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Elisabeth Wieland and
Ilja Kristian Kavonius

Estimating gross value added volumes and prices by institutional sector

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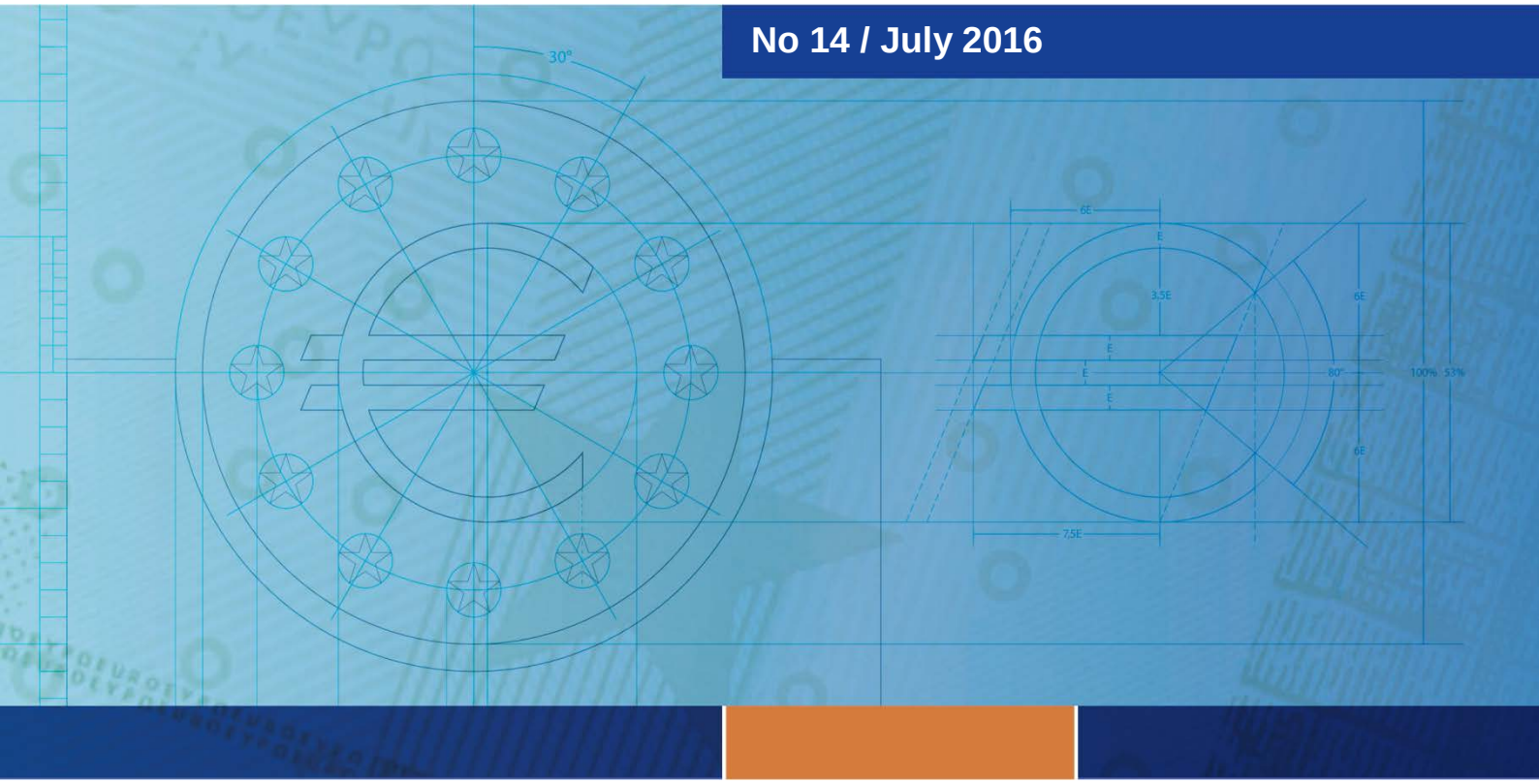

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Abstract

Integrated quarterly sector accounts (QSA) provide an analytical tool to understand the generation, allocation and use of income for all institutional sectors in the economy. They also provide a tool to analyse production from a sectoral point of view instead of an industry point of view. However, since QSA are published in current prices only, sectoral volume and price measures are lacking as an important toolkit for economic analysis and forecasting, notably in the case of gross value added. This paper introduces a methodology to estimate sectoral price and volume measures for euro area value added at a quarterly frequency and provides a comparison of alternative estimation methods. It presents a benchmark method which yields robust estimates of sectoral volumes and prices in the euro area.

Keywords: production account, value added, price, volume, institutional sector, national accounts

JEL codes: C33, C82, E01, E30

Non-technical summary

Integrated quarterly sector accounts (QSA) provide an analytical tool to understand the generation, allocation and use of income for all institutional sectors in the economy. They also provide a tool to analyse production process from a sectoral perspective instead of an industrial perspective. Whereas the QSA is published only in current prices, sectoral volume and price measures are lacking as an important toolkit for economic analysis and forecasting. The current Transmission Programme under the European System of Accounts (ESA 2010) includes gross value added volumes by institutional sector on a voluntary basis. However, to this date, Finland is the only euro area country which officially reports volume and price measures by institutional sector.

This paper introduces a methodology to estimate price and volume measures by institutional sector for euro area value added at a quarterly frequency.[1] The basic principle of this method is that prices are derived from implicit price indices broken down by the NACE Rev. 2 economic activities. The price indices are linked to the respective institutional sector using cross-classification tables by institutional sector and economic activity.

The paper presents different methodologies to derive a cross-classification table for the euro area. First, we apply a non-parametric approach, which relies on existing information on the distribution of institutional sectors across economic activities. For this purpose, we use cross-classification tables reported by euro area countries. Second, a parametric approach is selected to estimate the (unknown) joint distribution of sectors and activities by means of constrained linear optimisation techniques. Moreover, several applications for countries which do not report any cross-classified data are discussed.

The preferred method is the “Reported CCM” method, which uses reported cross-classification tables of current price value added to link the price indices broken down by industry to the corresponding institutional sectors. This method is considered to be most appropriate, as it is based on actually reported weights. The sensitivity analysis also confirms these results. The resulting quarterly estimates perform best in replicating the cross-classification tables by reporting countries and are robust to several modifications, such as the updating frequency of the cross-classified data. In addition, the proposed method is able to closely replicate the official sectoral volume series published by Statistics Finland.

[1] Time series of gross value added (GVA) in previous year prices and chain-linked volumes by institutional sector can be downloaded in ECB’s Statistical Data Warehouse (SDW).

1 Introduction

Within the European System of National Accounts (ESA) 2010, data from the quarterly sector accounts (QSA), defined here as non-financial and financial accounts by institutional sector, provide valuable insights into current economic developments, such as the business investment rate, household savings and sectoral debt ratios.[2] By grouping the activity of similar institutional units, the QSA provide a better understanding of the generation, allocation and use of income in the economy. However, sectoral volume and price measures are lacking as an important toolkit for economic analysis in the euro area.[3] This necessity becomes apparent for gross value added (GVA), i.e. the difference between output and intermediate consumption, by institutional sector. Whereas income concepts within the System of National Accounts (SNA) do not have a price or volume measure, GVA is typically analysed in real terms as derived from the output approach (European Commission (2001)).[4]

In the absence of quarterly volumes by institutional sector, a straightforward method exists in linking QSA data to quarterly national accounts (QNA) data, since the latter also provide information on GVA volumes and prices by economic activity according to NACE Rev. 2.[5] Both data sets are reported by Table 1 and Table 801 of the ESA 2010 Transmission Programme[6]; National Statistical Institutes (NSIs) transmit these data on a regular basis to Eurostat. Whereas the statistical indicators from QSA and QNA data correspond by definition at the level of the total economy, little is known about the linkages between both data concepts at a more detailed hierarchical level, e.g. which institutional sector is exactly involved in which kind of economic activity. Thereby, it is notably difficult to disentangle activities of non-financial corporations and households, given the different delineation approaches in the individual euro area countries. Therefore, the ECB carried out a data request in 2013/14 to collect annual GVA data cross-classified by economic activity and by institutional sector from NSIs in the Eurosystem.[7]

2 Note that ESA 2010 is broadly consistent with the System of National Accounts of the United Nations (2008 SNA) with regard to definitions, accounting rules and classifications. See European Union (2014).

3 Since the changeover from ESA 95 to ESA 2010 in September 2014, sectoral volumes of gross value added have been included as a voluntary item in the transmission programme (table 801), emphasizing the need of such information broken down by institutional sectors. To this date, Finland is the only euro area country, which publishes QSA data in constant prices.

4 For instance, see ECB (2015) for a discussion of the development in real value added for non-financial corporations in the context of profit margins.

5 NACE designates the statistical classifications of economic activities, which is mandatory within the European Statistical System (see Eurostat, 2008). A description of the NACE classifications can be found in Annex.

6 The ESA 2010 Transmission Programme refers to the part of the ESA Regulation which defines which parts of the national accounts need to be transmitted to the European Commission by the European Union Member States and in which timeliness.

7 Results are based on cross-classification tables by nine euro area countries (Belgium, Germany, France, Finland, Italy, Spain, the Netherlands, Portugal, and Slovakia).

This paper reviews different estimation techniques to derive sectoral volumes and prices of GVA for the euro area by linking QSA to QNA data.[8] First, we apply a non-parametric approach, which relies on existing information on the distribution of institutional sectors across economic activities. For this purpose, we use cross-classification tables reported by NSIs. Second, a parametric approach is selected to estimate the (unknown) joint distribution of economic activities and institutional sectors by means of constrained linear optimisation techniques. Moreover, we discuss several applications for countries which do not report any cross-classified data.

The contribution of this paper is twofold. First, we propose a benchmark method to estimate sectoral volumes and prices of GVA at a quarterly frequency. This benchmark method uses information from cross-classification tables provided by NSIs and does not rely on a specific estimation model. It can be shown that the proposed benchmark method performs best in replicating the actual cross-classified data and is robust to several modifications, such as using a time-invariant cross-classification table. Moreover, since Statistics Finland publishes GVA in constant prices, we also show that the Finnish estimate from our benchmark method provides the best forecast of the official series. Second, we demonstrate that this method can be applied for countries which do not report any cross-classified data as well, since the resulting estimates are robust to the underlying input matrix.

The outline of this paper is structured as follows. Section 2 explains the data sources and presents descriptive statistics on the cross-classification between institutional sectors and economic activities in the euro area. Section 3 describes the different estimation methods to derive sectoral volumes and prices of GVA. Results are presented in Section 4, followed by a sensitivity analysis in Section 5. Finally, Section 6 draws conclusions and points out suggestions for further improvement in estimating price and volume series of GVA by institutional sector.

[8] Time series of GVA in previous year prices and chain-linked volumes by institutional sector can be downloaded in ECB's Statistical Data Warehouse (SDW).

2 Data and descriptive statistics

The main sources for our estimation are quarterly series of value added (ESA code: B1G) from the QSA and QNA databases. In the QNA, GVA is available for the total economy (TTTT) and is further broken down by economic activity according to NACE Rev. 2. In contrast, the QSA report GVA not only for the total economy (S1), but also broken down by four main institutional sectors, which are "non-financial corporations" (S11), "financial corporations" (S12), "general government" (S13), and "households & NPISHs" (S1M). By definition, GVA at the level of the total economy should be the same in the QSA and QNA data sets.

To derive linkages between QSA and QNA data, this paper uses a novel data set which cross-classifies annual GVA in current prices by economic activity and institutional sector. Thereby, the institutional sectors are given by S = {S1, S11, S12, S13, S1M}. The economic activities according to NACE Rev. 2 at the A*10 level are Y = {TTTT, A_A, B_E, C_C, F_F,G_I, J_J, K_K, L_L, M_N, O_Q, R_U}, where B_E is excluding C_C.[9] Our country sample covers nine euro area countries which provided cross-classification tables for this exercise (Belgium, Germany, France, Finland, Italy, Spain, the Netherlands, Portugal, and Slovakia). These countries represent 92% of the euro area aggregate in terms of GVA. The reporting period of cross-classification tables mainly covers the calendar years 2005 and 2010. Exceptions are Finland and Italy, which provided annual cross-classification tables already from 1975 and 2005 onwards, respectively. With the exception of Finland, these tables are not regularly published by the NSIs concerned and were provided only as input for the further compilation procedure described in this paper. Except for Slovakia, eight of the nine reporting euro area countries transmit quarterly series of GVA according to the ESA 2010 Transmission Programme.[10]

Table 1 shows an estimate of cross-classified GVA for the euro area aggregate, which is derived from the data of reporting countries. As indicated by the first column, the largest share of GVA in 2010 is covered by non-financial corporations (S11) with 58%. Households and non-profit institutions serving households (NPISHs) (S1M, hereafter households)[11] account for less than one quarter of GVA, followed by the general government sector (S13) with 15%. The smallest part of only approximately 5% of GVA is produced by financial corporations (S12). Concerning the distribution across activities, non-financial corporations are dominating the GVA produced in manufacturing (C_C) and the service activities "trade, transportation, accommodation and food services" (G_I), "information and communication" (J_J), and "professional, scientific, technical, administration and support services" (M_N).

9 The denotation of economic activities and institutional sectors used throughout this paper is listed in Annex. See Table A.1 for an example of a cross-classification table.

10 The transmission of a full set of QSA is voluntary only for countries whose GDP at current prices represents less than 1% of the corresponding Union total.

11 Note that the household sector (S1M) also includes producers, which are not part of the non-financial corporations sector, e.g. in the case of sole proprietorships and partnerships which are not quasi-corporations (cf. European Commission (2013), Chapter 2 on units and groupings of units).

Households are mainly active in real estate activities (L_L), which also include imputed rents of owner-occupied dwellings, as well as in the primary sector (A_A) and "other services" (R_U). Financial corporations are only dominating in "financial and insurance activities" (K_K), by capturing 96% of the respective GVA. Likewise, general government is mainly involved in "public administration, defence, education, human health and social work activities" (O_Q). Thus, whereas the distribution between economic activities and institutional sectors seems to be straightforward for financial corporations and the general government sector, the corresponding splits for non-financial corporations and households are spread across a wider range of economic activities. **Table 1** also provides information on the standard deviation across the reporting euro area countries. The two largest sectors of the economy, non-financial corporations and households, also exhibit considerable cross-country differences, as reflected by a higher standard deviation. The largest difference can be observed for real estate activities (L_L), construction (F_F), and the primary sector (A_A), indicating that the underlying delineation method into non-financial corporations and households is country-specific. In contrast, the reporting countries do not differ substantially concerning the distribution of GVA by economic activity for financial corporations and general government.

Table 1

Relative shares of GVA by institutional sector and economic activity in the euro area, 2010

Sector / activity	TTTT	A_A	B_E	C_C	FF	G_I	J_J	K_K	L_L	M_N	O_Q	R_U
S1	100	1.6	2.9	16.5	5.7	18.6	4.6	5	11.3	10.6	19.6	3.6
	0	0.7	1.6	3.7	1.7	2.6	0.5	1.7	2.7	2.6	2.8	0.7
S11	58.1	37.9	**96.7**	**96.3**	**74**	**80.2**	**94.3**	1.1	25	**73**	17.6	35.1
	5.7	16.2	2.5	6.1	19	11.4	3.4	1.5	21.6	12.5	9.3	10.9
S12	4.9	0	0	0	0	0	0.5	**96**	0.8	0.4	0	0
	1.7	0	0	0	0	0	0.7	4	0.9	0.4	0.1	0
S13	14.9	0.5	2	0.7	0.3	1.2	1	0	0.4	4.7	**69**	0
	3.1	0.5	2.3	1.4	0.6	2.3	1.4	0	0.9	4.3	10	7.8
S1M	22	**61.6**	1.3	3.1	25.7	18.6	4.2	2.9	**73.7**	22	13.5	**53.2**
	6.7	16.2	1.4	6.1	19.1	11.7	3.3	3.4	21.4	14	5	10.8

Note: This table shows the relative shares of GVA based on the sum of the nine reporting euro area countries. The cross-country standard deviation is reported below. The most important sector within each economic activity is in red bold, and a standard deviation higher than 4 percentage points is indicated in blue. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). The total economy is denoted by S1 in the QSA and TTTT in the QNA. See Annex for a detailed description of economic activities.

Finally, we assess changes in the reported cross-classification tables over time. For this purpose, we compute for each reporting country the absolute change between the relative shares of institutional sectors across economic activities in 2005 and 2010. On average, the relative share changes by only 1.3 percentage points, where differences point out to redistributions between non-financial corporations and households.[12] The presented evidence on rather stable cross-classification tables is not surprising, given the fact that the marginal distribution of institutional sectors and economic activities in the total economy changes only slowly over time.

[12] Larger changes between shares of non-financial corporations and households mainly pertained to the economic activities agriculture (A_A) and construction (F_F).

Two main messages can be drawn from the descriptive analysis. First, a proper distribution of GVA by institutional sector and economic activity is mainly related to the disentanglement between the two largest sectors (non-financial corporations and households) and might be country-specific, as reflected by the high standard deviation of the related activity shares. Second, the economies' composition can be considered as being rather stable, at least when comparing a medium-term horizon of five years, as presented here.

3 Overview of different estimation methods

This Section describes possible approaches to derive volume and price series of GVA by institutional sector. In a first step, we present the overall estimation strategy (Section 3.1). Next, we explain the different estimation methods (Section 3.2). Finally, we discuss applications to countries which do not report any cross-classified QNA and QSA data (Section 3.3).

3.1 Estimation strategy: linking institutional sectors to economic activities

Whereas QSA and QNA data cover similar economic indicators such as GVA, their reporting units differ; the QSA represent accounts by institutional sectors, the QNA can be divided further into economic activities according to NACE Rev. 2. Moreover, QSA data are only available in current prices, while QNA data are reported also in constant prices. To derive volumes for GVA by institutional sector, a straightforward approach consists in using implicit price indices from QNA economic activities. Note that the crucial assumption is that the relationship between institutional sectors and economic activities holds in current and previous year prices. For instance, this would then imply that industries like health care, where the service providers are from several different sectors, have only one common price development, i.e. that the price development of services which are produced by the government, non-profit institutions or the private sector would be the same.

In the present paper, all estimation methods under consideration follow a similar sequence of steps. For each euro area country, let us denote an input cross-classification matrix CCM^{inp} of size $A \times S$, which represents a two-way classified system of institutional sectors $s \in S$ and economic activities $a \in A$. The (possibly time-invariant) CCM^{inp} is either observed or estimated. Current year prices and previous year prices are denoted by the superscripts CP and PPY, respectively. TTTT represents the total economic activity in the QNA and S1 the total economy within the QSA.

- **Step 1**
  In each quarter t, compute CCM_t^{inp} based on the input matrix CCM^{inp} in current prices.

- **Step 2**
  Apply CCM_t^{inp} (expressed in relative shares of TTTT or the individual economic

activities) to the observed QNA_t^{CP} level series. The resulting CCM_t^{CP} in levels is balanced by means of the Stone, Champernowne and Meade (1942) method.[13]

- **Step 3**
  Based on the reconciled levels, apply CCM_t^{CP} (now expressed in relative shares of the individual economic activities) to the observed QNA_t^{PPY} series, in order to derive the latent QSA_t^{PPY} series.

- **Step 4**
  Finally, the estimated QSA^{PPY} time series are chain-linked, with 2010 as the reference year.

The balancing mechanism in Step 2 leads to an internally consistent cross-classification system of GVA by economic activity and institutional sector at each point in time. In reconciling QNA with QSA data, an important aspect is that the marginal totals by economic activity and by institutional sector add up to the same total value of GVA. In principle, discrepancies for aggregates such as GVA from the QNA and QSA should be zero at the country level. In the case of the euro area accounts, euro area institutions such as, for instance, the European Commission and the ECB, are added to the sum of the accounts for all euro area countries and, thus, lead to discrepancies between TTTT and S1 for the euro area aggregate.[14] A solution consists in redistributing the difference between TTTT and S1 proportionally across S11, S12, S13, and S1M according to their respective share in S1.

3.2 Estimation approaches

In the following, we discuss different estimation approaches to derive sectoral volumes and prices of GVA for the euro area by linking QSA to QNA data. These approaches vary with respect to the computation of CCM^{inp} (Step 1). Thereby, the input matrix is either derived non-parametrically by using reported country tables (Section 3.2.1) or from a linear estimation model (Section 3.2.2).

3.2.1 Variant 1: “Reported CCM” method

The first estimation method is based on cross-classification tables reported by the NSIs. The advantage of the “Reported CCM” method is that it uses detailed information, which is directly derived from a country’s compilation system of national accounts. The main assumption of this method is the validity of the country-specific cross-classification tables. Moreover, since we derive a cross-classification table for the euro area from the sum of reporting countries only, the main assumption here is that non-reporting countries do not change the joint distribution of sectors and

[13] The Stone et al. (1942) method represents a least squares approach and is a widely accepted method in reconciling a system of series, with the balanced estimates shown to be best linear unbiased. Moreover, it allows for different degrees of reliability regarding the balancing input (Dagum and Cholette, 2006).

[14] See European Commission (2013), Chapter 19 on the European accounts.

activities for the euro area aggregate. As outlined in Section 2, this assumption should hold, given that we observe cross-classified data for 92% of the euro area in terms of value added.

In deriving an input matrix for a respective country or the euro area aggregate, we proceed as follows. Starting from a reported cross-classification table for a specific point in time, p, we construct an input matrix CCM_p^{inp} whose elements are expressed as a share of the total economy TTTT. Given the observed shares by institutional sectors and economic activities, the inner elements of CCM_p^{inp} are balanced in each quarter, which yields a quarterly series of cross-classification tables, CCM_t^{inp}. In balancing relative shares, we opt for the RAS method, which preserves zero entries and non-negative values (Bacharach (1965)). Subsequently, the "Reported CCM" method follows Step 2 as outlined in Section 3.1.

In reconciling the QSA and QNA data, the applied two-step procedure of balancing first shares (by means of the RAS method) and then levels (by means of the Stone et al. method) has two advantages. First, the balancing of shares yields a valid starting point in each quarter, given the observed QNA and QSA series. On the other hand, as outlined above, it is advisable to balance the estimated quarterly CCM in levels, again due to potential discrepancies between the absolute values of TTTT and S1.

We consider two modifications of the "Reported CCM" approach. First, the input matrix CCM_p^{inp} is updated regularly according to the reporting periods of the national cross-classification tables. Thereby, we use the first reporting year ($p = 1$) as an input for the period Q1 2000-Q4 2008 and the second reporting year ($p = 2$) for the period from Q1 2009 onwards. If a more recent calendar year has been reported, this table is included from Q1 2012 onwards ($p = 3$). For Finland and Italy, the input matrix has the highest updating frequency, where a cross-classification table is available for every calendar year from 2000 and 2005 onwards, respectively. For the euro area aggregate, the "Reported CCM" method uses an estimation input, which is based on three reporting periods as displayed in **Table 2**.[15] Second, in order to test whether a time-invariant input matrix leads to divergent results, we set $p = 2$ during the full sample, which corresponds to using only the cross-classification table for the calendar year 2010 in most cases. In the following, this modification is called the "Reported CCM (B)" method, which uses less information than the benchmark version of the "Reported CCM" method.

[15] Note that, in principle, a cross-classification table could be inter- and extrapolated to other calendar years. However, given that the economic structure changes only slowly over time, we believe that balancing the input matrix in each quarter is more precise in reconciling quarterly QSA and QNA data.

Table 2

Country-specific tables for the compilation of the euro area input CCM

Country	p=1 (Q1 2000-Q4 2008)	p=2 (Q1 2009-Q4 2011)	p=3 (Q1 2012-Q3 2014)
BE	2005	2010	2013
DE	2005	2010	2010
FI	2005	2010	2012
FR	2005	2010	2012
ES	2010	2010	2010
IT	2005	2010	2012
NL	2013	2013	2013
PT	2006	2010	2011
SK	2005	2010	2012

Note: p denotes the calendar year of the reported cross-classification table.

3.2.2 Variant 2: LO method

A second approach consists in a constrained linear optimisation (LO) method. The LO method "guesstimates" the linkages between the observed QSA and QNA data. The advantage of this method is that it does not necessarily require any prior information on cross-classified GVA. Whereas various parametric methods might be applied to estimate the unknown joint distribution of institutional sectors and economic activities, the constrained linear optimisation method guarantees that the estimated coefficients behave like weights (see Balabanova and van der Helm (2015)). Therefore, its estimates can be directly compared to the cross-classification tables reported by NSIs.

In the following, we denote the institutional sectors by $S = \{S11, S12, S13, S1M\}$ and GVA by economic activity as $Y = \{A\_A, B\_E, C\_C, F\_F, G\_I, J\_J, KK, L\_L, M\_N, O\_Q, R\_U\}$. For each country, the constrained linear least-squares model can be written as:

1. $min \frac{1}{2} \left\| \beta_{a,s} \sum_{a,s} (Y_a - Y_s) \right\|_2^2$

2. $\text{subject to} \begin{vmatrix} \forall a \in A \ \sum_s \beta_{a,s} = 1 \\ \forall a \in A, \forall s \in S \quad 0 \leq \beta_{a,s} \leq 1 \\ \text{add. restrictions (see Table 3)}, \end{vmatrix}$

where Y_a are the current-price GVA series by economic activity and Y_s by institutional sector. The first restriction imposes that the sectoral shares add up to one for each activity. The second set of restrictions imposes the coefficients' range within 0 to 1. The estimated coefficients $\hat{\beta}_{a,s}$ behave like weights which can be interpreted as the contribution of each sector to a specific economic activity. As given in equation (2), we also impose additional restrictions to simplify the delineation between value added generated by the household and non-financial corporations sectors (see **Table 3**). For this purpose, one dominating sector within each activity is determined beforehand. For instance, it is reasonable to assume that real estate activities (L_L), which also include self-employed persons and owner-occupied

housing, are mainly concentrated in the household sector.[16] From the LO method, we finally derive an estimate of CCM^{inp}, which is used in Step 2 as an input matrix for each quarter.

Note that for the general government sector, a possible approach might also consist in using the final consumption expenditure (FCE) deflator of this sector, which is available from the QNA database (**Table 1** of the Transmission Programme). Being a non-market producer, the general government could be considered as a consumer of its own production, which should be reflected in a similar implicit deflator of its value added in the QSA and QNA accounting systems. However, we did not opt for this modification, since the resulting estimate for the general government generally deviated more strongly from the "Reported CCM" method.[17]

Table 3

Input CCM for the Linear Optimisation method

	TTTT	A_A	B_E	C_C	F_F	G_I	J_J	K_K	L_L	M_N	O_Q	R_U
S1	1	0	0	0	0	0	0	0	0	0	0	0
S11	0	*	[2/3,1]	[2/3,1]	[2/3,1]	[2/3,1]	[2/3,1]	*	*	[2/3,1]	*	[0.2,1]
S12	0	0	0	0	0	0	*	[0.9,1]	*	*	*	*
S13	0	*	*	*	*	*	*	*	*	*	[2/3,1]	[0.05,1]
S1M	0	[2/3,1]	*	*	*	*	*	*	[2/3,1]	*	*	[0.5,1]

Note: This table shows the imposed restrictions on the input CCM for the LO method. The cell elements reflect the relative share of institutional sectors in a given economic activity. The range reflects a lower and upper bound on the coefficient, e.g. ranging between 2/3 and 1. An asterisk indicates a non-restricted element in the input CCM. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). The total economy is denoted by S1 in the QSA and TTTT in the QNA. See Annex for a detailed description of economic activities.

3.3 Extension to non-reporting euro area countries

Finally, we discuss estimation approaches for the case of euro area countries which do not report any cross-classified data of institutional sectors and economic activities.[18] For this purpose, the nine reporting euro area countries are used to test several strategies, by excluding the own reported cross-classification table from the subsequent analysis.

A first strategy consists in a modification of Variant 1, which we call the "Other Reported" CCM method. For this purpose, we use for each euro area country the CCM based on the sum of the remaining eight countries as an estimation input. In that sense, the input table represents a weighted average of the reporting euro area countries, according to their share in total value added. A second strategy is to use the LO method (Variant 2), which does not require any prior information and can

16 Note that we also considered a purely "guesstimated" approach without any prior restrictions. However, the LO method consequently failed to disentangle non-financial corporations and households correctly and, thus, led to more divergent results in comparison to the "Reported CCM" method (see Section 5.1). In general, results based on the LO method are strongly sensitive regarding the imposed restrictions.

17 See also the sensitivity analysis with Finnish data on this point (Section 5.2).

18 The non-reporting euro area countries are Ireland, Greece, Cyprus, Luxembourg, Malta, Austria, Slovenia, Estonia, Latvia, and Lithuania; in total, these countries represent about 8% of the euro area in terms of GVA.

therefore be used for estimating a cross-classification table for non-reporting euro area countries. Finally, we consider a so-called "Similarity-based CCM" approach (Variant 3). Similar to Variant 1, it uses information from countries which provide cross-classification tables. We follow Balabanova and van der Helm (2015), by assuming that countries with a similar industrial breakdown also exhibit a similar sectoral breakdown. The estimation consists in a two-step approach. First, we estimate, for each non-reporting country, weights of the reporting countries by means of a linear optimisation method. In a next step, we calculate the CCM for the non-reporting country as a weighted average of available CCMs.

Again, let us denote economic activity classes according to NACE Rev. 2 by $Y = \{A\_A, B\_E, C\_C, F\_F, G\_I, J\_J, K\_K, L\_L, M\_N, O\_Q, R\_U\}$. We denote GVA data for the available countries by Y_j, with $j \in J$ and for the non-reporting country by Y_i, with $i \in I$.[19] For each non-reporting country i, the constrained linear least-squares model is given by:

3. $$min \frac{1}{2} \left\| \beta_{i,j} \sum_j (Y_j - Y_i) \right\|_2^2$$

4. $$\text{subject to} \begin{vmatrix} \forall i \in I \ \sum_j \beta_{i,j} = 1 \\ \forall i \in I, \forall j \in J \quad 0 \leq \beta_{i,j} \leq 1 \end{vmatrix}.$$

The linear optimisation model in equation (3) faces two constraints to provide that the coefficients $\beta_{i,j}$ behave like weights. First, the weights of the available countries should add up to one. Second, the coefficients are restricted to the interval $[0,1]$. After estimating the country weights $\hat{\beta}_{i,j}$, we construct the input matrix for a non-reporting country as a weighted average of the other reporting countries:

5. $$CCM_{i,p}^{inp} = \sum_j \hat{\beta}_{i,j} CCM_{j,p}^{inp}$$

To simplify the estimation, we set $p = 1$ during the full sample, that is, we only consider a time-invariant input matrix. Similar to the "Reported CCM" method, we balance the resulting input matrix $CCM_{i,t}^{inp}$ in each quarter by means of the RAS method before proceeding with Step 2 as outlined in Section 3.1.

[19] Note that the vector Y_i is of dimension$(A-1)\,T$, that is, activities and time are stacked. Therefore, we use relative shares instead of level data in order not to run into non-stationarity problems.

4 Results

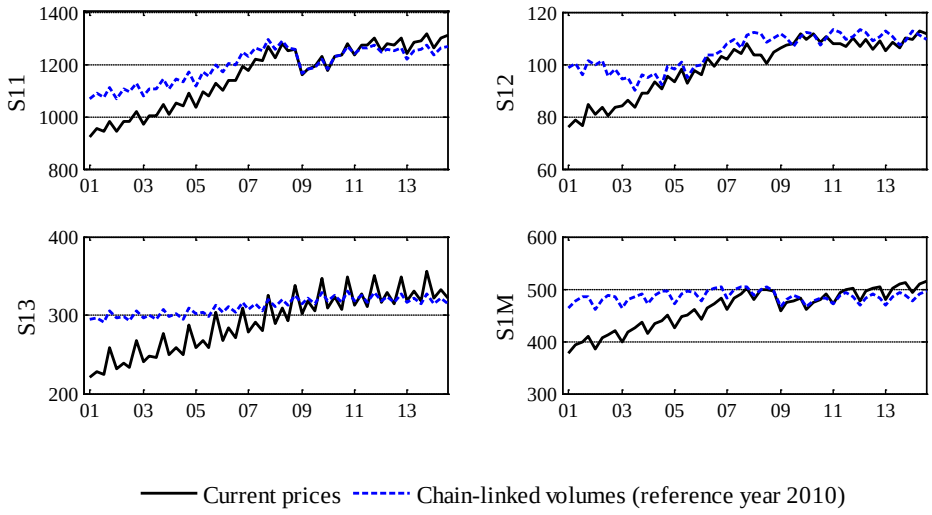
This Section presents estimates of sectoral GVA volumes and prices derived from the different estimation methods. In the first place, we discuss the results based on the "Reported CCM" method.[20] **Chart 1** shows the development of GVA in current prices and chain-linked volumes in the euro area from 2001 onwards. Whereas the current price series by institutional sector are figures from the euro area accounts, the chain-linked volume series are estimates based on the "Reported CCM" method and provide insight into the development of real GVA at the institutional sector level. Concerning non-financial corporations, real growth in GVA has experienced a strong dip in response to the financial crisis in 2008-09, followed by a sluggish rebound. With the end of the sample period, real GVA by non-financial corporations has remained still below the pre-crisis level. For financial corporations, real GVA has strongly increased before 2008 and stayed relatively constant afterwards, following closely the development of economic activity K_K. Thus, the observed decline in nominal GVA by financial corporations in 2008 is largely driven by the related price component. For general government, real GVA has rather stagnated since the onset of the recent crisis, attributing the observed increase in the current-price series to an increase in the implicit GVA deflator. Similar to non-financial corporations, real GVA in the household sector did not catch up with the pre-crisis level. As indicated by the increasing gap between the real and nominal series, the implicit price deflator of households' GVA has increased continuously during recent years. This development is also in line with the implicit deflator of real estate activities (L_L) being the largest component of final output in the household sector.

[20] Unless otherwise indicated, the "Reported CCM" method is used with regularly updated cross-classification tables as described in Section 3.2.1. As a robustness exercise, we modify this method by using a time-invariant input table, labelled "Reported CCM (B)" method.

Chart 1

Euro area gross value added in current and constant prices

(in EUR billions)



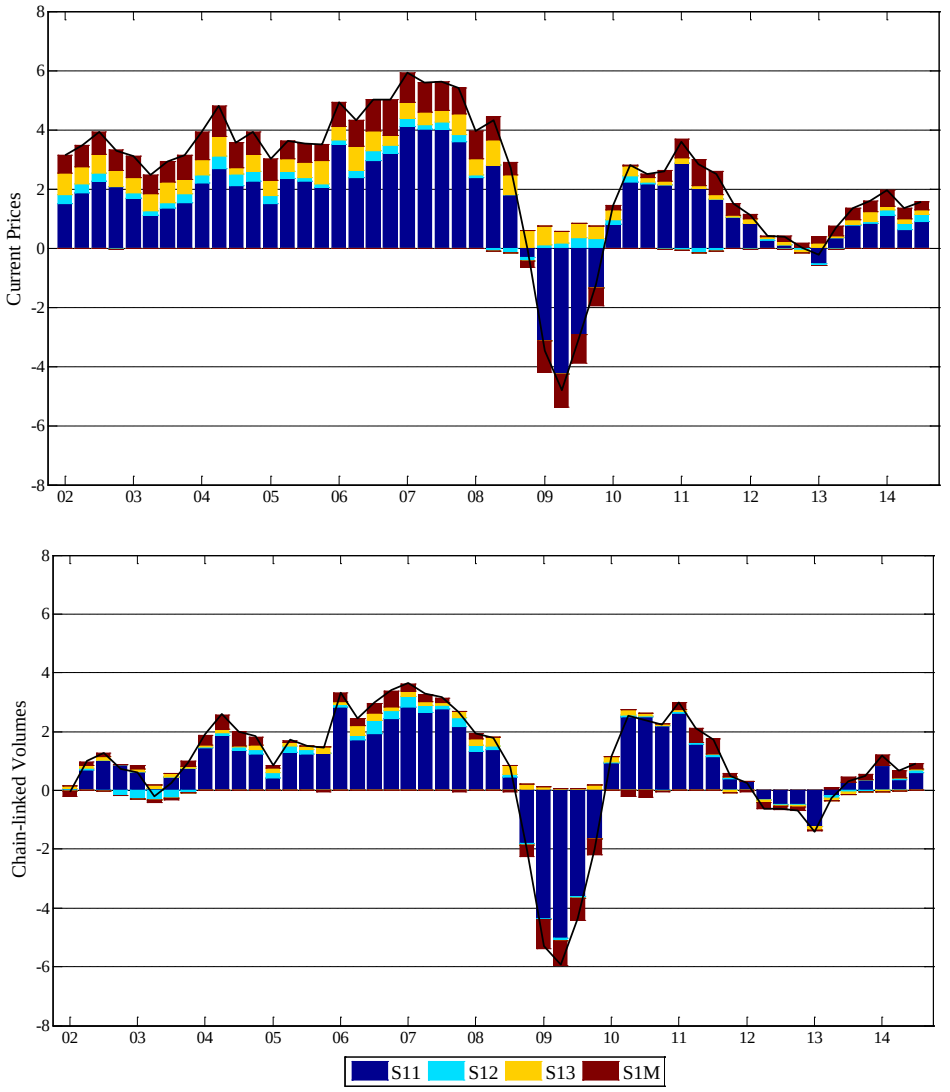
Note: The chain-linked volume series is estimated by means of the "Reported CCM" method. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). See Annex for a detailed description of economic activities.

Chart 2 contrasts the sector contributions to the annual growth rate of current-price GVA with their respective contributions to the chain-linked volume series.[21] In general, the relative contributions of non-financial corporations to the annual growth rate are higher in constant prices and, thus, seem to have a larger role in driving the business cycle in comparison to the remaining sectors. Notably the growth contributions by financial corporations and general government are relatively small when measured in constant prices. Periods of economic downturn in the euro area have been accompanied by large synchronised declines in GVA by non-financial corporations and households, although the recovery in the aftermath of the 2008-09 crisis took much longer in the latter sector. During the peak of the sovereign bond crisis in 2012, all four institutional sectors led to an overall decline in real GVA.

[21] Note that due to the non-additivity of chain-linked series, the sectoral contributions do not exactly sum up to the total growth rate.

Chart 2

Euro area annual growth rate of gross value added and growth contributions by institutional sector



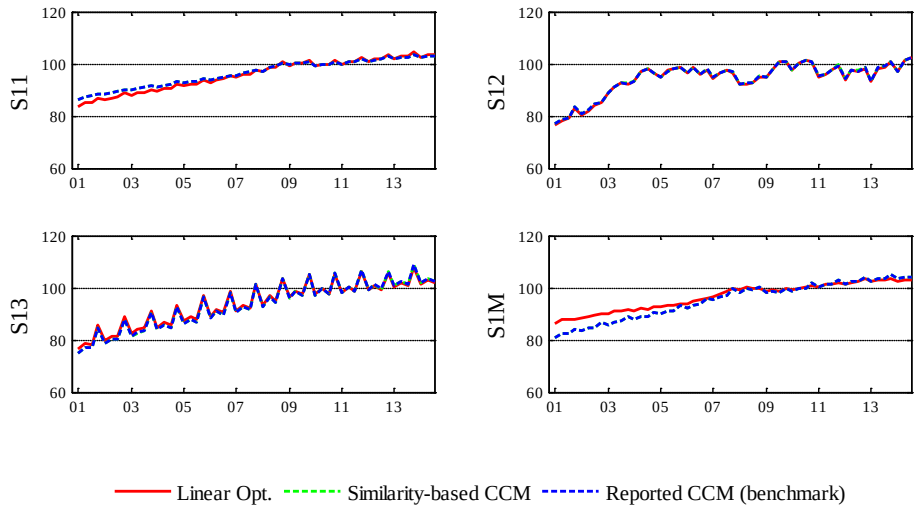
Note: The solid line represents the annual growth rate of the total economy's gross value added (in comparison to previous year's quarter). The chain-linked volume series are derived from the "Reported CCM" method. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). See Annex for a detailed description of economic activities.

In the following, we compare the estimates from the "Reported CCM" method with the alternative estimation methods presented in Section 3. **Chart 3** depicts the implicit GVA deflator based on the "Reported CCM" method, the "Similarity-based CCM" method, and the LO method. Both the "Reported CCM" and the "Similarity-based CCM" method produce quite similar results, with only minor differences in the resulting GVA deflator for each sector. Thereby, the implicit government deflator in the euro area exhibits the same seasonality of its dominating activity O_Q. Except for financial corporations and general government, where the mapping to QNA data is straightforward, the LO method deviates more strongly from the two other methods. For non-financial corporations, this "guesstimation" approach tends to underestimate the price increase in GVA during the first half of the sample, whereas

it overestimates the deflator from 2007 onwards. The reverse pattern can be observed for the household sector.

Chart 3

Euro area comparison of implicit gross value added deflator by different estimation methods



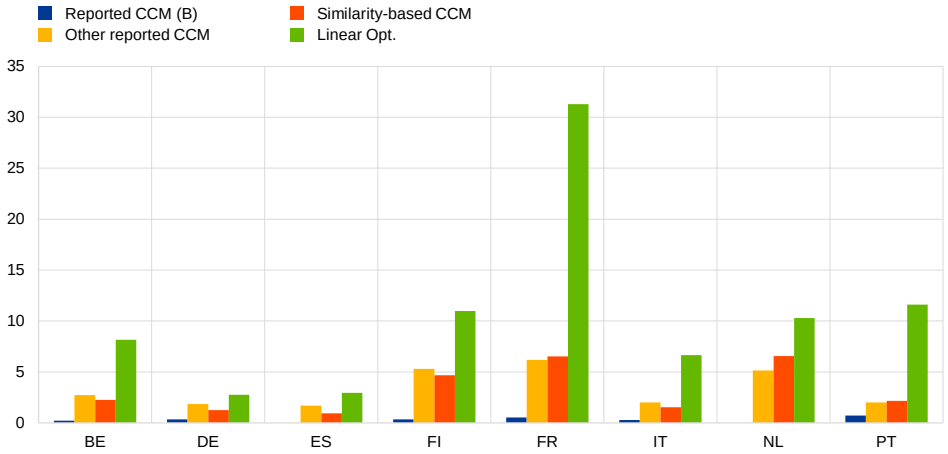
Note: The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). The reference year is chosen as 2010 = 100.

In a next step, we provide a quantitative assessment of the deviation of alternative estimation methods from the "Reported CCM" method for the individual countries. Note that this exercise excludes Slovakia, since no full set of QSA data is available for this country. As alternative methods, we consider: (i) the "Reported CCM (B)" method with a time-invariant CCM input; (ii) the "Other Reported CCM" method, by using the sum of the eight remaining countries as an estimation input; (iii) the "Similarity-based CCM" method, which puts more weight on more similar countries in terms of their economic structure; and (iv) the LO method.[22] **Chart 4** shows the normalised root mean square error (RMSE), which is expressed as a percentage of the "Reported CCM" method series' range and, thus, accounts for the variance of the respective series. Overall, differences are only minor when using a time-invariant CCM input, as indicated by the considerably low value of the normalised RMSE. Notably in Italy and Finland, where the "Reported CCM" method is based on the highest updating frequency of input tables, the normalised RMSE stays below 1%. Concerning the estimation for non-reporting countries, both the "Other Reported CCM" method and the "Similarity-based CCM" method produce quite similar results, with the normalised RMSE ranging between 0.9% and 6.9%. However, the normalised RMSE of the "Similarity-based CCM" method is slightly lower notably for the smaller economies in the sample, such as Belgium and Finland. In contrast, the LO method performs worse since it yields the highest RMSE for all countries.

[22] Note that comparison (i) is not available for the Netherlands and Spain, since only one cross-classification table was available for these countries.

Chart 4

Normalised RMSE with respect to the "Reported CCM" method



Note: The normalised RMSE is expressed as a *percentage of the range* of the estimate based on the "Reported CCM" method with regularly updated input tables. The range is defined as the maximum value minus the minimum value of the estimate. The sample period is Q1 2001-Q3 2014.

Concerning the performance of the different estimation methods at the institutional sector level, Table A-2 in the Annex reports two accuracy measures with respect to the "Reported CCM" method. Thereby, both the normalised RMSE and the Mean Absolute Percentage Error (MAPE) indicate deviations of a specific estimation method as a percentage of the "Reported CCM" method. Our findings at the institutional sector level are similar to the ones drawn from Chart 4. In general, the "Reported CCM (B)" method yields similar estimates as the "Reported CCM" method, which are reflected by a low normalised RMSE and MAPE. Moreover, the "Other reported CCM" and the "Similarity-based CCM" method tend to be both sector- as well as country-specific, although their deviations from the "Reported CCM" method are of similar magnitude in terms of the accuracy measures. Again, the LO method generally performs worst at the institutional sector level among the methods under consideration.

Finally, we assess the accuracy of the different estimation methods in replicating the official cross-classification tables by the NSIs. For this purpose, we compare the estimated cross-classification in current prices (as derived from Step 3) with the official table from the first reporting period. **Table 4** shows the resulting RMSE of the different estimation methods by country.[23] Evidently, the "Reported CCM" method with regularly updated input tables performs best in replicating a country's official cross-classification table, as indicated by the low value of the corresponding RMSE. The "Reported CCM (B)" method leads to a slightly higher RMSE, although the difference is rather small. Notably for Finland and Italy, where the "Reported CCM" method is based on frequently updated input tables, we do not observe a significant increase in the related RMSE. Concerning estimation methods for non-reporting countries, the "Other Reported CCM" method performs slightly better than the "Similarity-based CCM" method in replicating the official tables. Again, the LO

[23] We exclude the euro area aggregate from this exercise, since its cross-classification table is derived from the reporting countries and therefore provides no official benchmark.

method performs generally worse, since it yields the highest RMSE across the considered estimation methods.

Table 4

RMSE with respect to the official cross-classification tables by NSIs

Method	BE	DE	ES	FI	FR	IT	NL	PT
Reported CCM	0.09	0.00	0.01	0.00	0.54	0.01	0.00	0.02
Reported CCM (B)	0.11	0.08	-	0.08	0.56	0.07	-	0.14
Other reported CCM	0.65	0.39	0.78	0.55	0.85	0.50	0.53	0.36
Similarity-based CCM	0.75	0.48	0.63	0.70	0.94	0.54	0.75	0.57
Linear Optimisation	1.53	0.98	1.28	0.51	1.76	1.15	1.25	1.16

Note: This table shows the RMSE of the different estimation methods relative to the official cross-classification tables. The comparison is based on the following calendar years: 2005 for BE, DE, FI, FR, IT; 2006 for PT; 2010 for ES; and 2013 for NL.

Three findings can be drawn from the comparison of the different estimation methods. First, the “Reported CCM” method is robust when using a time-invariant input table instead of regularly updated input tables. This is shown by small differences between both estimates, which are reflected by the low RMSE of the “Reported CCM (B)” method shown in **Chart 4**. Second, both the “Other reporting CCM” and the “Similarity-based CCM” method perform similarly in terms of the “Reported CCM” method. Therefore, estimating sectoral volumes for non-reporting euro area countries seems to be robust with respect to the underlying input matrix, due to the applied balancing method. Third, since the LO estimates generally differ drastically from other estimation methods and are highly sensitive to the imposed restrictions, this method does not provide a robust approximation of sectoral GVA volumes and prices.[24]

[24] See also Section 5.1 on the sensitivity of the LO method to the imposed restrictions.

5 Sensitivity analysis

This Section tests the main assumptions and the robustness of the estimation methods under consideration. It comments on the overall validity of linking QSA to QNA in current and constant prices, relates our estimates to the official series for Finland, and tests the robustness of the input matrix for the euro area aggregate.

5.1 Validity of linking QNA and QSA data in current and constant prices

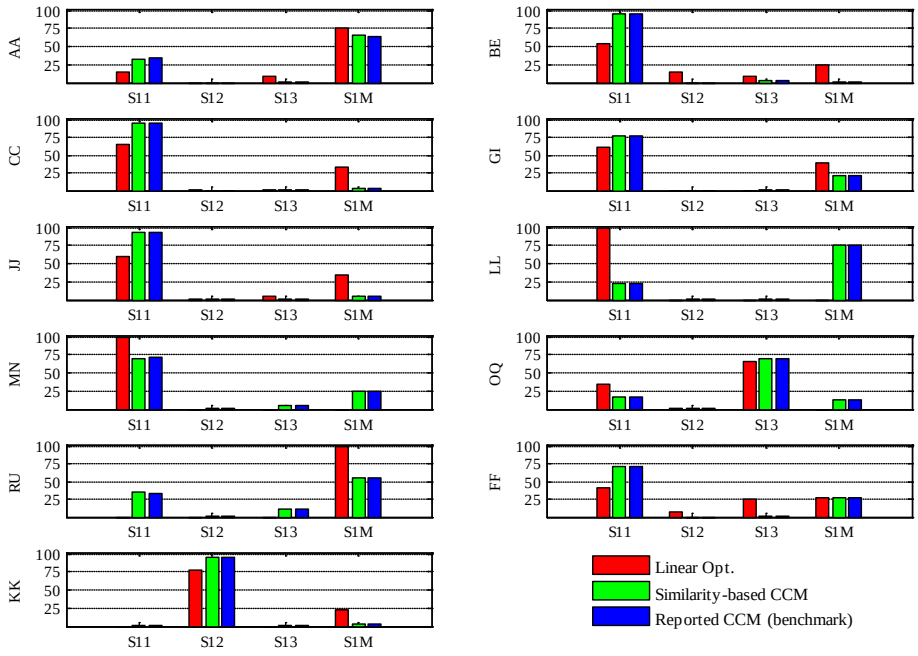
The main assumption of all estimation methods presented above is that the estimated or reported cross-classification in current prices holds for values in previous year prices as well. Since this implies the absence of any price discrimination across sectors, this assumption is debatable. However, given that each economic activity might be dominated by a specific institutional sector, potential price discriminations might not have an effect on the aggregate price level of the institutional sector. From **Table 1** for the euro area and the confidential cross-classification tables by NSIs, we find that the pattern of a dominating sector within an economic activity generally holds in our sample.[25]

Chart 5 presents, for each estimation method, the implied relative share of institutional sectors within each NACE subcategory. Thereby, the relative shares are computed as the average value over the period from Q1 2001 to Q3 2014. Both the "Reported CCM" and the "Similarity-based CCM" method are linked to the observed pattern that an economic activity is typically dominated by one specific sector. In contrast, Figure 5 also displays estimates based on the LO method without imposing prior restrictions on the dominating sector. The resulting estimates imply that a given activity is distributed more evenly across sectors. Without any prior restrictions, this method yields very different results for the distribution of non-financial corporations and households in comparison to the two other methods; this becomes evident, for instance, for activities C_C, J_J, and L_L. From **Chart 5**, we conclude that the strong assumption of a similar distribution of institutional sectors and economic activities in current and previous year prices might be valid in the case of the "Reported CCM" and the "Similarity-based CCM" method. Concerning the LO method, this assumption only holds by imposing sufficient restrictions on the dominating sector, as done in Section 4.

[25] One exception is the economic activity "Other Services" (R_U), which is relatively small in terms of GVA.

Chart 5

Relative shares by institutional sector and economic activity for the euro area, depending on various estimation methods



Note: The relative shares are computed as an average value over the period Q1 2001-Q3 2014. The LO method has been performed without any prior restrictions (cf. Table 3). The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). See Annex for a detailed description of economic activities.

5.2 Sensitivity analysis with Finnish data

To this date, Statistics Finland is the only NSI of the euro area which publishes annual cross-classification tables of GVA by institutional sector and economic activity.[26] Thereby, cross-classified data are obtained directly from the compilation system of Statistics Finland. The advantage of the Finnish series is that they are available in current and constant prices (previous year prices and volumes) and cover a long time span from 1975 onwards. It is, therefore, possible to relate the Finnish estimate to the officially reported volume series and to test the sensitivity of the various estimation methods.

5.2.1 Comparison with official Finnish series of GVA volumes

In the following, we compare volume estimates of GVA by sector with the official chain-linked series by Statistics Finland. **Chart 6** displays the estimates from the LO method, the "Similarity-based CCM" method and the "Reported CCM" method. Whereas the "Reported CCM" method performs well in proxying the official Finnish

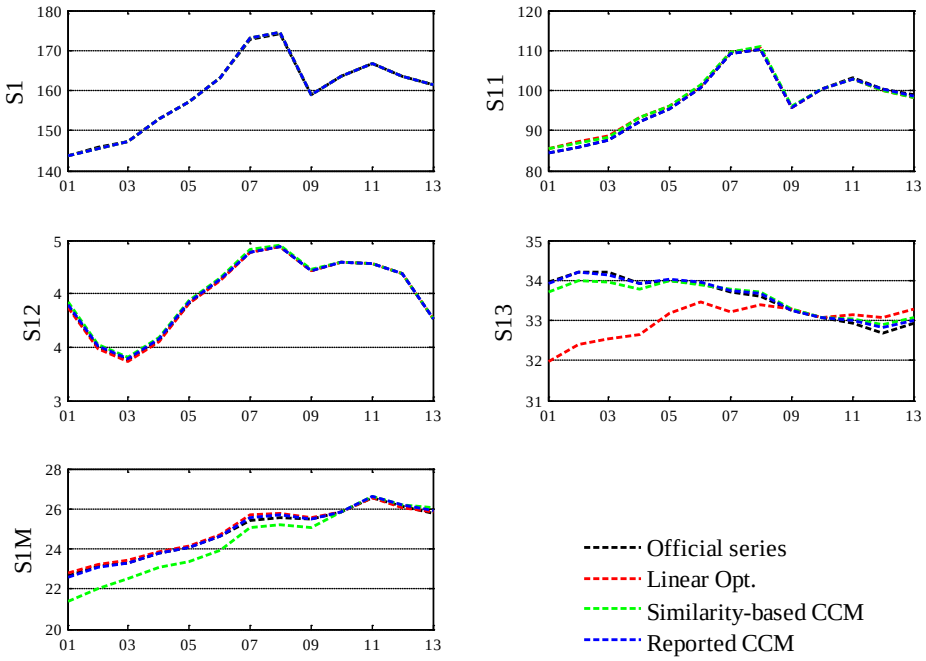
[26] Finnish cross-classification tables (Production and generation of income accounts).

series, the “Similarity-based CCM” method underestimates the GVA in the household sector. In contrast, the LO method fails to capture the volume series in the government sector, with discrepancies amounting to more than EUR 2 billion.

Chart 6

Finland, chain-linked gross value added by institutional sector

(in EUR billions)



Note: The total economy is represented by S1. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M).

Table 5 provides a quantitative assessment of the estimation performance by means of the normalised RMSE, relative to the range of the official series by Statistics Finland. Moreover, we assess how well the dynamic properties of the official Finnish series are captured. For this purpose, the table reports the R^2 obtained from regressing the annual growth rate of real GVA, as published by Statistics Finland, on the respective estimated series by using Ordinary Least Squares. In comparison to the official Finnish series, the “Reported CCM” method generally provides a lower normalised RMSE and a higher R2. Most importantly, using a time-invariant input table – as done in the “Reported CCM (B)” method – does not affect the estimation performance, with the normalised RMSE being slightly higher for the volume series of households only. The “Other Reported CCM” method performs slightly better than the “Similarity-based CCM” method, except in the case of the government sector. The LO method performs worse relative to the other specifications, as reflected by the sharp drop in the R2 notably for the government sector.

Table 5

Comparison with official Finnish data: Forecasting performance of different estimation methods for GVA by institutional sector

Method	S11 - Norm. RMSE	S11 - R2	S12 - Norm. RMSE	S12 - R2	S13 - Norm. RMSE	S13 - R2	S1M - Norm. RMSE	S1M - R2
Reported CCM	0.418	1.000	0.685	1.000	4.097	0.915	1.833	0.969
Reported CCM (B)	0.452	1.000	0.685	1.000	3.967	0.911	2.662	0.948
Other reported CCM	2.001	0.999	2.949	0.999	20.850	0.852	9.786	0.855
Similarity-based CCM	2.538	0.999	1.900	1.000	10.024	0.820	16.651	0.843
Linear Optimisation	2.695	1.000	0.807	1.000	66.960	0.553	3.206	0.940

Note: The normalised RMSE is expressed as a percentage of the official chain-linked series of GVA by Statistics Finland. R^2 is computed by regressing the annual growth rate of the official series on the respective estimated series by using Ordinary Least Squares. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M).

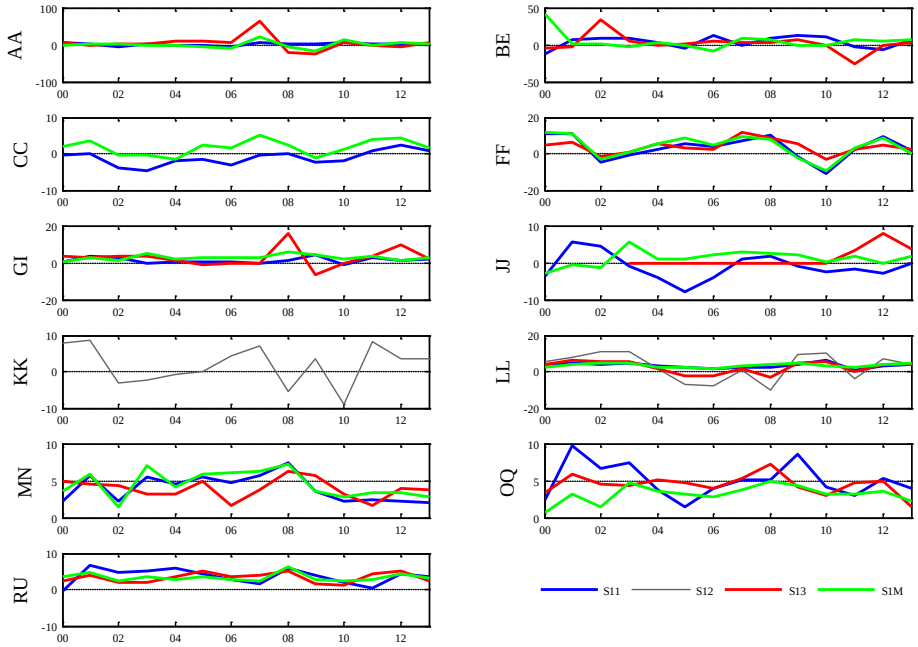
5.2.2 Sensitivity of assumptions concerning sectoral price development

As stated above, the main assumption of all estimation methods under consideration is that the relationship between economic activities and institutional sectors is the same in current and constant prices. Most importantly, this implies the same pricing strategy across institutional sectors, which is debatable. This assumption can be tested by means of the Finnish data, for which the implicit GVA deflator by institutional sector can be derived for each economic activity. **Chart 7** shows that the price development is quite different across institutional sectors, as indicated by the annual growth rate of the GVA deflator over time. Notably for economic activities J_J, M_N, and O_Q, sectoral price differences in GVA become evident. Nevertheless, given that our estimates track the compiled series by Statistics Finland well, different prices do not seem to have an effect at the sector-specific price level, since most activity classes are generally dominated by a given sector.

A second sensitivity test in relation to the official Finnish series refers to the price development in the government sector. In the previous Section, it became evident that the LO method fails to capture GVA volumes by general government properly. Therefore, a possible strategy for this estimation method consists in replacing the estimated implicit GVA deflator in the government sector by the observed government deflator for FCE, which could be assumed to be consistent with the government GVA price index, as government normally consumes its own production. **Chart 8** depicts the annual growth rates of the implicit GVA deflator and the FCE deflator, for general government. Although the deflators move strongly parallel over time, both measures deviate from 2001 onwards, with the annual growth rates of the FCE deflator being generally smaller. Thus, replacing the implicit GVA deflator with the FCE deflator would underestimate the price development in the government sector and, consequently, overestimate the related volume series. Note that Chart 8 also shows that the “Reported CCM” method closely matches the official GVA deflator for the government sector.

Chart 7

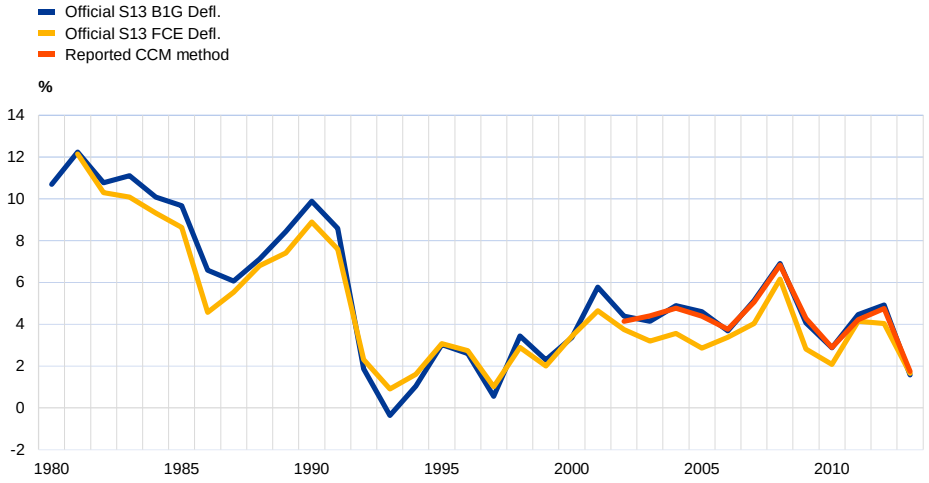
Finland, annual percentage change of implicit gross value added deflator



Note: The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M). See Annex for a detailed description of economic activities.

Chart 8

Comparison of deflators for general government (S13) in Finland



5.3 Sensitivity analysis of the “Reported CCM” method for the euro area

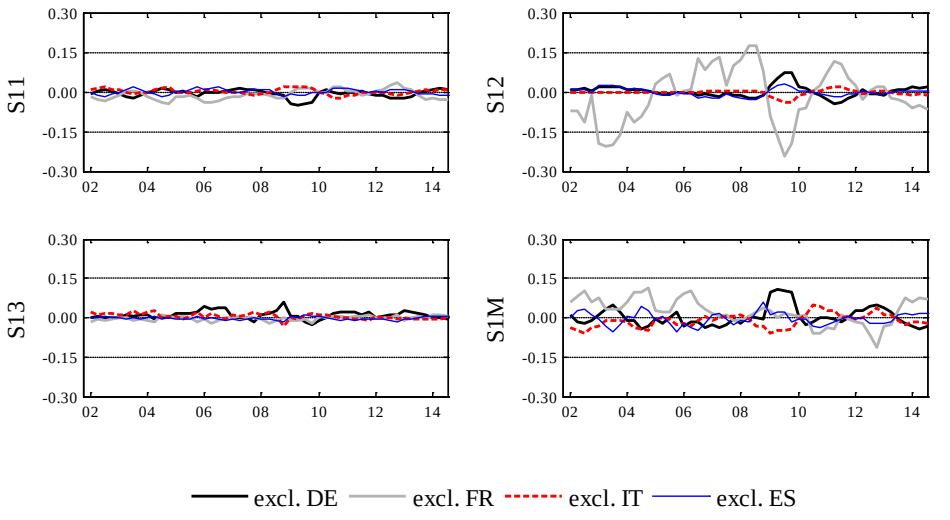
For the euro area aggregate, the crucial assumption of the “Reported CCM” method is that non-reporting euro area countries do not have an effect on the joint

distribution of institutional sectors and economic activities at the aggregate level. In the following, we test whether excluding one reporting euro area country from the calculated input matrix as shown in **Table 1** affects the euro area estimates. **Chart 9** shows the respective difference in the annual growth rate of real GVA in the euro area.[27] Overall, differences are rather small, with a maximum absolute change in the annual growth rate of only 0.2 percentage point. Deviations tend to be higher for the estimated household series. As reported in **Table 1**, the household sector also exhibited higher cross-country differences concerning the industrial composition, and is therefore more sensitive to the exclusion of specific euro area countries. The high deviation in the growth rate for financial corporations is mainly driven by the exclusion of France, which accounts, alone, for about one fifth of the euro area aggregate. Overall, we conclude that our results are robust when excluding one individual country from the euro area aggregate. Nevertheless, a high coverage of euro area countries in terms of GVA should always be envisaged, in order to capture the industrial composition of the euro area aggregate well. The different developments during 2009 and 2010 are actually explained by the different developments in value added volume in different countries. During the crisis, the financial corporation sector volume in Germany dropped sharply and then increased again. In Spain, the volume development also dropped but did not increase so rapidly thereafter, whereas in France there was no strong drop in the volume development of value added. This also explains different volume developments during this period of time, when different countries are excluded from the euro are aggregate.

Chart 9

Sensitivity of euro area estimates by excluding a specific country

(difference in annual growth rate, in percentage points)



Note: Estimates are based on the "Reported CCM" method by excluding subsequently one of the four largest euro area countries from the input CCM. The maximum absolute deviation of the remaining euro area countries is less than 0.04 percentage point and is therefore not reported. The sample period is Q1 2002-Q3 2014. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M).

[27] The maximum absolute deviation of the remaining euro area countries is less than 0.04 percentage point and is therefore not reported.

6 Conclusion

The aim of this paper is to analyse different estimation methods to derive quarterly volume and price series of GVA by institutional sector for the euro area. Moreover, it evaluates several approaches for the estimation at the euro area country level. Whereas the common strategy of all estimation methods consists in linking QSA data by institutional sector and QNA data by economic activity, the individual methods differ with respect to the derivation of such a cross-classification matrix (CCM) as an estimation input.

This paper proposes a benchmark method, which is based on using cross-classification tables by NSIs as an estimation input. The resulting quarterly estimates perform best in replicating the reported cross-classification tables and are robust to several modifications, such as the updating frequency of the input CCM. In addition, the proposed method is able to closely replicate the official sectoral volume series published by Statistics Finland.

Concerning euro area countries which currently do not report any cross-classification tables, we demonstrate that the proposed benchmark method is robust with respect to the input table used. A simple proxy of the euro area aggregate (as given by the sum of other reporting countries) seems to be a valid input to estimation a priori. Note, however, that an input CCM based on more similar economies might be a better strategy, since some of the non-reporting euro area countries[28] are expected to differ more strongly from the euro area aggregate in terms of their industrial composition.

Overall, the new measures of sectoral GVA prices and volumes provide valuable insight into understanding contributions to the domestic price and output development by institutional sector, and could help in monitoring potential risks and vulnerabilities of the economy. Since 2015, the ECB is publishing GVA in previous year prices and chain-linked volumes by institutional sector for the euro area aggregate, within its regular production of the euro area accounts. The potential application of these new measures in forecasting and economic analysis is left for future research.

[28] Note that the non-reporting euro area countries also include eastern European countries, which have undergone a considerable transition process concerning their economic structure since the 1990s.

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Annex

Classification of institutional sectors according to ESA 2010

Sector code	Sector
S1	Total Economy
S11	Non-financial corporations
S12	Financial corporations
S13	General government
S1M	Households and Non-profits institutions serving households (NPISH)

Classification of economic activities according to NACE Rev. 2 (A*10 level)

Economic activity code	Economic activity
A_A	Agriculture, forestry and fishing
B_E	Mining and quarrying and other industry (excluding C_C)
C_C	Manufacturing
F_F	Construction
G_I	Wholesale and retail trade, transportation and storage, accommodation and food service activities
J_J	Information and communication
K_K	Financial and insurance activities
L_L	Real estate activities (including imputed rents of owner-occupied dwellings)
M_N	Professional, scientific, technical, administration and support service activities
O_Q	Public administration, defence, education, human health and social work activities
R_U	Other services

Table A.1

Gross value added cross-classification table by institutional sector (QSA) and economic activity (QNA). The classification is presented at NACE A21 level but the economic activities in bold are also the sub-groups of NACE A10.

Economic activity code	Economic activity	S1 Total Economy	S11 Non-financial corporations	S12 Financial corporations	S13 General government	S1M Households and NPISHs
TTTT	**Total Economy**					
A	**Agriculture, forestry and fishing**					
B_E	**Mining and quarrying and other industry (excluding C_C)**					
B	Mining and quarring					
C	**Manufacturing**					
D	Electricity, gas, steam and air conditioning supply					
E	Water supply; sewerage, waste management and remediation activities					
F	**Construction**					
G_I	**Wholesale and retail trade, transportation and storage, accommodation and food service activities**					
G	Wholesale and retail trade; repair of motor vehicles and motorcycles					
H	Transportation and storage					
I	Accommodation and food service activities					
J	**Information and communication**					
K	**Financial and insurance activities**					
L	**Real estate activities (including imputed rents of owner-occupied dwellings)**					
M_N	**Professional, scientific, technical, administration and support service activities**					
M	Professional, scientific and technical activities					
N	Administrative and support service activities					
O_Q	**Public administration, defence, education, human health and social work activities**					
O	Public administration and defence; compulsory social security					
P	Education					
Q	Human health and social work activities					
R_U	**Other services**					
R	Arts, entertainment and recreation					
S	Other service activities					
T	Activities of households as employers; undifferentiated goods- and services-producing activities of private households for own use					
U	Activities of extraterritorial organisations and bodies					

Note: This table depicts the cross-classification between institutional sectors and economic activities for gross value added in a specific calendar year. The bold cells represent the main information needed for the estimation of gross value added volumes and prices by institutional sector.

Table A.2

Normalised RMSE and Mean Absolute Percentage Error with respect to the "Reported CCM" method

		S11 - Norm. RMSE	S11 - MAPE	S12 - Norm. RMSE	S12 - MAPE	S13 - Norm. RMSE	S13 - MAPE	S1M - Norm. RMSE	S1M - MAPE
BE	Reported CCM (B)	**0.04**	**0.01**	**0.23**	**0.04**	**0.08**	**0.01**	**0.54**	**0.05**
	Other Reported CCM	0.71	0.17	1.28	0.22	**0.99**	**0.20**	7.97	0.67
	Similarity-based CCM	**0.51**	**0.11**	**0.72**	**0.12**	1.34	0.22	**6.43**	**0.56**
	Linear Optimisation	3.02	0.69	3.94	0.61	2.68	0.48	23.02	1.98
DE	Reported CCM (B)	**0.09**	**0.02**	**0.21**	**0.05**	**0.92**	**0.06**	**0.18**	**0.02**
	Other Reported CCM	0.71	0.17	1.36	0.35	2.60	0.21	2.76	0.37
	Similarity-based CCM	**0.50**	**0.12**	**0.21**	**0.08**	**2.16**	**0.18**	**2.14**	**0.26**
	Linear Optimisation	1.19	0.25	0.49	0.11	3.06	0.22	6.28	0.76
ES	Other Reported CCM	**1.09**	**0.32**	1.06	0.55	**0.71**	**0.23**	**3.89**	**0.95**
	Similarity-based CCM	**0.79**	**0.23**	**0.21**	**0.04**	**0.49**	**0.17**	**2.26**	**0.54**
	Linear Optimisation	2.54	0.78	**0.14**	**0.07**	3.45	1.20	5.72	1.29
FI	Reported CCM (B)	**0.12**	**0.04**	**0.00**	**0.00**	**0.24**	**0.01**	**0.99**	**0.17**
	Other Reported CCM	**1.31**	**0.43**	1.80	0.61	11.72	0.62	6.39	1.18
	Similarity-based CCM	1.68	0.56	1.01	0.34	**4.70**	**0.27**	11.37	2.12
	Linear Optimisation	1.81	0.58	**0.97**	**0.30**	39.16	2.13	**2.00**	**0.39**
FR	Reported CCM (B)	**0.06**	**0.01**	**0.33**	**0.06**	**0.53**	**0.04**	**1.21**	**0.04**
	Other Reported CCM	**1.00**	**0.19**	2.53	0.56	1.53	0.16	**19.69**	**0.66**
	Similarity-based CCM	1.36	0.25	**2.41**	**0.56**	**1.20**	**0.12**	21.13	0.75
	Linear Optimisation	9.30	1.69	9.86	2.09	8.42	0.77	97.60	3.46
IT	Reported CCM (B)	**0.14**	**0.02**	**0.00**	**0.00**	**0.58**	**0.06**	**0.44**	**0.05**
	Other Reported CCM	**0.71**	**0.10**	0.48	0.18	4.57	0.59	2.28	0.26
	Similarity-based CCM	0.86	0.12	0.39	0.15	**2.87**	**0.36**	**1.99**	**0.25**
	Linear Optimisation	8.48	1.21	**0.07**	**0.03**	5.08	0.63	12.91	1.68
NL	Other Reported CCM	**3.40**	**0.57**	**1.87**	**0.65**	**2.01**	**0.49**	**13.28**	**2.68**
	Similarity-based CCM	**4.87**	**0.81**	**0.74**	**0.25**	**0.95**	**0.27**	**19.70**	**3.97**
	Linear Optimisation	7.01	1.33	7.84	2.82	2.21	0.56	24.07	5.53
PT	Reported CCM (B)	**0.52**	**0.05**	**0.00**	**0.00**	**0.76**	**0.09**	**1.54**	**0.12**
	Other Reported CCM	**1.36**	**0.15**	1.06	0.53	**1.37**	**0.19**	**4.19**	0.40
	Similarity-based CCM	1.91	0.21	**0.32**	**0.16**	2.12	0.29	4.24	**0.39**
	Linear Optimisation	11.52	1.29	3.03	1.45	3.02	0.47	28.88	2.72
Euro area	Reported CCM (B)	**0.04**	**0.01**	**0.19**	**0.03**	**0.24**	**0.02**	**0.50**	**0.03**
	Similarity-based CCM	**0.04**	**0.01**	**0.12**	**0.02**	**0.14**	**0.01**	**0.27**	**0.02**
	Linear Optimisation	6.28	0.94	0.80	0.14	5.98	0.66	28.83	1.87

Note: This table shows the normalised RMSE and Mean Absolute Percentage Error (MAPE) for estimated gross value added volumes, both expressed as a percentage of the estimate from the "Reported CCM" method. The estimation period is Q1 2001-Q3 2014. For each country, the two best performing estimation methods are in bold. The institutional sectors are non-financial corporations (S11), financial corporations (S12), general government (S13), and households & NPISHs (S1M).

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Elisabeth Wieland
Deutsche Bundesbank, Frankfurt, Germany; email: elisabeth.wieland@bundesbank.de

Ilja Kristian Kavonius
European Central Bank, Frankfurt, Germany; email: ilja_kristian.kavonius@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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