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Timo Baas[1]

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Abstract

The failure of the Maastricht criteria delayed Estonia's accession to the European Monetary Union (EMU) until January 2011. During this time, trading shares with Eurozone countries declined, raising questions about the optimal accession time. In this study, the macroeconomic effects of introducing a common currency are analyzed by considering the state of the economy in different years of accession. By accounting for currency conversion costs and in-house costs, we show that the trade effects of the EMU depend on the year of accession. In summary, a "late" accession induces higher benefits in terms of an increase in GDP, private consumption, and investment. However, the additional investment demand for building up capital stock in export industries is much higher in the "late" accession scenario. If foreign savings are not adjusted optimally, the "early" accession scenario might be beneficial.

JEL Classification: F15, F22, C68, J61, J30

Keywords: Eurozone; optimum currency areas; international trade; computable equilibrium model

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1 Introduction

The creation of the European Monetary Union (EMU) follows the insight that the full benefits of a single market can only be achieved by creating a common currency. In his seminal contribution, Rose (2000) confirms the positive effect of currency unions on trade through his finding that member countries of a currency union trade three times more than non-members do. Most of the literature on the "currency union effect" confirms a smaller and significant effect on trade of between 20 and 40 percent. For the EMU, it is unclear as to whether the benefits of common currency emerge soon after its creation. Early studies (Micco et al., 2003; Baldwin et al., 2005) show that the EMU produces a positive and significant effect of between 4 and 10 percent increase in trade. By clustering countries, (Baldwin and Taglioni, 2007) show that the effect depends on the tightness of economic integration and the distance from and trading share with currency union members. Because trade patterns change over time, the benefits of a currency union are not independent from the date of accession.

In this study, I address whether an "early" accession would have been more beneficial than the "late" accession that occurred in 2011. I build a dynamic general equilibrium model calibrated to different accession years by capturing the state of the economy for each year. This enables us to recognize economic integration as well as trading shares with EMU countries. Simulating a transaction cost saving shock shows that the effect of the EMU on trade depends on timing. Exports increase in the early accession scenario compared to the late one, whereas the opposite is true for imports. In both scenarios, additional investment is required to increase the capital stock of the economy. Investment demand, nevertheless, is considerably higher in the late accession scenario compared to the early one as the production of Estonia's exports becomes more capital-intensive.

The considerable catching-up process reflected in the increase in capital-intensive production is the most important reason why the literature on EMU accession timing is focused on Baltic countries. Based on the Balassa–Samuelson effect, the Maastricht inflation criteria seem inadequate because they prevent the accession of strong growing countries (a problem by which Estonia is most affected). After EU accession in 2004, the country experienced a period of a strong GDP growth and high inflation that did not meet the criteria. Only after growth and inflation slowed was Estonia finally able to join the EMU. During this time, trade and trading shares with the Eurozone countries declined. Because the benefits of the EMU are related to the amount of trade with member countries, the optimum accession timing can be questioned.

The second factor influencing the benefits of a common currency are transaction cost savings. To derive these savings, we distinguish two types of costs affected by the accession to a monetary union: Currency conversion costs and costs for working in a multi-currency environment. If these costs can be reduced or abolished, trade should increase with other member countries of the currency union and for imports from countries outside the EMU. Exporting firms in these countries still have to bear currency conversion costs but save in-house costs because of a reduction of the number of currencies involved in trade.

In our model, currency conversion cost savings account for 0.2 percent,[1] and in-house cost savings are set to 0.1 and 0.4 percent of GDP. These figures are in line with previous studies by the European Commission, who calculated total savings at 0.2 to 1.5 percent of GDP depending on the member state. Using these savings, the immediate effects of the common currency in our model are increases in EMU imports by 1 to 2 percent and in EMU exports by 0.7 to 1.4 percent. Extra-EMU trade accounts for approximately two-thirds of these figures. With these results, we are in line with more recent estimates of the currency union effect on trade while accounting for long-term integration trends (Bun, Maurice J. G. and Klaassen, Franc J. G. M., 2007).

In sum, the contribution of this study to the literature on currency unions and trade is threefold. First, the effect of a currency union on trade can be analyzed for different counterfactual accession dates considering the level of technology and competitiveness of the export sector during that period. Second, the adjustment process occurring after the transaction cost saving shock can be derived in detail as factors of production shift from non-tradable to tradable and investement goods. Third, because of the multisectoral structure, I can estimate third country effects of EMU accession depending on production chains scarcely mentioned in earlier studies.

The remainder of this paper is organized as follows: Section 2 provides a short overview of the existing literature; Section 3 explains transaction cost savings relative to the introduction of a common currency and provides a short overview of the structure of the model used in this study; Section 4 summarizes the assumptions made in our simulation exercise; Section 5 discusses the results; and Section 6 concludes.

[1] The ENB uses estimation techniques already applied in (European Commission, 1990, 1996).

2 The trade effects of a common currency

In recent years, a significant body of literature has discussed the effects of currency unions on trade. These articles follow the seminal contribution of Rose (2000), who analyzes the currency union effect for a large panel of countries using industry-level bilateral trade data. Although the EMU is one of the most important political experiments of our time, the Rose study relies first and foremost on the trade effect of currency unions for small and less-developed countries and does not seem entirely applicable to the Eurozone (Baldwin et al., 2008). The first study analyzing the trade effect of the EMU is Micco et al. (2003), who uses data from 1992 to 2002 (including 3 EMU years). Several other studied have followed, estimating an increase in trade of 5 to 15 percent caused by the creation of the Eurozone.[2]

Although most studies have focused on the trade effects on EMU members, Flam and Nordstrom (2006) estimate a trade effect of half that value for countries outside the Eurozone. As national currencies are abolished, these countries also benefit from a reduction in the number of currency conversions. A second related problem mentioned by Flam and Nordstrom (2006) is that transaction costs might still have been reduced in the intermediate phase between the introduction of the Euro in 1999 and the introduction of the paper Euro in 2001. Using two Euro dummies, they account for this problem and estimate the effects of the introduction of the electronic (1999–2001) and paper Euro (2001–2005) separately. In this study, the Euro boosted trade in the first and second periods by 10 and 19 percent, respectively.

Baldwin and Taglioni (2007), however, argue that the Euro effect captures some of the effects of a single market. Correcting for the ongoing progress in making the European Union a single market, Baldwin et al. (2008) estimate an increase in trade caused by the Euro of only 2 percent.

In general, the effect of the EMU on trade differs significantly among member states. The trade effect depends on the amount of transaction costs saved with the adoption of a common currency and the country's trade structure. For Estonia, transaction cost savings may be low because of a long history of fixed exchange rates with the Eurozone, but the trade structure of Estonia is still dominated by trade denominated in Euros. In the next section, the transaction cost savings associated with the introduction of a common currency are discussed. In Section 2.2, the trade structure of Estonia is described in more detail.

[2]Baldwin et al. (2008) provides an excellent overview of studies on the effects of the EMU on trade.

2.1 Transaction cost savings

A common currency reduces the microeconomic efficiency of trade through a variety of channels. The two most important channels are transaction costs and expectations. Transaction costs are affected through a reduction in costs related to a multi-currency environment. If two countries build a currency union, these costs can be cut to zero by reducing two parts (European European Commission, 1990):

- Financial costs consisting of the bid–ask spreads and commission fees that non-banks have to pay for foreign currency conversion.

- In-house costs faced by international operating companies to manage foreign exchange transactions.

These transaction costs were estimated by a couple of authors for either a single country (Grauwe, 1994) or for the whole European Union. The European Commission estimates the costs at 0.5 percent of the European Union's GDP. However, there are large differences among single member countries: The costs are estimated at 1 percent for small open economies and 0.1 to 0.2 percent for large economies with an international currency. Differences occur because the costs related to hedging are expected to be low for large industrialized countries with an international currency and high for small countries.

The National Bank of Estonia estimates the transaction costs savings using techniques similar to the European one European Commission (1990). Individuals and firms buying, selling, working, or investing in a foreign country face currency conversion costs if their currency is not accepted as a medium of exchange. These costs apply either to pegged or flexible monetary regimes. Estonian firms and households face the problem of converting the Kroon to the Euro. Transaction costs can be viewed as the volume of foreign exchange transactions to be converted into the Euro multiplied by the prices banks charge for these services. According to the Estonian Central Bank, 80 percent of trade transactions involve Euro currency conversion, resulting in financial costs worth 0.2 percent of GDP per year that are saved by joining the common currency. Reduction of in-house costs are more difficult to estimate. A set of case studies conducted on behalf of the European Commission suggests that on average, the costs for a company outside a currency union should be 0.1 percent of its exports to the currency union. This figure is a lower bound, because according to a business survey conducted by Ernst&Young (1990), one of three international active companies believe that their currency conversion costs exceed 0.5 percent turnover in foreign EU markets.

Costs related to expectations are hard to quantify. These evolve because there is a risk that fixed exchange-rate arrangements are split up in the future. A sudden split could cause tremendous costs to firms and households. Hutchison and Noy (2005) estimate costs of 5 to 8 percent of GDP in a period of 1 to 2 years after a currency crisis and up to 15 percent of GDP after a twin crisis, in which currency and banking crises follow each other. Thus, households securitize themselves against the risk of currency devaluation, which imposes costs. As a result, the risk premium over US bonds, that is, an additional charge on the interest rate of bonds with a similar rating emitted in different countries, is significant and varies over time.[3] Since 2010, solid exchange-rate regimes have not seemed to result in a reduction of country-specific risks. Agenor and Aizenman (2011) find mispricing in credit default swap (CDS) spreads of five Eurozone countries heavily affected by the sovereign debt crises of the Eurozone compared to countries with the same fundamentals outside the Eurozone. The authors conclude that there is either both excessive pessimism and overreaction to the fiscal deterioration, or because of the inflexibility of the exchange rate, expectations of the fiscal space of those countries markedly deteriorates. In summary, the sign of expectations is currently unclear. It may be that financial markets weight risks lower because of the possibility of a split in the case of a currency board (e.g., in years before the sovereign debt crises) or because the inflexible monetary regime of the Eurozone is seen as more risky because it is impossible to use monetary policy to improve the fiscal space of member countries.

Given the uncertainties regarding expectations, we focus on transaction costs in this model. As expectations seem to have reduced costs in the aftermath of the founding of the EMU and prior to the sovereign debt crises, a smaller increase in trade seen in recent literature on trade effects of the EMU can be partially explained.

2.2 Trade structure of Estonia

In the literature on the effects of the EMU on trade, highly integrated countries tend to gain most from the creation of the common currency. As indicated by (Frankel, 2004), waiting might increase the gains of a common currency as trade with the partner countries increases. This was not true for

[3] **?** estimate a risk-premium for the selection of Asian countries.

Estonia, because trade and trading shares with the Eurozone declined after EU accession.

The integration of Estonia into the international trading system occurred soon after gaining independence in 1990. The openness of Estonia increased sharply thereafter until it peaked at the beginning of the 2000s at over 80 percent. After the 2000s, openness declined to approximately 70 percent. During this decade, the geographical structure of trade changed from distant EU-15 countries to neighboring countries such as Sweden. In the same period, Estonia experienced strong foreign direct investment (FDI) inflows because of its privatization activity. It seemed that an early accession to the EMU would be beneficial because of strong trade links with Eurozone countries.

Price and Worgotter (2011) indicate that the initial boost in export market shares ahead of EU accession in 2004 was followed by a much smaller increase in the years thereafter. Other EU-8 countries such as Poland, the Czech Republic, or Slovakia experienced a long-lasting increase in export market shares.

This is somehow surprising as the division of trade in Estonia is similar to those countries and the trade structure of other OECD countries: the 51 percent share of intermediate goods is slightly lower than the OECD average, whereas capital (20 percent) and consumer goods (21 percent) nearly meet the OECD average. The division of production, however, follows a general structure of trade with post-socialist countries in the region. These countries are producing labor-intensive products, whereas developed countries are producing capital-intensive products. This division of production may not be sustainable. Labor mobility within Europe may result in higher wages in post-socialist countries, harming industries with labor-intensive production structures.

In detail, the Estonian economy exports agricultural goods (especially fish or fishing products), manufacturing goods (e.g., textiles, wood, paper, electrical machinery, and radios), basic metals, television, and communication products, and services with special focuses such as computers or computer-related services. According to Tiits et al. (2006), these products have low value added and are used foremost as intermediates. As a small open economy, Estonia imports a huge variety of products ranging from natural resources to high-end products. Estonia imports mining and quarrying products (e.g., petroleum and metal ores), manufacturing products (e.g., leather products, coke, and refined petroleum products), chemicals, basic metals, machinery, office machinery and computers, radio products, and motor vehicles.

The large share of intermediates indicates that there are strong trade chains between Estonia and the Eurozone but also with neighboring non-Eurozone countries. It is, therefore unlikely that the accession of Estonia to the Eurozone results in strong trade diversion. Concerning the export mix of the Estonian economy, the transaction cost savings may result in a gain in competitiveness, whereas an increase in wages caused by the rising economic efficiency may harm export sectors of Estonia, where wages are a dominant cost factor for these industries. With our computable general equilibrium (CGE) model, we account for these problems in considering different sectors, production chains, and limited labor mobility among different sectors of the economy.

3 The Model

In this section, we build a general-equilibrium model with imperfect labor markets and multiple regions. A reduction in currency conversion costs reduces the price for import goods produced in Eurozone countries and increases the return for exporting goods to Eurozone countries. World and Eurozone prices remain constant because of the small economy assumption applied. In a model without intermediate goods, the asymmetric reduction of prices results in trade creation and trade diversion towards Eurozone countries. In our model, the demand for intermediate goods follows production chains of the domestic industry, and Armington elasticities reflect preferences of households both reducing the scale of trade diversion and creation.

3.1 Firms

Our economy consists of i sectors, where a representative firm operates under perfect competition. Each firm has an infinite horizon and maximizes firm value by defining an optimum strategy for the use of investment, employment, and intermediate goods. Expectations are built according to the rational expectation hypothesis. Intertemporal firm value is defined by

$$\sum_{t=1}^{\infty}\prod_{s=1}^{t}\left(\frac{1}{1+R_s}\right)\left(D_{t,a}-\hat{V}_{t,a}\right). \tag{1}$$

Set $D_{t,a}$, denotes dividends, $\hat{V}_{t,a}$ new shares, and R_s the steady-state interest rate. Maximization of firm value is subject to four constraints: the law of motion of capital, the terminal condition, a fixed base-year capital stock in the first period, and the definition of dividends.

$$K_{t+1,a} = (1-\delta)\, K_{t,a} + QI_{t,a} \qquad (2)$$

$$K_{T+1,a} = (1+g)K_{T,a}$$

$$K_{1,a} = \bar{K}_{S,a}$$

The capital stock K_t contracts with the depreciation rate δ and increases with investment $QI_{t,a}$. It is assumed that the capital stock is in the steady-state from T, and therefore, the capital stock in $T+1$ is the terminal capital stock $K_{T,a}$ multiplied by the growth rate g.

Dividend payments are defined as the difference between turnover, wages of employees, costs for intermediate good usage, and retained profits used for investment.

$$D_{t,a} = P_{t,a}Q_{t,a} - W_{t,a}L_{t,a} - PN_{t,a}QN_a - ac_{t,a} - rp_t PI_t QI_{t,a}., \qquad (3)$$

where $P_{t,a}$ is the price of the output of commodity $Q_{t,a}$, $W_{t,a}$ the sector-specific wage, PN_t the price for intermediate goods, QN_a the quantity of intermediate goods, rp_t the share of profits retained, PI_t the price of capital, and $QI_{t,c}$ the quantity of investment goods demanded in activity a.

The output $Q_{t,a}$ is produced using a nested production function. In the two inner nests, the firm combines both single intermediate goods $QN_{t,c,a}$ to a composite good $QN_{t,a}$, and capital $K_{t,a}$ with labor $L_{t,a}$ to a good called value added $QV_{t,a}$. Finally, in the outer nest, gross value added $QV_{t,a}$ and intermediate goods are combined to produce gross output $Q_{t,a}$.

$$Q_{t,a} = (\mu_a QV_{t,a}^{-\rho_a} + (1-\mu_a)QN_{t,a}^{-\rho_a})^{\frac{-1}{\rho_a}} \qquad (4)$$

The parameter ρ_a denotes the elasticity of substitution among the different factors, A denotes factor productivity, and μ_a describes the share parameter of production. The corresponding parameters $\rho a, \rho l_{a,}, \rho k_a$ and $\mu a_a, \mu l_a, \mu k_a$ exist in each nest of the production function.

The factors of production are rewarded with the aggregate interest rate r_t on capital and the aggregate wage w_t on labor.

$$QV_{t,a} = A_a \left(\mu v_a K_{t,a}^{-\rho v_a} + (1-\mu v_a)L_{t,a}^{-\rho v_a}\right)^{\frac{-1}{\rho v_a}} \qquad (5)$$

Output $Q_{t,a}$ and the quantity of commodities $Q_{t,c}$ are subject to a different classification scheme. We choose the classification of commodities

(CPA) in such a way that the number of goods equals the number of activities (NACE). In principle, each activity a should produce a single good c, but there exist a variety of activities producing more than one good. The output, therefore, is a composite good containing $m \leq n$ commodities in fixed proportions $Q_{t,a} = \sum_{c=1}^{m} q_{t,a,c}$.

Equation 3 shows that one source of financial means for investment is retained profits. The second source is new shares $V_{t,a}$ issued by the firm.

$$\hat{V}_{t,a} = (1 - rp)PI_t QI_{t,a}. \tag{6}$$

where $\hat{V}_{t,q}$ is new shares. We know from our perfect financial market assumption that the expected return from holding equity in the firm must equal the return from holding safe assets in any period.

$$R_t = \frac{D_{t,a}}{V_{t,a}} + \frac{V^0_{t+1,a} - V_{t,a}}{V_{t,a}}.$$

Furthermore, we assume quadratic adjustment costs $adj_{t,a} = P_{t,a}\phi \frac{QI^2_{t,a}}{K_{t,a}}$,, where ϕ is the adjustment cost parameter. The presence of adjustment costs implies that the firm has to bear costs in terms of production for installing new capital. Because adjustment costs are quadratic, the firm smooths the adjustment of the capital stock. The total investment expenditures $TI_{t,a}$ are, therefore,

$$TI_{t,a} = PK_t QI_{t,a} + adj_{t,a},$$

where PK_t is the price for the composite investment good QI_t described as the CES composite

$$QI_t = aI \left(\sum_{c=1}^{n} \mu I_{t,c} I_{t,c}^{-\rho I_{c,t}} \right)^{\frac{-1}{\rho I_{a,t}}} \tag{7}$$

Considering that the economy is in the steady-state from T, the maximization problem of the firm is

$$\max_{K_{t,a},L_{t,a}} V_t = \sum_{t=1}^{T-1} \prod_{s=1}^{t} \left(\frac{1}{1+r_s} \right) \left(D_{t,a} - \hat{V}_{t,a} \right) + \frac{1+R_s}{R_s - g} \left(D_{T,a} - V_{T,a} \right) \prod_{s=1}^{T} \left(\frac{1}{1+r_s} \right). \tag{8}$$

Maximizing the firm value subject to the constraints provides the first-order conditions

$$P_{t,a} 2\phi \frac{QI_t}{K_{t,a}} + PK_t = \lambda_{t+1,a}$$

$$\left[P_{t,a}PV_{t,a}\delta_a\left(1-\delta_t\right)\left(\frac{Q_{t,a}}{QV_{t,a}}\right)^{(1+\rho_{a,t})}\frac{QV_{t,a}}{K_{t,a}}+P_{a,t}\phi\frac{QI_{t,a}^2}{K_{t,a}^2}\right]+\left(1-\delta\right)\lambda_{t+1,a}-\left(1+r_t\right)\lambda_{T,a}=0$$

$$K_{t+1,a}=\left(1-\delta\right)K_{t,a}+QI_{t,a}$$

$$L_{t,a}=\left(1-\mu v_{t,a}\right)\left(\frac{W_{t,a}}{PV_{t,a}}\right)^{\rho v_a}\mu_{t,a}\left(\frac{PV_{t,a}}{P_{t,a}}\right)^{\rho_a}Q_{t,a}$$

$$IN_{t,a}=\left(1-\mu_a\right)\left(\frac{PN_{t,a}}{P_{t,a}}\right)^{\rho_a}Q_{t,a}$$

and the terminal conditions

$$QI_{T,a}=\left(g+\delta_a\right)K_{T,a}$$

$$\lambda_{T,a}=PK_T+2\phi P_{T,a}QI_{T,a}/K_{T,a}$$

$$\rho=r_T.$$

3.2 World economy

The small open economy trades with intra- and extra-EMU countries f. Import prices $pm_{t,f,c}$ and export prices $px_{t,f,c}$ are measured in the local currency. Tariffs and non-tariff trade barriers on either imports $tm_{t,f,c}$ charged by the home country or exports $tx_{t,f,c}$ charged by the foreign country increase import prices and reduce export prices. The model accounts for country-specific exchange rate regimes, where $\epsilon_{t,f}$ denotes the exchange rate and $pm_{t,f,c}$ and $px_{t,f,c}$ denote import and export prices in foreign currency.

$$pm_{t,f,c}=\left(1+tm_{t,f,c}\right)\epsilon_{t,f}pm_{t,f,c}^{*} \tag{9}$$

$$px_{t,f,c}=\left(1-tx_{t,f,c}\right)\epsilon_{t,f}px_{t,f,c}^{*} \tag{10}$$

3.2.1 Export sector

The firm has a choice between selling a given amount of its product in the home market $QD_{t,c}$ or shipping it to export markets $X_{t,c}$. It maximizes revenues based on a CET transformation function considering the prices of goods for exports $PX_{t,c}$ and for domestic sales $PD_{t,c}$. The parameter ρq_c indicates the elasticity of the transformation, whereas the parameter γq_c is the share parameter of the CET function. The parameter $AW_{t,c}$ accounts for various levels of technology.

$$\max_{X_{t,c},QD_{t,c}} \Pi D_{t,c}\left(X_{t,c},QD_{t,c}\right) = PX_{t,c}X_{t,c} + PD_{t,c}QD_{t,c} \tag{11}$$

$$Q_{t,c} = AX_{t,c}\left[\gamma q_{t,c}X_{t,c}^{-\rho q_c} + \left(1-\gamma q_{t,c}\right)Q_{t,c}^{DD-\rho q_c}\right]^{-\frac{1}{1-\rho q_c}} \tag{12}$$

The destination of exports can be determined by maximizing the revenue function based on a sub-CET function. The firm receives revenues from selling goods $x_{t,f,c}$ to different countries that recognize the corresponding export prices $px_{t,f,c}$. The parameter γf_c is a shift parameter, whereas ρf_c accounts for the substitution elasticity of different destinations within the sub-CET function.

$$\max_{x_{t,f,c}} \Pi F_{t,f,c}\left(x_{t,f,c}\right) = \sum_{f=1}^{o} px_{t,f,c}x_{t,f,c} \tag{13}$$

$$X_{t,c} = ax_c\left(\sum_{f=1}^{o}\gamma x_c x_{t,f,c}^{-\rho f_c}\right)^{\frac{1}{1-\rho f_c}} \tag{14}$$

After setting up the Lagrangian and reparametrization of $\rho d_c = (1/\sigma d_c) - 1$, we can derive the optimum supply for the home market $QD_{t,c}$ and world markets $X_{t,c}$.

$$\begin{aligned} QD_{t,c} = \quad & (1-\gamma q_c)^{\sigma q_c} PD_{t,c}^{-\sigma q_c} \\ & \left[\gamma q_{t,c}{}^{\sigma q_c} PX_{t,c}^{-\sigma q_c} + (1-\gamma q_c)^{\sigma q_c} PD_{t,c}^{-\sigma q_c}\right]^{\frac{\sigma q_c}{1-\sigma q_c}} Q_{t,c}/AD_{t,c} \end{aligned} \tag{15}$$

$$\begin{aligned} X_{t,c} = \quad & \gamma q_c^{\sigma q_c} PX_{t,c}^{-\sigma q_c} \\ & \left[\gamma q_c^{\sigma q_c} PX_{t,c} + (1-\gamma q_c)^{\sigma q_c} PD_{t,c}^{1-\sigma q_c}\right]^{\frac{\sigma q_c}{1-\sigma q_c}} Q_{t,c}/AD_{t,c} \end{aligned} \tag{16}$$

3.2.2 Import sector

A wholesaler minimizes the costs of intermediate and final goods by combining different sources according to an Armington function Γ_{Mc}. The Armington function implies that goods are differentiated among countries; however, goods from different countries can be close substitutes. In the first nest of the Armington function, the wholesaler chooses between imported goods M_c with price PM_c and domestically produced goods QD_c with price PD_c. The parameter γa_c is the shift parameter of the Armington function, and ρa_c is the elasticity of substitution of goods from different source countries.

$$\min_{M_{t,c},QD_{t,c}} \Gamma D_{t,c}\left(M_{t,c}, QD_{t,c}\right) = PM_{t,c}M_{t,c} + PD_{t,c}QD_{t,c} \tag{17}$$

$s.t.$

$$Q_{t,c} = AA_{t,c}\left[\gamma a_{Ac}M_{tc}^{-\rho a_c} + \left(1-\gamma a_c\right)QD_{t,c}^{-\rho a_c}\right]^{\frac{1}{1-\rho a_c}} \tag{18}$$

In the second nest of the Armington function $\Gamma D_{t,f,c}$, the wholesaler minimizes its costs by choosing the optimum combination of different commodities $m_{t,f,c}$ with respective price $pm_{t,f,c}$ from each country. The parameter γ_{Sc} is a shift parameter, and ρ_{Sfc} is the elasticity of substitution of import goods from different source countries. The parameter AM_c denotes the different levels of technology in the various sectors.

$$\min_{m_{t,f,c}} \Gamma F_{t,f,c}\left(m_{t,f,c}\right) = \sum_{f=1}^{o} pm_{t,f,c}m_{t,f,c} \tag{19}$$

$s.t.$

$$M_{t,c} = AM_{t,c}\left(\sum_{f=1}^{o}\gamma m_{f,c}m_{t,f,c}^{-\rho m_{f,c}}\right).^{\frac{1}{1-\rho m_{f,c}}} \tag{20}$$

Thus, we can derive the demand for imports and domestic production in the home market.

$$\begin{aligned} QD_{t,c} = \quad & (1-\gamma a_c)^{\sigma a_c}PD_{t,c}^{-\sigma a_c} \\ & \left[\gamma a_c^{\sigma a_c}PM_{t,c}^{1-\sigma a_c} + \left(1-\gamma a_c\right)^{\sigma a_c}PD_{t,c}^{1-\sigma a_c}\right]^{\frac{\sigma a_c}{1-\sigma a_c}} Q_{t,c}/AA_{t,c} \end{aligned} \tag{21}$$

$$\begin{aligned} M_{t,c} = \quad & \gamma a_c^{\sigma a_c}PM_{t,c}^{-\sigma a_c} \\ & \left[\gamma a_c^{\sigma a_c}PM_{t,c}^{1-\sigma a_c} + \left(1-\gamma a_c\right)^{\sigma a_c}PD_{t,c}^{1-\sigma a_c}\right]^{\frac{\sigma a_c}{1-\sigma a_c}} Q_{t,c}/AA_{t,c} \end{aligned} \tag{22}$$

The demand for country-specific import goods is given by

$$m_{t,f,c} = \gamma m_{f,c}^{\sigma m_c}pm_{t,f,c}^{-\sigma m_c}\left(\sum_{f=1}^{o}\gamma m_{f,c}^{\sigma m_c}p_{t,f,c}^{-\sigma m_c}\right)^{\frac{\sigma m_c}{1-\sigma m_c}} M_{t,c}/AM_{t,c} \tag{23}$$

3.3 Households

The model economy is inhabited by a large number of households with infinite lifespans. We assume that the rational expectation hypothesis best describes the behavior of households and that households own labor and all financial assets except assets of public firms.

In each period, the household maximizes its utility function over an infinite horizon to find the optimum intertemporal allocation of consumption.

$$\max_{v} V_t = \prod_{t=1}^{\infty} \frac{(1+g)^{t-1}}{(1+\rho)^t} U_t(.)$$

The utility function is maximized subject to the budget constraint $A_{t+1} = (1+R_t)\,A_t + (1-t_Y-s)\,Y_t - p_v v$, where A_t is the stock of assets at the beginning of period t, r_t is the interest rate, ρ is the time preference rate, g_t is the growth rate of households [4], v is utility, and p_v is the price index for aggregate household consumption. If we assume that the household is in a steady-state growth path from period T, we can rewrite the utility function as

$$\max_{v_t} V_t = \prod_{t=1}^{T-1} \frac{(1+g_t)^{t-1}}{(1+\rho)^t} U_t(.) + \left(\frac{1}{\rho-\bar{g}}\right)\left(\frac{1+\bar{g}}{1+\rho}\right)^{T-1} U_T(.), \qquad (24)$$

which, by combining the first order conditions, results in the Euler-equation

$$\frac{C_t}{C_{t-1}} = \frac{(1+R_t)(1+g_t)}{(1+\rho)}\ t = 1, ..., T \qquad (25)$$

and the terminal condition

$$R_T = \rho. \qquad (26)$$

The income of the household is defined as the sum of labor and capital income, transfers, and remittances less taxes and social security contributions.

$$\begin{aligned} (1 - ty_t - s_t)Y_t = & \\ & \textstyle\sum_{t=1}^{\infty}\sum_{a=1}^{n}(1-tk_{t,a})d_{t,H}D_{t,a} \\ + & \textstyle\sum_{t=1}^{\infty}\sum_{a=1}^{n}(1-tl_{t,a})W_{t,a}L_{t,a} \\ + & \textstyle\sum_{t=1}^{\infty}\left(b_t \cdot W_t \cdot (N_t - \sum_{a=1}^{n} L_{t,a})\right) \end{aligned}$$

[4] The growth rate of households depends on exogenous growth rates and migration until period T and is constant thereafter.

The household receives dividends $D_{t,a}$ for the ownership of firm assets and wages $W_{t,a}$ for supplying labor $L_{t,a}$. Both sources of income are subject to specific capital $tk_{t,a}$ or labor-related taxes $tl_{t,a}$. Because of imperfect labor markets, labor supply N_t exceeds the aggregate labor demand. For the share of unused labor, the household receives unemployment benefits at a fraction b_t of average income W_t.

The remaining income available for consumption spending C_t is defined as net household income Y_t after income taxes ty_tY_t, savings s_tY_t, and transfers T_t. The parameter $tq_{t,c}$ denotes commodity-specific taxes. Consumers' preferences are specified using a Stone–Geary function. In this utility function, households derive utility from a fraction of total consumption $Q_{t,c}$. Therefore, there exists a subsistence level $\gamma_{t,c}$ of consumption that must be reached before utility is earned. If consumption of a good is below this subsistence level, every additional unit of disposable income is spent to reach this ceiling.

In general, we can setup an intra-period sub-utility function maximized subject to disposable income $DI_t = (1-\tau)C_t^* + \tau_t C$ and the budget constraint of the household. The parameter $\alpha_{t,c}$ denotes consumers preferences, and $p_{t,c}$ denotes the price of commodity c_t.

$$\max_{Q_{tc},\gamma_{tc}} u(Q_{t,c},\gamma_{t,c}) = \prod_{c=1}^{n}(Q_{t,c}-\gamma_{t,c})^{\alpha_c} \tag{27}$$

$s.t.$

$$DI_t \leq \sum_{c=1}^{n}(1+tq_{t,c})P_{t,c}Q_{t,c}$$

with $Q_{t,c} > \gamma_{t,c} \geq 0$ and $\sum_{c=1}^{n}\alpha_c = 1$ for $c = 1, 2, ...n$.

We derive the tangency condition by differentiating the Lagrangian with respect to its arguments followed by equating the results to zero and rearranging them. This process can be used to derive the demand relations for each good and to obtain the expenditures for each commodity. The parameter α_c can be taken as the marginal budget shares.

$$(1+tq_{t,c})P_{t,c}Q_{t,c} = (1+tq_{t,c})P_{t,c}\gamma_{t,c} + \alpha_c\left(E_t - \sum_{c=1}^{n}(1+tq_{t,c})P_{t,c}\gamma_{t,c}\right) \tag{28}$$

The expenditure on each commodity can be divided into two parts. The first part is the required quantity to obtain a minimum subsistence level of consumption. The second part depends on the available income remaining after buying the required quantities of each good. The budget constraint is only met if the sum of the exponents is equal to one. Deriving the income elasticity of commodity c_t is straightforward.

$$\xi_c(Q_{t,c}, E_t) = \frac{\partial Q_{t,c}}{\partial E_t} \cdot \frac{E_t}{Q_{t,c}} = \frac{\alpha_c E_t}{(1 + tQ_{t,c})p_{t,c}Q_{t,c}} \tag{29}$$

To derive the Frisch parameter ϕ, we solve the Lagrange function for the Lagrangian λ and calculate the expenditure elasticity of the marginal utility of expenditure (i.e., the Frisch parameter). In Section 4.1, we use the Frisch parameter to calibrate γ_{tc}, the minimum required quantity of a good.

$$\phi = \frac{d\lambda_t}{dE_t} \cdot \frac{E_t}{\lambda_t} = -\frac{E_t}{(I - \sum_{i=1}^{n} P_{t,c}\gamma_{t,c})} \tag{30}$$

3.4 Government

The government levies taxes on labor[5] and capital usage, income, and consumption. Additionally, it collects tariffs and receives dividends from the share of public firms $d_{t,G,a}$ in each sector a. Consequently, the government revenue function Y_{tG} is as follows:

$$\begin{aligned} YG_t = \; & \sum_{c=1}^{n} \left(tq_{t,c}Q_{t,c}P_{t,c} + \sum_{f=1}^{o} tm_{t,f,c}\epsilon_{t,f}p_{t,f,c}m_{t,f,c} \right) \\ & + \sum_{a=1}^{n} \sum_{j=1}^{n} \left(tk_t K_{t,a} R_{t,a} + tl_{t,Lt,a,j} w_{t,a,j} \right) + \sum_{a=1}^{n} d_{t,G,a} D_{t,a} \end{aligned} . \tag{31}$$

The government spends its income on consumption $QG_{t,c}$, government savings SG_t, sector-related subsidies to firms $Z_{t,a}$ and households $Z_{t,h}$, and unemployment benefits.

$$YG_t = (W_t b_t)\,(N_t - \sum_{j=1}^{n} L_{t,j}) + \sum_{a=1}^{n} P_{t,a}Z_{t,a} + \sum_{c=1}^{n} P_{t,c}QG_{t,c} + SG_t \tag{32}$$

With respect to consumption, the government maximizes a Stone–Geary utility function subject to a budget constraint derived from the equations 31 and 32.

$$\max_{CG_{t,c}, \gamma G_{t,c}} UG_t = \prod_{c} (QG_{t,c} - \gamma G_{t,c})^{\alpha g_c} \tag{33}$$

We assume that the state sector is not subject to VAT payments. The consumption of the government is split into subsistence consumption γG_c

[5]We assign public social security services to the state sector. Social security contributions are therefore treated as taxes and insurance payments are treated as transfers.

required for the state to function and a less-important part of consumption $\alpha g_c QG_c$ used for non-essential services.

$$P_{tc}QG_{t,c} = P_{t,c}\gamma G_{t,c} + \alpha g_{t,c}P_{t,c}QG_{t,c} \tag{34}$$

In addition to consumption and transfers, the state sector holds assets of firms producing public goods.

3.5 Equilibrium conditions

We complete the model using the respective equilibrium conditions for the factor, goods, and foreign markets. The goods markets are in equilibrium if domestic and foreign production equals the household, government, and intermediate goods demanded.

$$\begin{aligned} P_{t,c}Q_{t,g} + (1+tq_c)\,P_{t,c}Q_{t,c} + P_{t,c}\,(QN_{t,c} + QN_{t,g}) = \\ PD_{tc}QD_{t,c} + \textstyle\sum_{f=1}^{o}\,(pm_{t,f,c}m_{t,f,c}) - \textstyle\sum_{f=1}^{o}\,(px_{t,f,c}x_{t,f,c}) \end{aligned} \tag{35}$$

The share of public and private firms in each sector should add to unity. Labor markets are subject to a wage-setting curve $\hbar_t$ and, therefore, are in disequilibrium. The firms take the bargained wages as a given and adjust their labor demand.

$$\sum_{INS=0}^{q} d_{t,INS,a} = 1 \tag{36}$$

$$W_t = \hbar_t \left(N_t - \sum_{a=1}^{n}\sum_{g=1}^{n}\sum_{j=1}^{n} (l_{t,a,j} + L_{t,g,j}) \right) \tag{37}$$

The foreign sector is in equilibrium if imports, exports, and foreign savings are balanced.

$$\sum_{f=1}^{o}\sum_{c=1}^{n} pm_{t,f,c}m_{t,f,c} = \sum_{f=1}^{o}\sum_{c=1}^{n} px_{t,f,c}x_{t,f,c} + \sum_{f=1}^{o} S_{t,f} \tag{38}$$

4 Simulation

In this section, we discuss the calibration of the model, describe the three scenarios, and present the simulation results. The calibration of the model relies essentially on use and supply matrices that represent the interdependence between the different branches and commodities within the economy.

After the calibration process, the model is able to replicate the steady-state make-and-use matrix using the calibrated parameters. This enables us to conduct the simulation exercise, where two dates of accession and high and low in-house costs are compared.

The dynamic general equilibrium model as outlined in Section 3 is solved simultaneously by using the Path solver based on the Newson–Raphson method. The general equilibrium problem, therefore, is specified as a mixed-complementarity problem that, according to Cottle et al. (2009) and Rutherford (1995), is best solved using this type of solver.[6] In the MCP approach, equilibrium conditions are formulated as weak inequalities and conditions of complementary slackness between variables and equilibrium conditions. Given a change in the classification scheme in 2008, the model is setup as an Arrow–Debreu economy with either $n = 21$ commodities and $m = 21$ sectors respectively classified according to CPC Ver. 2 and NACE 2 or as $n = 16$ commodities and $m = 16$ sectors respectively classified according to CPC Ver. 1.1 and NACE 1.1.

4.1 Calibration

In this subsection, we describe the calibration of the model in more detail. Because of the setup of our theoretical model, we can calibrate most parameters using make-and-use matrices based on national accounts. For some broader categories such as transfers from the government sector to households or compensation of employees, we require additional information. In those cases, we use the labor market accounts that are part of the national accounts but are not included in the matrices. Because we use the same base year, these data are consistent with the information from the core matrices.

4.1.1 Households

In the household sector, we must calibrate the Stone–Geary parameter for subsistence consumption and the shift and share parameters of the sub-utility function. The Stone–Geary parameter is calibrated using the Frisch parameter derived in equation 30

$$\gamma_{c,h} = \frac{\sum_{c=1}^{n} (P_{s,c} Q_{s,c})}{P_{s,c} \bar{\alpha}_c (1 + \xi_c/\phi)}$$

[6]The Path solver is based on the Newson–Raphson method. According to the general algebraic modeling system (GAMS), the PATH solver combines a number of the most effective variations, extensions, and enhancements to increase the efficiency of finding new approximations with this solution method.

where ξ_c are the cross-price elasticities, $\bar{\alpha}_c$ are the budget shares, and $\alpha_c = \bar{\alpha}_c \xi_c$ are the marginal budget shares.

4.1.2 Firms

For firms, parameters of the nested production function, adjustment costs, and depreciation rate are calibrated. In the lower nest of the production function, capital and labor are combined as value added. We calibrate shift and share parameters. The shift parameters are calibrated using the first-order condition of equation 1

$$\mu_{s,a} = \left(\frac{P_{s,a,}}{PV_{s,a}}\right)^{\rho_a} \left(\frac{QV_{s,a}}{Q_{s,a}}\right), \mu v_{s,a} = 1 - \left(\frac{PV_{s,a,}}{W_{s,a}}\right)^{\rho v_a} \left(\frac{L_{s,a}}{QV_{s,a}}\right)$$

In a similar fashion, using equation 7, we derive $\mu I_{s,a}$ for the demand of a single investment good. The share parameter is calibrated using the production function of the value added (equation 5)

$$AV_{s,a} = QV_{s,a} / \left(\mu v_{s,a} K_{s,a}^{-\rho v_a} + (1 - \mu v_{s,a}) L_{s,a}^{-\rho v_a}\right)^{-1/\rho v_a}$$

Similarly, A_s, AI_s are calibrated as share parameters of the production function combining intermediate goods and value added (equation 4) and the share parameter of the production of the composite investment good (equation 7). The elasticities of substitution $\rho_a, \rho v_a, \rho l_j, \rho k_j, \rho I_a$, however, cannot be calibrated and must be set according to the literature[7].

4.1.3 Foreign sector

The exchange rate can be initialized in $t = 0$ as unity $\epsilon_{s,r} = 1$, because data on imports, exports, and transaction costs are available in the domestic currency. Transaction costs are calibrated in the form

$$tx_{f,c} = sx_{s,c} \left(\sum_{cx=1}^{mx} cx_{s,c} / pq(cx)_{s,c}\right) / qx_{s,c}$$

where $sx_{s,c}$ is the share of commodity c in the transaction services for export goods. The transaction coefficients for imports $tm_{f,c}$ and domestic sales $td_{f,c}$

[7] For the estimates, we rely on Sato (2004) but run several sensitivity checks with different sets of parameters showing that the results do not significantly vary.

are derived analogously. The share parameter of the sub-CET function is calibrated using the first-order condition (equation 12) solved for

$$\gamma q_{f,c} = px_{s,f,c} x_{t,f,c}^{1+\rho f_c} / \left(\sum_{f=1}^{o} px_{s,f,c} x_{t,f,c}^{1+\rho f_c} \right),$$

whereas the shift parameter is derived by solving equation 12 for

$$ax_c = X_{t,c} / \left(\sum_{f=1}^{o} px_{s,f,c} x_{t,f,c}^{-\rho f_c} \right)^{\frac{1}{1-\rho f_c}}.$$

Similar share and shift parameters for the Armington, sub-Armington, and CET functions are derived analogously. Tariffs are included in the transaction cost parameter, where tariffs are a type of government transaction good. The parameter ρf_c and similar parameters for the Armington, sub-Armington, and CET functions, however, cannot be calibrated. There are a variety of studies estimating Armington and CET preference parameters using different degrees of disaggregation and country coverage. We use the estimates of Saito (2004) and conduct several sensitivity tests with other estimates. In general, those alternative parameter settings do not significantly alter the results.

4.1.4 Government

The tax rates are calibrated as iceberg costs using the information from the make-and-use matrices. Therefore, value-added tax is calculated as

$$tq_{s,c} = T_{s,c} / \left(P_{s,c} Q_{s,c} \right)$$

where $T_{s,c}$ is the sum of tax receipts divided by the quantity sold of the taxed product. All other taxes $ta_{s,a}, tf_{s,a}, tk_{s,a}$ are calibrated in a similar manner.

4.2 Scenarios

The simulation exercise is conducted for two dates of accession, January 2005[8] and 2011. In both the early and late accession scenario, we use transaction cost estimates of the Estonian national bank by calculating currency

[8] This scenario is used to show the effect of an accession to the EMU right after receiving EU membership in 2004. Estonia officially announced its plan to accede in May 2006.

conversion costs worth 0.2 percent of GDP. In addition to conversion costs, exporters must bear in-house costs by working in a multi-currency environment. These costs tend to be lower for countries with a developed financial sector and higher for less-developed economies. As discussed in Section 2, estimates range from 0.1 to 0.8 percent of GDP European Commission (1990). (Rodriguez Mendizabal, 2002), however, finds higher savings of between 0.4 percent of GDP for Austria to 1.66 percent of GDP for Italy and interrelates the high savings calculated for Mediterranean countries with an inefficient banking sector measured in terms of operating costs to non-bank deposits. According to this measure, operating costs of Estonia today are up to twice the operating costs for EMU-countries such as France. Compared to operating costs ahead of the EMU, however, costs are similar to that of Germany, Belgium, and Ireland. Savings for these countries were estimated by (Rodriguez Mendizabal, 2002) as 0.47 to 0.7 percent of GDP. Foreign companies trading with a single-currency country have to bear similar costs. In our policy scenarios, therefore, we use three different types of settings for in-house costs.

4.2.1 Low in-house costs

In the first setting, transaction cost reduction is assumed to be 0.3 percent of GDP, 0.2 percent of which accounts for currency conversion and 0.1 percent of which accounts for in-house costs. As a small country, Estonia has to reimburse exporters for selling goods in its national currency or domestic importers have to conduct a currency conversion. This setting tends to be the lower case of transaction cost savings because of the low in-house costs firms bear in working in a multi-currency environment. Ahead of EMU creation, on average, EU countries saved an estimated 0.4 percent of GDP with a gain of more than 1 percent for small open economies.

4.2.2 Low in-house costs and no conversion cost savings for Extra-EMU importers

In the second setting, we make the counter-factual assumption that only domestic exporters benefit from a common currency. Most studies on the trade effect of the Euro analyze the difference in trade between intra- and extra-currency union countries, making the implicit assumption that only exporters in a member country are able to benefit from reduced transaction costs. In order to be able to compare the results of this study with previous ones, it seems to be beneficial to include this scenario.

4.2.3 Medium in-house costs

In the third setting, we assume a transaction cost reduction of 0.6 percent of GDP, 0.2 percent of which is currency conversion and 0.4 percent of which accounts for in-house costs. This scenario reflects that Estonia is a small open economy but has a long history of fixed exchange rates that reduce transaction cost savings for currency conversion and the in-house costs. A still-developing banking sector in Estonia, nevertheless, has operational costs over twice the amount of most EMU countries with a developed financial sector and more than one percent higher than the average EMU country. This setting, therefore, reflects a medium value of possible in-house transaction cost savings rather than a high value.

5 Results

Estonia planned to join the Euro as soon as possible after EU accession. A high inflation rate prevented the fulfillment of the Maastricht criteria and delayed accession until January 2011. During this time, trade was relocated to extra-Eurozone countries. According to the theory of optimum currency areas, such a reduction in trade with Eurozone partners reduces the trade-related benefits of a common currency. Our simulation results show a smaller relative increase in exports in the late accession scenario (LA) compared to the early accession scenario (EA). Imports increased more strongly with late compared to early accession (see Figure 4). In detail, intra-EU exports increased by 0.7 percent in EA and 0.4 percent in LA. Intra-EU imports increased by 0.9 (EA) and 1.1 percent (LA). We do not observe a strong redirection of trade. Extra-EU exports increased by 0.6 (EA) and 0.4 percent (LA), and extra-EU imports increased by 0.7 (EA) and 0.9 percent (LA). Because the trade balance worsens in both cases, foreign savings increase.

The increase in foreign savings drives production to substitute scarce labor with capital in nearly all sectors of the economy. This effect is most pronounced in construction and manufacturing. We also see a redistribution of labor from non-tradable good sectors of the economy to these two sectors. In Figure 6, the increase in the construction sector labor demand amounts to between 0.7 and 1.7 percent in EA and to between 1.8 and 3.0 percent in LA. Labor demand of the construction sector is diminishing over time. As the production of the economy gets more capital-intensive, real interest rates drop and investment demand declines. The manufacturing sector, with 20 percent of employees (i.e., the biggest sector of the economy), demands additional workforce to cope with the increase in export goods and investment demand. Over time, the demand for labor increases by 0.6 percent up to 0.8 percent compared to the baseline (0.2 to 0.5 percent for LA). All other sectors lose employment and have to substitute capital for labor.

In general, only a fraction of all sectors of the economy benefit from Euro accession in terms of an increase in production. Figures 2 and 3 show that production is shrinking in nearly all sectors of the economy except for construction and manufacturing.[9] Manufacturing production increases on average by 1 (EA) and 0.65 percent (LA), reflecting the increase in export demand. The capital stock requires time to adjust. As the capital stock increases, production rises by 0.1 percent for EA and 0.2 percent for LA.

In summary, sectoral relocation of production increases GDP by 0.8 (LA) and 0.6 percent (EA), investment demand increases by between 1.0 and 2.0 percent for EA and between 2.8 and 3.7 percent for LA. Government consumption increases by 0.4 (EA) and 0.5 (LA) percent (see Figure 1). Under LA, additional taxes always cover the additional government demand, whereas in EA, government demand is higher than taxes from 2020.

Households spend the majority of additional income on savings. This is surprising, because wages increase by 0.6 (EA) and 0.7 percent (LA) and the unemployment rate declines by 0.7 (EA) and 0.8 percent (LA; see Figure 7), which usually triggers private consumption. Household behavior can be explained by an increase in dividends of the manufacturing sector and of the construction sector by up to 1 percent and by up to 1.4 percent, respectively, having a positive effect on the interest paid on savings.

Low in-house costs and no transaction cost saving for Extra-EU exporters

Transaction costs in our first set of simulations also increase for extra-EU trading partners because they use fewer currencies. In a counter-factual scenario, we relaxed this assumption. The increase in extra-EU exports is 0.2 percent lower for EA and for LA compared to 0.1 percent lower for intra-EMU trade (see Figure 11). Given that Estonia imports natural resources such as gas and oil from Russia and machinery from Eurozone countries, higher transaction costs for imports from extra-Eurozone countries lowers exports. Imports from those countries are reduced by 0.2 percent for EA

[9] The classification of industries changed from NACE 1.1 to NACE 2 between 2007 and 2008. Thus, it is not technically possible to compare sectoral changes between 2004 and 2010. In the GDP chart, we present the changes between 2004 and 2007 and between 2008 and 2010 in different figures, which show that the sectors affected remain broadly the same.

and 0.3 percent for LA. This converts into lower imports from the Eurozone because fewer investment goods are needed. In summary, the increase in investment demand, the shift in production by industries, and the increase in GDP are slightly lower compared to our previous setting (see Figure 8).

Medium in-house costs

In our last group of settings, we assumed medium in-house costs for intra-EU exporters and importers and pre-accession-level in-house costs for extra-EU importers and exporters. Currency conversion costs, however, are reduced for intra-EU importers and exporters and for extra-EU importers. In this setting, EA increases GDP by an additional 1 percent and LA does so by an additional 1.3 percent compared to our previous scenarios (see Figure 9). The increase in intra-EMU trade is roughly twice the increase in the scenarios with low in-house costs, while extra-EMU trade is two-thirds this value (see Figure 10). Again, we see a strong increase in manufacturing production and construction while non-tradable sectors are contracting. The increase in investment demand is also higher in these countries and more than doubles for the LA.

6 Conclusions

In 1992, Estonia established a currency board with the German Mark and later with the Euro. Having a long tradition of fixed exchange rates, Estonia wanted to be among the first Middle- and Eastern- European countries to introduce the Euro. High inflation rates prevented accession until 2011, a time in which Estonia increased trade with extra-EMU countries. As trading shares decline, benefits of a common currency are expected to decrease. We show that even after such a redirection of trade, the accession is still beneficial in terms of higher investment, more capital-intensive production, and an increase in GDP. However, the full adjustment of the economy to the transaction cost savings shock takes time. An increase in export demand fosters a redistribution of labor among the sectors of the economy and an increase in capital stock. As the capital stock is built, an increase in investment demand occurs, peaking at the date of accession and gradually declining thereafter. Additional investment demand cannot solely be financed by private savings. Foreign savings increase strongly after accession and the trade balance worsens. This effect is more distinctive for LA compared to EA. The balance of payments adjustment, therefore, requires more time under this scenario.

In sum, our results indicate that a late accession was beneficial for Estonia in terms of a stronger increase in GDP. An obstacle remains. In our theoretical model, country-specific risks are kept constant over time. Because of the sovereign-debt crises, investors might be more reluctant to lend to small peripheral EMU countries. Because the adjustment of the capital stock is crucial for short- and long-term increases in trade, early accession, where a smaller increase in investment is required, might have been favorable in such a situation. In general, our results are in-line with more recent studies on the trade effects of common currency using gravity-type models. By accounting for currency conversion and in-house cost savings, we see a substantial increase in intra- and extra-EMU trade. Baldwin et al. (2008) estimate an increase in trade for intra-EMU countries of 2 percent and for extra-EMU countries of 1 percent. Reflecting the fact that the transaction cost reduction should be between 0.3 and 0.6 percent of GDP, our results are slightly smaller.

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Figure 1: GDP (A1 S1)

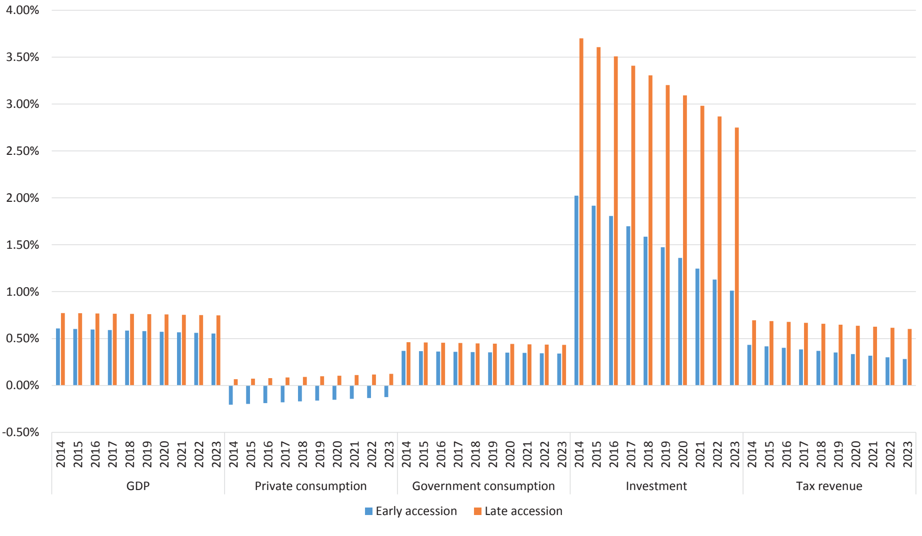

Figure 2: GDP by industries

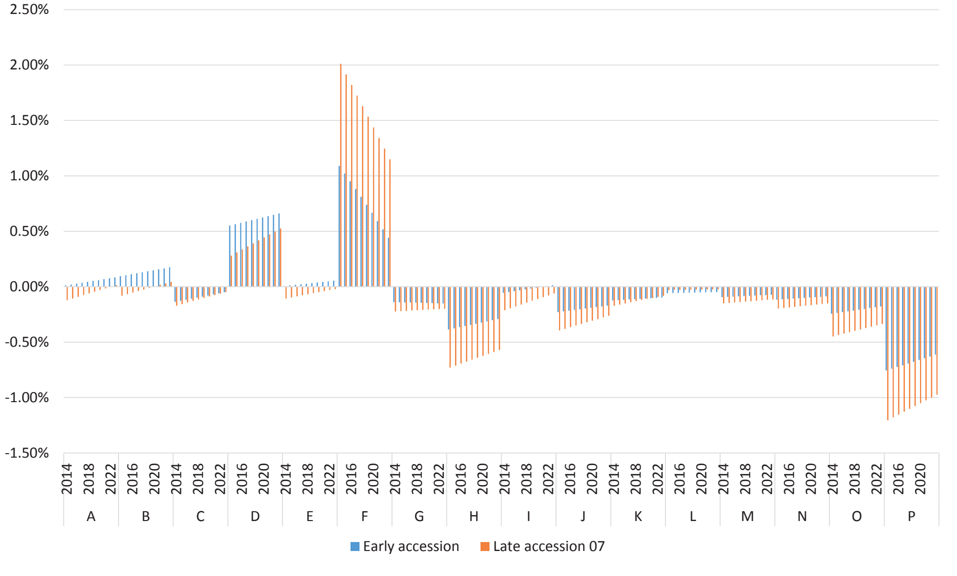

Figure 3: GDP by industries

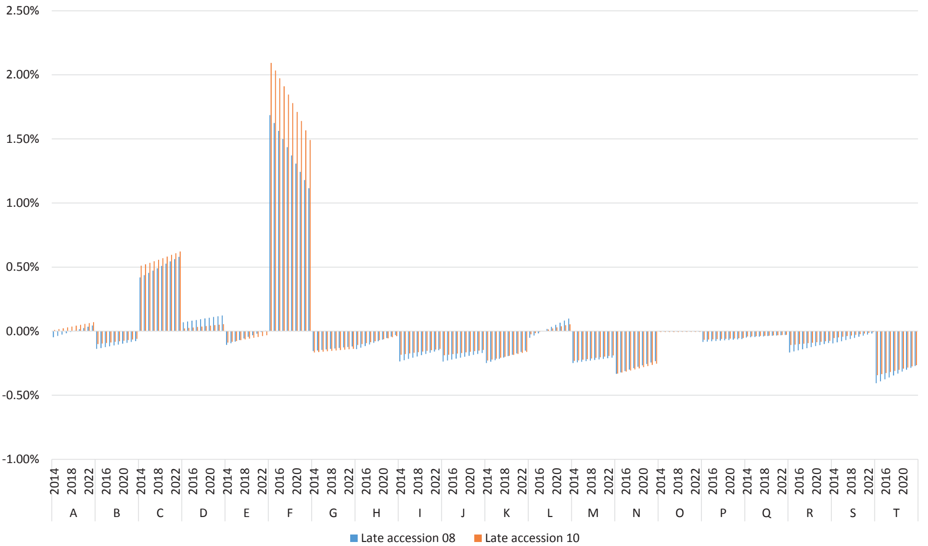

Figure 4: Trade

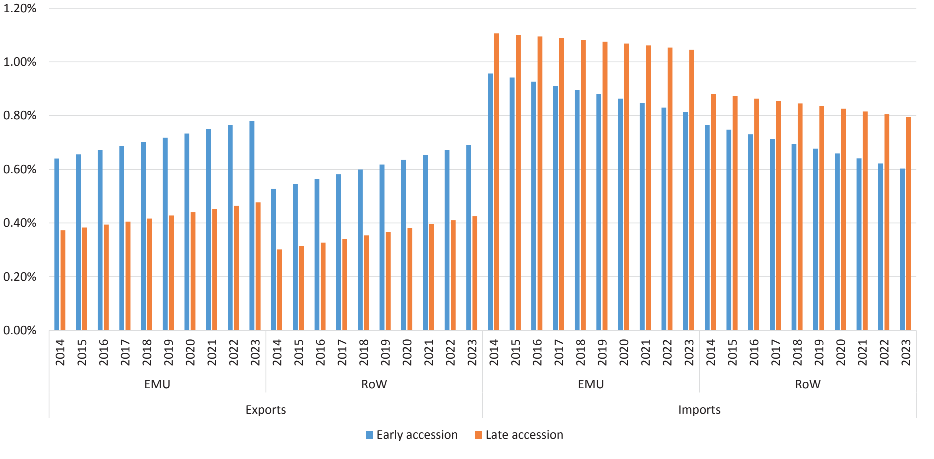

Figure 5: Investment by Industries

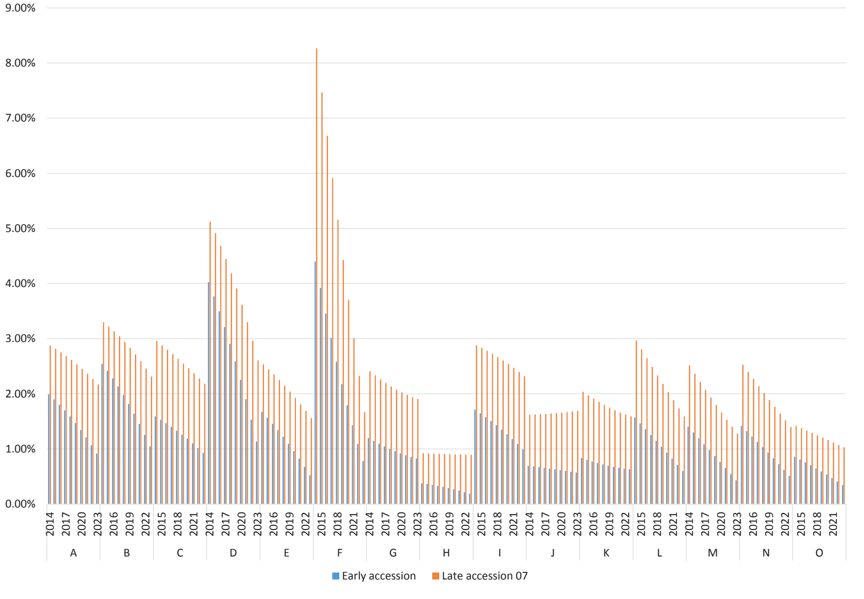

Figure 6: labor by industries

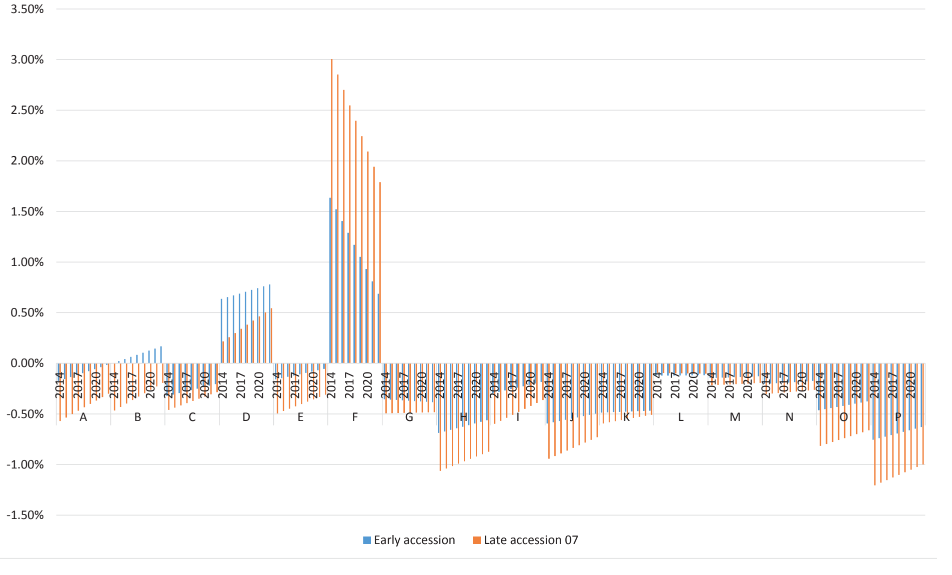

Figure 7: Wages and unemployment rate

Figure 8: GDP (A1 S2)

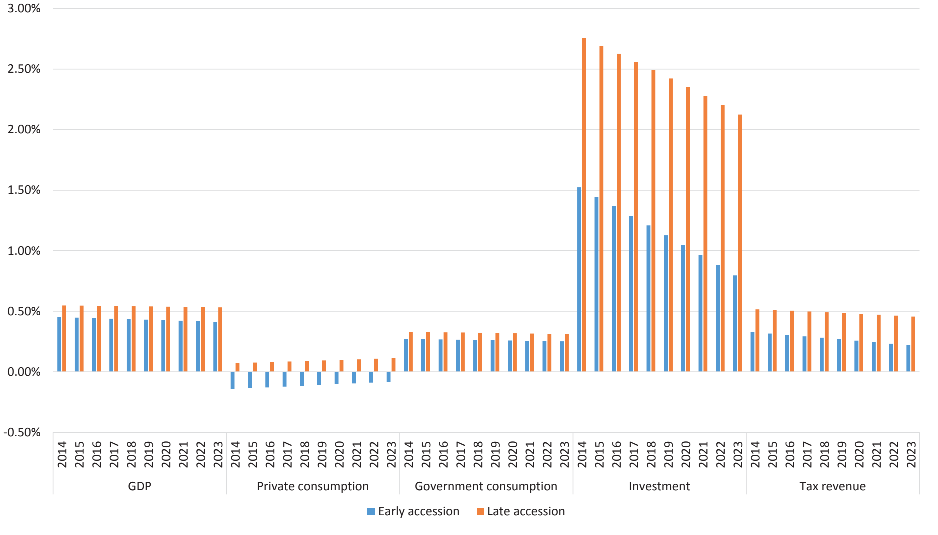

Figure 9: GDP (A2 S1)

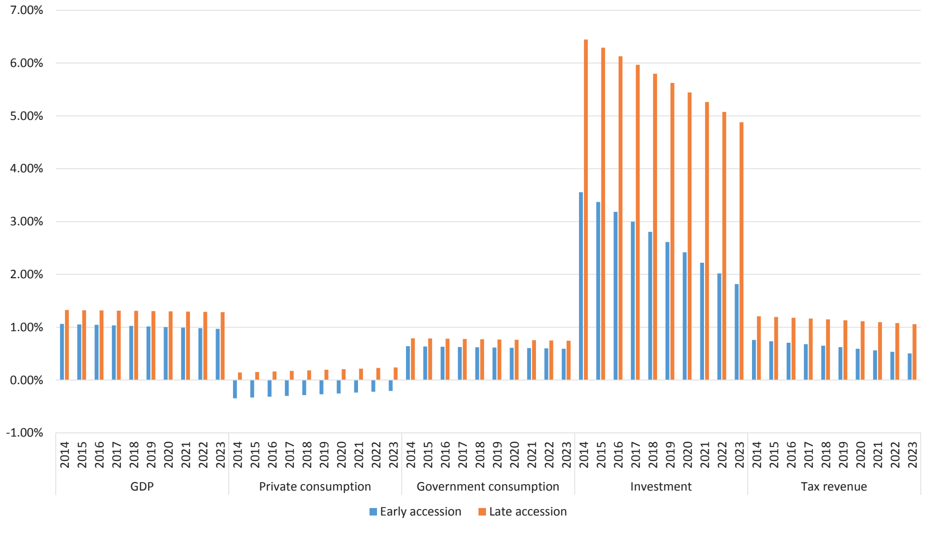

Figure 10: Trade (A2 S1)

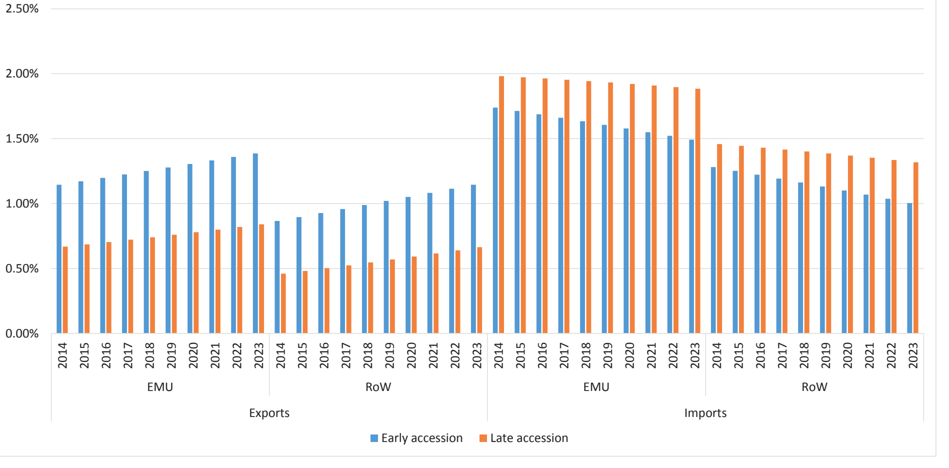

Figure 11: Trade (A1 S2)