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Jaan Masso* and Karsten Staehr**

Abstract: The paper seeks to explain the inflationary dynamics in the Baltic countries since the mid-1990s. While single-equation estimations generally yield poor results, panel data estimations provide statistically and economically satisfactory findings. Our main result is that the observed gradual disinflation can to a large extent be explained by adjustment to international prices. Stringent fixed exchange rate systems have exerted downward pressure on inflation both directly and via expectations of future inflation. Measures of excess capacity in the labour market have no effect on inflation, while industrial output gaps have some explanatory power. Real oil price shocks have an immediate but short-lived impact on inflation.

Keywords: Inflation, exchange rates, Phillips curve

JEL classification: E31, E42, P24

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CONTENTS

1. Introduction

This paper seeks to uncover the determinants and dynamics of the inflation processes in the Baltic States during the later part of the transition period. After secession from the Soviet Union, monetary chaos and extreme inflation in the early 1990s, is it possible to estimate relations that satisfactorily how different variables affects the inflation rate? Among other questions addressed are how foreign prices affect domestic inflation and whether there is a Phillips curve relationship, i.e. a short-term link between capacity constraints in labour or goods markets and inflationary pressure. Knowing more about the inflationary processes in the Baltic States is important for several reasons.

Firstly, Phillips curve relationships with a short-term link between capacity utilisation and inflation can be found in virtually all industrialised countries (see e.g. Fuhrer 1995, Turner & Seghezza 1999 and Paloviita 2002). The existence of a Phillips curve in the Baltic countries would imply that they have attained "monetary normality" in the form of a linkage between the real and monetary parts of the economy, indicating that the stabilisation part of transition has been accomplished.

Secondly, Estonia, Latvia and Lithuania have successfully brought down inflation, using the exchange rate as a nominal anchor, and stand out by having maintained their pegs for a decade or more. Experience in Latin America, East Asia and a number of transition economies has made it clear that such pegs are vulnerable to speculative attacks. Still, although all three Baltic States have experienced speculative attacks (using, *inter alia*, forward exchange contracts), the three countries have been able to maintain their pegs. Estimation of their inflationary dynamics can reveal insights into the factors behind the successful stabilisations.

Thirdly, knowing inflation determinants and whether there is a link between excess capacity and inflation is important when evaluating the inflationary impact of different economic policies and shocks on the economy. Examples are changes in fiscal and labour market policies, but also oil price shocks and price shocks from higher agricultural prices after joining the EU in 2004.

Fourthly, an important issue is whether the Baltic countries can sustain their hard currency pegs in the future (Berengaut *et al.* 1999). Lack of exchange rate flexibility is less challenging if domestic inflation exhibits a high degree of flexibility. For example, the existence of a feedback mechanism from real economy developments to inflation would lower the risk of sustained overvaluation of the currency.

Fifthly, one of the requirements for future membership of the EMU is sustained low inflation. Knowledge of inflationary dynamics would be useful for forecasting inflation and estimating the degree of convergence. The Baltic countries have experienced high inflation and therefore the possibility of resurgent inertia cannot be ruled out ex ante. A relatively high productivity growth in the Baltics might put upward pressure on the inflation rate (cf. the Balassa-Samuelson effect). Further, are the low inflation rates observed since 2000 sustainable if the economies are hit by various shocks, such as accelerating growth, import price changes, and oil price shocks?

Finally, it is important to consider whether future EMU membership would be a straightjacket that stifles economic development. A possible concern is that an initial or gradual emerging real overvaluation would suppress output and employment. Again, nominal flexibility in the goods and labour markets would reduce this risk if excess capacity led to nominal adjustment. A feedback mechanism in the form of a Phillips curve would suggest at least some flexibility.[1]

These issues are important for most transition economies, and in particular for the countries that joined the EU in 2004; the EMU membership requires their inflation rates to converge to the levels of the current EMU members. A sizeable body of literature discusses inflationary developments and monetary policies in the transition economies (see our brief survey in the next section). However, for the Baltic States very little formal empirical work has been carried out; the inflationary dynamics and the factors behind the inflation slowdown since the mid-1990s have not been fully explored. Likewise, there are no studies comparing the inflation processes in the three countries.

This paper addresses these issues by seeking to estimate the Phillips curves for the three Baltic countries. This allows us to analyse inflationary dynamics and how inflation adjusts to different changes in the real part of the economy, including capacity utilisation in the labour or goods markets. Having only reliable and relevant data since 1995, the sample is short and we must use monthly data. The lack of data points and reliable information about a number of explanatory variables, in particular import prices, imposes challenges on the econometric specification. It also means that all the results are preliminary and should be interpreted as such.

We find that it is generally difficult — or perhaps impossible — to estimate well-specified Phillips curves for each Baltic country separately. We resort to panel data estimations in order to increase the precision of the parameter estimates of main interest. A number of findings are recurrent in our estimations. The inflation can to a large extent be explained by adjustment to international prices that affect it both directly and via expecta-

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[1] This suggests that, *inter alia*, labour market flexibility is desirable when joining the EMU. The issue for the Baltic States is studied, for instance, by Paas *et al.* (2003), and Eamets & Masso (2003).

tions of future inflation. Measures of excess capacity in the labour market appear to have no effect on inflation, while industrial output gaps have some explanatory power. Real oil price shocks have an immediate but limited impact on inflation, while a clear seasonal pattern is apparent, partly resulting from discretionary increases in administered prices at the beginning of the year.

The paper is structured as follows. Section 2 briefly surveys the most recent literature discussing inflation dynamics in transition economies. Section 3 gives an overview of inflation developments and stabilisation policies in the three Baltic countries since the early 1990s. Section 4 succinctly describes the variables in our data set and their time series properties. Section 5 discusses the Phillips curve and its empirical implementation in the present case. Section 6 presents the results yielded by the estimations of the Phillips curves using country-specific monthly data. Section 7 reports the results, using panel data estimation. Section 8 concludes.

2. Related literature

An integral part of the transition process was the stabilisation of inflation from the very high levels that emerged after price liberalisation, money-based deficit financing and a lax monetary policy. In the transition countries that joined the EU in 2004, inflation fell gradually to single digit levels during the second half of the 1990s. A considerable literature has addressed monetary policy challenges, inflation management and the choice of monetary policy regime in the transition economies.

Pujol & Griffiths (1996) argue that the moderate inflation (in the range of 10–30 percent per year) seen in many Central European countries in the mid-1990s was largely the result of recurring structural changes; consequently, disinflation from moderate levels of inflation could entail substantial costs. Cottarelli & Doyle (1999) provide a descriptive overview of the disinflation experiences in the transition economies during the early stages of the reform. A concern at the time of writing was the possibility of persistent moderate inflation, but the authors concluded that in most cases the moderate inflation was the result of deliberate policy choices and, hence, could easily be reduced.[2]

Koch (1997) discusses exchange policies and argues, on the basis of a relatively informal empirical analysis, that there is a link between exchange rate developments and inflation in the Central European countries. Backe (2002) also discusses the disinflation experiences of the accession countries, especially the relationship between the exchange rate policies and the disinflation, arguing that the reformed institutions and the future integration will probably be enough to keep down inflationary pressures.

The research explicitly focusing on the inflation dynamics of transition economies can broadly be grouped into two strands. One research field seeks to quantify the importance of the Balassa-Samuelson effect on inflation in the accession countries and the other transition countries. The question is whether the productivity growth in the accession countries that is higher than that in the EU-15 countries will lead to substantial long-term inflation differentials.[3]

Backe *et al.* (2002) review the inflation developments in the accession countries since the time when the transition reforms

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[2] It is noticeable that while inflation has gone down in all accession countries, the Central European countries have generally had a weak growth since the end of the 1990s, while this has not been the case in the Baltic countries. A possible link between these observations has not to our knowledge been thoroughly examined.

[3] The Balassa-Samuelson hypothesis is that a high productivity growth in the tradable goods sector will lead to a high wage growth and will thus translate into a higher inflation in the non-tradable goods sector.

started. Liberalisation set about a spiral of price increases but stabilisation policies brought inflation under control. Using sectoral inflation and productivity data, the authors show that the Balassa-Samuelson effect — and thus implicitly the income catch-up process contribute substantially to the inflation in the accession countries. Using highly disaggregated inflation data, Egert (2002) found that the Balassa-Samuelson effect has had a relatively limited impact on headline inflation in a number of Central European countries. Considering the Balassa-Samuelson effect on Estonian inflation, Egert (2003) found that the effect is relatively limited for the most recent part of the sample period, perhaps 1-2 percentage points per year. These results are broadly in line with other analyses (see the survey in Arratibel *et al.* 2002). One possible explanation is that the productivity growth in the non-traded sector has also been relatively high during the transition period.

The other strand of research employs standard inflation models, particularly Phillips curve specifications, to estimate the inflation as functions of different explanatory factors. Arratibel *et al.* (2002) take as a starting point the New Keynesian Phillips curve with forward-looking expectations and combine it with variables capturing structural and institutional factors. Using a panel data set, the paper estimates this equation both on headline inflation, and traded and non-traded inflation separately. Arratibel *et al.* (2002) find that the exchange rate regime has an effect on the formation of inflation expectations but also that there are significant differences between inflation dynamics in the tradable and non-tradable sectors. The unemployment rate enters significantly into the non-tradable inflation equation.

A number of papers have modelled the inflation process in individual countries. Golinelli & Orsi (2002) employed co-integration techniques to model monthly inflation in three Central European countries. They found that inflation developments can particularly well be explained by the exchange rate and the output gap. These authors did not consider the possibility of forward-looking expectations. Kim (2001) modelled the quarterly inflation in Poland since 1990 and discovered that while in the early stages of the reform the inflation was mainly driven by imported inflation, at later stages a large part of the inflation could be explained by the domestic wage increase. Surprisingly, no structural breaks were identified in the turbulent sample period. Iacone & Orsi (2002) concluded from an econometric analysis of the CEE countries, using a structural model, that the effect of exchange rate on inflation is in line with economic theory and that exchange rates should be actively used to control the inflation in the CEE countries.

Only a few studies are available about the Baltics. Hansen & Pancs (2001) discuss whether a Phillips curve has emerged in Latvia since 1996. A graphic representation shows a negative correlation between the unemployment rate and the actual inflation level in Latvian data, but the authors do not consider this finding reliable. Bitans *et al.* (2002) estimate a very parsimonious Phillips curve for Latvia, but include very few tests for specification and robustness.

Vetlov (2002) provides an informal discussion of the factors affecting inflation in Lithuania after it regained independence. He argues that while in the pre-currency-board period the main factors affecting inflation had been factors like output collapse, shock of energy prices, price liberalization, etc., then after the introduction of currency board they were supplanted by factors like adjustment of relative prices, under-valuation of the national currency (litas), increases in administrative prices, and as a new factor, the Balassa-Samuelson effect. Vetlov (2001) performed an econometric analysis of the Lithuanian economy's dollarization.

Haan *et al.* (2001) discuss the experience of the Baltic countries in the two ways of reducing inflation, i.e. via a currency board and an independent central bank. They argue that while Estonia's currency board, which is based on the D-mark, is very much in line with the criteria for an optimal monetary regime, Lithuania's initial choice of a US dollar-based currency board is not. Lybek (1999) argues that a higher degree of autonomy of the Central Banks of the Baltics and other parts of the former Soviet Union appears to be positively correlated with lower average inflation.

In summary, the issues of inflation dynamics and nominal adjustment appear to be of key importance for future economic developments in the Baltic countries. Yet only a comparatively limited body of literature has sought to shed light on these topics and no studies draw comparisons between the three countries.

3. Inflation and stabilisation in the Baltics

The three Baltic states — Estonia, Latvia and Lithuania — regained independence after the August 1991 putsch in Moscow failed. Among the many problems inherited from the Soviet Union was high, increasing and volatile inflation. The rouble remained legal tender and the countries imported extreme inflation as monetary chaos reigned. See Table 1.

A first step in tackling the problem of inflation was to sever the monetary ties with Moscow. Estonia was the first country to introduce its own currency, the kroon, in June 1992. Latvia gradually phased in a temporary Latvian rouble, which was made the sole legal tender in July 1992 and was replaced by the lat in March 1993. Lithuania circulated the transitional currency, the talonas, which was made the sole legal tender in October 1992 and was replaced by the litas in June 1993. However, inflation remained extremely high and fluctuating.

Table 1

Consumer price inflation in Estonia, Latvia and Lithuania, 1989–2003[a)]

	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Estonia	6.1	23.1	210	1076	89.8	47.7	29	23.1	11.2	8.2	3.3	4.0	5.8	3.6	1.4
Latvia	4.7	10.5	172	951	109	35.9	25	17.6	8.4	4.7	2.4	2.6	2.5	1.9	3.3
Lithuania	2.1	8.4	225	1021	410	72.1	39.6	24.6	8.9	5.1	0.8	1.0	1.3	0.3	–1.2

[a)] Annual percentage change in average CPI index.

Source: EBRD (1998, 2003) and national statistics authorities for 2002 and 2003.

All the three countries instituted stabilisation programmes to curb ravaging inflation (Berengaut *et al.* 1998). Estonia put in place a currency board already in June 1992, when the national currency was introduced, linking the new kroon to the German mark. Latvian stabilisation did not initially rely on an explicit exchange rate target, although the lat *de facto* shadowed the SDR from an early stage (Vanags 1998).[4] A tight peg to the SDR was formalised in February 1994, but from 1 January 2005 onwards, the lat is pegged to the euro. Lithuania initially attempted to disinflate by means of other instruments than the exchange rate; however, as inflation remained high, in April 1994 a currency board was put in place, linking the litas to the US dollar. From the middle of 1994, all three Baltic countries had introduced hard pegs to western currencies, and these pegs have remained in place with only minor changes. Estonia switched its pegging to the euro when the common European currency replaced the German mark. Lithuania started pegging to the euro instead of the dollar in February 2002 as part of the country's preparations for EMU membership and future EMU participation (Alonso-Gamo *et al.* 2002).

The hard pegs of the Baltic countries have widely been considered successful (Berengaut *et al.* 1998, OECD 2000). Since the middle of the 1990s, all three countries have been on track to monetary stabilisation. In 1995, annual inflation was within the interval of 25-40 percent, but showing a clear downward trend, although it remained well above the Western European levels until the end of the 1990s. The currencies were initially strongly undervalued and some "catching up" was to be expected. Since 1999, however, inflation in the Baltics has approached or even been below the West European levels (the only exception being Estonia where inflation reached 5.8 percent in 2001). The hard pegs appear to have helped discipline the fiscal policies, and so

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4 SDR is the acronym for "Special Drawing Right", an artificial currency unit based upon several national currencies. The Special Drawing Right serves as the official monetary unit of several international organizations including the International Monetary Fund.

keep the government debt build-up at low levels compared to most other transition economies.

After monetary stability was achieved, GDP growth picked up and the countries have generally been among the top performers in Eastern Europe.[5] Thus, real appreciation — especially pronounced in the mid- and late 1990s — appears to have had a limited impact on growth, although all the three countries have experienced a substantial current account deficits. Mass closures of large manufacturing conglomerates and collective farms as well as the elimination of labour hoarding inherited from the Soviet time have contributed to both open and hidden unemployment. Unemployment, registered as well as survey-based (ILO definition), has increased gradually and especially from 1999 onwards, when the Baltic countries were hit by the repercussions of the Russian crisis.[6] At present (in 2004), official unemployment is highest in Lithuania and lowest in Estonia.

Estonia, Latvia and Lithuania have weathered a number of shocks comparatively well despite the constraints imposed by their tightly fixed exchange rates. Since the mid-1990s, the countries have experienced several banking crises: most notably in Latvia in early 1995, in Lithuania in late 1995 and again in Latvia in 1998 following the Russian crisis in August the same year (Sutela 2001). In spite of the central banks' limited lending facilities, the crises were resolved speedily by consolidation and sale of the distressed banks to foreign investors.[7] The Russian crisis caused a dramatic reduction of export to the CIS countries (OECD 2000) resulting in a severe backlash in 1999 with very

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[5] For a broader discussion of growth and its determinants in the transition countries, see Campos & Coricelli (2002), and Falcetti *et al.* (2002).

[6] For a discussion of the effect of the Russian crisis on the Estonian economy, see Eamets *et al.* (2003).

[7] Since 2001 the banking sectors of all three Baltic countries have performed rather well in terms of a low percentage of non-performing loans (Koivu 2002).

low or negative growth rates in all the Baltic countries followed by markedly increased official unemployment rates.

However, all the three economies started to recover already in 2000. Trade was reoriented towards the neighbouring Western European countries. In addition, direct investments and domestic demand helped bring back growth. Unemployment has fallen only gradually. One reason might be that the Russian crisis brought about substantial changes in the production structure, exacerbating mismatch problems in the labour markets (see e.g. Eamets *et al.* 2003). Inflation has remained low or even negative during the recent economic pick-up in the region: in 2003 the consumer price inflation was 1.4 in Estonia, 3.3 percent in Latvia and 1.2 percent in Lithuania. The inflation in the Baltic States has essentially converged to the level of the euro-zone.

4. Variables and time series properties

For several reasons, the study of the inflation dynamics in the Baltic countries is challenging. Inflation reached hyperinflationary levels in the early 1990s, and the standard Phillips curve cannot be expected to provide an adequate fit in the circumstances of extreme monetary instability. In addition, a lack of relevant data and generally poor data quality mean that the sample cannot start before the mid-1990s. This in turn dictates the use of monthly data in the estimations.

Our data set contains each country's monthly data of the consumer price index (CPI), the real effective exchange rate index (REX), the real effective exchange rate index towards only western trading partners (REXW), the oil price in domestic currency (OIL), the registered unemployment (U) and the industrial production (YI). The index _EE after a variable refers to Estonia, _LA to Latvia, and _LI to Lithuania. The data set (including statistical data sources) is documented in Appendix 1.

The following notational conventions are used throughout the paper: The prefix L denotes the logarithm of the variable. The prefix Δ indicates the difference operator. $\Delta_n X$ is the difference between the current value of X and X lagged *n* months. For brevity, we write $\Delta_1 X$ as ΔX. $\Delta_n LX$ is approximately the sum of *n* months of monthly relative changes in X.

The variables in the data set are graphically presented in Figure 1. The unemployment rate is shown without any transformations. All the other variables are in logarithm form, implying that the slope can be interpreted as the growth rate of the variable.

The log price level (LCPI, panel (a)) grows relatively fast until 1997, but then gradually tapers off in all three Baltic countries. Prices have remained broadly constant in Lithuania since 1999, but have continued to grow in Estonia and in Latvia.

The log real effective exchange rates (LREX, panel (b)) have appreciated markedly in the period 1995-2000.[8] This is mostly due to the inflation in the Baltic countries being higher than in the trading partners. The Lithuanian real effective exchange rate has depreciated since 2001, partly because of the country's very low inflation in this period. The very large real effective appreciations in 1998 arose from the Russian financial crisis, which led to large devaluations in most of the eastern trading partners. The Baltic States' import from the East consists to a large extent of energy and other raw materials priced in international currencies. Thus, the real effective appreciations after the Russian crisis hardly led to substantially lower import prices. The log real effective exchange rate index towards western trading partners (LREXW, panel (c)) shows the same overall developments as LREX, but with less dramatic changes.

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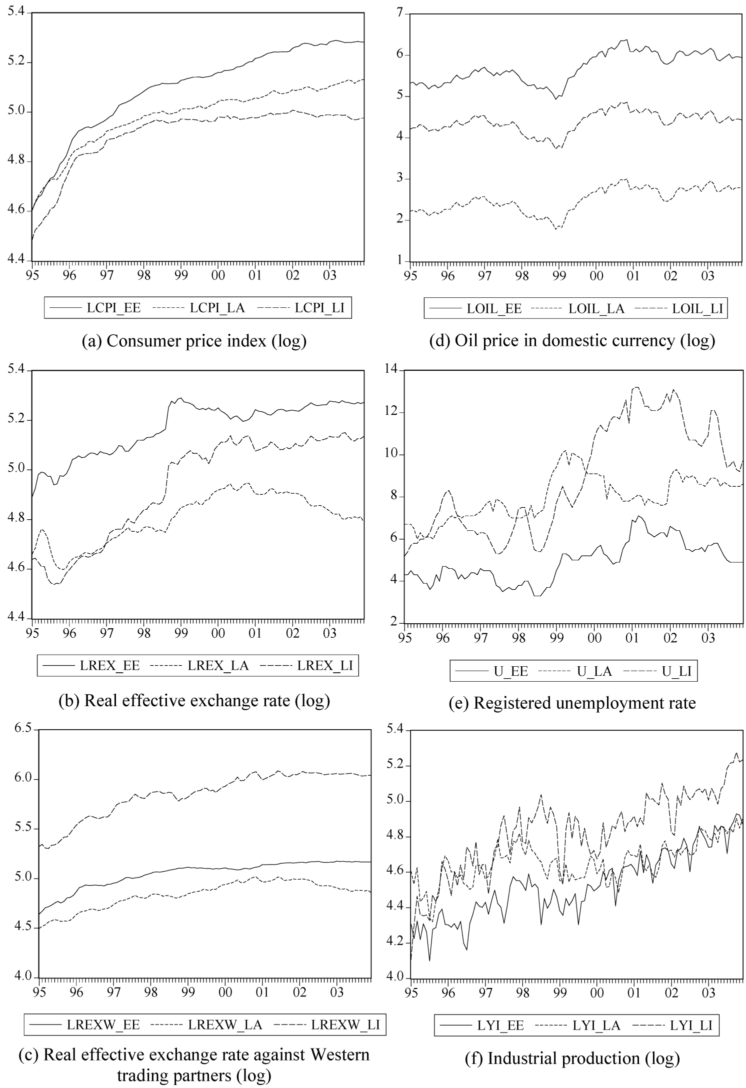
[8] The real effective exchange rate is here defined as the price level in the Baltic country divided by the weighted price levels in its trading partners measured in the currency of the Baltic country. Thus, a higher REX or REXW imply an appreciating real exchange rate.



(a) Consumer price index (log)

(d) Oil price in domestic currency (log)

(b) Real effective exchange rate (log)

(e) Registered unemployment rate

(c) Real effective exchange rate against Western trading partners (log)

(f) Industrial production (log)

Sources: See Appendix.

Figure 1. Selected variables for Estonia, Latvia and Lithuania, monthly, 1995:01–2003:12

The log nominal oil prices in domestic currency (LOIL, panel (d)) have shown little movement with the exception of the oil price drop in 1997–98 and the subsequent increase in 1999–2000. The registered unemployment (U, panel (e)) has been developing differently in the three countries. It has consistently been lowest in Estonia, increasing only moderately after the Russian crisis. Conversely, the Latvian and especially Lithuanian unemployment rates rose significantly after the Russian crisis, but while the unemployment fell back relatively rapidly in Latvia, in Lithuania its rate increased until the middle of 2000. Since 2001, the registered unemployment rate has either fallen or remained constant in all the three countries.

The log industrial production (LYI, panel (e)) exhibits lots of seasonal variation, but a trend pattern is also apparent. While in Estonia the industrial production has increased steadily with only a minor dip around the Russian crisis, in the two other Baltic States it fell more (in Latvia already from 1997) because of a banking crisis.

Before running any regressions, we examined the time series properties of each of the time series of the variables in the data set, in specific LCPI, LREX, LREXW, LOIL, U, LU and LYI, using an Augmented Dickey-Fuller unit root test. We employed specifications both with and without a trend component. The values of the *t*-statistics of the ADF-test on the sample 1995:01 to 2003:12 are reported in Table 2.

The presence of unit roots in the LCPI series can be rejected. This result that log price *indices* do not exhibit unit roots is likely to reflect the downward trend in the inflation during the sample period. For ΔLCPI, the unit root can be rejected at the 10% level for all the three countries. Somewhat surprisingly, unit roots cannot be rejected for the "real variables" LREX (at least for Latvia and Lithuania) and LREXW (when a trend is included). The unit roots in LREX and LREXW reflect the real effective appreciation during most of the sample period, cf. also the large differences between the *t*-values with and without inclusion of a trend. The nominal oil price LOIL has a unit root, while ΔLOIL has none.

Table 2

Augmented Dickey-Fuller test of unit root, *t*-statistics, 1995:01–2003:12[a)]

Estonia	Without trend	With trend	Latvia	Without trend	With trend	Lithuania	Without trend	With trend
LCPI_EE	–3.88	–3.31	LCPI_LA	–5.76	–6.26	LCPI_LI	–5.47	–4.88
ΔLCPI_EE	–2.55	–3.46	ΔLCPI_LA	–3.07	–3.83	ΔLCPI_LI	–3.11	–3.69
LREX_EE	–3.02	–2.60	LREX_LA	–0.84	–0.21	LREX_LI	–1.04	–1.02
ΔLREX_EE	–4.78	–5.33	ΔLREX_LA	–4.49	–4.66	ΔLREX_LI	–4.61	–4.64
LREXW_EE	–3.60	–2.89	LREXW_LA	–2.69	0.28	LREXW_LI	–3.28	–1.37
ΔLREXW_EE	–3.67	–4.72	ΔLREXW_LA	–3.89	–5.21	ΔLREXW_LI	–4.47	–5.39
LOIL_EE	–1.48	–2.05	LOIL_LA	–1.51	–2.18	LOIL_LI	–1.92	–2.03
ΔLOIL_EE	–4.57	–4.55	ΔLOIL_LA	–4.65	–4.62	ΔLOIL_LI	–4.62	–4.61
U_EE	–1.64	–1.97	U_LA	–1.80	–2.26	U_LI	–1.67	–1.61
LU_EE	–1.63	–2.04	LU_LA	–1.76	–2.14	LU_LI	–2.03	–2.15
ΔLU_EE	–6.25	–6.25	ΔLU_LA	–4.17	–4.17	ΔLU_LI	–5.04	–5.16
LYI_EE	0.20	–2.42	LYI_LA	–1.45	–2.78	LYI_LI	–1.52	–2.70
ΔLYI_EE	–8.48	–8.51	ΔLYI_LA	–6.13	–6.08	ΔLYI_LI	–6.35	–6.34

[a)] Augmented Dickey-Fuller test using *four* lagged first differences, a constant and, if indicated, a linear trend. Davidson & MacKinnon (1993, Table 20.1) provide critical values of the *t*-statistics for different levels of significance of the Augmented Dickey-Fuller test. Without trend the 1% critical value is –3.49, the 5% critical value is –2.89, and 10% critical value is –2.58. With trend the 1% critical value is –4.05, the 5% critical value is –3.45, and 10% critical value is –3.15.

The null hypothesis of unit roots in the unemployment series U and LU cannot be rejected. This suggests (as might also follow from Figure 1 panel (e)) that there is a slow-moving trend component in the unemployment. A shock leading to an increase in the unemployment rate may have a long-lasting impact on the unemployment rate, i.e., the unemployment rate appears to exhibit hysteresis. Unit roots can be rejected for the differenced unemployment series. The industrial production LYI appears to exhibit a deterministic trend as the H_0 of the presence of unit root is not rejected for the equation without a deterministic trend. The differences of LYI are stationary. The behaviour of some series changes over time, cf. Figure 1. We therefore experimented with different time samples but, generally, the qualitative results changed little.[9]

5. The Phillips curve and its implementation

The Phillips curve is one of the most frequently applied empirical models. Several theories are compatible with the underlying idea of an output-inflation trade-off (Romer 2001, ch. 5). In all cases, excess capacity is hypothesised to lead to downward pressure on inflation, while high capacity utilisation leads to upward inflation pressure. A typical specification is (Hogan 1998; Fuhrer 1995, 1997):

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[9] The augmented Dickey-Fuller test often lacks the power to reject the false null hypothesis, e.g., if the time series are short. Panel unit root tests incorporate the additional information from the cross-sectional dimension and thus exhibit higher power than ordinary ADF tests (Levin & Lin 2003, Im *et al.* 2003, Maddala & Wu 1999 and Hadri 2000). We have abstained from using panel data unit root tests as the ADF test in our case reject the H_0 in a number of cases.

$$\pi_t = \alpha\pi_t^e + \beta GAP_t + \gamma X_t + \varepsilon_t . \qquad (1)$$

The inflation rate is denoted by π_t with subscript t standing for time; π_t^e signifies the inflation expectation, GAP_t is a measure of excess capacity, X_t is a vector of control variables, and ε_t is an error term. $\alpha > 0$ and $\beta < 0$ are parameters, while γ is a vector of parameters. The main feature of this model is that, ceteris paribus, excess capacity in the goods and/or labour markets exerts downward pressure on the inflation rate. Assuming that GAP_t and X_t comprise only real variables and that the inflation expectations are not systematically biased, then $\alpha = 1$ implies that the long-term Phillips curve is vertical and thus that the inflation-output trade-off will cease to exist in the long term.

An important issue is the formation of the inflation expectations π_t^e.[10] Traditionally, the expectations have been considered to be backward-looking, e.g., adaptive. However, this assumption is theoretically not well grounded. Future inflation might be predictable at least to some extent, e.g., in case of policy shifts or other changes known to affect inflation. One approach is to allow for both forward- and backward-looking expectations by including both lags and leads of the inflation on the right-hand side.[11] Phillips curves with both backward- and forward-looking

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[10] The model specification as it stands does not strictly encompass the recent concept of the New Keynesian Phillips curve where the expectation to next period's inflation enters (Clarida *et al.* 1999).

[11] Vork (2000) showed for Estonia that during the 1990s, when the inflation trended downwards, that the inflation forecasts of economic experts surveyed regularly by the Estonian Institute of Economic Research were systematically above the realised inflation rate. Vork interpreted this as evidence in favour of the adaptive expectations hypothesis. A critique of this interpretation is that the systematic error of inflation forecast could have been caused by persistent devaluation expectations (the "Peso phenomenon").

inflation terms are occasionally called *hybrid* Phillips curves (Fuhrer 1997, Dupuis 2004).

Controlling for shocks is important as a possible correlation between shocks and capacity measures could otherwise bias the results. An oil price hike might, for instance, be directly carried into higher consumer prices, but might also lead to lower capacity utilisation and higher unemployment. Thus, to identify the partial effect of the oil price shock, both variables have to be entered into the right-hand side of the equation.[12]

Data availability and the choice of the Phillips curve model largely prescribe the overall choice of variables, but the empirical implementation still requires difficult choices to be made about specific variables, lag structures, etc. Moreover, the use of monthly data complicates the specification search because of the large number of lagged variables and the fact that the month-to-month differences can be volatile. We undertook preliminary specification searches but at stages we also employed an "eclectic" approach. The left-hand variable is in all cases the monthly change of log inflation, ΔLCPI.

The inflation expectations were modelled in a flexible way by using both lags and leads of the inflation rate ΔLCPI on the right-hand side. The lagged terms capture the backward-looking (autoregressive) component of the inflation expectations. The leads capture the correct forward-looking expectations consistent with many specifications of the New Keynesian Phillips curve (Clarida *et al.* 1999). This modelling choice implies that we presuppose very little about the expectations formation but derive them as an empirical result (cf. also Fuhrer 1997). Some experimentation showed that the dynamics played out within a relatively short time. So there was little loss from only using the 3-month change in consumer prices leaded three months,

[12] Correlated variables, e.g., in the form of oil price shocks and measures of capacity utilisation, might still give rise to multicollinearity problems and, hence, imprecisely estimated parameters.

Δ_3LCPI(3), and the 3-month change in consumer prices lagged by one period, Δ_3LCPI(−1), as the autoregressive terms on the right-hand side.[13]

A focal point of this paper is whether there is a link between the real and nominal economic variables in the Baltic countries. The choice of capacity gap measure must therefore be considered carefully. Capacity utilisation measures pertain to two different markets, namely, the labour market and the output market. The unemployment gap is the difference between the actual and natural rates of unemployment. The modelling of the natural rate relates to the degree of hysteresis. In the absence of hysteresis, the natural unemployment could be a constant, while significant hysteresis would imply that the natural unemployment is a function of previous unemployment realisations (and follows a stochastic trend). The output is typically calculated as the difference between actual production and a measure of trend production.

The "raw data" was the log unemployment LU and the log industrial production LYI. Using LU as the labour market gap implicitly assumes that the natural rate of unemployment is constant, which is not necessarily a realistic assumption. The industrial production has increased markedly in all the three countries since the mid-1990s and therefore LYI is a poor output gap measure.

We constructed the natural rates for both LU and LYI, using a slow-moving Hodrick-Prescott (HP) filter with $\lambda = 14400$. Slack measures were then calculated as the difference between the actual variable and the natural rate of the series. The unemployment gap is thus UGAP1 = LU — LUHP14400, where LUHP14400 is the HP-filtered unemployment. UGAP1 captures labour market slackness and the estimated parameter in

[13] Experimentation with polynomially distributed lags confirmed that the main dynamics plays out in the early periods before and after the period in which inflation is to be explained.

the Phillips curve is expected to have a negative sign. The industrial output gap is YIGAP1 = LYI — LYIHP14400, where the last term is the HP-filtered industrial production. The estimated parameter to YIGAP1 is expected to be positive.

Unemployment and industrial production are volatile series, so both UGAP1 and YIGAP1 are very "spiky". We therefore constructed two additional gap measures. We smoothed the actual series with a fast-reacting Hodrick-Prescott filter (λ = 100) to generate LUHP100 and LYIHP100, respectively. The smoothed gap measures could then be computed as UGAP2 = LUHP100 — LUHP14400 for the labour market, and YIGAP2 = LYIHP100 — LYIHP14400 for the output market. The expected sign of the parameter is negative for UGAP2 and positive for YIGAP2. In the specifications below, we will examine the explanatory power of each of the five measures LU, UGAP1, UGAP2, YIGAP1 and YIGAP2.[14]

Among the control variables, neither nominal import prices nor real import prices (import prices deflated with consumer prices) were available on a monthly basis. Experiments using the *relative change* in the real effective exchange rate REX (or REXW) as a proxy for real import price inflation proved unsuccessful, perhaps because changes in the real effective exchange rate is a relatively poor proxy for real import price inflation. Instead, we incorporated the lagged *level* of the real effective exchange rate in the estimations. A number of studies have shown that the real exchange rate plays an important role in the inflation process in other transition economies than

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[14] The choices of capacity gap measures have been dictated by the need for easily computable measures when using monthly data on a very short sample. We have thus not attempted other methods such as bandwidth filtering (Baxter & King 1999), the production function method for estimating output gaps (Room 2001 used that approach on Estonian data), or direct measures based, for instance, on surveys of employers on unused production capacity.

the Baltic States (see Golinelli & Orsi 2002, Kim 2001 for Poland).

The use of the lagged *level* of the real effective exchange rate in Phillips curve estimations can be given two slightly different interpretations. One rendition is that the lagged real effective exchange rate functions as an error correction term where domestic inflation adjusts to move the domestic price level toward its long-term solution. The implicit assumption is here that the real exchange rate is constant in the (very) long term, i.e. there exist a constant *equilibrium real exchange rate*.[15] The other rendition also builds on the implicit assumption of a constant real exchange rate in the long term. Deviations of the equilibrium real exchange rate from its long term constant rate would amount to a cost shock to the economy, which should be controlled for. In other words, if the equilibrium real exchange rate is relatively constant over time, then the actual real effective exchange rate proxies cost shocks.

During the estimation period, the Baltic States have experienced a number of large external shocks and have also received large capital inflows with corresponding persistent current account deficits as result. It is thus not clear that the domestic inflation developments would support the hypothesis of a long-term constant real effective exchange rate, i.e. that the inflation moves the domestic price level toward the level corresponding to a constant real exchange rate. Clearly, one cannot *a priori* be certain that the lagged real effective exchange rate enters sig-

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[15] A number of different methods have been proposed to estimate the equilibrium exchange rate, in some cases based on purchasing power parity, but in other cases based on broader economic considerations developed within partial equilibrium models and general equilibrium models. Suggestions include the Fundamental Equilibrium Exchange Rate proposed by Williamson (1994) and the Natural Real Exchange Rate proposed by Stein (1994).

nificantly in the Phillips curve; only empirical testing can address this issue.[16], [17]

The expected sign of the parameter of the lagged real effective exchange rate is negative. Both the overall real effective exchange rate (REX) and the real effective exchange rate towards Western trading (REXW) were available. LREXW fluctuates less than LREX, especially around and after the Russian crisis in 1998, cf. Figure 1 panels (b) and (c). We experimented with both measures, but obtained the most satisfactory results using LREXW.

We chose to control for possible effects of real oil price shocks by including lags of the *real* oil price change, ΔLOIL — ΔLCPI. The other control variables included a trend, monthly dummies for the first 11 months of the year, and a constant. The parameter to the trend was essentially zero in all estimations and therefore this variable is not included in the reported results.

6. Phillips curves estimated separately for each country

We commenced by attempting to estimate Phillips curves for each Baltic State separately. Based on experimentation, the

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16 Our method resembles closely the one used in Golinelli & Orsi (2002); they find that the lagged real exchange rate enters significantly and with the expected sign in inflation estimations for Poland, the Czech Republic and Hungary.

17 The lagged real effective exchange rate used here (REX, REXW) is constructed by dividing the domestic consumer price index by an weighted average of the trading partners' consumer price indices multiplied by their exchange rates. The fact that the domestic consumer price index enters the real effective exchange rate does not, however, cause any reverse causality problems. The right-hand level variable is lagged one period and thus cannot be influenced by current inflation.

following right-hand variables were included: the 3-month change in consumer prices leaded three months, Δ3LCPI(3); the 3-month change in consumer prices lagged by one period, Δ3LCPI(–1); the one-month lagged real effective exchange rate, LREXW(–1); the one-month change in the real oil price lagged by one period, ΔLOIL(–1) — ΔLCPI(–1); and one of the capacity terms LU(–1), UGAP1(–1), UGAP2(–1), YIGAP1(–1) or YIGAP2(–1).

The Phillips curves were estimated using GMM because of the leaded inflation terms on the right-hand side. As instruments, we used lags of the left-hand variable ΔLCPI in addition to the right-hand-side variables, excluding the inflation terms. This approach was chosen partly to circumvent the difficult problem of finding other meaningful instruments, but also because the Arellano-Bond method was used for the panel data estimations presented in section 7.

When estimating Phillips curves for the three countries separately, we did not manage to find a satisfactory specification for any of the countries. Thus, Table 3 presents only a subset of our results, namely, when either YIGAP1(–1) or UGAP1(–1) was used in the estimations. The diagnostic tests etc. are generally not reported.

For *Estonia*, column (3.1) shows the results when YIGAP1 was used as the capacity gap term. The parameter to the leaded inflation Δ_3LCPI(3) is insignificant, while the parameter to the lagged inflation Δ_3LCPI(–1) is positive and significant. The coefficient to the lagged log real effective exchange rate is insignificant, albeit having the expected sign. The coefficients to the real oil price inflation and the industrial production gap YIGAP1(–1) are positive as expected.

Table 3

Phillips curves estimated for each Baltic State separately, GMM estimation

	(3.1)	**(3.2)**	**(3.3)**	**(3.4)**	**(3.5)**	**(3.6)**
	Estonia	**Estonia**	**Latvia**	**Latvia**	**Lithuania**	**Lithuania**
Δ_3LCPI(3)	0.034	0.029	0.116	0.169	–0.278	–0.305
	(0.35)	*(0.26)*	*(1.73)*	*(2.95)*	*(–1.41)*	*(–1.54)*
Δ_3LCPI(–1)	0.119	0.103	0.039	0.040	0.134	0.134
	(5.21)	*(3.87)*	*(1.00)*	*(1.14)*	*(1.89)*	*(2.05)*
LREXW(–1)	–0.010	–0.011	–0.0043	–0.00097	–0.030	–0.033
	(–0.98)	*(–0.89)*	*(–0.73)*	*(–0.20)*	*(–2.41)*	*(–2.56)*
ΔLOIL(–1) — ΔLCPI(–1)	0.0092	0.0072	–0.0036	–0.0038	0.0021	0.0016
	(2.43)	*(1.82)*	*(–1.08)*	*(–1.04)*	*(0.29)*	*(0.24)*
YIGAP1(–1)	0.018	..	–0.0082	..	0.0043	..
	(4.22)		*(–1.59)*		*(0.63)*	
UGAP1(–1)	..	–0.0036	..	0.00092	..	0.0077
		(–1.10)		*(0.27)*		*(0.90)*
Constant & dummies	Yes	Yes	Yes	Yes	Yes	Yes
Estimation sample	95:07-03:11	95:07-03:11	95:07-03:11	95:07-03:11	95:07-03:11	95:07-03:11
No. of observations	101	101	101	101	101	101
R^2	0.65	0.61	0.62	0.63	0.29	0.29

The left-hand-side variable is ΔLCPI in all the cases. The instruments are lags of the left-hand variable in addition to all right-hand-side variables in the regression, except the inflation terms. Values in brackets are *t*-statistics calculated using heteroscedasticity consistent asymptotic standard errors.

Source: Own calculations, see text.

Leaded inflation, lagged inflation and the real effective exchange rate are highly correlated.[18] This has two consequences. First, it is difficult to obtain significant parameter estimates when all three terms enter the estimation simultaneously. Second, when the real effective exchange rate is included in the equation, the parameters to Δ_3LCPI(3) and Δ_3LCPI(–1) pick up short-term dynamics, while the real effective exchange rate in level form ensures long-term neutrality. If LREXW(–1) is excluded, the estimated coefficients to the inflation terms increase markedly.[19]

As seen from column (3.2), inclusion of the unemployment term UGAP1(–1) instead of the output term changes little. The estimated parameter to the unemployment gap is insignificant, although with the expected negative sign. Similar results were obtained using the other unemployment terms (not reported).

For *Latvia*, the main result of the single-country estimations is that the parameters are imprecisely estimated. Column (3.3) shows the results when the industrial production gap YIGAP1(–1) is used and no single parameter estimate is significant at the 5% level. The estimated coefficients to the real oil price inflation and the production capacity gap both attained "wrong" signs. Column (3.4) shows the results when the unemployment gap is included in the estimations. The parameter to UGAP1(–1) is wrongly signed but very imprecisely estimated.

For *Lithuania*, the estimation results are presented in the last two columns of Table 3. The negative sign to the forward-looking component of the inflation expectations in column (3.5) is the result of the correlation between the inflation terms and the real effective exchange rate. The real effective exchange rate enters, as expected, with a negative and significant coefficient. The coef-

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18 In the sample 1995:07-2003:11, the sample correlation coefficient between LREXW_EE(–1) and Δ_3LCPI_EE(3) is –0.76, and the correlation coefficient between Δ_3LCPI_EE(3) and Δ_3LCPI_EE(–1) is 0.60.

19 In general, the coefficients to the lagged and leaded inflation increase so much that monetary neutrality cannot be rejected.

ficient to the production gap measures YIGAP1(–1) is positive but insignificant. The estimated coefficients to the labour market gap in (3.6) are insignificant. The low goodness of fit for Lithuania is partly attributable to the very modest movements in the inflation rate during the period, but presumably also to noisy data of, for instance, industrial production.

In summary, none of the specifications in Table 3 denote well-specified Phillips curves. It is difficult, probably even impossible to estimate Phillips curves for each Baltic country separately; the short sample and noisy data imply that many parameters are imprecisely estimated. Nevertheless, the estimations yielded some information about the inflation processes in the countries.

In all the three countries, inflation exhibits some own-generated dynamics. Still, when the real effective exchange rate was included, the coefficient to the *lagged* inflation term is in most cases relatively small, indicating a relatively low degree of inertia in the inflation process. This is consistent with the fact that the countries emerged from monetary instability and high inflation in the first half of the 1990s (Fischer *et al.* 2002). Additionally, wage setting is not based on (backward-looking) indexation in any of the countries due, *inter alia*, to the limited coverage by collective agreements in all three countries (Cotterelli & Doyle 1999).

The coefficient to the lagged real effective exchange rate was not always significant, although it had the expected negative sign in all the cases. It was argued that the variable is highly correlated with leaded inflation, which unfortunately implies that it is difficult to identify the impact of foreign sources and dynamic adjustment on inflation. In other words, the correlation between the inflation terms and the real effective exchange rate makes it difficult to determine the relative importance for inflation of real exchange rate developments and “derived effects” via inflation expectations.

The capacity terms were generally not significant in the estimations and the estimated parameters did not have the expected sign in a number of cases. In this sense, our single-country estimations fail to shed light on one of our primary questions: whether there is a feedback from developments in the real economy to price inflation. To address these issues we need to improve the precision of the parameter estimates.

7. Phillips curves based on panel data estimations

The imprecise parameter estimates when the Phillips curves were estimated individually for each country were not surprising in the light of the short sample and the highly volatile monthly data. This suggests that a higher degree of freedom is needed to obtain reliable parameter estimates. The three Baltic States have broadly similar inflation experiences and also exhibit similarities in other respects. These considerations led us to estimate joint Phillips curves for a panel of the three countries. Turner & Seghezza (1999) and DiNardo & Moore (1999) are examples of recent papers that use panel data methods to estimate inflationary dynamics.

We estimated the model, using the Arellano-Bond method (Arellano & Bond 1991) that is commonly used for estimating dynamic panel data models, i.e. those with lagged and/or leaded dependent variables. The procedure is to difference the model (hence removing the fixed-effect) and then use lags of the original, un-differenced left-hand-side variable as instruments. Table 4 shows the results from the one-step Arellano-Bond GMM estimations.

Column (4.1) in Table 4 presents the model with the industrial output gap YIGAP1(–1). The coefficients to the forward and backward inflation terms are positive and significant, while the coefficient to the real effective exchange rate is significant with a negative sign. The parameter to the real oil price inflation is positive, and the output gap enters significantly and with the expected positive sign. Column (4.2) shows that if the real exchange rate drops, the coefficients to the lagged and leaded inflation will increase markedly. This result also emerged from the single equation estimations in section 6.

Column (4.3) presents the results when YIGAP2(–2) is used as the capacity utilisation variable. The coefficient to YIGAP2(–2) is larger than the one estimated to YIGAP1(–1) in (4.1), but attains a lower *t*-value. The reason is that YIGAP1 is very spiky and with its high leverage it might thus "lock in" the parameter estimates, while this situation is less likely with the smoothed series YIGAP2.

Columns (4.4)–(4.6) present the results with different unemployment capacity terms. In all the cases the labour market capacity terms have the "wrong" sign and are insignificant, although the estimated equations otherwise appear to be well specified.

In summary, the additional degrees of freedom have substantially improved the precision of the parameter estimates, which evidently facilitates making inferences based on the estimated Phillips curves. Inflation expectations, both forward- and backward-looking, play an important role in inflation determination, and so does the real exchange rate. Oil price shocks also influence inflation in the short term. Slack indicators based on industrial production enter strongly, while indicators based on labour market slackness have no detectable effect on inflation. Although not reported in Table 4, the estimations show that the seasonal pattern can only be explained with dummies. In all cases, the January dummy is positive and highly significant, while the August dummy is negative and significant.

Table 4

Estimated panel data Phillips curves for the Baltic States, Arellano-Bond GMM

	(4.1)	**(4.2)**	**(4.3)**	**(4.4)**	**(4.5)**	**(4.6)**
Δ_3LCPI(3)	0.108 *(8.80)*	0.141 *(13.0)*	0.117 *(7.84)*	0.104 *(11.54)*	0.109 *(7.35)*	0.107 *(8.55)*
Δ_3LCPI(–1)	0.087 *(2.47)*	0.134 *(11.7)*	0.087 *(2.60)*	0.085 *(2.57)*	0.086 *(2.83)*	0.086 *(2.69)*
LREXW(–1)	–0.017 *(–3.36)*	..	–0.016 *(–2.94)*	–0.018 *(–3.10)*	–0.016 *(–3.10)*	–0.016 *(–2.80)*
ΔLOIL(–1) — ΔLCPI(–1)	0.0065 *(3.61)*	0.0062 *(2.74)*	0.0076 *(3.01)*	0.0059 *(3.44)*	0.0061 *(3.52)*	0.0061 *(3.62)*
YIGAP1(–1)	0.0079 *(12.8)*	0.0066 *(7.71)*	..	..	..	..
YIGAP2(–1)	..	..	0.0152 *(3.07)*	..	..	..
LU(–1)	..	..	..	0.0020 *(1.47)*	..	..
UGAP1(–1)	..	..	..	..	0.0022 *(0.72)*	..
UGAP2(–1)	..	..	..	..	..	0.0038 *(0.89)*

	(4.1)	**(4.2)**	**(4.3)**	**(4.4)**	**(4.5)**	**(4.6)**
Constant & dummies	Yes	Yes	Yes	Yes	Yes	Yes
Estimation sample	95:07–03:11	95:07–03:11	95:07–03:11	95:07–03:11	95:07–03:11	95:07–03:11
No. of observations	303	303	303	303	303	303
Sargan test	227.4	205.5	225.3	229.2	228.2	229.1
	[1.00]	*[1.00]*	*[1.00]*	*[1.00]*	*[1.00]*	*[1.00]*
m1	–1.44	–1.48	–1.45	–1.45	–1.45	–1.45
	[0.15]	*[0.14]*	*[0.15]*	*[0.15]*	*[0.15]*	*[0.15]*
m2	–0.90	–0.89	–0.79	–0.79	–0.80	–0.80
	[0.37]	*[0.37]*	*[0.43]*	*[0.43]*	*[0.42]*	*[0.42]*
m12	1.364	1.368	1.388	1.367	1.375	1.352
	[0.172]	*[0.171]*	*[0.165]*	*[0.172]*	*[0.169]*	*[0.176]*

The left-hand-side variable is ΔLCPI in all the cases. The Arellano-Bond level instruments are lags of ΔLCPI. The values in brackets below the parameter estimates are *t*-statistics, calculated using heteroscedasticity consistent asymptotic standard errors. The Sargan test is the test of overidentifying restrictions (p-values in square brackets). m*i* is a serial correlation test of order *i*, asymptotically standard normal (p-values in parenthesis).

Source: Own calculations, see text.

The Sargan test indicated in all the cases that the instruments used were valid. The test for serial correlation of the 1st, 2nd and 12th did not reveal serial correlation in any of the specifications in Table 4. This suggests that the monthly dummy variables capture most serial autocorrelation.

There is some parameter instability in the estimations presented in Table 4. Specifically, if the estimation sample is shortened by removing observations from the *beginning* of the sample, the estimated coefficients to the leaded and lagged inflation terms and the real effective exchange rate will change. The explanation is that the data is rather noisy at the beginning of the sample and as the three variables are highly correlated, the *individual* parameter estimates change rather easily. It is noticeable, however, that the other estimated parameters — i.e. the parameters to the real oil price inflation and the capacity gaps — are stable. These parameters retain their sign and significance, even when the sample period is substantially shortened.

Until this stage in section 7, all parameters have been jointly estimated across the three countries. The implicit assumption is that the panel estimation method is valid, i.e. the parameters, when estimated independently for each country, are not significantly different from the parameters estimated jointly in a panel. We have tested whether this hypothesis is correct, i.e. whether the parameters to all variables in the Arellano-Bond estimations presented in Table 4 can be constrained to be equal across the three countries. The F-tests could not reject the null hypothesis of parameter equality across countries at the 5% level in any of the cases (4.1)–(4.6). We also tested for the equality across countries of the parameters to the slope variables, Δ_3LCPI(3), Δ_3LCPI(–1), LREXW(–1) and the capacity term, and again the null hypothesis of equal parameters across countries could not be rejected. These results are not surprising in the light of the imprecise parameter estimates attained when the Phillips curves were estimated separately for each country.

We are particularly interested in the parameters to the capacity utilisation terms. In Table 5, we have therefore chosen to present the results when the parameters of the *capacity terms* are estimated separately for Estonia, Latvia and Lithuania. All the other parameters are jointly estimated in order to attain a large degree of freedom. Space limitations necessitate that only the results for the separate estimation of parameters to YIGAP1(–1), YIGAP1(–2), LU(–1) and UGAP1(–1) are presented.

Column (5.1) shows that the parameter estimate to YIGAP1(–1) is insignificant at the 5% level for Estonia. The corresponding estimates for the two other countries are positive. The parameter estimates to YIGAP2(–1) are positive for all the three countries, cf. column (5.2), although it is only significant at the 15% level for Latvia. In both cases, an F-test rejects that the parameter estimates are significantly different across countries. It would thus appear unproblematic to use the jointly estimated Phillips curves presented in Table 4.

Columns (5.3) and (5.4) support the view that the unemployment terms LU and UGAP1 have little explanatory power, even when treated separately for each country. The same holds for UGAP2 (not shown).

The conclusion from the panel estimations in this section is relatively clear. The larger number of degrees of freedom ensured more precise parameter estimates. The forward and backward dynamics as well as the foreign price anchor are important, although the relative importance of the different factors appears to be sample dependent. The control for oil price shocks is important. The link between the nominal and the real sides of the Baltic economies is captured by industrial output gaps, and here the least spiky gap measure appears to be the most appropriate. Unemployment gaps as measured by LU, UGAP1 or UGAP2 have no explanatory power.

Table 5

Estimated panel data Phillips curves for the Baltic States with country-specific capacity term parameters, Arellano-Bond GMM

	(5.1)	**(5.2)**	**(5.3)**	**(5.4)**
Δ_3LCPI(3)	0.097 *(10.4)*	0.116 *(6.24)*	0.101 *(9.43)*	0.108 *(7.63)*
Δ_3LCPI(–1)	0.089 *(2.58)*	0.089 *(2.59)*	0.084 *(2.30)*	0.080 *(2.27)*
LREXW(–1)	–0.018 *(–3.21)*	–0.014 *(–3.17)*	–0.020 *(–2.98)*	–0.017 *(–2.92)*
ΔLOIL(–1) — ΔLCPI(–1)	0.0066 *(3.79)*	0.0077 *(2.83)*	0.0056 *(4.51)*	0.0060 *(4.35)*
YIGAP1_EE(–1)	–0.0095 *(–1.70)*	..	..	..
YIGAP1_LA(–1)	0.013 *(3.66)*	..	..	..
YIGAP1_LI(–1)	0.0087 *(6.08)*	..	..	..
YIGAP2_EE(–1)	..	0.019 *(9.91)*	..	..

	(5.1)	**(5.2)**	**(5.3)**	**(5.4)**
YIGAP2_LA(–1)	..	0.011 *(1.54)*	..	..
YIGAP2_LI(–1)	..	0.015 *(6.91)*	..	..
LU_EE(–1)	..	..	–0.00090 *(–0.25)*	..
LU_LA(–1)	..	..	0.00057 *(0.22)*	..
LU_LI(–1)	..	..	0.0026 *(2.21)*	..
UGAP1_EE(–1)	..	..	..	0.0016 *(0.38)*
UGAP1_LA(–1)	..	..	..	–0.0029 *(–1.12)*
UGAP1_LI(–1)	..	..	..	0.0050 *(18.8)*
Constant & dummies	Yes	Yes	Yes	Yes
Estimation sample	95:07–03:11	95:07–03:11	95:07–03:11	95:07–03:11
No. of observations	303	303	303	303

	(5.1)	**(5.2)**	**(5.3)**	**(5.4)**
Sargan test	227.1	225.3	236.7	236.2
	[1.00]	*[1.00]*	*[1.00]*	*[1.00]*
m1	–1.49	–1.45	–1.44	–1.44
	[0.14]	*[0.15]*	*[0.15]*	*[0.15]*
m2	–0.83	–0.79	–0.80	–0.79
	[0.41]	*[0.43]*	*[0.43]*	*[0.43]*
m12	1.29	1.399	1.37	1.394
	[0.194]	*[0.162]*	*[0.169]*	*[0.163]*

The left-hand-side variable is ΔLCPI in all the cases. The Arellano-Bond level instruments are lags of ΔLCPI. The values in brackets below the parameter estimates are *t*-statistics calculated using heteroscedasticity consistent asymptotic standard errors. The Sargan test is the test of overidentifying restrictions (p-values in square brackets). m*i* is a serial correlation test of order *i*, asymptotically standard normal (p-values in parenthesis).

Source: Own calculations, see text.

8. Final comments

This paper has sought to explain the inflationary dynamics and nominal adjustment in the Baltic States since the mid-1990s through the estimation of Phillips curves. The issue of nominal flexibility is important in the light of these countries' rigid exchange rate policies and future EMU membership. It is also important when seeking to access the inflationary consequences of shocks to the economy.

The results were largely "negative" when the Phillips curves for individual countries were considered. The short sample and the volatile monthly data made it impossible to estimate economically and statistically well-specified Phillips curves. Some qualitative results could still be derived from the single-country estimations, for example, the importance of real exchange rate movements, and the interdependence between own dynamics and the real exchange rate. It also followed that the unemployment gap measures had little or no explanatory power.

To increase the degrees of freedom and attain more precise parameter estimates, we turned to panel data estimations. It was shown that CPI inflation is strongly influenced by real exchange rate movements, i.e. the exchange rate pegs are likely to have continued contributing to lower inflation even after the extreme inflation had ceded. Forward-looking and backward-looking expectations have also played a role, but the specific contributions from different sources cannot be precisely identified because of a high degree of correlation.

The industrial output outpacing trend growth exerts, *ceteris paribus*, upward pressure on inflation. This result is of importance when considering past and future inflation developments. The high investment rates in the Baltic States since the mid-1990s have expanded their production capacity and might thus, *ceteris paribus*, have helped contain inflationary pressures. Industrial output growth might be a variable that should be watched closely in order to anticipate possible future inflation build-up.

The labour market gaps constructed in this paper did not influence the inflationary developments. This result can reflect that the gap variables are inappropriate measures of the underlying labour market pressure. Monthly data meant that we had to use data for registered unemployment. Given the large wedge between registered and survey-based unemployment in the Baltic States, the derived labour gap measures need not capture labour market tightness very well. Another, more straightforward interpretation is that the labour markets in the Baltic States are emergent and fragmented, so that overall unemployment rates have little impact on wage and inflationary pressures. It will be interesting to observe whether a trade-off between unemployment and inflation will emerge as the Baltic Countries continue their rapid economic progress and integration into the European structures.

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Appendix: Notation and data sources

Monthly data

A01–A12	Dummies = 1 for indicated month, 0 otherwise.
CPI	Consumer price index. Source: National Statistical Offices.
OIL	Oil price calculated as IMF average oil price in dollar converted to domestic currency. Source: IMF International Financial Statistics and Central Banks.
REX	Real effective exchange rate. Source: Central Banks.
REXW	Real effective exchange rate against western trading partners. Source: Central Banks.
U	Registered unemployment rate. Source: National Statistical Offices.
UHPλ	HP-filtered registered unemployment rate; $\lambda = 100$ (little smoothing, volatile), $\lambda = 14400$ (large degree of smoothing, trended).
YI	Production of industrial goods. Index. Source: National Statistical Offices.
YIHPλ	HP-filtered industrial production.

- The operator ($-t$) after a variable indicates the months of lags of the variable, e.g., X($-t$) is X lagged by t months.
- The operator L before a variable indicates the natural log to the variable.
- The operator Δ_n before a variable indicates the n month(s) difference of the variable, i.e. $\Delta_n X(-t) = X(-t) - X(-t-n)$.