt}^h(z) - p_{mt-1}^h(z))^2}{p_{mt-1}^h(z)} y_{mt}^d(z) \quad (3.24)$$

and to the downward sloping demand curve,

$$y_{mt}^d(z) = \left(\frac{p_{mt}^h(z)}{P_t} \right)^{-\theta} Y_t \quad (3.25)$$

where P_t is the aggregate home country price level and Y_t the aggregate demand for imports. Note that in the import sector, the nominal marginal cost consists of $e_t P_t^*$, ie the price of foreign goods in foreign currency multiplied by the exchange rate.

The steady state solution is

$$p_m^h = \left(\frac{\theta}{\theta - 1} \right) e P^*. \quad (3.26)$$

The optimal pricing rule is

$$\begin{aligned}
E_t \left[\frac{\rho_{t,t+1}}{\rho_{t,t}} \frac{\psi_m}{2} \left(\left(\frac{p_{m,t+1}^h(z)}{p_{mt}^h(z)} \right)^2 - 1 \right) \frac{y_{mt+1}^d}{y_{mt}^d} \right] - \psi_m \left(\frac{p_{mt}^h(z)}{p_{m,t-1}^h(z)} - 1 \right) \\
+ \theta \left(\frac{\psi_m}{2} \right) \left(\frac{p_{m,t-1}^h(z)}{p_{mt}^h(z)} \right) \left[\frac{p_{mt}^h(z)}{p_{m,t-1}^h(z)} - 1 \right]^2 \\
+ (1 - \theta) \left[1 - \left(\frac{\theta}{\theta - 1} \right) \frac{e_t P_t^*}{p_{mt}^h(z)} \right] = 0. \tag{3.27}
\end{aligned}$$

The log-linearized version of the first order condition is

$$\left(\frac{\psi_m}{1+r} \right) E_t \{ \Delta p_{m,t+1}^h \} - \psi_m \Delta p_{mt}^h + (\theta - 1) [e_t + p_t^* - p_{mt}^h] = 0. \tag{3.28}$$

Rearranging gives

$$\Delta p_{mt}^h = \left(\frac{1}{1+r} \right) E_t \{ \Delta p_{m,t+1}^h \} + \left(\frac{\theta - 1}{\psi_m} \right) m c_t. \tag{3.29}$$

3.2.2 Case 2: Producer currency pricing

Under producer currency pricing, the importing firms choose the resale price $p_{mt}^f(z)$ (now denominated in foreign currency) to maximize their (home-currency) profits. Their problem may be summarized as follows, after defining the variables in home currency.

The importing firm maximizes discounted profits:

$$\max E_t \sum_{n=0}^{\infty} \rho_{t,t+n} \pi_{m,t+n}(z) \tag{3.30}$$

where

$$\pi_{mt}(z) = (e_t p_{mt}^f(z) - e_t P_t^*) y_{mt}^d(z) - e_t AC_{mt}^f(z) \tag{3.31}$$

subject to adjustment costs defined as

$$AC_{mt}^f(z) = \frac{\psi_m}{2} \frac{\left(p_{mt}^f(z) - p_{m,t-1}^f(z) \right)^2}{p_{m,t-1}^f(z)} y_{mt}^d(z) \tag{3.32}$$

and to the downward sloping demand curve,

$$y_{mt}^d(z) = \left(\frac{e_t p_{mt}^f(z)}{P_t} \right)^{-\theta} Y_t. \quad (3.33)$$

The steady state solution is

$$p_m^f = \left(\frac{\theta}{\theta - 1} \right) P^* \quad (3.34)$$

which is equal to the steady state solution in the LCP case (equation (3.26)) after multiplication by the exchange rate, e_t .

The optimal pricing rule is

$$\begin{aligned} E_t \left[\frac{\rho_{t,t+1} \psi_m e_{t+1}}{\rho_{t,t} 2 e_t} \left(\left(\frac{p_{mt+1}^f(z)}{p_{mt}^f(z)} \right)^2 - 1 \right) \frac{y_{mt+1}^d}{y_{mt}^d} \right] - \psi_m \left(\frac{p_{mt}^f(z)}{p_{mt-1}^f(z)} - 1 \right) \\ + \theta \left(\frac{\psi_m}{2} \right) \left(\frac{p_{mt-1}^f(z)}{p_{mt}^f(z)} \right) \left[\frac{p_{mt}^f(z)}{p_{mt-1}^f(z)} - 1 \right]^2 \\ + (1 - \theta) \left[\frac{1}{e_t} - \left(\frac{\theta}{\theta - 1} \right) \frac{P_t^*}{e_t p_{mt}^f(z)} \right] = 0. \end{aligned} \quad (3.35)$$

Log-linearization yields

$$\left(\frac{\psi_m}{1+r} \right) E_t \{ \Delta p_{mt+1}^f \} - \psi_m \Delta p_{mt}^f + (\theta - 1) [p_t^* - p_{mt}^f] = 0. \quad (3.36)$$

Rearranging yields

$$\Delta p_{mt}^f = \left(\frac{1}{1+r} \right) E_t \{ \Delta p_{mt+1}^f \} + \left(\frac{\theta - 1}{\psi_m} \right) m c_t. \quad (3.37)$$

3.2.3 Combining case 1 & case 2

Let us rewrite here the two log-linearized price setting equations (3.29) and (3.37). (3.38) is the equation for LCP firms, while (3.39) is the equation for PCP firms. We denote as $\left(\frac{1}{1+r} \right) \equiv \beta$ the subjective

discount factor and as $(\frac{\theta-1}{\psi^m}) \equiv \delta$ the slope coefficient on real marginal cost. Once again, the two equations are in different currencies since Δp_{mt}^h is denominated in home currency, while Δp_{mt}^f is denominated in foreign currency:

$$\Delta p_{mt}^h = \beta E_t \{ \Delta p_{mt+1}^h \} + \delta [e_t + p_t^* - p_{mt}^h] \quad (3.38)$$

and

$$\Delta p_{mt}^f = \beta E_t \{ \Delta p_{mt+1}^f \} + \delta [p_t^* - p_{mt}^f]. \quad (3.39)$$

Let us assume that also in the import sector there are both LCP and PCP firms in the country and take a linear combination of the log-linearized first-order conditions, as we did in the case of export prices. The result of the combination is the following equation where the weight ω captures the share of imports priced in home currency, namely the share of LCP firms in the import sector. The relative shares of LCP and PCP firms are exogenous and assumed to be constant, as in the export sector.

$$\begin{aligned} \Delta p_t^m &= \beta E_t \{ \Delta p_{t+1}^m \} + (1 - \omega) [\Delta e_t - \beta E_t \{ \Delta e_{t+1} \}] \\ &\quad + \delta [e_t + p_t^* - p_t^m]. \end{aligned} \quad (3.40)$$

$e_t + p_t^* - p_t^m$ is the real marginal cost (in percent deviation from its steady state level) and ω is the share of imports priced in home currency, which for import firms is the fraction of LCP firms. δ is a slope coefficient, which depends on the primitive parameters of the model (ψ_m , the parameter that governs the degree of price stickiness, and price elasticity, θ). The interpretation of the equation is similar to the corresponding export price equation: Given constant import price inflation expectations, short-run fluctuations in import price inflation are due to either exchange rate fluctuation (the impact of which is the greater, the greater the share of importers that price in foreign currency, ie, the lower the value of ω) or variation in the real marginal costs.

Iterating equation (3.40) forward yields

$$\Delta p_t^m = (1 - \omega) \Delta e_t + \delta \int_{k=0}^{\infty} \beta^k E_t \{ mc_{t+k} \} \quad (3.41)$$

Once again, because the firm's markup price over marginal cost is forward looking due to price adjustment costs, the firm bases its pricing decision on the expected future behavior of marginal costs. Furthermore, fluctuation in the exchange rate leads to short-run variation in the import price inflation, while expected changes in the path of real marginal cost lead to permanent changes in import price inflation. We will estimate this model and present the results in chapter 4.

3.3 Discussion

Our model of import and export pricing combines monopolistic producers with nominal rigidities in a dynamic context with forward-looking economic actors. Due to the fact that the firms face constraints on adjusting the prices of the goods they produce or import, the nature of trade price inflation is forward looking. Firms find it optimal when making their current pricing decisions to take into account their expectations regarding the future path of marginal costs. In the steady state, the price is determined as a constant markup over (current) marginal cost.

In an open economy model, nominal rigidity may take the form of price stickiness in the currency of either the buyer (local currency pricing) or the seller (producer currency pricing). In the case of producer currency pricing, the domestic price of imports moves one-to-one with the exchange rate (full pass-through). When firms set the price of their goods in the currency of the market where they sell their products, the domestic price of imports does not change with the exchange rate and pass-through is zero. Instead of assuming either of the polar cases of nominal rigidities, we derive a model for aggregate trade price inflation that allows for intermediate degrees of pass-through. This is done by assuming the existence of both LCP and PCP firms in the economy. Several new open economy articles investigate the implications of the two polar cases theoretically (see eg Lane 1999). However, at least Betts and Devereux (1996 and 2000) and Corsetti and Pesenti (2001) complement and generalize the analysis by allowing for intermediate degrees of pass-through.

The short-run variation in trade price inflation thus has two

sources: the exchange rate and variations in markups. Let us first discuss the role of the exchange rate. A key idea in the model presented in this chapter is that the impulse from the exchange rate is the stronger, the greater the share of goods priced in foreign currency. The greater the share of LCP firms in the export sector and the greater the share of PCP firms in the import sector, the greater the effect of exchange rate fluctuation on trade prices measured in home currency. It is important to note that allowing for less than perfect pass-through of the exchange rate weakens the expenditure shifting effect of the exchange rate compared to the polar case, where exports are priced in home currency and imports in foreign currency, ie both are priced in the currency of the producer.

Let us now turn to the variations in markups (or, equivalently, in real marginal costs) as a source of trade price inflation. Whereas the role played by the exchange rate is a feature of our open economy price setting model, markup variation is a source of inflation also in Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001). Since the desired markup in the model is constant, any deviation from the optimal level of markup leads to price adjustment towards the optimum, as firms try to correct for misalignments between actual and desired markup.

The modeling approach could be extended to cover the following cases. Firstly, due to CES preferences, which lead to an isoelastic demand curve, the optimal markup over marginal cost is constant. This implies that in the export sector production costs, mainly consisting of labor inputs and also imported inputs, determines the price. In other words, competitors' prices play no role in export price determination. If the markup were not constant, but rather a function of foreign prices, there would be a role for competitors' prices in export price determination. In this case, however, the assumption concerning CES preferences would have to be altered. In general, a model that would allow for a non-constant optimal markup would be interesting. Secondly, the choice of denomination currency could be explicitly studied and the assumption of exogeneity of relative shares of PCP and LCP firms relaxed. This kind of analysis has been conducted eg by Friberg (1998), who studies the choice of price setting currency under exchange rate uncertainty. In particular, an interesting question is how the exchange rate regime affects the relative shares of PCP and LCP firms. A recent paper by Devereux

and Engel (2001) presents a two-country general equilibrium model in which the currency of price setting is endogenous. They argue that exporters will generally choose the currency of the country that has the most stable monetary policy. Thirdly, whereas Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) allow a subset of firms to use a backward looking rule to set prices, our model is purely forward looking. However, Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001) find in their empirical studies that although there are some signs of inertia, forward-looking behavior is dominant. Furthermore, they argue that searching for explanations for inflation inertia is preferable to relying on backward looking behavior.

In the next chapter, where we present the data that we use for estimating our model empirically, we will see that some of the assumptions made in the theoretical model might be too restrictive. In particular, the constancy of the optimal markup and the constancy and exogeneity of the shares of PCP and LCP firms might be questioned. Furthermore, one should bear in mind that the results obtained by linear approximations are only locally valid. It is possible that the exchange rate changes are not sufficiently small to ensure model validity for wide exchange rate fluctuations. Let us now turn to the estimation of the model with Finnish data.

4 The determination of Finnish foreign trade prices

We now have two equations that we are about to estimate. First, we discuss the data and then the estimation method. Sections 4.3 and 4.4 present and discuss the results.

4.1 Data

This section presents the empirical variables used to study Finnish export and import price determination. A list and details of operational counterparts of theoretical variables can be found in Appendix 1. The data is quarterly and covers 1980:1–1998:4. The base year for the variables is 1995.

Compared to some other price series, such as domestic inflation measured by the GDP deflator, the foreign trade price series appear to be fairly volatile (see Figure 2). This feature makes the task of finding a general model that explains the export and import price data challenging. It is often argued that one key factor behind such volatility is the exchange rate. However, as can be seen in Figure 2, the volatility of trade prices was large also during the period 1980–1991, when the exchange rate was fixed and relatively stable. During that period there were dramatic movements in the price of oil, which could help explain some of the volatility of trade prices. On the other hand, the exchange rate volatility of the 1990s is not clearly reflected in the foreign trade prices. The role of the exchange rate and other factors in determining Finnish foreign trade prices are the key issues in this chapter.

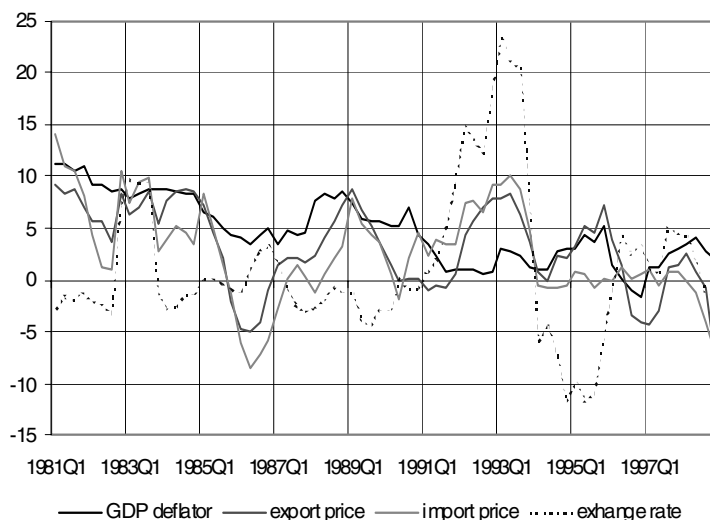


Figure 2. Annual rate of change of GDP deflator, export price deflator, import price deflator and trade-weighted exchange rate.

Before moving on to a more detailed presentation of the data, let us make some general remarks about the estimation period. Firstly, the estimation period includes different exchange rate regimes. The exchange rate was fixed from the beginning of the estimation period (1980:1) until the third quarter of 1992 when the markka was allowed to float. However, the fixed exchange rate period (1980:1–1992:2) includes some exchange rate realignments such as a devaluation in 1982:4 and in 1991:4. The decision to switch into a floating exchange rate in 1992:3 preceded a crises leading to an excessive depreciation of the Finnish currency followed by a recovery. In 1996:4 the markka became part of the exchange rate mechanism of the European Union. The estimation period ends at 1998:4, since the adoption of the euro at the start of 1999 led to a structural change the impact of which would require another careful study. The likely effects of the adoption of the euro are twofold: Firstly, the euro suddenly became the euro area countries’ home currency, which led to an increase in trade conducted in the home currency of all these countries. Secondly, the importance of the euro in world trade is likely to increase as its role as an important world currency becomes better established. Therefore, as a result of the adoption of the euro the foreign trade prices of the euro area countries have probably become, or are becoming, more insulated from exchange rate fluctuation.

Secondly, the Finnish economy and production structure experienced profound changes during the estimation period, implying that the content of trade and characteristics of traded goods did not remain unchanged. In particular, it is often noted that recovery from the deep recession that Finland experienced in the early 1990s is associated with a rise of the electronics and information technology industry. Earlier on, exports had been more dependent on forest industry output. The structure of imports has also changed so that the role of raw material and intermediate good imports, though still important, has gradually declined since the beginning of the estimation period.

In contrast to the theoretical framework presented in the previous chapter, it is possible that changes in the structure of trade mean that the optimal aggregate level markup has not remained unchanged during the estimation period as assumed. We discuss this possibility in section 4.1, where the data is presented, and also in section 4.3.3, which considers the robustness of the estimation results. The possible impact of the exchange rate regime shifts is taken up in section 4.3.3.

Baring all this in our mind, we attempt to build a general model of pricing behavior that will explain the behavior of Finnish foreign trade prices over the whole estimation period. Section 4.3 reports the estimation results of the theoretical model presented in chapter 3. Section 4.3.3 presents the robustness analysis. Finally, section 4.4 discusses and evaluates the results obtained in the empirical estimation of the model.

4.1.1 Import prices

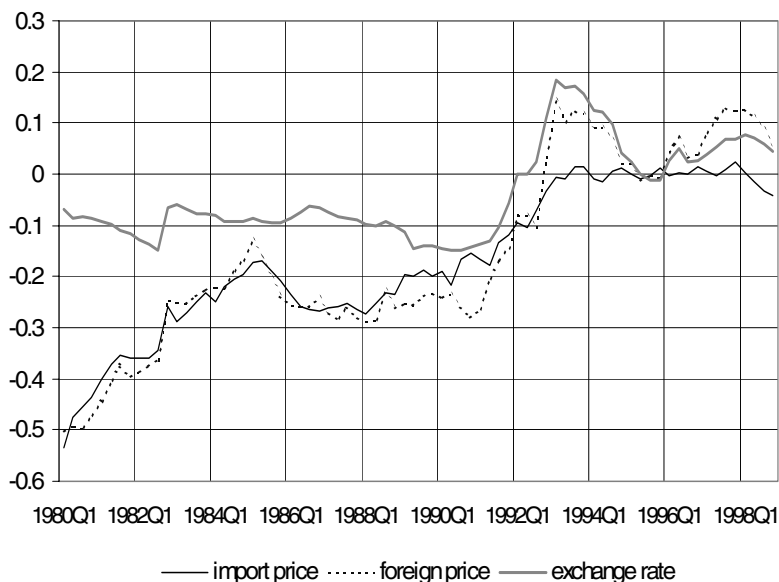


Figure 3. Logarithm of import price deflator, foreign price (in Finnish currency) and the trade-weighted exchange rate.

Figure 3 plots the logarithms of the three time series that are used in the empirical estimation of our import pricing model presented in chapter 3. Our import price measure is the Finnish import price deflator. For the nominal exchange rate, e_t , we use the trade-weighted exchange rate. Nominal marginal costs in the Finnish currency are measured by foreign prices and the exchange rate (see Appendix 1 for details).

As we see, the exchange rate fluctuated considerably in the 1990s. It is also clear that the nominal marginal cost measured by foreign prices and the exchange rate has been dominated by the movement in the exchange rate. Import prices, on the other hand, did not follow movements of the exchange rate. The observation of a weak link between the exchange rate and import prices is often considered evidence of local currency pricing.

The relationship between foreign prices (incl. the exchange rate) and import prices, however, remained fairly stable before the 1990s, raising the question whether after 1990 there has been a change in pricing behavior towards local currency pricing. This change might

have been either gradual or related to the exchange rate regime. We will discuss these possibilities further in section 4.3.3. However, it is difficult to determine whether a change in pricing behavior has taken place, since the stable link between foreign prices (incl. the exchange rate) and import prices before 1990s might as well be due to the fairly stable exchange rate during the fixed exchange rate regime and not due to price setting of import prices in foreign currency.

Before moving on, let us analyze the data from the perspective of our theoretical model. An increase in the nominal marginal cost without a proportional increase in the import price implies an increase in the real marginal cost. According to our model, an increase in the real marginal cost puts upward pressure on import prices, as importers try to get back to the optimal level of markup. However, if the expected path of future real marginal costs remains unchanged, there is only a short-run impact from the real marginal cost to import prices. One could thus argue that the increase in the real marginal cost of the import sector was due to exchange rate depreciation that was considered temporary so that there was no permanent change in import prices.

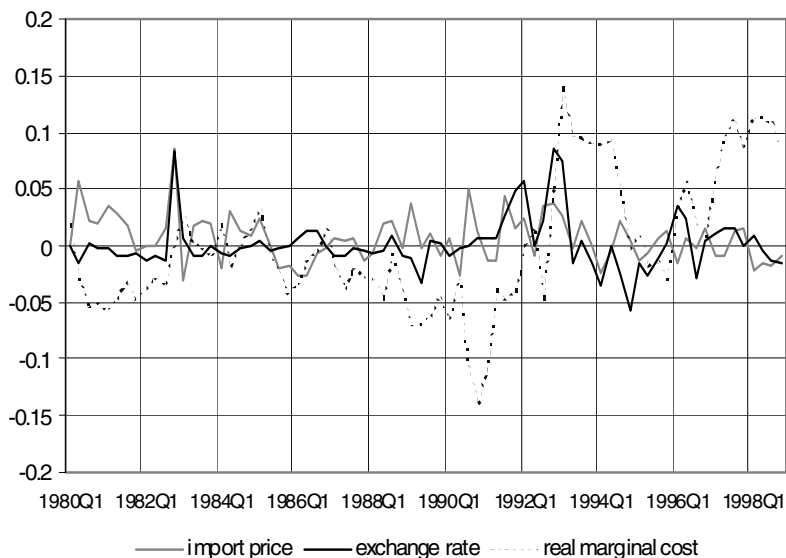


Figure 4. Log difference of import price deflator, log difference of trade-weighted exchange rate, and real marginal cost.

Figure 4 plots the log differences of the exchange rate and import prices, and the real marginal cost. In the short run, both exchange rate depreciation and an increase in the real marginal cost put upward pressure on import prices. According to our model the greater the share of imports priced in home currency, the weaker the short-run impact from exchange rate depreciation/appreciation to import prices. The contemporaneous correlation between a change in the exchange rate and a change in the import price is positive, around 0.35, giving support neither to full local currency pricing nor to full producer currency pricing. On the other hand, if we look at the exchange rate devaluation in 1982:4 we see that the change in the exchange rate was in fact almost exactly matched by a change in import prices (evidence of PCP). However, import prices responded only partially to the devaluation of 1991:4 and during the float of the Finnish markka (1992:4–1996:4). This evidence suggests that there could have been a change in the pricing behavior or that import prices respond fully to a change in the exchange rate only if the change is considered permanent, as is more likely in a fixed exchange rate regime.

Figure 4 also plots the real marginal cost, which was constructed in the following manner: For importing firms, our measure of nominal marginal cost is foreign prices including the exchange rate. This measure consists of foreign export price deflators converted into Finnish currency. The calculation of this variable has been carried out by the ECB (Appendix 1 describes in more detail how this variable is constructed). Our measure of real marginal cost is the nominal marginal cost divided by import prices. To be exact, we use the log deviation of the real marginal cost measure from its mean as a measure of mc_t^m .

Since real marginal costs are not directly observable, obtaining a measure for such a variable is tricky. Naturally, all the results are conditional on the measure of real marginal costs used in the estimation. It is also likely that there is an error in our measure of real marginal cost for imports. Although it is common practise to use weighted foreign export prices as a proxy for foreign price level rather than a cost variable, foreign export prices already include markups of foreign producers, and these markups are not solely for products sold to Finland. The use of a foreign cost variable does not suffer from such drawbacks, as it does not depend on the particular export market

targeted. However, we leave the construction of such a variable for further research.

Our estimation method presented in section 4.2 requires that the empirical counterparts (ie the three series in Figure 4) of the theoretical variables of the import pricing model are stationary. As we can see in Figure 4, the log differences of both import prices and the nominal (trade-weighted) exchange rate appear stationary. This is confirmed by formal tests for unit roots. The results of an augmented Dickey-Fuller test indicate that the null hypothesis of a unit root is rejected at the 5 per cent level of significance, meaning that the first differences of import price and exchange rate are stationary. Although less clear from Figure 4, the null hypothesis of nonstationarity is also rejected at the 5 per cent level of significance for the real marginal cost variable.

As already mentioned, our theory assumes that the optimal level of markup is constant, although there may be short-run variation around the long-run steady state markup. As we can see in Figure 4, the real marginal cost (ie the inverse of markup) has indeed fluctuated particularly in the 1990s when the real marginal cost increased, ie the markup decreased well below the optimal level (here normalized to zero). The obvious reason behind this phenomenon is the float of the Finnish markka in 1992:4, which increased nominal marginal costs but did not lead to a proportionate increase in import price. However, an important question is whether the optimal level of markup has in fact remained unchanged during the estimation period. If this was not the case and eg the optimal level of markup decreased after the markka was allowed to float (mc_t^m is a stationary series with a structural break), the increase in the real marginal cost that we see in Figure 4 would not put such strong upward pressure on the price level.

Several explanations may be offered for the changing optimal markup, one of them stemming from the fact that, even if the optimal markup of an individual firm or even a whole industry remained constant over time, changes in the production structure would lead to variation in the optimal markup at the aggregate level. Another explanation is that the optimal markup may be countercyclical. Whatever the explanation, one should also examine whether the change has been gradual or is due to the change in the exchange rate regime. The variation in the markup that we see in Figure 4 is in our opinion due to exchange rate depreciation related to the change in the

exchange rate regime. Thus, we believe that a good approximation to reality is to start with the assumption that the real marginal cost is a stationarity variable.

Alternatively, one might offer an explanation for the decrease in the markup in the 1990s with a more strategic perspective on price setting behavior. Namely, as Finland was undergoing an economic depression in the early 1990s there was only very mild upward movement in the domestic price level, which might have been optimal to take into account and set the import prices accordingly in order not to lose too many customers. This issue will be further discussed in section 4.3.

This section has touched upon many questions that we try to answer in the following sections. Before that, let us however first turn to the data for the export pricing equation, which shares many similar features with the import price data.

4.1.2 Export prices

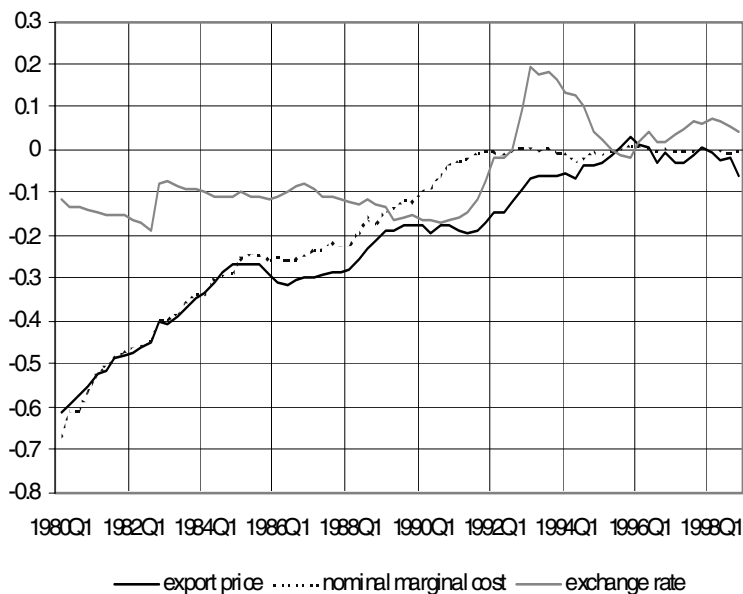


Figure 5. Logarithm of export price deflator, nominal marginal cost (MC1) and trade-weighted exchange rate.

Figure 5 plots the logarithms of the three time series that are used in the empirical estimation of our model for export prices. Our export price measure is the Finnish export price deflator. For the nominal exchange rate, e_t , we use the trade weighted exchange rate (details in Appendix 1). For the export sector, we use and compare three alternative measures for nominal marginal costs. Figure 5 plots the benchmark nominal marginal cost series constructed from unit labor costs (0.6) and import prices (0.4) (weights in parentheses).

As opposed to import prices, it is not necessarily surprising that the export price did not fully respond to exchange rate fluctuations in the 1990s if we believe in the traditional pricing convention, namely that export prices are set and sticky in the producer's currency. Instead, the depreciation of the 1990s had a positive impact on export sector competitiveness, as the depreciation led to a decrease in the price that foreign consumers face. Furthermore, the impact from exchange rate depreciation that might come via an increase in nominal marginal cost is definitely smaller in the case of export prices, due to the relatively smaller role of imported goods in export sector marginal cost. In other words, in contrast with the import price data, we can see in Figure 5 that there is no clear connection between the exchange rate and nominal marginal cost series.

Concerning the link between real marginal cost and export prices, the situation is similar to that for import prices, as one can question the mild reaction of export prices to increasing real marginal cost. However, the timing of the real marginal cost increase is different from the case of import prices: There is a period that starts in the middle of the 1980s and peaks around 1991, when nominal marginal costs increased relative to export prices, ie the real marginal cost increased (see Figure 6). The timing of the increase in the real marginal cost of the export sector is not, however, related to the change of exchange rate regime. The explanation behind the recovery of the real marginal cost to a lower level after the peak is probably related to the economic depression of the early 1990s.

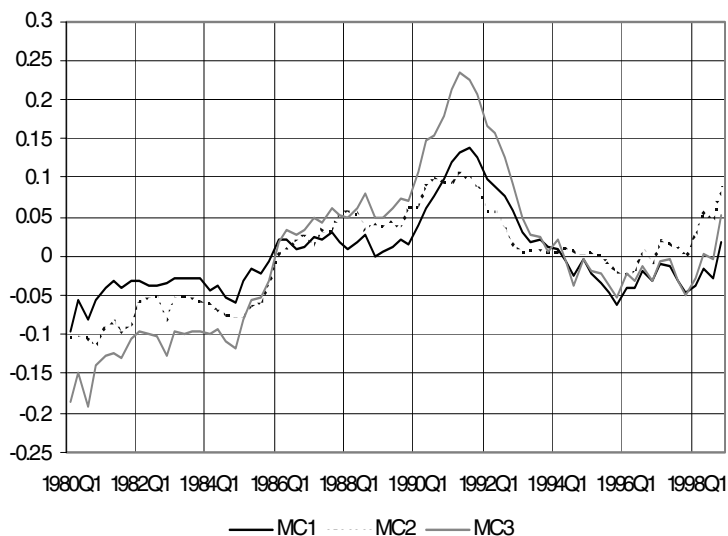


Figure 6. Three measures of real marginal cost

Figure 6 presents the three measures of real marginal cost used in this study as empirical proxies for mc_t^x . As we can see, these series resemble each other. The benchmark case (MC1), as already discussed, uses a combination of unit labor costs and import prices to measure export sector nominal marginal costs. The two other measures are the following: case (2) MC2 uses the private sector GDP deflator at factor prices, while case (3) MC3 consists of unit labor costs alone. The real marginal cost series are obtained by dividing nominal marginal cost by export price. To be exact, we use the log deviation from mean of the real marginal cost measure as a measure of mc_t^x .²³

Figure 6 shows us that the markup has experienced dramatic changes during the estimation period. What we also observe is substantial inertia in the movement of the markup. Galí, Gertler and López-Salido (2001) have examined factors that drive the real marginal cost variable by a simple decomposition. They argue that labor market frictions are the key factor behind the evolution of the real marginal cost both in the euro area and in United States. In the case of Finland, one should also recall the economic depression

²³We follow Galí and Gertler (1999) in the construction of both mc_t^x and mc_t^m . Galí and Gertler (1999, p. 205–206) base their measure of real marginal cost on a Cobb-Douglas technology and obtain a measure for real marginal cost, namely real unit labor costs, that is consistent with the theory.

of early 1990s and the change in the production structure (incl. the collapse of trade with the Soviet Union), which have contributed to the real marginal cost series in Figure 6.

An important question is once again whether the optimal level of markup has remained unchanged as assumed by our theory. There are several possible reasons why the (aggregate level) optimal markup did not necessarily remain constant during the estimation period, such as countercyclicality of optimal markup or a change in the optimal aggregate level of markup due to changes in the production structure. The issue of constancy of optimal aggregate level markup over time is important since, if the peak in the real marginal cost is in fact associated with a decrease in the optimal level of markup (eg if the optimal markup is countercyclical), the upward pressure on the price level would be weaker than with a constant optimal markup. This issue will be tackled in section 4.3.3 where we examine the possibility of a structural change in the optimal level of markup.

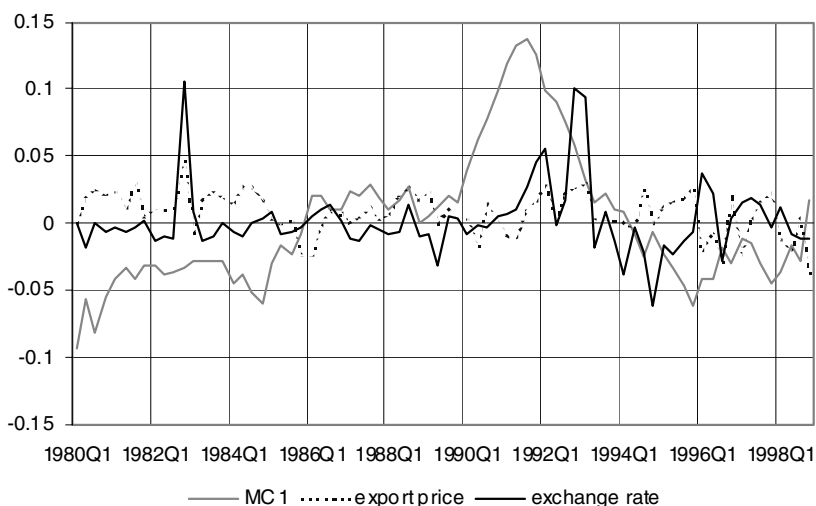


Figure 7. Log difference of export price deflator, log difference of trade-weighted exchange rate, and real marginal cost (MC1).

Figure 7 plots the log differences of the exchange rate and export prices, and the benchmark real marginal cost series (log deviation from the steady state). In the short run, both exchange rate depreciation and an increase in the real marginal cost put upward pressure on export prices measured in Finnish currency. Note that

for export prices measured in Finnish currency the impact of exchange rate fluctuation is the smaller, the greater the share of exports priced (and sticky) in home currency. In fact, the contemporaneous correlation between a change in the exchange rate and a change in the export price is positive (about 0.27) but smaller than in the case of import prices (0.35). Furthermore, the impact from the exchange rate to export price is the greater, the greater the share of imported inputs (the price of which reacts to exchange rate fluctuation) used in export sector production.

Looking at the exchange rate devaluation in 1982:4, we see that the export price did indeed increase (evidence of local currency pricing) but the change did not fully reflect the change in the exchange rate (evidence of producer currency pricing). Furthermore, export prices responded only partially to the devaluation of 1991:4 and during the float of the Finnish markka (1992:4–1996:4). In the light of this evidence, we cannot distinguish clearly between local currency pricing and producer currency pricing, but one can readily argue that pricing behavior is likely to be a combination of both. The question remains whether the shares of producer and local currency pricing have remained unchanged and whether this share is related to the exchange rate regime.

The log differences of both export prices and the nominal (trade-weighted) exchange rate appear stationary (see Figure 7), as is confirmed by formal tests of nonstationarity. The augmented Dickey-Fuller test rejects the null of a unit root at the 5 per cent level of significance. Figure 7 also plots our benchmark real marginal cost, MC1. The formal tests also reject the null hypothesis of a unit root for MC1 at the 5 per cent level of significance. For MC2 and for MC3 the null of unit root is rejected at the 10 per cent level of significance. However, especially in case (2) and case (3) this result is not robust to different lags. Furthermore, looking at the graphs of case (2) and case (3) real marginal cost series, the question arises whether there has been a change in the mean of an otherwise stationary series. For example, one might suspect that there was a structural change around 1986 after which the optimal level of markup has decreased. If this is the case, when there are structural breaks, the augmented Dickey-Fuller test statistic is biased towards not rejecting the null of

a unit root even though the series is stationary within each of the subperiods.²⁴

4.2 Choice of econometric method

We apply the generalized method of moments (GMM) in estimating equations (3.20) and (3.40). GMM is a standard approach for estimating rational expectations models.²⁵ For a reference, see eg Mátyás (1999), Davidson and MacKinnon (1993, Chapter 17) and Favero (2001, Chapter 7). The generalized method of moments proposed by Hansen (1982) estimates model parameters directly from moment conditions imposed by the theoretical model.

The starting point of our GMM estimation is the two theoretical relations (3.20) and (3.40) that the parameters should satisfy. The idea of GMM is to choose the parameter estimates so that the theoretical relation is satisfied as closely as possible.²⁶

The theoretical relations that the parameters should satisfy are given by the two orthogonality conditions (between residuals of the Euler equation and a set of instrumental variables z_t) below. Let z_t denote a vector of variables observed at time t (dated t and earlier). Then under rational expectations, we have the orthogonality condition for import prices,

$$E_t\{(\Delta p_t^m - \beta^m \Delta p_{t+1}^m - (1 - \omega^m)[\Delta e_t^m - \beta^m \Delta e_{t+1}^m] - \delta^m m c_t^m) z_t\} = 0 \quad (4.1)$$

²⁴Enders 1995, p. 243.

²⁵We also tried Ordinary Least Squares (OLS) but this method proved problematic and yielded parameter estimates that were not in line with our theory.

²⁶The model is characterized by a set of orthogonality conditions, $E\{f(x_t, \theta) z_t\} = 0$, where x_t is the observed sample ($t = 1, \dots, T$), θ is the parameter vector and z_t is the vector of instruments orthogonal to $f(x_t, \theta)$. The sample equivalent of the orthogonality condition above is given by $f_T(\theta) = \frac{1}{T} \sum_{t=1}^T [f(x_t, \theta) z_t]$. The estimator for θ is chosen to so that the vector of sample moments is as close as possible to zero in the sense that a quadratic form in $f_T(\theta)$ is minimized, ie $\min Q_T(\theta) = \min f_T(\theta)' W_T f_T(\theta)$. The solution to this problem provides the GMM estimator for θ . The optimal weighting matrix, W_T , is the inverse of the covariance matrix of the sample moments. The estimation of the covariance matrix is discussed briefly in Section 4.3.1.

and for export prices

$$E_t\{(\Delta p_t^x - \beta^x \Delta p_{t+1}^x - (1 - \omega^x)[\Delta e_t^x - \beta^x \Delta e_{t+1}^x] - \delta^x mc_t^x)z_t\} = 0. \quad (4.2)$$

The unknown parameters can now be estimated by applying GMM to the orthogonality conditions, (4.1) and (4.2).

After choosing the data used in the estimation, we have to solve a second empirical problem, namely the choice of the instruments. The validity of the instruments can be tested using the J-statistic (in the case of overidentification). To enable overidentification, the number of orthogonality conditions should be larger than the number of unknown parameters. For example, if we have five instruments to estimate two parameters, there are three overidentifying restrictions. Under the null hypothesis that the overidentifying restrictions are satisfied, the J-statistic is asymptotically χ^2 distributed with degrees of freedom equal to the number of overidentifying restrictions.²⁷ We report the results of these tests in the same table with the estimation results in section 4.3.

The vector of instruments, z_t , is the vector of variables that are within the decision makers' information set at the time the prices are set (variables that are either exogenous or predetermined may be used as instruments). It is required that the instruments not be correlated with the error term of the Euler equation but correlated with the regressors. Before choosing our set of instruments, we studied simple correlations between potential instruments and variables, and formed simple regression models to find links between the variables and the instrument set. However, since the choice of instruments matters, we discuss the robustness of our empirical results to different instrument sets in section 4.3.

Our vector of instruments, z_t , for the import price equation includes the constant, lags of import price, interest rate differential, foreign export prices (in Finnish currency), oil price (in Finnish currency), lags of real marginal cost, and domestic GDP deflator. The interest rate differential is the difference between the Finnish

²⁷Note that the J-test also tests whether the model is correctly specified. It indicates whether the moment conditions of the theoretical model are consistent with the data. If the test statistic is significantly larger than it should be under the null hypothesis, it is likely that either some of the instruments are invalid or the model is incorrectly specified.

and foreign (12 countries, trade-weighted) three-month interest rates. This was chosen to represent expectations of exchange rate movement since, according to the (uncovered) interest rate parity condition, a positive interest rate differential (nominal interest rate in domestic country greater than in foreign country) is matched by expected depreciation of the exchange rate.

The instrument set for export prices is similar to that for import prices. We use the constant, lags of export price, the interest rate differential, foreign export prices (in Finnish currency, export-weighted) and oil price (in Finnish currency).

Our method of estimation is based on the stationarity of the variables. See section 4.1 for a discussion of the stationarity of the time series used in the estimation.

Note that equations (3.20) and (3.40) contain an estimate of the overall slope coefficient on marginal cost and do not allow us to obtain direct estimates for the structural parameters θ and ψ . In other words, the parameters θ and ψ are unidentifiable.

4.3 Estimation results

4.3.1 Import prices

In this section, we report estimation results for the import price equation (3.40), rewritten here as

$$\Delta p_t^m = \beta^m E_t\{\Delta p_{t+1}^m\} + (1 - \omega^m)[\Delta e_t^m - \beta^m E_t\{\Delta e_{t+1}^m\}] + \delta^m mc_t^m \quad (4.3)$$

The results are reported below in Table 1. There are three columns reporting estimates of the parameters of the model, namely β^m , ω^m , and δ^m . Under the point estimates, we report the standard errors (in parentheses). The final column displays Hansen's J statistic of the overidentifying restrictions with the associated p-values in parentheses.

For robustness, we consider three cases associated with three different sets of instruments. Briefly, case (1) is treated as a benchmark. The instrument set for case (2) is narrower than that for case (1), while case (3) adds the domestic GDP deflator to the

set of case (1) instruments (for details, see the discussion below). Furthermore, in each case we also report the results when the estimate of the subjective discount factor, β^m , is restricted to 0.99, which is a typical value for this parameter used in the literature. We have chosen to consider and report the results obtained by using different instrument sets, to get an idea of the range of values that the point estimates take. We argue that this is important since the standard errors are fairly large and the results seem to be somewhat sensitive to variations in the set of instruments.

Estimation of the equation is implemented using EViews 3.0. Estimation of the covariance matrix is carried out using the correction for heteroscedasticity and autocorrelation of unknown form (HAC covariance matrix). In this case, the choice of kernel (used to weight the covariances) and the choice of bandwidth (which determines how the weights given by the kernel change with the lags in the covariance matrix estimation) must be specified. The results reported in this paper are obtained using Bartlett weights and Variable-Newey-West bandwidth selection method (for case (1) we also report the results obtained using a fixed bandwidth, referred to as fixed NW).²⁸

Table 1. **Estimates for the import price model**

	β^m	ω^m	δ^m	J-Test
Case (1):	0.826	0.657	0.049	6.622
	(0.193)	(0.121)	(0.024)	(0.357)
Fixed β	0.99	0.574	0.042	6.336
	–	(0.161)	(0.026)	(0.501)
Fixed NW	0.994	0.587	0.043	6.989
	(0.231)	(0.161)	(0.023)	(0.322)
Case (2):	1.134	0.631	0.022	1.213
	(0.233)	(0.253)	(0.035)	(0.750)
Fixed β	0.99	0.649	0.023	1.349
	–	(0.217)	(0.027)	(0.853)
Case (3):	1.107	0.713	0.067	6.000
	(0.150)	(0.125)	(0.030)	(0.740)
Fixed β	0.99	0.663	0.051	6.293
	–	(0.118)	(0.022)	(0.790)

²⁸For details of covariance matrix estimation, consult the EViews manual.

Overall, the results in Table 1 are reasonable. All the parameter values have the right sign and plausible values (especially after taking into account the standard error). Unfortunately, some of the estimates for δ^m are not significantly different from zero at the 5 per cent level of significance.

Let us analyze the results by starting with the estimate of β^m . Plausible values for the estimate (using quarterly data) of the coefficient of expected import price inflation, ie the subjective discount factor, β^m , are close to one, 0.99 implying an annual subjective real interest rate of around 4 per cent. We argue that our point estimates for β^m are reasonable since they are within two (estimated) standard deviations of the typical values for this parameter in the literature (eg 0.99). Furthermore, although the point estimates of β^m are somewhat large in cases (2) and (3) and somewhat low in case (1), taking into account the standard errors of estimates for β^m , we consider our exercise of fixing β^m to 0.99 justified.

We estimate the share of imports priced in domestic currency, ω^m , to be slightly over 60 per cent. Although the results are somewhat imprecise, we would argue that, since more than half of the imports are priced in domestic currency, the impact from exchange rate fluctuation is not fully reflected in the import prices in the short term.

The slope coefficient, δ^m , for real marginal cost is positive, which is consistent with the theory. Unfortunately, the standard errors appear fairly large so that in some cases the estimate is not significantly different from zero at the 5 per cent level of significance. Note that we estimate the overall slope coefficient for marginal costs, δ^m , and not the structural parameters that underlie the slope coefficient (θ and ψ_m). In their paper, Galí and Gertler (1999) also obtain an estimate of the marginal cost parameter (similar to δ^m in our case) that is only slightly greater than zero. They argue that if the markup in the frictionless benchmark model were countercyclical (rather than constant), desired price setting would be less sensitive to movements in marginal cost, which could help account for the low overall sensitivity of import price inflation to real marginal cost. For further discussion, see section 4.3.3.

The model works well in the sense that we do not reject the overidentifying restrictions in any case. The p-values for the null

hypothesis that the error term is uncorrelated with the instruments are all reasonably large (in the range of 0.35 or higher).

We now turn to the different instrument sets and their impact and to the impact of restricted β^m . As already mentioned, varying the instrument set affects somewhat the point estimates of the parameters. The benchmark case uses the following instruments: the constant, the first two lags of import price inflation, the interest rate differential and its first lag, the log difference of foreign export prices (in Finnish currency), the log difference of oil price (in Finnish currency), and three lags of the real marginal cost. The case (2) instrument set is narrower and it consists of the constant, the first lag of import price inflation, the interest rate differential and its first lag, the log difference of foreign export prices (in Finnish currency), and one lag of the real marginal cost. We thus show that the point estimates are almost unaltered despite a narrow instrument set, although the results are less precise. In case (3), we add the domestic GDP deflator (and its first lag) to the case (1) instrument set. The point estimates are slightly modified but the test for validity of instruments does not reject the null. In fact, the deflator seems to improve the p-value of the J-test. In the light of this evidence we can conclude that the domestic price level measured by the GDP deflator affects the agents' behavior as a leading indicator for future import price inflation but not as an independent argument of the pricing equation.²⁹

We next explore the implications of fixing β^m equal to 0.99. Overall, the effect is minimal and thus we would argue that restricting β^m to a plausible range does not affect the results in any significant way. Considering the estimates of ω^m when the value of β^m is restricted to 0.99, we see that case (3) yields the highest estimate of ω^m (around 0.66) with the smallest standard error. Altogether, the estimates of ω^m are fairly similar across the different cases.

To conclude, it appears that our model provides a reasonable description of import price inflation. Considering that the time series for import prices is somewhat volatile, we argue that the model fits the data fairly well for the period 1980–1998. Furthermore, the results are reasonably robust to different instrument sets and to fixed β^m . However, the imprecision of the point estimates remains a problem.

²⁹See also Favero 2001 (chapter 7, p. 234–235).

4.3.2 Export prices

This section presents estimation results for the export price equation (3.20), rewritten here as

$$\Delta p_t^x = \beta^x E_t\{\Delta p_{t+1}^x\} + (1 - \omega^x)[\Delta e_t^x - \beta^x E_t\{\Delta e_{t+1}^x\}] + \delta^x mc_t^x \quad (4.4)$$

The results are reported below in Table 2. There are three columns reporting estimates of the parameters of the model, namely β^x , ω^x , and δ^x . The standard errors are given in parentheses below each estimate. The final column displays Hansen's J statistic of overidentifying restrictions with the associated p-value in parentheses.

Rather than studying the robustness of the results by considering different instrument sets, as we did for the import price equation, we concentrate on the impact of three different measures of real marginal cost. Case (1) is once again the benchmark. The marginal cost measure of case (1) consists of unit labor costs and import prices with weights 0.6 and 0.4, respectively. Case (2) uses the private sector GDP deflator at factor prices as a measure of marginal cost, while in case (3) the unit labor cost alone is taken to represent marginal costs in the export sector. These measures were already discussed in section 4.1.2. In each case we also report the results when the estimate of the subjective discount factor, β^x , is restricted to 0.99, which is a typical value for this parameter in the literature.

The set of instruments that was maintained throughout the exercise reported in Table 2 consists of the constant, two lags of export price, the interest rate differential with four lags, two lags of the logarithm of oil price (in Finnish currency), and the logarithm of foreign export prices (in Finnish currency) with one lag.

The estimation of the equation was implemented using EViews 3.0. As for import prices, the estimation of the covariance matrix was carried out by using the correction for heteroscedasticity and autocorrelation of unknown form with Bartlett weights and the Variable-Newey-West bandwidth selection method.

Table 2. Estimates for the export price model

	β^x	ω^x	δ^x	J-Test
Case (1): MC1	0.948 (0.083)	0.625 (0.077)	0.053 (0.027)	5.514 (0.787)
Fixed β	0.99 –	0.655 (0.077)	0.054 (0.026)	5.455 (0.859)
Case (2): MC2	0.957 (0.086)	0.613 (0.074)	0.021 (0.019)	5.388 (0.799)
Fixed β	0.99 –	0.632 (0.074)	0.013 (0.020)	5.030 (0.889)
Case (3): MC3	0.961 (0.086)	0.616 (0.075)	0.018 (0.011)	5.372 (0.801)
Fixed β	0.99 –	0.635 (0.075)	0.011 (0.011)	5.092 (0.885)

All the parameter values reported in Table 2 have the right sign and plausible values. Moreover, the model's overidentification restrictions are not rejected under any specification. The p-value of the J-test statistic is in all cases fairly large (in the range of 0.79 or higher), implying that the null hypothesis that the overidentifying restrictions are valid is not rejected. However, the estimation of the slope coefficient, δ^x , proved slightly problematic, as we will discuss below.

We argue that our point estimates for β^x , ie the subjective discount factor, are reasonable since they are within two (estimated) standard deviations of typical values for this parameter in the literature. Although the point estimates of β^x are somewhat low, taking into account the standard errors of estimates we consider our exercise of fixing beta at 0.99 justified.

We estimate the share of exports priced in domestic currency, ω^x , to be around 60 percent, with relatively small standard errors. We can thus argue that the export prices measured in domestic currency are fairly insulated from fluctuation of the exchange rate since the majority of prices are set in the producer's currency.

The estimates of the slope coefficient, δ^x , for real marginal cost reported in Table 2 are positive, as is consistent with the a priori theory. However, except in case (1), they are not statistically significant at the 10 per cent level of significance. Furthermore, this parameter seemed to be somewhat sensitive to the set of

instruments used. As the two other parameters remained reasonably stable across different instrument sets, the point estimate for the parameter on marginal cost seemed to shift easily closer to zero and even into negative territory. Obviously, this phenomenon requires further investigation. One of the explanations could be related to countercyclical markups already mentioned in section 4.1. Let us, however, postpone the discussion of this issue to section 4.3.3.

We now turn to the different measures of real marginal costs and their impact on the estimates and to the impact of restricted β^m . Varying the real marginal cost measure seems to have hardly any impact on the estimates of β^x and ω^x . However, compared to case (1), the point estimates of δ^x appear to shift closer to zero, both in case (2) and in case (3). Otherwise, the results are reasonably robust across variations in the real marginal cost measure.

We next explore the implications of fixing β^x equal to 0.99. Overall, the effect is minimal and thus we would argue that restricting β^x to a plausible range does not affect the results in any significant way. The estimates of ω^x when the value of β^x is restricted to 0.99 are similar across the marginal cost measures, although fixing β^x seems to lead to slightly higher point estimates than in the unrestricted case. Overall, the estimates of ω^x remain nearly unaltered across the different cases.

Although there are some issues that need further investigation, we may conclude that our model appears to capture the essence of price setting behavior in the export sector.

4.3.3 Robustness analysis

The underlying theory assumes a constant markup of price over marginal cost in the absence of price rigidities. Thus, the empirical counterpart for the real marginal cost as a deviation from the steady state has been constructed so that the mean of the logarithm of the real marginal cost measure (representing the steady state level of markup) is subtracted from the logarithm of the real marginal cost series. However, the assumption of a constant optimal markup may be questioned. In this section, we discuss two possibilities, namely a structural change in the level of optimal markup and the possibility of a non-constant optimal markup. Furthermore, the stability of

the share of goods priced in domestic currency is discussed. The sensitivity of results regarding instrument sets, different measures of real marginal cost and fixing the coefficient of the subjective discount factor at a plausible value were already studied in the previous section.

Let us start by considering the three real marginal cost series for the export sector that are plotted in Figure 8. As opposed to Figure 6 in section 4.1.2, these three series are the logarithms of the real marginal cost without subtraction of a constant mean. Furthermore, the figure shows the Hodrick-Prescott trend for each series.

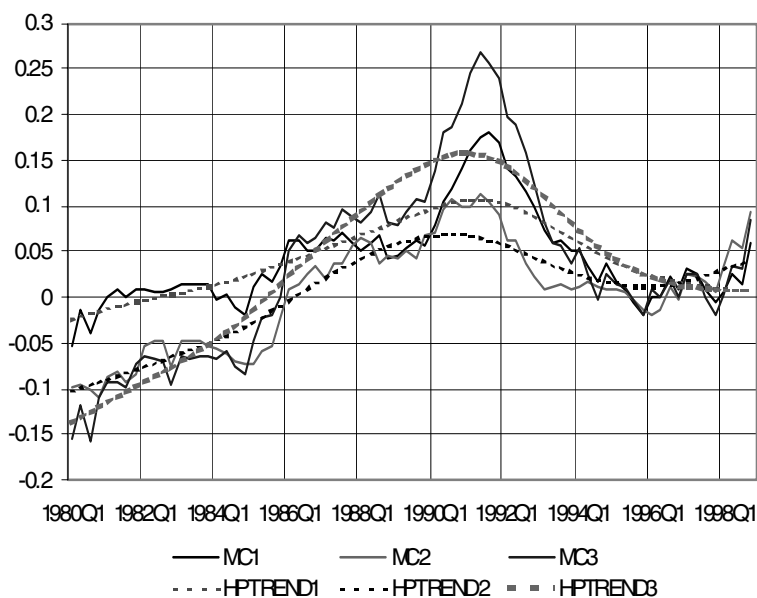


Figure 8. Logarithm of three measures of real marginal cost and their associated Hodrick-Prescott trends.

Looking at Figure 8, one could argue that there may have been changes in the means of all three series, since these do not appear to exhibit any tendency to return to the low levels of the early 1980s. In other words, it appears that the means of all three series increased, meaning that the average markup decreased. If, instead of a constant optimal level of markup, there has been a structural change in the optimal level of markup, one should naturally take this into account in the estimation.

We studied the possibility that there were changes in the means of the three series by considering the subperiod 1986:1–1998:4. The

three series for log real marginal cost as a deviation from steady state were recalculated so that the associated means of the series are from the period 1986:1–1998:4. We dropped only 5 years from the estimation period, so that there remain enough data points for GMM estimation. The instrument set used in the estimation is unaltered. Unfortunately, this exercise did not help in the estimation of δ^x since the same problem of a low or negative δ^x remained. For case (2), which uses the private sector GDP deflator at factor prices as the measure for the nominal marginal cost, the results were the following: with β^x fixed at 0.99, the estimate for ω^x is 0.709 (0.050), which is slightly higher than in the baseline, and the estimate for δ^x is 0.016 (0.040), which is about the same as in the baseline. However, the standard error for δ^x (shown in parentheses) is relatively large. The J-test statistic is 6.757 (0.748), implying that the overidentifying restrictions are not rejected. Overall, problems similar to those already reported in the baseline case remained for the subperiod 1986:1–1998:4, where the increase in the mean of the average markup was taken into account.

Another exercise is related to the possible non-constancy of the optimal markup. If the markup in the frictionless model were not constant, the steady state optimal markup, which is subtracted from the logarithm of real marginal cost, would not be a constant either but should be approximated eg by a Hodrick-Prescott trend. We have plotted the Hodrick-Prescott trends of the three marginal cost series in Figure 8.³⁰ The HP-trend was then subtracted from the associated real marginal cost series to get a new measure for the log real marginal cost as a deviation from steady state. The instrument set used in the estimation is unaltered. The point estimates for β^x and ω^x appear similar to the baseline values. The parameter δ^x proved still difficult to estimate, the point estimate having a large standard error or even obtaining a negative value. For case (1) we obtained the following results: For β^x fixed at 0.99, the estimate for ω^x is 0.644 (0.067) and the estimate for δ^x is 0.107 (0.132). Thus the estimate for δ^x is not statistically significant. The J-test statistic is 5.009 (0.891), implying that the overidentifying restrictions are not rejected. It is however important to remember that this exercise is in fact based on a totally different underlying theory, namely a theory that assumes a

³⁰The smoothing parameter is 1600.

non-constant optimal markup. Thus, no direct comparison to baseline results can be made.

Another interesting question is the stability of the share of goods priced in domestic currency. For example, one could ask whether there has been a gradual change in ω^x or whether the possible shift is related to the exchange rate regime. In this section we only report some preliminary results that consider the issue of parameter instability. The first experiment was conducted using a dummy variable that is zero for the period 1980:1–1990:4 and one for the period 1991:1–1998:4, so that the first period contains less exchange rate fluctuation than the second. The instrument set used in the estimation is unaltered. We studied the stability of ω^x by first investigating whether the dummy is significant, which was unfortunately not the case. However, by using the dummy for estimating ω^x for each period, we obtained a higher point estimate, 0.761 (0.212), for the period 1980:1–1990:4 and a lower point estimate, 0.408 (0.249), for the period 1991:1–1998:4, than for the whole estimation period benchmark case, 0.625 (0.077). However, the standard errors are so large that we cannot say whether these estimates are statistically different from the baseline results or from each other. Thus it seems that further research is needed to obtain reliable results for the stability of ω^x .

4.4 Discussion

The empirical results suggest that our forward-looking model of price setting behavior in an open economy provides a reasonably good description of both export and import price determination. The share of firms that set their price in the home currency was estimated at slightly over 60 per cent for both import and export firms. For exporting firms this implies that roughly 60 per cent of firms price in producer currency, while 40 per cent price in local currency. As a result, for the 60 per cent that price in the producer's currency, the pass-through of the exchange rate to destination-country prices is complete. Furthermore, for these 60 per cent of firms, profits in home currency are relatively insulated from exchange rate fluctuation.

However, a firm's profits may be affected by the exchange rate if it uses imported inputs in the production of its good.

Furthermore, the results suggest that about 40 per cent of firms in the export sector and 60 per cent of firms in the import sector use local currency pricing, which implies zero pass-through of the exchange rate in the short run. To the extent that there are local currency pricing firms, the prices that buyers face remain stable. However, local currency stability comes at a cost of profit exposure to exchange rate fluctuation. In other words, the price that these firms get for their product fluctuates one-to-one with the exchange rate.

From Finland's perspective, it seems that both export prices and import prices measured in domestic currency are relatively stable with respect to exchange rate fluctuation, with 60 per cent of foreign trade prices set in home currency. For the export industry this also means that the expenditure-shifting effect of exchange rate fluctuation is still relatively large, so that for 60 per cent of exporting firms exchange rate depreciation would lead to an improvement in competitiveness. At the same time, however, for 40 per cent of the firms, only profits are affected by movements in the exchange rate. In any case, the share of local currency pricing in Finnish foreign trade seems to be large enough for us to argue that producer currency pricing is not a good approximation of reality.

The finding that neither LCP nor PCP provides a full description of Finnish foreign trade price dynamics is in line with empirical literature on exchange rate pass-through. These empirical studies suggest that pass-through is positive but substantially below one (see eg Goldberg and Knetter 1997). In our model, which nests the two polar cases of PCP and LCP, the share of goods priced in home currency should be one instead of 0.60 for export prices and zero instead of 0.60 for import prices, in order to have full exchange rate pass-through. Even after taking into account the standard errors it is not likely that this would be the case. To sum up, both LCP and PCP assumptions are extreme in the light of our empirical evidence for Finland.

Unfortunately, our results do not shed light on the choice between local currency pricing and producer currency pricing. As we know, exporters and importers who want to keep the price faced by the buyer stable in order not to lose customers when the exchange rate fluctuates would choose local currency pricing. At the same time they

have to accept that their profit margin is exposed to exchange rate fluctuation. On the other hand, firms that appreciate a stable profit margin might want to choose producer currency pricing. The choice between LCP and PCP is not very important if the exchange rate is fixed and the probability of realignments low. However, under a floating exchange rate regime, the firm must consider the implications of its choice more carefully. Still, more research is needed to determine how the exchange rate regime and other factors would affect this choice.³¹

³¹Devereux and Engel (2001) have recently raised the issue of endogenous choice of currency of price setting in a two-country general equilibrium model. In their setup, exporters generally choose the currency of the country with the most stable monetary policy.

5 Conclusions

This paper addresses the question of how firms set prices of internationally traded goods. This matters because due to increasing world trade more and more goods are in fact internationally traded. In Finland, the share of exports of goods and services to GDP rose to over 40 per cent in the late 1990s. Furthermore, pricing behavior in the foreign trade sector is an important link via which the exchange rate affects the economy.

The traditional idea of trade price determination in a small open economy is relatively simplified. It is based on the assumption that all exporters face a horizontal demand schedule and thus act as price-takers. This implies that all internationally traded goods (both import and export goods) have exogenously given world market prices. In this case, both import and export prices would simply follow foreign trade prices, including changes in the exchange rate. Figure 1 shows that this does not appear to have always been the case. In particular, the exchange rate fluctuation in the 1990s is not fully reflected in Finnish foreign trade prices. This phenomenon, often referred to as limited pass-through of exchange rate, has also been witnessed in other countries.

What is puzzling in Figure 1 is the failure of markets to arbitrage international price differentials. Several empirical studies in fact argue that large price differentials can be found for seemingly identical goods (see eg Engel and Rogers 1996). A popular explanation is the international segmentation of markets, which allows monopoly producers to price to market by charging different prices in home and foreign markets. In his paper, Krugman (1987) started using term "pricing to market" for monopolistically competitive firms who choose to set different prices in segmented national markets. The importance of price setting behavior is also emphasized in Obstfeld and Rogoff (2000b) who consider two (short-term) pricing puzzles: the purchasing power parity puzzle (the weak connection between exchange rates and national price levels) and the exchange rate disconnect puzzle (the exceedingly weak relationship between the exchange rate and virtually all macroeconomic aggregates).

The theoretical literature has taken up the strong evidence that international markets for tradable goods remain highly segmented,

which allows firms to set prices according to the market. Moreover, since price taking behavior does not seem to provide a good explanation of trade price determination, the analysis starts with the assumption of product differentiation, which implies that there is monopolistic competition in the goods market; there are many similar but differentiated goods in the market. These are key assumptions also in the new open economy general equilibrium models. The idea of pricing to market has been incorporated into these models eg by Betts and Devereux (1996, 2000). Prices are assumed to be sticky in nominal terms and the firms face a choice of currency in which to set their prices. This leads to prices being sticky in the currency of either buyer (local currency pricing) or seller (producer currency pricing). The model thus generates pricing to market by assuming that some of the goods prices are set and are sticky in the currency of the destination market. However, if prices are flexible and the firms face identical demand curves in each market, the optimal price is equal across markets under both LCP and PCP. However, if prices are sticky, exchange rate fluctuations generate short-term price differentials and the law of one price no longer holds.

The main contribution of this paper is to develop a theoretical framework in which pricing behavior in an open economy can be analyzed and to examine aggregate Finnish trade price data within this framework. The model we develop draws on both the new open economy literature and the inflation dynamics literature. It is a rational expectations model of price setting behavior. Instead of price-taking, there is monopolistic competition in the goods markets and firms face a downward sloping demand curve that allows them to set their prices above marginal cost. Within this model we accommodate two different price setting regimes: local currency pricing and producer currency pricing.

Due to the assumption of nominal price rigidity, export and import price inflation are determined in a forward looking manner. Price setting decisions are influenced by current and anticipated marginal costs. In the short run, the price dynamics depend on the relative shares of LCP and PCP firms in the economy. This is an additional feature of our model compared to eg Galí and Gertler (1999) and Galí, Gertler and López-Salido (2001), who study inflation dynamics in a closed economy. In the export sector, the greater the share of firms setting their price in foreign currency (share of LCP firms), the larger

the impact from exchange rate fluctuation to export prices measured in domestic currency. The same applies to the import sector except that the firms that set their prices in foreign currency are exercising producer currency pricing. It is important to note that implicit in producer currency pricing is that export prices in foreign currency will be lowered (raised) by the full amount of the depreciation (appreciation) at the moment of the exchange rate change. Allowing for local currency pricing means that we allow for exporters to adjust foreign currency prices by less than the full extent of any exchange rate change. However, at the same time, under local currency pricing, all producers who hold their foreign-currency prices constant, allow their profit margins to adjust in proportion to unexpected exchange rate movements.

Since both LCP and PCP are extreme assumptions (LCP implies zero and PCP full exchange rate pass-through in the short run), our model is built on an assumption that allows for intermediate degrees of pass-through, ie the existence of both LCP and PCP firms in the economy. This is also in line with empirical evidence that pass-through to import prices is generally less than one but seldom zero. The implications of the two extreme assumptions have been studied theoretically and debated in the new open economy literature.

Confronting our model with Finnish data allows us to estimate the relative shares of LCP and PCP firms in the economy. We show that the model that assumes forward looking price setting and incorporates two types of firms (LCP and PCP) fits the data reasonably well for the period 1980–1998. For the export sector, the estimated share of LCP firms is approximately 40 per cent, and for the import sector, 60 per cent. The results obtained thus suggest that the expenditure shifting effect of the exchange rate is weaker than in the pure producer currency pricing case often assumed in theoretical models such as the Mundell-Fleming model. Furthermore, exchange rate volatility is not clearly reflected in the Finnish trade prices since roughly 60 per cent of both exports and imports are priced in home currency.

Although the estimate of the relative shares of LCP and PCP firms seemed to be fairly robust, this issue requires further study. For example, it is possible, that the choice of denomination currency depends on the exchange rate regime. The assumption of exogenous shares of LCP and PCP firms could thus be relaxed and the choice of currency naturally made endogenous. Furthermore, the model

generates pricing to market by assuming that goods prices are sticky in the currency of the importer. As a result, it is unable to explain pricing to market in the context of a monetary union with only one currency. A recent theoretical paper by Bergin (2000) tackles this issue. Introduction of the euro also raises the question of insularity of euro area trade prices from exchange rate fluctuations. If more and more trade is carried out in euros, it is likely that prices in the euro area are more and more insulated from exchange rate fluctuation. Naturally, the likely increased insularity of trade prices since 1999 applies to Finnish foreign trade prices as well, although currently the share of trade with countries outside the euro area remains larger than in most other euro area countries.

There is also a need for more analysis on the nature of optimal markups. It is worth recalling that our model is based on the assumption of a constant desired markup. This is a simplifying assumption. Perhaps a more realistic assumption would be that firms set prices as a variable markup on marginal costs, so that a model that accounts for variation in the desired markup would be more appropriate.

References

- [1] Betts, C. – Devereux, M. (1996) **The Exchange Rate in a Model of Pricing to Market.** *European Economic Review*, 40, 1007–1021.
- [2] Betts, C. – Devereux, M. (2000) **Exchange Rate Dynamics in a Model of Pricing to Market.** *Journal of International Economics*, 50, 215–244.
- [3] Bergin, P. (2000) **One Money One Price? Pricing to Market in a Monetary Union.** UC Davis, mimeo, (May).
- [4] Bergin, P. (2001) **Putting the 'New Open Economy Macroeconomics' to a Test.** UC Davis, mimeo, (August).
- [5] Calvo, G.A. (1983) **Staggered Prices in a Utility Maximizing Framework.** *Journal of Monetary Economics*, 12, 383–398.
- [6] Corsetti, G. – Pesenti, P. (2001) **International Dimensions of Optimal Monetary Policy.** NBER Working Paper 8230.
- [7] Davidson, R. – MacKinnon, J.G. (1993) **Estimation and Inference in Econometrics.** Oxford University Press.
- [8] Devereux, M. (1997) **Real Exchange Rates and Macroeconomics: Evidence and Theory.** *Canadian Journal of Economics*, 30, 773–808.
- [9] Devereux, M. – Engel, C. (2001) **Endogenous Currency of Price Setting in a Dynamic Open Economy Model.** NBER Working Paper 8559.
- [10] Devereux, M. – Engel, C. – Tille, C. (1999) **Exchange Rate Pass-Through and the Welfare Effects of the Euro.** NBER Working Paper 7382.
- [11] Dornbusch, R. (1987) **Exchange Rates and Prices.** *American Economic Review*, 77, 93–106.
- [12] Enders, W. (1995) **Applied Econometric Time Series.** John Wiley & Sons, Inc.

- [13] Engel, C. (1993) **Real Exchange Rates and Relative Prices. An Empirical Investigation.** Journal of Monetary Economics, 32, 35–50.
- [14] Engel, C. – Morley, J.C. (2001) **The Adjustment of Prices and the Adjustment of the Exchange Rate.** NBER Working Paper 8550.
- [15] Engel, C. – Rogers, J.H. (1996) **How Wide Is the Border?** American Economic Review, vol. 86 no. 5, 1112–1125.
- [16] Engel, C. – Rogers, J.H. (2001) **Deviations from Purchasing Power Parity: Causes and Welfare Costs.** Journal of International Economics, 55, 29–57.
- [17] Favero, C.A. (2001) **Applied Macroeconometrics.** Oxford University Press.
- [18] Friberg, R. (1998) **In Which Currency Should Exporters Set Their Prices?** Journal of International Economics 45, 59–76.
- [19] Galí, J. (2000) **New Perspectives on Monetary Policy, Inflation, and the Business Cycle.** Invited lecture at the World Congress of the Econometric Society, 2000.
- [20] Galí, J. – Gertler, M. (1999) **Inflation Dynamics: A Structural Econometric Analysis.** Journal of Monetary Economics 44, 195–222.
- [21] Galí, J. – Gertler, M. – López-Salido, J.D. (2001) **European Inflation Dynamics.** European Economic Review, 45, 1237–1270.
- [22] Goldberg, P. – Knetter, M. (1997) **Goods Prices and Exchange Rates: What Have we Learned?** Journal of Economic Literature, 35, 1243–1272.
- [23] Hansen, L.P. (1982) **Large Sample Properties of a Generalized Method of Moments Estimators.** Econometrica, 50, 1029–1052.

- [24] Kollman, R. (1997) **The Exchange Rate in a Dynamic-Optimizing Current Account Model with Nominal Rigidities: A Quantitative Investigation.** International Monetary Fund Working Paper 97/7.
- [25] Krugman, P. (1987) **Pricing to Market when the Exchange Rate Changes.** In S.W. Arndt and J.D. Richardson (eds.), Real Financial Linkages among Open Economies. MIT Press, Cambridge, MA.
- [26] Lane, P.R. (1999) **The New Open Economy Macroeconomics: A Survey.** CEPR Discussion Paper, No. 2115.
- [27] Mas-Colell, A. – Whinston, M.D. – Green, J.R. (1995) **Microeconomic Theory.** Oxford University Press.
- [28] Mátyás, L. (ed.) (1999) **Generalized Method of Moments Estimation.** Cambridge University Press.
- [29] Obstfeld, M. (2000) **International Macroeconomics: Beyond the Mundell-Fleming Model.** The Mundell-Fleming Lecture, First Annual Research Conference of the International Monetary Fund, November 9–10, 2000, Washington, D.C.
- [30] Obstfeld, M. – Rogoff, K. (1995) **Exchange Rate Dynamics Redux.** Journal of Political Economy, 103, 624–660.
- [31] Obstfeld, M. – Rogoff, K. (1996) **Foundations of International Macroeconomics.** MIT Press, Cambridge, MA.
- [32] Obstfeld, M. – Rogoff, K. (2000a) **New Directions for Stochastic Open Economy Models .** Journal of International Economics, 50, 117–154.
- [33] Obstfeld, M. – Rogoff, K. (2000b) **The Six Major Puzzles in International Macroeconomics: Is there a common Cause?** NBER Working Paper 7777.
- [34] Rogoff, K. (1996) **The Purchasing Power Parity Puzzle.** Journal of Economics Literature, 34, 647–668.

- [35] Rotemberg, J. (1982) **Monopolistic Price Adjustment and Aggregate Output.** *Review of Economic Studies*, 49, 517–531.
- [36] Rotemberg, J. (1987) **The New Keynesian Microfoundations.** *NBER Macroeconomics Annual*, 1, 69–104.
- [37] Sarno, L. (2000) **Towards a New Paradigm in Open Economy Modeling: Where do we Stand?** Mimeo, St. Louis FRB. (technical version of forthcoming Federal Reserve Bank of St. Louis Review paper).
- [38] Svensson, L. – van Wijnbergen, S. (1989) **Excess Capacity, Monopolistic Competition and International Transmission of Monetary Disturbances.** *Economic Journal*, 99, 785–805.
- [39] Uhlig, H. (1999) **A Toolkit for Analyzing Nonlinear Dynamic Stochastic Models Easily.** In Marimon, Ramon and Andrew Scott (eds.), *Computational Methods for the Study of Dynamic Economies*, Oxford University Press, New York.

A Appendix

A.1 Theoretical variables and operational counterparts

p_t^m	Import prices of goods and services. Index 1995=1. Statistics Finland: National Accounts.
p_t^x	Export prices of goods and services. Index 1995=1. Statistics Finland: National Accounts.
e_t^m	Effective exchange rate (nominal, import-based). Index 1995=1. Calculated by the ECB.
e_t^x	Effective exchange rate, (nominal, export-based). Index 1995=1. Calculated by the ECB.
mc_t^m	Real marginal cost on the import side. Obtained by dividing nominal marginal cost by p_t^m . Nominal marginal cost consists of competitors' prices on the import side. It is a weighted sum of trading partners' export prices in Finnish currency. The weights are the import shares, and their geographical coverage is the whole world. Calculated by the ECB.
mc_t^x	Real marginal cost on the export side. Obtained by dividing nominal marginal cost by p_t^x . There are three measures for nominal marginal cost 1) Unit labor costs and import prices, respective weights 0.6 and 0.4. Unit labor costs, total, 1995=1. Statistics Finland: National Accounts. Import prices of goods and services, Index 1995=1. Statistics Finland: National Accounts. 2) private sector GDP deflator at factor prices, 1995=1. Statistics Finland: National Accounts. 3) Unit labor costs , total, 1995=1. Statistics Finland: National Accounts.

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