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Risk sharing with gradual financial integration: the Visegrád countries and the euro area

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Abstract

Since the year 2000, three Visegrád Group economies – of Poland, the Czech Republic and Hungary – have gradually become financially integrated with the euro area (EA) economies. However, standard risk sharing regressions fail to show any significant consumption risk-sharing effects following integration. Using a measure of financial integration based on the coefficients of co-movement of interest rates between each country and the aggregate euro economies, I find that risk sharing occurs whenever there is a premium over the integrated area borrowing rates. For Poland, financial integration with the EA economies helps dampen the effects of income shocks as postulated by the risk sharing hypothesis. For Hungary, financial integration with the EA economies explains its consumption growth, but the latter is independent of its income. The results for Poland and Hungary show that a well-defined measure of financial integration is needed in order to find risk sharing between financially integrated regions.

Keywords: risk sharing, consumption smoothing, financial integration

JEL: F41, F36, E21

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1 Introduction

The role of financial integration in improving risk sharing through reducing consumption volatility is well founded in international macroeconomic theory. Risk sharing, which implies higher cross-country consumption correlations than output correlations, is intuitively linked to financial integration on the premise that if output risks are to be internationally shared, there should be trade in financial assets among residents of different countries. Trade in equity and debt instruments between countries can only occur if the countries fall in a financially integrated area or if their financial markets are well integrated into the world financial markets. The feasibility of international consumption smoothing therefore depends on the existence of, and actual trade in, debt and equity instruments. Trade in equity, which would allow economies to swap claims to output as measured by GDP, should result in smother income and consumption over time (see e.g. Obstfeld, Rogoff 1994, Chapter 5; Sorensen, Yosha 1998; Zhou 2006).

If financial integration is interpreted as the ability to trade in debt, equity and other financial instruments, then it should be expected that the volatility of consumption relative to that of output should go down as the degree of financial integration increases. However, this theoretical notion has been repeatedly rejected in empirical studies. For instance, Prasad et al. (2004), report that while the volatility of output growth for the emerging market economies declined in the 90s relative to the three earlier decades, the volatility of consumption growth relative to that of income growth increased over the same period. Yet the 1990s were characterized by a rapid increase in financial globalization in these economies, suggesting that pro-cyclical access to international capital markets had a perverse effect on the relative volatility of consumption for financially integrated developing countries. Similar findings have been made by, among others, Bai and Zhang (2012), Zhou (2006) and Kose, Prasad and Terrones (2009).

In this study, I investigate the role of financial integration on risk sharing using a novel approach that estimates consumption volatility and financial integration jointly. I first define financial integration as the stochastic slope and intercept in a regression of a country's interest rates on that of the integrated region, in this case the euro area (EA19) economy interest rates. By letting consumption growth be explained by individual country income growth, the integrated area consumption growth and the stochastic intercepts/slopes, I am able to capture the effect of integration on risk sharing.

My contribution to the literature is methodological. I specify a two equation system which is estimated as a state space model where the state is the level of financial integration and the measurement consists of two equations: (i) consumption growth as a function of income, the aggregate area consumption growth and the level of financial integration and (ii) interest rates co-movement with the aggregate area. The unobserved state in this two-equation system consists of the intercept and slope coefficients in the interest rate equation, initially defined as random walks with drift processes. There are two advantages to this approach. Firstly, unlike the standard cross-country regressions found in the literature, the analysis is performed for individual countries and the measure of risk-sharing effects does not depend on the overall cross-country effects (see e.g. Suzuki 2014). Studies using cross-sectional data implicitly impose a restriction on the equality of the risk-sharing effect across individual countries. Secondly, by letting the measure of integration be a stochastic process specific to each country, I can account for individual economy features such as the contract enforcement environment that can help explain the failure of risk sharing (Bai, Zhang 2012). I capture these in the stochastic intercept, which is both country-specific and time-varying.

Based on this two-equation system, I am able to find significant risk sharing for the two of the Visegrád countries: Poland and Hungary. In contrast, panel or single-country regressions with proxies for the level of financial integration as standard in the literature reject the risk-sharing hypothesis, suggesting that the result is driven by the novelty of my approach.

1.2 Relation to the literature

In theory, financial integration should help the financially integrated countries better manage output and consumption volatility (Prasad et al. 2004). However, this risk-sharing hypothesis has been rejected in many empirical studies. Backus, Kehoe and Kydland (1992) examined the cross country consumption correlations among 16 OECD countries and reported a "consumption puzzle": cross-country output correlations higher than consumption correlations. Following their work, a myriad of other papers, surveyed by van Wincoop (1999) and Ventura (2008), have all considered the issue of international risk sharing. Various reasons have been advanced for the rejection of the perfect risk-sharing hypothesis. These include, amongst others, the non-tradeability of goods (Tesar 1993), restrictions on ownership of foreign assets (Lewis 1995), contract writing costs (Levine 1997), the existence of non-tradable wealth such as human capital (Lewis 1999), the incentive effects arising from selling equity to outsiders (Eijffinger, Wagner 2001), incomplete markets due to contract enforcement problems (Kehoe, Perri 2002; Bai, Zhang 2012) and the differential tax treatment of financial income (Epstein, Mukherjee, Ramnath 2016).

Some recent empirical studies have, however, found significant levels of international risk sharing. These include the works of Kim (2014), Suzuki (2014), Malik (2015) and Holmes and Otero (2016). All these authors note that the standard finding of limited risk sharing can be overturned by accounting for some subtle properties of the data. Holmes and Otero (2016) first test for econometric co-integration of country *per capita* consumption with world *per capita* consumption using the augmented Dickey--Fuller tests and consequently find evidence on long-run consumption risk sharing, especially amongst industrialized countries. Their method does not, however, test the risk-sharing hypothesis directly, nor do they include any of the Visegrád countries. Kim (2014) obtains international risk sharing by looking at production rather than consumption risks, for which he finds large effects of financial integration. I now review in more detail the works of Suzuki (2014) and Malik (2015) in relation to my findings.

Suzuki (2014) has argued that the failure of the risk-sharing hypothesis to hold in most empirical tests is due to an incomplete accounting of shocks to the output growth process. When income growth is positively autocorrelated rather than mean reverting as assumed in most of the literature using cross--sectional data, consumption volatility can exceed income volatility even when there is risk sharing. If this is the case, then basic tests of risk sharing can fail even under financial integration. When income follows a random walk, one period bonds do not help the agent insure against a shock to income and the volatility of consumption is independent of the degree of financial integration. However, if state contingent bonds are available in the market, then financial integration should help smooth consumption nevertheless.

Aguiar and Gopinath (2004) using the methodology of King et al. (1991) to decompose the variance of income into permanent and transitory shocks have argued that the income process in emerging market economies may be more characterized by a permanent shock to the income growth process than transitory shock to the level process. This implies that volatility of consumption may be greater than that of income when there are permanent shocks. Suzuki (2014) decomposes the income process into permanent and transitory components and then regresses consumption growth on these components, a measure of financial integration defined by Lane and Milesi-Ferretti (2006)[1] and interactions of the shock components with the financial integration measure. This is done in two stages, with the first stage involving the decomposition of the income process. While I do not follow this approach, Suzuki's (2014) two stage regression results can be obtained in a single estimation using my approach and without the imposition of a cross-country restriction on equality of the financial integration parameter(s). Furthermore, I am able to find risk sharing without taking into account the variation in the income process required in her study.

Malik (2015) finds that the level of risk sharing follows a U-shaped pattern: at a low level of integration, there is limited but statistically significant risk sharing, and at a higher threshold there is large risk sharing. However, at some intermediate levels, financial integration is characterized by higher consumption volatility. My results suggest that Poland and Hungary fall into the high threshold region.

My results show that there is a more promising approach to evaluating the risk sharing hypothesis; recent empirical findings in the literature may be enhanced by modelling financial integration as a gradual, endogenous unobserved process. The remainder of the paper is organized as follows. I describe the basic empirical specification in Section 2. This includes the basic risk-sharing equation together with the measure of financial integration and the modelling of these equations as a state-space system. Section 3 describes the data and gives estimation results and a discussion. Conclusions are presented in Section 4.

2 Empirical models

In this section, I give a description of empirical specifications that have been used in the literature to evaluate risk sharing and financial integration. I first review the standard approach in the literature on: risk sharing in subsection 2.1; and on measuring financial integration in 2.2. I then describe the panel regressions and the dynamic linear model specifications with their state space representation and estimation.

2.1 Risk sharing

Most of the risk-sharing literature focuses on the time series or cross-section correlation of countries' consumption and output (Bai, Zhang 2012). In the cross-sectional case, the approach is to run a regression of the form:

$$\Delta \log C_i = \beta_0 + \beta_1 \Delta \log Y_i + e_i$$

[1] Lane and Milesi-Ferretti (2006) have developed a database that can be used to proxy for the cross-holdings of assets. Their database is based on gross assets and liabilities including portfolio equity, FDI, debt, financial derivatives and official reserves of over 140 countries over the period 1970–2004. A measure of financial integration based on this database has been suggested by Suzuki (2014) as the ratio: $LMF_{it} = \left(FA_{it} + FL_{it}\right) / GDP_{it}$, where $FA_{it}(FL_{it})$ refers to the financial assets (liabilities) of country i at time t. The ratio should be increasing as financial integration increases.

where:

$\Delta \log C_i$ – the rate of consumption growth defined as $\Delta \log C_i = \frac{\log C_{it} - \log C_{i1}}{T-1}$,

$\Delta \log Y_i$ – the growth rate of output – similarly defined,

e_i – the usual error term with subscript i denoting country.

If there is risk sharing, then the coefficient β_1 should be equal to zero. In some instances, this specification has been modified to deal with econometric issues, but the idea remains the same. The preceding specification is, however, suitable only for a large cross section of countries. An alternative approach due to Mace (1991) uses a panel regression counterpart of the same specification. The approaches are similar since the intercept in the cross-sectional case corresponds to the aggregate consumption growth rate in the panel regression:

$$\Delta \log C_{it} = \beta_0 + \beta_1 \Delta \log C_t^a + \beta_2 \Delta \log Y_{it} + e_{it}$$

where:

$\Delta \log C_{it}$ – period t real consumption growth for country i,

$\Delta \log Y_{it}$ – period t growth rate of country i's GDP,

$\Delta \log C_t^a$ – the consumption growth rate across all countries and is defined as

$$\Delta \log C_t^a = N^{-1} \sum_{i=1} \Delta \log C_{it}$$

v_i – the unobserved time invariant country specific effects,

e_{it} – the usual error term with zero mean and constant variance.

The real growth rate of consumption is defined as $\Delta \log C_{it} = \log C_{it} - \log C_{it-1}$ with growth rate of output similarly defined. Under full risk sharing, the individual country consumption growth rate is independent of the output growth rate and only responds to the aggregate growth rate of the financially integrated area. The null hypothesis of full risk sharing is hence $\beta_1 = 0$ and $\beta_2 = 0$.

2.2 Financial integration

Adam et al. (2002, p. 4) define financial markets as integrated "when the law of one price holds". The law of one price states that: "assets with the same risk should have the same expected return, irrespective of the residence of the issuer or the asset holder" (Baele et al. 2004, p. 12). Baele et al. (2004) define a market for financial instruments and/or services as fully integrated if all market participants that have similar characteristics operate within a scenario described by the following: (i) face the same rules, (ii) have equal access to all the instruments and (iii) are treated equally when participating in the market. Baele et al. then provide a framework for measuring financial integration. In their account, the focus of measuring financial integration is the determination of whether existing frictions affect the different regions under evaluation asymmetrically. Within such a framework then, the best way to evaluate integration would be to list all frictions and barriers to integration and then check whether they still hold. But given that the compilation of such a list would be unachievable, they suggest that the state of integration could be measured using equilibrium prices, since such prices should reflect all the information available to agents, including the frictions and barriers faced.

Baele et al. (2004) consider three broad categories of integration. These are: price-based measures, news-based measures and quantity-based measures. Price-based measures consider the discrepancies in prices or returns on assets caused by the geographic origin of such assets and are as a consequence, a direct check on the law of one price. News-based measures distinguish information effects from other frictions and/or barriers. The news based measures rely on the premise that in a financially integrated area, portfolios should be well diversified. This implies that news of a regional nature should have little impact on prices while news of a global nature (affecting the whole integrated area) should have more effect. Finally, quantity-based measures are used to quantify the effects of frictions faced by the demand for and supply of investment opportunities.

A check on integration can be performed on government bond markets. Typically, the 91 day Treasury bill provides an asset that can be considered homogeneous enough in the countries to facilitate a check on integration. Given similar maturities and other relevant characteristics, interest rate differentials between borrowers of the same risk class in different countries is a measure of the degree of integration since it is the equivalent of a test of the equality of discount rates. The variation in the size of the spread over time also serves as a measure of how the process of integration is proceeding. Let R_{it} represent the interest rate on an asset in country i at time t and R_{bt} be the rate at time t in the benchmark country. Then if the markets are integrated, the rate changes in the benchmark country should be a good proxy for changes that would take place in the rate in the other countries. Assuming identical systematic risks, then the following regression can be used to separate common from local influences:

$$R_{it} = \alpha_{it} + \gamma_{it} R_{bt} + \varepsilon_{it}$$

where:

α_{it} – a time varying parameter,
γ_{it} – the time dependent beta with respect to the benchmark asset,
ε_{it} – a country specific shock.

Increasing integration requires (i) the intercept α_{it} to converge to zero, (ii) the slope γ_{it} with respect to the benchmark asset to converge to one and, (iii) the proportion of variance in R_{it} explained by the benchmark R_{bt} to increase towards unity as markets become more integrated. The convergence of the intercept to zero is a consequence of changes in one country not being systematically larger than those in the benchmark country if markets are integrating. Since $\gamma_{it} = \frac{Cov(R_{it}, R_{bt})}{Var(R_{it})}$, where *Cov* and *Var* are the conditional covariance and variance operators respectively, it depends on the correlation between the local rates and the benchmark rates, as well as the ratio between the local and benchmark Treasury bill's volatility. As integration increases, the correlation should increase towards one. Similarly, the volatility should stabilize to that of the benchmark. The average distance of the γs of different countries from one should serve as an integration measure for the overall market. Finally, in the absence of country specific risks, 91 day Treasury bills can be considered as comparable assets across the three countries under consideration and the country specific error ε_{it} should shrink as integration increases. This implies that the proportion of local variance explained by common factors should also act as a measure of integration.

2.3 Empirical specifications

Panel linear regressions

I begin by performing panel regressions as standard in this literature and given in specification (1). For a panel of 8 new EU members' states[2] (joining in 2004), I estimate the panel regression:

$$\Delta \log C_{it} = \beta_i + \beta_1 \Delta \log C_{it}^{EA19} + \beta_2 \Delta \log Y_{it} + \beta_3 FI_{it} + \beta_4 \Delta \log Y_{it} \times FI_{it} + e_{it}^c \quad (1)$$

where:

β_i – a country fixed effect, $i = \{1,\ldots, 8\}$,

$\Delta \log C_{it}^{EA19}$ – the consumption growth of the 19 euro area economies,

$\Delta \log Y_{it}$ and FI_{it} – respectively, the GDP growth and financial integration measure of country *i*.

I also estimate equation (1) for the three Visegrád countries and for each country separately.

Specification (1) is similar to the specifications of Suzuki (2014) and Kose, Prasad and Terrones (2009). The financial integration measures used follow those of Kose, Prasad and Terrones (2009): the accumulation of financial assets (*Assets*), liabilities (*Liab.*) and debt (*Debt*); all as a percentage of GDP, and the *LMF* measure of Lane and Milesi-Ferretti (2006).[3] In addition to these, I also estimate equation (1) where the FI_{it} variable is the current account balance (CAB) and a dummy variable of membership of the European Union (*EU*).

The interpretation of the coefficient estimates is as follows. If there is full or efficient risk sharing between a country and the euro area economies, individual country consumption growth is perfectly correlated with the average consumption growth rate and independent of the income growth rate. The null hypothesis of full risk sharing is hence:

$$H_0^1 : \beta_1 = 1, \quad \beta_2 = 0$$

Depending on the measure, if financial integration is helping smooth consumption growth shocks, the coefficient β_3 should be negative (if $FI_t \equiv Assets$) and positive (if $FI_t \equiv debt$). We expect these signs since a financially integrated economy that faces an income shock would either sell assets or increase borrowing to maintain consumption. This would induce negative correlation between these variables and consumption growth. The coefficient β_4 should be negative and significant since in order to maintain consumption growth levels following an income shock (fall in GDP growth), an economy would borrow more (accumulate liabilities) so FI_t increases.

If financial integration is helping countries share risks, then consumption growth rates should respond to the average consumption growth rate; be independent of the income growth rates, while the coefficient of financial integration should be negatively significant and the coefficient of the interaction of financial integration with income growth should be negative and significant. The null hypothesis is hence:

$$H_0^2 : \quad \beta_1 = 1, \ \beta_2 = 0, \ \beta_3 \leq 0, \ \beta_4 \leq 0$$

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[2] Based on data availability, these countries are the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovakia and Slovenia.

[3] The measure *LMF* is the accumulation of assets plus liabilities as a percentage of GDP.

After estimating the system described by equations (2) and (3) below, I compute the correlation of the time varying parameters α_t and γ_t with consumption, income and the external measures of financial integration.

Dynamic linear models

I specify a dynamic two equation system that estimates the level of financial integration and its effect on consumption risk sharing. The time varying measure of financial integration enters as an explanatory variable in the equation for consumption growth. Both the level of integration and its effect on volatility are then estimated at the same time. For each country, I estimate the following equations:

$$\Delta \log C_t = \beta_0 + \beta_1 \Delta \log C_t^{EA19} + \beta_2 \Delta \log Y_t + \beta_3 FI_t + \beta_4 \Delta \log Y_t \times FI_t + e_t^c \tag{2}$$

$$R_t = \alpha_t + \gamma_t R_t^a + e_t^R \tag{3}$$

Equation (2), the risk-sharing regression, is the single country counterpart to equation (1), while (3) is the financial integration equation. In equation (2), the financial integration variable/measure FI_t is either the intercept α_t or the slope γ_t obtained from the interest rate co-movement equation (3). I let the intercept and slope in (3) be random walks with a drift:

$$\begin{aligned} \alpha_t &= \bar{\alpha} + \alpha_{t-1} + w_t^{\alpha} \\ \gamma_t &= \bar{\gamma} + \gamma_{t-1} + w_t^{\gamma} \end{aligned} \tag{4}$$

The specifications in (4) capture the potentially time-varying level of financial integration. When an economy is fully financially integrated with the aggregate area, then $\alpha_t \approx 0$ while $\gamma_t \approx 1$. If the risks faced by lenders are equivalent to those of the aggregated area, then the intercept α_t should equal zero. Interpretations of the parameters in specifications (2) are similar to those of (1). With $FI_t = \alpha_t$[5], an increase in this measure when $\Delta \log Y_t$ falls means that agents are borrowing more so we should expect β_4 to be negative as before.

State space representation. Equations (2) and (3) together with the time-varying intercept and slope can be written in the following state space form:

$$\begin{pmatrix} \Delta \log C_t \\ R_t \end{pmatrix} = \begin{bmatrix} \beta_3 + \beta_4 \times \Delta \log Y_t & 0 \\ 1 & R_t^a \end{bmatrix} \begin{pmatrix} \alpha_t \\ \gamma_t \end{pmatrix} + \begin{bmatrix} \beta_0 & \beta_1 & \beta_2 \\ 0 & 0 & 0 \end{bmatrix} \begin{pmatrix} 1 \\ \Delta \log C_t^a \\ \Delta \log Y_t \end{pmatrix} + \begin{pmatrix} e_t^c \\ e_t^R \end{pmatrix} \tag{5}$$

which is equivalent to a measurement equation with state $x_t = (\alpha_t, \gamma_t)'$ and time-varying state matrix A_t and time invariant input parameter matrix Γ with inputs $u_t = (1, \Delta \log C_t^a, \Delta \log Y_t)'$:

$$y_t = A_t x_t + \Gamma u_t + v_t, \quad vt \sim N(0, S) \tag{6.1}$$

where S is a 2×2 variance–covariance matrix.

The state process x_t is defined by:

$$x_t = x_{t-1} + \Psi u_t + w_t, \sim N(0, Q) \tag{6.2}$$

where Q is a 2×2 variance–covariance matrix and the time invariant state input matrix $\Psi = [\bar{\alpha}, 0, 0; \bar{\gamma}, 0, 0]$.

Estimation of this system is performed using maximum likelihood methods standard in the econometric and statistical literature. In estimating the model, I begin by this general state space system, and then eliminate variables based on their significance. When I fail to reject at a 90% level of confidence that a given parameter is ≠ 0, then the associated variable is removed and estimation performed again. As will be seen in Section 3, the final models are of the following form:

Czech Republic

$$\begin{pmatrix} \Delta \log C_t \\ R_t \end{pmatrix} = \begin{bmatrix} 0 \\ R_t^a \end{bmatrix} \gamma_t + \begin{bmatrix} \beta_2 & 0 \\ \bar{\alpha} & 0 \end{bmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} + \begin{pmatrix} e_t^c \\ 0 \end{pmatrix}, \qquad e_t^c \sim N(0, \sigma_c^2) \tag{7}$$

$$x_t = x_{t-1} + w_t, \qquad x_t = \gamma_t, \qquad w_t = w_t^\gamma \sim N(0, \sigma_\gamma^2)$$

Hungary

$$\begin{pmatrix} \Delta \log C_t \\ R_t \end{pmatrix} = \begin{bmatrix} \beta_3 & 0 \\ 1 & R_t^a \end{bmatrix} \begin{pmatrix} \alpha_t \\ \gamma_t \end{pmatrix} + \begin{bmatrix} \beta_0 \\ 0 \end{bmatrix} + \begin{pmatrix} e_t^c \\ 0 \end{pmatrix}, \qquad e_t^c \sim N(0, \sigma_c^2) \tag{8}$$

$$x_t = x_{t-1} + w_t, \qquad x_t = (\alpha_t, \gamma_t)', \quad w_t = (w_t^\alpha, w_t^\gamma)' \sim N(0, Q)$$

Poland

$$\begin{pmatrix} \Delta \log C_t \\ R_t \end{pmatrix} = \begin{bmatrix} \beta_4 \times \Delta \log Y_t & 0 \\ 1 & R_t^a \end{bmatrix} \begin{pmatrix} \alpha_t \\ \gamma_t \end{pmatrix} + \begin{bmatrix} \beta_2 \\ 0 \end{bmatrix} \Delta \log Y_t + \begin{pmatrix} e_t^c \\ 0 \end{pmatrix}, \quad e_t^c \sim N(0, \sigma_c^2) \tag{9}$$

$$x_t = x_{t-1} + w_t, \qquad x_t = (\alpha_t, \gamma_t)', \quad w_t = (w_t^\alpha, w_t^\gamma)' \sim N(0, Q)$$

Note that in equations (7)–(9) the volatility of R_t is fully captured by the state volatility. In the next section I give the results of estimating the basic models followed by the final model estimates.

3 Data and empirical results

3.1 Data

The data on consumption and GDP growth rates come from the OECD online database. The time series used are defined by the OECD as "P31S14–S15: Private final consumption expenditure" and "B1–GE: Gross domestic product – expenditure approach". The series cover the period from 1996 Q1–2016 Q4. The financial integration measures – assets, liabilities and current account balance – come from the OECD Balance of Payments database.[4] The debt statistics are the net external debt – quarterly data, % of GDP.[5] Interest rates are also obtained from the OECD, but in a different database covering a similar time period. The OECD describes these short-term interest rates as the "rates at which short--term borrowings are effected between financial institutions or the rate at which short-term government paper is issued or traded in the market. Short-term interest rates are generally averages of daily rates, measured as a percentage. Short-term interest rates are based on three-month money market rates where available. Typical standardised names are 'money market rate' and 'Treasury bill rate'.[6] Table 1 gives descriptive statistics of the data used in the paper. Figures 1 and 2 show the growth rates in consumption and income.

3.2 Empirical results

Descriptive statistics

Table 1 gives a summary of all variables used in the analysis. The maximum time period covered is 90 quarters, with missing observations limiting the debt time series to 54 quarters. Hungary experiences the largest drop in consumption and GDP growth at -3.5% and -4%. In all cases, the fall in consumption growth is always lower than the fall in income growth for all three Visegrád countries. Poland has the highest single quarter GDP growth as well as average growth over the sample period. Hungary has the highest average interest over the period but also the least variable (lowest standard deviation).

The Hungarian economy also scores highly in measures of financial integration. Its mean accumulation of financial assets is at 1.3% of GDP over the sample period, which is very large compared to the 0.2/0.17 values of the Czech Republic/Poland. This is also apparent in its average value of the LMF measure, which at 1.5% is three times the value of the other two countries. The lower part of Table 1 shows the correlation of different variables. The highest is between consumption and GDP growth for the Czech Republic, at 60%. All three countries show high negative correlation between their consumption growth and debt as a % of GDP suggesting this measure would be related to their ability to smooth income shocks. Finally, Figures 1 and 2 plot the time series of consumption and GDP growth. Apart from periods around the beginning of the time series in the second half of the 1990s and the Great Recession of 2008, the series exhibit stable positive growth rates between 0.5 to 1%. In the next sub-subsection, I discuss the regression results.

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[4] http://www.oecd.org/std/its/quarterly-balance-of-payments-statistics.htm.
[5] http://ec.europa.eu/eurostat/web/products-datasets/-/tipsii30.
[6] https://data.oecd.org/interest/short-term-interest-rates.htm.

Regression results

This sub-subsection presents 3 sets of regression results. First, I run the basic risk-sharing and financial integration regressions separately to determine if a country's consumption growth time series is explained by the growth rate of consumption in the euro area economies, own income growth and its level of financial integration as specified in equation (1). These results are presented in Table 2. Table 3 gives results of panel regressions for 3 countries and for all 8 new member states. Finally, Tables 4–6 give the results of estimating the dynamic system (2)–(3). Subsequently, the correlations between the measures of integration obtained from the dynamic system with standard proxies for financial integration in the literature are included in Table 7.

For single country regressions given in Table 2, each column uses a different measure of financial integration. Except for debt in the case of Hungary, the integration variable and its interaction term is always insignificant. This result is similar to previous findings in the literature. A similar outcome is obtained using the three country panel as shown in the results given in Table 3. Debt enters significantly, but so does the EU membership dummy, though with a negative sign. Again, all interaction terms are insignificant, suggesting financial integration does not help these countries smooth their consumption. The lower half of Table 3 shows that for the 8 country panel, one measure of integration gives results suggesting risk sharing: the current account balance (CAB). While debt and the EU dummy are significant, the signs of their interaction with GDP is positive, suggesting they exacerbate the effects of negative income shocks on consumption. I now present the results of the dynamic linear model estimation with time varying parameters of the financial integration equation entering the risk-sharing equation. In each case, I first estimate the general model (5) juxtaposed with results from the final specifications as given in equations (7), (8) and (9). Tables 4–6 give these estimates.

The results for the Czech Republic are summarized in Table 4. In this estimation, the financial integration measure used is γ_ts since the estimate of the intercept in the interest rate equation is a constant $\alpha_t = \bar{\alpha}$ with $\sigma_\alpha = 0$. Only the constant enters the risk-sharing part of this system significantly. I subsequently re-estimate this system after setting all insignificant parameters to zero (supported by a likelihood ratio test at the bottom of Table 4). The final estimates are as summarised in the last three columns of Table 4. The positive significant coefficient $\bar{\alpha}$ in the interest rate equation suggests that lenders still demand a premium from Czech borrowers, so it is not fully integrated with the EA economies in terms of treatment of borrowers. The second aspect of financial integration is on the similarity of interest changes. This is captured in Figure 3 which shows that the parameter γ_t has been slowly converging towards unity as we would expect if the Czech Republic has been financially integrated into the euro area. Integration appears to have occurred quite early, just around the year 2000 and stayed constant for another 13 years. Since around 2014, Czech interest rate movements seem to have decoupled from those of the euro area economies. In conclusion, while the Czech economy has been financially integrated with the EA economies, this has not helped in mitigating the effects of income shocks.

The results for Hungary are summarized in Table 5. The positive significant coefficient $\bar{\alpha}$ in the interest rate equation suggests that lenders still demand a premium from Hungarian borrowers, just like for the Czech Republic. However, unlike the Czech case, the premium is time varying as captured by the positive significant volatility parameter σ_α. As shown in Figure 4, this premium shows a large variation over time, but has generally remained above 25 percentage points, particularly in the years following Hungary's accession to the EU (vertical line in Figure 4). This premium is also visible in the middle panel of Figure 6. For the parameter γ_t, there is again, considerable variation over time, but it settles within the 99% confidence band for unity just after EU membership. The financial integration measure α_t enters significantly into the risk-sharing equation, but the interaction is insignificant, suggesting that while borrowing explains Hungary's consumption growth, it is unrelated to its income shocks. This can be seen in the correlation between α_t and other variables in the analysis: the correlation with consumption and debt is the highest, at -0.9 and 0.7 respectively.

The results for Poland summarized in Table 6 show two effects we should expect under risk sharing in a financially integrated area: consumption growth independent of income growth and a negative significant coefficient for the interaction between income and the integration measure. The final coefficient of the interaction variable ($\beta_4 < 0$) is what we should expect in the case where financial integration is helping reduce volatility. Similar to Hungary, the borrowing premium is time varying with a significant volatility $\sigma_\alpha > 0$. As shown in Figure 5, the borrowing premium over the EA19 remains high – reaching 40 basis points as recent as 5 years ago. However, these premiums are generally lower than those faced by Hungarian borrowers. In interest rates co-movement, integration with the euro area economies seems to occur about 2 years after the accession to the EU, with no large significant deviation since then. However, the confidence band for Poland is large, $\sigma_y = 0.42 > 0.34$ (for the Czech Republic), especially since the year 2008.

4 Conclusions

I have considered the effect of financial integration on risk sharing between three Visegrád countries and the euro area economies. Unlike the extant literature, I have estimated a system where both the level of financial integration and the effect on risk sharing are jointly determined. I have achieved this by defining a measure of financial integration as the unobserved coefficients of the co-movement of interest rates between individual economies and the aggregate financial area. In comparison to results using the standard approach in the literature, my method shows that using the time varying borrowing premium as a measure of integration one can capture the effect of financial integration in mitigating income shocks.

Although my modelling approach is novel and can be easily extended to incorporate more properties of the consumption or income growth process à la Suzuki (2014), I have not attempted these extensions (which are not necessary in light of the results from Poland and Hungary). A second possibility is developing an equilibrium open economy macroeconomic model along the lines of Bai and Zhang (2012), with micro-foundations that link consumption risk sharing to interest rate premiums. All these are interesting and important extensions to be explored in future research.

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Appendix

Table 1

Descriptive statistics

	Czech Republic							
	Δ log C	**Δ log Y**	**R**	**LMF**	**CAB**	**Assets**	**Liabilities**	**Debt**
N	89	86	87	90	90	90	90	54
Min	-1.8496	-3.5157	0.28	-1.6868	-8.0426	-0.7019	-1.1148	-23.6
Max	3.9404	2.5927	19.6733	4.3729	2.8045	1.4975	4.1859	0.8
Med	0.7184	0.705	2.3233	0.2891	-2.6935	0.0339	0.1517	-6.9
Mean	0.6667	0.6397	3.987	0.4841	-2.7184	0.1961	0.288	-7.9611
SD	1.3223	1.3893	1.1382	1.6037	-0.9431	1.7234	2.1597	-0.7937
	Hungary							
	Δ log C	**Δ log Y**	**R**	**LMF**	**CAB**	**Assets**	**Liabilities**	**Debt**
N	89	86	78	74	90	74	74	87
Min	-3.5413	-4.0411	0.2381	-9.4694	-10.7768	-9.0809	-2.6638	3.5
Max	4.8037	2.1399	26.3667	29.6624	6.7633	29.9341	2.6303	82.6
Med	0.6051	0.7901	8.1625	0.5532	-4.5949	0.2008	0.0557	30
Mean	0.4865	0.5792	9.1985	1.4779	-3.212	1.3051	0.1728	39.6632
SD	2.4737	1.5802	0.6757	3.4497	-1.476	3.8525	5.2212	0.5392
	Poland							
	Δ log C	**Δ log Y**	**R**	**LMF**	**CAB**	**Assets**	**Liabilities**	**Debt**
N	89	86	87	54	54	54	54	54
Min	-2.4152	-3.1704	1.6833	-0.7664	-7.0147	-0.39	-0.6716	13.8
Max	8.8718	6.1415	24.31	1.5417	1.1154	1.173	1.2892	38.2
Med	0.8991	1.0337	5.0633	0.4279	-3.7951	0.1291	0.2747	31.25
Mean	1.031	0.9701	8.403	0.4557	-3.5397	0.168	0.2877	27.9741
SD	1.1204	1.0679	0.8333	1.1114	-0.6391	1.4661	1.5629	0.2934

Table 1, cont' d

Correlation matrix								
	Czech Republic							
	Δ log C	**Δ log Y**	**R**	**LMF**	**CAB**	**Assets**	**Liabilities**	**Debt**
Δ log C	1	0.4267	0.6094	0.0568	-0.5091	0.0463	-0.1557	0.1468
Δ log C_{EA19}	0.4267	1	0.6659	0.1282	-0.6035	0.142	-0.0073	0.1569
Δ log Y	0.6094	0.6659	1	0.1087	-0.5433	0.0182	-0.0541	0.1573
Hungary								
Δ log C	1	0.3234	0.4849	-0.1072	-0.5033	-0.1605	-0.1234	0.0818
Δ log C_{EA19}	0.3234	1	0.4575	-0.0875	-0.5803	-0.238	-0.0894	0.0039
Δ log Y	0.4849	0.4575	1	-0.0819	-0.4106	-0.0957	-0.1302	0.2624
Poland								
Δ log C	1	0.3813	0.4732	-0.1675	-0.5064	-0.2714	0.3842	-0.3991
Δ log C_{EA19}	0.3813	1	0.404	0.043	-0.339	0.2913	0.297	-0.1143
Δ log Y	0.4732	0.404	1	0.1344	-0.358	-0.1608	0.3123	-0.0196

Table 2
Single country regressions: Czech Republic, Hungary and Poland

	Czech Republic: financial integration measure (FI)					
	LMF	**CAB**	**Assets**	**Liabilities**	**Debt**	**EU**
Const.	0.3141	0.2009	0.3047	0.298***	-0.0892	0.4538
	(0.1208)	(0.1513)	(0.1331)	(0.1112)	(0.1505)	(0.2146)
$\Delta\ \log C_{EA19}$	0.1129	0.0921	0.1401	0.1195	-0.3624	-0.0329
	(0.2248)	(0.2223)	(0.2320)	(0.2236)	(0.3155)	(0.2631)
$\Delta\ \log Y$	0.4338***	0.412***	0.4852***	0.4156***	0.662***	0.4825
	(0.1020)	(0.1536)	(0.1069)	(0.0993)	(0.1931)	(0.1950)
FI	-0.0018	-0.0377	0.0069	0.0247	-0.0758	-0.2082
	(0.1516)	(0.0394)	(0.3427)	(0.1808)	(0.0287)	(0.2409)
$\Delta\ \log Y \times FI$	-0.0498	-0.0064	-0.4228	-0.0079	0.0399	-0.0356
	(0.1275)	(0.0422)	(0.3404)	(0.1421)	(0.0220)	(0.2248)
R^2	0.2021	0.2175	0.2307	0.1988	0.4118	0.2143
N	86	86	86	86	54	86
	Hungary: financial integration measure (FI)					
	LMF	**CAB**	**Assets**	**Liabilities**	**Debt**	**EU**
Const.	0.149	0.057	0.161	0.1543	1.3572***	0.7934
	(0.1827)	(0.1760)	(0.1856)	(0.1792)	(0.4297)	(0.4330)
$\Delta\ \log C_{EA19}$	0.4019	0.3254	0.4135	0.4199	-0.2047	0.1509
	(0.3819)	(0.3345)	(0.3812)	(0.3848)	(0.3560)	(0.3468)
$\Delta\ \log Y$	0.4935***	0.4613	0.4688	0.4919***	0.2057	0.1564
	(0.1829)	(0.1893)	(0.1889)	(0.1778)	(0.3541)	(0.3739)
FI	-0.0237	-0.013	-0.0228	-0.0285	-0.0238***	-0.8165
	(0.0314)	(0.0333)	(0.0294)	(0.1502)	(0.0071)	(0.4406)
$\Delta\ \log Y \times FI$	0.0215	-0.0231	0.0227	-0.0943	0.0042	0.422
	(0.0459)	(0.0333)	(0.0373)	(0.1153)	(0.0056)	(0.4040)
R^2	0.211	0.2226	0.2122	0.2133	0.3067	0.2428
N	74	86	74	74	86	86

Table 2, cont' d

	Poland: financial integration measure (FI)					
	LMF	**CAB**	**Assets**	**Liabilities**	**Debt**	**EU**
Const.	0.6504***	0.159	0.4971***	0.6601***	1.2037***	0.7364***
	(0.1078)	(0.1936)	(0.1038)	(0.0982)	(0.3883)	(0.2010)
$\Delta \log C_{EA19}$	0.2542	0.4965***	0.2234	0.2158	0.1813	0.094
	(0.1617)	(0.1713)	(0.1664)	(0.1536)	(0.1596)	(0.2412)
$\Delta \log Y$	0.217	0.3507	0.234	0.2504***	0.1725	0.2575***
	(0.1068)	(0.1804)	(0.1030)	(0.0901)	(0.2849)	(0.0910)
FI	-0.3383	-0.1116	0.5297	-0.4411	-0.0211	-0.2096
	(0.1599)	(0.0474)	(0.5396)	(0.1681)	(0.0130)	(0.2661)
$\Delta \log Y \times FI$	0.1723	0.0424	-0.0805	0.0818	0.0009	0.0531
	(0.1638)	(0.0398)	(0.3964)	(0.1782)	(0.0106)	(0.1834)
R^2	0.2811	0.3233	0.2566	0.3567	0.3196	0.1127
N	54	54	54	54	54	86

* p < 0.1; ** p < 0.05; *** p < 0.01.

Table 3
Panel regressions

	3 Visegràd countries, Czech Republic, Hungary and Poland: financial integration measure					
	LMF	**CAB**	**Assets**	**Liabilities**	**Debt**	**EU**
$\Delta \log C_{EA19}$	0.2416 (0.1621)	0.2343 (0.1551)	0.2486 (0.1618)	0.2497 (0.1627)	-0.0476 (0.1789)	0.049 (0.1645)
$\Delta \log Y$	0.4109*** (0.0785)	0.3895*** (0.1013)	0.3994*** (0.0782)	0.4343*** (0.0743)	0.334*** (0.0891)	0.2913*** (0.0885)
FI	-0.0332 (0.0216)	-0.0235 (0.0212)	-0.03 (0.0204)	-0.0054 (0.0850)	-0.0217*** -0.4598*** (0.0041)	(0.1575)
$\Delta \log Y \times FI$	0.0338 (0.0290)	-0.0172 (0.0210)	0.0339 (0.0234)	-0.0965 (0.0630)	0.0016 (0.0018)	0.2038 (0.1172)
R^2	0.2185	0.228	0.2205	0.219	0.3255	0.207
N	214	226	214	214	194	258

	8 new EU States (2004 accession)[a]: financial integration measure					
	LMF	**CAB**	**Assets**	**Liabilities**	**Debt**	**EU**
$\Delta \log C_{EA19}$	0.4027 (0.1563)	0.3605 (0.1486)	0.4025 (0.1560)	0.4161*** (0.1562)	0.356 (0.1725)	0.1513 (0.1555)
$\Delta \log Y$	0.6362*** (0.0393)	0.537*** (0.0434)	0.6449*** (0.0403)	0.6423*** (0.0382)	0.3473*** (0.0784)	0.2925*** (0.0623)
FI	0.0026 (0.0291)	-0.0367*** (0.0116)	-0.0014 (0.0313)	0.032 (0.0557)	-0.0153*** -0.6148*** (0.0040)	(0.1455)
$\Delta \log Y \times FI$	0.0099 (0.0313)	-0.0161*** (0.0052)	-0.0127 (0.0307)	0.04 (0.0415)	0.0074*** (0.0020)	0.3762*** (0.0756)
R^2	0.3945	0.4246	0.3945	0.3963	0.4169	0.3304
N	564	576	564	564	517	688

[a] Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovakia, Slovenia.
* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 4
Final estimates: Czech Republic

Parameter	Initial estimates	Standard error	*t* stat.	Final estimates	Standard error	*t* stat.
$\bar{\alpha}$	-0.0098	0.0054	-1.8228	0.3118	0.0016	194.5449
β_0	0.3795	0.1538	2.4671	0.5899	0.0874	6.7488
β_1	0.194	0.2587	0.7498	–	–	–
β_2	0.2707	0.1843	1.4688	–	–	–
β_3	-0.0543	0.1029	-0.5271	–	–	–
β_4	0.1086	0.1382	0.7856	–	–	–
σ_α	0	0.0144	0	–	–	–
σ_γ	0.331	0.0274	12.1003	0.3402	0.0277	12.2647
σ_c	0.7059	0.0545	12.9614	0.8011	0.0618	12.9615
σ_R	0	0.0098	0	–	–	–
$\bar{\gamma}$	0.0075	0.0358	0.2083	–	–	–
log *L*	-1.7851		-7.9393			
N	11		4			
LR	12.3084					
df	7					

Note: financial integration measure used is the slope in the interest rate equation (since there is no variation in the intercept). log *L* is the attained log-likelihood. *n* is the number of parameters, *LR* is the likelihood ratio statistic and *df* is the degrees of freedom of the *LR* statistic.

Table 5
Final estimates: Hungary

Parameter	**Initial estimates**	**Standard error**	***t* stat.**	**Final estimates**	**Standard error**	***t* stat.**
$\bar{\alpha}$	-0.0018	0.1281	-0.014	–	–	–
β_0	1.878	0.3175	5.9158	1.7397	0.2172	8.011
β_1	-0.3706	0.3076	-1.2048	–	–	–
β_2	0.0089	0.2376	0.0376	–	–	–
β_3	-0.4186	0.0681	-6.1453	-0.4042	0.0604	-6.69
β_4	0.014	0.0382	0.3667	–	–	–
σ_α	1.1037	0.179	6.1671	1.1355	0.1824	6.2263
σ_γ	0.6682	0.083	8.0549	0.6588	0.0822	8.0105
σ_C	0.5991	0.0698	8.5846	0.6042	0.0699	8.6481
σ_R	0	0.1848	-0.0001	–	–	–
$\bar{\gamma}$	0.0233	0.0822	0.2835	–	–	–
log *L*	-109.7605		-110.7827			
N	11		5			
LR	2.0444					
df	6					

Note: financial integration measure used is the intercept. log *L* is the attained log-likelihood. *n* is the number of parameters, *LR* is the likelihood ratio statistic and *df* is the degrees of freedom of the *LR* statistic.

Table 6
Final estimates: Poland

Parameter	Initial estimates	Standard error	t stat.	Final estimates	Standard error	t stat.
$\overline{\alpha}$	0.0052	0.0403	0.1295	–	–	–
β_0	1.005	0.3539	2.8401	0.6502	0.0979	6.638
β_1	-0.1559	0.2251	-0.6925	–	–	–
β_2	1.5615	0.3493	4.4699	1.579	0.3559	4.4361
β_3	-0.1365	0.1382	-0.9882	–	–	–
β_4	-0.6678	0.1688	-3.9563	-0.6418	0.1683	-3.8136
σ_α	0.3655	0.0578	6.3221	0.3687	0.0586	6.2875
σ_γ	0.4267	0.0496	8.5969	0.4242	0.0498	8.522
σ_c	0.5142	0.0651	7.8971	0.5398	0.0613	8.8061
σ_R	0	0.0593	0	–	–	–
$\overline{\gamma}$	-0.0065	0.0481	-0.135	–	–	–
log L	-57.1224		-57.6021			
N	11		6			
LR	0.9594					
df	5					

Note: financial integration measure used is the intercept. log L is the attained log-likelihood. n is the number of parameters, LR is the likelihood ratio statistic and df is the degrees of freedom of the LR statistic.

Table 7
Correlation matrix: state variables

	Δ log C	Δ log C_{EA19}	Δ log Y	LMF	Debt	CAB	Assets	Liabilities
				Czech Republic				
γ_t	-0.1575	0.3052	-0.3302	-0.1855	0.2522	-0.3118	-0.224	-0.1001
				Hungary				
α_t	-0.8938	-0.4749	-0.5223	0.0786	0.6585	0.1522	0.0831	-0.021
γ_t	0.5361	0.434	0.4082	-0.2255	-0.3382	-0.1048	-0.2398	0.0685
				Poland				
α_t	-0.4305	-0.5909	-0.2383	0.2279	0.4062	-0.0265	-0.2925	0.4158
γ_t	0.1669	0.4479	0.0757	0.4318	0.1419	-0.073	-0.2524	0.6231

Figure 1
Consumption growth rates

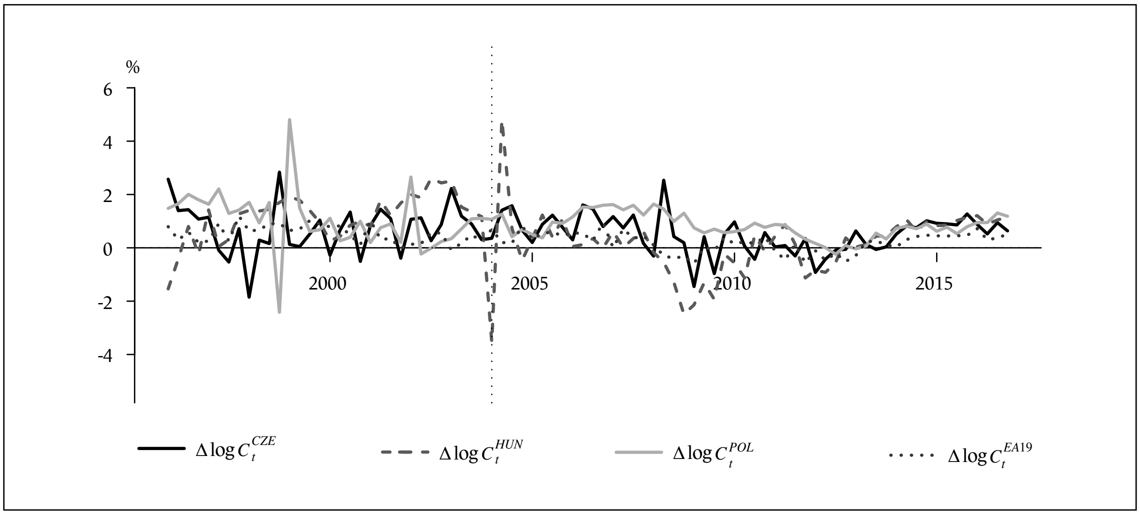

Figure 2
GDP growth rates

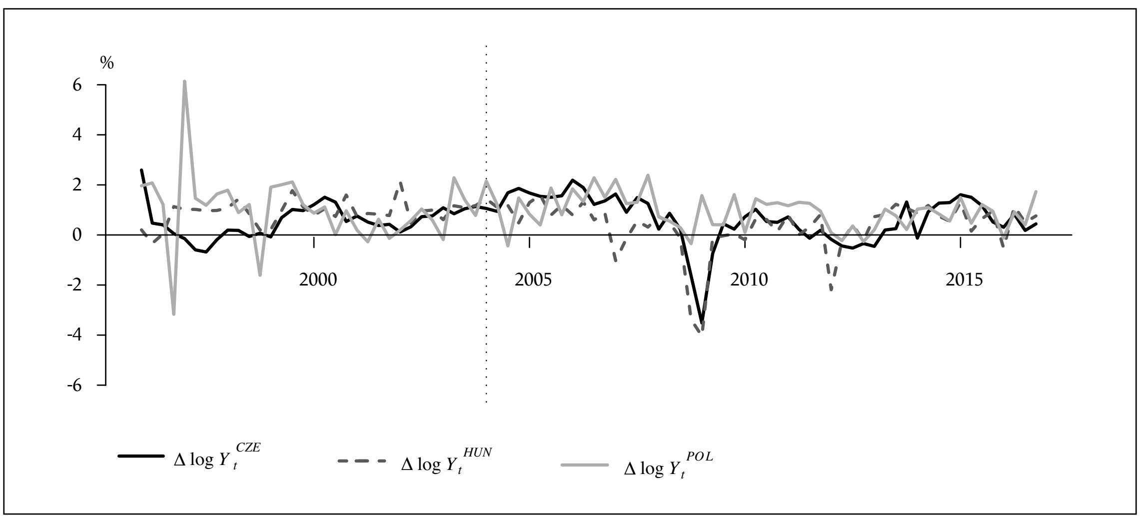

Figure 3
Czech financial integration with the euro area

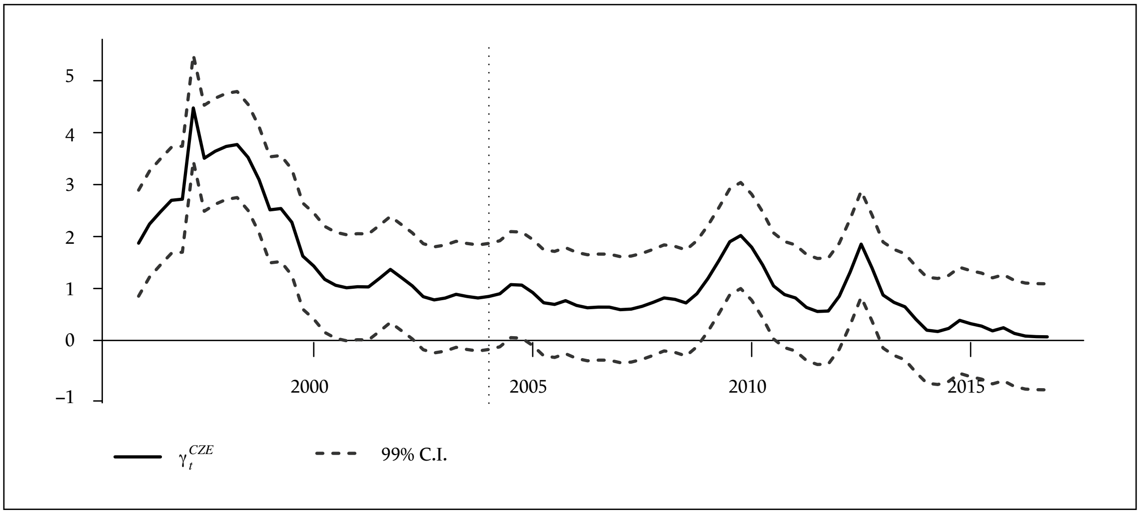

Figure 4.1
Hungary: financial integration with the euro area, intercept

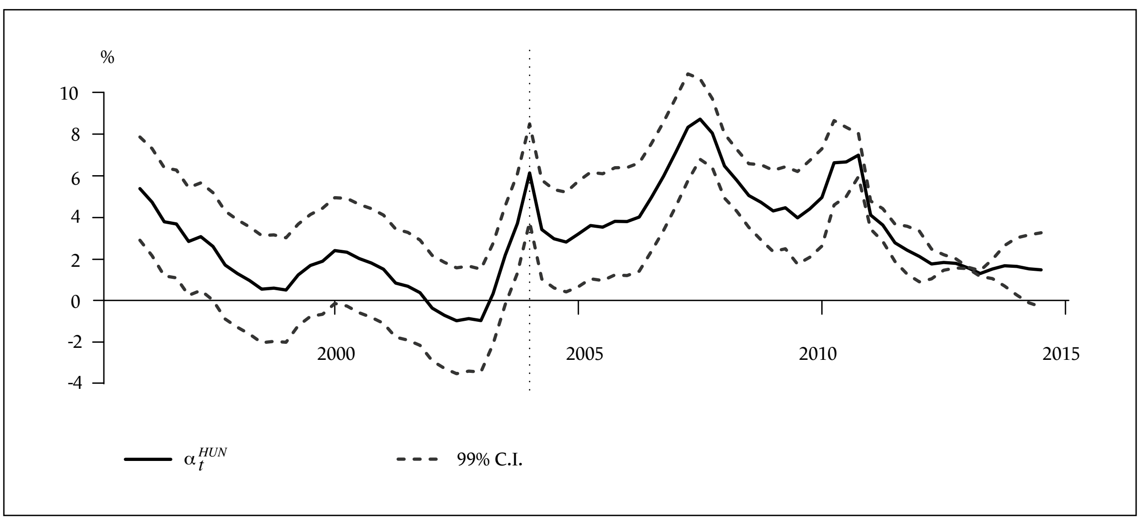

Figure 4.2
Hungary financial integration with the euro area, slope

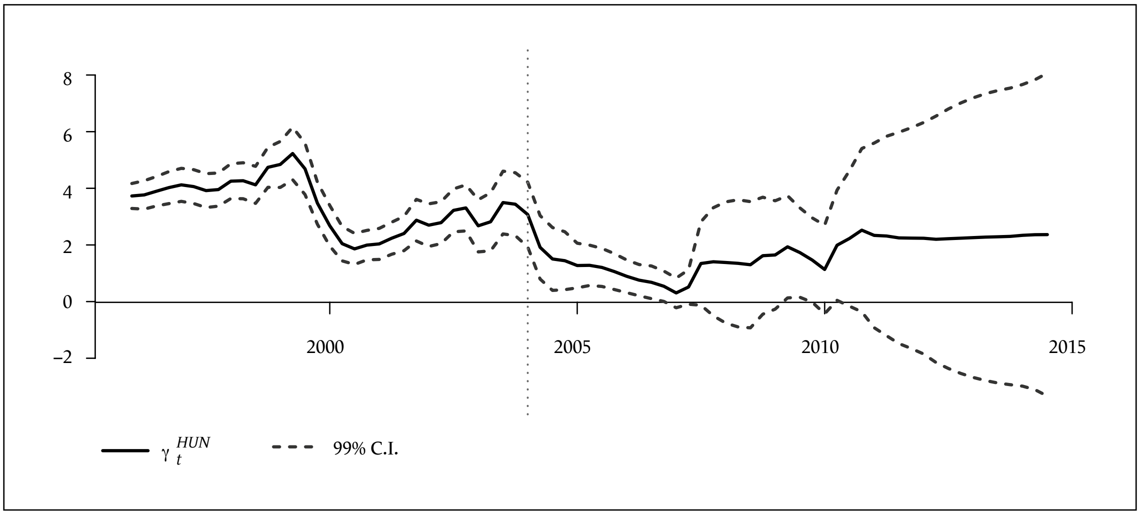

Figure 5.1
Poland financial integration with the euro area, intercept

Figure 5.2
Poland financial integration with the euro area, slope

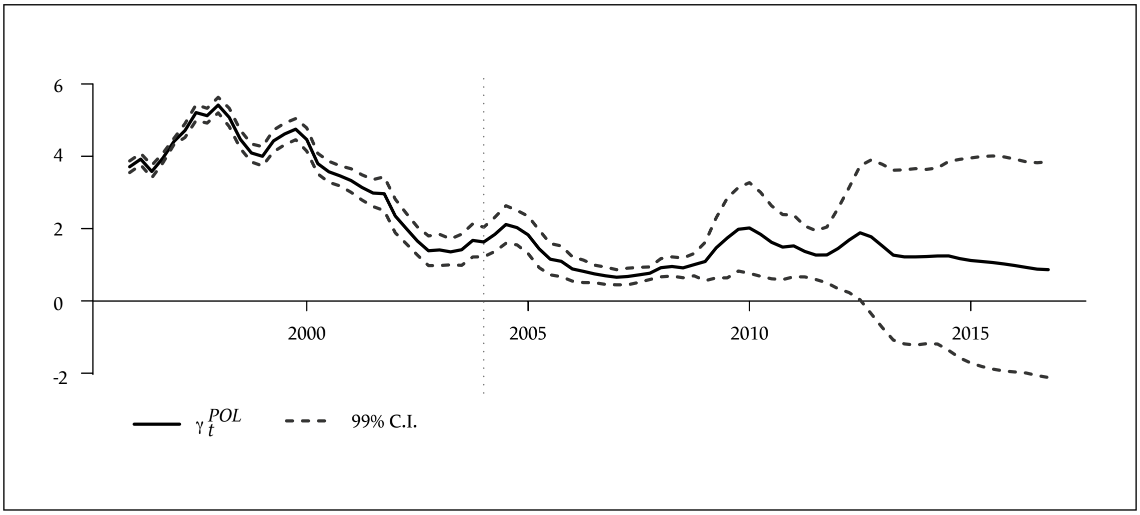

Figure 6.1
Interest rates co-movement, Czech Republic

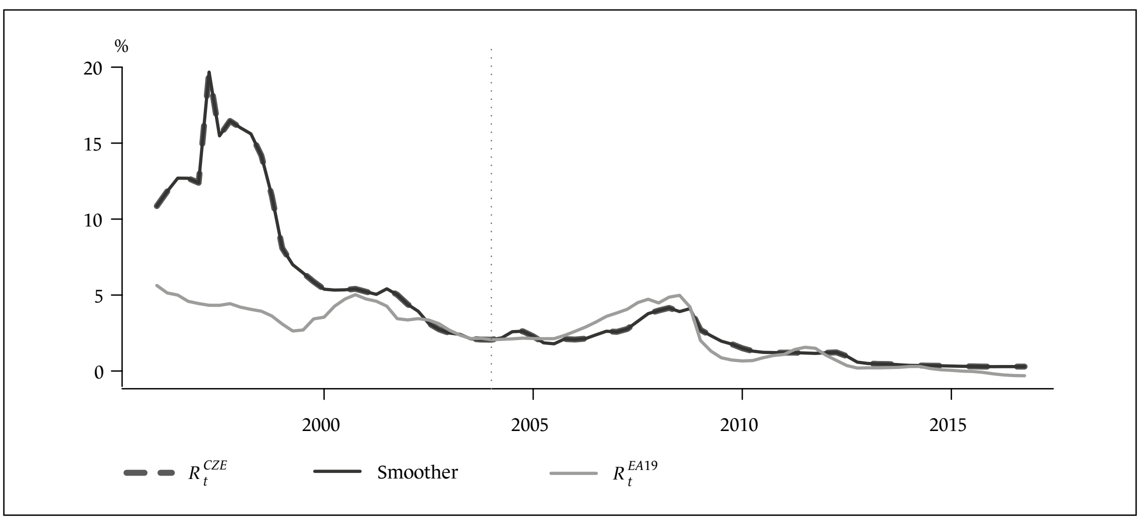

Figure 6.2
Interest rates co-movement, Hungary

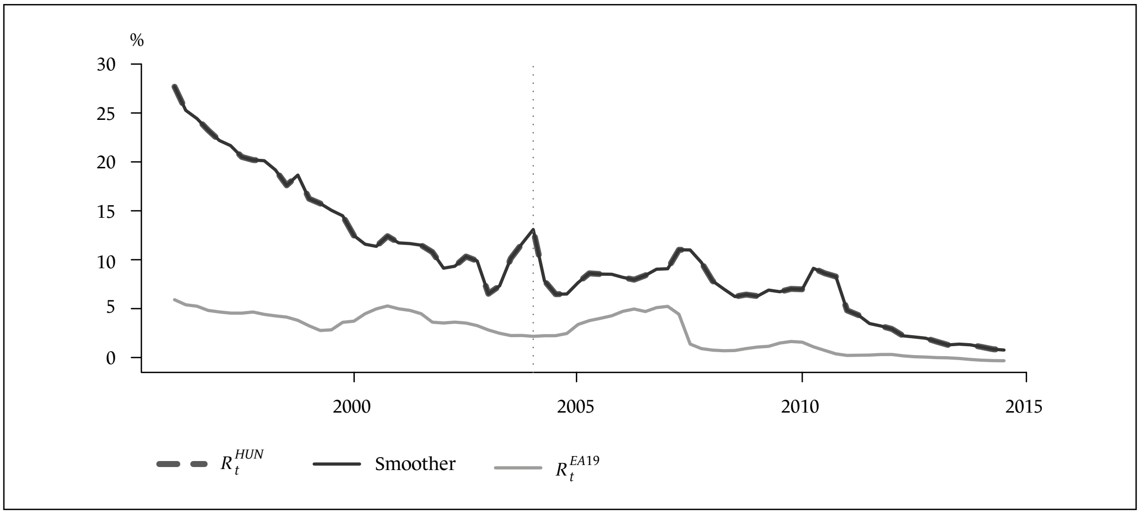

Figure 6.3
Interest rates co-movement, Poland