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Exchange Rate Pass-through in a Small Open Economy
The Importance of the Distribution Sector

Abstract:
Several small open economies switched to inflation targeting during the 1990s, thereby giving up various forms of exchange rate targeting in favour of flexible exchange rates. Norway did the same early in 2001, and has thereafter experienced highly varying nominal exchange rates with consumer price inflation dropping far below the target during 2003 and 2004. Knowledge of the degree of exchange rate pass-through to import prices and further to consumer prices is essential for inflation targeting. The literature suggests that pass-through is greater to import prices than to consumer prices, which presumably is related to the role of distributors in the economy. We present empirical evidence on these issues for Norway by estimating import price equations and a dynamic model of the distributors pricing behaviour. Using a large-scale macroeconometric model of the Norwegian economy, we find exchange rate pass-through to import prices to be quite rapid in the short run, while pass-through to consumer prices seems to be modest. We show that, among the numerous channels through which the exchange rate operate, trade margins in the distribution sector act as cushions to exchange rate fluctuations, thereby being one of the main important source for the delay in pass-through. In spite of moderate pass-through to consumer prices, we find inflationary effects of exchange rate changes even in the short run, an insight important for inflation targeting central banks.

Keywords: Exchange rate pass-through, pricing behaviour, the distribution sector, econometric modelling and macroeconomic analysis

JEL classification: C51, C52, E31, F31

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1. Introduction

The economic literature on small open economies has usually been based on the assumption of price taking behaviour, in particular when it comes to prices in international markets. The "Scandinavian model of inflation" is an example in which price taking behaviour of traded commodities is present, cf. Aukrust (1977) and Lindbeck (1979). The implication of this theory is that one should observe the "law of one price", at least for traded goods, while for aggregate prices one might well observe deviations from purchasing power parity (PPP) due to differences in productivity in the production of non-traded goods between countries and/or preferences. The evidence of systematic failure of the law of one price to hold for internationally traded goods has lead researchers to look for alternative assumptions that may explain the apparent "paradox".[1] The pricing-to-market hypothesis introduced by Krugman (1987) and others based on the assumptions of imperfect competition, nominal rigidities and market segmentation, is now the standard workhorse of the new open economy literature.

In the literature that follows Obstfeld and Rogoff (1995), a distinction is drawn between producer currency pricing (PCP) and local currency pricing (LCP), thereby giving attention to the role of the degree of exchange rate pass-through to domestic prices. According to PCP, prices on internationally traded goods are set in the currency of the producer (exporter). If PCP holds, producers do not change their prices frequently, whereas consumers (and importers) face prices that vary one-for-one with nominal exchange rate changes (due to full pass-through). In this framework, changes in the nominal exchange rate is passed on to the terms of trade and consumers' demand for home relative to foreign goods. LCP by exporters, on the other hand, is a price setting strategy in which prices are set in the currency of the consumer, with no (or limited) pass-through of nominal exchange rate changes to import prices, at least in the short run. Thus, there may be only small effects from exchange rate changes to producer costs (to the extent that production is based on imported materials) as well as to consumer prices (to the extent that consumption is based directly on imported goods and services). Furthermore, exchange rate changes will not have the expenditure switching effect that is the main channel of exchange rate effects to the real economy in the Mundell-Fleming model.

[1] See surveys by Rogoff (1996) and Goldberg and Knetter (1997). Persistent deviations from long run PPP is found by Engel (2000), while Chen and Rogoff (2003) show that the PPP puzzle applies to Australia, Canada and New Zealand.

Some investigators, such as Engel (1993)[2], use evidence of limited exchange rate pass-through to consumer prices as a justification for models with local currency pricing. Goldberg and Knetter (1997) emphasise this evidence as consumer prices often are found to be less affected by changes in exchanges rates than export prices. Possible explanations and failure of the law of one price are, according to Engel and Rogers (2001), tariff and non-tariff barriers to trade, transportation costs, and non-traded inputs such as marketing and other distribution services that are part of final goods prices, but not to the same extent part of prices of imported or exported goods. Others, such as Obstfeld and Rogoff (2000), argue that correlations between changes in terms of trade and exchange rates for a large sample of countries are consistent with models of producer currency pricing. On the other hand, they argue that local currency pricing is relevant for retail prices while prices on imported goods faced by retailers react to fluctuations in exchange rates as these prices (i.e., wholesale prices) are based on producer currency pricing.[3] Thus, there is both theoretical and empirical evidence suggesting low (or even zero) pass-through of exchange rate fluctuations to consumer prices that may be related to the role of distributors in the economy.

Inspired by Obstfeld and Rogoff (2000), we present empirical evidence on exchange rate pass-through in Norway by estimating import price equations and a dynamic model of the distributors pricing behaviour, which then are analysed within a large-scale macroeconometric model of the Norwegian economy. Unlike related studies, which typically are based on partial analyses of aggregated single-equation models (see references cited above), we examine the exchange rate pass-through on domestic prices, production costs and mark-ups for a large number of commodities and sectors in the economy. For instance, we include profitability effects in the exposed industries as well as price-wage spirals that are likely to occur and be important for consumer prices in the face of exchange rate shocks. Studying exchange rate pass-through along these lines enable us to take account of numerous channels through which the exchange rate is likely to operate in a small, open economy like the Norwegian. The Norwegian experience provides an interesting case as Norway has faced fairly high exchange rate volatility across different monetary policy regimes in recent decades. Also, the switch to inflation targeting early in 2001 has produced some rather large fluctuations in the exchange rate with consumer price inflation dropping far below the target of 2.5 per cent (and even the inflation band) during 2003 and 2004.

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[2] Others include for instance Rogers and Jenkins (1995), Betts and Devereux (1996), Obstfeld and Taylor (1997), Engel (1999, 2000) and Engel and Rogers (2001).

[3] Burstein *et al.* (2002) and Burstein *et al.* (2003) consider models in which the pass-through to consumer prices is lower than to import prices as a result of local distribution costs in the wholesale and retail trade sector.

We show that, although complete pass-through is prevalent and follows from our theoretical assumptions in the long run, the pass-through to consumer prices is not complete even within a ten-year horizon. Furthermore, we demonstrate that trade margins in the distribution sector act as cushions to exchange rate fluctuations in the short run, thus limiting the extent of exchange rate pass-through to consumer prices. If domestic inputs to the distribution sector are quantitatively important, then tradable goods sold to consumers include national value added that may partly explain why there is incomplete pass-through. Likewise, imports as intermediate goods that together with domestic inputs produce final goods sold to consumers may also contribute to limited pass-through of exchange rates to consumer prices. We argue that, in spite of moderate pass-through within a horizon relevant for monetary policy, the inflationary effects of exchange rate changes are important for inflation targeting central banks.

The rest of the paper is organised as follows: Section 2 outlines the main channels of exchange rate pass-through inherent in the macroeconometric model. Section 3 presents a dynamic model of the pricing behaviour in the distribution sector where the degree and timing of exchange rate pass-through are estimated econometrically. Section 4 reports empirical findings of exchange rate pass-through in the Norwegian economy following from simulations on the macroeconometric model. Section 5 concludes.

2. Channels of Exchange Rate Pass-through

A full description of the quarterly macroeconometric model used in this paper will not be given here, but can be found in Biørn *et al*. (1987) based on the original model version.[4] Briefly speaking, the model is a disaggregated (44 commodities of which 9 are non-competitive imports and 24 production sectors) input-output based, but otherwise conventional, macroeconometric model. Production is largely demand driven in the short run, while long run supply effects appear through labour supply and wage formation. Import and export equations are based on the Armington approach. Private consumption and investment in housing are mainly determined by household disposable income and real interest rates, while other private investments are determined by production and profitability. Labour supply is fairly inelastic with respect to after tax consumer real wage. In what follows, we present in some detail the main pass-through channels through which the exchange rate affects

[4] During the last two decades the model has been extended and updated in various ways. The model description in Boug *et al.* (2002) is to a large extent applicable as a description of the model used here. See also Bowitz and Cappelen (2001) for a discussion of the price and wage behaviour in the model.

domestic prices, production costs and mark-ups. For ease of exposition we omit subscripts for product and/or sector and present the model as if it was an aggregated model.

Our theoretical framework is based on the standard assumption of imperfectly competitive markets characterised by differentiated products when delivered to the domestic market (home goods) and abroad (exported goods). Producers are consequently assumed to face regular downward sloping demand curves. Profit maximisation then leads to the standard formula stating that the product price (*P*) equals a mark-up (*MU*) times marginal costs (*MC*).[5]

(1) $$P = MU \cdot MC \, .$$

The mark-up in (1) is often assumed to be a constant by referring to one particular case in Dixit and Stiglitz (1977). If the commodities under study are good substitutes among themselves, but poor substitutes for other goods, and a number of other assumptions are invoked, so-called two-stage budgeting is valid. Moreover, if the number of goods in the industry is large (denoted by *n*) so that $1/n$ is small, Dixit and Stiglitz (1977) show that the individual price has little impact on the aggregate price. Hence, one may assume that the individual producer ignores the effect of his price setting on the aggregated price. In the New Keynesian Phillips Curve literature it is common to assume that producers face isoelastic demand curves so that the mark-up is a constant, see e.g. Gali *et al.* (2001). In a less restrictive case, the mark-up is not constant but will depend on all factors affecting demand for the particular commodity, cf. equation 32 in Dixit and Stiglitz (1977). We allow the mark-up to depend on relative prices. Consequently, we do not assume the mark-up to be constant and we accommodate the view that lower imported inflation is an important explanatory variable for the disinflation that most OECD-countries have experienced recently.[6] Denoting the import price that domestic producers face for *PI*, we assume

(2) $$MU = m(P / PI) \, .$$

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[5] Until otherwise noted, we neglect the difference between export prices and domestic prices (prices on products delivered to the home market by domestic producers).

[6] Rogoff (2003) argues that deregulation and globalisation, which have increased competition and consequently lowered monopoly rents (i.e., mark-ups of price over marginal cost), have been powerful forces behind low inflation throughout much of the world over the past decade or so. One way of capturing such an argument is to allow for lower import prices to increase the competitive pressure in domestic markets by reducing mark-ups. This is what (2) below captures. Deregulation could be captured partly by lower tariffs included in our model, but these tariffs are very small in Norway. The main trade barriers are for some specific agricultural products where trade restrictions in practice imply no imports. These restrictions have been fairly constant for a long time.

The marginal costs are often specified as a variant of variable unit costs combined with a measure of capacity utilisation, see e.g. Smith (2000) and Bowitz and Cappelen (2001). For each sector, we assume a Cobb-Douglas production function with labour and materials as variable factors and capital as quasi fixed. Then, *MC* and variable unit costs (*VUC*) are proportional. Thus, we may replace *MC* with *VUC* in (1). Variable unit costs are given by

$$VUC = (PM \cdot M + W \cdot LW)/X \,, \tag{3}$$

where *M* is input of materials defined as a simple Leontief-aggregate of the 44 commodities included in the model, *PM* is the dual price index of *M*, *W* is wage costs per hour, *LW* is hours worked and *X* is gross production.[7] The input price index *PM* by sector is determined by[8]

$$PM = \sum_i \alpha_i \left[(1 + VAT_i) \cdot ((1 - IS_i) \cdot P_i + IS_i \cdot PI_i)\right], \tag{4}$$

where the α's are input-output coefficients, VAT_i are value added tax rates and IS_i are the import shares of various products. As inputs of imported materials are important for total material costs (many large values of $\alpha \cdot IS_i$ in (4)), changes in exchange rates – when passed through to prices in local currency – will affect domestic prices significantly to the extent that domestic producers have market power. For each commodity, assuming weak separability in demand between imported goods and home goods of the same variety, the import share is a function of the relative domestic price to the import price such that

$$IS = l(P/PI) \,. \tag{5}$$

Aggregate foreign export prices in foreign currency times the exchange rate relative to a basket of currencies would traditionally be considered as the main determinants of import prices in domestic currencies, at least in a small open economy. However, a number of empirical studies have found less than complete pass-through of exchange rate changes to prices of competitive imports, see for instance

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[7] We shall *not* go into details on how factor demands (i.e., *LW* and *M* in (3)) are modelled in the macroeconometric model. Briefly speaking, they are based on a CD/CES structure and cross-equation restrictions on parameters of the production function are imposed for the long run solution. The simulations in Section 4 show only small changes in factor proportions, so for our purpose we may leave this issue. The actual model specifies energy demand as a CES-aggregate of electricity and fuels in addition to other materials. We have lumped all material factors into the aggregate *M* to simplify the presentation.

[8] We have for ease of exposition ignored some details related to the treatment of indirect taxation in the equation below compared to the complete macroeconometric model.

Menon (1995), Goldberg and Knetter (1997), Campa and Goldberg (1999) and Brauer (2003). We base our modelling of import prices of manufactures (in local currency) on the pricing-to-market hypothesis advanced by Krugman (1987) and the econometric study by Naug and Nymoen (1996). As explained in Appendix A, we have included domestic costs (through *VUC*) in order to include pricing-to-market effects in the equation for import prices of manufactures, which in a simplified form reads as

(6) $$PI = g(PW \cdot E, VUC),$$

where *PW* is the aggregate foreign export price (in foreign currency) and *E* is the import-weighted nominal exchange rate. The function $g(\cdot)$ is homogenous of degree one in prices and the domestic cost component enters with an elasticity of 0.35. The pricing-to-market effects imply that the exchange rate is (partially) not fully passed on to import prices in domestic currency due to imperfect competition. However, domestic costs are also affected by the exchange rate, as previously described, so the exchange rate pass-through is complete in the long run by assumption. This assumption is in line with the idea that monetary policy has no real effects in the long run. The interesting question for an inflation targeting central bank, however, is the exact timing of inflation effects within a standard inflation forecasting horizon. We attempt to answer this question in Section 4. In the case of non-competitive imports where no similar domestic production exists we invoke the law of one price in the macroeconometric model, see Appendix A for details.

The modelling of wages is based on the symmetric Nash bargaining model following Nickell and Andrews (1983) and Hoel and Nymoen (1988). In manufacturing, wages are determined by profitability in that sector (which determines the "wage-corridor" in the long run version of the Scandinavian model of inflation) in addition to unemployment, while consumer prices as well as income taxes have no effect. Thus, the wage-curve is in terms of the producer real wage not the consumer real wage. In private and government services wages are based on the alternative or "outside" wage. Given our exposition of exchange rate pass-through, we write the simplified equation as

(7) $$W = Z \cdot PYF \cdot U^{-\eta},$$

where *Z* is labour productivity defined as value added per hours worked, $(X - M) / LW$, *PYF* is the factor income deflator defined as the value added deflator at factor prices, $P - (PM \cdot M / X)$, and *U* is the unemployment rate determined as the difference between supply and demand of labour in the model as a whole. Hence, we see that exchange rate pass-through to wages mainly works through import prices to the extent that imported materials are important for total material costs. We notice that the coefficient η, which is econometrically estimated, measures the degree of pass-through from unemployment changes to wages.

From (1), (2) and (3) we obtain

(8) $$P = h(VUC, PI).$$

According to theory, $h(\cdot)$ is homogenous of degree one in *VUC* and *PI*. The product price *P* is either the domestic price or the export price. In this paper, we assume no *direct* effects of exchange rates on export prices in domestic currency. Thus, our model of export prices is basically based on the producer currency pricing (PCP) assumption. We note, however, that there are *indirect* exchange rate effects on export prices both via domestic costs (*VUC)* and import prices (*PI*). Econometric results from estimating (8) show small effects of import prices on domestic prices implying that the mark-up is nearly constant in most domestic markets, while it is highly dependent on import prices in export markets.

Although the price equation (8) is derived from a theory of monopolistic competition, it also encompasses the main alternative, namely that of the law of one price or perfect competition for homogenous goods. In the latter case, the price is equal to the price of the competitors, so that $P = PI$.[9] A model of producer prices based on the assumption that producers in small open economies are "price-takers" in world markets, implies that PPP holds. But this model is rejected by most empirical studies, and is partly the rationale for the pricing-to-market assumption of Krugman (1987) and others.

Central banks often focus on inflation targets based on consumer prices. Prices on final demand such as consumer prices are in principle determined in the same way as prices on material inputs (*PM*) given by (4). For most consumer price indices the trade margins in the distribution sector play an

[9] To see this, let $MU = m_0 (P/PI)^{m_1}$. Then, using (1), we have $P = m_0^{1/(1-m_1)} \cdot PI^{-m_1/(1-m_1)} \cdot MC^{1/(1-m_1)}$ and $P = PI$ if m_1 approaches infinity.

important role and much more so than for producers. For each consumption group[10] we define a price index (*CP*) that generally reads as

$$CP = \sum_i \alpha_i \left[(1+VAT_i)\cdot((1-IS_i)\cdot P_i + IS_i \cdot PI_i + \psi_i ET_i)\right] + \alpha_D \cdot TM \tag{9}$$

which links domestic and import prices by import shares, value added taxes and excise taxes (*ET*).[11] In (9), as opposed to (4), we have made explicit the national accounts price index for the trade margins in the distribution sector (*TM)* as well as the share of the trade margins (α_D) out of total consumer price of each consumption group in the base year. For some categories of consumption, say electricity and services such as transportation, there is no trade margin at all so α_D is zero. But for the CPI as a whole, the share of the trade margins is close to 0.3. Thus, *TM* is of great importance for the determination of consumer prices and thereby inflation. The direct (and partial) effect of an import price increase on the CPI through the imported goods in (9) is estimated in the national accounts to 0.17 in 2000. As long as the trade margins are assumed constant in nominal terms, this effect is immediate, i.e., it takes place in the same quarter as import prices increase. Given the importance of the distribution sector and the trade margins for consumer prices, we now look closer at what determines the trade margins.

3. The Distribution Sector[12]

Our modelling of the pricing behaviour in the distribution sector (or the wholesale and retail trade sector) differs somewhat from the general price equation (8). According to the Norwegian national accounts, the domestic price in the wholesale and retail trade sector comprises the *trade margins* on the distribution services from supplier to user. As such, the national accounts make a clear distinction between services delivered and products traded, and it is the former that constitute the production activity in the distribution sector. The final consumer price thus consists of two components: the price on the services delivered (i.e., the trade margin) and the purchasing price (or costs) on goods sold (exclusive of the trade margin).

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[10] In the macroeconometric model household consumer demand is disaggregated into 15 subgroups determined by a dynamic Almost Ideal Demand System (AIDS), see Boug *et al*. (2002) and the references cited therein for details.

[11] The *VAT* rate varies between consumer goods as food items enjoy a lower rate than most items. The *ET* rate also varies between consumer goods with high rates on tobacco, alcohol and petrol. In the model simulations in Section 4, we assume all *ET* rates adjust in accordance with the consumer price index (CPI) to avoid any nominal price inertia due to these variables to affect the empirical findings.

[12] The econometric modelling was performed using PcGive 10, cf. Hendry and Doornik (2001) and Doornik and Hendry (2001). In the following, square brackets [..] and parenthesis (..) contain *p*-values and standard errors, respectively.

In line with (8), we assume trade margins to be proportional to marginal costs in the distribution sector. Here, we may think of two cases depending on the substance of the marginal costs in each particular wholesale and retail trade firm. First, some firms may set their trade margins as a *constant amount of money per unit traded commodity*, i.e., independent on the purchasing price per unit (exclusive of the trade margin). In this case, the marginal costs are only related to costs of production. We approximate these costs in accordance with (3); letting VUC^{d} denote variable unit costs in the distribution sector. Second, some firms may set their trade margins as a *constant percentage mark-up on the purchasing price* (exclusive of the trade margin). In this case, the marginal costs also depend on the purchasing price on goods sold, and not only on costs in production. Firms will for instance see goods not sold and risk of price reductions as costs, and these costs will normally increase with purchasing prices. We approximate these costs by constructing the following price index of purchasing prices (*PP*) in the distribution sector:

(10) $$PP = \sum_{k} \delta_{k} \left[\sum_{i} \beta_{ik} (1 - IS_{i}) \cdot P_{i} + \beta_{ik} \cdot IS_{i} \cdot PI_{i} \right],$$

where δ_k is the volume share of demand category k out of total trade, β_{ik} is the input-output coefficient for total delivery of commodity i to demand category k in the base year and IS_i, P_i and PI_i are as defined in the previous section.[13] This price index thus weighs together domestic and import prices on all commodities traded through the wholesale and retail trade sector. Both the import shares (through IS_i) and each demand category weight (through δ_k) are time series. For simplicity, we assume constant β_{ik} coefficients. We thus ignore any variations in these coefficients relative to the base year values in (10).

Our modelling of the distributors pricing behaviour further take into account the fact that the distribution sector in Norway has undergone significant structural changes in market conditions over the past two decades. Shopping centres and other huge trade houses (i.e., generalists) have replaced a large part of small self-employed shops (i.e., specialists). In this way generalists, resulting in a persistent dampening of trade margins over time, now trade much of the goods and services

[13] The main demand categories included in (10) are food, beverages and tobacco, fuels for heating purposes, purchase of and expenses on own transport vehicles, purchase of other durable goods, clothes and footwear, health services and gross investments in machines and transport vehicles. The β_{ik} coefficients in (10) are scaled such that for each demand category k they sum up to unity for those commodities included in k. Likewise, by definition, the δ_k coefficients also sum up to unity. We note that the prices included in *PP* are producer prices (exclusive of trade margins) based on sales to the domestic market only. The national accounts define a similar price index for sales on foreign markets and the export price deflator for the trade sector is equal to this index.

traditionally supplied by specialists. We try to capture this underlying trend by including a ratio between self-employed hours worked (H) and total production or services delivered (X^d) in the price equation for the trade margins. We may now specify the price equation as

$$(11) \qquad TM = PP^{\gamma} \cdot VUC^{d\,(1-\gamma)} \cdot (H / X^{d})^{\phi} ,$$

where the coefficients γ, $(1-\gamma)$ and ϕ measure the degree of pass-through of changes in purchasing prices (through domestic and/or import prices), variable unit costs and the mentioned ratio of the two "trend"-variables, respectively. We note that homogeneity between TM, PP and VUC^d is imposed in (11), and that potential asymmetric effects from the different marginal costs on the trade margins are allowed for (i.e., $\gamma \neq 0.5$). Although the exchange rate does not influence trade margins directly in (11), it does so indirectly through the definitions of variable unit costs and purchasing prices, cf. equations (3) and (10). It is likely that trade margins adjust gradually to changes in PP, VUC^d and (H/X^d) due to costs of adjustment or other inertia, so an econometric model should be specified dynamically. However, (11) may be interpreted as a long run, cointegrating relationship and will therefore serve as the starting point for the cointegration analysis below. In the dynamic modelling, we introduce changes in the nominal exchange rate (E) as an additional explanatory variable and suggest that trade margins act as cushions to exchange rate fluctuations in the short and medium term, thereby mitigating the degree of exchange rate pass-through. We also open up for the nominal interest rates (R) to play a potential role in the short run dynamics of trade margins to count for *financial* costs associated with stock of goods.[14]

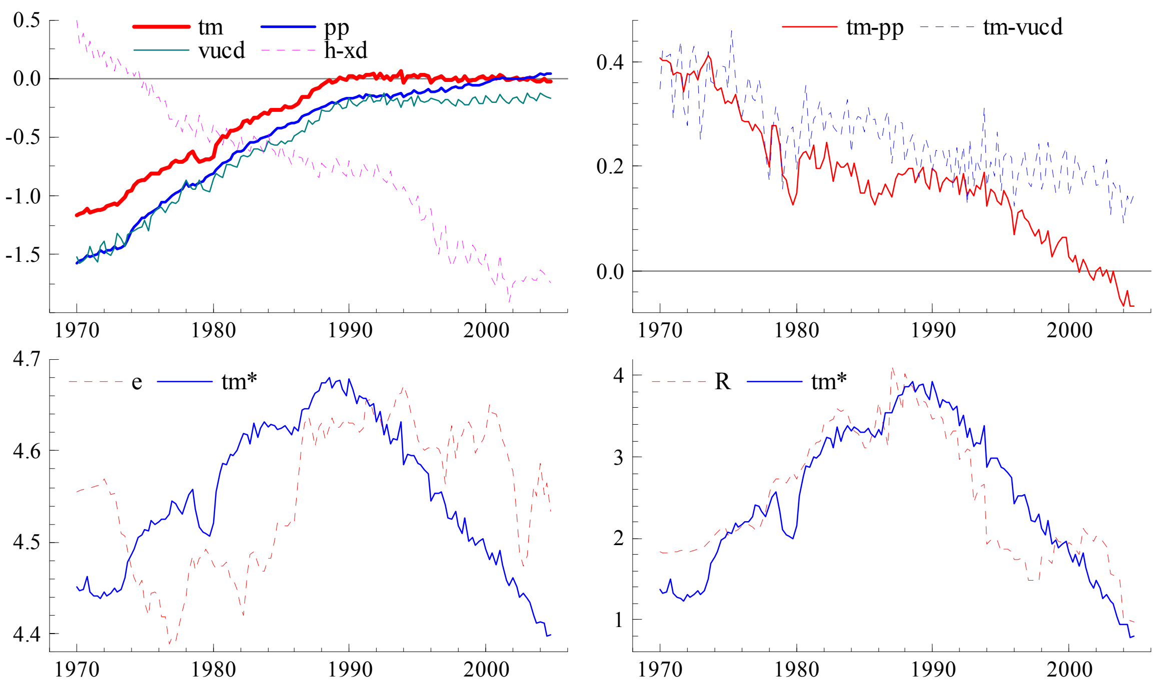
The econometric modelling of trade margins is conducted using quarterly, seasonally unadjusted data that spans the period 1970:1−1998:4.[15] The actual estimation period is shorter due to loss of

[14] We include other costs of stock holdings in the measure of variable unit costs.

[15] One may argue that the degree of exchange rate pass-through to domestic prices depends on the monetary policy regime in a given period, see Friberg (2001) and Berben (2004) among others for motivations. During the 1970s Norway joined the European exchange rate agreement, the so-called "snake". However, the Norwegian currency (the krone) experienced significant revaluations and devaluations during the first decade of our sample period. Also, when Norway left the "snake" at the end of the 1970s and established a currency basket, the krone showed relatively high variability during the 1980s. Following a 12 percent devaluation of the krone in May 1986, a flexible interest rate policy was introduced with the explicit goal of supporting a policy of fixed exchange rates, and as of October 1990 against the ECU. After the turmoil following the speculative attacks against the krone by the end of 1992, Norway more or less changed to a floating exchange rate regime. As noted, Norway *formally* changed to floating exchange rates following the introduction of inflation targeting in late March 2001, and has thereafter experienced highly varying nominal and real exchange rates. Several Norwegian economists argue that the regime change in fact occurred early in 1999. In any case, the policy change took place after 1998:4; the last observation used in our estimations. To sum up, Norway has experienced marked exchange rate volatility during the last decades, and different monetary policies could in principle have caused the degree of exchange rate pass-through to shift in accordance with the Lucas critique. We pursue this issue further below.

observations as a result of lags and differencing of variables. We extend the sample, however, by twenty four quarters in order to conduct *out-of-sample* forecasting following the introduction of inflation targeting in Norway. The exchange rate series is an import-weighted nominal exchange rate index that covers the main Norwegian trading partners, while the series for the interest rates comprises an average of nominal interest rates on bank loans in the private sector. Further details of the data definitions and sources can be found in Appendix B. All variables except the interest rates are in logarithms and denoted by lower case letters in what follows, hence $\Delta y_t = y_t - y_{t-1}$ is the growth rate of *Y*. Figure 1 displays time series of trade margins (tm_t), purchasing prices (pp_t) and variable unit costs (vuc_t^d), together with the three ratios $(tm–pp)_t$, $(tm–vuc^d)_t$ and $(h–x^d)_t$ over the period 1970:1–2004:4. To shed light on the empirical relationships between some key variables, the figure also shows time series of trade margins adjusted for deterministic seasonality and trend (tm_t*) together with the nominal exchange rate (e_t) and the nominal interest rate (R_t).[16]

Figure 1. Trade margins (*tm*, *tm), purchasing prices (*pp*), variable unit costs (*vuc^d*), the ratio between self-employed hours worked and production (*h–x^d*), the nominal exchange rate (*e*) and the nominal interest rate (*R*)**



[16] In Figure 1, the scale of tm_t* is adjusted to match that of e_t and R_t.

First, we observe that trade margins, purchasing prices and variable unit costs exhibit a clear upward trend. The underlying development in the market conditions described above is also evident in the data series as $(h{-}x^d)_t$ shows a clear downward trend, a trend which presumably has contributed to the observed price dampening since the late 1980s. These data properties suggest that tm_t, pp_t, vuc_t^d and $(h{-}x^d)_t$ can be modelled as non-stationary I(1) variables. A clear reduction in the trade margins through 1979 coincides with the massive governmental price regulations during the second half of the 1970s. We also observe that trade margins have decreased somewhat relative to both purchasing prices and variable unit costs over the entire period. Overall, the data set suggests that purchasing prices, variable unit costs and the ratio between self-employed hours worked and production are important candidates for explaining the trade margins in the wholesale and retail trade sector. It is not obvious, however, whether the data series have the property of forming a cointegrating vector that is consistent with the economic model. Contrary to the series just discussed, it seems reasonable to assume that the exchange rate and the interest rates are stationary I(0) variables as evidence of mean reversion (although slow) is present in the data. Over some of the sub-periods, the development of the trade margins (tm_t*) is matched rather closely by changes in the exchange rate and the interest rates, indicating that they are not independent of each other in the short run.

We utilise the multivariate method suggested by Johansen (1988) to fit a reduced rank vector autoregressive (VAR) model to the data. The starting point of the cointegration analysis and the tests that follows is an equilibrium correction representation of a VAR model of order k that reads as

$$(12) \qquad \Delta z_t = \mu + \sum_{i=1}^{k-1} \theta_i \Delta z_{t-i} + \pi z_{t-1} + \phi D_t + \varepsilon_t \, ,$$

where $\varepsilon_t \sim \mathrm{IN}(0,\Sigma)$, z_t is a (px1) vector of modelled variables, μ is a vector of constants and D_t is a vector of deterministic and stochastic variables that are assumed to be I(0) and weakly exogenous for the parameters in (12).[17] Assuming z_t to be I(1), presence of cointegration implies $0<r<p$, where r denotes the rank or the number of cointegrating vectors of π. The null hypothesis of r cointegrating vectors may be formulated as $H_0 : \pi = \alpha\beta'$, where α and β are pxr matrices, $\beta' z_t$ comprises r cointegrating I(0) linear combinations and α contains the adjustment coefficients.

[17] See e.g. Rahbek and Mosconi (1999) for a discussion of cointegration rank inferences with presence of stationary regressors in the VAR model.

In the following analyses, z_t contains the four assumed I(1) variables discussed above, that is the trade margins (tm_t), the purchasing prices (pp_t), the variable unit costs (vuc_t^d) and the ratio $(h-x^d)_t$. The exchange rate (e_t) and the interest rates (R_t), on the other hand, are included in D_t as conditioning variables. To account for seasonality in the series and effects on trade margins of price controls during the 1970s, D_t also contains three centered seasonal dummies (labelled CS_{1t}, CS_{2t} and CS_{3t}) and a price stop dummy (labelled $PSTOP_t$) with a value of unity in regulation periods and minus unity in catch-up periods, see Bowitz and Cappelen (2001) for details. The constants are kept unrestricted in (12). Initially, we estimated a 5th order VAR based on this information set. However, although the equation for Δtm_t had stable coefficients and well-behaved residuals, this was not the case for the other three equations in the VAR. To secure valid statistical inference, we included a set of impulse dummies to control for outliers and instabilities in the equations for Δpp_t, Δvuc_t^d and $\Delta(h-x^d)_t$ (see Appendix B for details). Diagnostic tests for the preferred VAR are reported in Table 1. None of the misspecification tests statistics are significant at the 10 percent level.[18]

Table 1. Residual misspecification tests

	Statistics						
Equation	AR_{1-5} $F(5, 64)$	$ARCH_{1-4}$ $F(4, 61)$	$NORM$ $\chi^2(2)$	HET_1 $F(40, 28)$	$AR^V{}_{1-5}$ $F(80, 183)$	$NORM^V$ $\chi^2(8)$	$HET^V{}_1$ $F(400, 213)$
Δtm_t	0.928	0.214	3.629	0.444			
Δpp_t	2.219	0.876	3.675	0.609			
Δvuc_t^d	1.106	0.269	4.479	0.560			
$\Delta(h-x^d)_t$	1.474	0.108	0.123	0.252			
VAR					1.285	7.513	0.439

Notes: AR_{1-5} is Harvey's (1981) test for 5th order residual autocorrelation; $ARCH_{1-4}$ is the Engle (1982) test for 4th order autoregressive conditional heteroskedasticity in the residuals; $NORM$ is the normality test described in Doornik and Hansen (1994) and HET_1 is a test for residual heteroskedasticity due to White (1980). Similar tests for the entire VAR are denoted by ^{V} [see Hendry and Doornik (2001)]. $F(\cdot)$ and $\chi^2(\cdot)$ represent the null distributions of F and χ^2, with degrees of freedom shown in parenthesis.

For our VAR to be considered as a valid starting point of the cointegration analysis, it should also contain reasonably constant parameters. Recursively estimated one step residuals (with ± 2 standard errors) and sequences of break-point Chow tests (scaled by their 1% critical values) are displayed in Figure C1 in Appendix C. We conclude that the system is constant over the sample.[19] The next step is

[18] Simplification to a 4th order VAR yielded a pp_t-equation that suffered from severe residual heteroskedasticity.

[19] Albeit the break-point Chow test associated with vuc_t^d is a borderline case at the 1 per cent level around the mid 1990s.

thus to investigate the cointegration properties between the selected variables by means of our preferred system. Table 2 contains results from applying the method suggested by Johansen (1988) to determine the rank of the VAR. The maximum eigenvalue and trace statistics without a small sample adjustments (λ_{max} and λ_{trace}) reject the null of no cointegration at the 5 per cent significance level, but the null of at most two cointegrating vectors is not rejected. However, based on the 5 percent level, the trace statistics with a small sample adjustment (λ^{a}_{trace}) suggest that there is only one cointegrating vector between *tm*, *pp*, vuc^d and $(h\text{–}x^d)$.[20] We therefore proceed under the assumption of one cointegrating vector.

Table 2. Johansen's cointegration tests

Information set: [*tm*, *pp*, vuc^d, $(h\text{–}x^d)$, *e*, *R*]
Non-modelled I(0) variables: *e*, *R*
Eigenvalues: 0.221, 0.181, 0.085, 0.003

	Statistics (*p*-values in brackets)			
Hypothesis	λ_{max}	λ^{a}_{max}	λ_{trace}	λ^{a}_{trace}
$r = 0$	27.71 [0.045]*	22.72 [0.191]	60.05 [0.002]**	49.23 [0.035]*
$r \leq 1$	22.13 [0.034]*	18.14 [0.128]	32.34 [0.024]*	26.51 [0.117]
$r \leq 2$	9.83 [0.228]	8.06 [0.381]	10.21 [0.270]	8.37 [0.434]
$r \leq 3$	0.38 [0.537]	0.31 [0.576]	0.38 [0.537]	0.31 [0.576]

Estimate of the *unrestricted* cointegrating vector (standard errors in parenthesis):

$$tm = \hat{\alpha}_0 + \underset{(0.175)}{0.384}pp + \underset{(0.176)}{0.529}vuc^d + \underset{(0.057)}{0.055}(h - x^d)$$

Weak exogeneity tests:	*tm*	*pp*	vuc^d	$(h\text{–}x^d)$
$\chi^2(1)$	5.504	2.659	4.949	0.093
p-value	[0.019]*	[0.103]	[0.026]*	[0.761]

Notes: *r* denotes the cointegration rank. The λ_{max} and λ_{trace} statistics are the maximum eigenvalue and trace statistics, whereas λ^{a}_{max} and λ^{a}_{trace} are the corresponding statistics with a degrees-of-freedom-adjustment. The *p*-values, which are reported in PcGive, are based on the approximations to the asymptotic distributions derived by Doornik (1998). It should be noted that the inclusion of impulse dummies in the VAR affects the asymptotic distribution of the reduced rank test statistics and therefore the critical values are only indicative. The asterisk * and ** denote rejection of the null hypothesis at the 5 per cent and 1 per cent significance levels. The weak exogeneity tests, which are asymptotically distributed as $\chi^2(1)$ under the null [see Johansen and Juselius (1990)], are calculated under the assumption that $r = 1$.

The estimate of the *unrestricted* cointegrating vector (normalised on *tm*) is interpretable as an equation for trade margins as the estimated coefficients for purchasing prices, marginal costs and the ratio

[20] Doornik and Hendry (2001, p. 175) point out that the sequence of trace tests leads to a consistent test procedure, but no such result is available for the maximum eigenvalue test. Hence, current practice is to only consider the former.

between self-employed hours worked and production are economically reasonable with expected signs. Besides, the results of the weak exogeneity tests imply that the cointegrating vector enters the Δtm_t-equation (in addition to the Δvuc_t^d -equation). We also notice that the sum of the estimated coefficients of γ and $(1-\gamma)$ inherent in the vector is not far from unity, as predicted by theory. To complete the cointegration analysis, we thus tested for, and could not reject, the existence of homogeneity between *tm*, *pp* and vuc^d. Imposing the homogeneity restriction and weak exogeneity of $(h-x^d)$ gives $\chi^2(2)=3.557$ (with a *p*-value of 0.169) and the following *restricted* estimate of the cointegrating vector (normalised on *tm*):

$$tm = \hat{\alpha}_0 + 0.365pp + \underset{(0.186)}{0.635}vuc^d + \underset{(0.019)}{0.123}(h - x^d) \tag{13}$$

As Figure C2 in Appendix C shows, the recursively estimated parameters of vuc^d and $(h-x^d)$ in (13) are reasonably constant and the sequence of $\chi^2(2)$ test statistics confirms the validity of the homogeneity restriction and the weak exogeneity status of the ratio between self-employed hours worked and production for any sample ending between 1985 and 1998 (the data until 1985:1 were used for initialisation). Also, the restricted cointegrating vector is virtually unchanged from the unrestricted one.

We now focus on (*i*) the dynamic adjustment of trade margins to changes in purchasing prices, variable unit costs and the ratio between self-employed hours worked and production and (*ii*) the role of the exchange rate and the interest rates as separate explanatory variables in the short and medium term. For this purpose, we formulate a dynamic equilibrium correction model for trade margins using deviations from (13) as an equilibrium correction mechanism (*EqCM*). Applying the same lag length as in the preferred VAR, we proceed from the following general model:

$$\begin{aligned} \Delta tm_t = \beta_0 &+ \sum_{i=1}^{4} \beta_{1i}\Delta tm_{t-i} + \sum_{i=0}^{4} \beta_{2i}\Delta pp_{t-i} + \sum_{i=0}^{4} \beta_{3i}\Delta vuc_{t-i}^d \\ &+ \sum_{i=0}^{4} \beta_{4i}\Delta(h - x^d)_{t-i} + \sum_{i=0}^{4} \beta_{5i}\Delta e_{t-i} + \sum_{i=0}^{4} \beta_{6i}\Delta R_{t-i} \\ &+ \beta_7[tm - 0.365pp - 0.635vuc^d - 0.123(h - x^d)]_{t-1} \\ &+ \sum_{i=1}^{3} \beta_{8i}CS_{it} + \beta_9 PSTOP_t + \varepsilon_t, \end{aligned} \tag{14}$$

where Δ is the first difference operator, the expression in $[\cdot]$ is the *EqCM* and ε_t is the error term, assumed to be white noise. A simplified model that approximates the data well is presented in (15). The conditioning on the two contemporaneous variables Δpp_t and $\Delta(h-x^d)_t$ may however pose caveats since they need not be weakly exogenous for the short run parameters in (15), cf. Urbain (1992). Adding the predicted counterparts to Δpp_t and $\Delta(h-x^d)_t$ from the VAR in (15), both individually and jointly, yield p-values of 0.307 and 0.545 and $\chi^2(2)$=1.386 (with a p-value of 0.500), and may be taken as evidence that Δpp_t and $\Delta(h-x^d)_t$ indeed are weakly exogenous for the short run parameters in (15). Consequently, the parameters in (15) are consistently estimated by OLS.[21]

$$
\begin{aligned}
\Delta tm_t = {} & const. - \underset{(0.066)}{0.188}\Delta_2 tm_{t-1} + \underset{(0.113)}{0.607}\Delta pp_t + \underset{(0.071)}{0.258}\Delta_2 pp_{t-2} + \underset{(0.041)}{0.092}\Delta vuc^d_{t-3} \\
& + \underset{(0.026)}{0.046}\Delta(h-x^d)_t - \underset{(0.107)}{0.252}\Delta e_t + \underset{(1.040)}{2.147}\Delta R_{t-2} + \underset{(1.050)}{3.279}\Delta R_{t-4} \\
& - \underset{(0.054)}{0.245}[tm - 0.365pp - 0.635vuc^d - 0.123(h-x^d)]_{t-1} \\
& - \underset{(0.006)}{0.019}CS_{1t} - \underset{(0.004)}{0.022}PSTOP_t
\end{aligned}
\tag{15}
$$

OLS, T=111(1971:2−1998:4), R^2=0.641, σ=1.73%, DW=2.12

AR_{1-5}:$F(5, 94)$ = 0.935 [0.462]
$ARCH_{1-4}$:$F(4, 91)$ = 1.581[0.186]
$NORM$:$\chi^2(2)$ = 1.036 [0.596]
HET_1:$F(21, 77)$ = 0.587 [0.916]
HET_2:$F(76, 22)$ = 0.493 [0.988]
$RESET$:$F(1, 98)$ = 1.580 [0.212]

Below (15) we report several test statistics.[22] None of the diagnostics are significant at the 1 per cent significance level. The economic variables entering (15) are all significant. For instance, the *EqCM* appears in the model with a t-value of −4.56, hence adding force to the results obtained from the cointegration analysis. We note that (15) implies rejection of *dynamic* homogeneity and that the mark-

[21] We notice that (15) is derived from a single equation analysis rather than a system one. Following Boswijk and Urbain (1997), one may apply single equation analysis with the long run relationship(s) estimated and deduced from a VAR model in cases where the conditioning variables are error correcting, but weakly exogenous for the short run parameters.

[22] The reported statistics are as follows: T, R^2, σ and DW are the number of observations, the squared multiple correlation coefficient, the residual standard error and the Durbin-Watson statistic, respectively. In addition to AR_{1-5}, $ARCH_{1-4}$, $NORM$ and HET_1 defined in Table 1, we report HET_2 and $RESET$. The former tests whether the squared residuals depend on the levels, squares and cross products of the regressors [cf. White (1980)], while the latter tests for functional form misspecification [cf. Ramsey (1969)].

up rates decrease with higher inflation, a finding which is in line with previous studies based on European and American data, see e.g. Bénabou (1992), Blanchard and Muet (1993), Bowitz and Cappelen (2001) and Banerjee and Russell (2004).

Empirical evidence of constancy of (15) is supported by one-step residuals, one-step Chow tests, break-point Chow tests, forecast Chow tests and recursively estimated coefficients, which do not reject constancy between 1979 and 1998, see Figures C3 and C4 in Appendix C (the data until 1979:1 were used for initialisation). Besides, the impulse dummies used to account for outliers in the Δpp_t, Δvuc_t^d and $\Delta(h-x^d)_t$ equations in the VAR are all insignificant when added to (15), both individually and jointly.[23] These findings are evidence against the Lucas critique being quantitatively important, see e.g. Favero and Hendry (1992), and we may claim that the degree of exchange rate pass-through to trade margins has remained constant throughout the sample period.

Figure 2a, 2b and 2c depict actual values of tm_t together with dynamic forecasts, four-step ahead forecasts and one-step ahead forecasts of tm_t, respectively, adding bands of 95 per cent confidence intervals to each forecast in the forecasting period.[24] Except 2003:4 in Figure 2c, which is a borderline case, the actual values of tm_t stay clearly within their corresponding confidence intervals over the forecasting period. Also, a Chow-test statistic of parameter constancy between the sample and the forecasting periods, cf. Hendry and Doornik (2001, p. 241), is far from being significant with $F[24, 98]=0.966$ and the corresponding p-value of 0.517. Thus, the *out-of-sample* forecasting ability of (15) is reasonably good despite the fact that monetary policy in Norway has undergone a *major* change from exchange rate targeting to a *formal* floating exchange rate regime following the introduction of inflation targeting in late March 2001. We also note that (15) is virtually unchanged when estimated with a sample period ending in 2002:4 rather than in 1998:4, see equation (C1) in Appendix C.[25] The regime robustness is further evidence that the Lucas-critique lacks force in our case.

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[23] These results are available upon request.

[24] The forecast for period s is $\hat{y}_s = x_s' \hat{\beta}_t$, where x_s is the observed value of x for period s, $\hat{\beta}_t$ is estimated from the first t observations of data and $s>t$. In our case s spans the period 1999:1–2004:4, while t covers the period 1970:1–1998:4. Although forecasts for the *level* tm_t could be derived from (15), the forecasts in Figure 2a, 2b and 2c (notice the different scales in the figures) were obtained directly by re-expressing the dependent variable as $tm_t - tm_{t-1}$ and estimating rather than imposing the unit coefficient on tm_{t-1}, cf. Hendry and Ericsson (1991, p. 852).

[25] The data observations for 2003 and 2004 are preliminary figures from the quarterly national accounts. Noticeably, we use equation (C1) in the simulations reported in Section (4).

Figure 2a. Actual values of tm_t and dynamic forecasts with 95 % bands

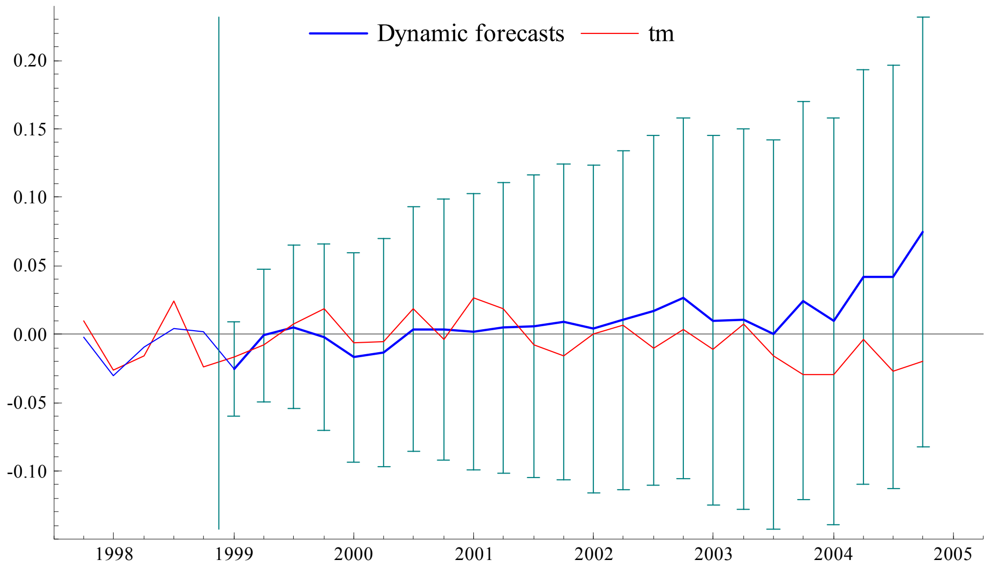


Figure 2b. Actual values of tm_t and 4-step ahead forecasts with 95 % bands

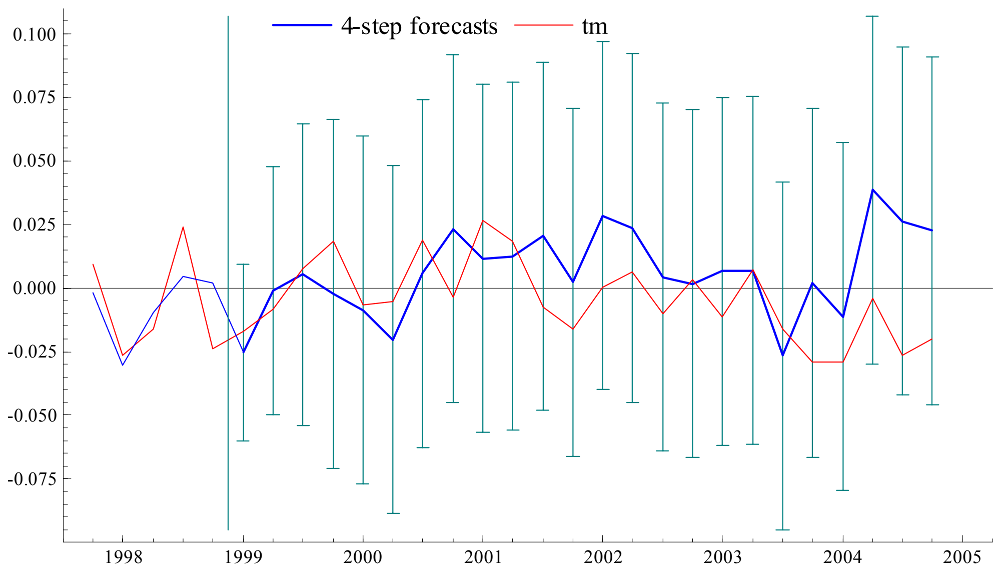
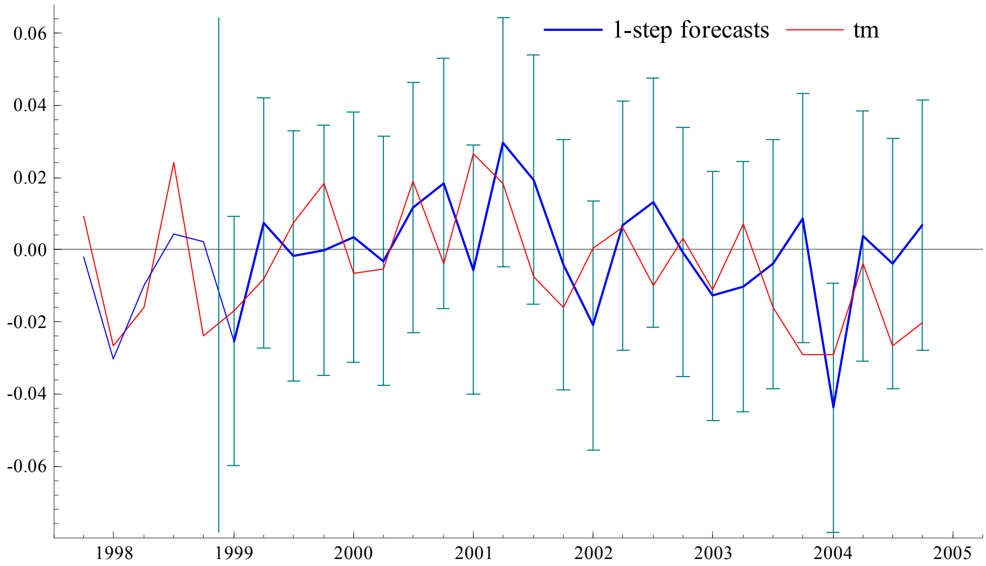


Figure 2c. Actual values of tm_t and 1-step ahead forecasts with 95 % bands



The estimated impact response of purchasing prices (0.6) is somewhat larger than its long run counterpart. Apparently, the trade margins overshoot with respect to changes in domestic as well as import prices on traded commodities in the short run. The pass-through from variable unit costs to the trade margins is, however, delayed and incomplete in the short run. Turning to the exchange rate itself, the estimated impact elasticity of −0.25 shows that trade margins are significantly affected by exchange rate fluctuations in the short run. These *direct* effects of the exchange rate, nevertheless work in the opposite direction compared to the *indirect* effects of purchasing prices and variable unit costs. If the exchange rate appreciates by 10 percent, say, then the trade margins increase immediately by 2.5 percent, but at the same time decrease with changes in purchasing prices (and variable unit costs with some delay) that are caused by decreased import prices of tradable goods and material inputs. Consequently, the overall exchange rate pass-through to trade margins seems to be moderate in the short run. With periods of large fluctuations in the exchange rate, firms may find it difficult to perceive whether the changes are transitory or permanent. Hence, it is likely that firms are reluctant to change their prices in response to exchange rate fluctuations for reasons such as menu costs and stock of products with different purchasing price than the current price. Under such circumstances, firms may increase their sales considerably by leaving the trade margins unchanged in periods of exchange rate appreciation. Some firms (importers) may also secure themselves against exchange rate fluctuations, either through financial instruments or price agreements, thereby contributing to modest exchange rate pass-through to trade margins and further to consumer prices. The short run dynamics of the trade margins are also in a quantitatively important way influenced by past changes in interest rates. The adjustment towards steady state is rather slow as reflected by the small estimated magnitude of the loading parameter (−0.24).

In order to explain how the *consumer price* effects are arrived at using (9), (11), (13) and (15), we make use of the price of new cars as an example. Since Norway has nearly no production of cars, we simplify and assume that only the import price of cars enters (9). However, cars are heavily taxed not only through *VAT*, but also through excise taxes (*ET*). A simplified version of (9) for cars may be formulated as $CP_{CARS} = 0.54 \cdot PI_{CARS} + 0.32 \cdot ET_{CARS} + 0.14 \cdot TM$,[26] where the coefficient 0.14 represents the cars share of the trade margins in the economy. We note that *ET* should be interpreted as the level of the excise tax on cars relative to the base year level. In the base year of the macroeconometric model, calibration to national accounts data implies that *CP*, *PI*, *ET* and *TM* are all one, such that the equation is balanced. Using the estimated coefficients in (13), ignoring the ratio of self-employed and production for simplicity, (11) becomes $TM = c \cdot PP^{0.37} \cdot VUC^{0.63}$. In *PP*, the partial weight of the import price of cars is small. Thus, if the import price on cars goes up by 10 per cent due to an increase in world market prices on cars, the effect on the consumer price of cars is 5.4 percent. Suppose instead that the krone depreciates by 10 percent. Then, with full and immediate pass-through to *PI*, the effect is again 5.4 percent, but now there are additional effects through *TM*. Assuming that import prices on all goods traded through the distribution sector make up *half* of the prices that enter *PP*, trade margins increase by 1.9 percent (0.37·0.5·10). However, only 0.14 times this increase adds to the consumer price of cars, which then increases by 5.7 percent (0.14·1.9+5.4). According to (15), the estimated dynamics of the trade margins imply that *TM* to some extent acts as a cushion to exchange rate fluctuations during the first year due to the isolated short run effects of the exchange rate on *TM*. In later years there is a gradual and smooth increase in the consumer prices on cars due to the fact that variable unit costs also increase gradually, in particular wages.

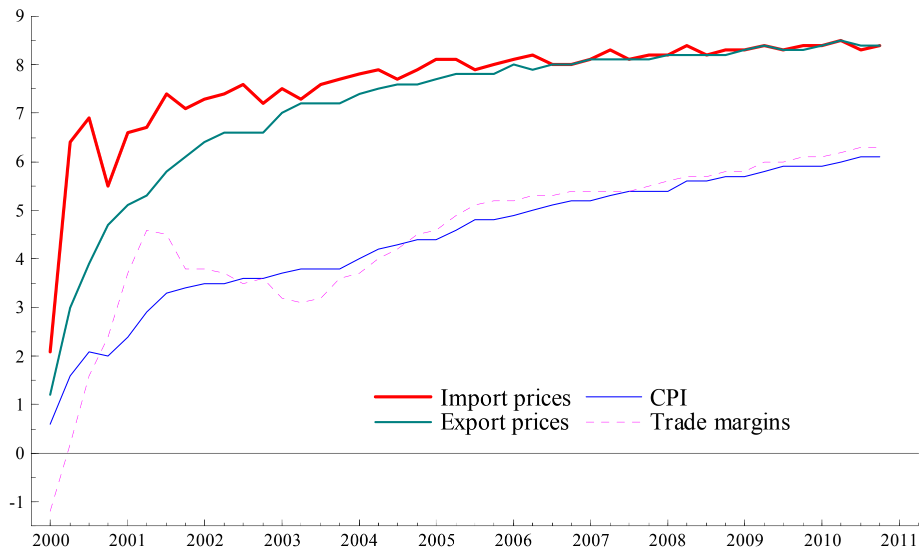
We conclude that the dynamic model of the trade margins in the wholesale and retail trade sector contains some interesting properties with respect to exchange rate pass-through. In the next section, we show the degree of exchange rate pass-through to the overall consumer price index when the model is analysed within the large-scale macroeconometric model of the Norwegian economy.

[26] Noticeably, the *VAT* rate is included in the coefficients of the equation.

4. Simulation Results

One of the purposes of this paper is to present an estimate of the pass-through of exchange rate changes to consumer prices. We therefore assume an exogenous exchange rate in our simulation study although clearly this is not an exogenous variable in an economy where monetary policy is based on inflation targeting. In the model simulations, the import-weighted exchange rate is permanently increased (depreciated) by 10 per cent compared to the baseline scenario.[27] The baseline scenario follows the historic development of the Norwegian economy until the fourth quarter of 2004 extended by forecasts to 2010. In the forecasting period, the average unemployment rate is kept at an average of 4.4 per cent, equal to the average of the previous 20 years. The real after tax interest rate is assumed constant throughout the simulation period by adjustments of the nominal interest rate according to changes in CPI-inflation. The degree of exchange rate pass-through to the Norwegian economy is studied in a full model simulation, thereby taking account of all modelled channels through which the exchange rate affects domestic prices (as described in Section 2). Main simulation results with respect to prices are shown in Figure 3.

Figure 3. Pass-through of a 10 per cent exchange rate depreciation (on a permanent basis). Deviations from baseline scenario in per cent



The exchange rate pass-through to import prices is quite rapid in the short run, but incomplete in the longer run (10 years) in accordance with the pricing-to-market hypothesis, cf. Appendix A. The speed

[27] The simulations begin in the first quarter of 2000, but the simulated effects reported below are for practical purposes independent of the actual time period.

of exchange rate pass-through to export prices is also rather fast, but nevertheless slower than the pass-through to import prices. One reason is that domestic costs affect export prices and domestic costs are slow to react to exchange rate changes. The more moderate response of export prices affects the exchange rate pass-through to wages and domestic costs through the wage-price spiral. This explains partly why the impact of exchange rate changes on consumer prices is fairly modest both in the short and medium term, an empirical finding which is in line with what is usually found in the literature, see e.g. Berben (2004) and Choudhri and Hakura (2001) and the references cited therein. Particularly during the first year, the exchange rate pass-through to consumer prices is delayed by the effects on the trade margins in the distribution sector, which act as cushions to exchange rate fluctuations in the short run. If the trade margins had increased in parallel with other consumer prices following the 10 per cent depreciation of the exchange rate, then the first year CPI effect would have been 0.3 percentage points higher. In the second year, the trade margins overshoot somewhat due to the exchange rate effects, while no significant contribution from the trade margins to the CPI is present after the third year. We notice that the exchange rate pass-through to consumer prices is far from completed even within a ten-year horizon.

Table 3 presents simulation results for the various components of the CPI. The exchange rate pass-through to consumer prices on purchases abroad (or tourism) is rapid and completed within a year. Generally speaking, prices on consumer goods react quicker to changes in the exchange rate than prices on services. This applies in particular to prices on durable goods due to relatively high import shares (cf. the *IS* in equation (9) is relatively high). The exchange rate pass-through to consumer prices on *other services*, which constitute around 20 per cent (in 2003) of total private consumption, is slow both in the short and medium run. The first year effects on these components of CPI are close to half of the total CPI effect. After 10 years the exchange rate pass-through to prices on *other services* is somewhat lower than the average pass-through to consumer prices. The slow exchange rate pass-through to *other services* is mainly caused by modest pass-through to wages, as production is labour intensive in most services. Also, the direct import share effect of this kind of consumption is small.

Table 3. Consumer price effects of a 10 per cent exchange rate depreciation (on a permanent basis). Deviations from baseline scenario in per cent unless otherwise noted

	1. year	2. year	3. year	4. year	10.year
Food	1.7	3.5	3.9	4.1	6.4
Beverages	1.8	3.5	4.1	4.5	6.6
Tobacco	1.6	3.5	3.9	4.0	6.2
Petrol, etc.	2.5	4.6	5.3	5.7	7.6
Electricity, heating oil etc.	1.8	3.7	4.1	4.6	6.3
Clothing and footwear	3.3	5.3	5.3	5.4	7.1
Cars	3.8	4.9	5.3	5.6	7.2
Furniture, el. appliances	2.7	4.7	5.0	5.2	7.1
Housing	0.0	1.0	1.9	1.8	3.9
Public transport	0.1	0.7	1.3	1.7	3.7
Health care	0.8	1.9	2.7	3.2	5.6
Other goods	2.6	4.8	5.0	5.1	7.1
Other services	0.8	1.9	2.6	3.1	5.5
Tourism	10.0	9.9	10.0	10.0	10.0
Trade margins[1]	0.8	4.2	3.7	3.3	6.0
Consumer price index (CPI)	1.6	3.0	3.6	3.8	5.8
CPI-inflation[2]	1.6	1.4	0.6	0.2	0.2
Core-inflation[2, 3]	1.6	1.4	0.6	0.2	0.2

[1] Margins on services traded in the distribution sector
[2] Percentage points
[3] CPI without energy goods and adjusted for real changes in indirect taxation (CPI-ATE)

From the third year, the effects of the exchange rate depreciation on housing rents are remarkable, as these rents to a large degree is an important factor behind the overall delayed pass-through to consumer prices. We observe that the third year effects on housing rents are roughly 50 per cent of the CPI effect, while the effects after 10 years are two thirds of the CPI effect.

Even though there is only moderate exchange rate pass-through to consumer prices, the inflationary effects of exchange rate changes are quite substantial in the short and medium term. The simulations show that CPI inflation increases by close to 1.5 percentage points compared to the baseline scenario in the first and second year.[28] These findings are rather substantial in magnitude relative to the inflationary effects of approximately 0.5 and 1.0 percentage points in the first and second year reported in a previous study of exchange rate pass-through in Norway, see Norges Bank (2002).[29] The

[28] Similar figures are also found for core inflation, the targeting variable of Norges Bank - the central bank of Norway.

[29] Certainly, the mentioned study examines the effects on consumer prices of a 5 percent appreciation of the import-weighted exchange rate (on a permanent basis). We have translated the reported findings into a case in which the exchange rate depreciates by 10 percent to make them comparable to our results.

differences in empirical findings may reflect that the mentioned study does not take account of profitability effects in the exposed industry and price-wage spirals that are likely to be important for consumer prices when the exchange rate depreciates by the magnitude studied here.

The simulated effects on the real economy (measured by GDP and unemployment) are rather small, as reported in Table 4. These findings originate from the moderate nominal exchange rate pass-through, which translates into opposite effects with respect to the level of activity. We notice that real wages decline during the entire simulation period. The fall in real wages is, however, most noticeable in the short and medium run implying that nominal wages adjust more slowly than prices. The institutional system of wage bargaining in Norway contributes on average to the slow adjustment in nominal wages. There is local bargaining in several industries as well as national bargaining, with the main national bargaining round taking place on a biannual basis. In the public sector there is often no local bargaining at all. Reduction in labour productivity partly explains the fall in real wages in the longer term. In the long run, static homogeneity (of wage equations) implies full pass-through of product prices to nominal wages. The decline in real wages causes demand from households to decline as well. Another source that slows down households demand is the development of real wealth. While positively related to real wealth, households demand decreases as the housing prices increase less than the CPI. Increased cost competitiveness, on the other hand, stimulates exports and reduces import shares. As wages react slower than prices, labour substitutes intermediate inputs, thereby causing unemployment to fall somewhat.

Overall, exchange rate changes do not seem to translate into important variability in GDP growth and unemployment in the short and medium term. We should notice that according to our simulations, the real exchange rate (measured as the nominal exchange rate times relative consumer prices) is strongly affected by the shock in the nominal exchange rate, without having sizeable effects on real variables (GDP and unemployment). Our explanation is simply that changes in relative consumer prices are not the best way to capture changes in price competitiveness. Comparing changes in the CPI with changes in the export prices, we notice much quicker pass-through to export prices. Thus, using export prices rather than consumer prices when calculating the real exchange rate, we would conclude that the shock in the nominal exchange rate produces only moderate effects on the real exchange rate. Even so, we observe that changes in the industry structure are likely to happen in the face of an exchange rate shock of the magnitude studied here as sizeable growth in manufacturing production is simulated both in the short and medium term.

Table 4. Macroeconomic effects of a 10 per cent exchange rate depreciation (on a permanent basis). Deviations from baseline scenario in per cent unless otherwise noted

	1. year	2. year	3. year	4. year	10.year
Household consumption	–0.8	–0.9	–1.3	–1.3	–1.2
Real investments, mainland economy	0.1	0.5	–0.2	–0.3	–0.2
Housing	–0.7	–1.5	–1.7	–1.4	–0.9
Business sector	0.6	1.8	0.5	0.1	0.1
Exports, traditional goods	1.4	1.5	1.5	1.4	1.1
Imports	–1.0	–1.1	–1.4	–1.5	–1.3
GDP, mainland economy	0.2	0.3	0.1	0.1	0.0
Manufacturing	1.9	2.5	2.7	2.7	2.2
Employed persons	0.3	0.5	0.4	0.4	0.3
Rate of unemployment[1]	–0.2	–0.3	–0.2	–0.2	0.0
Import prices, total	5.3	7.0	7.4	7.5	8.3
Export prices, traditional goods	3.3	5.6	6.6	7.1	8.3
Consumer price index (CPI)	1.6	3.0	3.6	3.8	5.8
Average wage rate	0.8	1.6	2.3	2.8	5.2
Money market rate[2]	3.0	1.7	0.4	0.3	0.3

[1] Percentage points.
[2] Percentage points pro anno.

5. Conclusions

In this paper we have shown, using a large-scale macroeconometric model of the Norwegian economy, that exchange rate pass-through to import prices in domestic currency seems to be quite rapid, but nevertheless incomplete within a ten-year horizon. However, in a complete model of pricing behaviour, where we take into account not only the effects of import prices on marginal costs in production, but also the effects of import prices on wages, there are numerous channels through which changes in the exchange rate affect consumer prices. Even if complete exchange rate pass-through to consumer prices follows from our model in the very long run, costs of adjustment or other inertia in the pricing behaviour cause the pass-through of exchange rate changes to consumer prices to take considerable time.

Model simulations showed that the pass-through of exchange rates to consumer prices is slow, although there is a much more rapid pass-through to export prices and other components of final demand. Econometric analysis also demonstrated that the pricing behaviour in the distribution sector plays some role during the first year in delaying the exchange rate pass-through to consumer prices. Our results point towards a possible interpretation of one finding in the recent literature on open economy models, namely that local currency pricing (LCP) has received some empirical support. The finding in our paper indicates that the exchange rate pass-through to consumer prices is not complete within a ten-year horizon, a finding that may be interpreted as supporting the LCP hypothesis.

In spite of the rather slow exchange rate pass-through to consumer prices, changes in the exchange rate have substantial effects on CPI inflation even in the short run, an insight important for inflation targeting central banks. Since nominal exchange rate changes and inflation seem to move together (at least partly), one may argue that stability in the one implies stability in the other. However, large first and second year effects and relatively high persistent effects in the medium term can make a strategy of stabilising inflation within a two-year horizon, say, by controlling fluctuations in the nominal exchange rate a difficult task.[30] Also, the finding that exchange rate changes do not seem to produce important variability in other targeting variables, like GDP growth and unemployment in the short run, suggests that the exchange rate could be permitted to float without the consequence of destabilising the real economy. It should, however, be emphasised that exchange rate fluctuations (of the magnitude studied here) are likely to produce changes in the industry structure of an open economy like the Norwegian. For an economy like the Norwegian that tries to avoid Dutch Disease problems likely to follow from spending large oil revenues, exchange rate fluctuations that result in de-industrialisation may seem just as undesirable.

[30] Interestingly, Norges Bank extended its forecasting horizon from two to three years in mid 2004, see Dørum *et al.* (2005, p.37).

References

Aukrust, O. (1977): Inflation in the Open Economy: A Norwegian Model, in *Worldwide Inflation,* L.B. Krause and W.S. Salant (eds), Brookings, 1977, Washington D.C.

Banerjee, A. and B. Russell (2004): A Reinvestigation of the Markup and the Business Cycle, *Economic Modelling* 21, 267-284.

Bénabou, R. (1992): Inflation and Markups, *European Economic Review* 36, 556-574.

Berben, R-P. (2004): Exchange Rate Pass-through in the Netherlands: Has it changed? *Applied Economics Letters* 11, 141-143.

Betts, C. and M.B. Devereux (1996): The Exchange Rate in a Model of Pricing to Market, *European Economic Review* 40, 1007-1021.

Biørn, E., M. Jensen and M. Reymert (1987): KVARTS - A Quarterly Model of the Norwegian Economy, *Economic Modelling* 4, 77-109.

Blanchard, O.J. and P.A. Muet (1993): Competitiveness through Disinflation: An Assessment of the French Macroeconomic strategy, *Economic Policy* 16, 12-56.

Boswijk, H.P. and J.-P. Urbain (1997): Lagrange–Multiplier Tests for Weak Exogeneity: A Synthesis, *Econometric Reviews* 16, 21-38.

Boug, P., Y. Dyvi, P.R. Johansen and B.E. Naug (2002): MODAG: A Macroeconometric Model of the Norwegian Economy (in Norwegian), *Social and Economic Studies* 108, Statistics Norway.

Bowitz, E. and Å. Cappelen (2001): Modeling Income Policies: Some Norwegian Experiences 1973-1993, *Economic Modelling* 18, 349-379.

Brauer, H. (2003): Empirical Results for the Degree of Pass-Through in Domestic and Export Markets. In H. Siebert (ed.), *The Real Exchange Rate and Prices of Traded Goods in OECD countries*, Ch. D, Springer-Verlag, Berlin.

Burstein, A.T., M. Eichenbaum and S. Rebelo (2002): Why are Rates of Inflation so Low After Devaluations?, National Bureau of Economic Research, Working Paper No. 8748.

Burstein, A.T, J.C. Neves and S. Rebelo (2003): Distribution Costs and Real Exchange Rate Dynamics During Exchange-Rate-Based Stabilizations, *Journal of Monetary Economics* 50, 1189-1214.

Campa, J.M. and L. Goldberg (1999): Investment, Pass-through, and Exchange Rates: A Cross-country Comparison, *International Economic Review* 40, 287-314.

Chen, Y.-C. and K. Rogoff (2003): Commodity Currencies, *Journal of International Economics* 60, 133-160.

Choudhri, E.U. and D.S. Hakura (2001): Exchange Rate Pass-through to Domestic Prices: Does the Inflation Environment Matter?, IMF Working Paper 01/194.

Dixit, A. and J. Stiglitz (1977): Monopolistic Competition and Optimum Product Diversity, *American Economic Review* 67, 297-308.

Doornik, J.A. (1998): Approximations to the Asymptotic Distribution of Cointegration Tests, *Journal of Economic Surveys* 12, 573-593.

Doornik, J.A. and H. Hansen (1994): A Practical Test for Univariate and Multivariate Normality, Discussion Paper, Nuffield College, University of Oxford.

Doornik, J.A. and D.F. Hendry (2001): Empirical Econometric Modelling using PcGive Volume I, Timberlake Consultants LTD, London.

Dørum, Ø., S. Holden and A.J. Isachsen (2005): Norges Bank Watch 2005: An Independent Review of Monetary Policymaking in Norway, Norges Bank Watch Report Series No. 6, Preliminary version, Center for Monetary Economics, BI Norwegian School of Management.

Engel, C. (1993): Real Exchange Rates and Relative Prices: An Empirical Investigation, *Journal of Monetary Economics* 32, 35-50.

Engel, C. (1999): Accounting for U.S. Real Exchange Rate Changes, *Journal of Political Economy* 107, 507-538.

Engel, C. (2000): Local-currency Pricing and the Choice of Exchange Rate Regime, *European Economic Review* 44, 1149-1472.

Engel, C. and J.H. Rogers (2001): Deviations from the Purchasing Power Parity: Causes and Welfare Costs, *Journal of International Economics* 55, 29-57.

Engle, R.F. (1982): Autoregressive Conditional Heteroscedastisity with Estimates of the Variance of United Kingdom Inflation, *Econometrica* 50, 987-1007.

Favero, C. and D.F. Hendry (1992): Testing the Lucas Critique: A Review, *Econometric Reviews* 11, 265-306.

Feenstra, R.C., J. Gagnon and M. Knetter (1996): Market Share and Exchange Rate Pass-through in World Automobile Trade, *Journal of International Economics* 40, 187-207.

Friberg, R. (2001): Two monies, two markets? Variability and the option to segment, *Journal of International Economics* 55, 317-327.

Gagnon, J. and M. Knetter (1995): Mark-up Adjustment and Exchange Rate Fluctuations: Evidence from Panel Data on Automobile Exports, *Journal of International Money and Finance* 14, 289-310.

Gali, J., M. Gertler and J.D. López-Salido (2001): European Inflation Dynamics, *European Economic Review*, 45, 1237-1270.

Giovanni, A. (1988): Exchange Rates and Traded Good Prices, *Journal of International Economics* 24, 45-68.

Goldberg, P.K. and M. Knetter (1997): Goods Prices and Exchange Rates: What Have We Learned?, *Journal of Economic Literature* 35, 1243-1272.

Harvey, A.C. (1981): *The Econometric Analysis of Time Series*, Philip Allan, Oxford.

Hendry, D.F. and J.A. Doornik (2001): Modelling Dynamic Systems using PcGive Volume II, Timberlake Consultants LTD, London.

Hendry, D.F. and N.R. Ericsson (1991): Modeling the Demand for Narrow Money in the United Kingdom and the United States, *European Economic Review* 35, 833-886.

Hoel, M. and R. Nymoen (1988): Wage Formation in Norwegian Manufacturing. An Empirical Application of a Theoretical Bargaining Model, *European Economic Review* 32, 977-997.

Johansen, S. (1988): Statistical Analysis of Cointegration Vectors, *Journal of Economic Dynamics and Control* 12, 231-254.

Johansen, S. and K. Juselius (1990): Maximum Likelihood Estimation and Inference on Cointegration – With Applications to the Demand for Money, *Oxford Bulletin of Economics and Statistics* 52, 169-210.

Kasa, K. (1992): Adjustment Costs and Pricing-to-market, *Journal of International Economics* 30, 1-30.

Khalaf, L. and M. Kichian (2004): Pricing-to-market Tests in Instrumental Regressions: Case of the Transportation Equipment Industry, *Empirical Economics* 29, 293-309.

Knetter, M. (1993): International Comparisons of Pricing-to-market Behaviour, *American Economic review* 83, 473-486.

Krugman, P.R. (1987): Pricing to market when the Exchange rate Changes. In S.W. Arndt and J.D. Richardson (eds.), *Real-Financial Linkages among Open Economies*, Ch. 3, MIT Press, Cambridge, MA.

Lindbeck, A. (ed.)(1979): *Inflation and Employment in Open Economies,* Amsterdam, North- Holland.

Marston, R. (1990): Pricing to market in Japanese Manufacturing, *Journal of International Economics* 29, 217-237.

Menon, J. (1995): Exchange Rate Pass-through, *Journal of Economic Surveys* 9, 197-231.

Naug, B. and R. Nymoen (1996): Pricing to Market in a Small Open Economy*, Scandinavian Journal of Economics* 98, 329-350.

Nickell, S.J. and M. Andrews (1983): Unions, Real Wages and Unemployment in Britain 1951-79, *Oxford Economic papers* (*supplement*) 35, 183-206.

Norges Bank (2002): Inflation Report 2/2002.

Obstfeld, M. and K. Rogoff (1995): Exchange Rate Dynamics Redux, *Journal of Political Economy* 103, 624-660.

Obstfeld, M. and K. Rogoff (2000): New Directions for Stochastic Open Economy Models, *Journal of International Economics* 50, 117-153.

Obstfeld, M. and A.M. Taylor (1997): Non-linear Aspects of Goods Market Arbitrage and Adjustment: Heckscher's Commodity Points Revisted, *Journal of the Japanese and International Economies* 11, 441-479.

Rahbek, A. and R. Mosconi (1999): Cointegration Rank Inference with Stationary Regressors in VAR Models, *Econometrics Journal* 2 76-91.

Ramsey, J.P. (1969): Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis, *Journal of the Royal Statistical Society* 31, *Series* B, 350-371.

Rogers, J.H. and M. Jenkins (1995): Haircuts or Hysteresis? Sources of Movements in Real Exchange Rates, *Journal of International Economics* 38, 339-360.

Rogoff, K. (1996): The Purchasing Power Parity Puzzle, *Journal of Economic Literature* 34, 647-668.

Rogoff, K. (2003): Globalization and Global Disinflation, paper prepared for the Federal Reserve Bank of Kansas City's symposium "Monetary Policy and Uncertainty: Adapting to a Changing Economy", August 28-30, 2003. The paper is available at *www.kc.frb.org*.

Smith, P.N. (2000): Output Price Determination and the Business Cycle, *Economic Modelling* 17, 49-69.

Urbain, J.-P. (1992) On Weak Exogeneity in Error Correction Models, *Oxford Bulletin of Economics and Statistics* 54, 187-207.

White, H. (1980): A Heteroskedasticity–Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity, *Econometrica* 48, 817-838.

Appendix A

The Modelling of Import Prices

Here, we shall describe the modelling of import prices of manufactures and cars. As noted in the text, the modelling of the former draws on the pricing-to-market (henceforth denoted PTM) theory advanced by Krugman (1987) whereas the modelling of the latter assumes price-taking behaviour in the market for cars. The PTM theory explains, by means of imperfect competition and segmented markets, the observation that movements in nominal exchange rates are *not* fully reflected in the import prices of the countries involved. Exporting monopolistic firms segment international markets by adjusting their destination-specific mark-ups in situations of exchange rate shocks, so as to limit changes in the price of their exports. Under these circumstances, market conditions in the importing countries are relevant in explaining the evolution of import prices. Empirical evidence in favour of PTM is given by Giovannini (1988), Kasa (1992), Knetter (1993), Gagnon and Knetter (1995), Menon (1995), Feenstra *et al*. (1996) and Campa and Goldberg (1999) among others. Evidence supporting PTM is also found by Naug and Nymoen (1996), who study the formation of Norwegian import prices of manufactures over the period 1970:1−1991:4.

We base our modelling of Norwegian import prices of manufactures on Naug and Nymoen (1996). The theoretical framework is that of mark-up pricing, which implies that a representative foreign firm sets the price of its exports to Norway as a mark-up on marginal costs. The mark-up is assumed to depend on the price of competing goods produced in Norway relative to the import price and on demand pressure in Norway. We consider only one destination country and abstract from competition between foreign exporters on the Norwegian market. The econometric model of import prices is as follows (letting lower case letters indicate logarithm of variables and using subscript *t* to denote time):[31]

(A1) $$pi_t^m = const. + (1-\theta)(pw_t + e_t) + \theta vuc_t^m - \phi u_t + \varepsilon_t ,$$

where pi_t^m is the price of imports (in local currency), pw_t is the aggregate foreign export price (in foreign currency) proxying the exporters marginal costs, e_t is the nominal exchange rate, vuc_t^m is variable units costs proxying the price of competing goods produced in Norway, u_t is the

[31] See Naug and Nymoen (1996) for details about the theoretical framework underlying (A1).

unemployment rate used as a measure of demand pressure in Norway and ε_t is a stochastic disturbance term. We note that the coefficient $(1-\theta)$ measures the degree of pass-through from changes in the foreign export price and the exchange rate to the import price. In line with Naug and Nymoen (1996), we impose the restriction that the import price is homogenous of degree one in foreign and domestic prices measured in the same currency. As long as $\theta>0$, changes in pw_t and e_t are *not* fully passed through to pi_t^m in a situation of unchanged vuc_t^m, and PTM behaviour is present in the terminology of Krugman (1987). In the case where $\theta=0$, the pass-through of shifts in the export price and the exchange rate is *complete* (at least in the long run) and the price of competing goods has no effect on the import price.

Following Naug and Nymoen (1996), we interpret (A1) as a long run cointegrating relationship. In the dynamic modelling, we let changes in the import price be determined by deviations from the long run relationship in addition to current and lagged changes in the explanatory variables included in (A1). Using quarterly, seasonally unadjusted data[32] that spans the period 1978:1–2003:2, we obtain the following simplified model of the import price (after simplification from a general model with four lags on each differenced explanatory variable):

(A2)
$$\begin{aligned}\Delta pi_t^m = {} & const. - \underset{(0.081)}{0.405}\Delta pi_{t-1}^m - \underset{(0.049)}{0.235}\Delta_2 pi_{t-2}^m \\ & + \underset{(0.213)}{0.450}\Delta pw_{t-1} + \underset{(0.052)}{0.317}\Delta_3 e_t + \underset{(0.081)}{0.175}\Delta vuc_{t-1}^m - \underset{(0.011)}{0.027}\Delta_2 u_{t-1} \\ & - \underset{(0.085)}{0.294}[pi^m - pw - e]_{t-1} + \underset{(0.054)}{0.103}[vuc^m - pw - e]_{t-1} - \underset{(0.0002)}{0.0007}Trend \\ & - \underset{(0.003)}{0.013}(CS_{1t} + CS_{2t})\end{aligned}$$

Method: *OLS* T=98(1979:1–2003:2) R^2=0.713 σ=1.40% DW=2.11
$AR_{1\text{-}5}$:$F(5, 82)$=0.416 $ARCH_{1\text{-}4}$:$F(4, 79)$=0.511 $NORM$:$\chi^2(2)$=1.418
HET_1:$F(19, 67)$=0.494 HET_2:$F(64, 22)$=0.667 $RESET$:$F(1, 86)$=3.273

where Δ is the first difference operator, CS_{1t} and CS_{2t} are centered seasonal dummies, figures in parentheses are estimated standard errors and the test statistics reported below (A2) are as defined in Section 3 in the text. None of the diagnostics are significant and the economic variables are all

[32] See Appendix B for details about the data.

significant at conventional levels. Evidence of constancy of (A2) is supported by one-step residuals, sequences of break point Chow tests and recursively estimated coefficients, which do not reject constancy between 1985 and 2003 (the data until 1985 were used for initialisation).[33] The empirical counterpart of (A1) is

(A3) $$pi_t^m = const. + 0.65(pw_t + e_t) + 0.35vuc_t^m - 0.0024Trend\ ,$$

which is close to the long run exchange rate pass-through and PTM effects (i.e., θ=0.35) reported in Naug and Nymoen (1996). However, presence of a deterministic trend and no effects from the unemployment rate (which turned out insignificant) are important differences between the findings in this paper and those in the earlier study. Factors such as different sample period, revisions in the data and dissimilarities in the construction of variables may have contributed to the differences in the results. In particular, we employ data for variable unit costs in manufacturing (including labour costs and costs associated with material inputs) while Naug and Nymoen (1996) use data for unit labour costs only. Nevertheless, the evidence of significant pricing to market effects in Norwegian import prices of manufactures appears to be a robust result and the weight to domestic factors (vuc_t^m) is very close to that found by Naug and Nymoen (1996).

As opposed to manufactures, there is no domestic production of cars in Norway. Hence, the PTM theory in the terminology of Krugman (1987) is a priori irrelevant in describing the formation of import price of cars. Instead, we assume price-taking behaviour and let aggregate foreign export prices (pw_t) and the exchange rate (e_t) be important determinants of the import price of cars measured in the Norwegian currency (pi_t^c) . In addition, we allow domestic absorption (abs_t) defined as the sum of private consumption, public consumption and gross investments in fixed capital (proxying demand pressure in Norway) to play a role in the formation of the import price of cars. We obtain the following simplified model of pi_t^c :[34] [35]

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[33] These results are available upon request.

[34] The model (A4) was simplified from a general model with four lags on each differenced explanatory variable. See Appendix B for details about the data.

[35] See (A2) for description of test statistics reported below (A4). We ignore that the *RESET* test is significant. The model (A4) is found to be reasonably stable when investigated by means of recursive methods. These investigations are available upon request.

$$\text{(A4)} \qquad \underset{}{\Delta pi_t^c} = const. - \underset{(0.072)}{0.421}\Delta pi_{t-1}^c - \underset{(0.059)}{0.235}\Delta pi_{t-2}^c - \underset{(0.036)}{0.323}\Delta pi_{t-3}^c$$

$$+ \underset{(0.388)}{0.650}\Delta pw_t + \underset{(0.182)}{0.542}\Delta e_t + \underset{(0.207)}{0.470}\Delta e_{t-1} + \underset{(0.087)}{0.326}\Delta abs_t$$

$$- \underset{(0.054)}{0.123}[pi^c - pw - e]_{t-1} + \underset{(0.112)}{0.237}abs_{t-1} + \underset{(0.014)}{0.021}CS_{1t}$$

Method: *OLS* T=98(1979:1–2003:2) R^2=0.717 σ=2.81% DW=1.78
$AR_{1\text{-}5}$:F(5, 82)=1.126 $ARCH_{1\text{-}4}$:F(4, 79)=0.384 $NORM$:χ^2(2)=4.071
HET_1:F(19, 67)=1.128 HET_2:F(64, 22)=0.631 $RESET$:F(1, 86)=19.022

We see that pass-through from both foreign prices and the exchange rate to the import price of cars is *complete* in the long run. Accordingly, the long run version of the law of one price seems to hold in this case since pi^c, pw and e cointegrate with cointegration parameters equal to unity. We also observe, however, that abs_t enters significantly in (A4), indicating that increases in domestic demand pressure lead to increases in pi^c.[36] The presence of domestic market conditions in this way may be interpreted as evidence of PTM behaviour, but not in the terminology of Krugman (1987). Interestingly, Khalaf and Kichian (2004) adopt the model developed by Marston (1990) and find evidence of PTM behaviour in German exports of passenger cars to Norway. Another important result inherent in (A4) is that the exchange rate pass-through to the import price of cars is far from complete in the short run. This is due to the phenomenon that foreign car producers fix prices in the Norwegian currency in the short run, which brings about local currency pricing, while sticking to producer currency pricing in the long run.

[36] The unemployment rate, both in levels and first differences (with lags), turned out insignificant in (A4).

Data Definitions and Sources

TM	Trade margins index in the wholesale and retail trade sector (2002=1). The index covers trade margins on all services delivered in the sector. The data on trade margins is taken from the Norwegian national accounts. The data are based on detailed surveys of trade margins by product every fifth year or so. In between these surveys, average margins by broader product categories are inflated in the national accounts using annual statistics on wholesale and retail trade. Source: Statistics Norway.
PP	Price index of purchasing prices faced by distributors in the wholesale and retail trade sector (2002=1). The index weights together domestic and import prices on main commodities traded in the sector. Source: Statistics Norway.
VUC^d	Variable unit costs in the wholesale and retail trade sector, defined as in (3) in the text. Source: Statistics Norway.
H	Hours worked by self-employed in the wholesale and retail trade sector, expressed in 1000. Source: Statistics Norway.
X^d	Gross production in the wholesale and retail trade sector (at fixed 2002 prices), expressed in millions. Source: Statistics Norway.
E	Import-weighted nominal exchange rate index (1995=1). The index covers the main Norwegian trading partners, i.e., the 44 countries with the largest weights in Norway's imports of goods. The weight of each trading partner is the imports from this partner as a share of total imports. Source: Central Bank of Norway.
R	Average nominal interest rates on bank loans in the private sector. Source: Statistics Norway.
PI^m	Implicit deflator for imports of manufactures with Norwegian substitutes (2002=1). Source: Statistics Norway
PI^c	Implicit deflator for imports of cars (2002=1). Source: Statistics Norway
PW	Index of foreign export prices measured in foreign currency (2002=1). Source: OECD
VUC^m	Variable unit costs in manufacturing defined as $(LW^m \cdot W^m + M^m \cdot PM^m)/X^m$, where LW^m is hours worked in manufacturing, W^m is nominal wage costs per man-hour in manufacturing, M^m is material inputs in manufacturing (at fixed 2002 prices), PM^m is the price index of material inputs in manufacturing (2002=1) and X^m is gross output in manufacturing (at fixed 2002 prices). Source: Statistics Norway
U	Unemployment rate. Source: Statistics Norway
ABS	Domestic absorption (at fixed 2002 prices) defined as $C+G+J$, where *C* is private consumption, *G* is public consumption and *J* is gross investment in fixed capital. Source: Statistics Norway

CS_{it} Centered seasonal dummy for quarter i, equals 0.75 in quarter i, −0.25 otherwise, i=1,2,3.

D74.1, D78.2 Dummy variables used to account for outliers and instabilities in the equation for Δpp_t in the VAR. Dxx.y equals 1 in 19xx.y, zero otherwise.

D78.1 Dummy variable used to account for an outlier and instability in the equations for Δpp_t, Δvuc_t^d and $\Delta(h-x^d)_t$ in the VAR. Equals 1 in the first quarter of 1978, zero otherwise.

D96.3, D98.2 Dummy variables used to account for outliers and instabilities in the equation for $\Delta(h-x^d)_t$ in the VAR. Dxx.y equals 1 in 19xx.y, zero otherwise.

PSTOP A combined regulation/catch-up dummy variable used to control for governmental price regulations during the 1970s. Equals 1 in years of regulations, −1 in years of catch-up and zero otherwise, see Bowitz and Cappelen (2001) for details.

Recursive Estimates and Test Statistics

Figure C1. Recursive test statistics for the preferred VAR

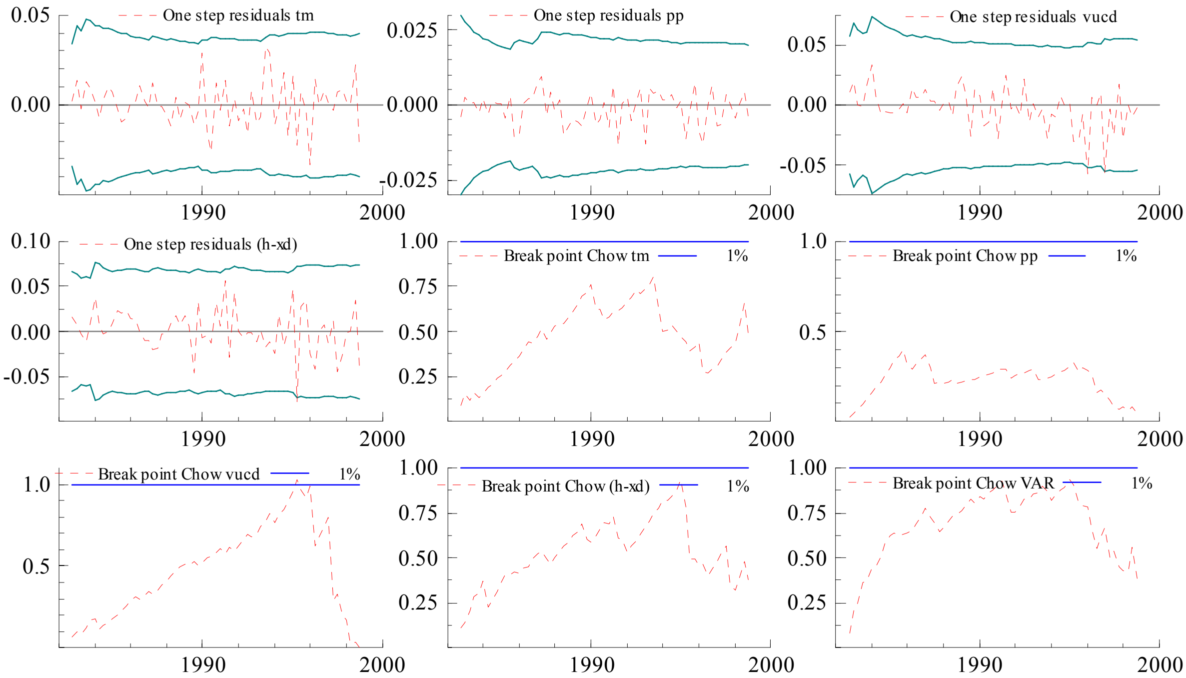


Figure C2. Recursive estimates of (13)

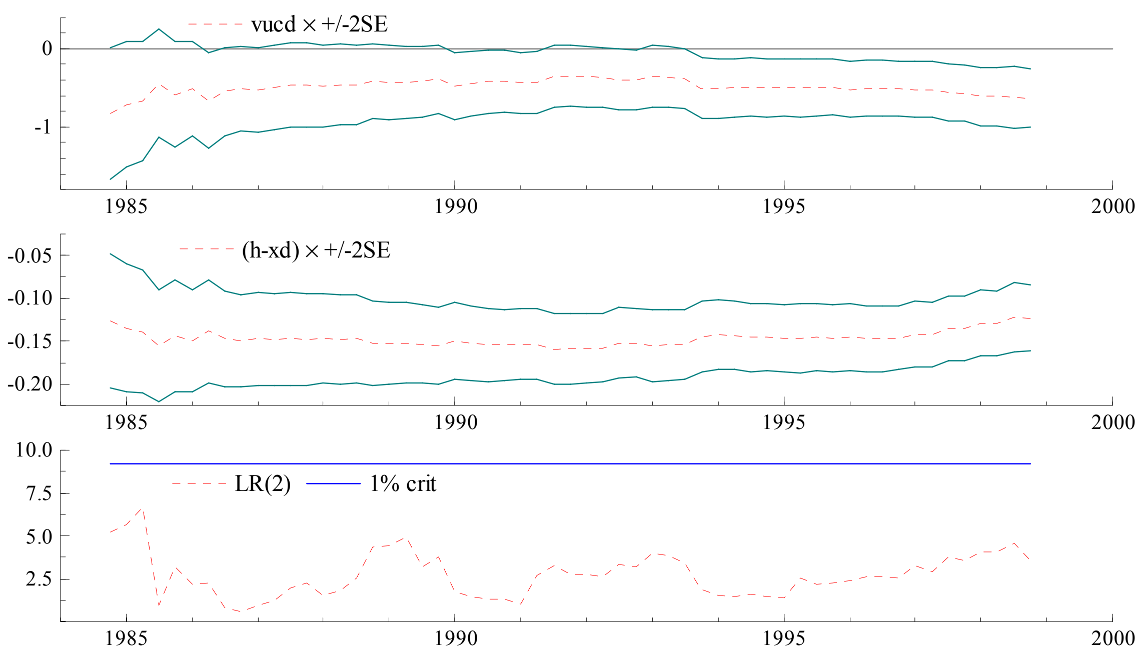


Figure C3. Recursive test statistics of (15)

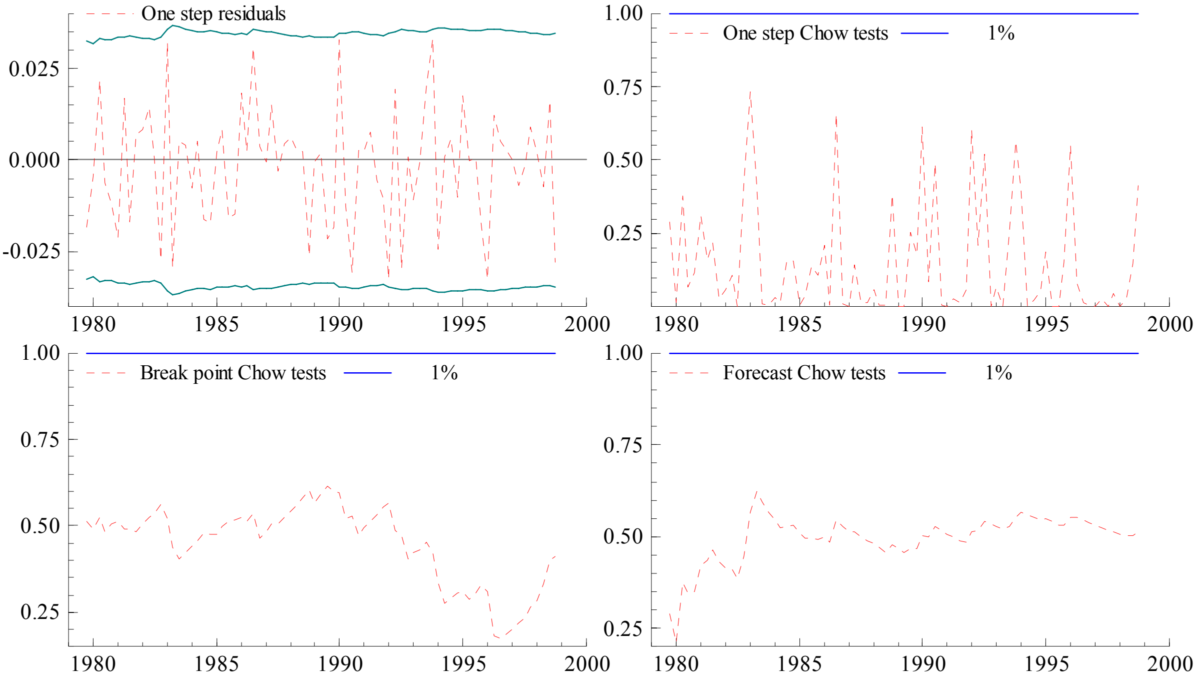
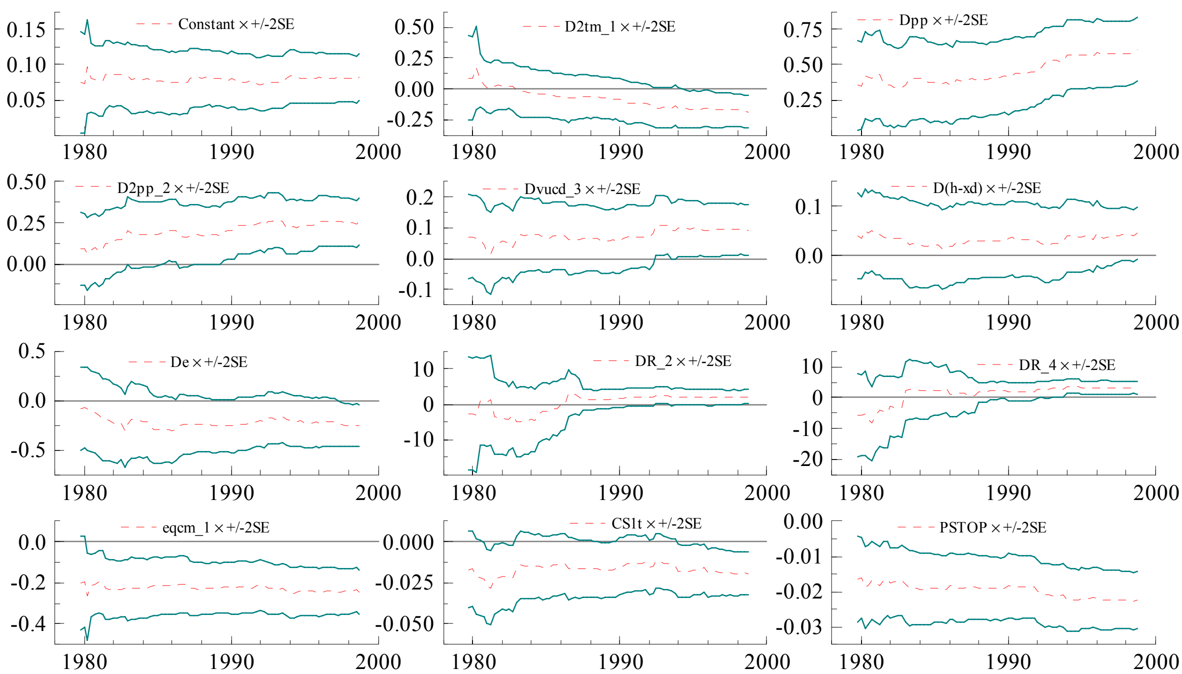


Figure C4. Recursive estimates of (15)



$$\Delta tm_t = const. - \underset{(0.061)}{0.192}\Delta_2 tm_{t-1} + \underset{(0.109)}{0.655}\Delta pp_t + \underset{(0.067)}{0.258}\Delta_2 pp_{t-2} + \underset{(0.039)}{0.097}\Delta vuc^d_{t-3}$$

$$+ \underset{(0.024)}{0.062}\Delta(h - x^d)_t - \underset{(0.096)}{0.208}\Delta e_t + \underset{(0.978)}{1.873}\Delta R_{t-2} + \underset{(0.985)}{3.284}\Delta R_{t-4}$$

(C1)

$$- \underset{(0.051)}{0.259}[tm - 0.365pp - 0.635vuc^d - 0.123(h - x^d)]_{t-1}$$

$$- \underset{(0.006)}{0.018}CS_{1t} - \underset{(0.004)}{0.022}PSTOP_t$$

OLS, T=127(1971:2–2002:4), R^2=0.616, σ=1.72%, DW=2.18

AR_{1-5}:$F(5, 110) = 1.197$ [0.316]
$ARCH_{1-4}$:$F(4, 107) = 1.265$[0.186]
$NORM$:$\chi^2(2) = 2.420$ [0.298]
HET_1:$F(21, 93) = 0.745$ [0.776]
HET_2:$F(76, 38) = 0.645$ [0.947]
$RESET$:$F(1, 114) = 1.372$ [0.244]

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