A macro-econometric model of Lithuania LITMOD

Frits Møller Andersen\textsuperscript{a,}\textsuperscript{*}, Dmitry Celov\textsuperscript{b}, Dorte Grinderslev\textsuperscript{a}, Arvydas Kazlauskas\textsuperscript{c}

\textsuperscript{a}Risø National Laboratory, Systems Analysis Department, P.O. Box 49, DK-4000 Roskilde, Denmark
\textsuperscript{b}Lithuanian Academy of Science, Institute of Economics, Lithuania
\textsuperscript{c}Lithuanian Ministry of Economy, Lithuania

Received 1 October 2004

Abstract

This paper presents a medium-sized macro-economic sectoral model of the Lithuanian economy using econometrics on a limited number of quarterly observations. A central element in the model is a 12-sector input/output table of the Lithuanian economy facilitating analyses of structural changes. The general formulation of equations is the error correction model. The paper presents a general overview of model characteristics and a few empirical results. Model properties are illustrated in a standard public consumption simulation experiment. In general, the model gives an acceptable reproduction of past changes and model properties are comparable with similar models for other countries.

\textcopyright{} 2005 Elsevier B.V. All rights reserved.

\textit{JEL classification:} C50; E17

\textit{Keywords:} Macro-economic models; Econometric modelling; Lithuania

1. Introduction

This paper presents a short to medium-term macro-economic model of the Lithuanian economy “LITMOD”. Lithuania has a small open economy and is one of the countries that joined EU on 1 May 2004. The period analysed and used for the calibration of the model is the first quarter of 1995 to the second quarter of 2002, i.e., the period just before EU entry
and the period characterised by the transition form a centrally planned economy to a market economy, that is, economic liberalisation, changing focus from Eastern to Western European economies and considerable structural changes.

The developed model is a standard demand-driven macro-economic sectoral model in the tradition of the European national models HERMES (Commission of the European Communities, 1993), E3ME (European Commission, 1995), the Danish model ADAM (Dam, 1996, 1986), all estimated on annual data, and the Finnish model BOF5 (Willman et al., 2000) estimated on quarterly data. However, due to data limitations, seen in relation to the models mentioned, the ambition in modelling and the use of econometrics are fairly moderate. The model operates with 12 sectors facilitating analyses of structural changes, which have been and will continue to be important for the economic development in Lithuania. Econometrics on a limited number of observations is used to calibrate the model. The limited number of observations implies that a few key long-term parameters are restricted to theoretical sound/interpretable values. However, in general, both short- and long-term parameters are estimated, i.e., instead of developing a CGE-model calibrated on 1 year, we use the limited number of observations and econometrics to calibrate a macro-economic model, including the determination of short-term dynamics.

The model may be used for aggregated macro-economic forecasts, policy and structural analyses. Another use of the model is to analyse exogenous assumptions required for the simulation of different levels of growth.

After a few general characteristics of the Lithuanian economy in Section 2, the model and a few empirical results are presented in Section 3. Model properties are illustrated in Section 4 presenting a standard public consumption experiment. Finally, Section 5 gives a few general conclusions.

2. A few general characteristics of Lithuanian economy and economic development

A fairly comprehensive survey of recent studies of economies in transition is given in Campos and Coricelli (2002). Capos and Coricelli summarise the first 10 years of transition in seven stylised facts of transition economies: Output fell, Capital shrank, Labour moved (i.e., the labour force/the participation rate decreased and the unemployment increased), Trade re-oriented, Structure changed, Institutions collapsed and Costs were high (measured by increased unemployment and income inequality).

Looking at the development in Lithuania, the stylised facts defined by Capos and Coricelli apply for Lithuania.1 However, looking at Fig. 1, although GDP has not reached the level in 1990, a considerable recovery of the economy after the initial decrease in GDP is observed. Due to the very close dependency of the Russian economy, the initial decrease was stronger in Lithuania than in most Central and Eastern European countries. However, the actual size of the decrease is difficult to assess, as the data quality is questionable and the period is characterised by considerable structural changes, factory closings, hyperinflation and probably a shadow economy growth. In Schneider and Enste (2000),

---

the size of the Shadow Economy for Lithuania is evaluated to have doubled from 1989–1990 to 1990–1993 (from 11% to 26% or from 19% to 38% depending on the method of calculation). In 1993, the exchange rate of Litas was fixed against USD and from 2002 against the EURO. Inflation decreased after fixing the exchange rate, but was rather high until 1997. From 1999 to 2003, prices have been almost constant; ± 1% p.a.

Looking at the re-orientation of trade, the share of export going to Central and Eastern European countries and Russia was reduced from above 2/3 in 1990 to below 1/2 in 1998 and in 1999 (due to the Russian crises) to 1/4. In addition, total export (and Lithuanian GDP) decreased in 1999. After 1999, total export and the share of export going to Central and Eastern European countries increased. In the same period, the share of export going to EU countries increased from about 10% in 1990 to about 50% in 2001.

Following the Russian crises, Lithuanian economy recovered fairly fast and the Lithuanian economy is today one of the fastest growing economies in Europe with about 9% growth in GDP in 2003.

Other characteristics of the Lithuanian economy are high education level (the share of graduates is significantly higher than the EU average; about twice the average in EU and in their neighbouring countries, Latvia and Estonia), low labour costs (the average hourly wage is eight times below EU average and lower than the average of the new EU countries) and a low overall tax burden.

3. Model description

This section describes the model and the estimation of equations. A detailed description of LITMOD is found in Andersen et al. (2004). Kazlauskas and Leppä (2000) developed a first version of the model within the Lithuanian Ministry of Economy. The present model operates with a further disaggregation of the production sector, and a revised specification of many of the equations.

3.1. Overview of the model

The model mainly determines the real flows of the Lithuanian economy with a 12-sector input/output table as a central element. Besides an input/output table, the minimum that are required to describe the real flows of an economy are equations determining categories of final consumption, import, and factor inputs by sectors. Equations explaining real flows of the economy include a number of variables such as prices and income flows determining the real flows. Most of these variables are endogenous in the model. Finally, the model includes a number of equations describing interesting balances in current prices, for example, the public sector deficit and the current account.

A summary flow chart of LITMOD is given in Fig. 2, where shaded boxes are exogenous variables. Total final demands, divided into private consumption, investments, governmental consumption, and export, determine domestic production and import. Production by branches is determined from demand from other branches and deliveries to categories of final consumption using input/output coefficients. Domestic production determines factor demand and income. Prices are determined from production costs. Productivity and a Phillips-curve relation describe the wage determination. Important exogenous variables to the model are population, various tax-rates, governmental consumption, interest rate, and foreign prices and demand.

3.2. Calibration of the model

To calibrate the model, available data is mainly quarterly national account data from Statistics Lithuania covering the first quarter of 1995 to the second quarter of 2002, i.e., the period after the initial drastic decrease in Lithuanian GDP (see Fig. 1) and a period where some of the largest structural changes after the dissolution of the Soviet Union were accomplished. However, the period 1995 to 2002 may be characterised by considerable structural changes, liberalisation of markets and re-orientation of export. Although the

![Fig. 2. A flow chart of LITMOD.](image-url)
model is estimated on quarterly data for analytical and short to medium-term forecasts, the
model is used as an annual model, and seasonal variations are omitted, for simplicity, in
simulations presented in this paper.

The model includes 205 equations. Approximately half of the equations are identities
and definitions, describing for instance the composition of the governmental revenue, or
quasi-identities where lack of data implies that some central parameter is calibrated, e.g.,
an average tax rate on profit. The behavioural equations are based on economic theory, and
the dynamic adjustment towards long-term behavioural relation is formulated as an error
correction equation with additional short-term explanatory variables. For a number of
equations, long-term equilibrium coefficients are pre-fixed in the estimation, and when a
parameter is estimated with a wrong sign (e.g., increased wage increases the labour
demand in some sectors), or an unreasonable size, the parameter is restricted to a
theoretical appropriate value. In some equations, a dummy variable is included to adjust
for unexplained shifts in the variables (e.g., in a number of equations, a dummy for data
differences due to a new population census in 2001 being included). The equations are
estimated with Least Square single equation method, and due to the few observations,
changing data sources and structural changes in the estimation period, it has been
challenging to estimate some of the equations.

The remainder of this section outlines a few general characteristics of central parts of
the model. A detailed description of equations and estimation results including a complete
listing of all model equations is found in Andersen et al. (2004).

3.3. Description of central parts of the model

Private consumption is modelled by an Error Correction Mechanism (ECM) wherein
long-term equilibrium private consumption is determined by real disposable income, only.
To explain short and medium-term changes, additional variables are tested in the first
difference equation of the ECM. Among these are consumer prices to account for effects
of inflation, unemployment to account for precautionary effects, and changes in the
interest rate to account for capital effects.

Estimation results give a choice between restricting the long-term marginal propensity
to consume to 1.0 and the estimation of a slow adjustment process, or to estimate the long-
term marginal propensity to 0.8 and a fast adjustment process (35% the first quarter).
Either way, for the first many years following a change in disposable income, the marginal
propensity to consume is below 0.8. The model includes the specification with an
estimated long-term marginal propensity to consume of 0.8. Considering short-term
effects, the effect of changes in consumer price is close to \(-1.0\), indicating that Lithuanian
customers have in the short-term a very strict budget limit. The estimated coefficient to
changes in the interest rate is negative, i.e., the effect of an increase in the interest rate is a
postponement of consumption. No significant effect of changes in the rate of
unemployment was estimated.

The governmental sector is rather simply formulated. Governmental consumption is
exogenous and produced by the public sector. Governmental revenue includes four parts:
Tax on wage income (approximately 26% of the revenue), tax on profit (approximately
8%), revenue from VAT paid by households (approximately 47%), and taxes minus
subsidies paid by the production sectors (approximately 19%). In addition, the State Social Security Fund collects a fixed rate of the wage payments, and expenditure is pensions, etc., to households.

Foreign trade is specified as an Armington model. A given demand is met by domestic production or import, and the same product may have different prices as consumers distinguish between domestic and foreign produced goods.

In the export equation, as a proxy for the foreign demand, a weighted index of GDP growth in Lithuania’s 14 main foreign trade partners is used. The weights used are the export shares in 2001. Due to the large re-orientation of the Lithuanian export, the assumption of constant weights is a critical simplification. However, with the data available, an estimate of this re-orientation was not possible. Instead, a dummy to shift the level of export down from the third quarter of 1998 is included. As seen in Fig. 3, export is seriously reduced in 1999, but after a few quarters, the export resumes the same annual growth rate as before. As explained in Section 2, the decrease is due to the Russian crises and the increase comes from a re-orientation of export. The estimated long-term export demand elasticity is 1.6, and the estimated parameter to the export price relative to the foreign prices is negative (−0.5) indicating a monopolistic competition on the export market for the Lithuanian goods. However, this is a small export price elasticity.

In the import equation, private consumption is used as a proxy for the domestic demand. The long-term import demand elasticity is estimated to 1.7 and the short-term elasticity is estimated to be higher; i.e., in the short-term, domestic production cannot meet the increased demand. The import is largely influenced by the import price relative to the consumer price and the estimated price elasticity is −0.8. As for export, there is a significant negative effect from the Russian crises.

Fig. 3. Export in constant prices, mill. Litas.

---

2 In macro-econometric models, it is often difficult to explain shifts in export when there is a major change in the export market. A common solution is to include a dummy variable, see, for example, Hall et al. (2000). Similarly, Basdevant (2000) estimating an econometric model for Russia uses a time varying constant in each ECM equation to account for structural changes, e.g., the Russian crises.
Domestic production in the 12 sectors is determined by using input/output coefficients. The model distinguishes four manufacturing sectors, three private service sectors, energy, mining, agriculture, construction, and a public service sector. Only one set of input/output coefficients based on annual data from 1997 is available. However, as there are different seasonal variations in production and demand, especially in the agricultural sector, seasonal adjustments are estimated (change of stocks). In addition, structural changes between sectors have been important and the production equations include estimated time trends. The adjustments are calibrated to ensure that the total annual production plus import equals aggregated demand.

In the production, constant return to scale is assumed. Minimising production costs subject to a fixed level of production gives the demand equations for production factors in sectors. The assumed separability structure of the production function with the production factors intermediate \( C \), labour \( L \), and capital \( K \) is \( Q=f(C,h(K,L)) \).

Intermediate in sectors are determined by constant input/output coefficients adding estimated negative time trends to account for production becoming more labour and capital intensive during the estimation period.

The demand for labour and investments in sectors is described by using a CES production function with simplifying assumptions due to limited data availability, for example, data are available for investments \( I \) only, and not for capital. In some sectors, the estimated effect of increasing factor prices was positive and the production function is in these cases restricted to a Leontief function.

Estimation results show that labour demand increases on average by 0.12% when the wage decreases by 1%, and due to increased labour productivity, labour demand decreases quarterly on average by 0.9%. Investments increase on average by 0.65% if the investment price decreases by 1%, increases by 0.03% on average if the interest rate decreases by 1%-point, and decreases on average by 0.8% each quarter due to increased capital productivity.

Labour supply is assumed to be a constant share of the population with an estimated small positive effect of increased real wage. Without success, we tried to estimate a negative effect on the unemployment rate (if the unemployment rate is high, there will be a lesser chance of obtaining a job if joining the labour force and hence the labour supply should decrease) and a positive effect of domestic GDP relative to foreign GDP (the idea was to capture that if the Lithuanian growth is high, people will stay and work in Lithuania instead of working abroad).

Producer prices in the 12 sectors are estimated as a mark-up on a weighted average of marginal costs and import price. Since constant return to scale is assumed in the production function, the marginal costs are equal to the unit production costs (to wages, investments, and intermediate). The estimated long-term weight to the import price is in average 0.3.

Prices on final consumption (private and public consumption, investments, and export) are determined by weighting the prices on deliveries from the different sectors and abroad using input/output coefficients or estimated weights. All price equations exhibit long-term price homogeneity.

According to neoclassic theory, the long-term real wage is positively related to labour productivity, and according to the Phillips curve theory, the wage is negatively related to the unemployment rate. This is the same kind of wage equation as in, for example,
Marcellino and Mizon (2000). In the short-term, estimations show that nominal wages compensate for 1/3 of the inflation only, but in the long-term, full compensation is imposed (also in Welfe (2000), the long-term price elasticity is unity). The estimated long-term effect of the unemployment rate is very high; if the unemployment rate increases by 1%-point, e.g., from 8% to 9%, wages decrease by 5%.

The analysis in Welfe (2000) on Polish data finds that the effect of the unemployment rate on the real wage (and on prices) is insignificant. However, compared with other studies of wage determination, our estimated effect is not unreasonable in estimation on macro-time series (Carnot, 2002). Looking at Fig. 4, it is noticed that the real wage increased until 1998 and has been constant, or even decreasing afterwards. Apart from the quarters following the Russian crises, the labour productivity increased in the estimation period. Following the crises, the unemployment rate increased. This illustrates why the elasticity of productivity is estimated just below one and the unemployment rate has a large negative effect (with a high level of unemployment and a low or no Unemployment Benefit, the employees do not demand a higher wage). However, this indicates that there could be a structural break in the wage equation due to a shift from Russian orientated export to western export. As argued in Marcellino and Mizon (2000), we should estimate two separate equations for the period before and after the break; however, the two sub-periods are too short for estimating separate equations. It may be discussed whether it is reasonable to use this strong relationship from unemployment to wages in the model. As will be seen later (see Section 4), the huge effect on wages of a small decrease in the unemployment rate (and the low export price elasticity) implies overcrowding out in the model.

Finally, for most of the equations, the fit to the historical period (1995–2002) is reasonably good, bearing in mind the difficulties with the available data and the considerable changes in the period (structural changes, high inflation in the beginning of the period, etc.). An ex-post simulation for the latest years in the estimation period using

Fig. 4. Real wage, productivity, and unemployment.
the entire LITMOD shows that the model gives an acceptable reproduction of the economic development.

4. Model properties

To illustrate the model properties, this section shows a standard fiscal shock simulation where the real public consumption is permanently increased from 2004 by 1%. The same type of simulation is found in, for example, Willman et al. (2000), Carnot (2002), and Bagnai and Carlucci (2003). For central variables, annual changes for the next 10 years are reported. The simulation experiment is based on a baseline scenario where growth rates in the long-term decline towards the EU level. However, the results depend only marginally on the actual baseline scenario. Additional simulation experiments are shown in Andersen et al. (2004), and, in general, the model rather quickly reaches a new equilibrium.

The direct effect of an increase in the public consumption is that production in the public sector is increased by 1%, and total production is, therefore, increased by 0.14%. This increases the demand for labour and investments in sectors.

Keeping wages unchanged from the baseline projection, prices only change marginally. Fig. 5 shows the percentage changes in quantities. As explained above, production and hence labour demand are increased. A higher rate of employment increases the disposable income implying increased private consumption and import. Since import increases more than total demand, total production is in the long-term increased with approximately half of the direct 0.14% increase only. Export is unchanged since prices and foreign demand are unchanged.

Simulating the model with an endogenous wage rate, the percentage changes in prices and quantities are shown in Figs. 6 and 7. As the unemployment rate decreases, the nominal wage increases, and as seen, wages are very sensitive to changes in the

![Fig. 5. Exogenous wage: changes in quantities.](image-url)
unemployment rate. A higher wage increases production costs and hence the domestic producer price and other domestic prices. In the long-term, this results in an (almost) unchanged private consumption. Import is increased approximately the same as in the case of exogenous wage, but here the increase is solely due to the increase in the consumer price (import becomes relatively cheaper). There is a small decrease in the export due to the increase in the price on exported goods. The initial increase in total production is almost the same as with exogenous wage, but due to the wage–price increases—the model shows crowding out after a few years. In the long-term, the model shows a slight overcrowding out and compared to the baseline, the production is slightly decreased, i.e., an increase in the public consumption has a positive short-term effect only.
Since import increases and export decreases, the balance of the current account is worsened each year by more than 40 mill. Litas (see Fig. 8). Also, the governmental balance is worsened as the public consumption is increased without a similar increase in the governmental revenue.

In the long-term, labour demand in the public sector increases by 0.55%. Therefore, although total production decreases, there is a small positive effect on the total labour demand of 0.075% (see Fig. 9). The labour supply is slightly increased due to the increase in the real wage. The net-effect is a decrease in the unemployment rate of 0.06%-point.

As in Carnot (2002), we see a permanent lower unemployment rate, worsened trade balance (import is increased more than export is decreased), and higher consumer prices,
and as in Bagnai and Carlucci (2003), there is a crowding out in the private consumption. As in the Finnish BOF5 model (Willman et al., 2000), the long-term level of production is slightly lower because the shift of resources from private sector to governmental sector reduces average productivity.

All in all, even though the model is simple and based on data covering a short period with major changes in the economy, this experiment shows that compared with models of the same type, LITMOD generates reasonable results in this standard experiment.

5. Conclusions

Although Lithuanian economy has experienced considerable structural and institutional changes during the estimation period, a fairly standard macro-economic model reasonably reproduces the past development. Two distinct conclusions from the estimations are that Lithuanian consumers are in the short-term on a very strict budget and that an explanation of the re-orientation of Lithuanian foreign trade requires additional data. However, the inclusion of a dummy in the import and export equations is a simple way to handle this effect. Finally, simulation experiments show that the overall properties of the model are comparable with similar models for other countries. However, as in other models, the estimated long-term effect of the unemployment rate on wages is relatively high and this may be a questionable effect in medium-term forecasts.

Acknowledgement

The present version of the model is developed by the Economic Institute of the Lithuanian Academy of Science and Risø National Laboratory, Denmark. LITMOD is developed for the Lithuanian Ministry of Economy in a project supported by the Danish Energy Authority.

References