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Quarterly Report on the Euro Area

Volume 18, No 1 (2019)

- **Does market discipline enter governments' fiscal reaction functions in the euro area?**
Section prepared by Eric Meyermans
- **Do global factors spell the end of the Phillips Curve?**
Section prepared by Eric McCoy, Matteo Salto and Václav Žďárek
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Section prepared by Leonor Coutinho and Alessandro Turrini

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European Commission
Directorate-General for Economic and Financial Affairs

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Marco Buti
Director-General

Do the changes that the euro area underwent during the financial crisis call for a fundamental reassessment of the rationale on which the European Union's economic policy framework is predicated? First, there is a question mark on whether market discipline, alongside the EU fiscal surveillance, can be relied upon to ensure sound fiscal policies. Indeed, the euro area is still feeling the effects of markets' failure to discipline adequately sovereign issuers in the run-up to the crisis which led to significant rise in sovereign debt. Second, the long period of subdued inflation that prevailed since the financial crisis, in spite of the surprisingly favourable labour market performance over the past few years, casts a doubt on whether the Philips curve can be relied upon to guide monetary policy. Finally, the process of convergence of the economies in the euro area, which used to be an established fact of the European narrative, has stalled over the last few years.

These elements call for a careful examination of the effectiveness of existing EMU tools and frameworks. More specifically, we should reflect on how to improve the existing fiscal frameworks and better exploit their interaction with market discipline to prevent the build-up of fiscal imbalances across the euro area. We also need to reflect carefully about the effectiveness of the Macro-economic Imbalance Procedure to reign in imbalances – particularly surpluses. Rebalancing in the euro areas is a necessary condition for sustainable convergence. Finally, we need to assess carefully how to account properly for the increased interconnectedness within the euro area, and especially vis-a-vis the rest of the world, for our assessment of monetary policy based on standard Phillips curve models.

This issue of the Quarterly Report on the euro area provides a contribution to these reflections and presents empirical evidence to support the ongoing policy debate on the completion of the EMU architecture. More specifically, the three

contributions herein examine the extent to which national governments' fiscal policies respond to market signals, they then discuss the impact of global factors on inflation developments in the euro area, and review the drivers of and obstacles to the process of convergence across the euro area, notably with a focus on the role of macro-economic imbalances.

The first section provides econometric evidence on the complementary interaction between markets and fiscal rules to discipline governments' fiscal policies. While in the run-up to the crisis, bond markets exerted limited pressure on sovereign issuers, the econometric analysis suggests that at the onset of the financial crisis, when risk premiums rose sharply, fiscal adjustment was more significant especially in countries with more effective national fiscal institutions (e.g. national fiscal councils). The analysis also suggests that the responsiveness of governments appears stronger in countries with a larger share of short-term debt, but weaker when elections are pending.

The second section explores to what extent the Phillips Curve framework, used as a reference for the conduct of monetary policies, should be adapted to take into account the presence of global determinants of inflation such as an aggregate measure of the rest-of-the-world output gap and global value chains. The econometric analysis does not provide evidence that it would be necessary, as available measures of domestic productivity or economic slack are not superseded by measures of global developments. As such, the empirical analysis confirms the scope for monetary policy to control inflation via its impact on the domestic output gap and inflation expectations.

The third section examines empirically the real convergence patterns across the euro area Member States since the inception of the euro. The analysis confirms that countries converged in

the last 20 years but some at a slower pace than implied by their fundamentals and also compared with other control-country groups. Slower convergence is noted among the initial members of the euro area, notably as concerns total factor productivity. The analysis shows that differences in convergence patterns in the euro area are to some extent linked to the presence of macroeconomic imbalances in some countries, particularly high private and public debt and excessive expansions of non-tradables sectors. The implication is that restoring sustainable convergence requires policies to address or prevent the accumulation of excessive imbalances, such as completing the structural adjustment to deal with legacy imbalances, and maintaining effective economic surveillance.

Altogether, the various contributions suggest that instruments of policy coordination at the euro area level should rather be strengthened and that their application requires a broadening of their initial scope and a rethinking of their interplay.

The finding that market discipline, measured by market interest rate rates, plays a role in influencing government behaviour – especially in conjunction with effective and transparent fiscal institutions – is important. It also shows that market can be indiscriminate during good times and result in exceedingly harsh adjustment, born primarily by the countries hit hardest, in bad times. This calls for an effective monitoring and stabilisation role at the EU level. It also underlines the important complementarity between fiscal rules and – a more proactive and consistent over time – market discipline, as well as structural reforms that boost productivity and potential growth. Together with a prudent macro-economic policy to avert excessive imbalances, this would allow euro area countries to reignite the convergence process. This would ensure that monetary policy remains effective and can respond both to the global shocks which affect price developments while adequately taking into account domestic signals coming notably from the domestic labour market.

I. Does market discipline enter governments' fiscal reaction functions in the euro area?

Section prepared by Eric Meyermans

This section assesses the role that markets have played in disciplining governments' behaviour across the euro area since the euro was launched. Discipline is measured by market interest rates, while governments' behaviour is measured by adjustments in primary budget balances. Using real-time data derived from DG ECFIN's forecast vintages released between 2002 and 2018 this section assesses the fiscal response of governments to changes in interest rates, conditioned by a variety of factors such as the maturity composition of public debt and other country characteristics.

The main finding is that bond markets exerted limited pressure on sovereign issuers in the run-up to the crisis. In contrast, during the crisis and afterwards Member States recorded a notable adjustment in their primary balances in response to interest rates soaring; this adjustment was more noticeable in those countries hardest hit by the crisis. The econometric analysis also suggests that the EU fiscal framework (e.g. national fiscal councils), the maturity structure of public debt and parliamentary elections have been significant factors affecting this responsiveness of fiscal policies. (1)

I.1. Introduction

Markets normally play a very useful role in modern economies by scrutinising the activities of public and private entities and individuals which can ultimately affect their incentives and actions. The extent to which markets exert such pressure and market participants respond is an empirical question. This section attempts to throw some light on this question by focusing on governments and fiscal policies.

A number of conditions have to be met for market discipline to be effective. First, the interest rate at which lenders lend to fiscal authorities has to correctly reflect default risk premiums specific to each of the sovereign issuer. (2) Second, on the fiscal side public primary balances have to respond in an appropriate way to the risk premiums set by markets. (3)

This section examines econometrically how public primary balances responded to interest rates – or

more precisely to Bund spreads – in the euro area over 2002-2018. The analysis introduces two new components to the existing methodology for assessing fiscal reaction functions. First, the standard fiscal reaction function (4) is augmented by adding the marginal interest rate paid on newly issued bonds in private capital markets and its impact is conditioned by a variety of factors such as the maturity composition of public debt and other country characteristics. (5) Second, the fiscal reaction function is estimated using real-time data derived from DG ECFIN's forecast vintages released between 2002 and 2018. This is significant as this is the information that market participants had at their disposal when they made their assessments about sovereign risk.

This section does not touch upon the question of the determinants of bond yields themselves. (6) For financial discipline to be effective a necessary (although not sufficient) condition is that risk premiums are closely aligned to fundamentals across sovereign issuers and over time. However, available evidence suggests that bond prices across

(1) This section was prepared in collaboration with Daniel Monteiro. The author wishes to thank Robert Markiewicz and Dris Rachik for their assistance with data collection as well as Sven Langedijk for his useful comments.

(2) In the EMU a correct default risk premium requires among other things a credible no-bailout rule. However, ex-post this is less clear-cut to establish if the cost of not having a bailout would be substantial enough. See, for instance, Allard, A. et al. (2013), 'Toward a Fiscal Union for the Euro Area', *IMF Staff Discussion Note* 2013/09.

(3) In turn, as argued by Lane, T. (1993), 'Market Discipline', *IMF Staff Papers*, Vol. 40, No. 1, pp. 53-88, this requires capital markets to be open (with, for instance, no preferential treatment of governments), information on the borrower's existing liabilities is readily available, and the no-bailout rule is credible.

(4) A fiscal reaction function relates the primary balance to a variety of economic factors, especially the outstanding debt to GDP ratio – as pioneered by Bohn, H. (1998), 'The Behavior of U.S. Public Debt and Deficits', *The Quarterly Journal of Economics*, Vol. 113, No. 3, pp. 949-963.

(5) This marginal interest rate is equal to the risk-free interest rate plus a risk premium. The former is the yield on an investment that carries zero risk and is set by general macro-economic conditions, while the latter is determined by the specific characteristics of the sovereign issuer.

(6) However, as discussed below, the estimation of the fiscal reaction function takes into account that the interest rate on new government borrowing (i.e. the "marginal interest rate") and the primary balance are set simultaneously.

the euro area in recent decades have been driven by bouts of illiquidity and divergent and time-varying market sensitivities regarding the fundamentals as well as redenomination risk; this can to some extent be related to the incomplete economic and monetary union (EMU) architecture. ⁽⁷⁾

This section is structured as follows. In the second sub-section, a fiscal reaction function is specified with a view to estimate the general government primary balance's sensitivity to marginal interest rates and more particularly its risk premium component. This sensitivity is conditioned by various factors such as the maturity composition of the public debt, the national fiscal framework as well as elections. The third sub-section discusses the real-time data retrieved from various forecast vintages in DG ECFIN's AMECO database to estimate the fiscal reaction function. The policy reaction function is estimated with real-time data to isolate the information that policy makers had at their disposal when the primary balance and interest rates for new funding were set. ⁽⁸⁾ The fourth section simulates the impact of Bund spreads on primary balances since the early 2000s. The last sub-section draws some policy conclusions.

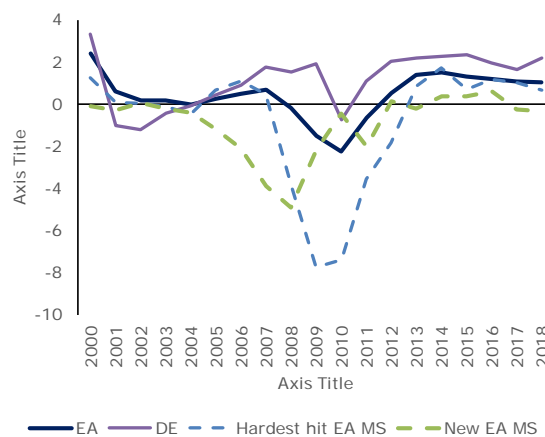
I.2. Financial market discipline and fiscal responsiveness

Since the onset of the global financial crisis, primary balances (net of interest payments and adjusted for the cyclical component as a percentage of potential GDP) have shown strong variation across the euro area countries - see Graph I.1.

For instance, while the primary balance in Germany recorded a deficit only in 2010, the aggregated primary balance of the Member States hardest hit showed a strong and persistent deficit since the onset of the crisis. At the same time, the

Baltic Member States recorded a decrease earlier on but recovered faster than the Member States hardest hit.

Graph I.1: Net public lending (+) and borrowing (-)



(1) Net lending (+) or net borrowing (-) excluding interest of general government adjusted for the cyclical component, % of potential GDP.
 (2) Euro area (EA) countries hardest hit covers Ireland, Greece, Spain, Cyprus and Portugal. New EA Member States covers Estonia, Latvia and Lithuania. Weighted averages.
Source: Author's estimates based on AMECO November 2018 forecast vintage.

At the same time, Bund spreads also showed strong differences closely linked to the observed differences in primary balances. For instance, Graph I.2 shows a positive unconditional correlation between the primary balance and the Bund spreads in 2012, while Graph I.3 shows a negative correlation in 2013.

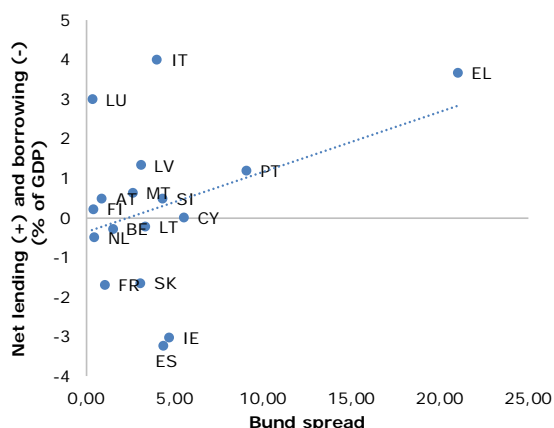
However, such unconditional correlations do not provide answers in terms of causality as the Bund spread and primary balances are simultaneously determined, and these correlations lack an unambiguous interpretation. For instance, the positive unconditional correlation in 2012 might suggest that a rise in the spread induced a rise in savings, while the negative unconditional correlation in 2013 might suggest that a rise in savings would induce a drop in the risk premium.

This section explores econometrically whether financial markets created incentives via the Bund spread to correct primary balances – taking into account possible reverse causality affected by other factors such as the outstanding debt level.

⁽⁷⁾ This has been discussed elsewhere, see for instance, Monteiro, D. (2018), 'A retrospective look at sovereign bond dynamics in the euro area', *Quarterly Report on the Euro Area*, Vol. 17, No 4, pp. 7-26, or Favero, C., M. Pagano and E.-L. von Thadden (2010), 'How does liquidity affect government bond yields?', *Journal of Financial and Quantitative Analysis*, Vol. 45, No. 1, pp. 107-134.

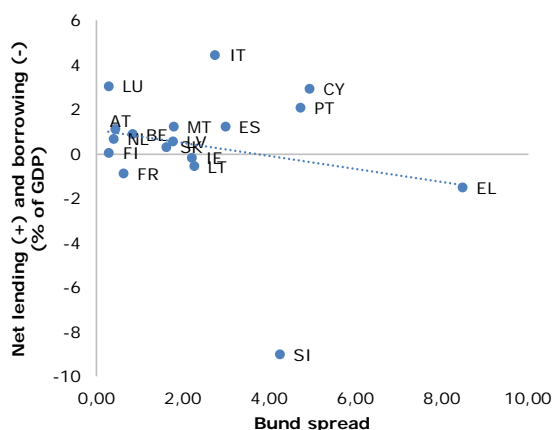
⁽⁸⁾ An argument made forcefully by Orphanides A. (2003), 'Historical monetary policy analysis and the Taylor rule', *Journal of Monetary Economics*, Vol. 50, pp. 983-1022 when assessing the Taylor rule for the conduct of monetary policy highlighting that real-time measurement difficulties may cause policy errors. See, for instance, Croushore, D. (2011), 'Frontiers of Real-Time Data Analysis', *Journal of Economic Literature*, Vol. 49, No 1, pp. 72-100 for a review of issues related to real-time data analysis.

Graph I.2: Net public lending (+) and borrowing (-) and Bund spread - 2012



(1) Net lending (+) or net borrowing (-) excluding interest of general government adjusted for the cyclical component, % of potential GDP. Yearly average Bund spread.
 Source: AMECO

Graph I.3: Net public lending (+) and borrowing (-) and Bund spread - 2013



(1) Net lending (+) or net borrowing (-) excluding interest of general government adjusted for the cyclical component, % of potential GDP. Yearly average Bund spread.
 Source: AMECO

I.2.1. The fiscal reaction function

Previous studies on public debt sustainability focused initially⁽⁹⁾ on the public primary balances' responsiveness to the debt accumulated in the past.⁽¹⁰⁾ In such a framework, an unconditional positive response is considered to be a sufficient condition to meet the public sector's intertemporal

budget constraint.⁽¹¹⁾ Further extensions of the literature in these studies focused on nonlinearities in the feedback of the debt level on the primary balance whereby the primary balance becomes more responsive with rises in public debt but potentially weakens when an upper limit for feasible primary balance has been reached (i.e. fiscal fatigue) and default becomes inevitable.⁽¹²⁾

While fiscal reaction functions were first estimated at the level of individual countries such as the US⁽¹³⁾, later they were estimated with panel data covering several countries⁽¹⁴⁾ to allow for more variation in some of the explanatory variables such as the debt-to-GDP ratios that often vary more intensively across countries than over time.

In addition, several alternative specifications of the fiscal reaction function have been proposed, including an error-correction model specification⁽¹⁵⁾, a static panel data setting⁽¹⁶⁾ as well as a dynamic panel data setting with heterogeneous parameter restrictions.⁽¹⁷⁾

A common characteristic of most previous studies⁽¹⁸⁾ is that, while they often include a measure of the interest paid on outstanding debt, they ignore the marginal cost of new borrowing in

⁽¹¹⁾ However, while positive feedback is sufficient to prevent the debt-GDP ratio from exploding (i.e. weak sustainability), it does not imply that the debt-GDP ratio converges to a desirable stable equilibrium value such as 60% of GDP target. See, for instance, Gosh, A. et al. (2013), 'Fiscal Fatigue, Fiscal Space And Debt Sustainability In Advanced Economies', *NBER Working Paper Series Working Paper 16782*. Checherita-Westphal, C. and V. Žďárek (2017), 'Fiscal reaction function and fiscal fatigue: evidence for the euro area', *ECB Working Paper Series No 2036* report that over the 1970-2013 period the euro area countries recorded, on average, weak sustainability as the primary balance improved by about 0.03-0.05 for every 1 percentage point increase in the debt-GDP ratio.

⁽¹²⁾ See, for instance, Gosh et al. (2013), *op cit.*

⁽¹³⁾ See, for instance Bohn (1998), *op cit.*

⁽¹⁴⁾ See, for instance, Mendoza and Ostry (2008), 'International Evidence on fiscal solvency: is fiscal solvency 'responsible'?', *Journal of Monetary Economics*, Vol. 55, No. 6, pp. 1081-1093.

⁽¹⁵⁾ Whereby the dependent variable is in first differences and the explanatory variables include an error correction term as discussed in, for instance, Schoder, C. (2014), 'The fundamentals of sovereign debt sustainability: evidence from 15 OECD countries', *Empirica*, Vol. 41, No. 2, pp. 247-271 and Berti et al. (2016), 'Fiscal Reaction Functions for European Union Countries', *European Economy Discussion Paper No. 28*.

⁽¹⁶⁾ See, for instance, Gosh, A. et al. (2013), *op cit.*

⁽¹⁷⁾ Such as cross-country heterogeneity in the responsiveness of the primary balance to the outstanding debt. See, for instance, Everaert, G. and S. Jansen (2018), 'On the estimation of panel fiscal reaction functions: Heterogeneity or fiscal fatigue?', *Economic Modelling*, Vol. 70, pp. 331-337.

⁽¹⁸⁾ For a selected review of these papers, see, for instance, Checherita-Westphal, C. and V. Žďárek (2017), *op cit.* and Berti, K. et al. (2016), *op cit.*

⁽⁹⁾ See, for instance, Bohn (1998), *op cit.*

⁽¹⁰⁾ Which is closely related to the so-called snowball effect whereby if the nominal interest rate is larger than nominal GDP growth the outstanding debt on its own is a source of instability.

private capital markets. Exploring the primary balances' responsiveness to marginal interest rates and specifically the marginal interest rates' risk premium component is the main focus of this brief section. ⁽¹⁹⁾

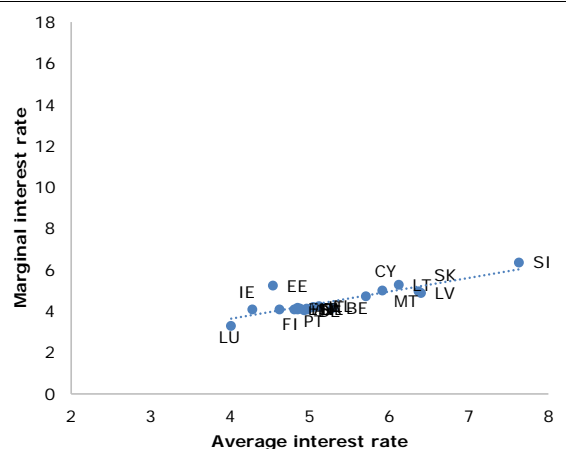
I.2.2. The marginal and average interest rate

The marginal interest rate is paid on newly issued bonds in private capital markets. This interest rate does not only apply to an increase in the stock of debt to GDP in period *t* (resulting from a primary deficit in period *t*), but would also apply to the part of outstanding debt that matures and has to be rolled over in period *t*. The average interest rate is paid on outstanding debt. Both interest rates may differ notably.

For instance, Graphs I.4 and I.5 show that before the crisis, e.g. 2003, both interest rates were closely aligned, but during the crisis, e.g. 2011, some Member States, such as Greece, Portugal and Ireland recorded marginal interest rates well above the average interest paid on outstanding debt. At the same time, other Member States such as Lithuania, recorded marginal interest rates well below the average interest rate. This divergent pattern reflects to some extent differences in recovery dynamics from the crisis. ⁽²⁰⁾

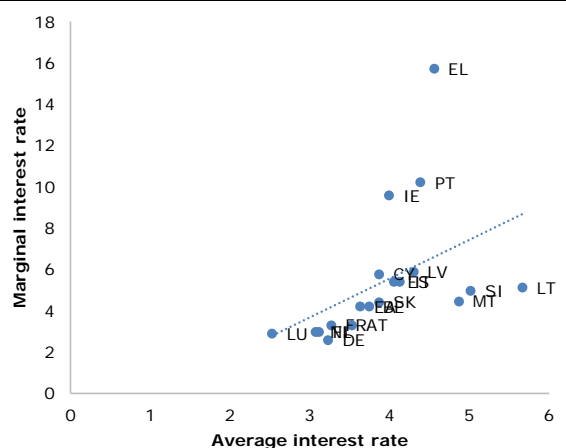
These interest rates have a different impact on the primary balance. While the marginal interest rate has a direct impact on the propensity to lend or borrow, the average interest rate paid on outstanding debt puts downward pressure on other expenditure or limits the room for tax cuts. With rising interest payments, governments may therefore want to improve the primary balance to avoid a deterioration of the overall balance. ⁽²¹⁾

Graph I.4: Marginal and average interest rate -2003



Source: Average interest rate AMECO indicator AYGD; Marginal interest rate (ex-post): AMECO indicator ILN.

Graph I.5: Marginal and average interest rate -2011



Source: Average interest rate AMECO indicators, AYGD; Marginal interest rate (ex-post): AMECO indicator ILN.

I.3. Yield spreads

The marginal nominal interest rate has two components, i.e. the risk-free nominal interest rate and a risk premium. The risk-free nominal interest rate is set by general macro-economic conditions affecting the risk-free real interest rate and expected inflation. In the regression analysis the risk free nominal interest rate is proxied by the 10-year German Bund yield.

US and Norway) having the same parameter. Bertie et al. (2016), *op cit.*, estimating fiscal reaction functions for 13 EU Member States covering 1950–2013, report that the real interest rate paid on outstanding debt is statistically significant in a greater number of cases, but with a positive sign in about half of the cases.

⁽¹⁹⁾ I.e. AMECO variable implicit interest rate general government - Interest as percent of gross public debt of preceding year. Excessive deficit procedure (based on ESA 2010).

⁽²⁰⁾ For instance, in Lithuania the 10 year bond yield stood at 14.5% from February 2009 to December 2009, but at about 5% in 2011.

⁽²¹⁾ The empirical evidence on the impact of the average interest rate on the primary balance is mixed. For example, Checherita-Westphal and Zďárek (2017), *op cit.*, examining a panel of 18 euro area countries covering 1970–2013, report that higher interest payments as measured as a ratio to lagged debt, current GDP or total revenues have a negative impact on the capacity of governments to maintain higher primary surpluses. Everaert, G. and S. Jansen (2018), *op cit.*, examining a panel of OECD countries over 1970–2014 report a positive impact, only significant in a panel specification with all countries (including EU Member States as well as non-EU countries such as Japan, South Korea,

The risk premium is related to investors' risk aversion, the relative supply of government bonds, and uncertainty driven by various factors including economic and political factors. When markets assess that a country's fiscal policy is too expansionary the risk premium will increase to compensate for the increased risk. ⁽²²⁾ In turn, a higher risk premium increases the domestic interest rate which may provide incentives for governments to save at least if governments care about the future and would like to smoothen primary balances over time.

In the regression analysis the risk premium is proxied by the Bund yield spread at 10-year maturity, i.e. the difference between the national bond yield and the German Bund yield. While in the early 2000s the risk premiums were fairly low and did not vary much among sovereigns issuers, they increased dramatically during the crisis for some Member States such as Greece, Portugal and Ireland – see Graph I.6.

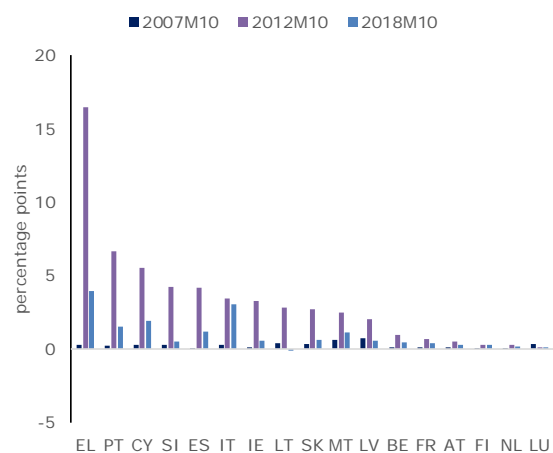
Such developments partly reflect changes in market participants' risk aversion which may be rooted in changes in the belief that countries would be bailed-out (or not) or that fiscal rules would suffice (or not) to promote sustainable fiscal policies. ⁽²³⁾

I.3.1. Factors affecting the responsiveness to risk premiums

In this section, we test various factors that may affect the governments' responsiveness to market forces. More specifically, we estimate a fiscal response function that is supplemented by factors that affect the responsiveness of the primary balance to the risk premium. ⁽²⁴⁾

First, the primary balances' responsiveness is affected by the short- and long-term debt stock (as percentage of GDP). The hypothesis is that governments show a stronger responsiveness to debt that has to be rolled over within the year than to debt with a long maturity.

Graph I.6: 10-year government bond spreads over the German Bund - before, during and after crisis



Source: Author's estimate based on Eurostat data.

The responses conditioned by short-term debt are triggered by changes in the short-term risk premiums, while the responses conditioned by long-term debt are triggered by the risk premiums on long term debt. More specifically, in the case of short-term debt it is the short-term risk premium squared that has been modelled, not only to capture its more pressing nature but also to reduce collinearity between the short and long-term risk premiums channel during estimation.

Graph I.7 shows some notable differences in maturity composition of public debt. For instance, in 2017, Estonia, followed by Greece and Austria, recorded the lowest share of short-term debt in total public debt, while Portugal and Italy recorded the highest.

Second, the regression analysis also makes it possible to assess any complementarity between fiscal rules and market discipline to be assessed by means of having responsiveness conditioned by a fiscal rule strength index. The hypothesis is that stricter fiscal rules should make the primary balance more responsive to developments in the risk premium as an increase in the risk premium induces a rise in interest payments and thus also in the overall fiscal deficit (if not compensated by increases in the primary balance). With stricter fiscal rules there is less room to let the primary

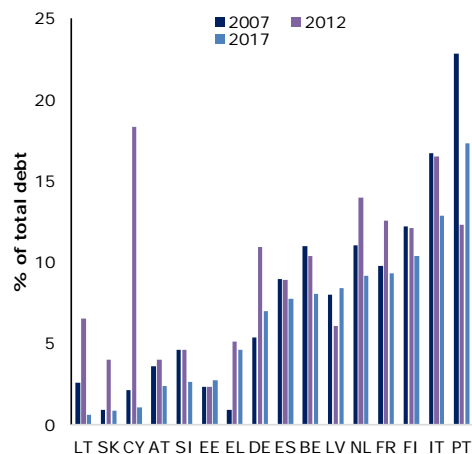
⁽²²⁾ Such risk can take different forms such as default, a rescheduling of existing debt or redenomination risk.

⁽²³⁾ See, for instance, Strauch, R. (2016), 'The future of the EU fiscal framework – rules, markets and what else?'

⁽²⁴⁾ Technically speaking, this means that the conditioning factor such as the short-term debt level as a percentage of GDP is multiplied with the Bund spread.

balance unchanged or reduce it only moderately. ⁽²⁵⁾

Graph I.7: **Maturity composition of public debt – share in total debt of short-term original maturity (up to 1 year)**



(1) Short-term original maturity (up to 1 year).

Source: ECB statistical Warehouse: Government Finance Statistics, gross government debt (consolidated).

Although it should be recognised that dummy variables are crude indicators to measure categorical characteristics, three dummy variables have been included to capture some very specific features that may affect the primary balances' responsiveness.

- Elections: the regression analysis also includes a dummy variable that allows the impact of parliamentary elections to be assessed. The hypothesis is that in an election year the responsiveness to changes in the risk premium weakens. ⁽²⁶⁾

⁽²⁵⁾ In the subsequent econometric analysis DG ECFIN's measure of fiscal rule strength is used. The Fiscal Rule Strength Index reflects a country's performance in terms of the following five criteria: 1) legal base ranging from political commitment to rules enshrined in the Constitution, 2) the binding character of targets ranging from a political commitment or annual budget law to very specific escape rules, 3) bodies monitoring compliance and the correction mechanism ranging from the rule not being publicly monitored on a regular basis to monitoring by an independent authority (i.e. fiscal council type of institution), 4) correction mechanisms ranging from governments not being obliged to take action to the correction mechanism being triggered automatically, and 5) resilience to external shocks. For more details see https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/fiscal-governance-eu-member-states/numerical-fiscal-rules-eu-member-countries_en

⁽²⁶⁾ However, Alesina, A., Favero, C. and F. Givazzi (2019), *Austerity, When it works and when it doesn't*, Princeton University Press, report evidence that in some cases voters might understand the necessity of austerity and at least not punish governments for it.

- Vintage release: the sample size covers (at least) two forecast vintages for each year ⁽²⁷⁾, i.e. one forecast released early in the year and one released later in the year. Between these releases the interest rates and risk premiums may change and responsiveness is expected to weaken as time progresses as most of the budget has already been implemented. In order to capture a possible difference in the sensitivity in the course of the year we added the risk premium multiplied with a vintage dummy which is equal to 1 when it concerns the last release of the year.
- Excessive deficit procedure. A dummy is added to capture whether the excessive deficit procedure (EDP) was applied. The Commission launches the EDP against Member States that exceed the budgetary deficit ceiling as imposed by the Stability and Growth Pact. The dummy takes a value equal to 1 when the Member State is subject to the EDP and equal to 0 otherwise.

I.3.2. The other macro-economic factors

The marginal nominal interest rate has a direct impact on a government's public balance as it increases the cost to service debt and affects the intertemporal trade-off between current and future. ⁽²⁸⁾

However, looking beyond this channel it should be noted that interest rates may also affect the public balance indirectly. ⁽²⁹⁾ For instance, as interest rates on government debt set the benchmark interest rate at which corporations can borrow, an increase may reduce interest rate sensitive private expenditures such as investments. This may in turn reduce output and subsequently tax revenues and public expenditures, affecting the numerator as well as the denominator of the primary balance as a percentage of GDP differently.

Moreover, while higher inflation lowers the real interest rate and the real value of the debt accumulated in the past that reduces the incentive

⁽²⁷⁾ I.e., two until 2012, and 3 as of 2013.

⁽²⁸⁾ Moreover, a higher interest rate decreases the market value of existing debt stock, which may provide incentives to save less. Changes in market value of public debt due to changes in the nominal interest rate are not explicitly modelled in the subsequent regression analysis.

⁽²⁹⁾ See, for instance, Rommerskirchen, C. (2015), 'Debt and punishment: Market discipline in the Eurozone', *New Political Economy*, DOI: 10.1080/13563467.2014.999760.

to save, in the case of partial inflation indexation of public expenditures and tax bases, higher inflation may give rise to additional channels affecting the primary balance and GDP differently. Similar changes may be related to changes in output if for instance public expenditures and tax revenues are not linked in the same way to output growth. ⁽³⁰⁾

As a consequence, instead of including the nominal interest rate adjusted for nominal growth as a single explanatory variable in the reduced form regression equation ⁽³¹⁾, the three components of this variable will be included separately, i.e. the nominal interest rate, GDP-deflator inflation and real GDP growth.

The outstanding debt level is also an important explanatory variable as governments are expected to take stronger corrective measures when facing an increase in the public debt-GDP ratio.

Finally, the regression equation also includes all factors separately that interact with the risk premium on their own (as described in the previous sub-section). ⁽³²⁾ ⁽³³⁾

I.4. Information constraints in real time

Estimating the fiscal reaction function with real time data (as opposed to ex post revised data) may improve the assessment of primary balances' responsiveness as it is these data that are available to market participants when they make their decisions. However, these data may be revised between the time when the market participants act and when the research is being prepared. ⁽³⁴⁾ For

this purpose, data retrieved from the AMECO forecast vintages released between 2002 and 2018 have been used to estimate the fiscal reaction function. ⁽³⁵⁾

The data of past vintages may be revised when new information becomes available ('news' such as the unexpected United States subprime mortgage crisis), measurement errors are corrected ('noise') or the measurement methodology is changed (such as the major data revisions in gross fixed capital formation affecting real GDP and other macro-economic variables notably Ireland in 2015).

In addition, this section refers to net lending and borrowing as a percentage of potential GDP. However, potential GDP can not be observed and is estimated using real-time data and applying a production function approach – so that it can be subject to major revisions especially in the upswing phase of cycles. ⁽³⁶⁾ As such overly optimistic real-time projections of conceptual variables such as potential GDP may lead to excessive weakening of the fiscal stance if compared with assessments making use of ex post data that revise potential GDP downwards. ⁽³⁷⁾

⁽³⁰⁾ The output gap is not included because the analysis focusses on net lending and borrowing adjusted for the cyclical component. Moreover, Checherita-Westphal and Zđárek (2017), *op cit.* report that the output gap does not have a significant impact in the setting of the cyclically-adjusted primary balance. The specification used in his section allows for interaction between changes in real GDP and the primary balance.

⁽³¹⁾ As suggested by the intertemporal budget constraints which reads as $d_t - d_{t-1} \cong (i_t - g_t) d_{t-1} - s_t$ with d the public debt-GDP ratio, i the nominal government bond yield, g nominal GDP growth and s the primary balance as a percentage of GDP. See, for instance, Blanchard, O. (1990), 'Suggestions for a New Set of Fiscal Indicators', *OECD Economics Department Working Papers*, No. 79.

⁽³²⁾ Apart from its economic relevance, this inclusion is also needed in order to prevent possible omitted variables biases estimating the equation. See, for instance, Aitken and West (1991), *Multiple Regression: Testing and Interpreting Interactions*, SAGE Publications

⁽³³⁾ Other studies include additional variables such as openness to international trade and crisis dummies (e.g. Checherita-Westphal and Zđárek (2017), *op cit.*) and the ratio of elderly (e.g. Everaert and Jansen (2018), *op cit.*)

⁽³⁴⁾ I.e. the November 2018 AMECO vintage.

⁽³⁵⁾ AMECO vintages released in the beginning of year t include forecasts for the primary balance (as well as other relevant macro-economic variables) for the years t and $t+1$, while the vintages released at the end of the year also include forecasts for the year $t+2$.

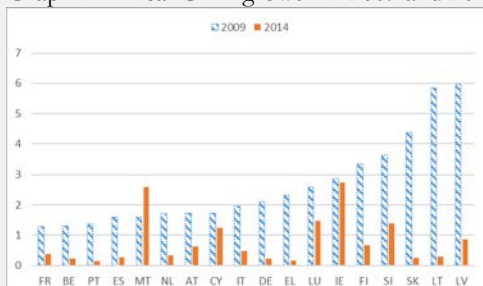
⁽³⁶⁾ See, for instance, Morrow, K., Roeger, W., Vandermeulen, V. and K. Havik (2015), 'An Assessment of the Relative Quality of the Output Gap Estimates Produced by the EU's Production Function Methodology', *European Economy Discussion Paper* 020. As such, revisions of potential output are not triggered by revisions in the underlying historical data, but by revisions as more forward data become available.

⁽³⁷⁾ For a discussion of problems related to revisions of conceptual variables, see for instance Croushore, D. (2011), 'Frontiers of Real-Time Data Analysis', *Journal of Economic Literature*, Vol. 49, No. 1, pp. 72–100.

Box I.1: Real time versus ex post data

Graph B.1 shows the standard deviation of real GDP growth across the euro area countries in 2009 and 2014, as reported in the various AMECO forecast vintages - highlighting that these revisions were especially strong in the Baltic Member States. For instance, the underlying data show that the second forecast vintage of 2007 projected real GDP growth for 2009 in Latvia and Germany to be, respectively, 6.2% and 2.2%, while the second vintage of 2009 assessed 2009 real GDP growth to be, respectively, -18.0% and -5.0%. Furthermore, the last vintage of 2018 established a -14.4% and -5.6% real growth in Latvia and Germany, respectively.

Graph B.1: Real GDP growth in 2009 and 2014 – real time estimates (standard deviation)

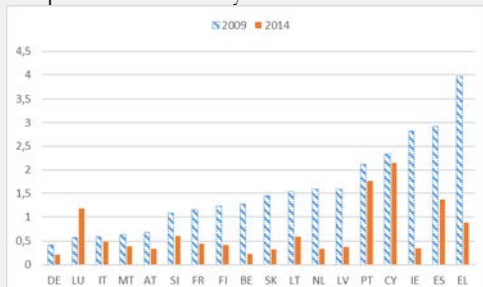


Note: The bars show per country the standard deviation of the 2009 and 2014 real GDP growth as reported in the AMECO forecast vintages released between late 2007 and late 2018.

Note: The bars should be compared across Member States for the same year and not across years for the same Member States as the standard deviation becomes smaller and smaller with more vintages included as less revisions are made over time.

Similarly, Graph B.2 shows the standard deviation in the 2009 and 2014 primary balances (as a percentage of potential GDP), showing more or less the same pattern as in Graph 4. For instance, in the second vintage of 2007 the 2009 primary balance (net of interest payments and cyclical components) was projected to be positive in all Member States except Slovakia. In the second vintage of 2009 it was projected that 14 euro area countries would have a deficit in 2009, with Greece recording a deficit of 7.7% of GDP. Finally, the last vintage of 2018 reported that 13 Member States recorded a deficit in 2009, with Greece recording a deficit of 10.0% of GDP. Overall, counting from the last vintage of 2007, the revisions of the 2009 primary balance were strongest in Greece, Spain, Ireland, Cyprus and Portugal, while they were weakest in Germany.

Graph B.2: Primary balance in 2009 and 2014 – real time estimates (standard deviation)



Note: The bars show per country the standard deviation of the 2009 and 2014 primary balance as reported in the AMECO forecast vintages released between late 2007 and late 2018.

Finally, while governments' fiscal decisions are based on the information they have at their disposal, the governments themselves are a primary source of transparent information on fiscal policies. (38) In other words, the well-functioning of bond markets also requires that the governments provide in a transparent and timely way the information needed to set risk premiums. (39)

I.5. Estimation results

Box I.2 briefly describes the data and methodology that underpins the estimation of this section's fiscal reaction function. Table I.1 shows the estimation results that capture the impact of financing costs in period t on the budget in period t , i.e. adjustments to an already established budget. (40)

The first column of Table I.1 shows estimation results of the base model (variant V1) The base model includes the main factors, i.e. the lagged public debt-GDP ratio, the risk-neutral interest rate proxied by the German 10-year Bund yield, the risk premium proxied by the 10-year Bund spread, GDP inflation, real GDP growth and the interest rate on outstanding debt. The point estimates show signs that are in line with the above narrative and literature. (41)

Variant V2 shows the regression results including a lagged dependent variable to capture inertia in public sector behaviour. The parameter of the

lagged dependent variable is highly significant and has the expected value between 0 and 1. (42)

The following columns show different variants of the base specification V2 by adding a selected set of factors that are expected to affect the responsiveness of the primary balance to changes in the risk premium. (43) These interaction factors are the ones discussed in the previous subsection, including outstanding short-term public debt (as a percentage of GDP), outstanding long-term public debt (as a percentage of GDP) and a measure of fiscal rule strength(44), as well as dummy variables that capture elections, the excessive deficit procedure and the vintage. The variant V9 shows estimation results for all interaction factors combined.

The point estimates of the stand-alone main effects not interacting with the risk premium are very similar across variants, with a high level of significance for the lagged debt level, the lagged primary balance, the risk-free interest rate and real GDP growth. (45)

However, the average interest rate paid on outstanding debt is insignificant (i.e. a p-value higher than 5%) in most variants. The Bund spread on its own (i.e. the third explanatory variable in Table I.1) provides a mixed picture, with strong positive significance in most variants but insignificance for variants V3, V6, V7 and V9. It is worth remembering that it is the stand-alone Bund spread in combination with the interaction effects that determines the net impact of the risk premium.

(38) For instance, IMF (2012), 'Fiscal Transparency, Accountability, and Risk', argues that fiscal transparency standards need to ensure that published fiscal reports (i) cover a wider range of public sector institutions; (ii) capture a broader range of direct and contingent assets and liabilities; (iii) recognise a wider range of transactions and flows; (iv) be published in a more timely manner; (v) take a more rigorous approach to fiscal forecasting and risk analysis; and (vi) present forecast and actual fiscal data on a consistent basis. Fiscal transparency refers to the clarity, reliability, frequency, timeliness, and relevance of public fiscal reporting.

(39) Reviewing the literature for the euro area, Cimadomo, J. (2011), 'Real-Time Data and Fiscal Policy Analysis: A survey of the literature', *Federal Reserve Bank of Philadelphia Working Paper* No. 11-25 reports that strong fiscal rules and institutions tend to lead to relatively accurate releases of fiscal data.

(40) The estimated equation is a reduced form equation (as is usually the case in the literature on fiscal reaction functions) and estimated with instrumental variables. As such, several specifications as well as instrumental variables have been tried out but it would be beyond the scope of this section to report them all.

(41) For instance, Checherita-Westphal and Žďárek (2017), *op cit.* report that the primary balance improves by about 0.03–0.05 for every 1 percentage point increase in the debt-to-GDP ratio which is closely related to the point estimates reported in Table I.1. Available studies also report a positive and highly significant point estimate for real GDP.

(42) I.e. varying from low inertia to very strong inertia in public policy making. The null-hypothesis that this parameter is equal to zero can be rejected with high confidence; even so, the null-hypothesis that this parameter is equal to 1 can be rejected with high confidence.

(43) Technically speaking, in the regression analysis this is done by multiplying the interaction factor with the bund spread. These interaction factors are also include as stand-alone explanatory variables to avoid any possible estimation bias when leaving them out. See, for instance, Aitken and West (1991), *op cit.*

(44) The fiscal rules strength indicator is a standardised index with an average of zero and a standard deviation of one. As such, negative values may be reported. In the regression analysis this indicator has been set strictly positive by adding 1 to its reported value.

(45) The following sub-section will take a closer look at the magnitude of the point estimates).

Box 1.2: Estimating the fiscal reaction function

The data

The sample covers the AMECO forecast vintages released between October 2002 and October 2018 covering 18 euro area countries. ⁽¹⁾ In the years t between 2002 and 2012, the first AMECO vintage (usually released in April) provided forecasts for the year t and $t+1$, while the second vintage (usually released in October/November) provided forecasts for the years t , $t+1$ and $t+2$. Between 2013 and 2018 the first (usually released in January/February) and second (usually released in April) vintage provided estimates for t and $t+1$, while the third vintage (usually released in November) provides forecasts for t , $t+1$ and $t+2$. ⁽²⁾ The observations for year t released in the second or third vintages of year t are stacked into vectors per Member States. These vectors are then used in equation (1) below.

The marginal interest rates are the interest rates observed in the month of the vintage. ⁽³⁾ The average interest paid on outstanding debt is measured by dividing interest payments made in period t by outstanding public debt stock in period $t-1$. The risk premium on long-term debt is proxied by the 10-year Bund spread, while the risk premium on short-term debt is proxied by the 1-year Bund spread. The 10-year bond yields are retrieved from the Eurostat database for all Member States, while the short-term interest rates are retrieved from the Bloomberg database. ⁽⁴⁾

The data on the strength of fiscal rules at national level are retrieved from DG ECFIN's webpage covering fiscal governance in the EU Member States. ⁽⁵⁾ The data available in the Voter Turnout Database of IDEA International is used in creating the election dummy. ⁽⁶⁾ The data on the maturity composition of public debt is retrieved from the ECB Statistical Data Warehouse. The information retrieved from DG ECFIN's webpage covering the Excessive Deficit Procedure (EDP) is used in creating the excessive deficit procedure dummy variable. ⁽⁷⁾

Specification

In the regression analysis, the dependent and explanatory variables are centred around their sample mean (i.e. observed value–sample mean). Without interaction terms, the point estimates of regressions with centred and original (untransformed) stand-alone variables (the “main effects”) should be the same. When the data are centred, the addition of interaction terms does not affect the point estimates of the main effects. Centring also reduces collinearity between explanatory variables. ⁽⁸⁾

More specifically, the fiscal reaction function reads as

$$(1) \quad (pb_{i,t} - PB_i) = \gamma(r_{i,t} - R_i) + \rho(bs_{i,t} - BS_i) + \sum_{j=1}^k \alpha_j (z_{j,i,t} - Z_{j,i}) \\ + \sum_{l=1}^n \beta_l [(x_{l,i,t} - X_{l,i})(bs_{i,t} - BS_i)] + \sum_{k=1}^n \sigma_k (x_{k,i,t} - X_{k,i}) + \mu_{it}$$

with pb signifying the primary balance (without interest payments and cyclical components), r signifying the risk-free interest rate, bs signifying the Bund spread, z_j signifying the factors directly affecting the primary balance (which include the lagged debt to GDP ratio, the risk neutral interest rate, the interest rate paid on outstanding debt, real GDP growth, GDP deflator growth) and with x_l signifying the factors

⁽¹⁾ I.e. excluding Estonia for which harmonised data on marginal interest rate are not available in the EUROSTAT or ECB database.

⁽²⁾ The first vintage of 2018 is not included for technical reasons.

⁽³⁾ I.e. Eurostat series EMU convergence criterion series - monthly data [irt_lt_mcby_m].

⁽⁴⁾ However, complete data series for the short-term interest rates are not available for all euro area countries. Missing observations were interpolated adjusting the corresponding 10 year yield with the 1y-10y time spread observed in similar economies such as Slovenia and Slovakia, and Lithuania and Latvia (with missing data usually differing across countries), and Finland, Belgium and Germany (with data gaps only in Finland and Belgium). For Cyprus the German time spread was used, while the Portuguese time spread was used for Greece.

⁽⁵⁾ See https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/fiscal-governance-eu-member-states/numerical-fiscal-rules-eu-member-countries_en

⁽⁶⁾ See <https://www.idea.int/data-tools/vt-advanced-search>

⁽⁷⁾ See https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/stability-and-growth-pact/corrective-arm-excessive-deficit-procedure/excessive-deficit-procedures-overview_en#overview-of-ongoing-and-closed-excessive-deficit-procedures

⁽⁸⁾ For more details, see, for instance, Aikin and West (1991), *Multiple Regression: Testing and interpreting interactions*. Sage Publications.

(Continued on the next page)

Box (continued)

conditioning the responsiveness of the primary balance to the Bund spread (which includes the short- and long-term public debt as % of GDP, fiscal rule strength and an elections dummy).

Variables denoted in lower case letters refer to the observed values while variables denoted in capital case letters denote the sample mean of this variable. Sample means are calculated for each Member State separately. The dummy variables, e.g. elections, are not centred. Country fixed effects are not necessary if dependent and explanatory variables are demeaned.

Furthermore, the subscripts $i = \text{BE, DE, ... , FI}$ and $t = 2002, \dots, 2016$ refer to the Member States and the time period respectively.

Estimation

Equation (1) is estimated by means of applying a least squares estimator with instrumental variables to take into account that the marginal interest rate and public balance are set simultaneously, as well as possible reverse causality between the risk premium and some of its conditioning factors. ⁽⁹⁾ The applied estimation technique also allows the variance of the random components to differ across countries (heteroscedasticity) and the random components to be correlated across Member States.

Simulation

The primary balances' responsiveness to the Bund spread (pb) over 2000-2018 ⁽¹⁰⁾ is simulated (deleting the sample means) as

$$pb_{i,t} = \sum_{l=1}^n \hat{\beta}_l x_{l,i,t} bs_{i,t}$$

⁽⁹⁾ In particular, the nominal marginal interest rate has been instrumentalised using the one-year lagged nominal marginal interest rate.
⁽¹⁰⁾ Missing 2017-2018 values for the fiscal rules variable have been set equal to the 2016 observed values.

Table I.1: A fiscal reaction function for the euro area

Dependent variable: Net lending (+) or net borrowing (-) excluding interest of general government adjusted for the cyclical component - Adjustment based on potential GDP - Excessive deficit procedure - Percentage of potential GDP at current prices									
	V1	V2	V3	V4	V5	V6	V7	V8	V9
Lagged public debt (% of GDP)	0.03 ** (10.78)	0.02 ** (7.13)	0.04 ** (8.27)	0.08 ** (8.09)	0.02 ** (2.87)	0.03 ** (6.71)	0.02 ** (6.83)	0.02 ** (6.68)	0.04 ** (7.99)
Risk-free interest rate (i.e. DE interest rate)	0.08 (1.83)	0.15 ** (3.50)	0.17 ** (3.19)	0.26 ** (7.35)	0.44 ** (3.43)	0.05 (0.95)	0.08 (1.96)	0.16 ** (3.93)	0.36 ** (5.90)
Spread (i.e. national - DE interest rate)	0.11 ** (3.13)	0.28 ** (10.48)	0.07 (1.79)	0.18 ** (5.97)	0.40 ** (6.24)	0.02 (0.31)	0.01 (0.17)	0.25 ** (3.59)	0.03 (0.33)
Inflation (GDP deflator)	0.11 ** (4.24)	0.07 ** (3.10)	0.08 ** (2.63)	0.01 (0.91)	0.13 (1.96)	0.06 * (2.21)	0.11 ** (2.96)	0.05 (1.91)	-0.03 (-0.66)
Real GDP growth	0.37 ** (11.03)	0.21 ** (8.75)	0.15 ** (6.62)	0.19 ** (7.88)	0.27 ** (6.53)	0.22 ** (12.98)	0.15 ** (6.64)	0.19 ** (6.63)	0.24 ** (10.76)
Average interest rate	0.10 * (2.56)	0.01 (0.44)	0.09 (1.88)	0.01 (0.78)	0.07 (0.57)	0.16 (1.93)	0.07 (1.91)	0.00 (0.10)	0.13 (1.80)
Lagged dependent variable		0.51 ** (31.46)	0.49 ** (20.33)	0.52 ** (27.38)	0.45 ** (14.63)	0.48 ** (31.18)	0.55 ** (28.47)	0.52 ** (26.12)	0.38 ** (11.03)
(ST Spread * ST spread) * ST debt (% of GDP)			1.54 ** (2.75)						1.26 * (2.26)
Spread * debt LT (% of GDP)				-0.06 (-0.48)					-0.19 (-0.56)
Spread * fiscal rules					-0.01 (-0.14)				0.22 * (2.08)
Spread * EDP dummy						0.28 ** (5.44)			0.51 ** (4.06)
Spread * parliamentary elections dummy							0.68 ** (4.27)		-0.87 ** (-3.37)
Spread * vintage								0.00 (0.02)	0.02 (0.27)
ST Debt (% of GDP)			-0.08 ** (-5.66)						-0.10 ** (-5.14)
LT Debt (% of GDP)				-0.05 ** (-5.04)					
Fiscal rules					0.75 ** (4.24)				0.43 ** (4.37)
EDP dummy						-0.24 ** (-5.81)			-0.35 ** (-4.33)
Parliamentary elections							-0.01 (-0.12)		-0.10 (-1.38)
Vintage								-0.08 (-1.68)	0.06 (0.94)
Unweighted R-squared	0,18	0,52	0,6	0,61	0,48	0,53	0,49	0,52	0,47
Number of observations	641	641	505	539	551	641	641	641	430
Number of explanatory variables	6	7	9	9	9	9	9	9	18

(1) Data available from second AMECO vintage 2002 until the last AMECO vintage of 2018 (except first vintage of 2018). Sample size varies across variants! The sample covers all EA countries (except EE) in all variants that do not include the maturity composition of public debt. The sample does not include IE, LU and MT for variants with debt maturity composition. Data on fiscal rule strength are available up to 2016.

(2) For each Member State separately the dependent and explanatory variables are centered around their sample mean (i.e. observed value - sample mean).

(3) Instrumental variables include lagged explanatory variables including GDP growth, inflation, primary balance, fixed effects. The applied estimation technique allows for heteroskedasticity of and contemporaneous correlation between error terms of the panel.

(4) Point estimates with their significance level: * for $p < 0.05$ and ** for $p < 0.01$. Differences in the R-squared diagnostic statistics are also affected by differences in the sample size.

(5) Not all estimated variants are shown in this table. Not reported because it did not show a significant estimate is the interaction of the spread with a dummy variable equal to 1 if the country is under a programme, and 0 if not affected by programme.

Source: Author's estimates based on data and methodology described in Box I.1.

Focussing on the significance of the point estimates of the interaction factors, variant V9 in Table I.1 shows that the point estimate of the short-term public debt as a percentage of GDP is significant (a p-value less than 5%), but the long-term public debt is not. The election and EDP dummies show a very significant point estimate (a p-value less than 1%) with the signs as explained above.

The interaction between fiscal rules strength and the Bund spread is insignificant in variant V5 but significant at 5% level in variant V9. This mixed result may be due to problems of reverse causality and weak instrumental variables. ⁽⁴⁶⁾ All in all, a significant positive point estimate suggests that credible fiscal rules may affect the responsiveness to changes in these spreads – in addition to their impact on the spreads themselves. ⁽⁴⁷⁾ Stricter rules provide fewer opportunities to limit the contraction of other public expenditures when the debt service cost increases.

The interaction of the Bund spread with the dummy variable that captures the timing of the vintage release (i.e. beginning or end of the year) does not show a significant impact.

I.6. The primary balances' responsiveness to Bund spreads

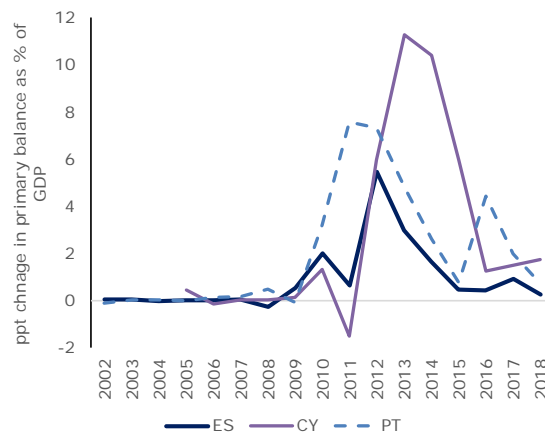
This sub-section shows simulations of the primary balances' responsiveness to the risk premium conditioned by the factors with a p-value less than

5% - as identified in variant V9 of Table I.1. These factors include short-term debt as a percentage of GDP, the fiscal rules as well as the elections and EDP dummies.

Graphs I.8 to I.10 show how changes in the risk premium affected the primary balances of the euro area countries (for which sufficient data are available ⁽⁴⁸⁾) between 2002 and 2018. ⁽⁴⁹⁾

Until the onset of the crisis the financial markets' risk assessment of Member States' public finances exerted little pressure on the primary balance. However, focussing on the Member States hardest hit by the crisis, Graph I.8 shows that as of the onset of the global financial crisis, the budgetary correction induced by changes in the risk premium intensified greatly - peaking in Cyprus in 2013. ⁽⁵⁰⁾

Graph I.8: **Primary balance adjustment triggered by changes in Bund spread – hardest hit Member States**



(1) Estimates obtained multiplying the point estimates of the interaction factors (i.e. variant 9 in Table I.1) with the observed value of the interaction factors and the Bund spread.

Source: Author's estimates.

Graph I.9 shows that among the old Member States, developments in the Bund-spread had the

⁽⁴⁶⁾ Recent research raises doubts about the feasibility of estimating the interaction between fiscal rules and a country's fiscal stance due to reverse causality in combination with a failure to identify an appropriate set of instruments. For instance, implementing a meta-regression-analysis for the budgetary impact of numerical fiscal rules based on 30 studies published in the last decade, Heinemann, F., M.-D. Moessinger and M. Yeter (2018), 'Do fiscal rules constrain fiscal policy? A meta-regression-analysis', *European Journal of Political Economy*, Vol. 51, pp 69–92 report that any type of fiscal rules have no statistically significant impact on the fiscal balance once properly taking into account the endogeneity of fiscal rules. Caselli, F. and J. Reynaud (2019), 'Do Fiscal Rules Cause Better Fiscal Balances? A New Instrumental Variable Strategy', IMF Working Paper WP/19/49 report that while the inclusion of fixed effects as a proxy for heterogeneity in fiscal preferences across countries does not make a systematic difference, the use of fiscal rules in neighbouring countries as instrumental variables leads to notable lower levels of significance.

⁽⁴⁷⁾ For instance, analysing euro area countries, Iara, A. and G. Wolff (2014), 'Rules and risk in the Euro area', *European Journal of Political Economy*, Vol. 34, pp. 222-236 and Heinemann, F., Moessinger, M. and M. Yeterb (2018), 'Do fiscal rules constrain fiscal policy? A meta-regression-analysis', *European Journal of Political Economy*, Vol. 51, pp. 69-92 report that in "normal" times fiscal rules have only a limited impact on bond spreads, but that in periods of extremely high risk aversion their impact can be strong.

⁽⁴⁸⁾ Not included IE, LU and MT because no data on debt maturity, EE because no data on interest rates, and DE which has by definition a Bund spread equal to zero.

⁽⁴⁹⁾ While the sample size for the estimation of the fiscal reaction function was 2002-2016 because fiscal rule data for 2017 and 2018 are not available when the section was prepared, the simulations are performed for the 2002-2018 period, with the level of the fiscal rules for 2017 and 2018 set equal to those of 2016.

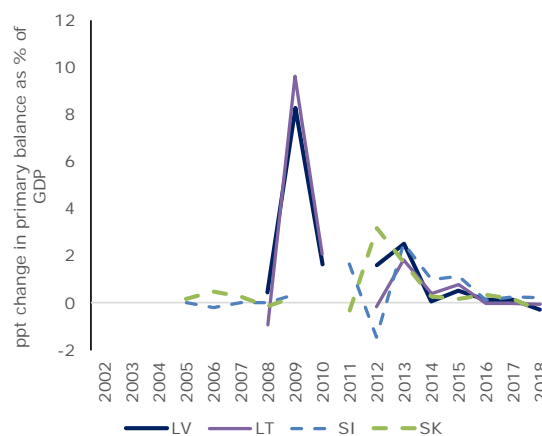
⁽⁵⁰⁾ Greece is not included in the simulations as the very high spreads during the 2010-2015 period created a virtual economic environment that would have triggered budget surpluses well above 20%. Exceptional one-off adjustment mechanisms were in place during that period.

strongest impact in Italy in 2011, with a notable relaxation in the election year 2013. Graph I.10 shows that in the Baltic Member States, the correction under the impulse of financial markets had already reached its peak in 2009 as these countries were hit earlier by the crisis.

All in all, comparing the simulations across countries shows that the Member States hardest hit also recorded the sharpest correction in their primary balance.

Graph I.11 shows the unweighted average impact of each of the factors that condition the primary balances' responsiveness to the risk premium between 2002 and 2018. The maturity composition of the public debt had a notable impact at the peak of the crisis. The impact of national fiscal rules started to matter only as of 2012-13 but their impact seems to be persistent afterwards; this suggests a complementarity between market forces and fiscal rules. The launching of the excessive deficit procedure exerted a disciplinary force as of the onset of the crisis.

Graph I.10: Primary balance adjustment triggered by changes in Bund spread - new Member States

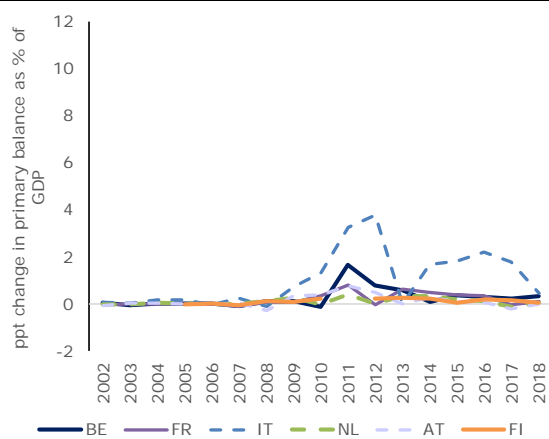


(1) Estimates obtained multiplying the point estimates of the interaction factors (i.e. variant 9 in Table I.1) with the observed value of the interaction factors and the Bund spread.

(2) Discontinuity in fit: for the years that no short-term interest rates data are available (i.e. between 2009 and 2012) no simulation result possible. See Box I.1 for the discussion on data availability.

Source: Author's estimates.

Graph I.9: Primary balance adjustment triggered by changes in Bund spread - old Member States

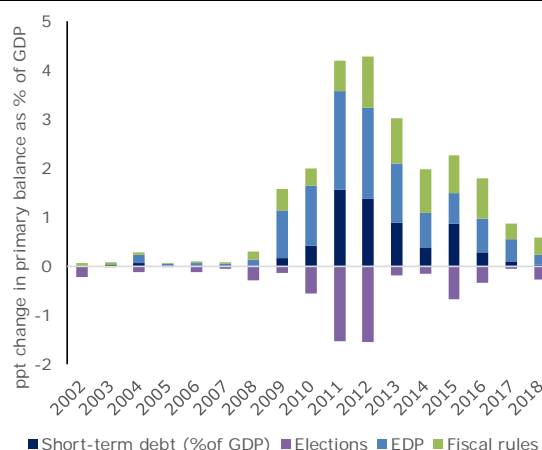


(1) Estimates obtained multiplying the point estimates of the interaction factors (i.e. variant 9 in Table I.1) with the observed value of the interaction factors and the Bund spread.

Source: Author's estimates.

Finally, reading these graphs it is worth remembering that they measure impacts. It would require a more detailed analysis to assess how these changes in risk premiums and primary balances affect the rest of the economy such as private investment, confidence etc.

Graph I.11: Contribution breakdown of sensibility to Bund spread (sample average)



(1) Estimates obtained multiplying the point estimates of the interaction factors (i.e. variant 9 in Table I.1) with the value of the interaction factors and the Bund spread.

Source: Author's estimates.

I.6.1. Conclusions

Using real-time data, this section investigated econometrically the euro area primary balances' responsiveness to risk premiums since the early 2000s.

The empirical analysis suggests that public debt – particularly its maturity structure – the electoral timetable, the national fiscal framework and the ongoing excessive deficit procedures are important conditions that affect the effectiveness of financial market discipline. More specifically, governments appear to react more to market pressures the higher the share of their short-term debt, whether the country is under an excessive deficit procedure and the more developed their national fiscal framework. However, the empirical analysis also suggests that governments tend to pay less attention to market signals when they are facing national elections.

Overall, the empirical analysis suggests that financial markets exerted limited pressure on sovereign issuers in the run-up to the crisis. This appears to have changed during the crisis and subsequently with the role of market discipline becoming much more evident in governments' fiscal reactions.

While the absence of any pressure from the markets prior to the crisis was problematic, the increased sensitivity since then is a useful disciplining mechanism. However, market discipline alone is not a sufficient condition to prevent the build-up of unsustainable fiscal positions and avert crises. This is particularly the case as markets tend to remain dormant or sometimes overshoot – driven by herd behaviour. Past large and sudden movements in interest rate spreads may reflect various factors such as the existence of multiple equilibria and an incomplete capital markets union.⁽⁵¹⁾ Hence, market discipline seems to be more effective when it is complemented by appropriate fiscal frameworks and rules. As a consequence, and in view of the ongoing discussions to deepen EMU, it will be important to carefully consider the complementarity between rules, institutions and the role of market discipline in combination of a further deepening of the EMU architecture.

Finally, the analysis presented in this section could be extended by using, for instance, more refined indicators for categorical features such as elections and ongoing excessive deficit procedures, and by expanding the sample to a larger number of countries. A more detailed analysis could also shed some light on the feedbacks of changes in Bund spreads and primary balances on the rest of the economy.

⁽⁵¹⁾ For instance, when yields increase sharply and bond prices fall the demand for these bonds will not necessarily increase as sharp increases in government bond yields may adversely affect the government's solvability.

II. Do global factors spell the end of the Phillips Curve?

Section prepared by Eric McCoy, Matteo Salto and Václav Žďárek

This chapter presents evidence that the determinants of domestic inflation present in the traditional Phillips curve framework remain relevant, while quantity-based measures of global shocks are not relevant. While global price shocks mainly related to oil and commodities are significant determinants of domestic inflation, domestic variables remain as significant as ever. These results are relevant as part of the debate on conducting monetary policy. The paper argues that the use of the Phillips curve in the current inflation-targeting framework is still relevant and that any argument against it cannot rely on inflation being determined by global factors⁽⁵²⁾.

II.1. Introduction

It is an agreed stylised fact that domestic inflation is highly correlated across advanced countries. In other words, domestic inflation in advanced countries shares ‘common factors’ or ‘global factors’.

The existence of common factors as such only points to the existence of co-movements in inflation rates rather than any specific causal relationship. In fact, whether the presence of such common factors points to some causality relationship and the role of those common factors in the causality of inflation is still a subject of discussion. The main issue for discussion from the policy point of view is the extent to which the presence of common factors puts into question the relevance of the Phillips curve model in understanding domestic inflation developments. As far as common factors reflect the existence of global shocks that directly impact domestic inflation independent of domestic channels, they should be reflected in the Phillips curve-based inflation estimates.

This article analyses to what extent and in which way the Phillips curve framework should be adapted to take into account the presence of global determinants of inflation. In particular, the main question that we want to answer is to what extent global determinants, and in particular global demand shocks, can fully substitute for domestic determinants in the Phillips curve framework.

The reply to this question is far from being an academic curiosity. The New Keynesian Phillips curve framework (hereinafter ‘NKPC’) is the main conceptual framework currently in use to provide a causal explanation of inflation developments and remains the workhorse of monetary policy analysis.

⁽⁵²⁾ The authors wish to thank Eric Ruscher, Zenon Kontolemis, and Eric Meyermans for useful comments.

Under this view, the domestic output gap, productivity and (past and expected) inflation developments are essential determinants of domestic inflation, along with certain price shocks of a global nature like shocks to oil prices or international prices of goods and their effects (or the effects of other foreign shocks) on the domestic output gap.

Borio and Filardo (2007), among others, have challenged this view. They interpret the increasing co-movements in inflation in advanced economies as evidence that the domestic drivers of inflation have become largely irrelevant and that domestic inflation is mostly determined by global factors⁽⁵³⁾.

This controversy is relevant from a macroeconomic policy standpoint. If the current view is still correct, traditional macro-policy tools — monetary and fiscal policy — are still effective in fighting domestic inflation (or disinflation) due to their effect on the domestic output gap or on inflation expectations. In the alternative view, as domestic inflation is mostly driven by global factors such as global activity, macroeconomic policies lose their traction over domestic inflation as their effect on domestic activity is not fully transmitted to domestic prices. The reply to this question carries some weight in the current debate on conducting monetary policy. If the Phillips curve is still valid and domestic prices are still driven by domestic factors, we can expect

⁽⁵³⁾ See Borio C., and A. Filardo (2007), ‘Globalisation and inflation: New cross-country evidence on the global determinants of domestic inflation,’ *BIS WP No 227*. A similar view had been expressed for example by Bean, Ch. (2006), ‘Globalisation and inflation’ speech given at the London School of Economics, 24 October 2006. For a more complex view on the globalisation process and its consequences see Carney, M. (2017), ‘[De]globalisation and inflation’, speech at the 2017 IMF Michel Camdessus Central Banking Lecture, Washington DC, 18 September 2017, or Constancio, V. (2017), ‘Understanding and overcoming low inflation’, remarks presented at the ECB conference *Understanding inflation: lessons from the past, lessons for the future?*, Frankfurt am Main, September 2017.

monetary policy to still influence inflation the way it used to. This reduces in part the necessity of international monetary policy cooperation in fighting inflation⁽⁵⁴⁾ or the necessity to resort to different instruments.

It also indirectly relates to the debate about the degree to which monetary policy should take into account financial stability considerations⁽⁵⁵⁾. The debate sees on the one hand the proponents of focusing monetary policy on financial stability and on the other those who believe that monetary policy should continue targeting inflation (and growth, if in the mandate), while financial stability should remain the remit of macro-prudential policies. Should global factors alone determine domestic prices, this would also influence the relationship between monetary and macro-prudential policy.

After documenting and discussing the presence of ‘global factors’ in domestic inflation across OECD countries in Section II.2, this article analyses the relevance of non-domestic inflation determinants within the NKPC framework in Sections II.3 and II.4. In particular, we first test in Section II.3 whether the presence of global demand conditions in the NKPC framework makes domestic inflation determinants superfluous. We then test in Section II.4 whether a direct link can be established between global demand conditions and wage developments.

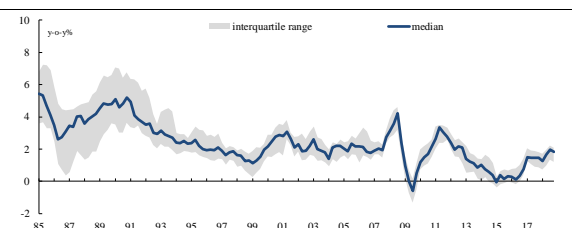
II.2. Global common trends of inflation

II.2.1. Some stylised facts

A simple look at the data shows a high correlation of consumer price inflation across developed OECD economies. Graph II.1 shows the median of year-on-year headline Consumer Price Index (‘CPI’) inflation of OECD countries and the interquartile range — computed as the difference between the 25% and 75% percentiles of the OECD countries’ inflation rates ordered by growth

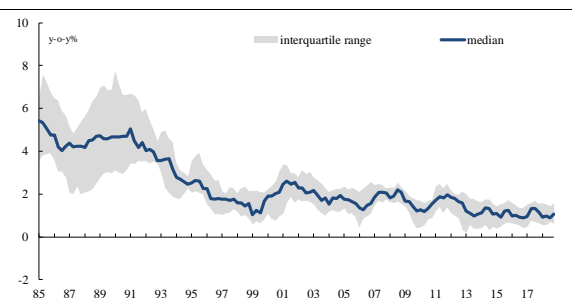
rate. The relatively narrow range around the median points to a high correlation of CPI inflation rates across the OECD. It is worth noting that this measure of dispersion of headline inflation rates around the median has been decreasing over time, in particular since 1999 and even more so after the Great Recession⁽⁵⁶⁾. The same findings hold for core CPI (see Graph II.2).

Graph II.1: **Headline inflation dispersion, Q1-1985 –Q4-2018**



(1) Sample averages: (a) Q1-1985-Q4-1998: 3.9% and (b) Q1-1999-Q4-2018: 1.7%. National definitions of CPI (all items); the country sample is defined in Footnote 6.
Source: ECFIN calculations based on OECD data.

Graph II.2: **Core CPI inflation dispersion, Q1-1985-Q4-2018**



(1) Sample averages: (a) Q1-1985-Q4-1998: 4.4% and (b) Q1-1999-Q4-2018: 1.5%. CPI all items excluding food and energy; the country sample is defined in Footnote 6.
Source: ECFIN calculations based on OECD data.

II.2.2. The common (global) components of domestic prices

A principal component analysis substantiates the correlation of inflation rates across OECD countries shown above. This analysis points to the existence of a relatively strong common component (usually named ‘global factor’). Since Ciccarelli and Mojon (2010)⁽⁵⁷⁾, many studies have found evidence of the presence of such a global

⁽⁵⁴⁾ There are other reasons that may make such cooperation desirable, like large international spillovers of monetary policy. See Engels, C. (2016), ‘International coordination of central bank policy’, *Journal of International Money and Finance*, vol. 67, pp.13-24.

⁽⁵⁵⁾ Eichengreen, B., M. El-Erian, A. Fraga, T. Ito, J. Pisani-Ferry, E. Prasad, R. Rajan, M. Ramos, C. Reinhart, H. Rey, D. Rodrik, K. Rogoff, H. S. Shin, A. Velasco, B. Weder di Mauro, and Y. Yu (2011), ‘Rethinking Central Banking,’ Brookings Institution. For an opposite view, Svensson, L. E. O. (2017), ‘Cost-benefit analysis of leaning against the wind’, *Journal of Monetary Economics*, vol. 90, pp. 193-213.

⁽⁵⁶⁾ This is not driven by the convergence happening in the euro area only. Splitting the sample between euro area and OECD non-euro area countries produces very similar results, even if the convergence in the euro area seems more pronounced.

⁽⁵⁷⁾ See e.g. Ciccarelli, A. and B. Mojon (2010), ‘Global inflation’, *The Review of Economics and Statistics*, vol. 92(3), pp. 524-535.

factor of inflation, which is common across developed countries⁽⁵⁸⁾.

A principal component analysis of CPI inflation for a sample of advanced OECD economies between 1986 and 2018⁽⁵⁹⁾ reveals that approximately 60% of the variability of headline inflation can be attributed to a common underlying component (see Graph II.3). The fact that the first principal component accounts for a large part of the total variance of the original variables is interpreted as the presence of ‘global’ factor underlying the inflation rates across developed OECD countries.

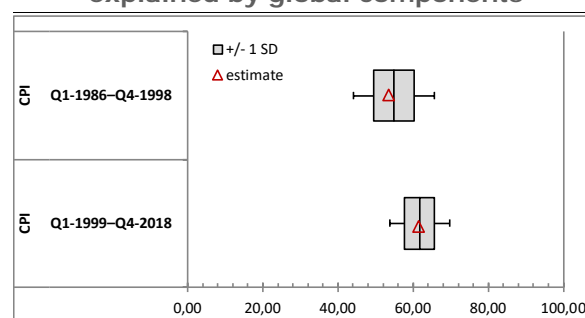
As euro area countries make up a large subset of the OECD countries, it is useful to check whether there was a structural break around 1999; to this end, we check the presence of such a common factor before and after the creation of the euro by splitting the sample into two sub-periods (before and after 1999)⁽⁶⁰⁾.

In all cases, the first principal component is sufficient to capture a large share of the total variation in inflation rates. The global component explains almost the same percentage of variation in the headline inflation series in the pre-euro and post euro sub-periods⁽⁶¹⁾. Moreover, the difference

between the estimates for the two sub-periods is smaller than two standard deviations⁽⁶²⁾. The similarities between the pre-euro and post-euro periods are likely explained by the fact that the existence of a global component is primarily related to shocks in oil and commodity prices, which have not changed dramatically since the turn of the millennium.

We carried out several robustness checks to verify the robustness of the results regarding the time dimension. Various alternative estimations were therefore performed, in particular shortening the other period (after 1999) to 2015, without major effects on the results. In particular, we compared the results with those of the BIS (2014) paper, which most stresses the role of global factors in domestic inflation, by reducing the country dimension to 11 countries and the time span to 2013. Our analysis indicates that the global component explains a slightly lower share of the total variation in inflation rates for both series compared to BIS (2014).

Graph II.3: Variation in headline inflation explained by global components



(1) The shaded box represents +/- one standard deviation, the whiskers +/- two standard deviations, and the country sample is defined in Footnote 6. The bootstrapping procedure (see Box 1) is used to compute standard deviations.

Source: ECFIN calculations based on OECD data.

A further analysis of the impact of the creation of the euro on the presence of common components can be performed by restricting the sample to the first 12 euro area countries. This is shown in Graph

⁽⁵⁸⁾ For similar analysis see also the ‘84th Annual Report’ by the Bank for International Settlements (BIS) (2014), and ECB (2017), ‘Domestic and global drivers of inflation in the euro area’, *ECB Economic Bulletin* No 4, pp. 72-96. For disaggregated approaches, see Monacelli, T., and L. Sala (2009), ‘The International Dimension of Inflation: Evidence from Disaggregated Consumer Price Data’, *Journal of Money, Credit and Banking*, 41(1), pp. 101-20 and Altansukh, G., Becker, R., Bratsiotis, G. and D. R. Osborn (2017), ‘What is the globalisation of inflation?’, *Journal of Economic Dynamics & Control*, vol. 74(1), pp. 1-27.

⁽⁵⁹⁾ The sample includes the first 12 euro area countries and Australia, Canada, Denmark, Japan, Sweden, Switzerland, the United Kingdom and the USA. We used both national consumer price indices and core CPI indices (excluding food and energy). All price indices (at a quarterly frequency) come from the OECD database and cover the period between 1980q1 and 2018q4. Since the time series are not adjusted seasonally or for working days, year-on-year growth rates are used for the analysis. See also Box I.1 in European Commission (2018), ‘European Economic Forecast’, Spring 2018, *ECFIN Institutional paper* No 077, May 2018.

⁽⁶⁰⁾ The choice of the sub-periods is driven by the introduction of the euro, which, by creating a new monetary area of a size comparable to the USA, can potentially have changed the commonalities of inflation in a large number of countries. This is relevant especially because the two sub-periods are roughly the same length. Note that the (beginning of the) sample was chosen to be identical to the one in the Bank for International Settlements (BIS) (2014) so that the findings can be compared. The methodology used here and in BIS (2014) are identical.

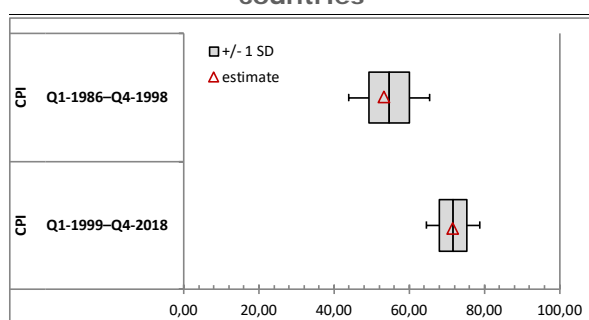
⁽⁶¹⁾ For comparison, Ciccarelli and Mojon (2010) report a global factor accounting for almost 70% of total variation in inflation for 22 OECD countries over the period (1960-2008). BIS (2014) reports almost 58% for a narrower group of 11 OECD countries

over the period 1999-2013 (almost 63% for 1986-1998). Maravalle, A., and Ł. Rawdanowicz (2018), ‘Changes in Economic and Financial Synchronisation’, *OECD WP* No 1517, report a country-specific, regional and global factor for CPI inflation using a sample of advanced economies. The share of inflation explained by those factors increased across the periods 1995-2006 and 2007-2017 from more than 20% to almost 50%.

⁽⁶²⁾ The bootstrapping procedure described in Box 1 is used to compute standard deviations. The exercise was repeated using series up to 2013q4 and 2015q2 respectively, with the results almost unchanged.

II.4. This subsample shares a common component, which accounts for almost 60% of the variance of inflation before 1999 and 70% after that. While the intervals delimited by two standard deviations overlap slightly, the difference is very large and points to the fact that the introduction of the single currency implies more co-movements at euro area level.

Graph II.4: **Variation in headline inflation explained by global components, euro area countries**



(1) See Graphs 1 and 3.

Source: ECFIN calculations based on OECD data.

II.2.3. Are commonalities in inflation across the OECD mostly driven by energy prices?

The literature suggests that the most important external variable that affects domestic inflation in advanced economies is the price of oil, or more broadly energy and other commodities. By contrast, the relevance of other possible sources of commonalities, including common shocks and spillovers from other countries, is harder to establish.

To gauge the importance of energy and commodities in the common component of inflation and before analysing the Phillips curve framework, we perform a principal component analysis of core CPI inflation similar to the analysis of the previous section. Core inflation provides a picture of underlying price pressures after excluding volatile components from the consumer basket⁽⁶³⁾.

A common component is also present in core inflation, which decreases over time. In the pre-1999 sub-period, the common component

accounted for 60% of the total variance of core inflation across OECD countries. However, in the post-1999 period, the common component only explains between 33% and 40% of the total variance of core inflation⁽⁶⁴⁾. First, the commonality of core inflation decreases after 1999, contrary to what happens to CPI inflation. Second, commonalities in core inflation are smaller than the commonality in headline inflation (as is visible by comparing Graphs II.3 and II.5). As such, this finding is not surprising. Oil, among many other commodities, is itself affected by global shocks common to OECD countries⁽⁶⁵⁾. Given that core inflation is only indirectly affected by energy and (most) commodity prices, we should expect core inflation to be less driven by global factors than headline inflation. While the prices of services or non-energy industrial goods that are included in the core inflation index are impacted by certain import prices, they are likely to be affected by domestic determinants like the domestic output gap.

⁽⁶³⁾ CPI core inflation is calculated as the CPI excluding prices of volatile components, i.e. food and energy, whose combined weight is around a fifth across the OECD sample of countries.

⁽⁶⁴⁾ Similar findings for 43 developed and developing countries (1990-2017) are reported by Forbes, K. J. (2018), 'Has Globalisation Changed the Inflation Process?', paper prepared for 17th BIS Annual Research Conference, Zurich, 22 June 2018.

⁽⁶⁵⁾ Ciccarelli and Mojon (2010) already discovered this result; a more recent study by Béreau, S., Faubert, V., and K. Schmidt (2018), 'Explaining and Forecasting Euro Area Inflation: the Role of Domestic and Global Factors', *Banque de France WP* No 663 had similar findings. Food prices seem to have a significant global component as well, see Parker, M. (2015), 'Global inflation: the role of food, housing and energy prices', *ECB WP* No 2024, February 2015.

Box II.1: Bootstrapping procedure.

To check the stability and reliability of the estimates of the global factor (calculated from the first principal component of the dataset), we carried out a number of bootstrapping exercises. These provide additional information on the uncertainty associated with the principal component extraction algorithm. We show that the uncertainty surrounding the calculation of the percentage of total variance explained by the first principal component is rather large.

More generally, bootstrapping refers to a re-sampling method commonly used to estimate the uncertainty properties of a statistic such as standard error or confidence intervals when more common estimators are not appropriate or cannot be implemented ⁽¹⁾. There are two broad types of bootstrapping algorithms: non-parametric and parametric.

Non-parametric bootstrapping works by making random draws, with replacement, from the original sample dataset. Using the resampled dataset, the statistic for which the uncertainty is to be established (in our case the share of total variance explained by the first principal component) is re-computed. This procedure is repeated a large number of times (we repeated it 10 000 times)⁽²⁾ and the data collected are used to calculate the standard errors (using the standard formula for the sample standard deviation). Non-parametric bootstrapping bases its resampling procedure on the assumption that the observed sample population is representative of the true underlying distribution function of the population. By contrast, parametric bootstrapping assumes that the observed sample is drawn from a given distribution function, whose moments are estimated from the sample.

We implemented a standard parametric bootstrapping algorithm ⁽³⁾ that was run with 10,000 simulations to construct a statistical distribution for the estimated share of total variance explained by the first principal component. More specifically, we assumed that the data are drawn from a standard normal distribution and we ensured that the draws reflect the correlation structure in the data⁽⁴⁾. This makes it possible to subsequently calculate ‘confidence intervals’ (one and two standard deviations) around the ‘average’ share of total variance explained by the first principal component⁽⁵⁾.

As a robustness check, we also implemented a standard non-parametric bootstrapping algorithm that yields comparable results. Since parametric and non-parametric methods generated similar results, we show those based on the parametric simulation framework in the main text.

Additional robustness checks were performed. These involved increasing the number of simulations (to 100,000) and carrying out a rerun of the Principal Component Analysis algorithm on the sample series after eliminating some quarters linked to the Great Recession (2008 and 2009). The effects of these changes were minor and did not change the conclusions of the bootstrapping exercise.

⁽¹⁾ Among many, see Efron, B., and R. J. Tibshirani. (1986), “Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy”. *Statistical Science* 1, and Stine, R. (1990), “An introduction to bootstrap methods: Examples and ideas. In *Modern Methods of Data Analysis*”, ed. J. Fox and J. S. Long, Newbury Park, CA.

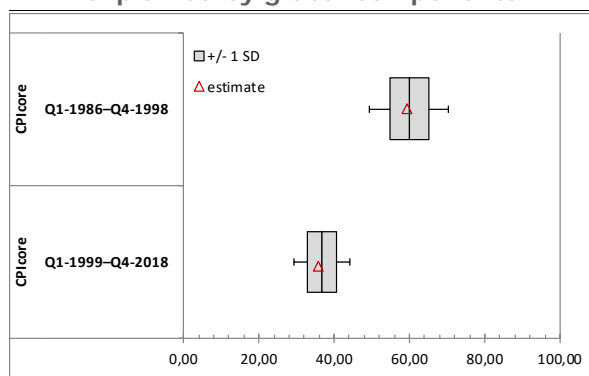
⁽²⁾ It is considered that replications of the order of 1,000 already produce good estimates, see Poi, B. P. (2004), “From the help desk: Some bootstrapping techniques” *Stata Journal* 4.

⁽³⁾ The code is in MATLAB and is available upon request to the authors. The particular bootstrapping algorithm implemented is an in-house adaptation of the code originally created by Susan Holmes of Stanford University.

⁽⁴⁾ To ensure that the draws are correlated, we apply the result of a Cholesky decomposition of the original covariance matrix to the random draws which are from a standard normal distribution.

⁽⁵⁾ The same analysis is also performed for core CPI and for hourly wages in the next section.

Graph II.5: **Variation in core CPI inflation explained by global components**

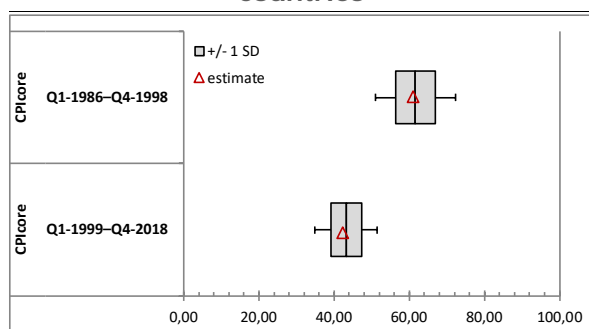


(1) See Graphs 1 and 3.

Source: ECFIN calculations based on OECD data.

If we restrict the sample to the euro area, a similar picture emerges (see Graph II.6), pointing to a reduction in the common component of core inflation across euro area countries. However, the decrease is smaller than that observed in the full OECD sample, and the difference between the two sub-periods becomes smaller than two standard deviations.

Graph II.6: **Variation in core inflation explained by global component, euro area countries**



(1) See Graphs 1 and 3.

Source: ECFIN calculations based on OECD data.

The analyses of domestic wages⁽⁶⁶⁾ in Graph II.7 illustrate a similar pattern. Wages in advanced OECD economies also share a common component, which explains more than 40% of the total variation in wages across countries before 1999, and less than 40% after 1999, even though

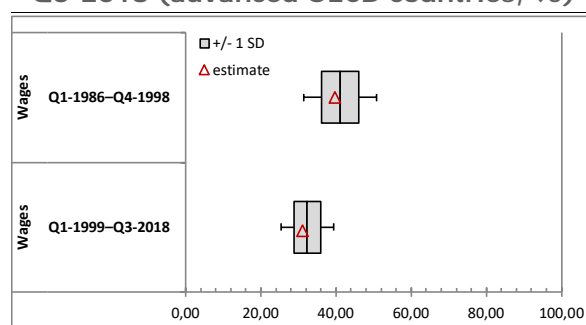
⁽⁶⁶⁾ We use year-on-year percentage changes of hourly wages in manufacturing.

the difference is even smaller than one standard deviation⁽⁶⁷⁾.

The analysis therefore shows that a common component is present in the core inflation and wage datasets, and not only in the CPI inflation dataset. This raises the possibility that global determinants other than oil and import prices affect domestic inflation directly, i.e. on top of the indirect effects that they have via the domestic output gap. This raises the question of whether the NKPC approach needs to be extended to global variables in order to analyse domestic inflation, and in particular whether the domestic output gap is perhaps not relevant in determining domestic inflation.

We will therefore test in the next section which types of global shocks could possibly affect inflation in the NKPC framework. We first look at headline inflation and then at a wage Phillips curve.

Graph II.7: **Shares of total variance explained by the first principal component, hourly wages in manufacturing, Q1-1986-Q3-2018 (advanced OECD countries, %)**



(1) See Graphs 1 and 3.

Source: ECFIN calculations based on OECD data.

II.3. Global inflation drivers in the Phillips curve framework

The data analysis in the previous section shows that CPI inflation is correlated across advanced countries. This correlation is partly driven by global shocks related to energy and commodity prices. However, once these are removed from the equation, domestic prices still tend to co-move across countries. The question is whether these

⁽⁶⁷⁾ As a robustness check, we also analysed year-on-year percentage changes of nominal compensation per employee and unit labour costs. Results are very similar to those presented in the text.

common shocks are sufficient to determine domestic inflation or whether the NKPC framework is still valid.

Traditionally, the Philips curve framework builds on the original observation that wages and unemployment are negatively related⁽⁶⁸⁾. It acknowledges the explicit role of expectations in the process of price developments and the transformation of the wage-unemployment relationship into a relationship between consumption prices, economic slack and policy variables⁽⁶⁹⁾. The development of NKPC models adds the microeconomic foundations of the trade-off between prices and economic slack to the core of the analysis. In particular, the NKPC builds upon the optimality of agents' behaviour and assumes some degree of price stickiness, which comes from limited possibilities to adjust prices optimally whenever a company wants to. In this context, Galí and Gertler (1999)⁽⁷⁰⁾ specify the most commonly used Philips curve model in its hybrid form for the inflation rate π_t . In this form, the main determinants of domestic price developments are typically domestic variables: a measure of 'slack'⁽⁷¹⁾ is the key conceptual variable, or, as in Galí and Gertler (ibid.), a measure of labour costs⁽⁷²⁾, a measure of (trend or expected)

labour productivity, measures of inflation expectations and, in the hybrid version of the model, past inflation⁽⁷³⁾.

In order to answer the question in this article, this framework, which is based on domestic determinants, is extended to capture the impact of the external environment on domestic price pressures. This extended NKPC framework adds international determinants to the NKPC framework to test their relevance in explaining domestic inflation.

A brief overview of the literature on global determinants of inflation

Extending the NKPC framework to understand whether global variables are causal determinants of domestic inflation has been tested often in the literature⁽⁷⁴⁾. Table 1 presents the main results from existing empirical studies⁽⁷⁵⁾.

For the sake of readability, we group global determinants of price inflation present in the literature into two different types of variables.

A first group of variables relates to 'price' variables like oil and other commodity prices or import prices. It is well known that oil and commodity price shocks affect headline inflation directly⁽⁷⁶⁾ — even more so in countries where the consumption baskets contain larger shares of volatile food and energy items like developing countries. According to the literature, prices of imported goods and international intermediate goods prices typically affect domestic prices directly in a significant

⁽⁶⁸⁾ Phillips, A. W. (1958), 'The relation between unemployment and the rate of change of money wage rates in the United Kingdom, 1861-1957', *Economica*, vol. 25(100), pp. 283-299.

⁽⁶⁹⁾ See Friedman, M. (1968), 'The Role of Monetary Policy', *American Economic Review*, vol. 58(1), pp. 1-17.

⁽⁷⁰⁾ See Galí, J., and M. Gertler (1999), 'Inflation dynamics: a structural econometric analysis', *Journal of Monetary Economics*, vol. 44(2), pp. 195-222 and also Clarida, R., Galí, J., and M. Gertler (1999), 'The science of monetary policy: a new Keynesian perspective', *Journal of Economic Literature*, vol. XXXVII(4), pp. 1661-1707.

⁽⁷¹⁾ The most widely used measure is the output gap, even if its coefficient has been decreasing recently. For example, see the derivation in Galí, J., M. Gertler, and D. López-Salido (2001), 'European inflation dynamics', *European Economic Review*, vol. 45(7) pp. 1237-1270. However, a definition of the unemployment gap has also been used as in Byrne, D. a Z. Zeikaite (2018), 'Missing wage growth in the euro area: is the wage Phillips curve non-linear?' Central Bank of Ireland, Economic Letters, No 9, November 2018; or industrial production like in Béreau, S., Faubert, V., and K. Schmidt (ibid.). Labour shortages are used in Bonam, D., De Haan, J. and D. van Limbergen (2018), 'Time-varying wage Philips curves in the euro area with a new measure for labor market slack', *DNB WP* No 587, February 2018.

⁽⁷²⁾ Compensation per employee is used in Bobeica, E., Ciccarelli, M. and I. Vansteenkiste (2018), 'The link between labor costs and price inflation in the euro area', *ECB WP* No 2235. Negotiated wages are used in Bohnam, D., de Hann, J., and D. van Limbergen (2018), 'Time-varying wage Phillips curves in the euro area with a new measure for labor market slack', *DNB WP* No 587, February 2018 (negotiated wages). The labour income share in the non-farm business sector is used in Galí and Gertler (ibid.) and in Paloviita, M. (2006), 'Inflation dynamics in the euro

area and the role of expectations', *Empirical Economics*, vol. 31(4), pp. 847-860.

⁽⁷³⁾ Various measures of inflation expectations have been used: mainly survey-based or market-based measures. For recent evidence on the impact on results from the choice of different survey-based measures in the euro area, see Abdih, Y., Lin, L., and A-Ch. Paret (2018), 'Understanding Euro Area Inflation Dynamics: Why So Low for So Long?', IMF Working Paper No. 188, August.

⁽⁷⁴⁾ The idea of incrementing the set of determinants with global variables is not necessarily associated with the acceleration of globalisation in the late 1990s and 2000s, but goes further back in time, for example Gordon, R. J. (1990), 'The Phillips Curve Now and Then', *NBER WP* No 3393.

⁽⁷⁵⁾ For a recent overview, see among many Abbas, S. K., Bhattacharya, and P. Sgro (2016), 'The new Keynesian Philips curve: an update on recent empirical advances', *International Review of Economics and Finance*, vol. 43, pp. 378-403. For a list of global determinants, see also Béreau, S., Faubert, V., and K. Schmidt (ibid.).

⁽⁷⁶⁾ The evidence about oil prices is well established. For international food prices or import prices, see Peersman, G. (2018), 'International food commodity prices and missing (dis)inflation in the euro area', *NBB WP* No 350.

Table II.1: Broad view of literature

Type	Global variable	Expected sign
Slack or demand measures	Global demand or trade-weighted foreign demand index	= (+ only if demand index is in value)
	Global output gap	–
	Global value chains	–
Price measures	Global intermediate goods prices	+
	(Non-oil) import prices	+
	Oil and commodity prices	+
	Nominal exchange rate	+

"+" stands for typically significant, "=" for ambiguous and "–" for typically insignificant.

Source: Studies listed, own adaptation.

manner⁽⁷⁷⁾. This is not surprising as energy and intermediate goods are inputs for companies according to their production function; companies therefore reflect the increase (or decrease) in prices of those goods in consumption prices. The same holds for exchange rates⁽⁷⁸⁾, since depreciations of the exchange rate are (partly) reflected directly by companies in domestic prices. These variables therefore significantly influence domestic prices on top of domestic variables. However, they simply reflect the existence of global shocks that are transmitted to the domestic economy via the traditional price channels so that they generally do not affect the relevance of domestic shocks.

A second group of variables ('global activity' variables) comprises measures of global demand or supply factors like exports and imports or foreign demand, measures of global slack, or changes in the structure of production ('global value chains' / GVCs)⁽⁷⁹⁾.

The empirical evidence provided by the literature on these global activity variables is mixed as the results, which are referred to in Table II.1, do not provide a conclusive answer to the question as to whether these variables affect domestic prices directly. Results on the global output gap⁽⁸⁰⁾, global

demand⁽⁸¹⁾ or GVCs⁽⁸²⁾ depend on the methodology employed and the particular data sample used; very few results indicate that these factors have a direct impact on domestic prices or that they nullify the impact of the domestic output gap on domestic inflation.

From a policy perspective, the global activity variables are the most critical when discussing the 'globalisation of inflation hypothesis': is their impact on domestic inflation mediated via the domestic output gap like in the current NKPC view, or global activity variables have a direct influence on domestic inflation that makes the domestic output gap irrelevant? Under the current NKPC view, the global output gap would increase domestic prices only to the extent that it affects the domestic output gap.

The next section analyses the relevance of the global output gap (as well as a proxy for GVCs in the next section) in an extended NKPC framework for the euro area. These variables are used to extend the traditional NKPC as they allow the possible implications of globalisation to be investigated. While world output gap measures try to capture additional (and more general) effects from foreign aggregated demand on the domestic economy, GVCs represent a very widely discussed channel through which companies can directly or indirectly exert influence on the demand and

⁽⁷⁷⁾ Forbes, K. J. (ibid.); Béreau, S., Faubert, V., and K. Schmidt (ibid.). For non-oil import prices, see Oinonen, S., Paloviita, M., Vilmi, L. (2013), 'How have inflation dynamics changed over time? Evidence from the euro area and USA', *Bank of Finland DP* No 6; Abdih, Y., Lin, L., and A.-Ch. Paret (ibid.).

⁽⁷⁸⁾ Abdih, Y., Lin, L., and A.-Ch. Paret (ibid.).

⁽⁷⁹⁾ See an overview of other determinants in Carney (2017) or ECB (2017), 'Domestic and global drivers of inflation in the euro area', *ECB Economic Bulletin* No 4, pp. 72-96.

⁽⁸⁰⁾ The evidence on the global output gap is at best ambiguous; significant effects are mostly found by BIS authors like in Borio, C., and A. Filardo (ibid.). Varying effects of the domestic and global output gap are found in Bianchi, F., and A. Civelli (2015), 'Globalisation and inflation: Evidence from a time-varying VAR', *Review of Economic Dynamics*, vol. 18(2), pp. 406-433. Most studies do not find any such effects. Among many, Ihrig, J., S. B. Kamin,

D. Lindner, and J. Marquez (2010), 'Some Simple Tests of Globalisation and Inflation Hypothesis', *International Finance*, vol. 13(3), pp. 343-375 and Mikolajun, S. I., and D. Lodge (2016), 'Advanced economy inflation: the role of global factors', *ECB WP* No 1948.

⁽⁸¹⁾ Béreau, S., Faubert, V., and K. Schmidt (ibid.).

⁽⁸²⁾ Andrews, D., Gal, P., and W. Witheridge (2018), 'A Genie in a Bottle? Globalisation, Competition and Inflation', *OECD WP* No 1462 or ECB (2017), 'Domestic and global drivers of inflation in the euro area', *ECB Economic Bulletin*, Issue 4, 2017, pp. 72-96.

Table II.2: Phillips curve estimates

Dependent Variable: EA QoQ inflation	Baseline	EA & RoW OG	EA & orthog. RoW OG	Non-oil import prices	EA & weighted orthog. RoW OG	RoW OG only
EA QoQ inflation (-1)	0,19 ***	0,19 ***	0,20 ***	0,17 **	0,21 ***	0,24 ***
EA Import Prices	0,03 **	0,03 **	0,04 **		0,03 *	0,03 **
Non-oil Import Prices				0,01		
SPF1	0,19 ***	0,19 ***	0,18 ***	0,19 ***	0,18 ***	0,18 ***
OIL in Eur	0,01 ***	0,01 ***	0,01 ***	0,02 ***	0,01 ***	0,01 ***
Output gap EA	0,03 ***	0,03 **	0,03 ***	0,03 ***	0,03 ***	
Output gap non-EA		-0,01				0,02
Orthog. Output gap non-EA			-0,06 *		-0,02	
Regression R ²	0,80	0,80	0,81	0,79	0,80	0,78

(1) Sample quarterly euro area aggregates over the period Q1-2000-Q3-2018. Least squares estimator with robust standard errors (HAC). Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: ECFIN calculations.

supply of particular goods and services in the domestic economy.

The results

We start with the estimate of a NKPC model, which we extend with relevant global price variables. More precisely, in our baseline model headline inflation is a function of lagged inflation, euro area import prices, the euro-denominated oil price, one-year ahead inflation expectations, and the euro area output gap⁽⁸³⁾. The corresponding regression model reads:

$$\pi_t = a_1\pi_{t-1} + a_2imp_t + a_3E(\pi_{t+1}) + a_4oil_t + a_5OG_t + v_t.$$

where v_t represents the error term.

The baseline estimate therefore corresponds to an extended NKPC, where we use only price variables that were chosen based on the indications provided by our previous analysis of the data as well as by the review of the literature for the extensions. The estimates of the baseline model, presented in column (1) of Table II.2, are in line with the theory

⁽⁸³⁾ The model is estimated on a quarterly basis. More precisely, all variables are defined as quarter-on-quarter changes, except inflation expectations, which are taken from the Survey of Professional Forecasters (SPF) run by the ECB and from the output gap, which is calculated as the (quarterly) percentage ratio of real GDP (taken from ESTAT) to trend GDP (taken from DG ECFIN's AMECO database). Lagged quarter-on-quarter growth in seasonally adjusted inflation measures lagged inflation, the one-year ahead SPF inflation expectations proxy expected inflation. The quarterly inflation series, which are adjusted seasonally and for working days, are taken from the statistical data warehouse of the ECB. The oil price evolution is the quarter-on-quarter percentage change of the Brent oil price expressed in euro. Quarter-on-quarter growth rates of import prices are constructed using the euro area price index for industry available on the ESTAT website.

and with the majority of estimates that currently exist in the literature. All estimated coefficients have the expected signs and are statistically significant at the p-value threshold of 5%.

The size of the estimated coefficient for the output gap is 0.03, which is in line with the literature that typically finds small coefficients for the output gap or other measures of slack. The coefficient for the backward-looking component of inflation is estimated at 0.19, with the coefficient for the forward-looking one-year ahead expected inflation estimated at 0.19. This is in line with the underlying New Keynesian theory, which suggests that the coefficients of inflation should sum to one. When adding the coefficient relating to backward-looking inflation (~0.19) to the coefficient for the forward-looking component after converting it into a quarterly frequency (i.e. 0.19/4), we obtain the sum of 0.24. In annualised terms, this is close to the expected theoretical value of one. The global terms of this extended model are also in line with expectations. A 10% increase in oil prices increases the inflation rate by 0.1. It is worth noting that these are Brent oil prices denominated in euro — the estimated parameter therefore captures the combined effect of an increase in Brent oil prices in dollars and a simultaneous euro depreciation (or appreciation). Similarly, a 10% increase in import prices in euro increases domestic consumption inflation by 0.3.

Given that oil prices could influence industry import prices directly, we also tested the significance of an export-weighted deflator of non-oil imports for euro area countries instead of

industry import prices⁽⁸⁴⁾. The results (see column (4) of Table II.2) indicate that this variable is not significant, while the other coefficients remain stable. This points to the fact that globalisation has an impact in particular on domestic inflation via oil prices, which appear to be the main transmission channel of international prices⁽⁸⁵⁾.

As the main question concerns the relevance of the domestic output gap in affecting domestic inflation once global slack or demand variables are taken into account, we further extend the baseline model with measures of the non-euro area global output gap.

The analysis shows that global slack variables are not significant in explaining domestic inflation. Column (2) of Table II.2 presents the results of a regression in which an aggregate measure of the output gap for non-euro area countries was added to pick up on possible global forces that drive economic slack⁽⁸⁶⁾. The estimated coefficient has a negative sign, which is contrary to what is expected and is not statistically significant with a p-value of 0.8.

Simply adding a rest-of-the-world (i.e. non-euro area) output gap variable to the baseline regression may generate multi-collinearity⁽⁸⁷⁾ problems. These arise when the euro area output gap, oil prices and the rest-of-the-world output gap are all employed in the same model. It is therefore possible that the conclusions on the estimated coefficient of the rest-of-the-world output gap variable are not meaningful. However, it is worth noting that the value and significance of all the coefficients of the

variables of the baseline regression remain unchanged.

To better isolate the effects on domestic inflation of the rest-of-the-world output gap independent of the effects of oil prices and euro area output gap, we replace the rest-of-the-world output gap with an ‘orthogonal’ rest-of-the-world output gap. The latter is computed by taking the residuals obtained after regressing a measure of global output gap (comprised of G20 members) on the euro area output gap and aims to capture the part of the world output gap unrelated to the variations of the domestic output gap⁽⁸⁸⁾.

Column (3) of Table II.2 shows the results, and the conclusion does not change: there is no significant statistical evidence to support the claim that global measures of economic slack (originating from outside of the euro area) have a direct impact on domestic euro area inflation. By addressing the issue of multi-collinearity, a clearer interpretation can be given to the euro area output gap coefficient. The euro area output gap coefficient remains unchanged (0.03), with a p-value close to the 1% level, and the other coefficients are broadly unchanged with a slight increase in the coefficient of past inflation (0.20) and import prices (0.04) and a slight decrease in the coefficient of expected inflation (0.18). The coefficient of the ‘orthogonal’ non-euro area output gap, which is the one of interest, again posts a ‘wrong’ negative sign that is almost significant at the 5% level (with a p-value of 0.051%).

As an additional robustness check, column (5) of Table II.2 presents the results of integrating another proxy into the regression framework for the ‘orthogonal’ non-euro area output gap; however, this time it results from aggregating output gaps using trade weights⁽⁸⁹⁾. Once again, the results do not change: the coefficients of the base variables remain stable and the coefficient of

⁽⁸⁴⁾ For details on the data, see Abdih, Y., Lin, L., and A.-Ch. Paret (ibid.); we thank A. Ch. Paret-Onorato from the IMF for providing us with the data.

⁽⁸⁵⁾ Furthermore, as an additional robustness check, the same baseline regression was also run using the quarterly growth rates of the euro area consumption deflator (household and non-profit institutions serving households (NPISH) final consumption) instead of headline inflation. The overall conclusions obtained are the same and are not reported here.

⁽⁸⁶⁾ The rest-of-the-world output gap is computed as the percentage/ratio of rest-of-the-world real GDP over rest-of-the-world trend GDP. Both the numerator and denominator are computed respectively as the sum of the (quarterly) real GDP and of the (quarterly) trend GDP across a large group of non-euro area countries from the rest of the world. The group comprises 25 countries outside the euro area with widespread geographical coverage. Data are taken from the OECD database.

⁽⁸⁷⁾ Multi-collinearity occurs when one (or more) of the independent variables in a regression model is correlated with other independent variables. In this situation, the coefficient estimates of the variables concerned tend to be unstable and the standard errors of the affected coefficients tend to be overstated. This makes hypothesis testing of the regression coefficients unreliable.

⁽⁸⁸⁾ Similar empirical results are obtained if we use the residuals after regressing the global output gap on the domestic output gap and oil prices (as a different proxy for the ‘orthogonal non-euro area output gap’).

⁽⁸⁹⁾ In a first step, the output gaps of a large sample of countries (comprised of the EU-28 countries plus others, which are in the G20) were weighted according to their relative share of total export flows. Once this ‘trade-weighted’ proxy for the world output gap was constructed, the ‘orthogonal’ non-euro area ‘weighted’ output gap variable was obtained by taking the residuals from a regression of the ‘trade-weighted’ world output gap on the euro area output gap.

this indicator of external activity is negative and not significant.

Finally, we test whether, in the absence of the domestic output gap, the rest-of-the-world output gap has explanatory power for domestic inflation. Column (6) of Table II.2 shows the results. While the coefficient is very similar to that of the domestic output gap, it is statistically insignificant (the unreported p-value is around 0.2).

This analysis points to the conclusion that integrating a global dimension into the output gap adds little information to the domestic output gap in terms of the domestic euro area inflation dynamics. This is in line with the findings of most of the literature. The explanation underlying the limited ability of global factors (such as the various measures of global slack that were tested) in explaining domestic price developments despite the high correlation between domestic and global inflation can perhaps be related to a more generally observed synchronisation of business cycles across advanced economies.

II.4. Wages and inflation: is this the channel?

The previous section found that global activity variables do not have a direct impact on domestic inflation. In this section, we check whether the driving forces that (potentially) determine domestic inflation also affect domestic wage dynamics⁽⁹⁰⁾ and whether there are any other possible global forces driving wage dynamics. If domestic inflation is transmitted via wages, global factors should directly influence domestic wage formation and their effect should appear in the NKPC estimation. As shown in Section II.2, wages co-move across advanced OECD countries, which provides further motivation for this analysis⁽⁹¹⁾.

To evaluate whether domestic factors remain the main driving force of wage inflation, we replicate the exercise from the previous section by using a New Keynesian wage Phillips curve as the baseline

model for euro area wages. We start from a specification of the wage NKPC akin to the one used in the previous section⁽⁹²⁾.

Quarter-on-quarter wage growth is the dependent variable⁽⁹³⁾. Wage changes are traditionally related first to output gap pressures: a large positive output gap tends to increase the bargaining power of workers and their inflation expectations, pushing wages up. The first explanatory variable included is therefore the euro area output gap⁽⁹⁴⁾.

Wages are also determined by (i) labour productivity developments, as, at equilibrium, real wages are proportional to labour productivity⁽⁹⁵⁾, (ii) by expected inflation⁽⁹⁶⁾, and (iii) by past inflation as measured by the second lag of year-on-year core inflation developments in the euro area.

Table II.3: Wage Phillips curve estimates

Dependent Variable: QoQ Comp. per employee	Baseline Regression	Regression with non-EA OG	Regression with orthog. non-EA OG
Output gap EA	0,04 ***	0,05 ***	0,04 ***
Output gap non-EA		-0,01	
Orthog. Output gap non-EA			-0,01
QoQ productivity EA	0,21 ***	0,21 ***	0,21 ***
SPF1	0,21 ***	0,22 ***	0,21 ***
YoY core inflation(-2)	0,09 *	0,07	0,08
Regression R ²	0,34	0,35	0,34

(1) Sample quarterly aggregate euro area over the period Q1-2000:Q1-Q3-2018. Least squares estimator with robust standard errors. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: ECFIN calculations.

The wage NKPC model is then extended to investigate the effect of two global slack determinants. As was the case in the previous section, while domestic economic slack remains a significant determinant of domestic wage developments, proxies for the rest-of-the-world economic slack do not seem to have a direct impact on domestic wage developments.

⁽⁹⁰⁾ According to Borio and Filardo (2007), a condition for the existence of such a direct link between global slack and domestic wage inflation is the increased substitutability of goods and especially of capital and labour inputs.

⁽⁹¹⁾ While there is some empirical evidence that globalisation has affected wage levels or at least the wage distribution in advanced economies, there is little evidence of the effect of globalisation on wage inflation (as opposed to wage levels). Determinants referred to include the growing importance of multinational companies and GVCs in international production together with the emergence of China.

⁽⁹²⁾ It is the same specification used in Box 1 of Vandeplas, A. et al. (2018), 'Wage dynamics in the EMU', *EC Quarterly Review*, vol. 17(3), pp. 9-26, which also discuss factors affecting the wage Phillips curve. Alternatively, a panel of big euro area countries in IMF (2018), 'European wage dynamics and labour market integration', Regional Economic Outlook, May 2018.

⁽⁹³⁾ This is measured using compensation per employee taken from EUROSTAT.

⁽⁹⁴⁾ As before, the quarterly output gap series are constructed based on the trend real GDP published in DG ECFIN's AMECO database.

⁽⁹⁵⁾ These are proxied here by quarter-on-quarter changes in euro area real output per employee.

⁽⁹⁶⁾ The latter are proxied here by one-year ahead inflation expectations taken from the ECB's Survey of Professional Forecasters.

Box 11.2: Global Value Chains and wage growth.

This box presents the results from augmenting the traditional new Keynesian wage Phillips curve with a measure of global value chains (“GVCs”)⁽¹⁾. The box analyses whether GVCs are relevant in determining wage developments, with particular attention paid to the effect of adding a GVC proxy to the Phillips curve on the measure of economic slack. We chose to test the link between wages and global value chains by augmenting a new Keynesian wage Phillips curve with a term for GVCs.

Given that most information on the effects of GVCs comes from the comparison across countries rather than from the time series information, we had to depart from the previous specifications and techniques and moved to a panel data specification. More precisely, we used some panels of annual data for EU and euro area countries over the period 2000–2014. Annual data used as GVC proxies are available on an annual basis.

Table 1:

	EU28		EA17		EU15		EA5	
	Baseline	With GVC	Baseline	With GVC	Baseline	With GVC	Baseline	With GVC
Unemployment GAP (NAWRU)	-0.314 ***	-0.242 ***	-0.255 ***	-0.126 *	-0.253 ***	-0.192 ***	-0.245 ***	-0.146 **
1-year inflation expectations	0.634 ***	0.711 ***	0.629 ***	0.716 ***	0.646 ***	0.576 ***	0.633 ***	0.596 ***
HICP lagged 1-year	0.301 ***	0.299 ***	0.337 ***	0.311 ***	0.340 ***	0.346 ***	0.423 ***	0.346 ***
Expected labor productivity	0.492 ***	0.676 ***	0.464 ***	0.555 ***	0.476 ***	0.582 ***	0.255 *	0.215
Global output gap * GVC		0.000103		0.000125		0.000213		0.00154 **
Global output gap		-0.00154		-0.000427		-0.00299		-0.0363 **
GVC		0.0515		-0.00366		-0.0662		0.00234
Constant	0.0457	-1.953	-0.0181	-0.379	-0.0793	1.357	-0.00683	-0.0670
No. Observations	563	258	404	186	465	210	157	90
R-squared	0.752	0.672	0.766	0.637	0.772	0.588	0.788	0.679

(1) fixed effect estimator. Sample: yearly data (2000–2014). EU28 indicates all EU countries, EA17 are all EA members except CY and MT, EU15 are EU “old” members, EA5 are DE, ES, FR, IT, NL. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Source: ECFIN calculations.

As a dependent variable, we used year-on-year percentage changes in compensation per employee. In our specification, we include the usual same independent variables as in Vandeplas et al. (2018)⁽²⁾, on top of country fixed effects. First, as a measure of slack, we use the unemployment gap as measured by the percentage difference between unemployment and the non-accelerating wage rate of unemployment (NAWRU)⁽³⁾; we then use past and expected price inflation⁽⁴⁾, expected labour productivity⁽⁵⁾ and the global output gap. The latter is defined as in the main text.

The measure of GVC is the most delicate issue. We measure GVCs by the foreign value-added shares of gross exports, as in most of the literature. For robustness, we also proxied GVCs with the foreign value-added embodied in domestic final demand share, which is the other definition of GVCs commonly found in the literature. The results did not change significantly and are not reported here.

To test the impact at the cyclical frequency relevant for monetary policy, we interacted GVCs with our measure of the global output gap, as we are measuring the impact of GVCs on wage developments at the cyclical frequency.

Table 5 shows results in line with the rest of the paper, with the global output gap (and GVCs) having very little impact, if any, on wage developments. These findings are in line with most of the existing literature on wage and inflation determinants, which finds at best mixed evidence about the effects of GVCs’ growing importance on wage inflation.

⁽¹⁾ The box draws on work carried out by L. Lebastard during her internship with DG ECFIN.

⁽²⁾ Quoted in the main text.

⁽³⁾ The NAWRU is taken from the DG ECFIN’s AMECO database and is the definition used for the computation of the potential output according to the common methodology supported by the Economic and Financial Committee and run by DG ECFIN. The methodology for the computation of NAWRU is described in Havik, K., K. Mc Morrow, F. Orlandi, C. Planas, R. Raciborski, W. Roeger, A. Rossi, A. Thum-Thysen and V. Vandermeulen (2014), “The production function methodology for calculating potential growth rates & output gaps”, European Economy, Economic Paper 535.

⁽⁴⁾ Past inflation is measured using the harmonised index of consumer prices. Expectations are 1-year ahead inflation expectations obtained from the ECB’s Survey of Professional Forecaster.

⁽⁵⁾ Expected productivity is measured as changes in trend productivity, where productivity is proxied by real output per employee.

Column (1) of Table II.3 presents the results of the estimated baseline regression. The coefficients and their significance level are in line with existing analysis using a similar baseline wage Phillips curve⁽⁹⁷⁾: 0.04 for the euro area output gap, 0.21 for labour productivity, 0.21 for inflation expectations, and 0.09 for lagged core inflation (which is however only significant at the 10% level). They show that the forward-looking inflation component bears more weight than the backward-looking inflation component.

As in the previous section, we have extended the baseline NKPC model to capture the effect of rest-of-the-world slack measures on domestic wages. First, the traditional version of the euro area wage Philips curve has been augmented with an aggregate measure of the rest-of-the-world output gap. As in the previous section, we do not find that these global variables have any effect on euro area wage developments. Columns (2) and (3) of Table II.3 show the same pattern already seen in the previous section and shown in Table II.2. The coefficient for the rest-of-the-world output gap is very small, has the wrong sign and is not significant — this applies to both the case where we used the simple rest-of-the-world output gap and the case where we used the orthogonal rest-of-the-world output gap⁽⁹⁸⁾. At the same time, the coefficients of the baseline specification remain stable and significant.

In a parallel exercise we tested the link between the euro area wage dynamics and global value chains ('GVCs'). GVCs are related to developments in international trade and the globalisation of production and refer to a production process whereby the different stages are located across different countries. GVCs have developed substantially over the last few decades as vertically integrated trade doubled between 1999 and 2008 in the OECD countries⁽⁹⁹⁾, reflecting the integration of more countries in the global production and trade system. As the literature suggests, GVCs are expected to reduce wage growth as outsourcing likely exerts a downward pressure on wages.

The results obtained, which use a slightly different framework, are presented in Box II.2 and indicate that there are no statistically significant direct effects of GVCs on wage dynamics in EU or euro area countries. These results are surprising in view of the large changes in the production structure related to developments in GVCs in recent years make of GVCs.

However, the result that foreign variables like GVCs (and the foreign output gap) are not significant determinants of domestic wage or price inflation once traditional determinants like import prices are taken account of, is relatively common in the literature⁽¹⁰⁰⁾. Concerning wages more specifically, these result is not too surprising for at least two reasons. First, the impact on wages by GVCs depend on the position of the country in the supply chain, with GVCs typically favouring the increase in demand (and wages) of high skilled workers. The overall euro effect remains therefore unclear. Second, Phillips curve analysis focuses on cyclical developments. As far as GVCs affect wage levels over the long term, this impact will not be captured by the present analysis.

II.5. Conclusions

The analysis presented in this article starts from the observation that inflation, core inflation and wage inflation share a common component across OECD developed economies. However, it also shows that there is no solid argument to support the view that the traditional transmission channels of economic shocks on domestic price developments in the euro area are not relevant anymore and have been dominated by new channels in which global determinants of inflation have taken over.

It remains true that some of the domestic price developments are driven by common global shocks, in particular by shocks caused by oil and commodity prices and exchange rates. The global commonalities that we find in Section 2, in line with the literature, have a causal relationship with domestic inflation as companies pass input price increases onto prices.

However, we do not find any statistical evidence that measures of domestic productivity or

⁽⁹⁷⁾ See Vandeplas et al. (2018), quoted.

⁽⁹⁸⁾ Results for the other measures of the rest-of-world output gap are similar and not shown here.

⁽⁹⁹⁾ See 'Globalisation of industrial production chains and measurement of trade in value added', proceedings of the joint conference organised by the Senate Finance Commission and the Secretariat of the WTO, Paris, October 2010.

⁽¹⁰⁰⁾ See for example ECB (2019), 'The impact of global value chains on the euro area economy', *ECB Occasional Paper* No 221.

economic slack are superseded by measures of global developments. We also do not find evidence to support the weaker proposition that direct effects of global output gap variables on domestic price developments outweigh the effects of domestic variables.

In our view, it remains likely that the traditional Phillips curve framework still prevails: while shocks to prices that constitute direct inputs into the domestic economy are sooner or later transferred onto consumer prices, foreign activity shocks are transmitted to the domestic economy via the domestic output gap.

There is one caveat to the interpretation of the results. The analysis was carried out on a quarterly basis, which is relevant for counter-cyclical policy. As a result, these negative results do not preclude effects of globalisation on wages in level terms, but only effects of global factors on wage inflation. Conclusions on structural wage formation over longer-term periods should not be inferred.

The results of the paper are relevant as part of discussions about monetary policy. While most central banks' analytical framework for monetary policy is built on a large set of tools and indicators to assess price developments⁽¹⁰¹⁾, the Phillips curve remains the most relevant conceptual framework for policy purposes.

However, the most efficient tools and policy setting to secure this objective are currently under debate. On the one hand, the conceptual framework needed to analyse the interplay between monetary, fiscal and macro-prudential policies is still under construction both at an academic level and within policy institutions⁽¹⁰²⁾. On the other hand, the relevance of the current framework for controlling domestic inflation is an important point in the discussion; some questions are still open for debate, namely how much monetary policy should be leaning against the wind (of asset prices and credit booms) rather than targeting domestic inflation. For inflation targeting to remain the core aspect of monetary policy in its current form, it is necessary that domestic inflation be determined by domestic components (which themselves can however be determined by global shocks) so that monetary policy can effectively impact them. Our findings support the view that counter-cyclical policies — in particular monetary policy — still have an important role to play in controlling domestic inflation due to their impact on the output gap and inflation expectations. There are other questions currently present in the debate concerning possible changes to the monetary policy framework, but these go beyond the scope of this paper.

⁽¹⁰¹⁾ For the evolution of the ECB, see Hartmann P. and F. Smets (2018), 'The first 20 years of the European Central Bank: Monetary policy', *Brookings Papers on Economic Activity*, autumn 2018.

⁽¹⁰²⁾ In the euro area, the supranational nature of certain (but not all) relevant institutions makes this construction even more complex. However, the European Systemic Risk Board set up an expert group to develop a conceptual framework to guide the discussion on macro-prudential policies.

III. Convergence and macroeconomic imbalances

Section prepared by Leonor Coutinho and Alessandro Turrini

This section looks at the relationship between convergence patterns across the euro area and dynamics following the unwinding of imbalances. It compares the main features of convergence within the euro area with that of other country groups. It looks at both 'sigma' and 'beta' convergence, in relation to output and total factor productivity (TFP), conditioning on relevant variables that affect long-run growth. Expected convergence paths for euro area countries are estimated using growth regressions run on a large panel of advanced and emerging market economies. Our findings suggest that macroeconomic imbalances such as high private and government debt or strong growth in the non-tradables sector can hamper economic convergence. Overall, the analysis underscores the importance of conditions that ensure macro stability and resilience for economic convergence.

III.1. Introduction

In the run-up to the economic and monetary union (EMU), the Maastricht criteria emphasised nominal convergence as a requirement for achieving a stable common currency. This implied convergence in nominal variables including inflation, interest rates, deficits and debts. At the same time, academic debate was largely focused on the desirable characteristics of countries sharing a common currency. In line with the optimal currency area (OCA) theory (Mundell, 1961), countries ought to be sufficiently similar and integrated to reduce the likelihood of asymmetric shocks. They should also, have flexible product and labour markets to lower the costs of adjusting to asymmetric shocks in the absence of nominal exchange rates⁽¹⁰³⁾. In this respect, the emphasis was more on real convergence, whereby poorer countries grow faster than richer ones. In the process, these countries undergo a structural transformation, making them more like countries with a high per-capita income. This limits the occurrence of asymmetric shocks and reduces adjustment costs in a monetary union⁽¹⁰⁴⁾.

During the first decade of EMU nominal convergence appeared to go hand in hand with real convergence. Nominal interest rates converged on the back of financial integration and a reduction in perceived risks. Capital flowed from richer countries in the euro area 'core' to the euro area 'periphery'. Current account divergences (a gradual

build-up of surpluses in the core and deficits in the periphery) were generally seen as supportive of this convergence process⁽¹⁰⁵⁾.

The financial crisis led to a reversal of the current account deficits accumulated in the euro area periphery during the first years of EMU and to a subsequent period of nominal and real divergence. This was driven by increased interest rate spreads and deep and protracted recessions in the countries most affected by the crisis.

To better understand these developments and their causes, this article intends to shed more light on the relationship between real convergence patterns in the euro area and dynamics following the unwinding of imbalances. It goes a step forward than existing companion analyses in several respects⁽¹⁰⁶⁾. First, it assesses convergence patterns in the euro area against the experience of benchmark country groups. Second, it considers convergence along different dimensions, not only in terms of per-capita GDP but also in terms of per-capita capital stock, TFP and GDP per employee. Third, it estimates expected convergence paths for euro area countries, and connects the distance from these paths to the presence of macroeconomic imbalances.

⁽¹⁰³⁾ Mundell, R. A. (1961), 'A theory of optimum currency areas', *The American Economic Review*, 51(4), 657-665. See also Artis, M. J. (2003), 'Reflections on the optimal currency area (OCA) criteria in the light of EMU', *International Journal of Finance and Economics*, 8(4), 297-307.

⁽¹⁰⁴⁾ This concept differs from that of convergence towards efficient economic structures introduced in Berti, K. and Meyermans, E. (2017), 'Sustainable convergence in the euro area: A multidimensional process', *Quarterly Report of the Euro Area*, 3.

⁽¹⁰⁵⁾ There were nevertheless signs of concern. See European Commission (2006), 'Focus: Widening current account differences within the euro area', *Quarterly Report of the Euro Area*, 4, pp. 25-37.

⁽¹⁰⁶⁾ Recent analyses on convergence in the EU and euro area are found in Sondermann, D. (2014), 'Productivity in the euro area: any evidence of convergence?', *Empirical Economics*, 47(3), 999-1027; Estrada, Á. and López-Salido, D. (2013), 'Patterns of convergence and divergence in the euro area', *IMF Economic Review*, 61(4), 601-630; ECB (2015), 'Real convergence in the euro area: evidence, theory and policy implications', in *European Central Bank Economic Bulletin* 2015(5); and Berti and Meyermans (2017) op. cit.

Section I.2 of the article documents the main patterns observed in euro area convergence, both nominal and real. Section I.3 presents the main insights into real convergence patterns measured in terms of ‘sigma’ convergence, i.e. based on dispersion across countries (see Box III.1), by comparing different country groups, and studying the behaviour of variables beyond per-capita GDP. It also analyses ‘beta’ convergence — when countries with lower income per capita tend to grow faster, based on growth regressions (Barro and Sala-i-Martin, 2004) — run on a large panel of advanced and emerging market economies⁽¹⁰⁷⁾. These growth regressions are used to estimate expected convergence paths. Section I.4 then focuses on investigating whether ‘convergence gaps’, i.e. deviations from these estimated paths, are associated with a set of variables that measure the presence of macroeconomic imbalances⁽¹⁰⁸⁾.

Results show differences in convergence patterns within the euro area, as convergence among the founding members, excluding Luxembourg (EA-11), appears to be less strong than among the euro area as a whole. Growth rates below expected convergence paths also tend to be associated with high initial stocks of private debt, both for euro area and non- euro area countries. Government debt and strong growth in the non-tradable sector also reduce convergence in the euro area. The effect of the latter confirms that interest rate differentials prior to the crisis led to an excessive expansion of the non-tradable sector in the euro area periphery, which did not support convergence (Buti and Turrini, 2015)⁽¹⁰⁹⁾.

⁽¹⁰⁷⁾ Barro, R. J., and Sala-i-Martin, X. (2004), *Economic Growth*, MIT Press, Cambridge, Massachusetts.

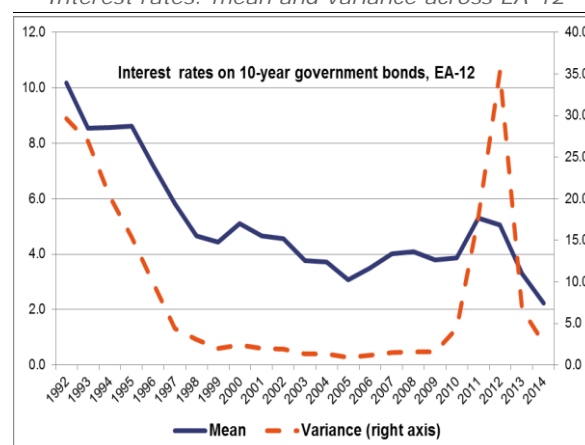
⁽¹⁰⁸⁾ Previous literature has analysed the link between business cycle synchronisation and variables related to macroeconomic imbalances (see Inklaar, R., Jong-A-Pin, R., de Haan, J. (2008), ‘Will business cycles in the euro area converge? A critical survey of empirical research’, *Journal of Economic Surveys*, 22 (2), 234-273.). More recently, Lukmanova, E., and Tondl, G. (2017), ‘Macroeconomic imbalances and business cycle synchronisation. Why common governance is imperative in the Eurozone’, *Economic Modelling*, 62, 130-144, find an important role for differences in government and private debt in lowering the degree of business cycle synchronisation in the euro area. The present focuses on the role of imbalances in explaining the pace of convergence rather than business cycle synchronisation.

⁽¹⁰⁹⁾ Buti, M., and Turrini, A. (2015), ‘Three waves of convergence. Can Eurozone countries start growing together again?’ *Vox*, EU, 17.

III.2. Main patterns in euro area convergence

The Maastricht criteria mainly focused on nominal convergence. Fast convergence was achieved in the run-up to the launching of the euro in January 1999 for nominal interest rates. In anticipation of a stable currency and no redenomination risks, both the mean and the variance of 10-year government bond rates across EA-12 countries dropped significantly between 1994 and 1997 (see Graph III.1). This convergence lasted for about a decade, but was interrupted by the European sovereign debt crisis of 2010-2012, during which the variance of 10-year government bond rates across the EA-12 spiked to levels last seen only prior to the 1990s.

Graph III.1: **Nominal convergence**
Interest rates: mean and variance across EA-12

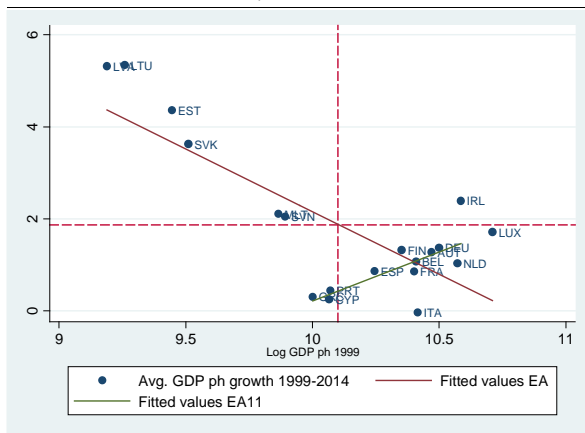


Source: AMECO database, European Commission

Regarding real convergence - the convergence of GDP per capita - conclusions are less clear-cut. Without conditioning on other factors, convergence is present in the euro area. In other words, on average poorer countries have grown faster than richer countries in the period 1999-2014. However, among the EA-11 (founding members excluding Luxembourg), divergence occurred instead (see Graph III.2). Recent analyses have also highlighted this finding (ECB, 2015; Berti and Meyermans, 2017)⁽¹¹⁰⁾.

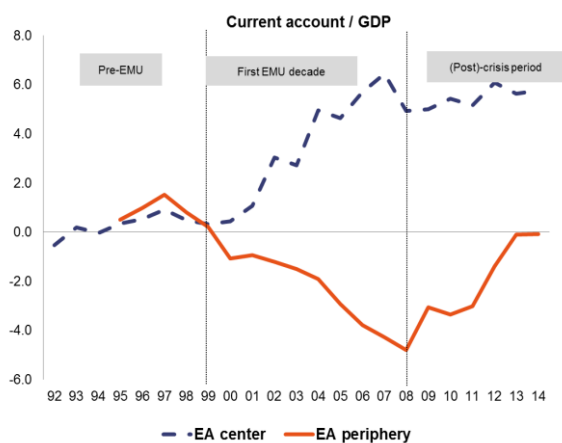
⁽¹¹⁰⁾ Op. cit.

Graph III.2: Real convergence
Real GDP growth vs initial log GDP per capita in euro area, 1999-2014



Source: Penn World Tables 9.0

Graph III.3: External balances
Current account average for euro area centre vs periphery (weighted average)



(1) Centre: BE DE LU NL AT FI. Periphery: EE IE EL ES FR IT CY LV LT MT PT SI SK. Centre and periphery euro area countries grouped according to their external position over the 1999-2009 period.

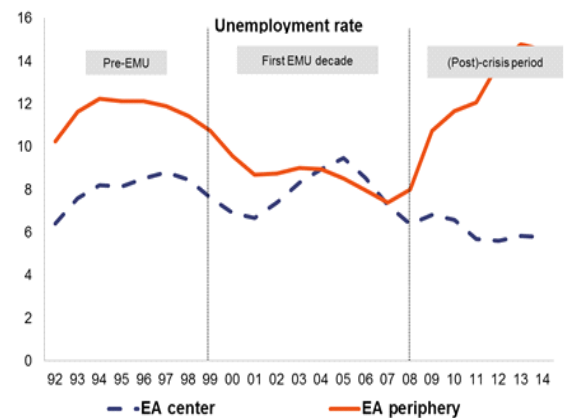
Source: Eurostat

During the first decade of EMU, capital flows in fact supported convergence. The euro area was an exception to the Feldstein-Horioka puzzle, as capital flowed from relatively high-income countries to relatively low-income ones⁽¹¹⁾. This translated into a positive and growing current account balance in the rich centre of the euro area and a negative and growing current account deficit in the poorer periphery (see Graph III.3).

⁽¹¹⁾ Feldstein M. and Horioka, C. (1980), 'Domestic Saving and International Capital Flows', *Economic Journal*, 90 (358): 314-329. In this paper, the authors observed that savings are usually invested in the country where they occur and not where the highest rates of return on capital are observed.

Prior to the crisis, the flow of investment to the periphery was channelled primarily to the non-tradable sector. This meant that persistent real interest rate differentials did not only shape cyclical positions according to the Walters' critique of EMU but also economic structures (Buti and Turrini, 2015)⁽¹²⁾. The growth of the non-tradable sector in the euro area periphery - in some cases the counterpart of large-scale housing market bubbles - was generally accompanied by cost competitiveness losses, and worsened the prospects for a more durable growth engine based on exports.

Graph III.4: Unemployment developments
Average for euro area core versus periphery (weighted average)



(1) Centre and periphery defined as before.

Source: Eurostat

The global financial crisis implied a re-appraisal of risk and a sudden withdrawal of capital from the periphery, forcing this group of countries to contract. This market reaction reversed the trend on the current account deficits of the euro area periphery. However, it did not impose the same symmetric adjustment on the euro area centre. 'Sudden stops' such as these tend to affect deficit countries more than surplus countries, as surplus countries redirect their savings to other locations. Growth slowed significantly in the periphery, in light of a sudden contraction in demand, stalling the convergence process.

⁽¹²⁾ The economic structure shapes the way the economy responds to shocks. For instance, the excessive weight of the construction sector left several economies particularly vulnerable to the credit crunch experienced in the global financial crisis.

Box III.1: Concepts of convergence

Beta convergence

Unconditional beta convergence is observed when the growth rate of real per capita GDP is negatively related to the starting level of real per capita GDP. This type of convergence implies that poorer economies eventually catch up with richer ones, by growing faster. Hence the parameter β in equation (1) is expected to be negative and statistically different from zero.

$$\Delta \log Y_{it} = \alpha + \beta \log Y_{it-1} + u_{it} \quad (1)$$

where, the average growth rate of country i over a time period t is approximated by the log difference of GDP per capita, $\Delta \log Y_{it}$. On the right hand side is the level of GDP per capita at the start of the period, Y_{it-1} , and a random disturbance u_{it} with mean zero and constant variance, uncorrelated with Y_{it-1} .

Conditional beta convergence is observed when the growth rate of real per capita GDP is negatively related to the initial level of real GDP per capita, holding fixed other variables that may affect growth, such as population growth, investment, or the initial level of human capital. Formally, the right hand side of equation (1) is extended to account for the effect of a vector of control variables Z_{it} .

Sigma convergence

The concept of sigma convergence relates to the cross-sectional dispersion of income. There is sigma convergence if income dispersion, measured by the standard deviation of the logarithm of GDP per head across a specific group of countries, declines over time. In the absence of shocks in per capita income and with a common steady-state, beta convergence tends to result into sigma convergence. Abstracting from the set conditioning variables Z , equation (1) can be rewritten as follows (see Barro Sala-i-Martin, 2004).

$$\Delta \log Y_{it} = \alpha - (1 - e^{-\lambda}) \log Y_{it-1} + u_{it} \quad (2)$$

If $\lambda > 0$, equation (2) implies that poorer countries grow faster than richer ones ($\beta = -(1 - e^{-\lambda}) < 0$, beta convergence). Defining the variance of $\log Y_{it}$ as σ_t^2 , equation (2) also implies equation (3), where σ_u^2 is the variance of u_{it} :

$$\sigma_t^2 = e^{-2\lambda} \sigma_{t-1}^2 + \sigma_u^2 \quad (3)$$

Equation (3) also implies that the speed of convergence depends on the degree of dispersion in per capita GDP. The higher the dispersion that faster the speed of convergence.

Equation (3) is a first-order difference equation with a solution given by equation (4).

$$\sigma_t^2 = \mu + (\sigma_0^2 - \mu) e^{-2\lambda t} \quad (4)$$

where $\mu = \sigma_u^2 / (1 - e^{-2\lambda})$ is the steady-state value of σ_t^2 and σ_0^2 is the variance of the initial levels of income. Equation (4) shows that the dispersion in per-capita income across countries depends on whether the initial value of sigma is above or below the steady-state value. Therefore, $\lambda > 0$ ($\beta < 0$) is a necessary but not a sufficient condition for a declining sigma. However, notice that the conditions on the error term will be violated if, for instance, there is an additional common disturbance S_t affecting countries differently depending on their level of income. In this case, equation (3) becomes:

$$\sigma_t^2 = e^{-2\lambda} \sigma_{t-1}^2 + \sigma_u^2 + \sigma_\eta^2 S_t^2 + 2S_t e^{-\lambda} \text{cov}[\log Y_{it-1}, \eta_i] \quad (5)$$

where σ_η^2 is the variance of the coefficient η_i determining the impact of S_t in each region. In this case, temporarily large or small realisations of S_t can move σ_t^2 temporarily above or below its long-run value σ^2 , interrupting the sigma convergence process.

The dispersion in cyclical positions across the euro area observed from 1999 is mirrored in diverging unemployment trends (see Graph III.4). From 1999 to 2007, the periphery experienced a prolonged expansion, which resulted in unemployment falling sharply. On the other hand, the euro area centre experienced a slowdown between 2000 and 2005, with increasing unemployment. As the crisis unfolded,

unemployment shot up in the periphery along with the deep recession. In the centre, where output started to recover much faster, it even slightly declined. This pattern in unemployment reflects the evolution of external positions during the first decade of EMU (Graph III.3). A key lesson from the crisis was that macroeconomic imbalances matter greatly for the stability of EMU, while the

focus on growth before the crisis led to an attitude of benign neglect.

III.3. Real convergence in the euro area

Real convergence across the euro area is first assessed in terms of sigma convergence, using time plots of the standard deviation of the logarithm of GDP per capita, capital per capita, TFP, and other real variables (see Box III.1 for definitions). Insights from sigma convergence help distil a number of stylised facts. Beta convergence is analysed instead using growth regressions, which condition on a number of variables that determine differences in steady states, in addition to the initial level of income or TFP. These growth regressions are used to estimate expected convergence paths and to compare deviations from these paths to variables that measure the presence of macroeconomic imbalances.

III.3.1. Sigma convergence

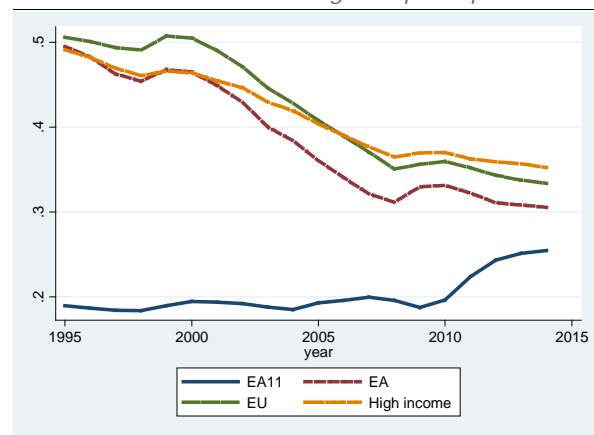
Sigma convergence requires a decline in cross-country variation of income per capita over time. To assess sigma convergence, Graph III.5 shows the standard deviation of log GDP per capita for the euro area and three other country groups, including the EA-11 - the euro area founding members including Greece and excluding Luxembourg -, the EU and high-income countries. The graph displays data from 1995 to avoid missing data for former transition countries.

The dynamics of income dispersion indicate that sigma convergence has been faster in the EU and the euro area than among other high-income countries. This confirms previous studies that regard the EU as a ‘convergence club’ (see Schadler et al., 2006, and Böwer and Turrini, 2010)⁽¹¹³⁾. However, this convergence has concerned mostly Member States from central and eastern Europe that joined the EU more recently. Consistently, the EA-11 group displays virtually no convergence pattern until the financial crisis, as well as divergence after this period.

⁽¹¹³⁾ Schadler, S, Mody, A, Abiad, A and Leigh, D. (2006), ‘Growth in the central and in eastern European countries of the European Union’, IMF Occasional paper no 252, International Monetary Fund, Washington D.C.

Böwer, U. and Turrini, A. (2010), ‘EU Accession: A Road to Fast-track Convergence?’ *Comparative Economic Studies*, 52, 181-205.

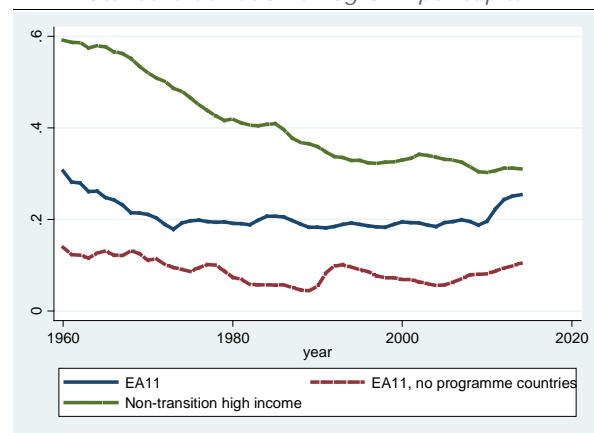
Graph III.5: **Sigma convergence: euro area vs other country groups**
Standard deviation log GDP per capita



Source: Penn World Tables 9.0

Graph III.6 displays convergence patterns over a longer period to provide better insight into what could drive the result for the EA-11. The graph displays a comparison of the EA-11 with (i) a larger group of advanced, non-transition economies, and (ii) the EA-11 excluding the countries that underwent the most notable recessions after the financial crisis, i.e. countries that received official financial assistance.

Graph III.6: **Sigma convergence: EA-11 vs other country groups**
Standard deviation of log GDP per capita



Source: Penn World Tables 9.0

When measured over a longer period, sigma convergence reveals that the EA-11 countries experienced convergence at similar rates to those of the larger group of advanced economies from the 1960s to the early 1970s. In the second half of the 1970s, convergence stalled for the EA-11, and slowed down for the non-transition advanced economies. The exclusion of programme countries from the EA-11 reduces in the degree of income

Box III.2: Data Sources

An important data source for the study is the Penn World Table (PWT), release 9.0. PWT is a dataset of real GDP and its components, including also growth accounting. Quantities in this database are converted into a common currency using purchasing power parities (PPP) to make them comparable across a large group of countries. PPP attempt to measure the relative price level of an economy and tend to be different from market exchange rates because they cover not only the price of traded but also of non-traded goods and services. PPP-converted GDP per capita of low-income countries tends to be higher than exchange-rate-converted GDP per capita, because their prices of non-traded products tend to be lower and vice-versa for high-income countries. For this, PWT uses the results of detailed price surveys from the International Comparison Program and other sources. The 9.0 release of the PWT represents a substantial change to previous versions. The changes can be classified into four broad categories:

- (1) the incorporation of new PPP data from the 2011 International Comparison Program (previously the reference year was 2005). In the 2011 release, run by the World Bank, a number of methodological issues were addressed. The most important related to the selection of a more representative global product basket.
- (2) the incorporation of revised and extended National Accounts data, covering the period up until 2014
- (3) improvements in the data sources and compilation methods for factor inputs, which improved estimates of the labour shares, TFP, and human capital
- (4) The number of countries included in the database has been increased from 162 to 182 and the share of world population covered increased from 96.9 to 98.5%

The PWT 9.0 data was complemented with data from other sources. A detailed list is provided below:

Variable	Description	Source
GDP per head PPP	GDP per capita PPP	PWT 9.0
Schooling	Human capital index using years of schooling and rates of return on education	PWT 9.0
Investment/GDP	Investment at constant national prices, divided by GDP	PWT 9.0
Population growth	Rate of change in population	PWT 9.0
Openness	5-year average of the ratio of imports plus exports to GDP	Eurostat, WEO
Fraser index	Index of economic freedom	Fraser Institute
Private debt/GDP	NFCs and household loans and debt securities, non-consolidated, divided by GDP	Eurostat, BIS
Government debt/GDP	General government debt, divided by GDP	AMECO, WEO
NIIP/GDP	Net international investment position, divided by GDP	Eurostat
Credit flow/GDP	Proxied by change in total private debt (%GDP)	Eurostat, BIS
Current account gap	Difference between the current account (%GDP) and a country-specific benchmark based on fundamentals	Coutinho et al. (2018)
Construction VA share	Share of construction sector value added in total value added (NACE 2)	AMECO

Country groups:

- EA: 19 euro area countries (fixed composition)
- EA-11: founding euro area countries, excluding Luxembourg
- High income: high income countries in the sample according to World Bank definition
- Non-transition high income: high income countries in the sample according to World Bank definition, excluding transition countries in Eastern Europe, as well as Luxembourg, Malta and Cyprus

dispersion and slows down the rate of convergence over the 1960s and 1970s, but also the rate of divergence over the post-crisis period.

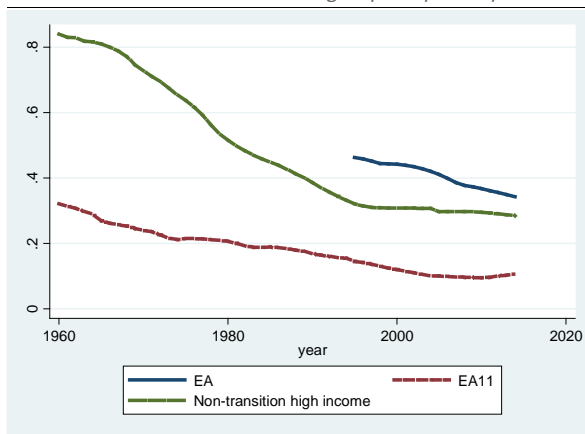
Overall, it appears that the slow convergence process within the EA-11 could be due, among other things, to the fact that the EA-11 was already characterised by a low degree of dispersion in per-capita income in the 1960s. The result follows mechanically, as the rate of convergence is expected to be faster the higher the initial degree of dispersion in income conditions (see Box III.1).

Moreover, the divergence pattern observed over the post-crisis period appears to be partly related to the dismal growth of a limited number of countries heavily affected by the financial crisis.

In the neoclassical growth model (Solow, 1956; Swan, 1956), output convergence is driven by convergence in the capital stock. Incentives to invest are higher in countries with a relatively low capital stock and higher marginal productivity of

capital⁽¹¹⁴⁾. Graph III.7 looks at convergence patterns in the capital stock per capita to check whether the neoclassical model prediction matches the data. The graph compares the EA-11 group and the larger group of advanced non-transition economies since 1960 and the euro area since 1995 (due to missing data). It appears that convergence is much more visible when looking at capital per capita rather than GDP per capita, including for the EA-11 group. This confirms the standard mechanism of convergence from neoclassical growth theory.

Graph III.7: **Sigma convergence: capital per capita in EA-11 and other country groups**
Standard deviation of log capital per capita



Source: Penn World Tables 9.0

Dynamics in GDP per capita may differ from those in capital per capita because of the impact of TFP⁽¹¹⁵⁾. In the neoclassical growth model, TFP growth is exogenous. In modern growth theory, where TFP growth is the result of a process of innovation — the introduction of new technologies — and gradual adoption of new vintage technologies (Aghion and Howitt, 2006), income convergence can be also driven by TFP convergence⁽¹¹⁶⁾. In this framework, TFP growth depends on both the rate of innovation and the rate at which ‘state-of-the-art’ technologies are adopted or imitated. The weight of these

⁽¹¹⁴⁾ Solow, R. (1956), ‘A contribution to the theory of economic growth’, *Quarterly Journal of Economics*, 70 (1) (1956), 65-94. Swan, T. (1956), ‘Economic growth and capital accumulation’, *Economic Record*, 32 (63), 334-361.

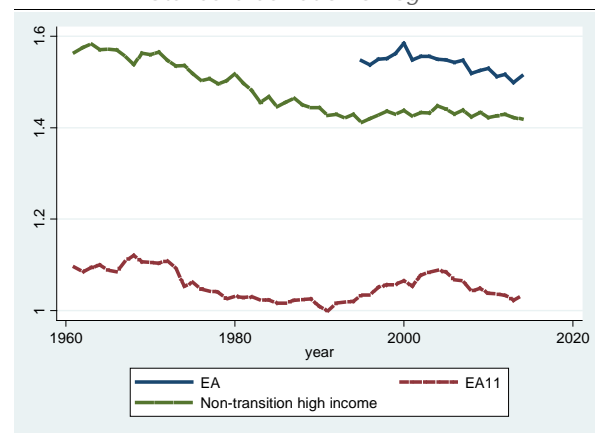
⁽¹¹⁵⁾ Using a standard Cobb-Douglas production function, with capital and labour as inputs, capital per capita is expressed as $\frac{Y}{L} = A \left(\frac{K}{L}\right)^\alpha$, where Y , L , K stand, respectively, for output, labour and capital inputs, while A is TFP.

⁽¹¹⁶⁾ Aghion, P., and Howitt, P. (2006), ‘Joseph Schumpeter lecture appropriate growth policy: A unifying framework’, *Journal of the European Economic Association*, 4(2-3), 269-314.

components in each country depends on its distance from the ‘technology frontier’. For countries closer to the frontier, TFP growth generally comes from the introduction of new technologies. For countries further away from the frontier, TFP growth generally comes from the adoption of state-of-the-art technologies.

A convergence process for TFP is therefore expected as countries further away from the frontier have more room to grow by simply adopting better technologies that already exist. Graph III.8 shows the standard deviation of TFP in the EA-11. Some limited convergence seems to have played a role up until the 1990s. However, TFP dispersion fluctuated afterwards. There is more evidence of steady convergence for the broader set of non-transition advanced economies as well as for the euro area, despite the short time series available for the latter. Also noticeable is the very narrow dispersion of TFP levels across the EA-11 group compared to other country groups.

Graph III.8: **Sigma convergence: TFP in EA-11 and other country groups**
Standard deviation of log TFP



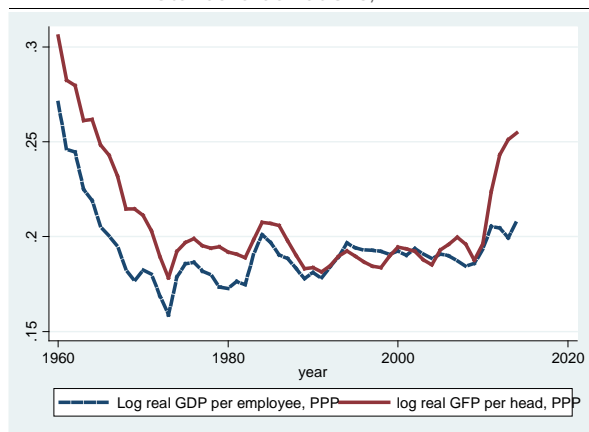
Source: Penn World Tables 9.0

The analysis so far does not distinguish between population and employment. It follows the standard assumption in empirical growth literature that long-run dynamics in GDP per capita tend to coincide with those in GDP per employee.

However, this assumption may not be satisfactory over periods where employment rates fluctuate significantly. Graph III.9 compares sigma convergence for GDP per capita with GDP per employee in the EA-11. It clearly shows that dispersion in the two variables co-moves up to the crisis. However, there is an upward spike in the dispersion of GDP per capita after the crisis, which

is not observed in GDP per employee. This finding allows us to better interpret the divergence process in the post-crisis period as a phenomenon that was not caused by strong divergence in capital per employee or TFP, but rather by a very large divergence in employment rates, reflected also GDP per capita figures.

Graph III.9: **Sigma convergence: GDP per capita vs GDP per employee**
Standard deviations, EA-11



Source: Penn World Tables 9.0

Overall, there is evidence of sigma convergence in the euro area occurring at rates similar to those observed across other country groups. For the EA-11, sigma convergence appears to have occurred until the 1970s at slow rates. The relatively slow rate of convergence in GDP per capita is partly due to the EA-11 group being highly homogenous in terms of income conditions. An additional factor that underpins the stall in income convergence is the lack of TFP convergence in recent decades. The divergence in income per capita in the post-crisis period is mainly linked to divergent employment rates. This phenomenon is likely transitory and concentrated in the few countries most affected by post-crisis recessions, induced by the unwinding of macroeconomic imbalances and debt crises.

The absence of sigma convergence does not imply absence of beta convergence. In other words, it does not exclude that in general countries with relatively low income per capita have witnessed faster growth, as the occurrence of certain types of shocks can produce dispersion (see Box III.1). The next section investigates beta convergence, which is the notion of convergence most often used in empirical analysis as it enables researchers to assess growth patterns in a more comprehensive

framework. This analysis will also allow us to estimate expected convergence paths.

III.3.2. Beta convergence

Beta convergence takes place when countries with a lower income per capita grow faster over a medium to long-term period. Graph III.2 shows prima facie evidence of beta convergence in the euro area. A more rigorous analysis also needs to take into account that growth rates across countries not only vary because of different initial income conditions, but also because of other factors that explain the growth performance over the medium to long term.

Growth regressions traditionally rely on cross-section variation. However, more recent applications build on panel data to also exploit time series variation and qualify if convergence rates differ over different time periods. The dataset used in this analysis is a large panel of advanced and emerging economies, obtained mostly from the Summers-Heston Penn World Tables (PWT) version 9. These contain comparable information on variables expressed in purchasing power parity for many countries and years (see Box III.2).

With this data, the methodology described in Box III.3 is used to estimate growth regressions, with the results displayed in Table III.1. In addition to initial income per capita, growth rates are put in relation to other explanatory variables that help determine growth. The results should therefore be interpreted as a test for 'conditional' beta convergence i.e. convergence to steady-state growth rates that differ across countries.

Box III.3: Empirical methodology

To test for beta convergence and estimate a ‘normal’ convergence path, regression (1) is estimated using the large panel of 66 countries: ⁽¹⁾

$$\Delta_5 \log Y_{it} = \alpha + \beta \log Y_{it-5} + \beta Z_{it} + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

where the dependent variable Y_{it} is either output per capita (in PPP) or TFP. Z_{it} is a vector of control variables. The subscript i refers to countries, while t is the time period over which growth rates are computed. Such regression has been typically estimated in the cross section, with growth rates computed over relatively long time periods. This analysis makes use of a panel dimension to use of variation in the time series and allows us to estimate convergence paths over different time periods. Following standard practice in the estimation of growth regressions with panel data, annual observations are converted into averages over 5-year, non-overlapping sub-periods to avoid short-term disturbances affecting the results (see Barro Sala-i-Martin, 2004).

The set of control variables includes: average schooling over the 5-year period; investment-to-GDP ratio (instrumented with the deflator for investment, lagged 5 periods); average population growth over the 5-year period; the average Fraser index of Economic Freedom over the 5-year period (to capture the role of institutional quality); and average openness (exports + imports/GDP) over the 5-year period.

The terms γ and δ are region and time effects, respectively. The literature has advocated including regional effects to control for common shocks like climate change and regional spillovers, which are difficult to model and could lead to cross-sectional correlation. Regional dummies can also be seen as an alternative to including country-specific fixed effects. The latter can exacerbate the problem of measurement errors, when these errors are not persistent, by throwing away all the between-country variation (see Temple, 1999, and references therein, also for a discussion on the broader choice of explanatory variables). ⁽²⁾ The regressions are estimated using ordinary least squares (OLS), with robust (clustered) standard errors. However, the results do not vary significantly when instrumental variables are used, and exogeneity tests indicate that investment can be treated as exogenous for this sample (see Table I.1). The investment-to-GDP ratio is instrumented with the deflator for investment, following the literature and tests reported in Table I.1 confirm the validity of this instrument.

Predictions from regression (1) are used to estimate “normal growth” paths, which are plotted in Graph B.1 together with actual growth. The deviations between the two series (residuals from the panel regression) are then used to infer the role of macroeconomic imbalances in explaining these deviations. The advantage of this two step approach is that ‘normal’ convergence paths can be inferred from a larger panel of 66 countries, providing estimates that are more unbiased than those which would be obtained from the more limited sample of variables linked to imbalances (516 versus 200 observations). To formally test for the role that imbalances have played in the convergence process, regression (2) is estimated, also using OLS:

$$\varepsilon_{it} = \alpha + \lambda IMB_{it-5} + \gamma_i + \delta_t + u_{it} \quad (2)$$

where ε_{it} are the residuals obtained from the large panel regression (less biased in principle than residuals resulting from smaller samples), either using GDP growth or TFP as the dependent variable. The vector IMB contains a set of variables associated with macroeconomic imbalances, including private and government debt-to-GDP ratios, financial sector credit as a ratio to GDP, the NIIP in percent of GDP, the share of construction sector GVA in total GVA, and the current account gap. The latter is estimated as the difference between the observed current account and the current account that can be explained by the country’s fundamentals, estimated as described in Coutinho et al. (2018). The regression uses robust (clustered) standard errors and time and region effects when applicable.

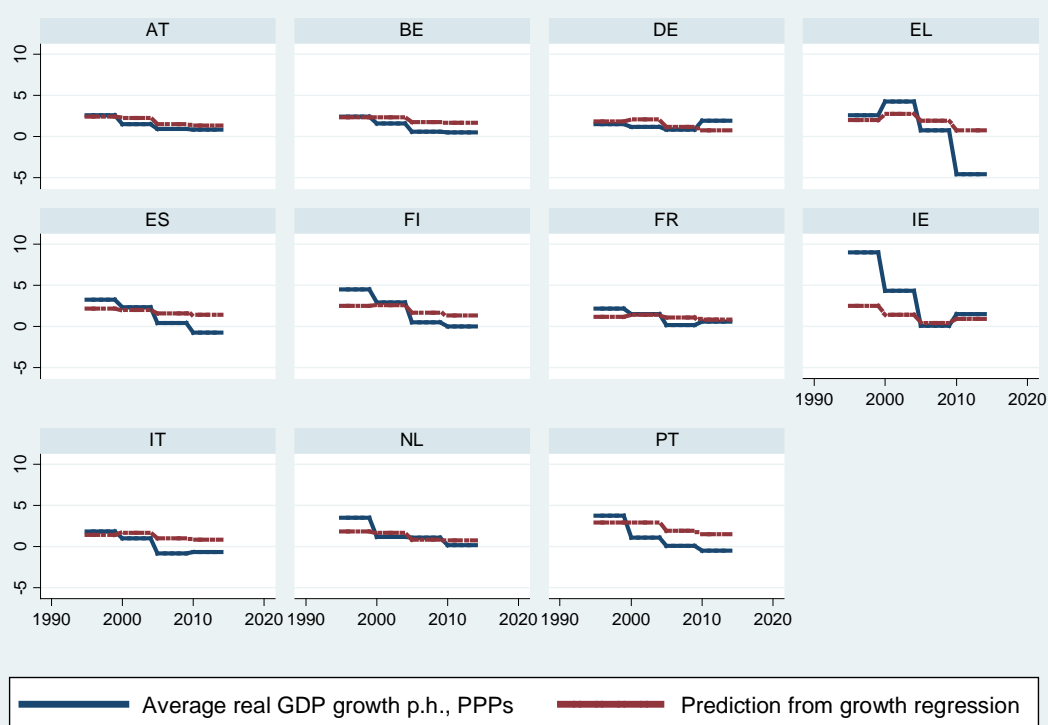
(1) The set of countries includes: Albania, Argentina, Australia, Austria, Belgium, Bulgaria, Brazil, Canada, Switzerland, Chile, China, Colombia, Costa Rica, Cyprus, Czechia, Germany, Denmark, Egypt, Spain, Estonia, Finland, France, United Kingdom, Greece, Guatemala, Hong Kong, Croatia, Hungary, Indonesia, India, Ireland, Iceland, Israel, Italy, Japan, Korea, Republic of, Sri Lanka, Lithuania, Luxembourg, Latvia, Morocco, Mexico, Malta, Malaysia, Netherlands, Norway, New Zealand, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Singapore, Serbia, Slovakia, Slovenia, Sweden, Thailand, Tunisia, Turkey, Ukraine, Uruguay, United States of America, South Africa.

(2) Temple, J. (1999), “The new growth evidence. *Journal of economic Literature*”, 37(1), 112-156.

(Continued on the next page)

Box (continued)

Graph B.1 Actual growth rates in GDP per head and predictions from growth regressions



Following standard practice, variables are averaged over 5 years to remove cyclical effects and eliminate autocorrelation. Initial conditions are lagged by 5 years to capture those at the start of each of the 5-year growth periods (see Box III.3). A number of control variables capture factors that affect steady-state growth in the neo-classical growth model. Population growth, which accounts for the dilution of capital stock per capita, is associated with an expected negative coefficient. The average share of investment in GDP serves as a proxy for the savings rate relevant to investment. This is expected to be associated with faster capital accumulation and will therefore have a positive coefficient. Human capital — an index based on years of schooling and return to education — is also included to account for investment in skills. This is also expected to have a positive coefficient through improvements in labour input⁽¹¹⁷⁾. Two

⁽¹¹⁷⁾ In the PWT 9.0, the average years of schooling combine data from Barro, R. J. and Lee, J.-W. (2013), 'A new data set of educational attainment in the world, 1950-2010' *Journal of Development Economics*, 104: 184-198; and Cohen, D. and Leker L. (2014), 'Health and Education: Another Look with the Proper Data', mimeo Paris School of Economics. Rates of return

additional variables aim to control for factors that may affect TFP growth. Openness to trade — imports plus exports as a share of GDP — is included to account for the fact that open economies can borrow abroad and import technology and know-how (Edwards, 1998; Frankel and Romer, 1999)⁽¹¹⁸⁾. Moreover, the quality of institutions, as measured by the Fraser index of economic freedom, aims to take into account the fact that good institutions are

on education are from Psacharopoulos, G. (1994), 'Returns to investment in education: A global update', *World development*, 22(9):1325-1343. See also Feenstra, R. C., Inklaar, R., et Timmer, M. P. (2016), 'What is new in PWT 9.0?', The University of Groningen. On the reason for the inclusion of this variable, see Mankiw, N. G., Romer, D. and Weil, D. N. (1992), 'A contribution to the empirics of economic growth', *Quarterly Journal of Economics* 107, 407-437.

⁽¹¹⁸⁾ Edwards, S. (1998), 'Openness, productivity and growth: what do we really know?' *The Economic Journal*, 108(447), 383-398. Frankel, J. A., and Romer, D. H. (1999), 'Does trade cause growth?' *American Economic Review*, 89(3), 379-399.

Table III.1: Conditional beta convergence: output per capita

Dep var: GDP p.h. growth, 5- year averages	(1) All sample	(2) All sample, IV	(3) EU	(4) EA	(5) EA11	(6) EU>1999	(7) EA>1999	(8) EA11>1999	(9) EU>2007	(10) EA>2007	(11) EA11>2007
Ln GDP p.h. PPP, 5 lags	-2.207** [-6.53]	-2.035** [-4.22]	-3.018** [-6.39]	-2.695** [-6.01]	-0.853 [-0.95]	-3.643** [-6.51]	-3.684** [-5.54]	-2.706+ [-1.98]	-1.030 [-1.28]	-1.036+ [-1.82]	6.670 [1.05]
Human capital, 5 lags	0.435 [1.18]	0.359 [0.81]	0.286 [0.93]	0.382 [1.25]	-0.311 [-0.44]	1.309** [3.07]	1.403** [3.18]	1.526+ [2.18]	2.345** [4.44]	2.563** [4.04]	-0.524 [-0.21]
I/GDP, avg	9.982** [5.91]	6.845 [0.90]	8.337** [3.29]	5.933* [2.44]	3.835 [1.10]	3.921 [0.69]	5.611 [0.78]	8.598 [0.68]	10.518 [1.07]	19.206* [2.22]	17.225 [0.88]
Pop growth, avg	-0.555** [-2.81]	-0.571** [-2.84]	-0.518+ [-2.05]	-0.718* [-2.81]	-0.049 [-0.18]	-0.592+ [-1.73]	-0.723+ [-1.80]	0.319 [0.68]	-1.794** [-4.19]	-2.246** [-11.30]	-1.984 [-0.52]
Economic freedom, 5 lags	0.537** [3.82]	0.552** [3.75]	1.031** [3.78]	0.516 [1.30]	0.371 [0.68]	1.225* [2.60]	2.184** [3.24]	1.658+ [1.98]	3.111** [2.92]	2.965* [2.48]	2.810 [1.07]
Openness, avg	0.810* [2.42]	0.946+ [1.84]	0.842+ [1.83]	1.350** [3.07]	2.129 [1.69]	1.399** [2.83]	1.351* [2.57]	1.426 [1.12]	1.591** [2.94]	1.544* [2.25]	-1.530 [-0.55]
Observations	516	516	203	143	99	84	57	33	28	19	11
Countries	66	66	28	19	11	28	19	11	28	19	11
R-squared	0.41	0.40	0.58	0.65	0.64	0.72	0.75	0.57	0.74	0.88	0.78

(1) Constant time effects and regional effects included, but estimated coefficients omitted. Robust (clustered) t-statistics in brackets. **p<0.01, *p<0.05, +p<0.1. I/GDP instrumented with investment deflator (5 lags). IV tests: Kleibergen-Paap rk LM statistic p-value: 0.0005; Kleibergen-Paap rk Wald F statistic: 36.5210; Exogeneity test (Hausman type) p-value: 0.6647.

Source: Authors calculations

associated with stronger incentives to innovate and take risks (e.g. Glaeser et al. 2004)⁽¹¹⁹⁾.

The control variables generally have the expected signs, even though some coefficients are not significant for all regions and samples. A typical difficulty when estimating growth regressions is the possible endogeneity of the investment variable – investment not only affects growth, but is also driven by expected growth rates. However, the issue does not seem to be relevant in these estimates, as the coefficient of the investment variable is qualitatively unchanged when using instrumental variables (IV) estimation, i.e. instrumenting investment with the price of investment goods as customary in related literature. Exogeneity tests also indicate that investment can be treated as exogenous for this sample⁽¹²⁰⁾. Under exogeneity conditions, ordinary least squares (OLS) is consistent and more efficient than IV estimates.

For the whole sample of countries, there is evidence of beta convergence as the coefficient on the logarithm of the initial GDP per capita is negative and statistically significant, in support of

catching-up. This is also the case for the EU (column 3) and for the euro area (column 4), but not for the EA-11 (column 5). Looking only at the period after euro adoption (columns 6-8), the same results still hold for the euro area, the EU and the EA-11. However, looking at the period after 2007, which includes mostly the global financial crisis and the European sovereign debt crisis, evidence of convergence for the euro area and the EU becomes weaker (columns 9 and 10). There is evidence of divergence for the EA-11 after 2007, where the coefficient becomes positive, although insignificant in column 11. However, it is important to note that the number of observations is considerably smaller in this subsample, leaving only a few degrees of freedom for the estimation⁽¹²¹⁾.

Growth regressions have also been run to test for convergence in TFP growth. Table III.2 shows the estimation results. Initial TFP, human capital, investment, institutions (Fraser index) and openness have been included as control variables. Initial TFP is expected to be negatively associated with TFP growth as laggard countries have more room to grow out of the adoption of up-to-date technologies. Human capital, as measured by the PWT 9.0 index of human capital, allows to control for the fact that countries with a more educated

⁽¹¹⁹⁾ Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F., and Shleifer, A. (2004), 'Do institutions cause growth?', *Journal of Economic Growth*, 9(3), 271-303.

⁽¹²⁰⁾ The orthogonality is test C statistic, which is numerically equal to a Hausman test statistic under conditional homoscedasticity and has a p-value of 0.66. It therefore cannot reject the null hypothesis that investment can be treated as exogenous in this sample. See Baum, C. F., Schaffer, M. E. and Stillman, S. (2003), 'Instrumental variables and GMM: Estimation and testing', *Stata Journal* 3: 1-31. Tests for the validity of instruments are also reported in Table I.1.

⁽¹²¹⁾ The estimation results for the shorter sample starting after 2007 are only indicative, as the number of observations is small. In particular, inference for this sample should be viewed with caution.

Dep var. TFP growth	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All sample	All sample	EU	EA	EA11	EA 1999-2007	EA>2007	EA11, 1960-2007	EA11>2007
Log TFP level PPP, 5lag	-1.663** [-4.79]	-1.599** [-4.62]	-2.488** [-4.16]	-2.817** [-3.06]	0.562 [1.60]	-4.122** [-3.85]	-2.824* [-2.31]	0.266 [0.66]	2.112 [1.03]
Avg. schooling, 5 lags	0.164 [0.80]								
1/GDP, avg	-1.253 [-0.92]								
Fraser index, avg.	0.301** [2.74]	0.311** [3.10]	0.569** [4.89]	0.429+ [2.03]	0.843** [4.64]	0.415 [0.83]	2.424+ [2.03]	0.815** [4.76]	1.742 [1.54]
Openness, avg.	0.246 [0.83]								
Observations	502	502	203	143	99	38	19	88	11
Countries	64	64	28	19	11	19	19	11	11
R-squared	0.25	0.25	0.33	0.40	0.59	0.60	0.29	0.58	0.71

(1) Constant, time effects and region effects included, but coefficient results omitted. Robust (clustered) t-statistics in brackets. ** p<0.01, * p<0.05, + p<0.1

Source: Authors' estimations.

population tend to innovate more. The variable that measures institutional quality accounts for different incentives for innovation and entrepreneurship. Openness controls for the degree of impediments to technology absorption. Apart from initial TFP levels and institutions, other control variables are statistically insignificant in explaining TFP growth (column 1). The absence of insignificant control variables in column 2 does not affect the significant coefficients. Columns 3-9 therefore use the restricted specification, controlling only initial TFP and institutions.

Results provide evidence that TFP convergence exists among the whole sample of countries (columns 1 and 2), as well as for the EU and the euro area (columns 3 and 4). There is no evidence of convergence for the EA-11, where TFP appears to diverge after the financial crisis (columns 5, 8 and 9). On the other hand, convergence exists in the EU as a whole even for the post-crisis subsample (columns 6 and 7)⁽¹²²⁾.

Overall, the evidence of beta convergence from growth regressions indicates that the euro area is not faring worse in terms of output convergence than other country groups⁽¹²³⁾. Instead, there is no significant evidence of conditional output convergence for the EA-11, where income per

capita appears to have been diverging over the post-crisis period. Regarding TFP convergence, the euro area as a whole is not faring worse than other country groups. However, there is no evidence of TFP convergence among the EA-11.

III.4. Deviations from convergence paths: a role for macroeconomic imbalances?

EA-11 countries appear not to have followed a convergence pattern like that of countries in the comparator groups. What factors could have been responsible for this lack of convergence? Inspired by the stylised facts presented earlier regarding macroeconomic imbalances across the euro area, namely swallowing current account deficits in the euro area periphery fuelled by public and private debt and housing investment, the aim of this section is to investigate more systematically whether these can account for lack of convergence in some countries.

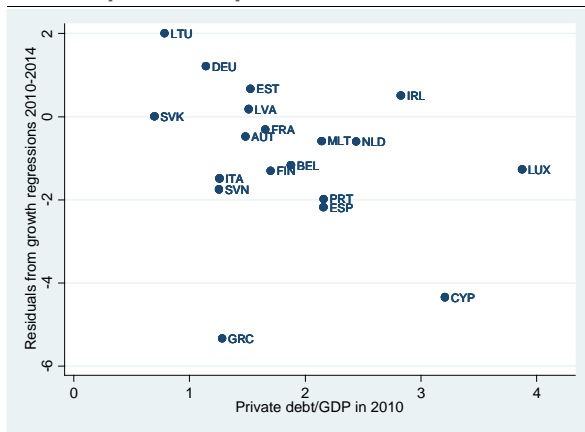
To answer this question, the first step is to estimate a standard convergence path. Namely, a convergence path that would normally be expected based on the relevant characteristics of countries, i.e. the initial level of output per capita and all other conditioning factors. This path is obtained using the prediction from the regression estimated on the largest panel of countries and time periods (column 1, Table III.1 and column 2, Table III.2) to have more robust and less distorted estimates (see Box III.3). The second step is to relate deviations of per

⁽¹²²⁾ For the EU and euro area, which include new member states, it is not possible to go further back than 1999, which is the start of the split sample in column (6) of Table I.2, due to the availability of the Fraser Index.

⁽¹²³⁾ Bower and Turrini (2010), op. cit., find that EU accession has accelerated growth and convergence for new member states.

capita GDP (or TFP) from these predicted convergence paths to variables reflecting the presence of macroeconomic imbalances.

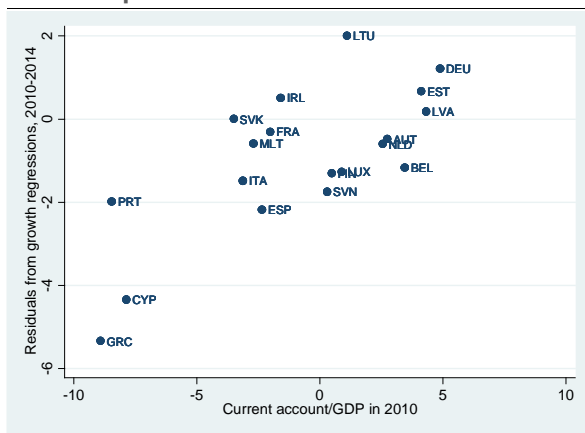
Graph III.10: Deviations from convergence path and private debt stocks



Source: Eurostat and authors' estimations.

Graph III.10 plots the average value of deviations from expected convergence paths in 2010-2014 for euro area countries against private debt-to-GDP ratios in 2010. Excluding Greece, there is a clear downward sloping relationship. This indicates that countries with the highest debt ratios in 2010 are those that have exhibited GDP per capita well below growth regression-based expectations.

Graph III.11: Deviations from convergence path and current accounts



Source: Eurostat and authors' estimations.

Similarly, Graph III.11 plots the average value of residuals between 2010-2014 for euro area countries against current account to GDP ratios in 2010. The plot displays a clear upward sloping relationship. This shows that countries with more negative current account ratios in 2010 are also

those that have shown GDP per capita clearly below what was predicted.

To simultaneously take into account the role of different sources of macroeconomic imbalances, we carry out a multivariate regression analysis. Six variables reflecting sources of macro-economic imbalances are considered: (i) the initial private debt-to-GDP ratio; (ii) the initial government debt-to-GDP ratio; (iii) the initial net international investment position (NIIP) in per cent of GDP; (iv) credit to the private sector as a share of GDP; (v) the current account gap; and (vi) the share of construction in total value added, as a proxy for changes in the weight of the non-tradable sector⁽¹²⁴⁾. All variables are in percentages. The credit variable and the construction share are both demeaned by the country long-term average to allow for different economic structures. The current account gap is estimated as the difference between the actual current account balance and what can be explained by the fundamentals of the economy, following the methodology proposed in Coutinho et al. (2018)⁽¹²⁵⁾. Box III.3 contains more details on the methodology.

Table I.3 shows the results from the regression analysis. These are displayed separately for the euro area and for a comparator group consisting of all countries except the euro area. It also shows two sample splits in time: after 1999, i.e. EMU completion, and after 2007, i.e. after the financial crisis. The same is repeated for GDP per capita and for TFP growth.

For the sample starting in 1999, private debt, government debt, NIIP and the share of construction are significant in explaining euro area GDP per capita convergence gaps. The corresponding coefficients have the expected signs. Looking at non-euro area countries, the loss in significance is observed for all variables except private debt, while current accounts have significant explanatory power. For the euro area, the estimated coefficients suggest that a reduction

⁽¹²⁴⁾ In this analysis, an excess weight of non-tradables, which are proxied by the weight of the construction sector in total GVA, is demanded by the country-specific average. This is used instead of unit labour costs (as used in Lukmanova and Tondl, 2017, op. cit.). One variable tends to correlate with the other and the weight of the construction sector in total GVA is available for a broader set of countries.

⁽¹²⁵⁾ Coutinho, L., Turrini, A., Zeugner, S. (2018), 'Methodologies for the Assessment of Current Account Benchmarks', European Economy Discussion Paper 086/September 2018.

Table III.3: Deviations from convergence paths and macroeconomic imbalances

	GDP growth residuals				TFP growth residuals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	EA>1999	Non-EA>1999	EA>2007	Non-EA>2007	EA>1999	Non-EA>1999	EA>2007	Non-EA>2007
Private debt/GDP, 5 lags	-0.008** [-3.80]	-0.014** [-3.89]	-0.013** [-3.64]	-0.001 [-0.20]	-0.008** [-3.96]	-0.011** [-3.55]	-0.010* [-2.45]	-0.003 [-0.78]
Gov. debt/GDP, 5 lags	-0.026** [-5.30]	-0.005 [-1.18]	-0.029* [-2.22]	-0.001 [-0.14]	-0.028** [-4.82]	-0.004 [-1.54]	-0.021 [-1.71]	-0.003 [-0.90]
NIP/GDP, 5 lags	0.008* [2.33]	-0.002 [-0.62]	0.011+ [1.76]	-0.001 [-0.21]	0.004 [1.16]	0.001 [0.43]	0.000 [0.07]	0.002 [0.65]
Credit flow/GDP, 5 lags (relative to country long-term average)	0.013 [1.38]	0.020 [1.45]	-0.023 [-1.36]	-0.030 [-0.86]	0.021* [2.30]	-0.005 [-0.44]	-0.008 [-0.52]	-0.024 [-1.07]
Current account gap, 5 lags	0.028 [0.91]	0.092+ [1.89]	0.078 [0.93]	-0.031 [-0.36]	-0.013 [-0.49]	0.068+ [1.86]	0.073 [0.87]	-0.021 [-0.49]
Construction VA share, 5 lags (relative to country long-term average)	-0.412* [-2.48]	-0.195 [-1.40]	-0.707** [-3.62]	-0.342 [-1.42]	-0.510** [-3.79]	-0.103 [-0.69]	-0.492* [-2.57]	-0.143 [-0.67]
Observations	53	93	19	32	53	93	19	32
Countries	19	32	19	32	19	32	19	32
R-squared	0.51	0.35	0.75	0.40	0.53	0.28	0.64	0.42

(1) Robust t-statistics in brackets. ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$

Source: Authors' estimations.

of 10 percentage points (pps) in private debt would reduce the convergence gap by around 1 pps. While reducing government debt by 10 pps would reduce the convergence gap by around 2.5 pps.

Results remain statistically unchanged for the euro area when restricting the analysis to the post-crisis period. Wald tests fail to reject the null hypothesis that the estimated coefficients for the two sub-periods are equal at the 95% confidence level. Conversely, for non-euro area countries, the significance is lost for all variables. This is likely due to the reduced number of observations. Across time and country samples, the most robust factor deterring convergence is the presence of high private debt. However, for the euro area high public debt and a high weight of non-tradables also seem important. Turning to the analysis of deviations from TFP growth paths, the role of private and government debt as well as construction is confirmed for euro area countries. For non-euro area countries, a significant role is found only for private debt and current accounts.

Overall, results indicate that to a certain extent convergence gaps across the euro area are a consequence of the presence of macroeconomic imbalances. Also, that the relevant factors underpinning imbalances are not the same as those that explain convergence gaps across the comparator country group. The relatively stronger role of government debt in explaining convergence gaps of euro area countries can be linked to the

probability of bond market tensions increasing more than proportionally with the size of debt, i.e. threshold effects. As government debt is on average higher in euro area countries, the result appears consistent with this hypothesis. Furthermore, de Grauwe et al. (2013) demonstrate that euro area countries are more vulnerable to self-fulfilling government debt crisis⁽¹²⁶⁾. On the other hand, current accounts seem less important for euro area countries in explaining deviations from convergence paths. A possible interpretation is that the liquidity provision by the European System of Central Banks helps mitigate the real effects of current account sudden stops. Finally, convergence paths among euro area countries appear to be comparatively more related to a past of strong growth in the tradable sector. This is not significant for non-euro area countries and appears consistent with the stylised facts reviewed in Section I.2. The narrowing of interest rates in the euro area periphery, as a result of monetary union, was matched by capital inflows largely channelled into the construction sector and other non-tradable activities. After the crisis, the contraction in domestic demand led to the contraction of non-tradables, in some cases amid the bursting of housing bubbles. The fact that resources were largely absorbed in non-tradable activities meant the euro area periphery had less room to keep

⁽¹²⁶⁾ De Grauwe, P. and Ji, Y., 2013. Self-fulfilling crises in the Eurozone: An empirical test. *Journal of International Money and Finance*, 34, pp. 15-36.

growing out of exports, in a context where domestic demand remained persistently subdued in the presence of deleveraging needs. Moreover, as TFP growth is generally faster in the tradable sector, the growth of construction and non-tradable activities is associated with subsequent disappointing growth rates in TFP.

III.5. Conclusions

This article uses a large dataset of advanced and emerging economies to: analyse convergence in the euro area from a comparative perspective; disentangle which components of per-capita GDP have been converging or diverging; estimate expected convergence paths; and lastly, assess the role played by macroeconomic imbalances in explaining deviations from these paths.

The analysis of sigma convergence, i.e. a falling dispersion in real variables, indicates that convergence across the EU and the euro area does not differ much compared to comparator country groups. However, when focusing solely on EA-11 founders, excluding Luxembourg, evidence of convergence gets weaker and divergence is rather prevalent in post-crisis years. Lack of convergence for the EA-11 could partly be related to the fact that this is a much more homogenous group in terms of per capita income, especially when compared to the EU, euro area or other comparator groups. It is therefore expected to exhibit a slower rate of convergence.

Moreover, the divergence process observed for this group of countries after the crisis is largely related to divergent employment rates. This is evident when comparing the dispersion in GDP per capita with the dispersion in GDP per employee and is likely to be a transitory phenomenon. Nonetheless, a more worrying and structural aspect underpinning weak convergence among the EA-11 is the virtual absence of convergence in TFP in recent decades.

The estimation of growth regressions confirms that the EU and euro area exhibit conditional beta convergence, i.e. per capita GDP grows faster when initial levels are lower, taking into account the effect of other growth drivers. However, this is not the case for the EA-11. The result is similar for TFP convergence.

Predictions from growth regressions allow us to estimate expected convergence paths. Deviations from these paths are associated with a number of initial conditions, which summarise the presence of macroeconomic imbalances, private debt in particular. Most interestingly, the euro area seems to be affected by a number of peculiar factors, notably government debt and the share of the construction sector on value added, which have no significant role among a comparator group. The fact that government debt is on average higher in euro area countries and the increased vulnerability of single currency members to a self-fulfilling government debt crisis could explain this result. As for construction, this could be explained by the fact that the EMU start-up shock led to a decline in real interest rates in the euro area periphery, followed by a relative expansion of non-tradable activities, characterised by relatively low TFP growth.

Overall, the analysis underscores the importance of conditions ensuring macro stability and resilience for economic convergence. Preventing the accumulation of excessive private debt is particularly important both inside and outside the euro area. In addition, there is a specific role for maintaining prudent levels of public debt and running prudent fiscal policies within the euro area. An important policy implication is that sustainable convergence requires continuing to address legacy imbalances. In this respect, it will be important not only to maintain effective economic surveillance to monitor the completion of the structural adjustment, but also to ensure a more symmetric adjustment within the euro area as this would support nominal growth in the periphery and a faster adjustment of stock imbalances. Moreover, completing and deepening EMU would help prevent the accumulation of new harmful imbalances and their negative repercussions on convergence dynamics. Completing the banking union in order to delink bank and sovereign risk should help reduce the euro area's vulnerability to self-fulfilling debt crisis. Completing the capital markets union would also help reallocate surpluses in the euro area through equity rather than debt. It might also help prevent the misallocation of capital that led to the excessive expansion of non-tradable sectors in the EU (Buti and Turrini, 2015).

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