EURONA

EUROSTAT **R**EVIEW
ON **N**ATIONAL **A**CCOUNTS
AND MACROECONOMIC
INDICATORS

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EUROSTAT REVIEW ON NATIONAL ACCOUNTS AND MACROECONOMIC INDICATORS

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Aims and scope

EURONA is an open access, peer-reviewed, scholarly journal dedicated to National Accounts and Macroeconomic Indicators. EURONA aims at providing a platform for researchers, scholars, producers and users of macroeconomic statistics to exchange their research findings, thereby facilitating and promoting the advancement of National Accounts and Macroeconomic Indicators.

EURONA publishes empirical and theoretical articles within the scope of National Accounts and Macroeconomic Indicators, as well as articles on important policy uses of these statistics. They may relate to both users' and producers' interests, present subjects of general relevance or investigate specific topics.

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Editorial

This edition of EURONA includes articles on an eclectic selection of subjects related to national accounts and macro-economic indicators.

In the first article, Celestino Girón, Enrique Quilis, Daniel Santabárbara and Carlos Torregrosa develop a methodology and a tool to estimate the future path of interest payments by central government on cash and on accruals (ESA 2010) basis. As interest burdens have become large expenditure items on many countries' government accounts, the tool can be used to evaluate the impact on size and structure of future interest payments of, for example, different macroeconomic or budgetary scenarios.

In July 2016, the Central Statistics Office of Ireland revised its GDP for 2015 to take into account the relocation to Ireland of balance sheets of large multi-national enterprises. In the second article, Silke Stapel-Weber and John Verrinder discuss the implications of this case, and of globalisation in general, on the national accounts. Globalisation raises profound questions for national statistics. The authors argue that the issue is not about revisiting the methodology, but about the practical aspects of international cooperation for producing statistics and of communicating with users.

The third article makes a contribution to the analysis of productivity level differences across countries. Laurent Olislager and yours truly describe the estimation of experimental Purchasing Power Parities (PPPs) for industries. These PPPs can be used to calculate price-level adjusted labour productivity values which enable users to more reliably identify which industries in which countries are more and which are less productive and thereby support policies towards increasing productivity and growth.

Finally, this edition closes with an analysis of the similarities and dissimilarities in the business cycles of European countries before, during and after the double-dip recession in Europe. Using an innovative approach to define and analyse the different stages of the business cycle of each country, Jacques Anas, Ludovic Calès and Gian Luigi Mazzi demonstrate that the recessions had the effect of increasing the divergence in the business cycles.

I hope you will enjoy this issue of EURONA.

Paul Konijn

Editor of EURONA

1 Modeling interest payments for macroeconomic assessment

CELESTINO GIRÓN [1], ENRIQUE M. QUILIS [2], DANIEL SANTABÁRBARA [3] AND CARLOS TORREGROSA [4]

Abstract: In this paper we present a methodology designed to estimate the future path of interest payments by the central government. The basic idea is to represent in a compact way the joint dynamics of debt liabilities and interest payments as a function of four elements: the initial outstanding amounts of debt, the expected primary funding needs, the expected yield curves and the government expected issuance strategy. Our methodology delivers estimates of interest payments on both cash and accrual basis (following ESA2010), as well as a detailed representation of the debt term structure. Moreover, the procedure is amenable to scenario-based simulation. We illustrate this approach estimating the Spanish central government interest burden for the period 2015-2025.

Keywords: Interest payments, yield curve, forward rates, debt dynamics.

JEL codes: E43, E44, E47, E63.

(1) European Central Bank.
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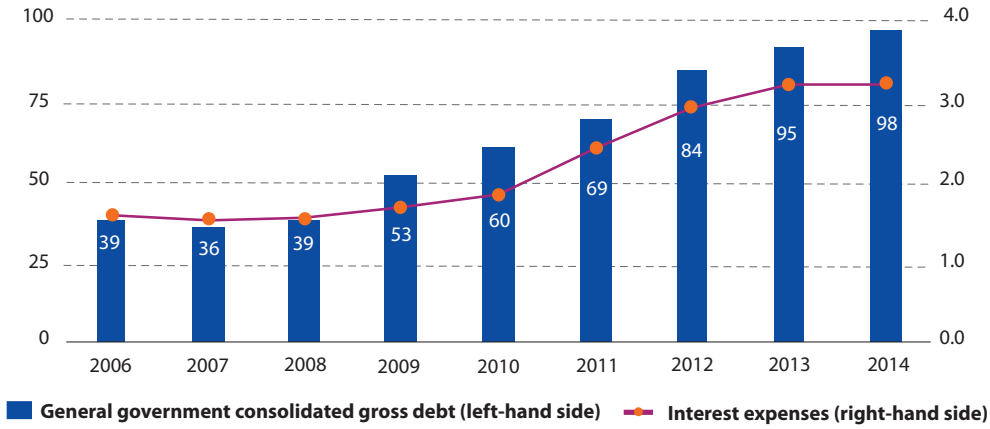
1. Introduction

Since the start of the economic and financial crisis, the level of government debt in Spain has dramatically risen from 36 % in 2007 to 98 % at the end of 2014. In parallel to this, the interest burden has become one of the most important government expenditure items (exceeding 3 % of GDP) and, therefore, central to the monitoring of budget stability and debt sustainability, see Figure 1.

Figure 1: Spanish interest burden
(% GDP)



Source: AMECO

Thus, a thorough monitoring of the trend of the expected interest burden, both on a cash basis and in national accounts terms, becomes very relevant, also with the aim of exploring the existence of room for maneuver for government expenditure in other areas.

Against this background, we developed a toolkit to forecast the interest burden evolution. This paper presents the methodological development and, as an application of it, an estimate of interest expenses for the period from 2015 to 2025.

The basic idea behind the methodology is to represent in a compact way the joint dynamics of debt liabilities and interest payments as a function of five elements: the initial outstanding amounts of debt (i.e. 'debt portfolio') and their associated payment streams, the expected path of the primary funding needs, the expected yield curves and the expected issuance strategy by the issuer.

Our methodology takes into account the distinction between budgetary data (mainly recorded on a cash basis) and national accounts data according to ESA2010 ([5]) (recorded on an accrual basis).

The illustrative 2015–2025 exercise is run at the quarterly frequency, using input data provided by the Spanish Treasury (initial State debt portfolio), the Bank of Spain (initial Other Central Government Units debt portfolio) and Bloomberg (forward yield curve). It requires undertaking initial calculations that can be grouped into two stages, each of them related to a distinctive

([5]) see Eurostat (2013)

component of the methodology. In the first stage we calculate the interest burden of the pre-existing debt portfolio of the central government, using the specific features of each individual security outstanding at the beginning of the period to build the interest cash payments and the underlying interest rate in accrual terms.

The illustrative 2015–2025 exercise requires initial calculations that can be grouped into two categories or stages, each of them related to a distinctive output of the methodology. In the first stage we calculate the interest burden of the pre-existing debt portfolio of the central government, using the specific features of each individual security outstanding at the beginning of the period to build the interest cash payments and the underlying interest rate in accrual terms.

In the second stage, we derive estimates of the expected interest expenses on future gross financing needs. For that, we make use of the forward yield curve for estimating the cost of financing, and we obtain a path for the expected gross financing needs based on the redemption schedule derived from our dynamic equations and estimates on primary funding needs. Both outputs of the numerical exercise, initial interest cost and future cost, are recorded in cash and accrued terms to make it comparable with the state budget (cash) and national accounts figures (accrued).

Modeling interest payments is not only a key ingredient of the monitoring of the central government budget and fiscal conditions but also has relevant implications for debt management purposes, see for example Denmarks Nationalbank (2014), Bolder (2008) or Bolder and Deeley (2011). However, the focus of our approach is aimed at the general implications of macroeconomic and budgetary projections on the interest burden rather than on the quantification of alternative financial scenarios (e.g. yield curve scenarios) on the interest burden and its cost and risk profile.

The paper has two main parts. The first one is devoted to general methodological issues and comprises sections two and three. The second part deals with the basic inputs of our modeling approach and comprises sections four to seven. Exposing the structure of the paper in greater detail, section 2 summarizes the conceptual framework behind the recording of interests on cash basis and in national accounts. In section 3 we describe the dynamics of debt in our modeling framework. Section 4 details the sources, methods and assumptions taken to estimate the set of initial outstanding amounts and yields of government liabilities bearing interests for our numerical exercise. Section 5 describes the use of the forward interest rates to estimate the expected cost of future issuances Section 6 is devoted to the assumptions behind the government issuance strategies. Section 7 covers the establishment of paths of primary funding needs, which is the contemporary impulse for the debt dynamics. Complete numerical results are presented for the period 2015–2025 in section 8 and section 9 concludes. Finally, several appendixes provide a detailed overview of the national accounts conventions used (Appendix A), the computation of accrued interests (Appendix B), the budgetary information (Appendix C) and the MATLAB code used to perform all the computations that, apart from avoiding messy spreadsheet calculations, provide an easy way to perform scenario-based simulations and risk analysis (Appendix D).

2. Cash and accrual recording

To calculate interest expenses two criteria can be followed: cash recording, consistent with budget figures, or accrual recording, in line with national accounts standards. The methodological difference between accrual and cash recording is the timing of recognition of the interest expenses. The cash method accounts for interest expenses only when the money is paid out, whereas accrual recording accounts for the interest expenses in a smooth way over the whole life of the financial instrument reflecting the building-up of the economic liability.

2.1. Cash recording

In cash recording interest expenses are accounted for in the moment they are paid. In the case of zero coupon bonds, implicit interest payments are recorded at maturity. For bonds with coupons, interest expenses amounts to the coupons actually paid and are recorded in the moment that they are paid. Loans are treated in a similar manner: interest payments are reflected when the cash payments are made. Hence, knowing the cash flow structure of each security is sufficient for calculating and temporary allocating the interest expenses.

2.2. Accrual recording

In national accounts interest expenses are recorded on an accrual basis continuously in time as the corresponding liability is arising. Moreover, the European standards for national accounts prescribes the recording on a compound interest basis using the rate prevailing at inception, and following a principle of reinvestment of the interest accrued but not paid in the corresponding debt instrument, see the Appendix A.

In analytical terms the national account requirements implies that the interests recorded in each period t, I_t, depend on the yield at inception, r_0, and the outstanding amount at the beginning of the period, S_{t-1}, — which should include interests accrued and not paid — according to the rule $I_t = r_0 * S_{t-1}$, r_0 expressing yield per period t, if there is no coupon or other cash payments during the period.

In more general terms, if there is a cash payment P_t at a fraction a_t of the length of the period t, the interests accrued would then be:

$$[1]\ I_t = S_{t-1}[(1+r_0)^{a_t} - 1] + [S_{t-1}(1+r_0)^{a_t} - P_t][(1+r_0)^{1-a_t} - 1]$$

where the two right-hand side additive members capture the accruals before and after the payment respectively. The accruals after the payment ($[S_{t-1}(1+r_0)^{a_t} - P_t][(1+r_0)^{1-a_t} - 1]$) result from applying the interest rate r_0 on an outstanding amount that has been increased over the stock at the beginning of the period (S_{t-1}) by the interest accrued before the payment ($S_{t-1}[(1+r_0)^{a_t} - 1$) and reduced by the amount of cash effectively paid (P_t). Note that if $P_t = 0$ then [1] collapses into $I_t = r_0 * S_{t-1}$. Equation [1] can be easily generalized to any number of cash payments during the period.

Taking $S_t = [S_{t-1}(1+r_0)^{a_t} - P_t][(1+r_0)^{1-a_t}$ (which derives from the rule of reinvestment of accruals), [1] can be expressed in the convenient way:

$$[2]\ I_t = S_t - S_{t-1} + P_t$$

where S_t can in turn be derived, calculating iteratively, forwardly from:

$$S_t = \frac{S_{t+1}}{1+r_0} + \frac{P_{t+1}}{(1+r_0)^{a\,t'}}$$

as

$$S_t = \sum_{i=t+1}^{n} \frac{P_i}{(1+r_0)^{i-t-1+a\,i}}$$

n being the period in which the last payment is made; i.e, S_t is the net present value (NPV) discounted with the rate at inception r_0 of all future cash payments.

[1] and [2] tell us that to derive a full set of accruals for $t = 0 \ldots T$ it is necessary to have at our disposal an initial stock S_0, the associated yields at issuance (r_0) and the stream of cash flows (P_t).

When bonds are issued at premium (above nominal) — by product of coupons exceeding market rates — interest expenses in cash terms are over-estimated compared to national accounting over the whole life of the debt instrument as the premium fees are considered, in budgetary term, as non-financial revenues (and not as a reduction in interest expenditure).

3. Modeling debt dynamics

In this section, we explain the procedure used to project the debt portfolio and its corresponding flow of interest payments stratified by residual maturity. The procedure considers a discrete state space representation of both elements that provide a compact representation of the joint dynamics of debt and interest payments.

The quarterly evolution of the debt portfolio is driven by its intrinsic dynamics (determined by its motion to maturity) and an impulse factor related to the new flow of debt. The equation is:

[3] $B_t = FB_{t-1} + \Delta B_t$

Being:

- B_t is a $kx1$ vector that represents the outstanding debt at the end of period t at the different $i=1 \ldots k$ residual maturities. The first element represents the debt that matures immediately (and has to be refinanced).
- F is a square k-dimensional binary matrix that embeds the motion in residual maturity of a bond from period t to $t+1$; i.e F is of the form.

$$F_{kxk} = \begin{bmatrix} 0_{(k-1)x1} & I_{(k-1)x(k-1)} \\ 0 & I_{1x(k-1)} \end{bmatrix}$$

- ΔB_t is a $kx1$ vector that contains the issuance of new debt (gross financing needs) at the various maturities $i=1 \ldots k$ in period t.

The new debt is issued to finance redemptions of existing debt, coupon payments and primary funding needs:

[4] $\Delta B_t = w(B_{t-1,1} + \rho C_{t-1} + x_t)$

Being:

- w is a $kx1$ vector that defines the issuance strategy (see section 6).
- $B_{t-1,1}$ contains the debt refinanced in period t (first element of the vector B_{t-1}).
- C_{t-1} is a $kx1$ vector that comprises the coupons attached to the outstanding amounts at the end of period $t-1$ contained in vector B_{t-1} for the $i=1\ldots k$ residual maturities.
- ρ is a $1xk$ binary vector that signals the residual maturities at the end of $t-1$ that pay coupon in period t (for quarterly data — of annually paying par bonds — as in this exercise, this is a vector with 1 in its components multiples of 4 and 0 otherwise).
- x_t is the primary funding needs: operations that have to be financed without relation to the existing debt portfolio (see section 7).

The issuance vector w is constrained: $w_i \geq 0 \; \forall \; i$ and $\sum_i w_i = 1$.

Independently of the composition of the current debt portfolio, we assume that the new debt is only formed by fixed income bonds issued at par and, hence, the evolution of the coupons mirrors the evolution of the debt portfolio:

[5] $C_t = FC_{t-1} + y_t \bullet \Delta B_t$

Where:

- y_t is the $kx1$ vector of yields of the newly issued bonds in t at different maturities $i=1 \ldots k$ (see section 5 for the derivation of this vector from the market forward rates).The fixed coupon is defined as the element-by-element (•) product of y_t and ΔB_t.

The simplification that future emissions will be made at par can be justified as a neutral approach. The difficulty to know in advance the specific conditions that will prevail in the sovereign debt markets during time horizon of the model (10 years) makes it virtually impossible to model so far ahead the preference for specific cash-flow profiles, i.e., the decisions whether to issue at par, above par or below par.

The interests accrued in period t depend on the frequency of the coupon relative to the frequency of the time series in the model:

[6] $I_t = \beta C_{t-1}$

Where:

- β is a scalar capturing the relative frequencies. For quarterly data of annually paying par bonds, $\beta = 1/4$ (ignoring differences in the length of the quarters).

Assuming an initial debt portfolio with its corresponding coupons B_0 *and* C_0 (see section 4), the model [3]-[6] can be iterated from $t = 1$ to $t = T$ to generate the corresponding paths for debt, coupons and interest accrued.

4. Initial debt portfolio

The first step of our methodology requires setting the initial stock of public debt outstanding. For our numerical exercise an initial stock of debt at the beginning of 2015 has been prepared for the central government mainly using the security by security information about the outstanding amount of the negotiable State debt or T-bonds (Bonos y Obligaciones del Estado) at the end of 2014, provided by the Spanish Treasury, and completed with the issuances of the first quarter of 2015 and shorter-term securities.

Additional information for the remaining units of the central government subsector and for loans has been obtained from the Bank of Spain and other sources (e.g., debt assumptions made by the Treasury reported in the Official State Gazette). A detailed description of the instruments that make up the portfolio is provided in Appendix C, whose summary is as follows:

Table 1: 2015 State budget: interest expenditure (Chapter 3)

	1000 million EUR	%
Medium & long term securities (Treasury bonds and notes)	32.55	91.72
Loans	1.02	2.88
Short term securities (Treasury bills)	0.58	1.63
Assumed debt	1.23	3.47
Others	0.11	0.30
Total interest expenditure (cash basis)	35.49	100.00

The information from the Treasury covers the details singled out above necessary to estimate cash payments and accrued interest. In particular, it includes the relevant data on the coupon payments (rate, frequency, date of payment, fixed or variable nature), the dates of issuance and maturity, and the outstanding amount at the end of 2014. All this information is provided for every issued tranche of a particular bond.

In addition, data for zero coupon short-term securities (Letras del Tesoro or T-bills) was taken from information of issuances published in the web page of the Treasury. The information used for relevant T-bills was the average yield, allotted amount and the issuing and maturity dates. The Spanish Treasury also provides information on an aggregated basis about the outstanding amount, average maturity and average interest of the State debt other than Treasury bills and bonds.

All this information enables to construct monthly cash flows for each of the securities or loans with fixed coupon rates. For variable coupons rates, which are linked to inflation, a smooth convergence to 2 % inflation rate (the ECB policy objective) by 2018 has been assumed. For coupon payments linked to the EURIBOR, EONIA or other market rates, the particular conditions of each issuance, such as spread and reference indices, have been considered.

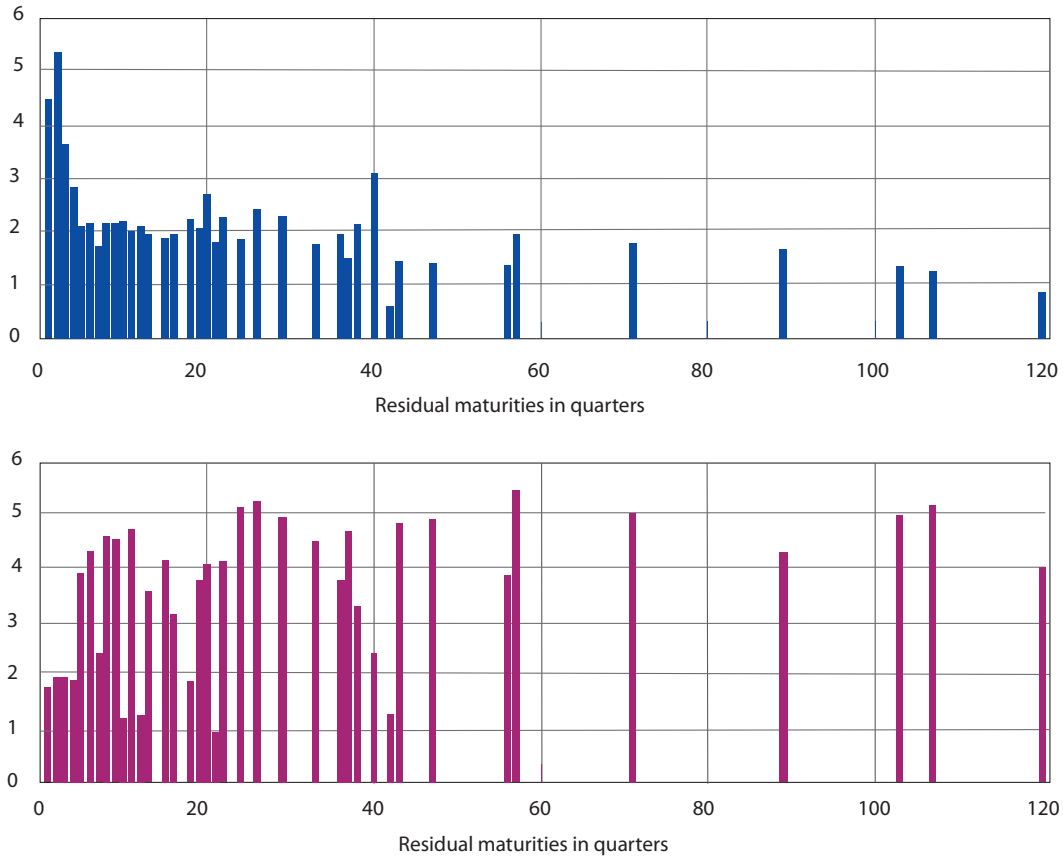
Furthermore, the outstanding amounts have been stratified according to the number of quarters to redemption or residual maturity. To assign an Internal Rate of Return (IRR) to the strata, the weighted average across the several IRR_j of the j elements in each strata i has been calculated (to obtain an average IRR_i per residual maturity i).

The simplifications above enables us to construct the initial conditions for the dynamic modelling: two vectors of dimension *kx1*, where *k* is the residual maturity in quarters, B_0 and C_0, containing respectively the initial nominal value and the corresponding coupon payment for every $i = 1 \ldots k$ residual maturity, where $C_{0,i} = IRR_i B_{0,i}$.

Note that vector C0 does not correspond with the actual coupon payments of the initial securities, but it rather represents a re-basement of the payments as if the securities had all been issued at par at the calculated IRRs. This aligns with the simplification in the dynamic modelling of reissuance at par (see section 3).

Figure 2 shows the initial debt portfolio of the central government and its corresponding interest rate profile.

Figure 2: Initial debt portfolio and interest rate profile
(Debt (million EUR), interest rate (%))



Source: Authors' calculations

5. Forward interest rates

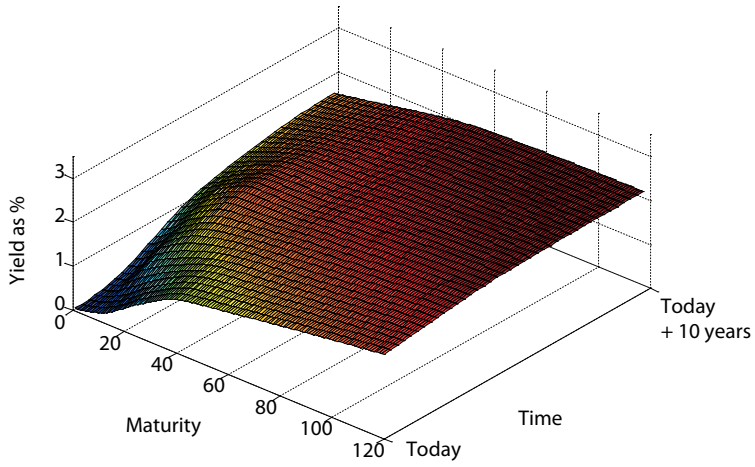
To estimate the interest payments for the future gross financing needs of the central government, there is a need to assess its financing needs (related both to refinancing and new financing needs) and its issuing strategy, but also the expected interest rates at which that new government debt will be issued.

To estimate such rates in different points in time, we have used the information on implied market forward rates, the expected future yield on the Spanish government bonds, based on trading market data. Forward rates are usually presented in two ways. First, as (market expectations on) the path of future interest rates on bonds for the same maturity. Second, as the relationship between yield and a bond's maturity at some point in time (spot or future). This two presentations are put together in the 'market forward matrix' where the path of future interest rates on bonds with the same maturity are placed in columns (or rows) and the relationship between the yield and a bond's maturity is in rows (columns).

For this exercise, the forward matrix used was based on market data as of March, 18th 2015. The precise date was chosen once all issuance of the first quarter were completed.

To get enough data granularity, interpolation by means of cubic splines has been applied on both dimensions of the forward matrix (maturities and calendar time) to obtain a yield surface:

Figure 3: Surface of forward interest rates (March 18th, 2015)
(%)



Source: Authors' calculations based on Bloomberg data.

Note that forward rates are based on arbitrage-free rates for dealing today at rates that are effective at some point of time in the future. As such, forward rates are a type of market view on where interest rates should be in the future. Irrespective of their forecasting performance, forward rates provide an objective benchmark broadly used in financial markets. Moreover, the forward matrix could serve as a basis to gauge alternative projections or to generate stochastic scenarios of the yield curve.

6. Issuance strategy

For the time horizon of the exercise we have distinguished two distinctive periods. For 2015 the assumed strategy follows the Spanish Treasury published guidelines. For 2016–2018 it has been assumed that results in maintaining the maturity structure, i.e., the same share of bonds at each maturity, prevailing at the end of 2015.

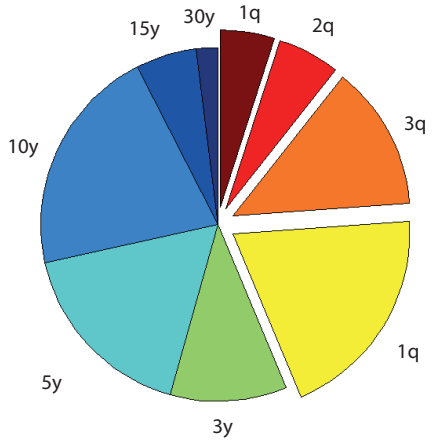
For 2015 we follow the guidelines included in its Issuance Strategy Report (Spanish Treasury (2015)) that includes gross and net financing plans and a tentative issuance calendar. Briefly, the Treasury funding needs are, both in gross and in net terms, very similar to those of 2014, although the central government is also offering regional and local governments additional funding tools, through which the Treasury would take over most of their market financing (see section 7 on the impact of this policy on the future primary funding needs).

- Total gross issuance will be around 239.369 bn €. Medium- and long-term instruments (T-bonds) gross funding will be around 141.996 bn € and short-term T-bills will be 97.373 bn €.
- Net funding target is 55 bn €. Medium and long-term net funding is set in 50 bn € and net issuance of short-term T-bills in 5 bn €.
- On the securities issued (i) T-bills issuance schedule and maturity pattern is not expected to change substantially compared to 2014 (regular auctions of 3 to 12 months securities) although the maturity structure will slightly move towards longer maturities; (ii) nominal fixed-coupon T-bonds auctions are l also not expected to change in schedule, though the maturity structure could change; and (iii) inflation-linked T-bonds will be reinforced and incorporated into regular auctions.

Note that the Treasury might also conduct special auctions, resort to bank syndication and issue debt through private placements, in which specific securities are sold directly to investors.

Based on this plans, the issuance strategy assumed for our numerical simulations is represented in the following pie chart:

Figure 4: Issuance strategy
(%)



Source: Authors' calculations based on Treasury data

7. Primary funding

The debt dynamics are ultimately driven by the evolution of the primary funding needs. In this way, its state space representation [3]-[6] can be considered as an amplification filter of the basic impulses contained in the primary funding.

We have considered a simple model that assumes that the primary funding is a time-varying linear function of the nominal GDP:

$$[7]\ X_t = \delta_t P_t Y_t$$

Equation [7] provides a simple way to generate complex stochastic scenarios combining alternative paths for the δ ratio (fiscal dimension), the price level P (inflation dimension) and the real GDP Y (growth dimension).

On the one hand, the inflation and growth dimension can be linked to an explicit macroeconomic model, granting a well-rooted economic support for the simulations. On the other hand, the δ ratio is a simplified, reduced-form attempt to capture the complex mapping from macro conditions (nominal GDP) to primary funding. We have encapsulated in one variable the interactions of the expenditure and income side of the government's budget as well as government's financial investment activities, simplifying many gears and levers in order to achieve a compact representation amenable for scenario-based simulation.

This simplified approach is the standard practice for Debt Management Offices, see Adamo et al. (2004) and Jensen and Blommestein (2005), and must be considered as the starting point of a more structural, comprehensive approach that integrates macro and financial factors. Of course, the greater structural content of the latter approach must be balanced against its greater complexity; see De Paoli et al. (2007) for a case in point related to the integration of the complete (real and nominal) yield curve in state-of-the-art dynamic macro models.

From 2016 onwards, we have considered that the primary funding is derived from the macroeconomic scenarios internally computed by AIReF, the Spanish independent authority for fiscal authority. This parametric way to introduce alternative paths for the primary funding is simple and transparent and allows us to assess the consistency of other assumptions, e.g. those contained in the Stability Program.

The future annual primary funding path includes, together with an assumed primary deficit dynamic, an estimate of the stock-flow adjustments associated with the progressive financing support offered by the central government to the regional governments ([6]). The annual profile resulting from these estimates is depicted in Figure 5.

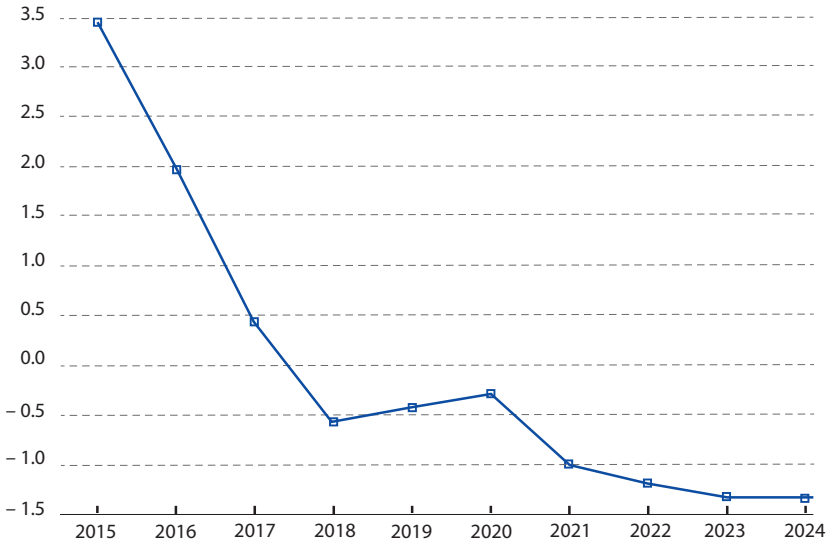
Note that this ratio becomes negative from 2018 onwards. In this way, the ultimate source of debt issuance will eventually disappear. This sign reversal opens different possibilities for the issuer, which range from stopping new issuance to embracing an active program of debt repurchases aimed at reducing the debt level and its corresponding interest burden.

We have assumed that new issuance stops when the primary funding requirements become negative, while existing debt continues to be refinanced. This simple schedule provides a benchmark for more sophisticated strategies.

([6]) Since 2012 the central government has been offering the regional governments financing lines in order to reduce their cost of finance in a context of excessive risk premium and/or lack of access to financial markets. At the end of 2015 these financing mechanisms meant 48 % and 21 % of regional and local governments EDP outstanding debt, respectively. The net funding needs of central government in 2015 amounted to 38 billion €, very similar to the net financing granted to regional governments, while most of the central government deficit was financed via the disposal of financial assets.

A given path for the annual nominal GDP would allow us to map the ratio into an annual nominal time series. This series can then be interpolated by means of a univariate temporal disaggregation procedure to be properly plugged in our quarterly debt simulation engine. The next figure plots the assumed annual nominal GDP profile we have used in our calculations.

Figure 5: Primary funding to GDP ratio, 2015–24
(%)



Source: Authors' calculations based on AIReF's scenarios.

8. Numerical results

The final output of our methodological approach is a quarterly path for the interest payments linked to the combination of an exogenous path for the primary funding needs, a yield surface based on the forward rates, an initial debt portfolio and an issuance strategy.

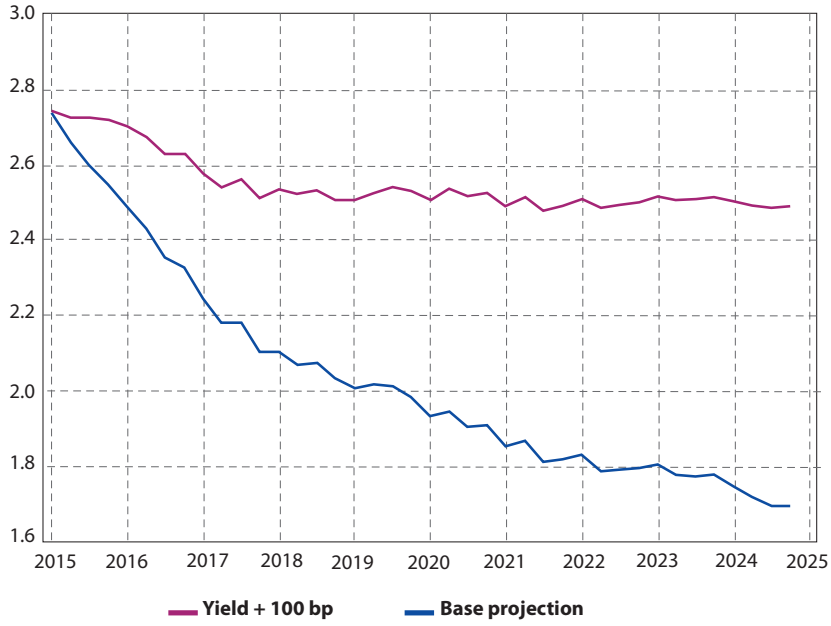
We provide here some numerical results related to a complete computation starting at the second quarter of 2015. The time scale of the model is quarterly and the maturities range from 1 to 120 quarters (0.25 to 30 years). The inputs for the numerical results have been described in the previous sections.

Figure 6 depicts two ten-year-ahead quarterly paths of interest accrued, one resulting from using all the above mentioned inputs and another one linked to a 100 basis points (bp) parallel shift of the yield surface.

The base projection draws a steady reduction of the interest burden with respect to nominal GDP, ending at around 1.7 % in 2024. However, this result is quite sensitive to movements in the yield surface. The 100 bp shift generates a much slower decline of the interest burden, ending at around 2.5 % in 2024, despite the sign reversal of the primary funding needs common to

both projections. Refinancing the new debt issued at higher interest rates has thus a noticeable accumulative impact. In the long run, this impact increases the interest payments over nominal GDP ratio in about one point.

Figure 6: Interest payments to GDP ratio, 2015–25
(%)



Source: Authors' calculations

9. Conclusions

In this paper we have outlined a fully-fledged methodology to estimate the evolution of interest payments as a result of its basic determinants: initial debt portfolio, primary funding requirements, expected yield surface and issuance strategy. This methodology can be considered in a stand-alone way or embedded in a more complex system (e.g. as a component of a structural macro model).

We apply the methodology to produce an estimate of the interest burden for the Spanish central government for the period 2015-2025. More generally, the model can be used to assess official interest burden projections (e.g. those from the Stability Program) and exploring the sensitivity of interest expenditure to changes in the yield curve, primary deficit assumptions or macroeconomic factors like inflation and GDP growth. The methodology is easy to replicate and takes into consideration the main drivers of the dynamics of debt and interest payments, making it suitable as a fiscal surveillance monitory device.

The methodology can be extended and improved in various ways. For instance, a more sophisticated issuance strategy when the primary funding becomes negative may provide

an interesting complement to the inertial 'no pumping' scheme used in this paper. Similarly, a comprehensive macroeconomic scenario analysis, exploring alternative combinations of growth, inflation and primary funding requirements, can offer a better understanding of the dynamics of debt and interest payments and its sensitivity to alternative assumptions.

Risk analysis deserves a special mention. The exposure to alternative yield scenarios is a key ingredient in any modern debt management procedure. Thus, by assuming that the yield curve evolves in its three basic components (level, slope and curvature) we can simulate alternative yield surfaces and compute the probability distribution of the present value of the future payment cash-flow. This probability distribution will enable us to compute location measures (mean/median cost) as well as risk measures (cost at risk, expected shortfall cost, variance).

Finally, using the issuance strategy as an instrument variable, a cost-risk frontier can be generated and a search for efficient strategies can be implemented.

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Appendix A: National accounts conventions

According to the European system of national and regional accounts in the European Union (ESA 2010, see Eurostat (2013)), interests are to be recorded on an accrual basis ('as accruing continuously over time to the creditor on the amount of principal outstanding'), and, if not paid, as reinvested in an asset of the creditor vis-à-vis the debtor (ESA 2010 4.50), preferably under the same financial instrument on which they accrue (5.242). Moreover, for the government sector they are to be recorded under the 'debtor approach': 'based on the rate or yield prevailing at the time of creation of the financial instrument' (20.180). Although there is no clear prescription in the ESA, the Manual on Government Deficit and Debt (MDD, see Eurostat (2016)), which complements the ESA 2010 by clarifying the statistical treatment of government related issues, recommends the recording of interests on a compound interest basis. Table A1 shows the difference between interest payments recorded on a cash and accrual basis based in actual data for the Spanish State during the period 2009-2015:

Table A1: Spanish State: interest payments
(million EUR)

Spanish State. Interest payments			
Year	**Cash basis**	**Accrual basis**	**Difference**
2009	17 652	16 359	1 293
2010	19 641	18 157	1 484
2011	22 195	22 403	– 208
2012	26 059	25 694	365
2013	28 410	28 797	– 387
2014	31 818	30 826	992
2015	31 744	29 488	2 256

The role of the cash-accrual adjustment attributed to the difference between the redemption price and the issue price is also interesting as, according to the ESA 2010, it has to be distributed over the years to the maturity of the bond.

Due to the recent decline of interest rates during 2014 and 2015, the cash-accrual adjustment resulting from the re-issuance of bonds above par has become substantial and is one of the main factors behind the deficit-debt adjustment in Spain, as well as the national accounts adjustment of interest payments. Table A2 compares for 2014 and 2015 the amount of the premium fees with the cash-accrual adjustment, according to the actual data published for the Spanish State:

Table A2: Premium fees and cash-accrual adjustment
(million EUR)

Year	Premium fees	Cash-accrual adjustment
2014	8 454	– 6 012
2015	12 259	– 9 070

Appendix B: The role of the internal rate of return to estimate accrued interest

In Table B1 a numerical example is provided in order to illustrate how the Internal Rate of Return (IRR) is used to estimate accrued interest. We assume a four year bond issued above par on 12/03/2016, with a premium of 5 %, nominal value of 500, coupon rate of 2.4 % to be paid each March 12th, and date of redemption fixed on 12/03/2021.

The annual IIR is 1.36 %, that is, the annual rate that makes the Net Present Value (NPV) of all cash flows of the bond (P_t) — shown in the second column — equal to zero at inception. The NPVs (S_t) after each payment or at the end of each year, calculated using the IIR of 1.36 % as discount rate, are shown in the third column of the table.

Table B1: Accrued interests

Date	Cash-flows (P_t)	NPV (S_t)	Interest accrued from previous date (using equation B2)	Interest accrued in the year (using equation B3)
12/03/2016	– 525	525.00		
31/12/2016	0	530.74	5.74	5.74
12/03/2017	12	520.13	1.39	
31/12/2017	0	525.81	5.68	7.08
12/03/2018	12	515.19	1.38	
31/12/2018	0	520.82	5.63	7.01
12/03/2019	12	510.19	1.37	
31/12/2019	0	515.77	5.57	6.94
12/03/2020	12	505.14	1.37	
31/12/2020	0	510.66	5.52	6.89
12/03/2021	512	0.00	1.34	
31/12/2021	0	0.00	0.00	1.34
TOTAL	35		35.00	35.00

As shown in section 2, accrued interest can be derived according to equation

$$[B1]\ I_t = S_{t-1}\,[(1+r_0)^{a_t} + [S_{t-1}\,(1+r_0)^{a_t} - P_t][(1+r_0)^{1-a_t} - 1]$$

Where r_0 is the interest rate at inception — the annual IRR of 1.36 % in our example —, a_t is the fraction of the length of the (annual) period t where a payment is made, and the two right-hand side additive members capture the accruals before and after the payment respectively.

The entries in the fourth column of the table below correspond to interest accrued since the previous date. As the table entries refer to dates of cash payments (or end of year), no intra-period payment takes place, and only the first of the two additive terms is operative, according to the rule:

$$[B2]\ I_t = S_{t-1}\,[(1+r_0)^{a_t} - 1]$$

where a_t is the fraction of the years elapsed since the previous period and $a_{t-1} + a_t = 1$.

The last column of Table B1 has entries for the end of year dates and uses equation [B3] for the calculation of accrued interest during the year:

[B3] $I_t = S_t - S_{t-1} + P_t$

As discussed in section 2, both calculation approaches deliver the same result for the annual accruals.

Appendix C: Budgetary information

Computing debt dynamics in a general context that takes into account refinancing and primary funding can be quite cumbersome. The standard approach based on spreadsheets can render scenario-based macroeconomic analysis intractable, leaving aside its well-known propensity to generate erroneous results due to inaccurate coding.

The annual General State Budget includes a detailed annex in which the interest burden on the debt portfolio and on loans are accounted on a cash basis, according to the information provided by the Spanish Treasury. At the same time, the Treasury also provides as part of the General State Budget an estimate of interest burden on an accrual basis, i.e. in line with the ESA 2010, although only in aggregate terms.

Specifically, the General State Budget includes in its chapter 3 details on a cash basis of the expected interest payments by type of debt:

- Treasury bonds. The General State Budget identifies each issue of T-Bonds with a rate and a date. Foreign currency bonds and inflation-linked bonds are also detailed. This item accounts for 91.5 % of the total interest expenditure in the 2015 budget.
- Treasury Bills. The T-Bills interests are less than 2 % of the total interest expenditure.
- Loans. The Budget identifies on a loan-by-loan basis the interests due to Schuldschein loans, those granted by the European Investment Bank, the European Stability Mechanism (being the main part of this item) and other loans. It accounts for around 3 % of the total interest expenditure.
- Debt assumptions from loans to public entities, like the Spanish National Railway Network (RENFE) or the Administrator Railway Infrastructure (ADIF), granted by the European Investment Bank and assumed by the Treasury. Since July 2014 part of the financial mechanisms for the regions called 'Fondo de Pago a Proveedores' (FFPP), which were banking loans, is also included. Those interests account for around 3.5 % of the total interest expenditure.

In order to assess the accuracy of the results and the reliability of our estimate of the initial debt portfolio, a comparison has been made with the data from chapter 3 of the initial State budget for 2015 described above. Combining again as explained above the security-by-security information on outstanding amounts and coupon payments regarding Treasury bonds, an estimate of the cash interests linked to the Treasury bills and, finally, an estimate on the interests paid on a cash basis regarding loans granted to the State, a homogeneous comparison has been made with the amounts of the initial State budget.

While the initial 2015 State budget included an amount of 35 490 million EUR for interest payments on cash basis, our estimate amounted to 31 267 million EUR. The difference of 4 223 could be partially explained by a prudent buffer fund. The comparison on an accrual

basis shows a smaller difference. While the initial State budget provides an amount of 31 650 million EUR, our estimate is lower 29 175, therefore the difference between both figures is 2 475. However, this buffer in cash interest payments forecast is not reflected in a similar buffer in the forecast for accrued interest (without which there is no 'true' buffer as far as budgetary stability objectives are concerned).

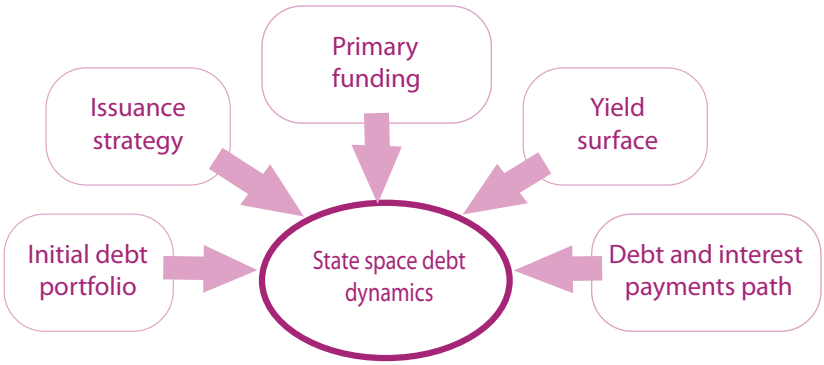
Appendix D: MATLAB code

Computing debt dynamics in a general context that takes into account refinancing and primary funding can be quite cumbersome. The standard approach based on spreadsheets can render scenario-based macroeconomic analysis intractable, leaving aside its well-known propensity to generate erroneous results due to inaccurate coding.

In this appendix we present a MATLAB simulator that allows the analyst to project debt and interest payments in a quite general setting. As explained in the text, this projection is based on a state space representation of their joint dynamics that includes an initial debt portfolio and the issuance of new bonds to finance endogenous payments (redemptions and interest payments of existing debt) and exogenous payments (primary funding). The code is written adopting an object oriented format that separates the input/output structures from the dynamics encapsulated in the MATLAB function. In this way, we make the code more reusable and robust. The structure of the simulator is outlined in Figure D1.

The debt simulator requires, apart from some overall parameters, some specific inputs: initial debt portfolio, expected primary funding, issuance strategy and expected yield surface. This section provides some background on them.

Figure D1: Debt simulator structure



OVERALL PARAMETERS

The simulator operates at the quarterly frequency, $s = 4$, and uses two time indices:

- Calendar index: $t = 0...T$.
- Maturity index: $\tau = 1...k$.

The model requires as inputs the simulation horizon in years T_y and the maximum maturity of the debt portfolio k. The code automatically constructs the corresponding time indices t and τ, as well as the maximum maturity at the quarterly frequency: $T=sT_y$.

INITIAL DEBT PORTFOLIO

One of the key inputs of the model is an initial debt portfolio defined by the outstanding amounts of debt at the different maturities and the corresponding interest rates that define the coupons:

$$[D1] \quad B_0 = \begin{bmatrix} B_{0,1} \\ B_{0,2} \\ \vdots \\ B_{0,k} \end{bmatrix} \qquad y_0 = \begin{bmatrix} y_{0,1} \\ y_{0,2} \\ \vdots \\ y_{0,k} \end{bmatrix}$$

We compute an initial debt portfolio that comprises the outstanding instruments B_0 that have been issued at par, below par or above par. In any case, we compute an internal rate of return (IRR, y_0) that takes into account the real cash-flow of each instrument (initial disbursement, coupon payments and redemptions) and we use this IRR to calculate the corresponding interest payments. Note that the IRR is the relevant rate to be applied following the accrual principle used by the national accounts. This portfolio is considered free from credit risk. Therefore, the initial interest payments are:

$$[D2] \; C_0 = B_0 \bullet y_0$$

Where • is the element-by-element product.

The initial debt portfolio [D1] has an inner weight structure:

$$[D3] \quad v_{\tau,0} = \frac{B_{\tau,0}}{\sum_{\tau=1}^{k} B_{\tau,0}} \; \forall \, \tau$$

This structure determines one classical risk measure: the proportion of debt that matures in the short-run (e.g. in a year or less, τ_s=4):

$$[D4] \quad rr(\tau_s)_0 = \sum_{\tau=1}^{\tau_s} v_{\tau,0}$$

The debt structure [D1] linked to the initial debt-portfolio implies, among other things, an average duration and an average cost:

$$[D5] \quad \begin{aligned} <\tau_0> &= \sum_{\tau=1}^{k} v_{\tau,0}\,\tau \\ <y_0> &= \sum_{\tau=1}^{k} v_{\tau,0}\,y_{\tau,0} \end{aligned}$$

Finally, the initial debt portfolio defines a redemptions profile and an interest payments profile. Both profiles are one of the components of the future financing needs.

PRIMARY FUNDING

Debt dynamics depend on an endogenous component and an exogenous component. The former is linked to the redemptions profile and the interest payments while the latter is driven by forces independent from the structure of the existing debt.

The debt simulator only considers an exogenous term that pushes up the total financing need, without entering into its macroeconomic determinants.

$$[D6] \quad X = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_T \end{bmatrix}$$

In general, the forcing term x includes the primary deficit and the stock-flow adjustment (e.g. additional funding required by liquidity facilities provided by the central government to the regional governments).

ISSUANCE STRATEGY

The debt simulator requires a given strategy to issue debt in order to cover the total funding needs: redemptions, interest payments and primary funding. This strategy is encompassed in a matrix of weights that set the issuance of new bonds by tenor for each point in time:

$$[D7] \; W = \{w_{\tau,t0} \quad \tau = 1 \,..\, k \quad t = 1 \,..\, T\}$$

The issuance strategy is constrained to be non-negative and add up to one:

$$w_{\tau,t} \geq 0 \quad \forall \tau$$

$$[D8] \quad \sum_{\tau=1}^{k} w_{\tau,t} = 1 \quad \forall \tau$$

YIELD SURFACE

Future issuance generates interest payments depending on the yield curve that will prevail in the future. The debt simulator requires as input a complete yield surface that determines the expected interest rates of the issued bonds according to their maturity for each point in time:

$$[D9] \; Y = \{y_{\tau,t} \quad \tau = 1 \,..\, k \quad t = 1 \,..\, T\}$$

NOMINAL GROSS DOMESTIC PRODUCT (GDP)

Nominal GDP provides a standard reference to compute several key macroeconomic ratios (e.g. the debt/GDP ratio) although it does not play any role in the basic computations of the simulator.

$$[D10] \; GDP = \{GDP_t \quad t = 1 \,..\, T\}$$

The MATLAB code can operate in four different modes:

- Inertial dynamics without refinancing: only the redemptions profile and interest payments linked to the initial debt portfolio are considered.
- Inertial dynamics with refinancing: only the redemptions profile and interest payments linked to the initial debt porfolio determine the new debt issuance:
- Primary funding mode: the existing debt portfolio is omitted and the new debt issuance depends only on the primary funding:
- The complete operation mode that includes both the initial debt portfolio and the funding needs linked to the sum of redemptions, interest payments and primary funding (primary deficit plus stock-flow adjustment). The complete mode was represented in Figure 1.

Once the simulator has been fed with the inputs described in section 2 of the main text, the MATLAB function combines them according to the state space representation of the debt dynamics presented in section 3 and the selected operation mode to generate the following basic output:

- Debt portfolio (outstanding debt and coupons) for the complete simulation period:

$$B = \{B_{\tau,t} \quad \tau = 1 .. k \quad t = 1 .. T\}$$

- Interest payments:

$$ic = \{ic_t \quad t = 1 .. T\}$$

- Issuance of new debt, decompose according to the corresponding funding (redemptions, interest payments and primary deficit):

$$\Delta B = \{\Delta B_{\tau,t} \quad \tau = 1 .. k \quad t = 1 .. T\}$$

- Implicit rates (mean and marginal):

$$v_{\tau,0} = \{\frac{ic_t}{\sum_{\tau=1}^{k} B_{\tau,t}} \quad t = 1 .. T\}$$

$$ym = \{ym_t = w'_t y_t \quad t = 1 .. T\}$$

In addition to this basic output, the debt simulator computes aggregates across the cross-section dimension (maturities), the corresponding macroeconomic ratios (e.g. debt to GDP, interest payments to GDP) as well as some features of the evolving debt portfolio (average life of outstanding debt, share of short-term liabilities), etc.

2 Globalisation at work in statistics — Questions arising from the 'Irish case'

SILKE STAPEL-WEBER [1] AND JOHN VERRINDER [2]

Abstract: This is the first time — despite long conceptual discussions — that statisticians have been prompted by real economic events to take globalisation as seriously as it has to be taken, with major impacts for all kinds of economic statistics (national accounts, balance of payments, business, employment and trade). The Riga 2014 memorandum 'Towards Global Business Statistics' (European Statistical System (2014)) and the Sturgeon Report (Sturgeon (2013)) opened some doors, while the practical consequences for national and international production systems were actually quite limited. This will have to change now.

However, in the view of the authors, the key to understanding globalisation is not about changing the accounting methodologies, but (1) consistently implementing them over all countries, supported by further guidelines for accounting frameworks and primary statistics, (2) presenting the accounts in 'building' blocks that enable users to distinguish domestic and globalisation impacts, through (3) providing statisticians with the necessary information about the structure and transactions of multinational enterprises and (4) enhanced cross border statistical collaboration, including data exchange and enterprise profiling.

This paper is intended as a first, arguably provocative, reaction to the revisions implemented in Ireland. It can be expected — and encouraged — that this paper will prompt constructive reactions from compilers and users.

JEL codes: E01, E22, F62.

Keywords: Globalisation, national accounts, gross domestic product.

[1] Eurostat, Director National accounts, prices, and key indicators.
[2] Eurostat, unit C1 National accounts methodology, indicators.

1. Introduction

On-shoring, off-shoring, producing where economies offer comparative advantages in terms of costs, paying taxes where the national governments allow the most favourable rates, selling the goods to global consumers and disseminating the profits: we have known for a long time that this pattern is used by large globally operating economic actors, and the consequences have been evident to compilers and expert users, which has led to considerable efforts to improve guidance and practical compilation. However it now clearly surfaces for the first time amongst general users and the public with all its numerical consequences, thanks to huge transactions involving a relatively small economy with a developed statistical system, following international accounting rules. Statisticians around the globe should be grateful for the Irish case; it will surely help to overcome some cognitive dissonances we retain in our cosy and fully consistent world of accounting frameworks. It may also help to discover and address some blind spots in the relation between primary statistics, namely, business and employment statistics, and the accounting frameworks, particularly in the trend to fully align them in methodological terms.

The challenge we face now (not only) in Ireland is that Gross Domestic Product (GDP) and Gross National income (GNI) no longer ([3]) really provide useful insights into the economic activity that is physically taking place in the national territory, as such domestic production can be dwarfed by globalisation activities. This raises concerns with regard to the actual value of those figures and the insights on the domestic economy that can be taken from them.

What makes the case very relevant for Europe, and the work of Eurostat, is that this could happen again any time as huge multinationals move their business around Europe and the globe. Indeed in the case that a move takes place between two EU Member States, then there must be an offsetting double effect — an increase in GDP in one and a matching decrease in the second. Moreover, there is high uncertainty concerning the current recording practice for multinational enterprises across Member States. For national accounts one could at least assume that comparability is ensured through common principles (enshrined in the European System of Accounts, 2010 (Eurostat (2013)) and quality control of compliance (e.g. through GNI verification). For business statistics there is at the moment no comparable set of European overarching common principles and guidelines covering in a coherent manner this issue for all business surveys. Consequently, the comparability of European (and international) statistics is questioned and at stake.

This paper does not provide any solutions. It intends to ask questions that need to be answered by the statistical community in order to continue to produce relevant and high quality macroeconomic (and business) statistics, addressing information and policy needs at national, European and global level. This necessarily includes the question if traditional (national) methods of data collection still provide a sufficient base for acquiring the necessary primary data and what could be done if this is not the case. The paper also has a new look at how these macroeconomic (and business) statistics could be presented and which additional indicators may complement GDP to explain the recording of complex processes to users. It also suggests better (European) rules on pro-actively communicating major statistical events and seeking ex-ante advice and peer intelligence on related methodological questions.

([3]) It may be noted that — in response to user requests — the 2008 System of National Accounts (United Nations (2009)) (and the ESA 2010) introduced clearer rules on recording globalised business models based on the principle of economic ownership, and also capitalised research and development expenditure. The interaction of these two conceptual developments is particularly noticeable in the Irish case.

Box 1: The Irish revision

Worldwide and European national accounts rules deal specifically with the criteria for the country of residency of a statistical unit, and follow the principle of economic ownership with regard to the recording of assets. The economic owner is defined as being able to claim the benefits associated with the use of an asset by virtue of accepting the associated risks. These benefits, and associated risks, can vary by type of asset and the UNECE Guide on measuring global production (UN Economic Commission for Europe (2015)) provides extensive practical guidance to follow, for both physical assets and intellectual property assets, and notably introduces guidance for so-called 'factoryless goods production' (sometime known as a 'contract manufacturing model'). The Eurostat Manual on measuring Research and Development in ESA 2010 (Eurostat (2014)) is also relevant.

The Irish Central Statistical Office (CSO) has explained that the multinational companies concerned — which are largely classified in the manufacturing branch and clearly have substantial Irish resident units — now base their assets in Ireland, and their extensive analysis — based on the guidance in the UNECE Guide on measuring global production — has confirmed that the economic ownership of the assets rests in Ireland. This is part of an 'on-shoring' trend that has been observed (and recorded in the accounts) for several years, but was particularly large in 2015.

The transfer of the (extremely large) capital stock of assets to Ireland is recorded by the CSO as an 'other economic flow' since it is viewed as a restructuring operation and not as a transaction (the Irish resident units have not 'purchased' the assets). This means that data on domestic investment (gross fixed capital formation) and import flows are unaffected by the transfer of the stock in 2015. However the overall stock of assets (balance sheet) in the Irish economy is now higher by the amount of transferred assets, which also has a major impact on depreciation (consumption of fixed capital).

The result of this is that the goods (and the services arising from intellectual property) provided from the companies' assets are recorded as output of the Irish economy and — where appropriate — as exports from Ireland. Furthermore the new assets created by these companies (i.e. after the transfer of the balance sheet to Ireland) are recorded as investment in Ireland. All of this adds to Irish GDP, and will continue to do so in the coming years (i.e. this is a level shift).

The upward revision in GNI is smaller than for GDP because there are additional outward income flows relating to the companies' activities. Nevertheless the rise in GNI is still very substantial because the additional income flows of the companies (interest and dividends) concerned are considerably smaller than the value added of their activities. The calculation of outward flows of 'reinvested earnings' from these companies is also relatively small because the level of depreciation on the assets (which reduces reinvested earnings) is very high.

2. The Irish facts

On July 12th 2016 the Central Statistical Office (CSO) of Ireland published a level shift for its GDP and GNI, significantly revising the growth rates for 2015 upwards to 26.3 % and 18.7 %, respectively, on a constant prices basis (see CSO Ireland (2016)). Corresponding revisions have been made to the Balance of Payments (BOP) and the industrial production index. These revisions are attributable to the globalisation activities of a very small number of multinational companies, namely bringing their balance sheets from 'off-shore' locations into Ireland, and are based on data collected directly from these companies (see Box 1). Based on the preliminary information provided by the CSO, including data, and a Eurostat visit, Eurostat considered the revision as plausible and the data were endorsed by the EU's GNI Committee. Eurostat, therefore, published the new data and used them for euro area (EA) and European Union (EU) aggregates. Eurostat examines the methodology used in this revision as part of the regular GNI verification procedure which applies to all Member States.

This upwards revision to GDP has an impact on any indicator which is presented as a ratio to GDP. In the absence of any other changes, such ratios will fall as a simple mathematical result of an increase in GDP. The exact changes to the value of any specific indicator will depend not only on the change in GDP (the denominator), but also on possible changes in the numerator. It is also acknowledged that the upward revisions to GNI will also have upward implications for the amount of Irish contributions to the EU budget.

3. The model

To discuss the questions raised above, the following simple model ([4]) has been developed. It is not intended to depict the Irish case specifically, but to provide a generic framework in which to understand how a combination of application of the principle of economic ownership, together with capitalisation of research and development, can have major consequences on a country's national accounts and balance of payments.

In Figure 1 the observed (physical) flows ([5]) are shown as black arrows, whilst the imputed flows after recording on an economic ownership basis are shown as purple arrows.

The world consists of only 4 countries (A, B, C, D). Countries C and D are members of the EU, A and B are outside Europe. There is only one multi-national enterprise (MNE) that moves its headquarters (HQ) and its complete balance sheet (100 % intellectual property rights, IP ([6])) from A to C. It is assumed that before the move all criteria for residency and economic ownership are fulfilled in A, and after the move they are so fulfilled in C. After the move the former HQ remains in A as a residual Unit A1, whereas in C the HQ is formed from a former affiliate unit (C1).

Units B1 and D1 are affiliated with the MNE, before and after the move. B1 is the main producer in the MNE, whereas D1 provides inputs to B1. Under the principle of economic

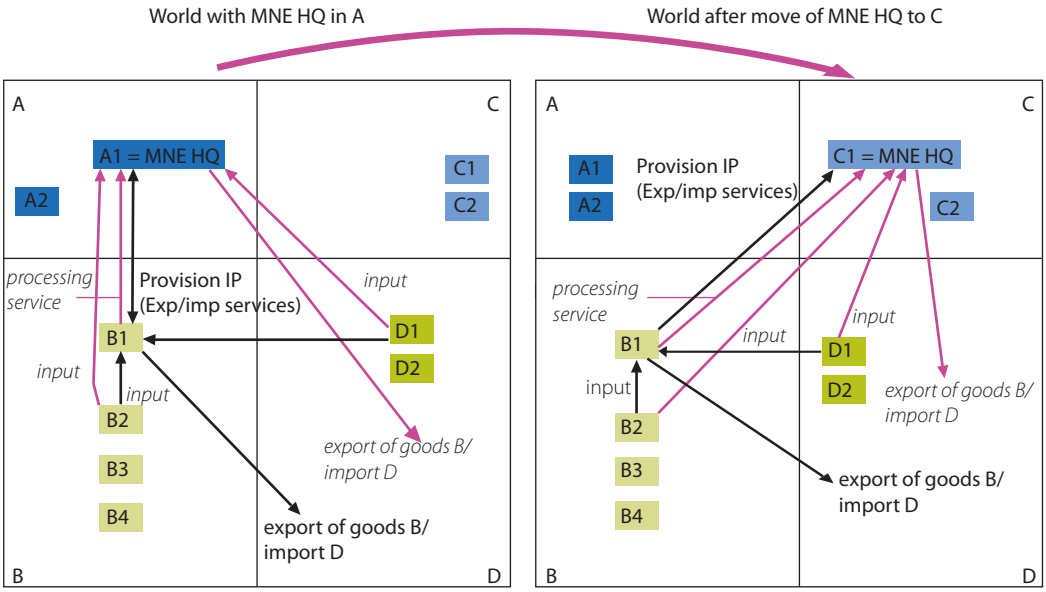
([4]) The model could be extended to deal with financial relationships etc, but has been kept focused on non-financial flows for the purposes of this paper.

([5]) The term 'observed' is properly applicable to primary data sources such as trade statistics, but its use is extended in this paper to hypothetical measures for aggregates such as GDP. The black arrows would be observed in statistics for trade in goods.

([6]) One should note that, in the absence of a straightforward indicator of economic ownership, the UNECE Guide on measuring global production relies on legal ownership. It is assumed here that there is sufficient evidence for statisticians that a change of economic ownership has been identified.

ownership, the HQ provides the IP to B1 and receives a fee in return ([7]). The HQ also pays processing fees to B1. B2 is an unaffiliated contractor to the MNE, providing inputs to B1.

Figure 1: The model



Nothing changes in the economic structure and outsourcing arrangements of the MNE after the move of HQ.

All goods produced by B1 are physically exported to D and consumed there.

There are five other independent producers (A2, B3, B4, C2, D2). All their goods and services are produced and consumed domestically only in their respective countries.

Application of the principle of economic ownership requires the imputation of a number of flows and stocks (i.e. moving away from the observed flows marked as black lines in the diagram, towards imputed flows marked as purple lines in the diagram). The main imputations to be made relate to cross-border flows of finished goods (considered as exports from the country where economic ownership is located), flows of intermediate goods and services (considered as imports to the country where economic ownership is located) and flows of assets (notably imports of intellectual property to the country where economic ownership is located).

Under those model conditions, assumptions have been made for output, intermediate consumption, exports and imports of goods and services, number and compensation of employees (CoE). Net taxes on production have been set to be zero to simplify calculations. These assumptions have been made for three cases:

1. Situation before the move of the MNE from A to C, information that is directly observable (i.e. it relates to physical production or flows) on the respective domestic territories;

([7]) Although in practice this fee may not be present, depending on the MNE's internal arrangements.

2. Situation before the move of the MNE from A to C, with application of the principle of economic ownership for recording (as described in Box 1);

3. Situation after the move of the MNE from A to C, with application of the principle of economic ownership for recording.

The assumed values and the derived value added (VA), GDP, labour productivity and unit labour cost (ULC) are provided in Annex 1 for each of the 3 cases and for each of the production units, countries and regions, where appropriate.

The number of employees recorded in each unit is assumed not to be impacted by the application of the principle of economic ownership, as the employees of B1 continue to provide processing services in B. However this assumption can certainly be further discussed.

Table 1 summarises for the four countries, the EU, the rest of the world (ROW) and the world, the GDP and selected main components and indicators for each of the three cases.

Table 1: Summary of GDP and selected components and indicators for the model

Country/region		GDP	Exports		Imports		Number of employees	Compensation of employees	GDP/ employee	Unit labour cost
			Goods	Services	Goods	Services				
A	observed	15	0	0	0	0	110	6	0.14	0.20
	before	35	100	10	70	20	110	6	0.32	0.04
	after	15	0	0	0	0	100	4	0.14	0.20
B	observed	120	100	0	50	0	2600	58	0.05	0.11
	before	100	20	20	0	10	2600	58	0.04	0.13
	after	100	20	20	0	10	1000	20	0.04	0.13
C	observed	15	0	0	0	0	160	12	0.09	0.30
	before	15	0	0	0	0	160	12	0.09	0.30
	after	35	100	10	70	20	150	8	0.22	0.08
D	observed	120	50	0	100	0	1750	90	0.07	0.26
	before	120	50	0	100	0	1750	90	0.07	0.26
	after	120	50	0	100	0	1750	90	0.07	0.26
ROW	observed	120	50	0	100	0	1750	90	0.05	0.12
	before	135	120	30	70	30	2710	64	0.05	0.12
	after	125	20	20	0	10	2710	64	0.04	0.14
EU	observed	135	50	0	100	0	1910	102	0.07	0.26
	before	135	50	0	100	0	1910	102	0.07	0.26
	after	155	150	10	170	20	1910	102	0.08	0.20
World	observed	270	150	0	150	0	4620	166	0.06	0.18
	before	270	170	30	170	30	4620	166	0.06	0.17
	after	270	170	30	170	30	4620	166	0.06	0.17

With regard to GDP ([8]), the main impact of following the economic ownership approach to recording is that the GDP rises in the country where the HQ is located (A or C) and falls by the same amount in the country where physical production takes place (B). In the example, the fall in GDP in large country B is less noticeable than the huge rise in smaller countries A and C.

([8]) This paper does not explore a possible focus on Net Domestic Product (NDP; removing the impact of capital consumption), which would be considerably less impacted than GDP owing to the high level of capital consumption recorded for intellectual property assets. The use of net measures for presentational purposes has been growing in recent years, however there remain some concerns about the quality of the practical calculation of capital consumption.

With regard to productivity measures (here using GDP divided by employment), the fact that employment data remain unchanged (whilst value added moves towards countries A or C) means that measured productivity falls in country A and rises strongly in country C.

Corresponding movements can be observed for the EU and the ROW, as the on-shoring was assumed to happen from the ROW to the EU.

At world-level the noticeable difference between the directly observable values (those measured from physical merchandise flows, which will not all be based on the principle of economic ownership) and the application of the economic ownership principle are the totals for exports and imports of goods and services. The reason is that the goods and services flows appear on the basis of economic ownership, which includes services flows within the MNE which were not directly observable and which are now shown explicitly.

With regard to unit labour cost measures (here compensation of employees divided by total output), these rise in country A and fall strongly in country C. Because of the increase in global gross output (as cross-border service transactions are recorded), the global unit cost measure falls marginally when an economic ownership approach is adopted.

4. How to shed (statistical) light on globalisation and produce meaningful information for domestic economies?

Globalisation is a historic process of increasing interaction between national economies on a world-wide scale. While not new, interconnectedness has accelerated in recent years due to political developments and technical enablers, such as informatics and new communication tools. Statistical evidence for the globalisation phenomenon includes increasing exports and imports of goods and services and FDI as a share of GDP, as well as the share of foreign controlled enterprises in all activities of the national non-financial and financial corporations sector.

In methodological terms, in the most recent releases of the international standards for national accounts and BOP (2008 SNA (United Nations et al (2009), ESA 2010 (Eurostat (2013)), BPM6 (International Monetary Fund (2009))), globalisation phenomena such as 'goods sent abroad for processing' and 'merchanting' (where the recording of both has been changed compared to previous standards), 'special purpose entities' or 'other captive institutions' have been given more attention ([9]) and subsequently more detailed guidance has been developed, e.g. in the 'Guide to measuring Global Production' (UN Economic Commission for Europe (2015)) and the report of the international 'Task Force on Head Offices, Holding Companies and Special Purpose Entities (see European Central Bank, Eurostat and OECD (2013))' However, in the light of many issues impacting the allocation of value added and profits to national economies, such as:

- intra-MNE transactions crossing national borders;
- the valuation of these transactions ('transfer pricing');
- recording of the intra-MNE use of intangible assets (notably IP);
- development, recording and payments for the use of R&D;

([9]) See also e.g. OECD (2014) and chapter 16 of Lequiller and Blades (2014).

- reallocation of royalties, licence fees and profits;
- design of complex financial relationships (e.g. loan structures) with associated property income flows,

we have to admit that we are only at the very beginning of getting a grip on properly measuring globalisation in a systematic cross-country way. Moreover, many already existing provisions for providing relevant sector and other breakdowns are only on a voluntary basis, even in a European context.

To shed light on globalisation, various tools have already been developed by statisticians and initiatives have been taken to go beyond GDP. The establishment of the EuroGroups Register ([10]) was an important step within Europe to foster collaboration between statistical offices.

Globalisation is closely related to activities by MNEs. Fragmented production processes span the whole world, exploiting comparative production advantages and tax competition between nations. This is also helped by the fact that increasingly a main component of many (particularly high tech) products is intellectual property — the know-how, the blue print. Exactly those intangible assets of an MNE, however, are extremely mobile. All it takes to move them around the globe from one host country to another is a registration in a business and tax register, a desk, a PC and an internet connection, obviously to exaggerate. Often they are also extremely huge assets, leading to the effects we now witness in Ireland.

The most developed tool to follow value creation by MNE around the globe is the trade in value added (TiVA) database and methodology, jointly developed by OECD and WTO ([11]). It is based on input-output modelling and Eurostat contributes consolidated EU and euro area tables to it, alongside the 28 national supply and use tables. TiVA addresses the issue of double counting implicit in gross trade flows. It explicitly shows the value that is added by a country in the production chain of a product that this country is exporting. One of the main uses is the calculation of more realistic trade balances between countries by taking out foreign content from exports. However one should note that some types of globalisation model (for example, factoryless goods production) are even disruptive for the TiVA data.

Given this background, users of the national accounts therefore ask if GDP should be replaced by another measure. This is not a new request, unique to globalisation. For example, the 'Beyond GDP initiative' acknowledged that economic indicators such as GDP were never designed to be comprehensive measures of prosperity and well-being. Based on the recommendations in the Stiglitz-Sen-Fitoussi report of 2009 (Stiglitz et al (2009)), this has helped to develop indicators that are as clear and appealing as GDP, but more inclusive of environmental and social aspects of progress, allowing to monitor global challenges of the 21st century such as climate change, poverty, resource depletion, health and quality of life. Particular emphasis was also given to the household sector and the distribution of income and wealth ([12]).

It is however important to understand that neither 'beyond GDP' nor TiVA adjust or challenge the main components of national accounts (and BOP). They complement them, help to provide additional insights and — in case of TiVA — allow deeper analysis of gross trade flows. However, these initiatives and tools are not sufficient to answer the main question globalisation is presenting to statisticians: Which parts of the production activities of MNEs are actually taking place in the domestic territory of any given country? Or in other words, how can we distinguish between movements in GDP or its components which are relevant for the domestic 'real

([10]) http://ec.europa.eu/eurostat/web/structural-business-statistics/structural-business-statistics/eurogroups-register.
([11]) http://www.oecd.org/sti/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm.
([12]) For example, see Eurostat's GDP and beyond site http://ec.europa.eu/eurostat/web/gdp-and-beyond.

economy' and those which are driven by the worldwide activities of multinational companies (and their statistical representation according to the international rules)?

In developing answers to those questions, it should be clear that there is an ESA 2010 definition of GDP ([13]) which is a European legislative requirement. Nevertheless the activities of multinationals have always been part of the Irish economic data and therefore analysis has always required a careful appreciation of where such multinationals impact on the data, both at national level but also in the framework of the European semester. The Irish CSO has developed and published additional analysis of impacts on domestic demand and imports, which are intended to help users in this analysis. Now, as the possible impact of globalisation on an economy has jumped into our face, it is about doing more in this direction, generalise the findings and develop guidance for all (EU) countries.

Points to be addressed, within the existing national accounts and BOP framework, are:

a. development and expansion of existing indicators;

b. identification of where additional detail would best help to provide insights;

c. the potential to develop new indicators;

d. whether new presentations of existing information would improve communication and understanding;

e. ways of having access to the necessary information about the MNE activities.

Efforts to single out globalisation activities and present them alongside purely domestic developments are very challenging, given that they require statisticians to isolate in balance sheets and flow accounts those positions and flows relating to the re-routing of profits. Access to intra-MNE information is therefore the most fundamental point. Already today many national statistical institutions have specific investigations of MNE in place, such as targeted surveys or 'profiling'. However, their attempts often end at the national border and there is no system in place to consistently record transactions in the counter-part countries world- or at least EU-wide. This leads to the conclusion that international comparability of at least national accounts, BOP and business statistics at a regional and worldwide level may be currently substantially hampered by missing values or double counting.

As a consequence, data collection can no longer be seen as a purely national exercise. Without an ambitious profiling approach and the use of detailed companies' data which included their activities abroad, the need for revision may not have been discovered by the Irish authorities. Nevertheless, the only thing known about the counterparts of the transactions is that they are outside the EU. This may ease life for Eurostat this time around, but causes headaches for worldwide agencies such as the IMF, OECD, World Bank and UN.

Apart from confidentiality issues, this raises (again) sensitive questions concerning enhanced cross border cooperation amongst statistical authorities. Nevertheless, the price for not addressing them, to start with at least within the ESS, would be increasing irrelevance of our statistical products and growing bias and asymmetries between countries. Is it time to think about a European (and world-wide) MNE profiling capacity, working closely with national counterparts? Do we need to invest more in cross-country business registers — such as the EuroGroups Register — and unique identifiers ([14]), eventually with the globe in mind? The

([13]) ESA 2010 paragraph 8.89.

([14]) There are several initiatives under way to develop unique (European or global) identifiers for enterprises. Although they are not driven primarily by statistical needs, statisticians see strong potential for such indicators to improve the collection of data.

authors would clearly answer yes to these questions. The details and partially sensitive questions will have to be worked out in close cooperation with all ESS and international partners, building on first steps already taken.

The current statistical infrastructure has been developed when production processes ended at the national border and customs captured all movements across borderlines, at least for goods. Businesses now move around the globe with ease. Statisticians have to find a way to follow, if necessary supported by appropriate EU legal provisions.

5. A different presentation of the accounts to support communication

As shown by the Irish case indeed globalisation presents significant communications challenges. Particularly when smaller countries are involved the ability to fully explain the rationale behind the changes is hampered by the overriding need to protect the confidentiality of the contributing multinational companies. This leads to a substantial loss of detail (at national and European level) and has understandably been an issue for many users.

Economists and statisticians have already pointed to the fact that publishing core GDP will no longer suffice in the future. New presentations are needed to tell the story about the state of an economy, adding the globalisation, environmental and social dimension. However, just having different, extended indicator systems next to each other will not do. Data will have to be presented in relation to each other, explaining complex issues in an understandable way to users, and building on the broader satellite accounts approach which is already used. Since the IARIW/OECD conference on the future of SNA in April 2015 ([15]), there have been emerging suggestions for a four column presentation, adding the three dimensions listed above alongside core GDP. This may become too complex again, but will certainly be subject to further discussion.

Using our example, however, it is possible to develop the simple conceptually-based Table 2 ([16]) for country C and the EU after the on-shoring of the MNE, adding the necessary information about the 'impact of globalisation ([17])' on the domestic economy to core GDP.

Such a tabular-type presentation would provide the necessary 'building blocks' to answer different policy questions. If one has to devise and monitor e.g. national policies for economic development, infrastructure, environment, health, housing, education etc. one is interested in the development of that directly observable part of GDP that relates to the domestic territory (e.g. 15 in our example for C). It is for these purposes of little interest how much production is controlled and owned in the rest of the world by resident MNEs (e.g. 20 in our example for C). If one is, however, responsible for finance and taxation, the total income generated by resident MNEs in all parts of the globe is very relevant as it potentially provides a taxation basis (e.g. 35 in our example for C).

([15]) http://www.iariw.org/papers/2015/Summary.pdf.

([16]) This is not to say that the compilation of such a table in practice would be straightforward, particularly if the split presented goes beyond trade flows. The necessary source information, generated through a suitable statistical infrastructure, is a pre-requisite.

([17]) Implicitly the adjustments (imputations) that have to be made to move from observed flows in primary statistics to national accounts and balance of payments data which comply with the principle of economic ownership.

Table 2: Example showing the effect of globalisation

Country C	Output	Intermediate consumption	Value added	GDP	Trade balance	Number of employees
Observed	40	25	15	15	0	160
Globalisation effect	110	90	20	20	+ 20	0
SNA/ESA figures	150	115	35	35	+ 20	160
EU	**Output**	**Intermediate consumption**	**Value added**	**GDP**	**Trade balance**	**Number of employees**
Observed	390	255	135	135	– 50	1910
Globalisation effect	110	90	20	20	+ 20	0
SNA/ ESA figures	500	345	155	155	– 30	1910

Interesting insights could also be gained from the relation of the directly observable part of GDP to the globalisation effect. In our example the globalisation effect is higher than the directly observable part of GDP. This would indicate a very high exposure and vulnerability to changes in the globalisation arrangements of MNEs, at least with regard to the capacity to tax.

Similar reasoning applies to the EU as a whole in relation to C and the rest of the world.

It is important to address an observation from some national accountants that identifying observed/physical flows marks an attempt to return to a traditional 'pre-globalisation' model that is no longer valid. However many users, especially those which have used national accounts data for many years, seek greater transparency of the globalisation effects which impact on the accounts. And, as with other areas of the national accounts, improved transparency of compilation approaches can only be beneficial.

In summary, the key to understanding globalisation is in our view not about changing the accounting methodologies ([18]), but (1) consistently implementing them over all countries, supported by further guidelines for accounting frameworks and primary statistics, (2) presenting the accounts in 'building blocks' that enable users to distinguish domestic and globalisation impacts, through (3) providing statisticians with the necessary information about the structure and transactions of MNEs and (4) cross border collaboration of statisticians.

6. Consistency between business statistics and accounting frameworks

National accountants and BOP statisticians have been in the past almost imperialistic in trying to create a fully consistent world and encourage primary statistics to follow national accounts methodology. This systematic approach has many advantages and helps to overcome shortcomings in primary data, reconcile data and fill data gaps. However, the Irish case has taught us now that a monolithical system of economic statistics, completely aligned with national accounts, will most likely not be the right answer to globalisation. Macro- and micro-statistics must serve a number of diverging purposes and give answers to a multiplicity of questions.

([18]) Even if there is important work to be done in improving the clarity of guidance, based on experience and the proliferation of globalised business models, and this is ongoing in international groups.

On first sight it seems that business statistics lend themselves more to events on the domestic territory, and there is no requirement that business statistics must follow national accounts solutions, especially where users have a strongly domestic focus. The 'building block' approach suggested above for national accounts could as well be a solution here. Maybe it is time for a paradigm shift in the relation between accounting frameworks and underlying primary statistics?

However, statisticians have to step back and try to see the whole picture, before trying to solve the problem with quick fixes. This is particularly important as the current European guidance on globalisation for the system of business statistics is not yet well developed. A general objective should be a further development of the guidelines on globalisation in national accounts, BOP, business and trade statistics in the light of the recent events, before adapting corresponding individual legal prescriptions.

7. Early information from national statistical institutions and ex-ante advice

As outlined above, communication is key in explaining complex globalisation issues to users. This includes first and foremost communication to international organisations, peers and other statisticians to help them to understand, gain their support in communicating the methodological approach more broadly and explaining the reliability and quality of the figures.

In order to avoid last minute surprises, and as a matter of good practice, it is recommended that international organisations are notified as early as possible in the event of a significant upcoming revision to the recording of MNEs in the national accounts of countries, or where a new case is identified which will impact accounts significantly in the future. Whilst it is accepted that statisticians at national level have delicate ongoing bilateral discussions with MNEs on access to source data, which are a national responsibility, arrangements can be made to ensure that all correspondence/discussions are suitably anonymised. This could be combined — in cases of doubts over the conceptual approach — with recourse to an ex-ante advice function, which is described below, and to expert visits as needed.

As mentioned elsewhere in this paper, the recording of globalisation arrangements can be particularly challenging for NSIs, especially as these evolve over time and new or mixed forms of arrangement may emerge. Within a regional context in Europe, there is also the important cross-Member State dimension, where it is preferable that the same recording approach for an MNE is adopted across countries in which it operates, so as to prevent asymmetries.

The authors would therefore raise the idea of developing a centralised function in Eurostat to provide advice to European NSIs in their preparation of recording changes in MNE structures (i.e. an ex-ante advice function), which would also ensure appropriate liaison with other MSs concerned so that a common solution is developed ([19]), and involve business statisticians as necessary. The advice would be developed based on descriptions/material provided by the NSI(s), including a detailed analysis, and be grounded in national accounts rules and guidance. Statistical confidentiality would be fully respected. Should a transversal conceptual issue

([19]) One should not pretend that this would be a straightforward process, as a solution would rely on the willingness of national accountants, balance of payments compilers, and compilers of primary statistics to reach a common understanding of the case, exchange company-level data, and agree on the required adjustments to primary data. However it is a necessary process to reach consistent data.

be identified with an impact on recording of other MNEs, this could be brought (in a fully anonymised way) to the appropriate Working Group for discussion, perhaps preceded by a Task Force if particularly complex.

Following such an approach would also have the advantage that Eurostat would be fully supporting the data provided by the NSIs in question as soon as they surface, being able to use them without doubt for EU aggregates and would not have to engage in last minute validation under pressure. This way, Eurostat could also reassure other MSs, e.g. in the GNI context, that everything has been done consistently across Europe and according to the rules.

Looking further, beyond Europe, there have been a number of calls in past years for better global statistical cooperation on the globalisation phenomenon; MNEs are not confined to Europe and information on counterparties is a necessary part of ensuring consistency and completeness. Work has started on related projects and Europe is closely involved in providing inputs from its own projects, with further developments as described above adding to these inputs.

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Annex 1: Accounts for example

Table 1: Observations of physical processes

	Output		Intermediate consumption	Value added	Net taxes on production	GDP	Exports		Imports		Number of employees	Compensation of employees	GDP/employee	Unit labour cost
	Goods	Services					Goods	Services	Goods	Services				
A1		10	5	5	0	5					10	2	0.50	0.20
A2	20		10	10	0	10					100	4	0.10	0.20
A	20	10	15	15	0	15	0	0	0	0	110	6	0.14	0.20
B1	100		70	30	0	30	100		50		500	15	0.06	0.15
B2	20		10	10	0	10					100	3	0.10	0.15
B3		200	160	40	0	40					1000	20	0.04	0.10
B4	200		160	40	0	40					1000	20	0.04	0.10
B	320	200	400	120	0	120	100	0	50	0	2600	58	0.05	0.11
ROW	340	210	415	135	0	135	100	0	50	0	2710	64	0.05	0.12
C1		10	5	5	0	5					10	4	0.50	0.40
C2	30		20	10	0	10					150	8	0.07	0.27
C	30	10	25	15	0	15	0	0	0	0	160	12	0.09	0.30
D1	50		20	30	0	30	50		100		250	20	0.12	0.40
D2		300	210	90	0	90					1500	70	0.06	0.23
D	50	300	230	120	0	120	50	0	100	0	1750	90	0.07	0.26
EU	80	310	255	135	0	35	50	0	100	0	1910	102	0.07	0.26
World	420	520	670	270	0	270	150	0	150	0	4620	166	0.06	0.18

Table 2: National accounts before on-shoring, principal of economic ownership

	Output		Intermediate consumption	Value added	Net taxes on production	GDP	Exports		Imports		Number of employees	Compensation of employees	GDP/employee	Unit labour cost
	Goods	Services					Goods	Services	Goods	Services				
A1	100	20	95	25	0	25	100	10	70	20	10	2	2.50	0.02
A2	20		10	10	0	10					100	4	0.10	0.2
A	120	20	105	35	0	35	100	10	70	20	110	6	0.32	0.04
B1		20	10	10	0	10		20		10	500	15	0.02	0.75
B2	20		10	10	0	10	20				100	3	0.10	0.15
B3		200	160	40	0	40					1000	20	0.04	0.10
B4	200		160	40	0	40					1000	20	0.04	0.10
B	220	220	340	100	0	100	20	20	0	10	2600	58	0.04	0.13
ROW	340	240	445	135	0	135	120	30	70	30	2710	64	0.05	0.11
C1		10	5	5	0	5					10	4	0.50	0.40
C2	30		20	10	0	10					150	8	0.07	0.27
C	30	10	25	15	0	15	0	0	0	0	160	12	0.09	0.30
D1	50		20	30	0	30	50		100		250	20	0.12	0.40
D2		300	210	90	0	90					1500	70	0.06	0.23
D	50	300	230	120	0	130	50	0	100	0	1750	90	0.07	0.26
EU	80	310	255	135	0	135	50	0	100	0	1910	102	0.07	0.26
World	420	550	700	270	0	270	170	30	170	30	4620	166	0.06	0.17

Table 3 : National accounts after on-shoring,principal of economic ownership

	Output		Intermediate consumption	Value added	Net taxes on production	GDP	Exports		Imports		Number of employees	Compensation of employees	GDP/employee	Unit labour cost
	Goods	Services					Goods	Services	Goods	Services				
A1		10	5	5	0	5					10	2	0.50	0.20
A2	20		10	10	0	10					100	4	0.10	0.20
A	20	10	15	15	0	15	0	0	0	0	110	6	0.14	0.20
B1		20	10	10	0	10		20		10	500	15	0.02	0.75
B2	20		10	10	0	10	20				100	3	0.10	0.15
B3		200	160	40	0	40					1000	20	0.04	0.10
B4	200		160	40	0	40					1000	20	0.04	0.10
B	220	220	340	100	0	100	20	20	0	10	2600	58	0.04	0.13
ROW	240	230	355	115	0	115	20	20	0	10	2710	64	0.04	0.14
C1	100	20	95	25	0	25	100	10	70	20	10	4	2.50	0.03
C2	30		20	10	0	10					150	8	0.07	0.27
C	130	20	115	35	0	35	100	10	70	20	160	12	0.22	0.08
D1	50		20	30	0	30	50		100		250	20	0.12	0.40
D2		300	210	90	0	90					1500	70	0.06	0.23
D	50	300	230	120	0	120	50	0	100	0	1750	90	0.07	0.26
EU	180	320	345	155	0	155	150	10	170	20	1910	102	0.08	0.2
World	420	550	700	270	0	270	170	30	170	30	4620	166	0.06	0.17

3 Estimating purchasing power parities for the production side of GDP

LAURENT OLISLAGER AND PAUL KONIJN [1]

Abstract: Purchasing power parities (PPPs) are indicators of price level differences across countries. They allow international comparisons of GDP, which would be biased without adjusting for price level differences. The Eurostat-OECD PPP Programme makes use of price surveys and a well-established methodology to estimate them, from the expenditure side of GDP. However, this approach does not identify individual industries. Therefore, productivity comparisons can be made only at the level of the whole economy. In this work we describe an alternative calculation of PPPs from the production side of GDP. This is done based solely on official European datasets: value data from national accounts and from structural business statistics, and price data from the PPP programme, from the annual Eurostat survey on production of manufactured goods and from the annual Eurostat agricultural price collection. The use of a mixture of consumer prices and producer prices allows a high coverage of activities contributing to GDP. PPPs are obtained for the year 2014 for 31 European countries (EU28, Switzerland, Iceland and Norway) for the 64 main economic activities and broader aggregates as defined in national accounts. The quality of the results is assessed with numerical criteria in terms of coverage, reliability and plausibility. We also derive experimental PPP-adjusted productivity measures at the industry level. Future work should focus on extending the coverage of activities to include those that are mainly intermediate consumption, particularly for services. This would in principle allow calculating value-added PPPs instead of output PPPs, strengthening their use for productivity comparisons.

Keywords: International comparisons, price statistics, purchasing power parities, EKS method, economic activities and industries, output and productivity comparisons.

JEL codes: C82, E24, E31.

[1] Eurostat, unit C4 Price statistics, purchasing power parities, housing statistics.

1. Introduction

Purchasing power parities (PPPs) are indicators of price level differences across countries. Traditionally, Eurostat has produced PPPs only from the expenditure side of gross domestic product (GDP). The methodological manual on purchasing power parities (Eurostat and OECD (2012)) says the following about this:

> 'The reasons for this are: the inherent usefulness of making comparisons from the expenditure or demand side; the difficulties of organising comparisons from the production or supply side which require data for both intermediate consumption and gross output in order to effect double deflation; and the generally better comparability among countries of their detailed breakdowns of GDP expenditures. The disadvantage of the expenditure side is that, although it enables levels and structures of consumption and investment to be compared, it does not identify individual industries. Therefore, productivity comparisons can be made only at the level of the whole economy. To compare productivity at the industry level, comparisons have to be made from the production side.'

Productivity measurement is at the heart of discussions about competitiveness, and Eurostat is frequently faced with the demand for PPPs specific to industries that could aid the comparison of productivity levels across countries. This would enable users to more reliably identify which industries in which countries are more and which are less productive and thereby support policies towards increasing productivity and growth.

The lack of official data on production PPPs ([2]) made users look for other sources of such information. The most prominent sources are: the World Input-Output Database (WIOD), which produced 2005 PPPs for 35 industries and 42 countries (WIOD (2005)); the EU KLEMS project, whose latest update included PPPs up to 2007 for 72 industries and 30 countries, incorporated in the World KLEMS datasets (EU KLEMS (2007)); the Penn World Table (PWT), whose latest release included data up to 2014 for 182 countries (Feenstra, Inklaar and Timmer (2015); PWT (2016)). In all cases, the University of Groningen carried out the analysis and calculations, with a methodology developed for evaluating production PPPs based on a mixture of adjusted expenditure PPPs and direct sources for output prices (Timmer, Ypma and van Ark (2007); Inklaar and Timmer (2011); Inklaar and Timmer (2014)).

In Europe, the main sources of expenditure PPPs and output prices are respectively the Eurostat-OECD PPP Programme and PRODCOM, the annual EU survey on production of manufactured goods. Eurostat is in a position to use these data sources at the greatest level of detail: Eurostat has access to the confidential individual prices on which the expenditure PPPs are based, and to PRODCOM confidential prices that are not published. The aim of this paper is to investigate the possibility to estimate production PPPs from these internal Eurostat sources.

We made one important restriction to our work from the outset: we aim to produce PPPs for output of industries, not for value added. The latter would require the estimation of PPPs for intermediate consumption as well, for which at the moment no data sources are available. It would be possible to make imputations from expenditure and output PPPs to intermediate consumption, but we have not attempted to do so (this would be a subject for further work). Nevertheless, we will use the output PPPs to deflate value added in the calculation of labour productivity measures, which implies the assumption that the cross-country price relatives for

([2]) We use the term 'production PPPs' to indicate PPPs that reflect price levels of output of individual industries. Alternative terms are 'output PPPs' and 'industry(-level) PPPs'.

output and intermediate consumption are the same. Hence, we apply single deflation rather than double deflation.

In section 2 we outline the basic methodology. In section 3 we describe the sources of prices and PPPs, as well as the sources used to estimate weights, and the data treatment performed before calculation. In section 4 we detail the calculation procedure and in section 5 we discuss the results. We end with conclusions in section 6.

We incorporated in the text the description of data, tools and methods and all other relevant information needed to support the paper's conclusions. Unfortunately we are not able to provide the full datasets allowing replication of the work, as they contain confidential data. Those who are interested can download an Excel file that contains all tables included in this article as well as links to the public source data on this location: http://ec.europa.eu/eurostat/web/products-statistical-books/-/KS-GP-16-002-EN-XL. The Excel file also contains a few additional tables that are not reproduced in the article itself for the sake of space.

2. Basic methodology

This research tests the possibility of obtaining reliable production PPPs for the purpose of productivity measurement. It aims at estimating PPPs for the 64 industries that are used in the supply, use and input-output tables (SUIOTs) (Eurostat (2008a)) of the national accounts, for the year 2014, for as many European countries as possible ([3]). This classification of 64 industries ('A*64' in the European System of Accounts, ESA 2010) (Eurostat (2013)) is based on the Statistical Classification of Economic Activities in the European Community, NACE Rev. 2 (Eurostat (2008b)). Eurostat currently publishes gross value added and employment at this level of detail, but refrains from calculating labour productivity because of the lack of PPPs. Labour productivity without PPP adjustment would overstate the productivity of richer countries and understate that of less rich countries.

The lowest level of detail at which the production PPPs are calculated is the 4-digit NACE/CPA level ([4]). Using the PPP terminology, this level will be termed the 'basic heading' (BH) level. Below this level, no weights are used; above the BH level, value-added data from mainly Structural Business Statistics (SBS) and from national accounts are used, respectively below and above the A*64 level. PPPs are calculated using the standard Èltetö-Köves-Szulc (EKS) method ([5]).

Different data sources for prices are used, as described in the next section ([6]). As a first step, each product available in each source has to be allocated to one of the 576 BHs based on CPA. Though pre-defined links between classifications exist, this requires assumptions. In particular, one has to differentiate between the varying types of prices reported.

([3]) EU28, Switzerland, Iceland and Norway were selected on the basis of data availability (see Table 1).
([4]) We use the Classification of Products by Activity (CPA) version 2.1, entered into force in 2015.
([5]) Details on the calculation of PPPs using the EKS method, both below and above the BH level, can be found in the methodological manual on purchasing power parities (Eurostat and OECD (2012)).
([6]) Table 1 and Table 2 summarise the data provided by the various sources, per country and per A*64 category respectively.

3. Data sources

3.1. PPP programme

The Eurostat-OECD PPP Programme is the main source for comparable price data. It relies on tailor-made surveys so as to collect price data comparable across countries for a large variety of goods and services. However, the data are compiled in order to deflate final expenditures rather than output or value added. This means for example that all prices are purchasers' prices (i.e. the price paid by the purchasers, including all taxes, subsidies, and trade and transport margins) whereas output and value added in national accounts are valued at basic prices (i.e. the price received by the producers).

Furthermore, all consumer products, classified by COICOP (Classification of individual consumption by purpose ([7])), as well as all machinery and equipment products, need to be classified according to CPA. This work has to be performed manually, with options available.

A first option is to link the products to the corresponding activities for producing them. For example, all food products could be allocated to one of the BHs under the activity 'manufacture of food products, beverages and tobacco products'. This requires making adjustments for product taxes (including VAT) and for trade and transport margins, effectively converting purchasers' prices into basic prices. This information is available (but not annually) in the SUIOTs at A*64 level; the adjustments can thus be done at the product level only if one arbitrarily assumes uniformity of taxes and margins inside each category. However, even with such adjustments, the allocation is doubtful, particularly for BHs for which international trade is important: the product consumed in country X may have been produced in country Y, so that the pseudo-basic price derived from the purchasers' price may be irrelevant for country X. For example, prices for cars purchased in Germany (covering all international car brands) cannot be used as a proxy for the basic price of producing cars in that country. With the datasets at hand, it is impossible to attribute the purchasers' price (converted to a basic price) to the corresponding activity in the correct country.

A second option is to link the products to the corresponding wholesale trade services ([8]). In this case, one assumes that the level of the purchasers' price reflects the price of the output (i.e. the trade margin) of the wholesale trading activity. If no further price adjustments are made, we thus ignore any differences in retail trade and transport margins and taxes or subsidies across countries. Whereas this is a simplifying assumption, it must be noted that, as described above, the possibilities to make further adjustments are limited (also because the distinction between wholesale trade, retail trade and transport margins is not available in the national accounts database).

The approach provides the additional advantages that a clear separation is drawn between producing activities and trading activities, as well as between the corresponding data sources. As explained below, data on production prices can be used for producing activities and data on consumption or investment prices for trading activities. With the above example, it is then assumed that the price of a car sold in Germany reflects the output of the trade of cars in Germany while the prices for cars produced in Germany are solely originated from production-

([7]) See http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=COICOP_5&StrLanguageCode=EN&IntPcKey=&StrLayoutCode=HIERARCHIC.

([8]) In principle, retail trade services would have been preferred, but contrary to wholesale trade services, retail trade services are not broken down by category in NACE/CPA.

based data. This also overcomes the problem that expenditure PPPs include import prices and exclude export prices ([9]).

It should be noted that the above options are relevant mainly for goods. Since trade and transport margins do not play a major role for services, the difference between purchasers' prices and basic prices of services consist only of taxes and subsidies on products. In a follow-up research, the methodology could be refined by first adjusting the prices of services for these taxes and subsidies before using them as output prices.

We experimented with both options and found that, for some activities in some countries, they can lead to very different results, the overall average deviation (in absolute value) of deduced price level indices (PLIs) ([10]) being of the order of 10 %. Based on its advantages, but somewhat arbitrarily, we selected the second method: consumer goods and machinery and equipment were classified to the 6-digit level of CPA among trading activities. Prices from the PPP surveys of 2013, 2014 and 2015 were extracted from the PPP database and, where necessary, extrapolated to 2014 using CPI data.

In addition, expenditure PPPs for the important categories of construction, education, health and collective government services were used directly as production PPPs for the corresponding categories ([11]). Other expenditure PPPs from the PPP programme are used as proxies for production PPPs for specific categories, for example:

- aggregate expenditure PPPs for energy for production and distribution activities of electricity and gas;
- PPPs for actual and imputed rents for real estate activities;
- PPPs for social protection for social work activities;
- PPPs for consumption expenditure by non-profit institutions serving households (NPISH) for activities of membership organisations.

Furthermore, there are a number of aggregate PPPs that are used as proxy:

- the PPPs for the aggregate of all consumer goods, used as reference PPPs for retail trade services;
- the PPPs for the aggregate of all consumer services, used as reference PPPs for as many as 121 CPA BHs, adding up to 22 % of GDP on average for the 31 countries.

Those services represent an important challenge for a reliable and detailed estimation of production PPPs. Future work should focus on more advanced methods to estimate them ([12]).

([9]) It would also have been possible to allocate the consumer products from the PPP programme to both the manufacturing industries and the corresponding wholesale trade services, at least for the cases where the trade issue does not play an important role. We have not done so, because it would require, for each of the 2 080 products, a more or less subjective assessment as to whether it is appropriate to use the purchasers' prices as proxy for output prices.

([10]) PLIs are defined as PPPs divided by exchange rates, expressed in percentage points. A country with a PLI equal to x times 100 has a price level equal to x times the average price level. Thus, a country with a PLI above (respectively below) 100 has a price level above (respectively below) the average of the set of countries considered.

([11]) The PPPs calculated in the PPP programme make use of a technicality known as 'fixity'. Fixity involves defining a subset of countries (in this case, EU28) whose PPPs become independent of other countries' PPPs (for more details, see Eurostat and OECD (2012)). It was decided not to use fixity here. This leads in particular to a different normalization of the results. The PPPs calculated in the PPP programme were therefore re-scaled before using them as production PPPs. This procedure leads to a uniform presentation of PPPs from the production and the expenditure sides; it does not cancel the effect of fixity, but it was estimated that the effect is minor.

([12]) The Structure of Earnings Survey gives comparable data on wage levels and could be used in a proxy 'input' method. Acquiring comparable data on the output of services is however a difficult challenge.

A couple of other proxy PPPs are used. For undifferentiated goods and services produced by private households for own use, PPPs are defined as the overall GDP PPPs. For mining and quarrying activities linked to energy products and for services provided by extraterritorial organisations and bodies, PPPs are defined as equal to the exchange rates of each country, so that all PLIs are set to the value 100. Due to the international nature of these products and services, it is indeed expected that price differences across European countries are not significant ([13]).

3.2. PRODCOM

PRODCOM (abbreviated PRC) is the annual European survey on production of manufactured goods. It is based on an annually renewed list of detailed products, for which production values and quantities are collected. As shown in Table 1, all EU Member States participate with the exceptions of Cyprus, Luxembourg and Malta; in addition, other countries participate, including Iceland and Norway, but not Switzerland.

The product list consisted in 2014 of more than 3 000 products that are identified with an 8-digit code of which the first six are based on CPA. This rather high granularity of products allows in many cases relatively reliable estimation of unit values, defined as ratios of values to quantities. They can be used as proxies for basic prices to estimate production PPPs.

It is well known (see e.g. the discussion in Eurostat (2016), pp. 27–29) that using unit values instead of real price data can lead to comparability issues, in particular due to product heterogeneity. Unit values incorporate any differences in the composition of the products. The high granularity of the used PRC data, together with the outlier elimination described below, limits such issues in this work, without removing them altogether, as is demonstrated by the variation coefficients discussed below.

Most of the PRC data is publicly released by Eurostat, but data is treated as confidential if the total values or quantities are based on too few data providers. The confidential data is available for processing only internally at Eurostat. Given that more than 40 % of the unit values in 2014 were marked as confidential, their use significantly strengthens the robustness of the results. In total, almost 50 000 unit values (before cleaning, see paragraph below) could be used to calculate PPPs.

However, before the unit values are used in calculations, they should be cleaned for outliers. To this end, corresponding PPP-converted unit values were calculated using the overall 2014 expenditure PPPs from the PPP programme (listed in Table 3), so that the values should be at approximately the same price level among countries. The cleaning process was then performed in two steps: first, maximum and minimum values for a product were eliminated if the ratio of these values was higher than 20, until no such extreme price variations existed; second, values whose price ratio to the average for other countries was above 5 or below 1/5 were removed. The thresholds 20 and 5 were selected empirically to balance between the need for a clean dataset and the limitation of the number of rejected values. In total, a bit less than 20 % of the unit values were eliminated this way. This lowered the average item variation coefficient ([14]) from 131 % to 55 %. According to PPP standards, this is still a rather high value; we will discuss the implications on the quality of the results in section 5.

([13]) For energy products, production prices or unit values (derived from each country's value and quantity data) could enhance the PPP estimation. However, available datasets did not seem to provide sufficiently complete and comparable data.

([14]) Defined as the standard deviation of PPP-converted unit values normalized by their average.

The production values for each product can in principle serve as product weights in the EKS calculation below the BH level. We experimented with such an option, but found that the quality of the results seems not to be enhanced compared to a non-weighted calculation. This could be explained as follows: as shown by the quality assessment of unit values, the production values entering their definition may include outliers, but no cleaning process can be applied directly on these values with the datasets at hand. Using the production values for both the calculation of unit values and the weighting of the PPP calculation would amplify the effect of outliers, if they are not eliminated by the cleaning process. We therefore decided to proceed with a non-weighted calculation up to the BH level.

3.3. Agricultural database

Eurostat's agricultural database includes annual producer prices of 128 crop and animal products for EU28 (Switzerland, Iceland and Norway are not covered), classified according to the Agricultural Prices and Price Indices (APRI) nomenclature. All products were reclassified into CPA and all available prices for 2014 used in the calculations.

The Economic Accounts for Agriculture (EAA) provide data on production values at basic prices for specific aggregates for all countries considered in this work except Iceland. Using a correspondence table between EAA and CPA, these data provided detailed weights for the 30 agricultural BHs of the first A*64 category ([15]).

3.4. Sources for weights

In the EKS procedure, the aggregation of PPPs from the BH level is weighted by the BH values (expenditures for expenditure PPPs, gross value added (GVA) for production PPPs ([16])) for each country. Our main source for estimating weights is Eurostat's national accounts database, which provides value-added data for all 31 countries at A*64 level. The most recent full dataset at the time of calculation, for the year 2013 ([17]), was extracted from the database, including confidential data that are not published. The public data for the year 2014 is to be found in Table A1 in the Excel file.

The national accounts data have to be broken down to the BH level. Our main source of weights at that level is Eurostat's SBS database, which provides value-added data down to the 4-digit level of NACE/CPA for all 31 countries except Ireland and Iceland ([18]). The most recent data, for the year 2013, were extracted from the database, including confidential data that are not published. This allowed reliable estimation of weights for 459 BHs covering: mining and quarrying; manufactured products; electricity, gas, steam and air conditioning; water supply, sewerage, waste management and remediation services; constructions and construction works; wholesale and retail trade services; repair services of motor vehicles and motorcycles; transportation and storage services; accommodation and food services; information and

([15]) The table linking EAA and CPA does not provide a one-to-one correspondence for all BHs. Assumptions were thus necessary to realise a breakdown of a few BHs. In absence of a better estimate, Iceland production structure was estimated to follow the average structure of other countries.

([16]) Even though the PPPs are estimated for output, we use value added as weights, first of all in order to be able to aggregate up to GVA/GDP, and secondly because ultimately the PPPs will be used to deflate value added.

([17]) It is expected that using 2013 data instead of 2014 data does not lead to significant discrepancies, as in the aggregation procedure only structures (ratios of values between categories and between countries) are important, and not absolute levels. Production patterns usually evolve slowly with time.

([18]) Ireland and Iceland do participate in SBS but the value-added data was not yet available at the time of extraction for this research. Data for Switzerland are provided only down to the 3-digit level of CPA.

communication services; real estate services; professional, scientific and technical services; administrative and support services; and some other services ([19]).

Other sources were used to estimate weights for BHs not covered by SBS. As noted in the previous subsection, EAA data covered 30 agricultural BHs. Data from the PPP programme provided weights for 5 BHs in the health sector. Four A*64 categories consist of only one BH. For the remaining 78 BHs, national accounts data were distributed uniformly, in absence of a better estimate. This rough allocation has no impact on the results: the BHs not covered by our data sources are services that are attributed the same set of proxy PPPs, as detailed at the end of subsection 3.1.

4. PPP calculation

Once the methodology and sources have been defined, the calculation of PPPs is performed in three steps.

First, direct calculation using available price data allows the estimation of PPPs for 329 BHs (out of 576 BHs in total), covering 34 % of total-economy GVA ([20]). Using weights data, these BH PPPs, defined at the 4-digit NACE/CPA level, are aggregated up to the 2-digit NACE/CPA level, the A*64 level, and total-economy GVA ([21]). However these PPPs are only preliminary results.

The second step of the calculation involves several operations. First, the quality (see section 5) of all calculated sets of PPPs is evaluated, so that the results can be deleted for BHs that do not meet the criteria defined. The non-deleted results are however not final: PPPs may be missing for some countries. As can be anticipated in view of the coverage of the sources (see Table 1), the countries with the fewest PPPs at this stage are Switzerland, Malta, Luxembourg, Cyprus, Iceland and Norway. PPPs are thus imputed to the missing BHs, country by country, from higher-level aggregates or from similar BHs ([22]). Aggregated PPPs are then re-calculated, based on available BH PPPs with gaps filled.

In the third step of the calculation, all empty BHs, i.e. those for which no prices are available at all or those for which the results were deleted in the previous step, are filled with either:

- specific or aggregate PPPs from the PPP programme as discussed in section 3.1;
- or PPPs calculated for a higher-level aggregate or similar category in the previous step.

At the end of this process, PPPs estimated by direct calculation from available prices or unit values account for 308 BHs, while 195 BHs are filled with specific or aggregate PPPs from the PPP programme and 73 BHs with PPPs from a higher-level aggregate or similar category. After completion, the full matrix of BH PPPs is used to calculate the final aggregated PPPs up to the 2-digit NACE/CPA level, the A*64, A*21 and A*10 levels, and the total GVA level.

([19]) The total value of a category at A*64 level, as provided by the national accounts database, is distributed among all the BHs belonging to the category according to the relative weights provided by the SBS database. Ireland and Iceland structures were estimated equal to the average structure of other countries; a similar assumption was made to break the 3-digit Swiss weights down to the 4-digit level.

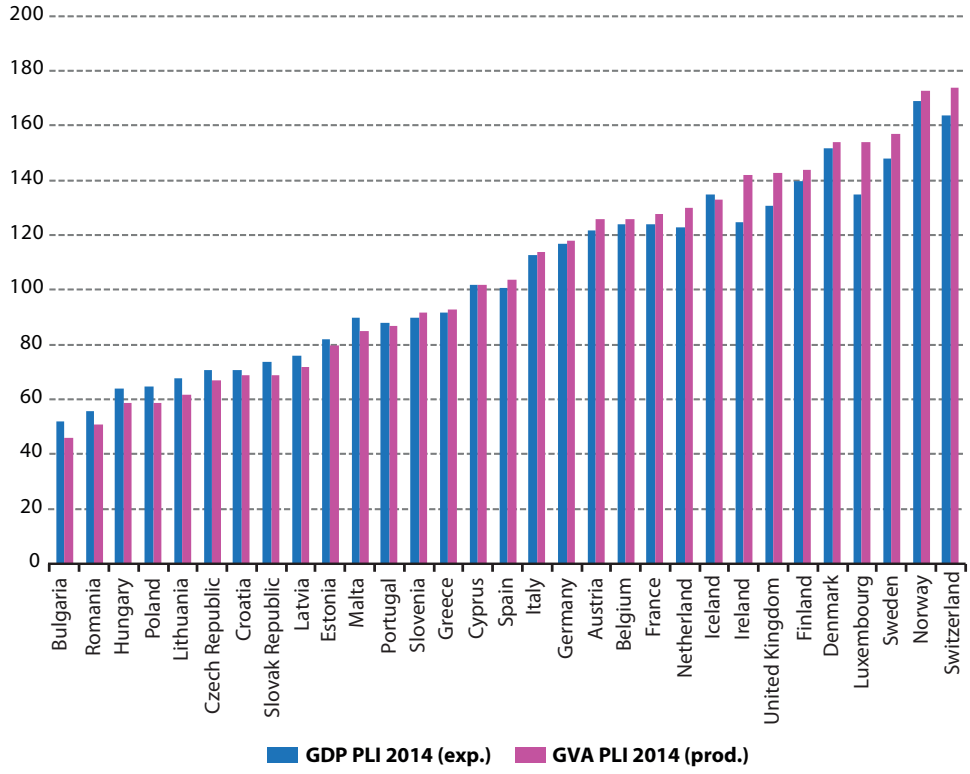
([20]) From the production side, GDP is defined as the sum of GVA of all industries plus taxes minus subsidies on products. As no PPPs can be made for taxes and subsidies, it is not possible to calculate GDP PPPs from the production side, only for total GVA.

([21]) For some countries, the total value of a few aggregates was zero. This would lead to numerical errors when aggregating PPPs. The weights equal to zero were thus set to an arbitrary small value (1€) when necessary.

([22]) Important cases are the gap filling of APRI-based BHs (especially for Switzerland, Iceland and Norway) and PRODCOM-based BHs (especially for Switzerland, Cyprus, Luxembourg and Malta) with BH PPPs from the PPP programme.

In Table 3, the results at total level are expressed in the form of PLIs, and compared with the GDP PLIs calculated in the PPP programme. The average deviation (in absolute value) between the two approaches is approximately 5 %. It is interesting to note that there is a correlation between price level and the direction of the difference between production and expenditure PPPs: differences in price levels for production are higher than those for expenditure — see Figure 1. This could be explained by the fact that the share of services in GVA is higher (for European countries) than the share of services in expenditures.

Figure 1: Comparison of aggregate level PLIs calculated from the expenditure side (for GDP) and from the production side (for GVA)



Source: Authors' calculations.

It should be noted that a high level of correlation between expenditure and production PPPs at GDP/GVA level is to be expected, because the PPPs for the expenditure BHs are used in the calculation of the production PPPs.

However, the main interest of the production PPP approach is to allow comparisons of PLIs for specific industries. To this end, the PLIs at A*64 level are listed in Table 4 ([23]). Hereafter, we discuss the quality of the results, we briefly analyse the results themselves, and we highlight some of their potential uses.

([23]) The Excel file also includes PLIs at the more aggregate levels A*21 and A*10.

5. Quality assessment and discussion of the results

5.1. Quality measures

As the calculation of PPPs relies on various data sources and is somewhat intricate, it is impossible in practice to reliably estimate the uncertainty of the results. However, the quality of the input and output data can be assessed in several ways, in areas such as coverage, reliability and plausibility. Quantitative quality measures were calculated at the BH level, and summed or averaged at the A*64 level, as shown in Table 2 and Table 5.

As regards the quality of the price data used as input, the number of products per BH or category (for each source and in total) and the number of available prices ([24]) per BH or category (or, equivalently, the average number of countries providing a price per product) are important. From Table 2 it can be seen that a total of 5 960 products account for 102 580 prices, i.e. an average of 17 prices per product (on 31 possible prices for each product, if all countries price it). A breakdown by source shows that the average is 23 for the PPP surveys, while for PRC and APRI only 12 prices on average are available.

The number of products per BH and the completeness of the matrix of prices are of paramount importance in the first step of the PPP calculation, as they will allow, or not, the calculation of a full set of PPPs for the BH. PPPs will not be estimated for countries with insufficient data availability. The number of PPPs available for each BH at the end of the first step of the calculation ([25]) is therefore used as a quality criterion for the output data: the greater the number, the better. An average of 14 PPPs per BH were calculated at the end of the first step of the calculation; restricted to the non-empty BHs, the average goes up to 25.

The availability of PPPs is not the only important criterion for evaluating output data. BH variation coefficients measure the dispersion of PPP-converted prices in a BH. High deviations from the average price levels of the BH indicate an unexpected heterogeneity of the BH, casting doubt on the reliability of the calculated PPPs. At the end of the first step of the calculation, the BH variation coefficients are equal to 35 on average. In the PPP programme, values above 33 are considered outliers. This tends to indicate that the quality of the results is less than the quality required in the PPP programme. This can be explained by the use of PRC unit values as proxies for basic prices: as noted in section 3.2, the comparability issue concerning unit values is well known in the price statistics literature. The validation of PRC data focuses on production values and quantities separately, as the primary purpose of the PRC data is not to be used for deriving proxies of prices. The average of the BH variation coefficients restricted to PRC-sourced BHs is approximately 60 (with a maximum of 67), to be compared to the value 18 (with a maximum of 51) for other BHs, based on 'true' price data. Despite the high granularity of products and the filtration process we applied on the PRC data, one has thus to be aware of the higher variability of these data for this purpose.

Finally, the values of the PPPs ([26]) themselves can provide quality measures. The standard deviation of PLIs is an indication of the extent of price differences among countries. High

([24]) In the following, the term 'price' is used whether data are prices or unit values.
([25]) The gap filling performed in subsequent steps of the calculation completes the matrix of BH PPPs.
([26]) More specifically, PLIs are used, as they allow for straightforward comparisons.

dispersion of PLIs may reflect a real economic fact ([27]), but it could also indicate a statistical anomaly. This can be investigated further by considering outlier price levels (e.g., that deviate from the average by a factor of more than 3). At the BH level, less than one country on average shows such an extreme PLI. We also calculated the correlation of each set of PLIs at the BH level and at the A*64 level with the set of PLIs at total GVA level. Again, a low or negative correlation may reflect a real economic fact, but it could also indicate a statistical anomaly. As can be seen in Table 5, the only negative correlation at the A*64 level in the final results is found for air transport, essentially an international activity whose price levels are likely to be more dependent on geography than on the GDP level of the considered country. Correlations between other sets of PLIs may provide useful insight as well.

5.2. Analysis of the results

All quality measures are used after the first step of the calculation to determine if the calculated PPPs will be kept or replaced by other sets of PPPs. Doubtful cases are flagged and checked manually. The quality measures also allow users to assess the quality of the final results, as can be done at A*64 level in Table 5. In the table, the main source used for each A*64 category is highlighted. This gives an overview of the relative importance of calculated PPPs and imputed PPPs, and could guide future work — which should focus on extending the sources and/or methods for important (in terms of share of GDP) categories not covered by satisfactory data sources or proxy PPPs.

Finally, the quality of the final results can be evaluated indirectly through relevant comparisons. As already pointed out, Table 3 draws a comparison between PLIs at the aggregate level calculated from the production side and from the expenditure side. The average deviation (in absolute value) of 5 % can be considered satisfactory. It shows that, in principle, production PPPs could provide a cross-check of the official PPPs (but only at the GDP level). However, the good agreement between production PPPs and expenditure PPPs can primarily be attributed to an extended use of the same data sources. Therefore, it does not provide an independent test of the quality of the results.

It would be interesting to calculate production PPPs for another reference year, using the same methodology and sources, so as to assess the volatility of the results, and their relation with the official PPPs. In addition to comparisons over time, sensitivity analyses would allow estimating the robustness of the results when subject to, e.g., methodological changes (for example, by calculating PPPs with the additive Geary-Khamis method instead of the EKS method). The Excel file contains a direct comparison of production-side PLIs at GVA level resulting from our study and those of the current version of the Penn World Table (PWT (2016)) ([28]). The correlation between the two sets of data is high, but, presumably due to a different treatment of imports and exports, there are some significant differences for smaller countries, as well as for example for Norway.

([27]) In particular, differences in price levels are expected to be important for activities highly dependent on labour (since no productivity adjustment for labour is used), such as services.
([28]) See Chart A1 in the Excel file.

5.3. Productivity comparisons

The main purpose of calculating production PPPs is to derive industry-specific PPP-adjusted productivity measures. In ESA 2010, the labour productivity per hour worked is calculated as real value added (deflated GDP) per unit of labour input (measured by the total number of hours worked). Using gross value added data and employment data ([29]) at A*64 level from Eurostat's national accounts database, and adjusting the ratios with the category-level PLIs listed in Table 4, leads to the productivity indicators of Table 6, presented at the A*21 level. The Excel file lists the indicators at A*64 and A*10 levels as well ([30]). As noted earlier, it should be emphasised that single deflation was used here: value added was divided by PPPs for output.

The interpretation and analysis of these experimental productivity numbers are outside the scope of this paper.

6. Conclusions

This article describes our research aimed at estimating production PPPs for 64 industries in 31 European countries. This is done by using comparable price and value data from European official databases only, including confidential data from several sources. Together these datasets allow the calculation of high-granularity PPPs, following the standard methodology of the Eurostat-OECD PPP Programme. The coverage, in terms of countries and industries, is high. The assessment of the quality of the input and output data tends to show that the results are not unrealistic. Further assessment could involve sensitivity analyses and comparisons with other datasets, so as to assess the robustness, reliability and plausibility of the present results. In the meantime, users should use them with care, taking into account all the limitations described in the present document.

The most important methodological choice that was made in this work was the sole use of PRODCOM data for calculating PPPs for manufacturing industries. We did not mix unit values from PRODCOM with actual prices from the PPP exercise. This has several advantages, most importantly that it removes the need for adjusting purchasers' prices for trade and transport margins (which can only be done in a very rough way) as well as for taking account of imports and exports. In addition, the methodology developed in this work allows it to be relatively easily reproduced in the future for other years. In our view, these advantages outweigh the well-known quality issue related to the use of unit values.

The ultimate aim is to develop PPPs in order to compare productivity levels of industries across countries, as demonstrated in this report on an experimental basis. With suitable refinements of the data sources and methods, production PPPs may become more than experimental data. Future work should focus on extending the coverage of activities to include those that are mainly intermediate consumption, particularly for services. This would in principle allow calculating value-added PPPs instead of output PPPs, strengthening their use for productivity comparisons.

([29]) See Tables A1 and A2, respectively, in the Excel file.
([30]) Of course, these indicators differ from the productivity indicators derived without PPP adjustment, listed in Table A3 in the Excel file.

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ANNEX

Table 1: Availability of data sources per country

Country code	Country name	Gross value added (GVA) 2014, m€	GVA 2014 (%31)	XR 2014 (NC/€)	NA	SBS	PPP	PRC	APRI
AT	Austria	294 443	2.2	1.000					
BE	Belgium	358 165	2.7	1.000					
BG	Bulgaria	37 125	0.3	1.956					
CY	Cyprus	15 847	0.1	1.000					
CZ	Czech Republic	141 582	1.1	27.536					
DE	Germany	2 631 268	19.7	1.000					
DK	Denmark	225 392	1.7	7.455					
EE	Estonia	17 194	0.1	1.000					
EL	Greece	156 826	1.2	1.000					
ES	Spain	948 309	7.1	1.000					
FI	Finland	176 877	1.3	1.000					
FR	France	1 917 675	14.3	1.000					
HR	Croatia	36 254	0.3	7.634					
HU	Hungary	87 726	0.7	308.710					
IE	Ireland	177 539	1.3	1.000					
IT	Italy	1 448 038	10.8	1.000					
LT	Lithuania	32 912	0.2	3.453					
LU	Luxembourg	43 633	0.3	1.000					
LV	Latvia	20 892	0.2	1.000					
MT	Malta	7 058	0.1	1.000					
NL	Netherlands	597 414	4.5	1.000					
PL	Poland	364 516	2.7	4.184					
PT	Portugal	151 714	1.1	1.000					
RO	Romania	132 743	1.0	4.444					
SE	Sweden	381 300	2.9	9.099					
SI	Slovenia	32 231	0.2	1.000					
SK	Slovakia	68 578	0.5	1.000					
UK	United Kingdom	2 014 931	15.1	0.806					
CH	Switzerland	512 719	3.8	1.215					
IS	Iceland	11 177	0.1	154.860					
NO	Norway	336 093	2.5	8.354					

Note: For each country, the availability of NA (national accounts), SBS (structural business statistics), PPP (purchasing power parities), PRC (PRODCOM) and APRI (agricultural prices and price indices) databases is indicated by a green cell, while pink cells correspond to non-covered countries. Shaded country codes indicate non-EU Member States. The column 'GVA 2014 (%31)' indicates the contribution of each country to the aggregated GVA of all 31 countries, for the year 2014, in percentage points. The column 'XR 2014 (NC/€)' indicates the exchange rate of the national currency to the euro, averaged over the year 2014; the listed values are used to convert national prices into euros and PPPs into PLIs.

Source: Eurostat

Table 2: Availability of data sources per A*64 category

A*64	NACE codes	NACE description	% GVA 2013	# BHs	CGS 2013-2015	EGS 2013	PRC 2014	APRI 2014	Total # items	Total # prices
1	01	Crop and animal production, hunting and related service activities	1.4	30	0	0	0	115	115	1 474
2	02	Forestry and logging	0.2	4	0	0	0	0	0	0
3	03	Fishing and aquaculture	0.1	1	0	0	0	0	0	0
4	05-09	Mining and quarrying	1.4	15	0	0	37	0	37	432
5	10-12	Manufacture of food products, beverages and tobacco products	2.1	33	0	0	379	13	392	7 105
6	13-15	Manufacture of textiles, wearing apparel and leather products	0.5	21	0	0	305	0	305	4 470
7	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	0.3	6	0	0	57	0	57	943
8	17	Manufacture of paper and paper products	0.3	7	0	0	104	0	104	1 446
9	18	Printing and reproduction of recorded media	0.3	5	0	0	0	0	0	0
10	19	Manufacture of coke and refined petroleum products	0.2	2	0	0	1	0	1	7
11	20	Manufacture of chemicals and chemical products	1.0	16	0	0	504	0	504	5 394
12	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	1.0	2	0	0	16	0	16	103
13	22	Manufacture of rubber and plastic products	0.7	6	0	0	127	0	127	2 018
14	23	Manufacture of other non-metallic mineral products	0.5	24	0	0	144	0	144	1 825
15	24	Manufacture of basic metals	0.5	16	0	0	259	0	259	2 859
16	25	Manufacture of fabricated metal products, except machinery and equipment	1.4	17	0	0	234	0	234	3 197
17	26	Manufacture of computer, electronic and optical products	0.9	10	0	0	175	0	175	1 386
18	27	Manufacture of electrical equipment	0.8	10	0	0	184	0	184	2 078
19	28	Manufacture of machinery and equipment n.e.c.	1.7	21	0	0	465	0	465	4 232
20	29	Manufacture of motor vehicles, trailers and semi-trailers	1.4	4	0	0	57	0	57	685
21	30	Manufacture of other transport equipment	0.5	8	0	0	46	0	46	353
22	31-32	Manufacture of furniture; other manufacturing	0.7	14	0	0	120	0	120	1 341
23	33	Repair and installation of machinery and equipment	0.6	9	0	0	0	0	0	0
24	35	Electricity, gas, steam and air conditioning supply	2.0	8	4	0	0	0	4	47
25	36	Water collection, treatment and supply	0.3	1	4	0	0	0	4	107
26	37-39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	0.7	8	0	0	0	0	0	0

Table 2: Availability of data sources per A*64 category (Cont.)

A*64	NACE codes	NACE description	% GVA 2013	# BHs	CGS 2013-2015	EGS 2013	PRC 2014	APRI 2014	Total # items	Total # prices
27	41-43	Construction	5.3	21	13	0	0	0	13	306
28	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	1.4	6	111	56	0	0	167	3 465
29	46	Wholesale trade, except of motor vehicles and motorcycles	5.2	48	1 497	444	0	0	1 941	45 985
30	47	Retail trade, except of motor vehicles and motorcycles	4.4	1	0	0	0	0	0	0
31	49	Land transport and transport via pipelines	2.3	8	32	0	0	0	32	695
32	50	Water transport	0.3	4	4	0	0	0	4	57
33	51	Air transport	0.3	3	19	0	0	0	19	495
34	52	Warehousing and support activities for transportation	1.7	6	5	0	0	0	5	130
35	53	Postal and courier activities	0.5	2	5	0	0	0	5	146
36	55-56	Accommodation; food and beverage service activities	2.7	8	157	0	0	0	157	3 545
37	58	Publishing activities	0.6	7	58	38	0	0	96	1 879
38	59-60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	0.6	7	12	0	0	0	12	335
39	61	Telecommunications	1.4	4	55	0	0	0	55	1 132
40	62-63	Computer programming, consultancy and related activities; information service activities	2.3	8	0	0	0	0	0	0
41	64	Financial service activities, except insurance and pension funding	3.6	7	0	0	0	0	0	0
42	65	Insurance, reinsurance and pension funding, except compulsory social security	1.2	4	0	0	0	0	0	0
43	66	Activities auxiliary to financial services and insurance activities	0.8	7	0	0	0	0	0	0
44	68	Real estate activities	10.6	4	0	0	0	0	0	0
45	69-70	Legal and accounting activities; activities of head offices; management consultancy activities	3.2	5	0	0	0	0	0	0
46	71	Architecture and engineering activities; technical testing and analysis	1.4	3	0	0	0	0	0	0
47	72	Scientific research and development	0.8	4	0	0	0	0	0	0
48	73	Advertising and market research	0.5	3	0	0	0	0	0	0
49	74-75	Other professional, scientific and technical activities; veterinary activities	0.5	5	8	0	0	0	8	217
50	77	Rental and leasing activities	1.0	12	8	0	0	0	8	192
51	78	Employment activities	1.0	3	0	0	0	0	0	0
52	79	Travel agency, tour operator reservation service and related activities	0.3	3	0	0	0	0	0	0

Table 2: Availability of data sources per A*64 category (Cont.)

A*64	NACE codes	NACE description	% GVA 2013	# BHs	CGS 2013-2015	EGS 2013	PRC 2014	APRI 2014	Total # items	Total # prices
50	77	Rental and leasing activities	1.0	12	8	0	0	0	8	192
51	78	Employment activities	1.0	3	0	0	0	0	0	0
52	79	Travel agency, tour operator reservation service and related activities	0.3	3	0	0	0	0	0	0
53	80-82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support	1.8	15	0	0	0	0	0	0
54	84	Public administration and defence; compulsory social security	6.7	9	0	0	0	0	0	0
55	85	Education	5.1	11	6	0	0	0	6	177
56	86	Human health activities	5.2	5	29	0	0	0	29	823
57	87-88	Social work activities	2.3	7	0	0	0	0	0	0
58	90-92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	0.9	9	2	0	0	0	2	61
59	93	Sports activities and amusement and recreation activities	0.5	6	11	0	0	0	11	299
60	94	Activities of membership organisations	0.7	6	0	0	0	0	0	0
61	95	Repair of computers and personal and household goods	0.1	8	12	0	0	0	12	332
62	96	Other personal service activities	0.9	5	24	0	0	0	24	709
63	97-98	Activities of households as employers of domestic personnel and undifferentiated goods and services production of households for own use	0.7	3	4	0	0	0	4	98
64	99	Activities of extraterritorial organisations and bodies	0.0	1	0	0	0	0	0	0
		Total	100	576	2 080	538	3 214	128	5 960	102 580

Note: Each A*64 category is defined by the corresponding NACE codes and description. The category's share in GVA (averaged over all 31 countries, for the year 2013) is given in column '% GVA 2013'. The column '# BHs' indicates the number of basic headings (defined at the 4-digit NACE/CPA level) included in the category. The number of products from price data sources 'CGS 2013-2015' (PPP consumer goods and services surveys), 'EGS 2013' (PPP equipment goods and services survey), 'PRC 2014' (PRODCOM survey) and 'APRI 2014' (agricultural prices and price indices survey) included in BHs of the category is listed in the respective columns. These figures are summed in the column 'Total # items', while the column 'Total # prices' gives the total number of prices (per category) used for PPP calculation. The ratio of the last two columns therefore indicates the average number of countries pricing the items of the category. Note that the numbers indicated correspond to the availability of price data for the first step of the calculation; as described in section 4, results that do not meet quality criteria will be deleted and replaced by proxy PPPs in subsequent steps.

Source: Authors' calculations.

Table 3: Overall price level indices for the year 2014 per country

Country code	GVA 2014 (%31)	XR 2014 (NC/€)	GDP PLI 2014 (exp.)	GVA PLI 2014 (prod.)	Differ. prod./ exp. (%)	GDP 2014 (PPS/cap.)
AT	2.2	1.000	122	126	3	35 600
BE	2.7	1.000	124	126	2	32 500
BG	0.3	1.956	52	46	– 12	12 800
CY	0.1	1.000	102	102	0	22 600
CZ	1.1	27.536	71	67	– 6	23 500
DE	19.7	1.000	117	118	1	34 600
DK	1.7	7.455	152	154	1	34 800
EE	0.1	1.000	82	80	– 2	20 700
EL	1.2	1.000	92	93	1	20 000
ES	7.0	1.000	101	104	3	24 900
FI	1.3	1.000	140	144	3	30 300
FR	14.3	1.000	124	128	3	29 400
HR	0.3	7.634	71	69	– 3	16 100
HU	0.7	308.710	64	59	– 8	18 800
IE	1.3	1.000	125	142	14	37 600
IT	10.9	1.000	113	114	1	26 500
LT	0.2	3.453	68	62	– 9	20 700
LU	0.3	1.000	135	154	14	73 600
LV	0.2	1.000	76	72	– 5	17 500
MT	0.1	1.000	90	85	– 6	23 600
NL	4.5	1.000	123	130	6	35 900
PL	2.7	4.184	65	59	– 9	18 600
PT	1.1	1.000	88	87	– 1	21 400
RO	1.0	4.444	56	51	– 9	15 200
SE	2.9	9.099	148	157	6	33 900
SI	0.2	1.000	90	92	2	22 600
SK	0.5	1.000	74	69	– 7	21 200
UK	15.0	0.806	131	143	9	30 000
CH	3.8	1.2146	164	174	6	44 400
IS	0.1	154.860	135	133	– 1	33 000
NO	2.5	8.354	169	173	2	48 700

Note: The first three columns also appear in Table 1. For each country are indicated the overall GDP/GVA price level index (PLI), for the year 2014, either calculated from the expenditure side (column 'GDP PLI 2014 (exp.)'), in the PPP programme, or from the production side (column 'GVA PLI 2014 (prod.)'), in the present work. To allow the comparison made in the column 'Differ. prod./exp.', the 31 PLIs are scaled so that their geometric mean is equal to 100 in both cases, a scaling which differs from the one used in the official datasets of the PPP programme. Large relative differences are accentuated in colour. In the last column is indicated the 2014 GDP per capita of each country, expressed in purchasing power standard (i.e., adjusting monetary values with the official GDP expenditure PPPs). Cells are coloured depending on the level of GDP per capita. The last two columns are correlated: the price levels of less rich (richer) countries are usually smaller (bigger) when evaluated from the production side compared to the expenditure side.

Source: Authors' calculations.

Table 4: Price level indices for the year 2014 per A*64 category

A*64	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT
1	100	71	79	108	90	96	105	79	114	88	115	119	88	79	108	128
2	113	97	57	103	75	107	133	78	102	98	134	125	76	65	130	126
3	99	70	83	107	91	96	103	80	115	88	114	119	90	81	107	129
4	112	113	81	105	86	100	122	98	79	91	121	130	86	70	112	99
5	121	112	63	109	75	94	112	92	115	90	123	110	95	68	110	112
6	189	108	61	95	70	128	116	87	95	83	161	150	75	59	111	108
7	122	127	64	109	69	101	143	97	117	76	93	114	86	62	124	131
8	115	121	78	127	77	99	136	80	70	97	105	124	84	81	143	94
9	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
10	121	97	72	92	77	96	143	97	95	85	127	107	92	83	136	89
11	121	97	72	92	77	96	143	97	95	85	127	107	92	83	136	89
12	88	61	68	133	65	106	60	83	172	104	127	147	203	81	279	106
13	130	101	56	104	80	113	140	110	81	86	128	132	103	82	113	85
14	121	107	63	107	71	94	149	91	76	79	129	132	84	79	126	81
15	124	125	70	103	88	100	224	120	82	92	122	112	86	83	154	83
16	158	128	53	103	70	112	155	104	67	77	129	146	87	61	125	90
17	115	107	59	105	77	93	127	116	88	83	134	122	89	48	105	81
18	124	136	49	99	74	98	146	79	82	82	169	114	81	62	156	94
19	128	146	48	99	75	120	139	83	77	94	141	117	90	64	101	97
20	104	108	52	105	86	115	124	120	103	77	143	90	93	101	133	91
21	107	91	47	96	82	207	115	125	94	95	136	135	73	108	102	119
22	172	155	65	100	71	118	178	82	82	89	111	109	70	80	116	105
23	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
24	118	112	58	130	88	139	153	83	115	128	101	111	77	64	134	138
25	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
26	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
27	132	115	55	86	75	146	160	87	76	82	157	142	63	64	94	95
28	113	104	73	96	74	107	155	89	90	95	115	106	87	81	108	101
29	108	113	75	105	81	100	127	93	100	94	114	106	83	75	117	106
30	108	108	71	104	79	106	135	91	99	97	117	106	86	76	120	109
31	123	120	42	85	50	147	186	60	81	88	157	120	86	79	180	75
32	120	84	41	87	50	110	225	109	67	149	117	149	57	59	128	139
33	104	93	94	142	86	98	88	128	105	93	107	104	101	97	91	80
34	131	97	45	70	88	96	171	106	230	138	136	105	49	54	136	123
35	93	125	54	69	71	93	202	101	91	94	153	119	91	79	133	125
36	111	128	51	105	60	99	159	84	82	99	143	123	80	57	133	117
37	107	113	58	102	67	122	169	90	101	104	154	107	83	68	122	103
38	110	118	62	111	68	105	153	83	101	109	128	126	71	65	126	119
39	103	136	75	88	101	110	113	59	132	134	91	104	91	95	148	126
40	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
41	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
42	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
43	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
44	119	151	31	99	62	131	199	77	97	128	191	161	49	46	178	130

Table 4: Price level indices for the year 2014 per A*64 category (Cont.)

A*64	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	CH	IS	NO
1	78	105	86	100	86	73	92	96	106	111	86	106	129	137	227
2	65	133	76	91	108	62	89	65	132	100	74	130	160	139	212
3	79	104	87	101	83	74	92	98	104	111	88	104	126	137	228
4	91	118	88	99	112	81	76	82	153	109	77	123	108	109	120
5	77	103	77	101	97	77	97	74	116	105	78	124	137	143	173
6	77	113	66	89	107	62	77	59	173	95	82	126	130	126	211
7	82	119	69	122	122	69	85	59	111	99	102	124	104	140	165
8	86	113	91	104	98	84	85	72	117	100	92	117	115	173	95
9	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
10	85	112	100	79	102	80	92	77	127	113	80	122	114	120	149
11	85	112	100	79	102	80	92	77	127	113	80	122	114	120	149
12	87	127	92	143	92	81	26	83	75	245	65	87	172	162	53
13	78	95	101	108	90	77	78	74	130	104	101	111	127	125	124
14	74	107	91	117	126	63	71	66	165	105	84	128	113	131	212
15	98	89	81	57	114	83	86	81	146	95	94	114	77	99	138
16	72	119	88	94	134	68	78	61	151	103	79	133	132	117	157
17	93	100	91	114	237	64	83	75	152	99	84	118	111	131	140
18	74	101	103	112	167	58	88	58	182	87	83	113	113	111	193
19	85	103	73	110	151	70	78	64	138	104	75	128	120	125	205
20	98	102	88	112	142	65	81	76	133	89	94	123	119	100	107
21	83	97	82	97	92	77	63	66	116	111	90	112	114	110	201
22	71	114	110	101	125	59	84	59	159	86	68	101	116	130	168
23	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
24	76	100	75	88	118	77	135	63	136	101	96	114	111	67	100
25	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
26	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
27	77	129	80	85	124	81	61	48	191	80	77	123	194	166	195
28	85	103	87	89	111	79	105	79	118	93	87	101	146	126	155
29	85	101	91	109	106	74	99	80	121	92	88	102	126	136	137
30	84	103	88	104	106	73	97	74	122	94	87	109	128	125	147
31	70	126	55	78	165	54	84	45	175	99	57	186	209	176	221
32	56	129	56	91	148	126	119	43	79	98	57	219	308	133	141
33	96	77	106	123	85	103	133	89	92	126	64	108	78	194	85
34	53	86	108	146	133	55	104	31	184	71	93	186	127	75	222
35	64	112	86	64	118	84	104	41	211	70	78	113	131	139	238
36	72	116	80	97	126	80	80	58	157	94	73	124	165	138	184
37	64	109	76	107	120	57	98	63	139	105	71	97	152	155	166
38	56	128	66	113	128	57	92	54	137	99	103	126	159	116	164
39	60	112	70	94	125	54	117	65	100	107	90	129	145	106	124
40	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
41	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
42	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
43	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
44	44	241	67	57	167	33	91	48	150	74	47	221	265	125	204

Table 4: Price level indices for the year 2014 per A*64 category (Cont.)

A*64	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT
45	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
46	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
47	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
48	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
49	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
50	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
51	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
52	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
53	129	136	39	99	62	120	172	76	90	110	158	132	65	53	158	123
54	143	148	34	122	57	129	171	66	88	108	153	135	59	49	152	128
55	178	159	27	105	50	131	178	60	85	105	162	132	58	45	134	113
56	139	135	26	134	51	118	151	71	79	137	169	126	60	45	208	149
57	149	168	27	133	44	134	223	53	78	143	165	162	39	33	192	120
58	261	164	24	57	58	249	214	74	109	110	145	183	44	45	168	106
59	132	129	53	84	45	149	120	117	140	151	141	148	68	59	111	177
60	143	136	34	107	55	124	169	73	77	114	150	129	66	48	168	121
61	165	131	27	84	69	132	223	117	75	90	187	117	55	57	192	114
62	132	133	37	91	60	117	184	80	84	106	170	127	65	50	143	117
63	126	120	56	83	65	120	169	97	83	101	163	132	73	62	131	107
64	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Note: The price level indices (PLIs) for the year 2014, as calculated in this work, are given for each country per A*64 category (whose NACE definitions are listed in Table 2). The geometric mean of each set of 31 PLIs is equal to 100; countries with PLIs above (respectively below) this value have a price level above (respectively below) average.

Source: Authors' calculations.

Table 4: Price level indices for the year 2014 per A*64 category (Cont.)

A*64	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	CH	IS	NO
45	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
46	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
47	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
48	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
49	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
50	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
51	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
52	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
53	52	170	66	82	142	52	86	44	166	89	61	161	203	142	197
54	49	210	59	86	144	52	85	37	181	88	59	141	229	147	226
55	42	307	57	88	141	44	84	30	230	99	60	158	281	150	256
56	43	202	48	88	131	52	98	29	226	98	58	169	220	153	242
57	30	251	40	97	162	48	92	26	257	102	41	133	288	243	342
58	40	141	76	49	137	54	82	32	212	66	63	297	214	124	239
59	66	124	76	56	112	47	90	56	163	92	62	111	174	138	173
60	51	207	65	90	132	47	89	35	188	99	58	151	233	154	228
61	51	172	61	71	118	42	78	42	191	110	89	107	189	148	239
62	59	158	70	79	137	60	77	44	179	92	65	145	203	148	224
63	66	117	76	87	118	51	87	53	176	91	73	125	159	136	231
64	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 5: Quality assessment of the results per A*64 category

A*64	NACE codes	% GVA 2013	# BHs	Main source	Av. BH VCs	St. dev. of PLIs	Correl. w/ GVA (%)
1	01	1.4	30	APRI	19	28	61
2	02	0.2	4	Proxy from category 1	:	33	93
3	03	0.1	1	Proxy from category 1	:	28	57
4	05-09	1.4	15	PRC+exchange rates	:	19	83
5	10-12	2.1	33	PRC	33	24	84
6	13-15	0.5	21	PRC	45	38	83
7	16	0.3	6	PRC	45	26	77
8	17	0.3	7	PRC	43	23	67
9	18	0.3	5	PPPs for services	:	47	100
10	19	0.2	2	Proxy from category 11	:	20	85
11	20	1.0	16	PRC	50	20	85
12	21	1.0	2	PRC	52	56	16
13	22	0.7	6	PRC	48	21	75
14	23	0.5	24	PRC	37	33	82
15	24	0.5	16	PRC	39	31	57
16	25	1.4	17	PRC	41	32	89
17	26	0.9	10	PRC	49	34	62
18	27	0.8	10	PRC	54	37	82
19	28	1.7	21	PRC	53	33	84
20	29	1.4	4	PRC	57	21	67
21	30	0.5	8	PRC	39	33	59
22	31-32	0.7	14	PRC	38	33	81
23	33	0.6	9	PPPs for services	:	47	100
24	35	2.0	8	PPPs for energy	:	26	61
25	36	0.3	1	PPPs for services	:	47	100
26	37-39	0.7	8	PPPs for services	:	47	100
27	41-43	5.3	21	PPPs for construction	:	42	90
28	45	1.4	6	CGS+EGS	13	21	88
29	46	5.2	48	CGS+EGS	19	17	88
30	47	4.4	1	PPPs for goods	:	18	93
31	49	2.3	8	CGS	19	53	92
32	50	0.3	4	CGS	40	58	72
33	51	0.3	3	CGS	20	24	– 7
34	52	1.7	6	CGS	17	50	64
35	53	0.5	2	CGS	31	44	81
36	55-56	2.7	8	CGS	17	34	95
37	58	0.6	7	CGS+EGS	16	31	89
38	59-60	0.6	7	CGS	11	30	94
39	61	1.4	4	CGS	32	25	68
40	62-63	2.3	8	PPPs for services	:	47	100
41	64	3.6	7	PPPs for services	:	47	100
42	65	1.2	4	PPPs for services	:	47	100
43	66	0.8	7	PPPs for services	:	47	100

Table 5: Quality assessment of the results per A*64 category (Cont.)

A*64	NACE codes	% GVA 2013	# BHs	Main source	Av. BH VCs	St. dev. of PLIs	Correl. w/ GVA (%)
44	68	10.6	4	PPPs for rents	:	65	95
45	69-70	3.2	5	PPPs for services	:	47	100
46	71	1.4	3	PPPs for services	:	47	100
47	72	0.8	4	PPPs for services	:	47	100
48	73	0.5	3	PPPs for services	:	47	100
49	74-75	0.5	5	PPPs for services	:	47	100
50	77	1.0	12	PPPs for services	:	47	100
51	78	1.0	3	PPPs for services	:	47	100
52	79	0.3	3	PPPs for services	:	47	100
53	80-82	1.8	15	PPPs for services	:	47	100
54	84	6.7	9	PPPs for government services	:	55	98
55	85	5.1	11	PPPs for education	:	73	93
56	86	5.2	5	CGS	23	61	96
57	87-88	2.3	7	PPPs for social protection	:	85	95
58	90-92	0.9	9	CGS	16	76	84
59	93	0.5	6	CGS	10	41	82
60	94	0.7	6	PPPs for NPISH	:	55	98
61	95	0.1	8	CGS	10	56	92
62	96	0.9	5	CGS+PPPs for services	21	49	98
63	97-98	0.7	3	CGS+PPPs for GDP	24	41	93
64	99	0.0	1	exchange rates	:	0	:
		100	576			37	100

Note: As in Table 2, each A*64 category is defined by the corresponding NACE codes whose description is to be found in Table 2. The category's share in GVA (averaged over all 31 countries, for the year 2013) is given in column '% GVA 2013'. The column '# BHs' indicates the number of basic headings (defined at the 4-digit NACE/CPA level) included in the category. The main data source for estimating the basic-heading PPPs of the category is indicated in the corresponding column. The average basic-heading variation coefficients are listed in column 'Av. BH VCs'; when no price data is directly used within a category, the symbol ':' is used. The standard deviation of the PLIs of the category (Table 4) is given in the corresponding column. The last column indicates the correlation of the set of PLIs of the category (Table 4) with the set of PLIs at total GVA level (Table 3, column 'GVA PLI 2014 (prod.)').

Source: Authors' calculations.

Table 6: Labour productivity in the year 2014 per A*21 category
(PPP-adjusted euro/hour worked)

A*21	NACE description	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE
A	Agriculture, forestry and fishing	9	26	3	7	14	20	32	17	5	19	16	18	7	10	10
B	Mining and quarrying	116	59	29	13	29	53	603	36	46	46	43	58	61	26	67
C	Manufacturing	42	57	10	13	22	52	59	14	23	42	43	43	11	22	69
D	Electricity, gas, steam and air conditioning supply	94	152	46	72	98	89	102	46	79	193	192	162	47	51	126
E	Water supply; sewerage, waste management and remediation activities	61	50	16	30	24	58	61	30	52	34	53	42	17	19	41
F	Construction	29	39	10	16	13	20	24	14	16	35	19	26	15	13	24
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	33	44	7	15	14	31	38	15	10	20	31	34	12	12	31
H	Transportation and storage	37	47	16	46	22	34	36	19	24	28	24	37	10	18	28
I	Accommodation and food service activities	27	24	7	13	12	18	19	8	18	27	14	24	12	11	13
J	Information and communication	45	60	29	46	40	60	47	31	27	44	48	64	27	32	99
K	Financial and insurance activities	48	88	67	64	59	52	72	60	50	56	47	58	57	42	66
L	Real estate activities	258	512	280	533	111	400	174	124	1 802	273	294	296	785	143	356
M	Professional, scientific and technical activities	25	27	20	32	22	34	30	21	13	24	24	37	31	26	27
N	Administrative and support service activities	29	20	10	15	15	30	23	26	11	15	18	27	19	15	47
O	Public administration and defence; compulsory social security	25	28	19	22	30	35	32	20	25	24	26	34	17	21	23
P	Education	25	34	22	31	25	29	27	15	30	30	27	40	15	21	37
Q	Human health and social work activities	22	25	20	17	23	23	21	12	22	21	18	25	15	18	15
R	Arts, entertainment and recreation	18	25	23	39	21	20	31	11	21	22	23	20	27	19	29
S	Other service activities	17	22	15	15	15	28	22	11	12	13	15	22	13	17	13
T	Activities of household as employers; undifferentiated goods- and services-producing activities of households for own use	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
U	Activities of extraterritorial organisations and bodies	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:

Note: Dividing the value-added data by the number of hours worked leads to productivity measures (in euros per hour), whose price bias is compensated by adjusting for the category-specific price differences listed in Table 4, therefore obtaining the productivity measures listed in this table (in PPP-adjusted euros, or equivalently in purchasing power standard, per hour). The values listed in this table are calculated on an experimental basis, and should be used for research purposes only.

Source: Authors' calculations.

Table 6: Labour productivity in the year 2014 per A*21 category (Cont.)
(PPP-adjusted euro/hour worked)

A*21	NACE description	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK	CH	IS	NO
A	Agriculture, forestry and fishing	10	7	44	6	:	35	4	6	2	18	5	26	14	8	:	20
B	Mining and quarrying	137	17	56	20	:	835	15	33	10	78	29	38	158	:	:	540
C	Manufacturing	35	22	45	13	17	45	16	20	16	48	23	22	36	:	:	41
D	Electricity, gas, steam and air conditioning supply	120	51	172	34	:	143	44	199	39	136	61	80	107	:	:	327
E	Water supply; sewerage, waste management and remediation activities	31	28	43	20	24	45	26	28	14	35	23	28	40	:	:	43
F	Construction	26	17	27	13	17	26	13	19	16	20	21	22	25	23	:	30
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	23	17	68	11	13	41	19	17	7	35	22	15	27	60	:	37
H	Transportation and storage	38	32	46	19	19	35	19	23	25	31	28	31	21	34	:	34
I	Accommodation and food service activities	17	11	25	9	13	18	8	17	10	16	14	8	16	14	:	22
J	Information and communication	43	41	66	27	:	47	37	34	52	57	31	34	39	45	:	54
K	Financial and insurance activities	59	38	106	47	:	91	41	65	61	76	40	60	47	62	:	109
L	Real estate activities	433	176	304	101	:	185	187	285	439	172	335	254	146	:	:	315
M	Professional, scientific and technical activities	26	26	36	18	28	31	34	18	48	38	20	27	22	28	:	39
N	Administrative and support service activities	19	17	24	14	18	20	17	11	18	22	14	16	15	:	:	24
O	Public administration and defence; compulsory social security	39	27	35	24	:	41	18	26	21	25	28	28	28	81	:	31
P	Education	33	17	21	12	:	32	18	20	33	13	17	17	21	2	:	23
Q	Human health and social work activities	23	19	23	16	:	24	17	14	34	15	17	21	16	19	:	19
R	Arts, entertainment and recreation	25	14	43	24	111	25	13	16	63	16	24	56	11	:	:	21
S	Other service activities	16	13	19	7	8	18	23	12	14	19	12	19	25	:	:	23
T	Activities of household as employers; undifferentiated goods- and services-producing activities of households for own use	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
U	Activities of extraterritorial organisations and bodies	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:

4

Cyclical dissimilarities among the European economies: the impact of the European recessions

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Abstract: In this paper, we study the cyclical dissimilarities of European economies in the course of the current crisis. To this aim, we first suggest an extension of the Harding and Pagan's measure by quantifying the similarity of series in terms of business and growth cycles. This measure is based on the cyclical turning points defined in the ABCD approach and which are estimated by Eurostat. We use this measure to cluster the countries according to their cyclical dissimilarities in relation to their business and growth cycle. This clustering is performed over two time frames: a 4-year rolling window and fixed periods. Different clustering methods have been compared. We found an increase in dissimilarities among European countries in the wake of the European crisis of 2011-12.

Keywords: Business cycle, cyclical dissimilarities, clustering.

JEL codes: C32, E01, E32.

(1) ACE — Analyzing Cycles in Economies.
(2) Joint Research Centre, European Commission and Hendyplan.
(3) At the time of producing this article: Eurostat, Unit C1 National accounts methodology, indicators.

1. Introduction

The European Union aims at the convergence of its member economies. For its members, to be part of the euro area, they have to meet economic and legal convergence criteria ([4]). Its members, except the UK and Denmark ([5]), pursue this goal and the European Commission periodically assesses the fulfillment of these criteria whose analysis and conclusions can be found in the Convergence Reports ([6]). However, while the common currency aims at the convergence of the euro area business cycles, it is only when the business cycles co-move closely across countries that the benefit of participating into the common currency exceeds the cost of losing national autonomous monetary policy, as shown in Alesina et al. (2005) among others.

In the last years, the great recession has threatened this convergence, in particular in long-term interest rates and national public finances. Overall, the European Union has known a double dip crisis. The international financial recession in 2007-2008 morphed into a subsequent European sovereign debt crisis and a double-dip recession in 2011-2012. Its impact on the Union was a concern for policymakers. The '5 presidents report' (Juncker et al. (2015)) strongly pushed towards more monetary union to better diffuse the benefits of monetary policy decisions and avoid the deepening of economic divergences which happened during the crisis ([7]).

Further analysis on the effect of the crisis on the European Union economies show that it indeed implied divergences. While the concept of convergence entails many dimensions, most of the literature focuses on convergence in terms of GDP per capita, and business and growth cycles. In terms of GDP per capita convergence in the aftermath of the last crisis, Forgó and Jevčák (2015) observe that, for the ten Central and Eastern European (CEE10) countries which entered the EU between 2004 and 2007, the rapid pace of economic convergence in the pre-crisis period partly reflected an investment boom which was not sustained in the post-crisis period. Similarly, Stanišić (2012) found that GDP per capita had been diverging among the EU15 countries, that the recent economic crisis had led to an income convergence within EU15 and to a divergence within CEE10 and that the income differences among the EU25 countries had increased during the crisis without affecting the long term convergence path even though the convergence was slower. More recently, Begu et al. (2014) observe the continuous increase in divergence between the EU27 states due to the crisis.

Regarding the business and growth cycle convergences, with an international perspective and focusing on GDP, Gomez et al. (2013) show that globalization in terms of business cycle synchronization is a regional process rather than a global one. Using data from the 50's up to the first dip of the crisis, they find that in the EU and the ASEAN the integration is significantly higher than elsewhere. Similarly, Kose et al. (2012) analyzes the evolution of the degree of global cyclical interdependence over the 1960-2008 period. In the 1985-2008 period, they observe business cycle convergence within the industrial countries and within the emerging economies but divergence between these two groups. At the European level, and over the same period, Crespo-Cuaresma and Fernández-Amador (2013) find significant business cycle divergence in the mid-eighties, followed by a persistent convergence in the nineties which coincides with the period of fiscal consolidation and convergence among European countries following the

([4]) These criteria mostly concern price stability, sound public finances, exchange rate stability, convergence in long-term interest rates, and the compatibility of national legislation with the existing EU legislation.
([5]) The UK and Denmark have negotiated opt-out arrangements and will therefore not be the subject of a convergence assessment until they request it.
([6]) See http://ec.europa.eu/economy_finance/euro/adoption/convergence_reports/index_en.htm.
([7]) 'In a Monetary Union, the financial system must be truly single or else the impulses from monetary policy decisions (e.g. changes in policy interest rates) will not be transmitted uniformly across its Member States. This is what happened during the crisis, which in turn aggravated economic divergence.'

Maastricht Treaty. During this period, Europe differentiates itself with respect to other advanced economies in terms of cyclical synchronization before being diluted within a global cycle since 2004. Focusing on the post-crisis period, Ferroni and Klaus (2015) study the effect of the crisis on the business cycle properties of the four largest euro area economies (Germany, France, Italy and Spain). They found that while the economic fluctuations of the four countries were similar before the crisis, Spain diverges substantially from the euro area afterwards. Gächter et al. (2013) analyzes the business cycle convergence in the EU and focusing on the central, eastern and south Eastern Europe (CESEE) countries. They find that business cycles in CESEE have decoupled considerably from the euro area during the financial crisis in terms of both cyclical dispersion and cyclical correlation. Considering the first dip, Lee (2013) finds that the European countries tended to be more synchronized during the run-up to the EMU, and that there is no strong evidence to support the argument that the regional effects prevail after 1999.

In this paper we aim at clustering dynamically the 19 countries of the euro area according to their cyclical similarities before, during and after the crisis, which enables us to analyze their evolution. While much of the existing literature computes the synchronization of business cycles with correlation coefficients, this definition presents a drawback as noted in De Haan et al (2007): correlation coefficients are linear and mix the synchronicity and amplitude of the business cycle and thus even if business cycles are perfectly synchronous, their correlation coefficient could differ from unity because of different amplitudes. As a consequence, and following De Haan et al (2007), we rely on a concordance measure as defined in Harding and Pagan (2002). We extend their concordance measure of synchronicity to take into account a more precise characterization of cyclical phases. Indeed, our data is the cyclical turning points assessed by Eurostat and based on the ABCD approach by Anas and Ferrara (2004). The data is quarterly and ranges from 2000 to 2015. As in Billio et al. (2016), this approach considers 3 main states in the business and growth cycles: expansion, slowdown ([8]) and recession.

Billio et al. (2016) study the industrial production business cycle similarities of the United States, Germany, France, Italy, Spain, the Netherlands and Belgium using a model-based approach (panel Markov switching VAR model). They find two clusters over the period spanning from 1991 to 2013, one gathers France, Germany, the Netherlands and to a lesser extent Belgium, and the other one gathers Italy and Spain. It is also worth mentioning Camacho et al. (2006) who consider monthly Industrial Production Index data from 1990M1 to 2003M1, for 30 countries ([9]) including non-European countries. Their results ([10]) show the pre-crisis homogeneity of the European countries, except for Finland which is cyclically similar to the US and, and for some Eastern countries which joined the EU in 2004, i.e. after their study ([11]).

While the methodology of this paper is standard, this paper contributes to the literature by the number of countries it considers and by its sample size which includes the second dip of the crisis, for which literature is still scarce. The identification of the causes of the dissimilarities as well as suggestions for possible remedies are out of the scope of this paper. The structure of this paper is as follows. Section 2 presents the methodology, i.e. the ABCD approach, a homogeneity index, the proposed extension of Harding and Pagan's measure of cyclical dissimilarity, and the clustering techniques considered. Section 3 presents the data and the clustering analysis. Section 4 concludes.

([8]) Even though in our case, we distinguish downward and upward slowdowns.

([9]) Norway (NO), Turkey (TK), Latvia (LV), Czech Republic (CZ), Slovakia (SK), Estonia (EE), Romania (RO), Lithuania (LT), Finland (FI), the United Kingdom (UK), Canada (CA), the United States (US), Portugal (PT), Greece (EL), Cyprus (CY), Luxembourg (LU), Japan (JP), Poland (PO), Bulgaria (BG), Italy (IT), Denmark (DK), Slovenia (SI), Ireland (IE), the Netherlands (NL), Germany (DE), France (FR), Austria (AT), Hungary (HU), Sweden (SE) and Spain (ES).

([10]) Overall, their clustering is the following: [1] EL, PT, CY, ES, AT, FR, NL, DE, LU, SI, IT, IE (+ LT, SE, DK, BG) [2] FI (+ US, CA, UK, JP) [3] EE, SK, LV (+ PL, CZ, RO, TK, NO).

([11]) Slovakia joined the euro area in 2009, Estonia in 2011 and Latvia in 2014.

2. Methodology

2.1. The ABCD approach

The main idea of the ABCD approach introduced in Anas and Ferrara (2004) is that there exists a chronology in the sequence of the turning points of the business and growth cycles. The business cycle is made up of expansions and recessions, as it is defined by the fluctuations of the level of the series. Conversely, the growth cycle represents the deviation from trend. It is sometimes called deviation cycle. Specific turning points are associated with those two cycles. Points B and C will be the extreme points of the classical cycle, while points A and D will be those of the growth cycle, as illustrated in Figures 1 and 2.

Figure 1: Business cycle

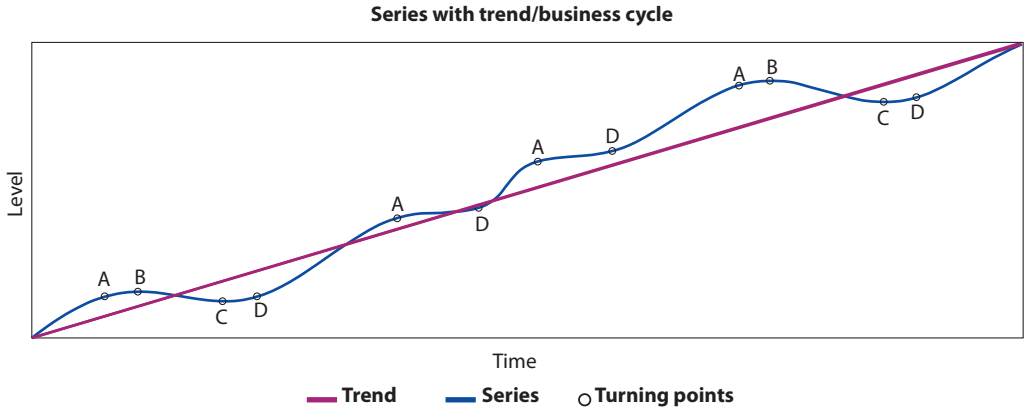
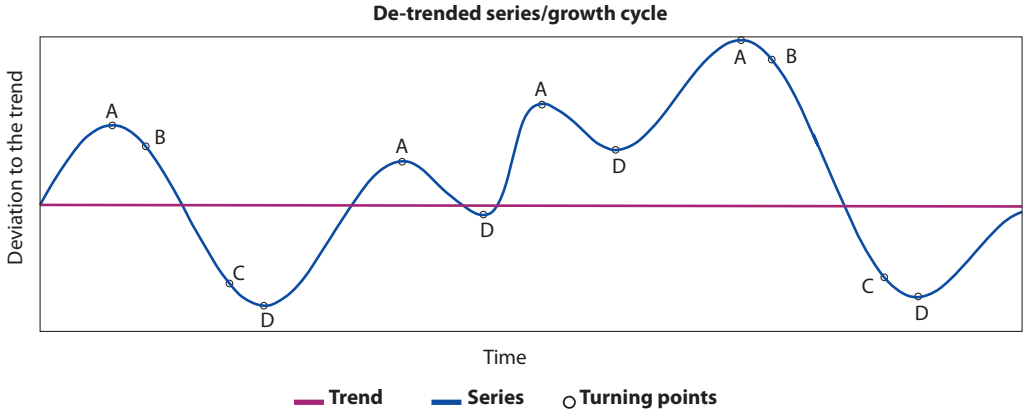


Figure 2: Growth cycle



The sequence ABCD of turning points is always respected in practice ([12]). A slowdown movement will first materialize in a peak in the growth cycle (point A) and if it is getting worse,

([12]) Except when the trend growth rate turns negative, which seldom happens.

the growth rate will become negative (point B) determining a recession. When the growth rate will be positive again, the sequence will be a trough of the business cycle (point C) and a recovery of the growth rate above the trend growth rate (point D). However, if the slowdown does not gain in intensity to become a recession, then point A will not be followed by point B. In other words, the economy can experience a descending phase of the growth cycle (peak A and trough D) without going through a recession (peak B and trough C), as shown in Figure 1.

The ABCD approach is an empirical one. There are different patterns of cyclical development. A recession may occur suddenly so that A and B would coincide. Symmetrically, in a rapid exit of a recession, C and D would coincide. As regards the C-D phase, the economy can go from C to D either with a fast pace (V-shaped exit, the dates of C and D are close) or with a slow pace (e.g. jobless recovery, the dates of C and D are distant), but D will always be the date when the deviation to trend reaches a minimum. We will call A-B: downward slowdown, (defined as an exit of recession), B-C: recession, C-D: upward slowdown and D-A: expansion. In case of an A-D phase, we will consider to be in a downward slowdown (A-B).

A recent publication by Billio et al. (2016) has provided substantial empirical evidence of the existence of those three cyclical regimes in the industrial production evolution for a long period of time, confirming the same results found by Kim and Murray (2002) and Kim and Piger (2002).

2.2. Homogeneity

A first global approach to measure the dissymmetry between countries is met by measuring a homogeneity index. In each quarter, the distribution of the four cyclical codes among the 19 countries gives an idea of the homogeneity of the countries in relation to their cyclical situation. For example, looking at the country classification by cyclical phase in Table 11, in annex, we observe a perfect homogeneity in 2008Q4 and 2009Q1 when all 19 countries are in recession at the same time. There is also a perfect homogeneity between 2005Q3 and 2007Q2, two years in which all the countries are simultaneously growing (i.e. in the growth phase of their growth cycle). On the contrary, the period 2012-2013 reveals a heterogeneous distribution of the 19 countries cyclical position.

To summarize this distribution in one index, we will use a concentration index largely used in the marketing industry, namely the Herfindahl-Hirschman index (H). This index is generally used to measure the degree of concentration of a market. It is computed by adding the squared market shares of all the considered companies. The higher the index, the higher the concentration of sales or productions.

(1) $H = \sum_{i=1}^{n} s_i^2$

where s_i is the market share.

The index can be normalized to vary between 0 and 1.

(2) $H^* = \frac{H - 1/n}{1 - 1/n}$

The Theil entropy index could have been used alternatively but it requires the non-nullity of s_i. We apply equation (2) to compute a cyclical homogeneity index (CHI). When the CHI reaches 1, there is a total concentration on one cyclical position. In other words, all the countries are in the same cyclical phase.

2.3. Extension of Harding and Pagan's measure

Let us express the cyclical situation of an economy with a series $s_{i,t}$ taking value 1 when the economy is in expansion at time t and 0 if it is in contraction. The degree of concordance proposed in Harding and Pagan (2002) measures the degree of synchronization of an economy with a reference economy as the proportion of time the two economies are in the same phase. Comparing the economy i to a reference economy r, the degree of concordance between the two economies is defined as:

$$(3)\quad I_{i,r} = \frac{\sum_{t=1}^{T} s_{i,t}\, s_{r,t} + (1 - s_{i,t})(1 - s_{r,t})}{T}$$

where T is the sample size.

Now let us consider the ABCD approach which is composed of 4 different phases: expansion (D-A), downward slowdown (A-B), recession (B-C) and upward slowdown (C-D). We generalize Harding and Pagan's index by introducing different distances between the 4 cyclical phases of two countries. In the following we consider four different distance schemes. Distance scheme A proposes a distance of 0.5 between adjacent phases and of 1 between opposite phases. It is presented in Table 1. Distance scheme B insists on the recessions by proportionally giving a larger distance between the expansion (D-A) and recession (B-C) phases. It is presented in Table 2. Distance scheme C considers that the downward (A-B) and upward (C-D) slowdown are not so different, setting the distance between the two phases at 0.25. It is presented in Table 3. Distance scheme D emphasizes the differences between the (A-B) and the expansion (D-A), and the recession (B-C) and the expansion (D-A). It is presented in Table 4. The maximum distances in the schemes A, B, C and D are 1, 2, 1 and 1.5, respectively.

Table 1: Distance scheme A

	Downward slowdown (A-B)	Recession (B-C)	Upward slowdown (C-D)	Expansion (D-A)
Downward slowdown (A-B)	0.00	0.50	1.00	0.50
Recession (B-C)		0.00	0.50	1.00
Upward slowdown (C-D)			0.00	0.50
Expansion (D-A)				0.00

Table 2: Distance scheme B

	Downward slowdown (A-B)	Recession (B-C)	Upward slowdown (C-D)	Expansion (D-A)
Downward slowdown (A-B)	0.00	0.50	1.00	0.50
Recession (B-C)		0.00	0.50	2.00
Upward slowdown (C-D)			0.00	0.50
Expansion (D-A)				0.00

Table 3: Distance scheme C

	Downward slowdown (A-B)	Recession (B-C)	Upward slowdown (C-D)	Expansion (D-A)
Downward slowdown (A-B)	0.00	0.50	0.25	0.75
Recession (B-C)		0.00	0.50	1.00
Upward slowdown (C-D)			0.00	0.50
Expansion (D-A)				0.00

Table 4: Distance scheme D

	Downward slowdown (A-B)	Recession (B-C)	Upward slowdown (C-D)	Expansion (D-A)
Downward slowdown (A-B)	0.00	0.50	0.25	1.00
Recession (B-C)		0.00	0.50	1.50
Upward slowdown (C-D)			0.00	0.50
Expansion (D-A)				0.00

Overall, the extended dissimilarity measure I^e between two series of phases is given by the average over time of the distances as in equation (4)

$$(4)\quad I^{e}_{i,r} = \frac{\sum_{t=1}^{T} d(S_{i,t}, S_{r,t})}{T}$$

where T is the sample size.

2.4. Clustering techniques

In order to gather countries based on their cyclical similarities, we will rely on a hierarchical clustering and in particular on the agglomeration approach which builds a hierarchy of clusters merging pairs of clusters when we move up in the hierarchy, i.e. the 'bottom up' approach. The merge of two clusters is based on the distance between the clusters, denoted d^c, which will be computed using one of the 3 methods proposed in Table 5, while the distance between the countries, denoted d, will stem from the 4 distance schemes. This clustering approach is convenient because of the non-Euclidean nature of the inter-country distances.

Table 5: Clustering methods

Method	Name	Quantity to minimize	Interpretation
complete	Furthest distance	$d^c(r,s) = max\,(d(x_{r,i}, x_{s,j}))$	Minimizing the maximum distance between countries of different clusters
single	Shortest distance	$d^c(r,s) = min\,(d(x_{r,i}, x_{s,j}))$	Minimizing the minimum distance between countries of different clusters
average	Average distance	$d^c(r,s) = \frac{1}{n_r n_s} \sum_{i=1}^{n_r} \sum_{j=1}^{n_s} d(x_{r,i}, x_{s,j})$	Minimizing the average distance between countries of different clusters

Note: r and s are clusters. n_r and are n_s the numbers of countries in clusters r and s, respectively. $x_{r,i}$ is the *ith* country in cluster r.

With the 'complete' method, the distance between two clusters is the maximum distance between two countries in two different clusters. With the 'single' method, the distance between two clusters is the minimum distance between two countries in two different clusters. In the 'average' method, the distance between two clusters is the average distance between the countries of the two clusters. Finally, the search of the nearest clusters is performed by minimizing these distances over the different clusters.

3. Application

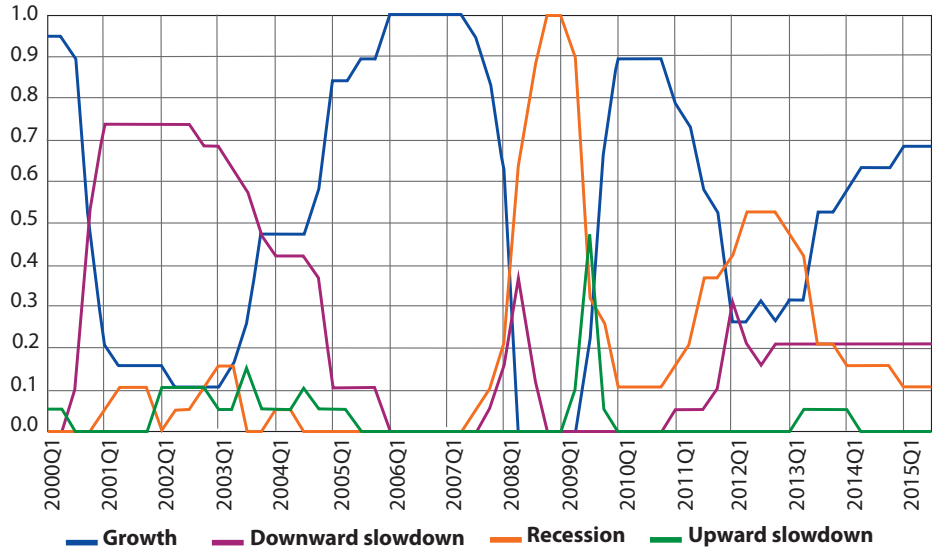
3.1. Data

The data used in this application is from the experimental database of Eurostat which provides a historical dating based on GDP and industrial production cycles estimates. It consists of 4-value series such that over each period the economy of a country is either in expansion (=1), downward slowdown (=2), recession (=3) or upward slowdown (=4), as described in Section 2.1. We consider 18 euro area countries and the United Kingdom over the 2000Q1–2015Q3 period. The series are presented in the annex, in Table 6.

3.2. Homogeneity

In Figure 3, we show the percentage of countries in each cyclical phase over the period considered (2000Q1-2015Q3). The extreme value of 1 indicates that all countries are in the same cyclical phase. Figure 4 summarizes the distribution of countries by computing the Cyclical Homogeneity Index as defined in Section 2.2.

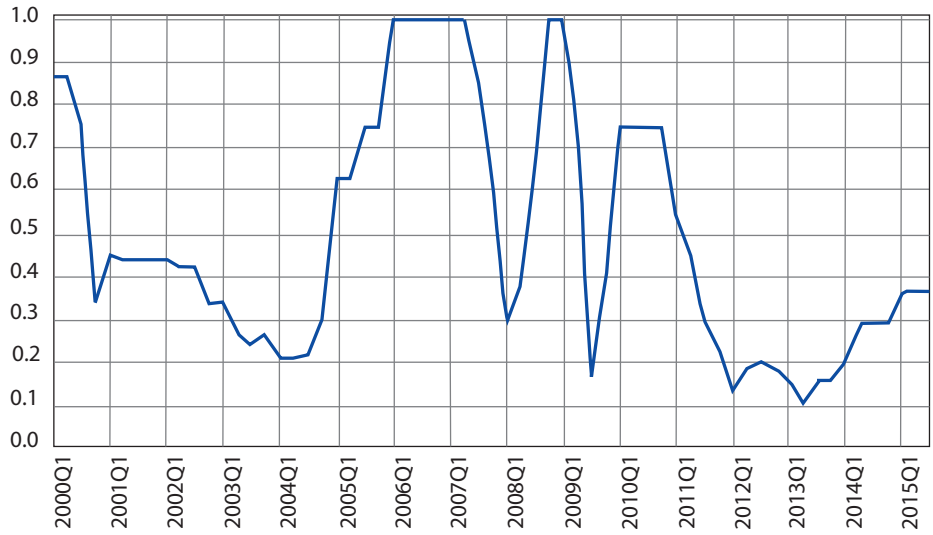
Figure 3: Distribution over time of the country cyclical phases, EA18 and UK, 2000–2015
(%)



In Figure 4, we observe a 2-year long period of high heterogeneity, between 2012Q1 and 2014Q1, when the index is below 0.2. During this period, on average, 33 % of the countries are in expansion, 25 % in downward slowdown, 40 % in recession and 2 % in upward slowdown.

The heterogeneity is decreasing since then but still remains quite high (index below 0.4). In the last quarter 2015Q3, 70 % of the countries are growing, 20 % are in a slowdown and 10 % are in recession.

Figure 4: Cyclical homogeneity index, EA18 and UK 2000–2015



Over a total period of 16 years, almost all the countries have been growing or declining simultaneously during 3 different time intervals (1999Q4–2000Q2, 2005Q3–2007Q2 and 2010Q1–2011Q1) summing up to 16 quarters. This indicates a quasi-perfect homogeneity in growth for 25 % of the time.

3.3. Clustering analysis

SELECTION OF THE METHODS

Tables 7, 8, 9 and 10, in annex, present the empirical distances obtained between the different countries considered over the 2000Q1–2015Q3 period, using the distance schemes A, B, C and D respectively. They are used with the 3 clustering methods introduced in Section 2.4. The analysis of the dendrograms shows that the 'complete' method is both the most discriminant and the most robust over the different distance schemes ([13]). The 'single' method mostly merges the countries one by one and the 'average' method produces mixed results of the two latter ones. Considering the 'complete' method, the results of distance scheme A and B as well as C and D are similar except for the UK which changes group. Finally, we choose to consider the distance

([13]) The resulting dendrograms for all possible distance schemes and clustering techniques are available upon request to the authors.

scheme D and the 'complete' method from now on because we prefer the UK to be gathered with the group including Germany rather than the group of 'small' countries which were in slowdown at the beginning of the years 2000. In the remaining of the paper we will be using the selected distance scheme D and the 'complete' clustering technique.

Figure 5: Dendrogram based on the distance scheme D and on the 'complete' clustering method over the 2000Q1-2015Q3 period

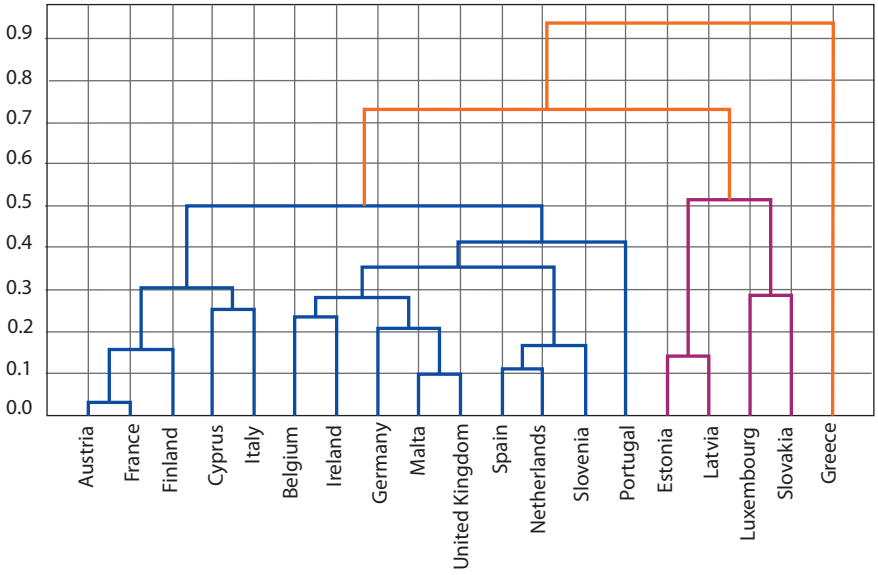


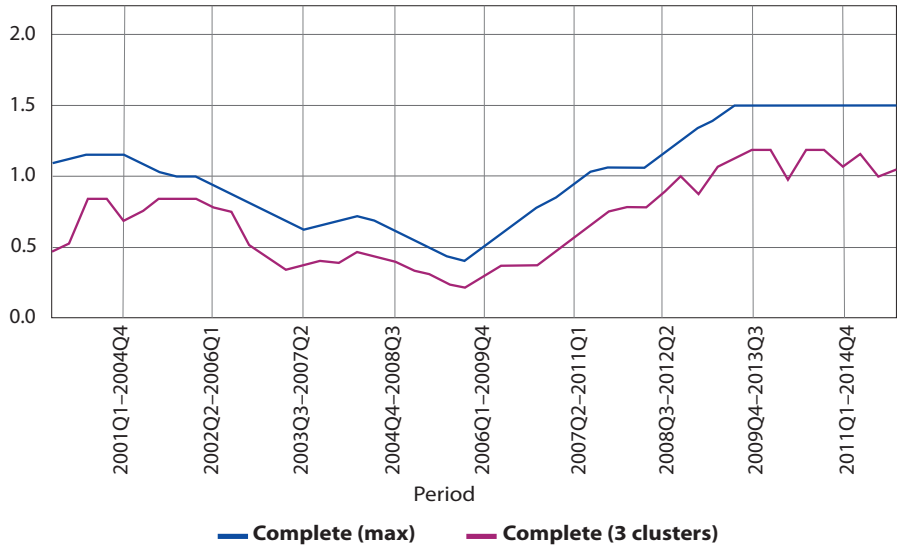
Figure 5 reports the dendrogram for the full sample (2000Q1-2015Q3). It shows a first cluster of countries (Austria, France, Finland, Cyprus and Italy) which have experienced a strong recession since 2011 (Finland, Cyprus and Italy) or a long slowdown period (Austria and France). The second cluster (Belgium, Ireland, Germany, United Kingdom, Malta, Spain, Netherlands, Slovenia and Portugal) gathers countries which avoided a recession in 2011-12 or, otherwise, have rebounded strongly from the recession (Spain, Netherlands, Slovenia and Portugal). Slovenia, due its strong economic links with Italy, is the only eastern country belonging to the second cluster. Greece has experienced the longest and most severe recession and constitutes its own cluster (whatever the distance scheme and clustering method). The last cluster gathers eastern countries (Estonia, Latvia and Slovakia) and Luxembourg .

ANALYSIS OF THE RESULTS OVER FIXED SUB-PERIODS

We begin by analyzing the evolution of the depth of the dendrograms computed over a 4-year rolling window. The depth of a dendrogram is the maximal distance between clusters, corresponding to the upper node of the dendrogram, which shows how clustered the countries were. Figure 6 shows a decrease of the depth over the 2001-2009 period and an increase of the depth in the following periods, illustrating a converging cyclical behavior in the first period and a diverging one after the 2007-2009 crisis. All methods considered show the same pattern ([14]).

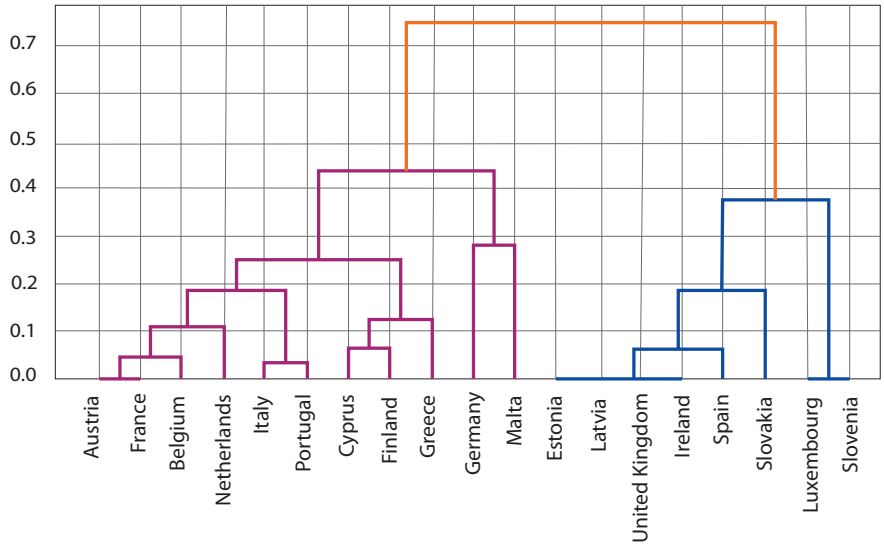
([14]) As stated earlier, the dendrograms for all the methods are available upon request.

Figure 6: Evolution of the depth of the dendrograms, over a 4-year rolling window from 2000Q1 to 2015Q3 (Distance scheme D and 'complete' cluster method)



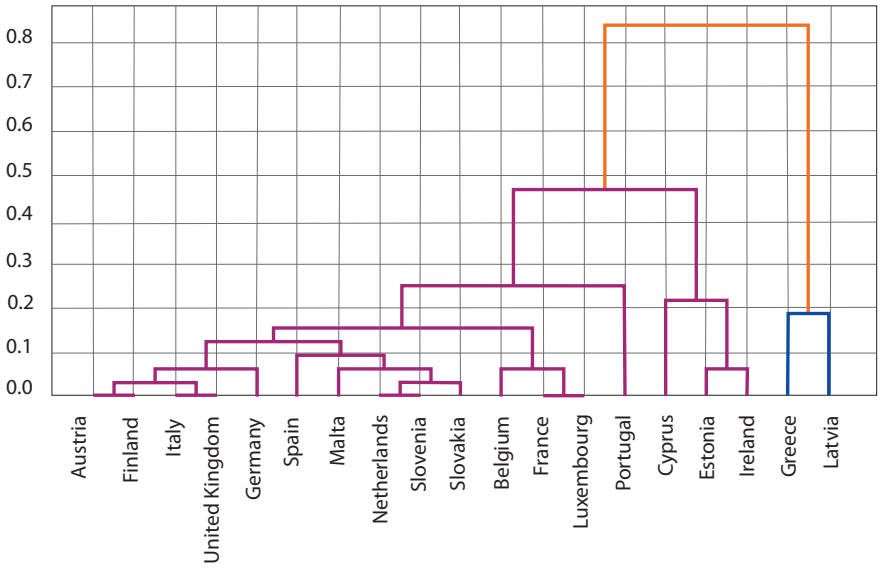
The general picture of the cyclical classification over the period 2000-2015 reveals different periods of more or less intense cyclical divergence. We will therefore comment the results of the classification over three sub-periods: 2003Q1-2006Q4, 2007Q1-2010Q4 and 2011Q1-2014Q4. The respective dendrograms are presented in Figures 7, 8 and 9.

Figure 7: Dendrogram based on the distance scheme D and the 'complete' clustering method, over the 2003Q1-2006Q4 period



During the 2003-2006 period (Figure 7) we observe a clustering into two groups. The first cluster gathers countries for which the exit of the 2001-2002 slowdown happens as soon as mid-2003. In the second group (United Kingdom, Latvia, Estonia, Ireland, Spain, Slovakia, Luxembourg and Slovenia), the slowdown continues until mid-2005 (Germany is close to this second group with a late slowdown exit).

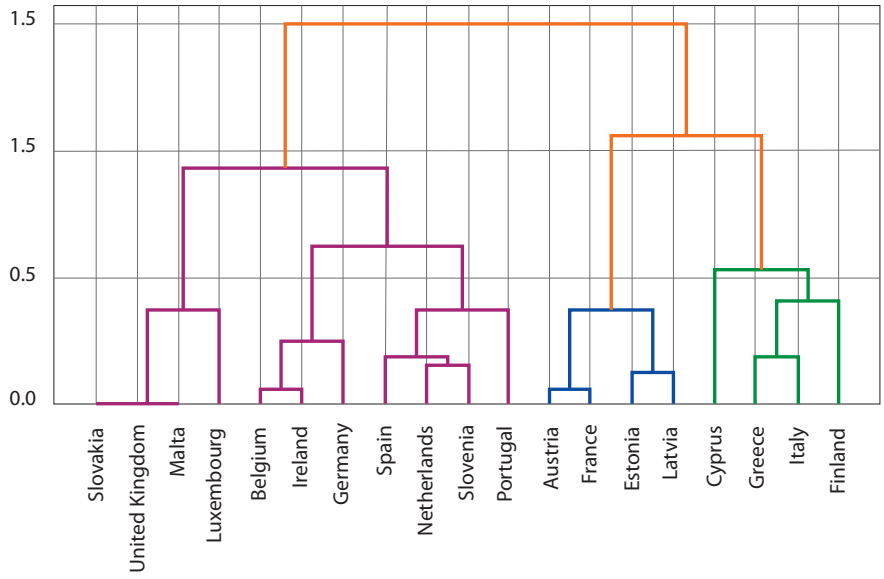
Figure 8: Dendrogram based on the distance scheme D and the 'complete' clustering method, over the 2007Q1-2010Q4 period



During the 2007-2010 period, Figure 8, there is a strong convergence due to the global great recession. The difference between clusters only reflects the duration of the recession. Two countries are apart in a special cluster with an early entry into recession of Latvia and Greece as soon as 2007. Another cluster regroups Cyprus, Estonia and Ireland where the recession lasted between 7 and 9 quarters.

The most important period is the last one, 2011-2014, where we observe strong cyclical dissimilarities. While the depth of the dendrograms was only 0.7 and 0.8 during the first two periods, it more than doubled to reach 1.5 during the last period. We conclude to a strong increase of cyclical dissimilarities between European countries during the European crisis starting mid-2011. This is also reflected in the index of homogeneity which remains at its lowest level (below 0.2). The main distinction is between a cluster of countries with lasting recessions (Finland, Italy, Cyprus and Greece) and lasting slowdowns (Austria and France, Estonia and Latvia) versus a cluster of countries with no recession or only a short one, even though their recession might have been strong. The distance between those clusters is 1.5.

Figure 9: Dendrogram based on the distance scheme D and the 'complete' clustering method, over the 2011Q1-2014Q4 period



In the first cluster, we observe:

- Two countries which were still in recession in 2015Q4: Finland (14 quarters recession until 2015Q3) and Greece (8 years recession).
- Two countries where recession ended before 2015Q4 but lasted a long time: Italy and Cyprus (14 quarters).
- Two countries with a lasting slowdown which has not ended yet in 2015Q4: France and Austria (15 quarters until 2015Q3).
- The two Baltic countries with a lasting slowdown which has not ended yet (between 10 and 12 quarters until 2015Q3).

In the second cluster, we observe:

- Four countries with no recession and no slowdown: United Kingdom, Slovakia, Malta and Luxembourg.
- Three countries with a very short recession/slowdown: Germany, Belgium and Ireland.
- Four countries with a substantial recession (8 to 10 quarters) followed by a strong rebound (without a slowdown exit however, except for Portugal): Spain, Portugal, Netherlands and Slovenia.

4. Conclusion

Before the great recession, a central question was to assess whether the introduction of the euro would foster business cycle synchronicity. There was a fear: when a country joins a monetary union, the resulting loss of the monetary policy instrument at the national level can create an economic cost in the presence of asymmetric shocks.

By using extended measures of concordance to fit the ABCD approach, this paper shows an increase in dissimilarities among European countries in the wake of the European crisis of 2011-12. If the Great Recession (external symmetric shock) had a common similar impact on the national European business cycles under the form of a drastic recession, the second shock in 2011-2012 which was internal and asymmetric (the euro sovereign debt crisis) provoked a heterogeneous response onto national cycles as illustrated in this paper. Therefore, the economic and financial integration process in the wake of the euro area creation has not been sufficient to increase the business cycle synchronicity in the euro area.

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Annexes

Table 6: Time series assessing the cyclical situation based on the Eurostat historical dating in 19 European countries and in the euro area based on the 4 cyclical codes

	EA	AT	BE	CY	DE	EE	EL	ES	FI	FR	IE	IT	LU	LV	MT	NL	PT	SI	SK	UK
2000Q1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1
2000Q2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1
2000Q3	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1
2000Q4	1	2	2	2	1	1	1	2	2	2	2	1	1	1	2	1	2	1	1	2
2001Q1	2	2	3	2	2	2	1	2	2	2	2	2	1	1	2	2	2	2	1	2
2001Q2	2	2	3	2	2	2	1	2	2	2	2	3	1	2	2	2	2	2	1	2
2001Q3	2	2	3	2	2	2	1	2	2	2	2	3	1	2	2	2	2	2	1	2
2001Q4	2	2	3	2	2	2	1	2	2	2	2	3	1	2	2	2	2	2	1	2
2002Q1	2	2	4	2	2	2	1	2	2	2	2	4	1	2	2	2	2	2	1	2
2002Q2	2	2	4	2	2	2	1	2	2	2	2	4	2	2	2	2	3	2	1	2
2002Q3	2	2	4	2	2	2	1	2	2	2	2	4	2	2	2	2	3	2	1	2
2002Q4	2	2	4	2	3	2	1	2	2	2	2	4	2	2	2	2	3	2	1	2
2003Q1	2	2	4	2	3	2	1	2	2	2	2	3	2	2	2	2	3	2	1	2
2003Q2	2	2	4	1	3	2	1	2	2	2	2	3	2	2	2	2	3	2	1	2
2003Q3	2	2	4	1	4	2	1	2	1	2	2	4	2	2	1	2	1	2	2	2
2003Q4	1	1	1	1	4	2	1	2	1	1	2	1	2	2	1	2	1	2	2	2
2004Q1	1	1	1	1	4	2	1	2	1	1	2	1	2	2	3	1	1	2	2	2
2004Q2	1	1	1	1	4	2	1	2	1	1	2	1	2	2	3	1	1	2	2	2
2004Q3	1	1	1	1	4	2	1	2	1	1	2	1	2	2	4	1	1	2	2	2
2004Q4	1	1	1	1	4	2	1	1	1	1	2	1	2	2	1	1	1	2	2	2
2005Q1	1	1	1	1	4	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1
2005Q2	1	1	1	1	4	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1
2005Q3	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1
2005Q4	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1
2006Q1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2006Q2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2006Q3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2006Q4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2007Q1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2007Q2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2007Q3	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
2007Q4	1	1	1	1	1	1	3	1	1	1	2	1	1	3	1	1	1	1	1	1
2008Q1	1	1	2	1	1	3	3	1	1	2	3	1	2	3	1	1	1	1	1	1
2008Q2	3	3	2	2	3	3	3	2	3	3	3	3	3	3	2	2	3	2	2	3
2008Q3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3
2008Q4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 6: Time series assessing the cyclical situation based on the Eurostat historical dating in 19 European countries and in the euro area based on the 4 cyclical codes (Cont.)

	EA	AT	BE	CY	DE	EE	EL	ES	FI	FR	IE	IT	LU	LV	MT	NL	PT	SI	SK	UK
2009Q1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2009Q2	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	4	3	3	3
2009Q3	4	4	1	3	4	3	3	3	4	4	3	1	4	3	4	4	1	4	4	1
2009Q4	1	1	1	3	1	3	3	1	1	1	3	1	1	3	4	1	1	1	1	1
2010Q1	1	1	1	1	1	1	3	1	1	1	1	1	1	3	1	1	1	1	1	1
2010Q2	1	1	1	1	1	1	3	1	1	1	1	1	1	3	1	1	1	1	1	1
2010Q3	1	1	1	1	1	1	3	1	1	1	1	1	1	3	1	1	1	1	1	1
2010Q4	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	1	3	1	1	1
2011Q1	1	1	1	1	1	1	3	3	1	1	1	1	2	1	1	1	3	1	1	1
2011Q2	1	1	1	1	1	1	3	3	1	1	1	1	2	1	1	3	3	1	1	1
2011Q3	1	1	1	3	1	1	3	3	1	1	1	3	2	1	1	3	3	3	1	1
2011Q4	3	1	1	3	1	1	3	3	1	2	1	3	2	1	1	3	3	3	1	1
2012Q1	3	2	2	3	2	1	3	3	2	2	3	3	2	1	1	3	3	3	1	1
2012Q2	3	2	3	3	2	1	3	3	3	2	3	3	2	1	1	3	3	3	1	1
2012Q3	3	2	3	3	2	1	3	3	3	2	3	3	1	1	1	3	3	3	1	1
2012Q4	3	2	3	3	2	2	3	3	3	2	3	3	1	1	1	3	3	3	1	1
2013Q1	3	2	3	3	2	2	3	3	3	2	3	3	1	1	1	3	1	3	1	1
2013Q2	1	2	4	3	1	2	3	3	3	2	3	3	1	2	1	3	1	3	1	1
2013Q3	1	2	1	3	1	2	3	1	3	2	1	3	1	2	1	4	1	1	1	1
2013Q4	1	2	1	3	1	2	3	1	3	2	1	3	1	2	1	4	1	1	1	1
2014Q1	1	2	1	4	1	2	3	1	3	2	1	3	1	2	1	1	1	1	1	1
2014Q2	1	2	1	1	1	2	3	1	3	2	1	3	1	2	1	1	1	1	1	1
2014Q3	1	2	1	1	1	2	3	1	3	2	1	3	1	2	1	1	1	1	1	1
2014Q4	1	2	1	1	1	2	3	1	3	2	1	3	1	2	1	1	1	1	1	1
2015Q1	1	2	1	1	1	2	3	1	3	2	1	1	1	2	1	1	1	1	1	1
2015Q2	1	2	1	1	1	2	3	1	3	2	1	1	1	2	1	1	1	1	1	1
2015Q3	1	2	1	1	1	2	3	1	3	2	1	1	1	2	1	1	1	1	1	1
2015Q4	1	1	1	1	1	1	3	1	1	1	2	1	1	3	1	1	1	1	1	1

Note: Expansion= 1, downward slowdown= 2, recession= 3, upward slowdown= 4. EA= euro area, AT= Austria, BE= Belgium, CY= Cyprus, DE= Germany, EE= Estonia, EL= Greece, ES= Spain, FI= Finland, FR= France, IE= Ireland, IT= Italy, LU= Luxembourg, LV= Latvia, MT= Malta, NL= Netherlands, PT= Portugal, SI= Slovenia, SK= Slovakia, UK= United Kingdom.

Source: Eurostat.

Table 7: Empirical dissimilarities between countries using distance scheme A, over the 2000Q1-2015Q3 period.

	AT	BE	CY	DE	EE	EL	ES	FI	FR	IE	IT	LU	LV	MT	NL	PT	SI	SK	UK
AT	0.00	0.29	0.22	0.19	0.11	0.41	0.23	0.12	0.02	0.21	0.29	0.26	0.2	0.19	0.21	0.27	0.24	0.28	0.17
BE		0.00	0.27	0.24	0.38	0.49	0.28	0.31	0.29	0.25	0.19	0.36	0.47	0.29	0.25	0.24	0.29	0.29	0.28
CY			0.00	0.29	0.29	0.35	0.15	0.2	0.22	0.17	0.24	0.34	0.37	0.24	0.11	0.22	0.17	0.34	0.28
DE				0.00	0.29	0.57	0.28	0.29	0.21	0.25	0.33	0.28	0.37	0.16	0.24	0.22	0.27	0.29	0.2
EE					0.00	0.43	0.26	0.23	0.11	0.16	0.38	0.25	0.09	0.21	0.29	0.38	0.25	0.25	0.15
EL						0.00	0.4	0.29	0.4	0.43	0.35	0.5	0.37	0.57	0.38	0.44	0.48	0.52	0.58
ES							0.00	0.27	0.23	0.12	0.31	0.22	0.35	0.23	0.07	0.17	0.09	0.29	0.19
FI								0.00	0.13	0.25	0.21	0.38	0.32	0.29	0.21	0.33	0.28	0.4	0.29
FR									0.00	0.21	0.29	0.25	0.2	0.21	0.21	0.27	0.24	0.29	0.18
IE										0.00	0.35	0.23	0.23	0.21	0.16	0.27	0.13	0.26	0.15
IT											0.00	0.44	0.47	0.41	0.24	0.27	0.3	0.44	0.39
LU												0.00	0.29	0.21	0.25	0.29	0.17	0.16	0.14
LV													0.00	0.26	0.37	0.45	0.34	0.29	0.21
MT														0.00	0.24	0.27	0.24	0.17	0.09
NL															0.00	0.17	0.1	0.29	0.21
PT																0.00	0.24	0.37	0.25
SI																	0.00	0.26	0.18
SK																		0.00	0.13
UK																			0.00

Source: Authors' calculations

Table 8: Empirical dissimilarities between countries using distance scheme B, over the 2000Q1-2015Q3 period.

	AT	BE	CY	DE	EE	EL	ES	FI	FR	IE	IT	LU	LV	MT	NL	PT	SI	SK	UK
AT	0.00	0.29	0.27	0.19	0.14	0.60	0.29	0.12	0.02	0.24	0.32	0.26	0.29	0.22	0.25	0.35	0.27	0.28	0.17
BE		0.00	0.37	0.24	0.44	0.89	0.36	0.45	0.29	0.29	0.32	0.47	0.64	0.38	0.30	0.33	0.32	0.42	0.34
CY			0.00	0.40	0.38	0.59	0.23	0.34	0.25	0.25	0.33	0.45	0.56	0.43	0.14	0.38	0.22	0.52	0.47
DE				0.00	0.32	0.97	0.36	0.45	0.21	0.30	0.48	0.28	0.47	0.16	0.30	0.30	0.32	0.34	0.20
EE					0.00	0.63	0.40	0.29	0.13	0.21	0.51	0.26	0.15	0.22	0.41	0.56	0.37	0.28	0.20
EL						0.00	0.67	0.48	0.56	0.71	0.65	0.82	0.55	1.02	0.63	0.83	0.78	0.94	1.02
ES							0.00	0.48	0.28	0.21	0.45	0.29	0.59	0.39	0.09	0.23	0.12	0.44	0.37
FI								0.00	0.13	0.42	0.29	0.59	0.48	0.55	0.37	0.58	0.45	0.62	0.51
FR									0.00	0.22	0.3	0.25	0.28	0.24	0.24	0.33	0.25	0.29	0.18
IE										0.00	0.52	0.31	0.36	0.32	0.24	0.43	0.19	0.39	0.29
IT											0.00	0.64	0.69	0.67	0.32	0.44	0.40	0.74	0.61
LU												0.00	0.37	0.21	0.31	0.34	0.23	0.16	0.14
LV													0.00	0.34	0.6	0.71	0.55	0.38	0.32
MT														0.00	0.41	0.44	0.37	0.17	0.09
NL															0.00	0.24	0.11	0.44	0.36
PT																0.00	0.32	0.6	0.39
SI																	0.00	0.39	0.31
SK																		0.00	0.13
UK																			0.00

Source: Authors' calculations

Table 9: Empirical dissimilarities between countries using distance scheme C, over the 2000Q1-2015Q3 period.

	AT	BE	CY	DE	EE	EL	ES	FI	FR	IE	IT	LU	LV	MT	NL	PT	SI	SK	UK
AT	0.00	0.23	0.25	0.22	0.15	0.46	0.28	0.12	0.02	0.27	0.24	0.39	0.25	0.25	0.22	0.32	0.31	0.4	0.25
BE		0.00	0.22	0.21	0.35	0.50	0.21	0.24	0.23	0.19	0.2	0.34	0.44	0.22	0.18	0.23	0.25	0.31	0.22
CY			0.00	0.29	0.33	0.39	0.18	0.21	0.25	0.21	0.2	0.42	0.42	0.25	0.13	0.22	0.23	0.41	0.31
DE				0.00	0.27	0.60	0.22	0.30	0.25	0.19	0.3	0.24	0.37	0.18	0.21	0.23	0.18	0.27	0.15
EE					0.00	0.49	0.31	0.26	0.15	0.20	0.35	0.35	0.10	0.26	0.31	0.46	0.31	0.33	0.2
EL						0.00	0.47	0.34	0.44	0.50	0.35	0.56	0.43	0.62	0.43	0.47	0.56	0.54	0.65
ES							0.00	0.29	0.29	0.13	0.27	0.27	0.40	0.23	0.09	0.19	0.11	0.33	0.19
FI								0.00	0.15	0.27	0.17	0.46	0.35	0.30	0.23	0.33	0.32	0.47	0.31
FR									0.00	0.27	0.25	0.37	0.25	0.28	0.22	0.33	0.32	0.42	0.27
IE										0.00	0.32	0.29	0.27	0.21	0.18	0.3	0.15	0.31	0.15
IT											0.00	0.44	0.44	0.37	0.18	0.27	0.28	0.45	0.35
LU												0.00	0.38	0.28	0.31	0.37	0.20	0.22	0.21
LV													0.00	0.31	0.4	0.53	0.40	0.36	0.25
MT														0.00	0.25	0.27	0.26	0.21	0.09
NL															0.00	0.19	0.13	0.35	0.23
PT																0.00	0.29	0.42	0.27
SI																	0.00	0.32	0.2
SK																		0.00	0.17
UK																			0.00

Source: Authors' calculations

Table 10: Empirical dissimilarities between countries using distance scheme D, over the 2000Q1-2015Q3 period.

	AT	BE	CY	DE	EE	EL	ES	FI	FR	IE	IT	LU	LV	MT	NL	PT	SI	SK	UK
AT	0.00	0.27	0.31	0.27	0.2	0.60	0.37	0.13	0.03	0.34	0.27	0.52	0.34	0.33	0.28	0.41	0.4	0.52	0.33
BE		0.00	0.27	0.22	0.44	0.70	0.27	0.32	0.27	0.23	0.27	0.45	0.59	0.28	0.22	0.29	0.31	0.41	0.28
CY			0.00	0.36	0.44	0.56	0.25	0.29	0.31	0.29	0.25	0.56	0.58	0.35	0.17	0.30	0.30	0.56	0.44
DE				0.00	0.33	0.83	0.27	0.38	0.30	0.22	0.37	0.30	0.48	0.21	0.25	0.29	0.21	0.34	0.17
EE					0.00	0.66	0.42	0.33	0.20	0.27	0.45	0.47	0.14	0.33	0.41	0.62	0.41	0.44	0.28
EL						0.00	0.67	0.48	0.57	0.71	0.51	0.78	0.58	0.88	0.60	0.69	0.79	0.78	0.94
ES							0.00	0.41	0.37	0.18	0.36	0.35	0.56	0.31	0.11	0.25	0.15	0.46	0.29
FI								0.00	0.16	0.39	0.21	0.65	0.47	0.43	0.32	0.46	0.45	0.65	0.45
FR									0.00	0.34	0.27	0.49	0.34	0.37	0.28	0.41	0.40	0.56	0.36
IE										0.00	0.43	0.39	0.38	0.28	0.25	0.41	0.21	0.42	0.23
IT											0.00	0.6	0.59	0.5	0.23	0.36	0.36	0.62	0.49
LU												0.00	0.52	0.36	0.4	0.46	0.26	0.29	0.28
LV													0.00	0.41	0.56	0.73	0.56	0.48	0.36
MT														0.00	0.35	0.37	0.35	0.27	0.10
NL															0.00	0.24	0.17	0.48	0.33
PT																0.00	0.37	0.59	0.37
SI																	0.00	0.44	0.29
SK																		0.00	0.21
UK																			0.00

Source: Authors' calculations

Table 11: Countries by cyclical phases over the 2000Q1-2015Q3 period

	Growth	Downward slowdown	Recession	Upward slowdown
2000Q1	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, UK			SK
2000Q2	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, UK			SK
2000Q3	AT, BE, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, SI, SK, UK	CY, PT		
2000Q4	DE, EE, EL, IT, LU, LV, NL, SI, SK	AT, BE, CY, ES, FI, FR, IE, MT, PT, UK		
2001Q1	EL, LU, LV, SK	AT, CY, DE, EE, ES, FI, FR, IE, IT, MT, NL, PT, SI, UK	BE	
2001Q2	EL, LU, SK	AT, CY, DE, EE, ES, FI, FR, IE, LV, MT, NL, PT, SI, UK	BE, IT	
2001Q3	EL, LU, SK	AT, CY, DE, EE, ES, FI, FR, IE, LV, MT, NL, PT, SI, UK	BE, IT	
2001Q4	EL, LU, SK	AT, CY, DE, EE, ES, FI, FR, IE, LV, MT, NL, PT, SI, UK	BE, IT	
2002Q1	EL, LU, SK	AT, CY, DE, EE, ES, FI, FR, IE, LV, MT, NL, PT, SI, UK		BE, IT
2002Q2	EL, SK	AT, CY, DE, EE, ES, FI, FR, IE, LU, LV, MT, NL, SI, UK	PT	BE, IT
2002Q3	EL, SK	AT, CY, DE, EE, ES, FI, FR, IE, LU, LV, MT, NL, SI, UK	PT	BE, IT
2002Q4	EL, SK	AT, CY, EE, ES, FI, FR, IE, LU, LV, MT, NL, SI, UK	DE, PT	BE, IT
2003Q1	EL, SK	AT, CY, EE, ES, FI, FR, IE, LU, LV, MT, NL, SI, UK	DE, IT, PT	BE
2003Q2	CY, EL, SK	AT, EE, ES, FI, FR, IE, LU, LV, MT, NL, SI, UK	DE, IT, PT	BE
2003Q3	CY, EL, FI, MT, PT	AT, EE, ES, FR, IE, LU, LV, NL, SI, SK, UK		BE, DE, IT
2003Q4	AT, BE, CY, EL, FI, FR, IT, MT, PT	EE, ES, IE, LU, LV, NL, SI, SK, UK		DE
2004Q1	AT, BE, CY, EL, FI, FR, IT, NL, PT	EE, ES, IE, LU, LV, SI, SK, UK	MT	DE
2004Q2	AT, BE, CY, EL, FI, FR, IT, NL, PT	EE, ES, IE, LU, LV, SI, SK, UK	MT	DE
2004Q3	AT, BE, CY, EL, FI, FR, IT, NL, PT	EE, ES, IE, LU, LV, SI, SK, UK		DE, MT
2004Q4	AT, BE, CY, EL, ES, FI, FR, IT, MT, NL, PT	EE, IE, LU, LV, SI, SK, UK		DE
2005Q1	AT, BE, CY, EE, EL, ES, FI, FR, IE, IT, LV, MT, NL, PT, SK, UK	LU, SI		DE
2005Q2	AT, BE, CY, EE, EL, ES, FI, FR, IE, IT, LV, MT, NL, PT, SK, UK	LU, SI		DE
2005Q3	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LV, MT, NL, PT, SK, UK	LU, SI		
2005Q4	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LV, MT, NL, PT, SK, UK	LU, SI		
2006Q1	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			
2006Q2	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			
2006Q3	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			
2006Q4	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			

Table 11: Countries by cyclical phases over the 2000Q1-2015Q3 period (Cont.)

	Growth	Downward slowdown	Recession	Upward lowdown
2006Q4	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			
2007Q1	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			
2007Q2	AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK			
2007Q3	AT, BE, CY, DE, EE, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK		EL	
2007Q4	AT, BE, CY, DE, EE, ES, FI, FR, IT, LU, MT, NL, PT, SI, SK, UK	IE	EL, LV	
2008Q1	AT, CY, DE, ES, FI, IT, MT, NL, PT, SI, SK, UK	BE, FR, LU	EE, EL, IE, LV	
2008Q2		BE, CY, ES, MT, NL, SI, SK	AT, DE, EE, EL, FI, FR, IE, IT, LU, LV, PT, UK	
2008Q3		CY, MT, SK	AT, BE, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, NL, PT, SI, UK	
2008Q4			AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK	
2009Q1			AT, BE, CY, DE, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, PT, SI, SK, UK	
2009Q2			AT, BE, CY, EE, EL, ES, FI, FR, IE, IT, LU, LV, MT, NL, SI, SK, UK	DE, PT
2009Q3	BE, IT, PT, UK		CY, EE, EL, ES, IE, LV	AT, DE, FI, FR, LU, MT, NL, SI, SK
2009Q4	AT, BE, DE, ES, FI, FR, IT, LU, NL, PT, SI, SK, UK		CY, EE, EL, IE, LV	MT
2010Q1	AT, BE, CY, DE, EE, ES, FI, FR, IE, IT, LU, MT, NL, PT, SI, SK, UK		EL, LV	
2010Q2	AT, BE, CY, DE, EE, ES, FI, FR, IE, IT, LU, MT, NL, PT, SI, SK, UK		EL, LV	
2010Q3	AT, BE, CY, DE, EE, ES, FI, FR, IE, IT, LU, MT, NL, PT, SI, SK, UK		EL, LV	
2010Q4	AT, BE, CY, DE, EE, ES, FI, FR, IE, IT, LU, LV, MT, NL, SI, SK, UK		EL, PT	
2011Q1	AT, BE, CY, DE, EE, FI, FR, IE, IT, LV, MT, NL, SI, SK, UK	LU	EL, ES, PT	
2011Q2	AT, BE, CY, DE, EE, FI, FR, IE, IT, LV, MT, SI, SK, UK	LU	EL, ES, NL, PT	
2011Q3	AT, BE, DE, EE, FI, FR, IE, LV, MT, SK, UK	LU	CY, EL, ES, IT, NL, PT, SI	
2011Q4	AT, BE, DE, EE, FI, IE, LV, MT, SK, UK	FR, LU	CY, EL, ES, IT, NL, PT, SI	
2012Q1	EE, LV, MT, SK, UK	AT, BE, DE, FI, FR, LU	CY, EL, ES, IE, IT, NL, PT, SI	
2012Q2	EE, LV, MT, SK, UK	AT, DE, FR, LU	BE, CY, EL, ES, FI, IE, IT, NL, PT, SI	
2012Q3	EE, LU, LV, MT, SK, UK	AT, DE, FR	BE, CY, EL, ES, FI, IE, IT, NL, PT, SI	
2012Q4	LU, LV, MT, SK, UK	AT, DE, EE, FR	BE, CY, EL, ES, FI, IE, IT, NL, PT, SI	

Table 11: Countries by cyclical phases over the 2000Q1-2015Q3 period (Cont.)

	Growth	Downward slowdown	Recession	Upward lowdown
2013Q1	LU, LV, MT, PT, SK, UK	AT, DE, EE, FR	BE, CY, EL, ES, FI, IE, IT, NL, SI	
2013Q2	DE, LU, MT, PT, SK, UK	AT, EE, FR, LV	CY, EL, ES, FI, IE, IT, NL, SI	BE
2013Q3	BE, DE, ES, IE, LU, MT, PT, SI, SK, UK	AT, EE, FR, LV	CY, EL, FI, IT	NL
2013Q4	BE, DE, ES, IE, LU, MT, PT, SI, SK, UK	AT, EE, FR, LV	CY, EL, FI, IT	NL
2014Q1	BE, DE, ES, IE, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI, IT	CY
2014Q2	BE, CY, DE, ES, IE, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI, IT	
2014Q3	BE, CY, DE, ES, IE, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI, IT	
2014Q4	BE, CY, DE, ES, IE, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI, IT	
2015Q1	BE, CY, DE, ES, IE, IT, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI	
2015Q2	BE, CY, DE, ES, IE, IT, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI	
2015Q3	BE, CY, DE, ES, IE, IT, LU, MT, NL, PT, SI, SK, UK	AT, EE, FR, LV	EL, FI	

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