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**Working Paper**

## The Belgian production network 2002-2012

NBB Working Paper, No. 288

**Provided in Cooperation with:**

National Bank of Belgium, Brussels

*Suggested Citation:* Dhyne, Emmanuel; Magerman, Glenn; Rubínova, Stela (2015) : The Belgian production network 2002-2012, NBB Working Paper, No. 288, National Bank of Belgium, Brussels

This Version is available at:

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# The Belgian production network 2002-2012



## Working Paper Research

by Emmanuel Dhyne, Glenn Magerman and Stela Rubínová

October 2015 No 288

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ISSN: 1375-680X (print)

ISSN: 1784-2476 (online)

## Abstract

This paper presents the Belgian inter-firm network for the years 2002 to 2012. Combining raw data from VAT listings, VAT declarations and annual accounts information, we build a unique and consistent database containing values of transactions between enterprises in the Belgian economy. The dataset spans Primary Industries, Manufacturing, Utilities, Market Services and Non-Market Services. This dataset, unparalleled in coverage at the firm-to-firm level and its panel dimension, allows one to analyze a broad spectrum of research questions in industrial organization, international trade, network theory etc. As a simple example of the potential of this dataset, we evaluate the position of enterprises in the Belgian network, their distance to final demand and their relationship with exports and imports. The degree of upstreamness, defined as a weighted distance to final demand, of the average enterprise is 1.6, ranging between 1 and 9.5. While only 5 % of enterprises export, 82 % of the enterprises in the Belgian network are producing goods and services that are either directly or indirectly exported after transformation or use. On the ip side, only 9 % of enterprises are importers but 99 % of firms are either importers or have importers in their supply chain and therefore consume imported inputs indirectly. However, we find large inter- and intra-sectoral as well as inter-regional heterogeneity in enterprise positions in the Belgian production network.

JEL Classification: C67, C81 et L23.

Keywords: Enterprises, firm-level analysis, networks, international trade.

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### **Acknowledgements:**

We thank Catherine Fuss and Cédric Duprez for valuable and detailed comments. Glenn Magerman gratefully acknowledges financial support from the USA Fulbright Foundation Belgium-Luxembourg, the Otlet-La Fontaine scholarship granted by Yves Moreau at the Department of Engineering at the University of Leuven, the NBB 2014 Sponsorship program at the National Bank of Belgium and the Junior Mobility grant by the University of Leuven. Stela Rubínová gratefully acknowledges financial support by the Swiss National Science Foundation. The results presented totally respect the confidentiality restrictions associated with some of the data sources used.

The views expressed in this paper are those of the authors and do not necessarily reflect the views of the National Bank of Belgium or any other institutions to which one of the author is affiliated. All remaining errors are our own.

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# 1 Introduction

With the rise of data availability over the past decade, firm-level analysis has become extremely popular and increasingly more feasible. The bulk of both the theoretical and empirical literature in international trade is driven by firm-level observations and firm characteristics (Bernard and Jensen, 1995; Pavcnik, 2002; Melitz, 2003; Bernard, Eaton, Jensen and Kortum, 2003; Bernard, Jensen and Schott, 2007; Bernard, Jensen, Redding and Schott, 2007; Verhoogen, 2008; Kugler and Verhoogen, 2012; Chor, Manova, and Yu, 2014; Antras, Fort and Tintelnot, 2014, and many, many more). Information on firm heterogeneity has pushed boundaries of the theory of the firm and international trade forward. Empirical observations have simultaneously driven and reinforced theoretical models, all of which are now in the standard toolkit of every economist in this field. For excellent surveys on firm heterogeneity and trade, see for instance Bernard, Jensen, Redding and Schott (2012) and Melitz and Redding (2014). Using raw data from VAT declarations,<sup>1</sup> this paper constructs and describes a new and unique dataset that goes even one step further by providing information on bilateral business relations. In this unique dataset, we observe almost all commercial transactions between Belgian firms. Deriving stylized facts from this unique dimension of data opens up a whole new playing field for both empirical observations and theoretical underpinnings for models of the theory of the firm, international trade and network theory.

After matching and cleaning, the resulting dataset is an unbalanced panel of 88,437,335 yearly firm-to-firm transactions (in euro) for the years 2002-2012, that can be matched with firm-level characteristics from other sources. For example, the annual accounts database from the National Bank of Belgium (NBB) contains information on turnover, input consumption, value added, employment, wages, various financial variables etc. The database from the crossroad bank for Belgian firms contains information on the branch of activity and the location of the firm. The international trade statistics database from the National Bank of Belgium contains information on exports and imports. The annual VAT declarations from the tax administration contain information on turnover, input consumption and investment; the database on social security declarations from the Department of Social Security of Belgium contain information on employment and wages, etc.

The purpose of this paper is to present this new dataset, its potential use for research and to document in detail how this dataset has been constructed.<sup>2</sup> First, we describe all data manipulations, heuristics and choices in constructing the final dataset. Then, we use this dataset to evaluate how the production network in Belgium is organized. Merged with sectoral information from the World Input Output Database, we evaluate for each firm the degree of fragmentation of its production chain and its relative position in that chain with respect to the final consumer. To that end, we calculate the “upstreamness” and “downstreamness” measures for each firm as a weighted dis-

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<sup>1</sup>The VAT data we have access to are data coming from the raw declarations of Belgian VAT affiliates to the tax administration. The data used represents the declarations received at the time of the delivery of the data to the NBB by the tax administration. Any correction introduced after the declaration, either by the fiscal administration or the firm, and any late declaration are not included in our dataset, even if they are considered by the tax administration for its own fiscal exercise.

<sup>2</sup>The access to this new dataset for research is still highly restricted because of the confidential nature of the data.

tance to final demand. This additionally allows us to evaluate the direct and indirect participation of Belgian firms in international trade. Indeed, a large fraction of exporters act as international trade intermediaries (see for instance Bernard, Blanchard, Van Beveren and Vandenbussche, 2014 on the importance of carry-along trade in Belgian exports). Therefore, using only the number of exporters is not a sufficient statistic to quantify the participation of Belgian firms in exports. We find that only 5% of firms directly export, but 82% of Belgian firms are either directly or indirectly connected to international trade through the network of production. On the flip side, only 9% of enterprises are importers but 99% of firms are either importers or have importers in their supply chain and therefore consume imported inputs indirectly.

## **2 The NBB B2B transactions dataset**

As mentioned above, the purpose of this paper is to describe a unique dataset that provides information on the organization of the production network in Belgium. In its spirit, the dataset is similar to the one used by Atalay, Hortaçsu, Roberts and Syverson (2011) for the US, or by Bernard, Moxnes and Saito (2015) for Japan. However, the information content and coverage of the current dataset is superior. The Japanese data has a high coverage (all Japanese firms have to report their 24 largest suppliers and 24 largest business customers), but it only provides information on the existence of a business relationship; quantities or values associated to these relationships are not recorded. The US data covers transactions from Computstat, but only from publicly listed firms (39,000 firms). Additionally, it considers only the main business relations of these firms (customers that represent at least 10% of turnover for a seller). Compared to these datasets, the NBB B2B transactions dataset not only covers almost all business relations between two Belgian enterprises registered in the NBB Balance sheet database, but it also records the transaction values in euro. The final dataset contains over 400,000 firms and over 88 million transactions over 11 years. It is constructed from three sources of raw data: the VAT listings to the Belgian tax administration, the VAT declarations to the Belgian tax administration and the NBB balance sheet database. The resulting dataset is the network representation of the Belgian economy, which covers the whole Belgian private sector, spanning all industries.

### **2.1 VAT listings**

The primary source of information for the NBB B2B transactions dataset is the collection of VAT listings of Belgian enterprises for the years 2002 up to 2012. This raw dataset contains 170,179,744 observations over 11 years and reports the yearly value of a transaction between two enterprises in euro. Each enterprise that has a VAT number and is liable to pay VAT has to file yearly a list of his Belgian VAT customers from Jan 1 to Dec 31, to the tax authorities at the Department of Finance. Only those reporters fully exempt from VAT through Article 44 of the VAT legislation do not have to report their VAT listings. In case of multiple plants or establishments under one VAT identifier, the listing is filed as a single file for that VAT identifier. This listing contains the reference year of the declaration, the VAT identifier of the seller (the reporter), the VAT identifier of each of his

buyers, the yearly transaction value from the seller to each of his buyers and the allocated amount of VAT on that yearly aggregate.<sup>3</sup> Yearly values are recorded for invoices sent to a given buyer in a given calendar year.<sup>4</sup>

All amounts have to be reported by the seller, even if no VAT amount was due for whatever reason, as long as the annual transaction value with a given customer is greater than or equal to 250 euro. If there is a credit note or a negative correction, the amount has to be reported with a “-” sign, even if this amount is less than 250 euro. Each enterprise has to file this listing before March 31 of the following year through an online application called INTERVAT,<sup>5</sup> apart from some exceptions for enterprises that can file a paper format and send this to the VAT authorities.<sup>6</sup> Administrative sanctions for misreporting and incomplete reporting guarantee a high quality of the data collected.

It is worth noting that the data we use comes from the raw declarations to the VAT authorities. It is not updated or corrected in any way. Therefore, it does not include any revision or correction of the data introduced by the tax authorities during their control or any late declaration.

## 2.2 VAT declarations

The second source of information used is that of the VAT declarations. These declaration forms contain self-reported information on the sales of an enterprise and the purchases of an enterprise that entail VAT liable transactions, including domestic and international transactions, and final demand. The declaration has to be filed online through INTERVAT by all enterprises that have a VAT number.<sup>7</sup> In case of multiple plants or establishments under one VAT identifier, this declaration is filed as a single file for that VAT identifier. There are some exceptions of enterprises that do not have to report VAT declarations: (i) micro enterprises that have a yearly turnover less than 5,580 euro per calendar year (these do have to report VAT listings), and (ii) VAT liable enterprises that are exempt from VAT (these do not have to report VAT declarations nor VAT listings, and cannot recover VAT in return). Almost all of these exceptions are self-employed workers. Each enterprise has to file this declaration before the 20th of the month after the period that is applicable, either a monthly or a quarterly frequency, depending on some thresholds.<sup>8</sup> Enterprises that have no turnover relating to the VAT declaration have to file a zero-declaration.

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<sup>3</sup>A sample form can be found in [Dutch](#) and in [French](#), together with a guide on filing these listings by the Department of Finance.

<sup>4</sup>The year of transaction and the year of delivery of goods or services can be different. As we do not observe specific dates of delivery, we assume both years coincide. Discrepancy between the years of invoice and delivery can potentially affect any enterprise-level measure of turnover or input consumption observed in the annual accounts data. There is no indication that this issue might be more problematic at the transaction level.

<sup>5</sup>Available at <https://idp.iamfas.belgium.be>. The data is collected online since the period 2009. For the period 2005-2008, paper listings had to be sent to the regional tax authority in Flanders, Brussels and Wallonia, who checked and digitalized the listings. Before 2005, paper submissions were sent to local tax authorities across the country.

<sup>6</sup>An enterprise can only be exempt from filing electronically in specially approved circumstances when the reporter has no access to the necessary online infrastructure (computer and internet connection), and some exceptions for special agricultural entities and international entities with a Belgian VAT. These entities then file a paper format.

<sup>7</sup>A sample form can be found in [Dutch](#) and in [French](#), together with a guide on filing these forms.

<sup>8</sup>Each enterprise that has a turnover larger than 2,500,000 euro excl. VAT (threshold for 2014), has to file monthly VAT declarations. Enterprises below that threshold can choose to report monthly or quarterly declarations. Additionally, enterprises that have a turnover larger than 250,000 euro and are active in the delivery of energy products, telecom or some motorized vehicles, always have to report a monthly declaration.



We now describe the structure of the form that has to be filed by the enterprise, focusing on the items that are needed to measure the turnover and the input consumption of the enterprise. Regarding the turnover, enterprises have to file total sales value due to special VAT regimes on line '0' and per VAT regime of 6%, 12% or 21% on lines '1', '2' and '3' respectively. This first set of records provides the total value of domestic sales, including business-to-business and business-to-consumers transactions. There are separate lines for filing VAT amounts that are liable to international counterparts or paid by the international counterparts (lines '44' and '45') and one for intra-EU sales (line '46'). Also, enterprises have to report sales that are exempt from VAT liabilities (line '47') and they have to report credit notes (lines '48' and '49'). To obtain the annual turnover of an enterprise from the VAT declaration, one needs to sum the values associated to lines '0'-'47', and subtract values declared in items '48' and '49'.

Regarding inputs consumption, there are lines for sourcing commercial goods and raw materials (line '81'), other goods and services (line '82') and assets for production (line '83'). Input consumption computed based on lines '81' and '82' not only cover domestic inputs but also imported inputs. Lines '81', '82' and '83' may also contain intra firm sales if the VAT declaration is filed by a single VAT file for several plants or establishments. To compute the total value of entries at the enterprise level, one needs to sum the values reported in lines '81', '82' and '83'. We refer to the total value of entries by the *tot\_expenses\_VAT* variable, while input consumption is referred to as *inputs\_VAT* in the dataset.

### 2.3 Annual accounts

Finally, we use the NBB annual account database as a third source of raw data. We use this database to select the enterprises included in the NBB B2B transactions dataset. This allows us to remove very small enterprises from our database, who are mostly self-employed.<sup>9</sup>

## 3 Setting up the NBB B2B transactions database

### 3.1 Selection of the sample of enterprises / transactions

The collection of the raw VAT listings contains 170,179,744 observations for the years 2002-2012. An observation refers to the value (in euro) of a sales transaction of goods, services or capital goods between two VAT entities. Each observation includes a seller identifier, a buyer identifier, the year of the transaction, the transaction amount excluding VAT and the VAT amount of the transaction. This dataset is subsequently merged with the two other data sources and we keep only observations for which both the seller and the buyer report both their VAT declarations and their annual accounts.

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<sup>9</sup>Sample forms in Dutch, French and German can be found on the NBB website <http://www.nbb.be>. Large enterprises have to file a complete form, while small enterprises only have to report using an abbreviated form. An enterprise is labeled as small if it has not exceeded more than one of the following ceilings in the last two financial years for which the accounts are closed: annual average workforce: 50 FTE; turnover (excluding VAT): 7,300,000 euro; balance sheet total: 3,650,000 euro. Enterprises with an annual average workforce above 100 FTEs are always labeled as large.

After merging the VAT listings with the VAT declarations, we lose 15,201,025 observations over 11 years. These transactions mostly involve micro enterprises and self-employed workers that are exempt from VAT declarations. After merging the resulting dataset with the annual accounts dataset, we lose an additional 64,926,224 observations. These transactions involve at least one party that does not have to report annual accounts (see Appendix A for the rules on filing annual accounts).

We now have a dataset of 90,052,495 observations that characterizes the domestic transactions between Belgian enterprises for the years 2002-2012, and contains the following information: ID seller, ID buyer, year, transaction value in euro excluding taxes and value added taxes in euro. For all enterprises recorded in this dataset, we also observe annual turnover, the total value of entries and total input consumption. This additional information is used to check the consistency of the transaction dataset with enterprise-level aggregates. For most enterprises, these enterprise-level aggregates come from the VAT declarations. However, for large enterprises, we prefer to use the turnover and the input consumption reported in the annual accounts (which are validated ex-post and updated in case of revisions) instead of the values observed in the VAT declarations, as the latter may be subject to a correction by the fiscal authorities.

### 3.2 Cleaning the data

Because, the transaction dataset we use comes from the raw declarations and does not take into account any ex-post correction introduced by the tax administration, we have identified several potential sources of manual misreporting in the transaction data, which we sort out below. Additionally, we drop some observations that do not make sense from an economic point of view. First, we drop transactions with sales values equal to zero and intra-enterprise transactions (222,800 observations)<sup>10</sup>. We also drop transactions of enterprises that report turnover or total entries equal to zero in the VAT declarations (respectively 304 and 512 observations). Second, we clean the misreporting of the data due to one of the following sources: (i) misreporting of decimal points, (ii) observations that have transactions amounts and VAT amounts swapped, (iii) wrongly coded negative transactions, (iv) clear mistakes at the transaction level, (v) large inconsistencies over time, and (vi) inconsistencies between enterprise level observations and recorded transactions.

#### 1. *Misreporting of decimal points*

We identify mistakes in decimal points by using the observed VAT rate implied by the VAT paid on the transaction. We first generate the observed VAT rate ( $= (VAT/sales) * 100$ ). The standard tax rates in Belgium are 21%, 12% and 6%. We find that several observations have observed VAT rates that are around 2,1%, 0,21%, 0,021% etc. or 210%, 2,100% etc. and similar for the tax rates of 12% and 6%. For example, misreporting of a factor of 100 can be due to the fact that in the paper form, all amounts have to be reported up to the

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<sup>10</sup>We drop intra-enterprise transactions since all intra-enterprise transactions may not be subject to a invoice and to VAT charges.

eurocent. We assume that these observations have a correct VAT paid, and that there has been misreporting in the transaction value. This is most likely, since a huge incorrect VAT amount would be reported by the VAT administration or the enterprise itself, as that reported VAT amount has to be paid to the tax authority. We thus correct the sales amounts if the observed VAT rate is off by a factor 10, 100, 1,000 or 10,000 to one of the standard rates, by dividing the transaction value by 10, 100, 1,000 or 10,000 respectively. Furthermore we correct the sales amount if it is less than 250 euro and the observed VAT rate is off by a factor of 0.1, 0.01 or 0.001 to one of the standard rates as 250 euro is the threshold for reporting.

## 2. *Swapped VAT amounts and transaction amounts*

There are observations where the VAT amount is greater than the transaction amount. Therefore, we swap the VAT amount with the transaction amount whenever the VAT paid is greater than the transaction *and* the VAT rate is within the inverse of (20.5; 21.5), (11.5; 12.5) and (5.5; 6.5) intervals.

## 3. *Wrongly coded negative transactions*

Some customer-buyer pairs do not report only one aggregate transaction per year but have several entries in one year. It is then hard to correctly identify wrongly coded negative transactions, as credit notes and negative corrections also are reported. At the same time, there are some transactions that are stable over time in terms of transaction value, but reported with a “-” in a given year. We then assume this is wrongly coded and correct these particular observations to a positive value. We then visually check the largest negative transactions and apply the following rule: if a transaction between a given enterprise pair is negative and unique in a given year, we assume it is a false negative and code it positive. We drop 3 observations for which we are not sure. Finally, we sum multiple transactions per year per pair in order to generate a dataset with one entry for each supplier-buyer-year. Any remaining negative observations are then assumed to be wrongly coded and corrected to positive.

## 4. *Clear reporting mistakes*

We check all observations that are larger than 1 billion euro and compare these to the size of the enterprise. Several observations are clear misreports, as a tiny enterprise sells (buys) for a huge amount to (from) another enterprise. These outliers are corrected if the imputed value is obvious (i.e. the order of magnitude is adjusted according to the observations one year before and one year after). We observe transactions larger than 10 billion euro between wholesalers and their distributors with the same name but different VAT identifiers, wholesalers and

retailers, and parent-daughter transactions. We assume these are correct given the size of these enterprises. The remaining 2 observations larger than 10 billion euro are dropped.

#### 5. *Clear inconsistencies over time*

It occurs that enterprises have a stable trading relationship, and still we observe a huge transaction peak in one of the years. We assume that those observations which are more than 100 times greater than previous and following years between those two enterprises are outliers, and correct the size of those transactions with an appropriate factor: observations 100 times larger than the preceding and following year are divided by 100. Similarly for transactions with factors 1,000, 10,000, 100,000 and 1,000,000.

#### 6. *Additional cleaning*

Finally, we remove some additional outliers in the transaction dataset. We first drop any transaction that has a value larger than both the total turnover of the seller and the total entries of the buyer, as this is clearly an indication of misreporting. We also drop observations for which the input share, defined as the transaction value to firm  $j$  divided by total expenses of firm  $j$ , is greater than 10. Similarly, we also drop observations for which the output share, defined as the transaction value from firm  $i$  divided by turnover of firm  $i$ , is greater than 10. Note that we do not impose that the transactions are fully consistent with the enterprise-level turnover or input consumption data. This has to be done in a later stage depending on the analysis at hand. For instance, in Dhyne and Duprez (2015), it is assumed that if the turnover observed in the annual accounts or the tax declaration is smaller than the sum of all domestic transactions of a given seller and of all its exports (observed in the international dataset), the turnover has to be replaced by the sum of domestic and exports transactions.

### **3.3 Imputing missing VAT transactions**

In principle, the VAT listing data should be complete. Enterprises are fined for late, incomplete or incorrect reporting, and the VAT listings data is checked against the VAT declaration by the fiscal authorities. However, because any late declaration or any ex-post correction of the data is not included in our dataset, missing observations can degrade the overall quality of the dataset. If these missing observations are non-random, this can bias any analysis, and without insight in the structure of missingness, it is impossible to predict which way the bias goes. For instance, missing observations might be more prevalent in large enterprises, particular sectors etc. Secondly, we want to get an idea about whether transactions between any two given enterprises are stable over time, or whether we observe repeated time intervals between transactions (e.g. with depreciating goods

such as computers, inputs could be bought every 3 years). Without any insight in the structure of missingness it is hard to evaluate these questions.

We first merge the resulting dataset with the annual accounts and VAT listings again, adding the enterprises that were active (i.e. reporting in the annual accounts and VAT declarations), but did not report the customers file at time  $t$ . We assume these enterprises are active in a given year that they report, and that they have made transactions but that these are not recorded. We further assume that if an enterprise has filed its VAT listing, it has filed all of its transactions, as the VAT listing has to be complete (except yearly values less than 250 euro). If the transactions of an enterprise are not present at time  $t$  while the enterprise was active at time  $t$ , we reconstruct them in the following way. If we observe a link between two enterprises in  $t - 1$  and in  $t + 1$  but not in  $t$ , this indicates that the seller might have reported too late and that the transaction is not in the data. We then reconstruct the missing link at time  $t$  if it is present at  $t - 1$  and  $t + 1$ . We only impute gaps of one year.<sup>11</sup> These imputed transactions are flagged with a dummy variable *fictive*. Then we predict the value of the imputed transactions using a fixed effects panel regression with the following specification:

$$y_{ijt} = \beta_0 + \beta_1 y_{ijt-1} + \beta_2 y_{ijt+1} + \gamma_i + \delta_j + \eta_t + \varepsilon_{ijt}$$

where  $y_{ijt}$  is the value of sales from enterprise  $i$  to enterprise  $j$  at time  $t$ ,  $\beta_i$  represent estimated coefficients,  $y_{ijt-1}$  and  $y_{ijt+1}$  are lags and leads respectively,  $\gamma_i$  and  $\delta_j$  are enterprise fixed effects,  $\eta_t$  is a year fixed effect and  $\varepsilon_{ijt}$  is the remaining unobserved part of the variation of transactions. This way, we use the information of transaction values of the previous and next years, we capture all time-invariant unobservable enterprise-level effects in enterprise fixed effects and we add a time fixed effect that captures the general business cycles. As we are only interested in the predicted values  $\hat{y}_{ijt}$ , no other corrections (e.g. for standard errors) are necessary. The proposed estimation gives an adjusted  $R^2$  of 0.94. We then impute the VAT transactions with the predicted values of the regression for the *fictive* observations. Since the method can predict negative sales flows, we drop the newly imputed observations that generate non-positive flows. In other words, we assume there was no link between those enterprises after all, if the predicted transaction value was negative.

Table 1 shows the number of missing transactions by year that have observations in  $t - 1$  and  $t + 1$ , but not in  $t$ , and the aggregate imputed values. Note that there are no imputations for the first and last years in the dataset. The number of imputed transactions amounts to 0.74% of the total number of transactions and the sum of imputed values amounts to 1.18% of the total observed values in the transaction data.

Table 2 shows the proportion of imputed transactions, broken down by aggregated sectors. We have aggregated economic activity by the following classification: Primary Industry (NACE

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<sup>11</sup>It is possible that there are recurring patterns of input sourcing that are only bi-annual or tri-annual. For instance, many capital investments are completely depreciated after three years (such as computers), after which an enterprise might choose to source it again. We do not capture these patterns here, it is up to the researcher to use the imputation as he or she sees fit. Also, these recurrent patterns probably reflect actual transaction patterns, so imputing these would actually induce more measurement noise into the data.

Categories 1 to 9), Manufacturing (NACE Categories 10 to 33), Utilities (NACE Categories 35 to 43), Market Services (NACE Categories 45 to 82) and Non-Market Services (NACE Categories 83 to 99). The columns show the sector aggregates, the number of imputed transactions for each sector, the total transactions by sector, and the percentage of imputed transactions respectively. The overall effect of imputing transaction values is very low, so it is up to the researcher to include or exclude imputed values in his/her analysis.

Finally, Table 3 shows the enterprise-year observations for enterprises that have at least 1 imputed transaction, against the rest of our dataset. There are 22,542 enterprise-year observations with at least 1 imputation, compared to 2,344,468 enterprise-year observations with no imputation. The mean turnover of enterprises with at least one imputation is 5,909,689 euro/year, which is larger than the mean turnover of the rest of the dataset (3,059,501 euro/year). However, enterprise-year observations have a lower mean number of customers (29) than non-imputed (37.44). We also report the median values. Hence, there is some indication that misreporting is positively correlated with the size of the enterprise.

Table 1: Imputed transactions, by year.

Year	# Imputed	Value imputed <sup>(1)</sup>
2003	39,432	3.63
2004	189,093	12.3
2005	77,671	4.07
2006	84,837	3.94
2007	124,964	7.27
2008	84,678	5.54
2009	26,600	5.12
2010	10,927	1.35
2011	15,518	0.56
<b>Total</b>	<b>653,720</b>	<b>31.5</b>

<sup>(1)</sup> in billions of euros.

Table 2: Imputed transactions, by sector.

Sector aggregate	# Imputed	Total transactions	% Imputed
Primary	3,011	520,377	0.58%
Manufacturing	88,527	11,648,732	0.76%
Utilities	38,023	7,579,970	0.50%
Market Services	514,766	66,869,759	0.77%
Non-Market Services	9,393	1,818,497	0.52%
<b>Total</b>	<b>653,720</b>	<b>88,437,335</b>	<b>0.74%</b>

Table 3: Comparison of turnover and number of customers if imputed.

Enterprise-year	No imputation	At least 1 imputation
Observations	2,344,468	22,542
Mean turnover	3,059,501 euro/year	5,909,689 euro/year
Median turnover	213,528 euro/year	270,158 euro/year
Mean # customers	37.44	29.00
Median # customers	5	2

## 4 Descriptive statistics

This section briefly describes some variables of interest in the dataset. After cleaning and imputation, the NBB B2B dataset contains information on 88,437,335 transactions between 2002 and 2012. This dataset can be merged with enterprise-level observations to characterize sellers and/or buyers. First, we present some summary statistics of our sample across years in Table 4. The average transaction value recorded in our dataset is 30,152 euro, but the distribution is clearly skewed as the standard deviation is 1.8 million euro. Note that the reporting threshold for yearly VAT transactions is 250 euro, but some enterprises still report smaller transactions. The other variables are at the enterprise level (2,766,444 observations). We first characterize the size distribution of enterprises in our dataset. Again, this distribution is heavily skewed. The mean turnover of an enterprise in our dataset is 2.7 million euro, with a standard deviation of 79 million euro. The median turnover is only 0.2 million euro. Similar reasoning holds for total entries: the mean observation is 2.4 million euro with a standard deviation of 74 million euro, while the median input is only 100,000 euro. Finally, we calculate the number of buyers each enterprise has and similarly its number of suppliers. There are enterprises that do not sell to other enterprises in the Belgian economy, hence their number of buyers is zero in our dataset. Similarly, there are enterprises that do not purchase inputs from other enterprises in the Belgian economy. Note that these enterprises might still export/import. Again, the distributions are heavily skewed: the mean number of business customers an enterprise has in a given year is 1,021 with a standard deviation of 5,629. Even up to the 90th percentile, an enterprise only has 393 business customers in the Belgian economy. The number of business suppliers is much less skewed: the mean is 135 with a standard deviation of 317 and a median of 46.

Next, we check the coverage of the dataset across sectors. To that end, we calculate the growth rates of turnover and of the sum of transactions at each NACE 2-digit level. Figures are in Appendix B. We find that across most sectors, aggregate growth rates and growth rates of total sales are strongly in line, hence coverage over time is largely consistent.

Finally, in Table 6, we compare aggregate numbers of our dataset to other data sources. Our B2B transactions data represent around 35% of the total turnover (which also includes sales to final demand and exports) of our sampled enterprises, which represent around 95% of the total production recorded in the Belgian National accounts. Therefore, we can consider that our sample

is representative for the Belgian economy.

Table 4: Summary statistics.

	Mean	St. dev	Percentiles				
			10th	25th	50th	75th	90th
Transaction <sup>(1)</sup>	30	1,799	0.4	0.6	1.6	5.9	24
Turnover <sup>(1)</sup>	2,739	78,700	24	72	186	594	2,060
Total expenses <sup>(1)</sup>	2,405	74,400	16	44	140	512	1,897
Number of buyers	1,021	5,629	1	2	8	49	393
Number of suppliers	135	317	8	19	46	118	289

<sup>(1)</sup> in thousands of euros.

## 5 An application of the NBB B2B transactions dataset - The integration of Belgian enterprises into Global Value Chains

Even if its access is restricted due to the confidentiality of the data, the NBB B2B transactions dataset is a unique source of information that may allow to investigate new research questions that could previously only been addressed by using sectoral linkages information coming from input-output tables. As this dataset can be merged with other enterprise-level datasets that identify enterprises by their VAT number, its potential applications are numerous. For instance, it has been used to analyze the organization of the Belgian production network by Dhyne and Duprez (2015), by Magerman, De Bruyne, Dhyne and Van Hove (2015) to analyze shock propagation and by Dhyne and Rubinova (2015) to characterize the supplier network of Belgian exporters. As an illustration, we will briefly describe some of the results presented in Dhyne and Duprez (2015), focusing on some data related issues.

In their contribution, Dhyne and Duprez have computed several indicators that characterize the organisation of the production chains using an analytical framework derived from the Input-Output analysis. Basically, they used the B2B transactions data to build an enterprise-level input-output table for each year during the 2002-2011 period. This has been done under the constraint that, unlike in the input-output tables where sectoral linkages only concern the delivery of intermediate inputs by one sector to another, the transactions recorded in the B2B dataset not only cover the delivery of intermediate inputs from enterprise  $i$  to enterprise  $j$ , but also the delivery of capital goods from  $i$  to  $j$ . This implies that for enterprises that make large investments in capital during a given year, the turnover of that year may be smaller than the sum of all entries, leading to technical coefficients (ratios of the delivery of  $i$  to  $j$  on the turnover of  $j$ ) that sum above 1 and to a negative value added.

There are several ways to deal with that issue. For instance, one could split all the transactions between input deliveries and investments according to a given proportionality rule. For example,



if in the annual supply and use tables, one branch produces  $x$  euro of intermediate inputs to other branches and  $y$  euro of investment goods, one could consider that the fraction  $\frac{x}{x+y}$  of the transactions of all enterprises belonging to that branch corresponds to the delivery of intermediate inputs and the remaining part is considered to be investment and therefore a part of final demand. Dhyne and Duprez (2015) did not follow that path and preferred to remove from the B2B transactions dataset all the transactions associated to enterprises for which the sum of their total entries recorded and of their imports are above their turnover.

Based on their “cleaned” enterprise-level input-output tables, Dhyne and Duprez computed the degree of upstreamness or downstreamness of the production of all the enterprises in their sample. To do so, they followed the methodology presented in Antras et al. (2012). In this framework, the turnover of an enterprise can be represented as the sum of all deliveries to the other enterprises of the network and of all deliveries to final demand.

$$Y_i = FD_i + \sum_{j=1}^n F_{ij} \quad (1)$$

where  $Y_i$  is the turnover,  $FD_i$ , the deliveries of enterprise  $i$  to final demand and  $F_{ij}$  the deliveries of enterprise  $i$  to enterprise  $j$ , or if  $F_{ij}$  is expressed as a fraction of  $j$ 's turnover

$$Y_i = FD_i + \sum_{j=1}^n \theta_{ij} Y_j \quad (2)$$

Under this representation, Antras et al. (2012) have shown that the upstreamness of the production of enterprise  $i$ , which represents how many transactions / transformations are needed on average for all the production of  $i$  to finally reach the final demand, is given by

$$U_i = 1 \times \frac{FD_i}{Y_i} + 2 \times \sum_{j=1}^n \theta_{ij} \frac{FD_j}{Y_i} + 3 \times \sum_{j=1}^n \sum_{k=1}^n \theta_{ij} \theta_{jk} \frac{FD_k}{Y_i} + 4 \times \sum_{j=1}^n \sum_{k=1}^n \sum_{l=1}^n \theta_{ij} \theta_{jk} \theta_{kl} \frac{FD_l}{Y_i} + \dots \quad (3)$$

where the first term of this expression represents the share of enterprise  $i$ 's turnover directly sold to final demand, the second term represents the share of enterprise  $i$ 's turnover that is sold to final demand after a first transformation by the other enterprises multiplied by the factor 2 (two transactions are needed to reach final demand), the third term represents the share of enterprise  $i$ 's turnover that is sold to final demand after two transformations by the other enterprises multiplied by the factor 3 (three transactions are needed to reach final demand),...

Antras et al. (2012) have shown that the vector of the upstreamness of all the enterprises in the network,  $U$ , is given by solving the equation

$$U = [I - \Delta]^{-1} \mathbf{1} \quad (4)$$

where  $\Delta$  is a  $(n \times n)$  squared matrix of the  $\delta_{ij}$  coefficients, given by  $F_{ij}/Y_i$ , the fraction of sales to

enterprise  $j$  in  $i$ 's turnover and  $\mathbf{1}$  is a vector of ones.

Alternatively, one can compute the downstreamness of the production of enterprise  $i$ , which represents how many transactions / transformation have been needed to produce  $i$ 's output. Do to so, one needs to consider the alternative decomposition of  $i$ 's turnover as the sum of all deliveries from other enterprises to enterprise  $i$  and of the value added of enterprise  $i$

$$Y_i = VA_i + \sum_{j=1}^n F_{ji} \quad (5)$$

or

$$Y_i = VA_i + \sum_{j=1}^n \delta_{ji} Y_j \quad (6)$$

Under this representation, the downstream of the production of enterprise  $i$  is given by

$$D_i = 1 \times \frac{VA_i}{Y_i} + 2 \times \sum_{j=1}^n \delta_{ji} \frac{VA_j}{Y_i} + 3 \times \sum_{k=1}^n \sum_{j=1}^n \delta_{kj} \delta_{ji} \frac{VA_k}{Y_i} + 4 \times \sum_{l=1}^n \sum_{k=1}^n \sum_{j=1}^n \delta_{lk} \delta_{kj} \delta_{ji} \frac{VA_l}{Y_i} + \dots \quad (7)$$

This expression represents the average number of transformation applied to the various amount of value added embodied in enterprise  $i$ 's output.

Alternatively, the vector of the downstreamness of all the enterprises in the network,  $D$ , is given by solving the equation

$$Down = [I - \Theta']^{-1} \mathbf{1} \quad (8)$$

where  $\Theta$  is a  $(n \times n)$  squared matrix of the  $\theta_{ij}$  coefficients, given by  $F_{ij}/Y_j$ .

Considering both the upstreamness and the downstreamness of the production of enterprise  $i$ , Dhyne and Duprez (2015) define the average length of the production chains in which firm  $i$  is involved or the average number of stages of the production chains to which enterprise  $i$  participates as

$$L_i = U_i + D_i - 1 \quad (9)$$

and the relative position of enterprise  $i$  in its production chain as

$$x_i = \frac{D_i - 0.5}{L_i} \quad (10)$$

As indicated by Dhyne and Duprez, the upstreamness and downstreamness measures should not only take into account the transformations made by Belgian firms but also those that take place abroad either before being imported or after being exported. To do so, the authors use the export and import transactions at the enterprise level by country of destination for exports and by country of origin for imports and the international linkages observed in the World Input-Output (WIOD) database to infer the international components of the value chain.

The matrix representation presented above are also useful to compute additional enterprise-level characteristics such as the exposure of a given firm to international trade. For instance, one can

estimate the value of the turnover of enterprise that is exported directly or indirectly as the value of the import content of enterprise  $i$ 's production.

The first measure is given by

$$TotX = [I - \Theta]^{-1} X \quad (11)$$

while the second is given by

$$TotM = [I - \Delta']^{-1} M \quad (12)$$

Table 5 summarizes the characteristics of the production network in 2011. On average, the total length of a production chain in Belgium is equal to 2.55 but it varies across sectors. The primary sector is the sector that is the most fragmented, followed by manufacturing, utilities and market services. On average, Belgian firms operate at an early stage of the production chain as upstreamness tends to be larger than downstreamness. The network representation also allows to better characterize the implication of Belgian firms in international trade. Based on their estimates, Dhyne and Duprez (2015) find that 81.9% of the firms are directly or indirectly involved in exports and almost all Belgian firms have access to imported inputs. This contrasts with the relatively small percentage of exporting or importing firms (4.9% for exporters, 8.7% for imports) observed in the economy. This high degree of integration in GVCs of Belgian firms implies that 8.4% of the turnover of a firm is on average exported. This share of exported turnover reaches 21.5 and 28.1% respectively for manufacturing and for the primary sector.

Table 5: Some characteristics of the Belgian production network in 2011 (averages).

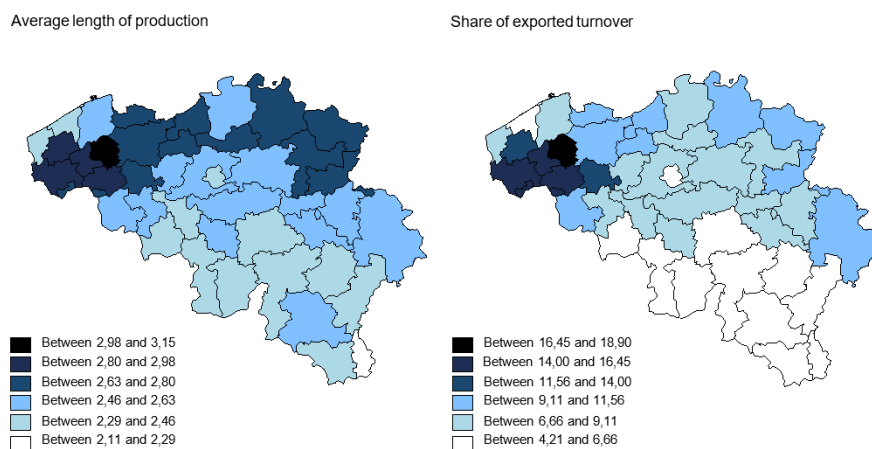
	(1)	(2)	(3)	(4)	(5)	(6)
Upstreamness	2.596	2.170	1.640	1.827	1.442	1.818
Downstreamness	1.981	1.914	1.998	1.667	1.590	1.735
Total length	3.577	3.084	2.638	2.494	2.032	2.553
Relative position	0.447	0.486	0.584	0.497	0.563	0.511
Share of (directly and indirectly) exported turnover	0.281	0.215	0.040	0.079	0.031	0.084
Share of (directly and indirectly) imported inputs in turnover	0.090	0.121	0.091	0.060	0.042	0.069
Share of direct exporters	0.056	0.191	0.012	0.045	0.014	0.049
Share of direct and indirect exporters	0.903	0.916	0.891	0.805	0.642	0.819
Share of direct importers	0.045	0.238	0.032	0.085	0.065	0.087
Share of direct and indirect importers	0.996	0.995	0.996	0.988	0.990	0.990

Notes : (1) Primary sector, (2) Manufacturing, (3) Electricity, gas and water supply + Construction, (4) Market services, (5) Non-market services, (6) Total economy.

Dhyne and Duprez (2015) not only document the heterogeneity in the degree of fragmentation across sectors but also across regions. Using the address of a firm (or of its main office for multi-plant firms), the authors have located each firm in an administrative unit (NUTS 3 level) and they have computed the average characteristics of a firm at the NUTS 3 level. This is represented in Figure 1. This allows to identify important regional differences in the organisation of production chains. It seems that production is more fragmented in Flanders and especially around the Kortrijk area. It also seems that firms are more exposed to foreign demand in Flanders as Flemish firms export

a larger fraction of their turnover.

Figure 1: Fragmentation of the production chains and participation to export activities by NUTS3



Finally, Dhyne and Duprez relate the degree of fragmentation of the production chains to (i) TFP and employment growth and (ii) to firm's survival during the crisis. They find that firms that operate in highly fragmented production chains tend to experience larger TFP growth and larger employment growth, especially when they operate close to the final consumer. Therefore, it seems that specialization in one narrow segment of the production chain is beneficial to the firm. However, there is a downside. Indeed, Dhyne and Duprez (2015) also find during the crisis, firms that were active in initial production phases were more at risk of disappearing than firms that operated close to the final consumer. Higher specialization in one particular phase of production is per se not protecting the firm, especially if it is specialized in one of the most downstream segment. To survive downstream, a firm has to keep improving its productivity as it can be easily replaced by domestic or foreign competitors.

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## Appendix A - who files annual accounts?

Enterprises in Belgium report annual accounts according to the following rules:<sup>12</sup>

1. All enterprises in Belgium report a full annual account, including foreign companies with a branch in Belgium or whose securities are officially listed in Belgium.
2. Abridged format of the annual accounts may be used by companies that do not exceed more than one of the following thresholds in the last two financial years for which the accounts are closed:
  - Annual average workforce: 50 FTEs
  - Turnover excl. VAT: 7,300,000 EUR
  - Balance sheet total: 3,650,000 EUR (pro rated if the financial year covers more or less than 12 months).

These enterprises file an annual account, but do not have to report employment, turnover, inputs and some other traits. All companies with workforce above 100 FTEs unambiguously have to file the full format. Criteria for parents and subsidiaries and group members are calculated on a consolidated basis.

3. Commercial corporations or civil corporations in the following form of a commercial corporation do not have to report annual accounts:
  - Public institutions performing a corporate function of a commercial, financial or industrial nature
  - Insurance companies, also mutual funds
  - Investment funds
4. Belgian enterprises that fulfill any of the following properties do not have to file annual accounts:
  - self-employed workers
  - Small and cooperative companies with unlimited liability

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<sup>12</sup>See [here](#) for the complete set of rules.

- Large companies with unlimited liability if none of the members is a legal entity
- Agricultural partnerships
- Hospitals (unless in a form of trading company ltd)
- Health insurance funds
- Professional associations
- Schools and higher education institutions



# Appendix B - Growth rates of sectoral outputs and transaction aggregates

We break down the time series of the growth rates of turnover and transactions aggregates of each NACE 2-digit sector.

Figure 2: Growth rates of turnover and aggregate sales in NACE Section A (Agriculture, Forestry and Fishery) and NACE Section B (Extraction).

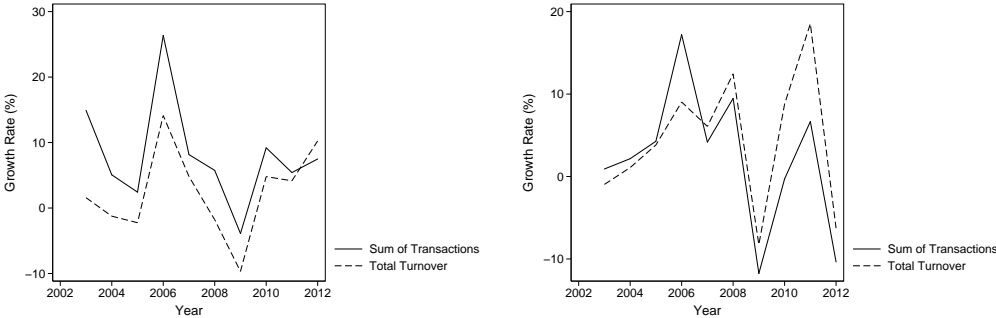


Figure 3: Growth rates of turnover and aggregate sales in Manufacturing: NACE Sections C (Manufacturing) and F (Construction).

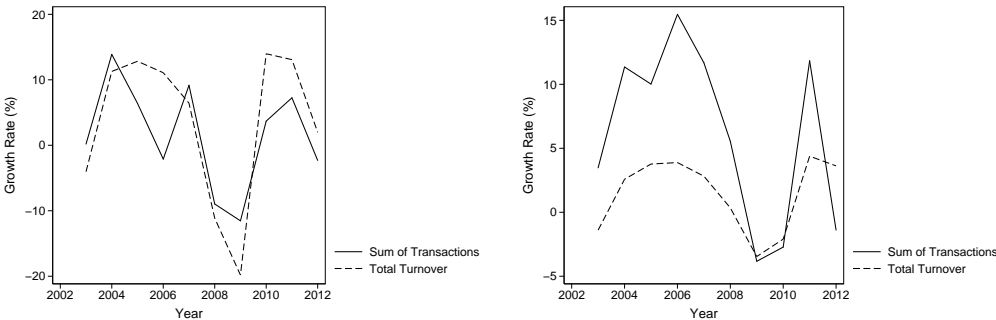


Figure 4: Growth rates of turnover and aggregate sales in Utilities: NACE sections D (Production and distribution of Gas, Electricity and Steam) and E (Distribution of Water and Sanitizing)

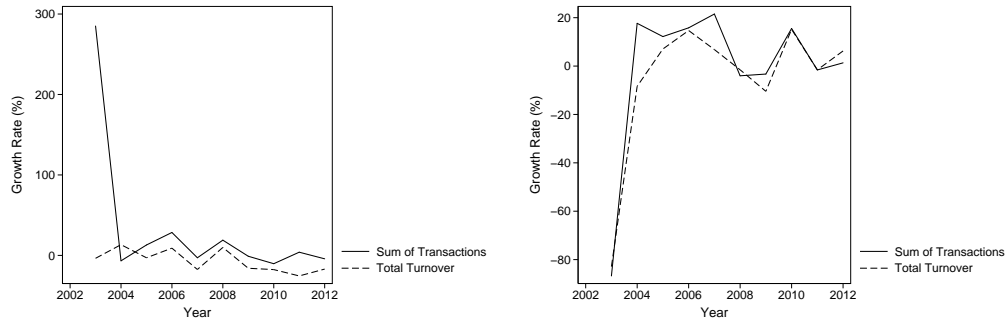


Figure 5: Growth rates of turnover and aggregate sales in Services: Sectors G to L.

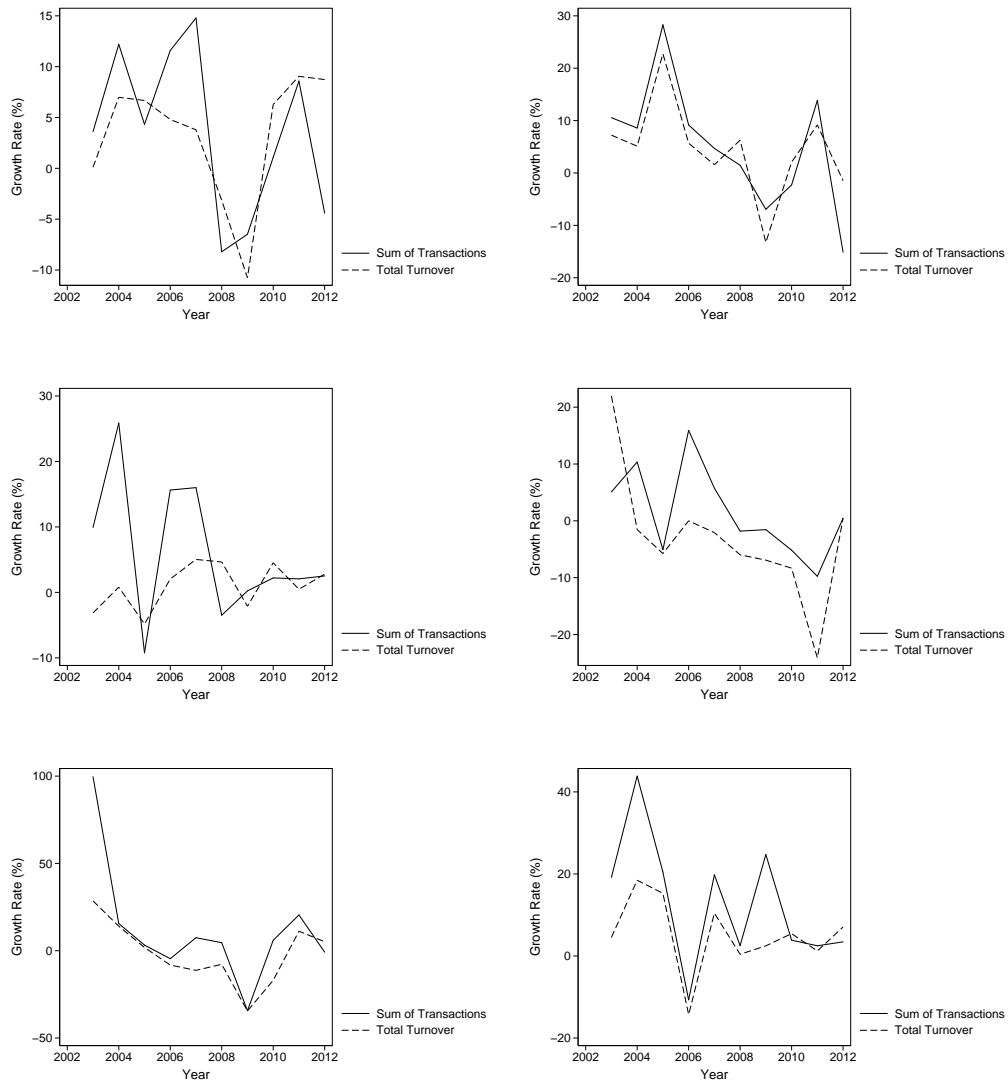
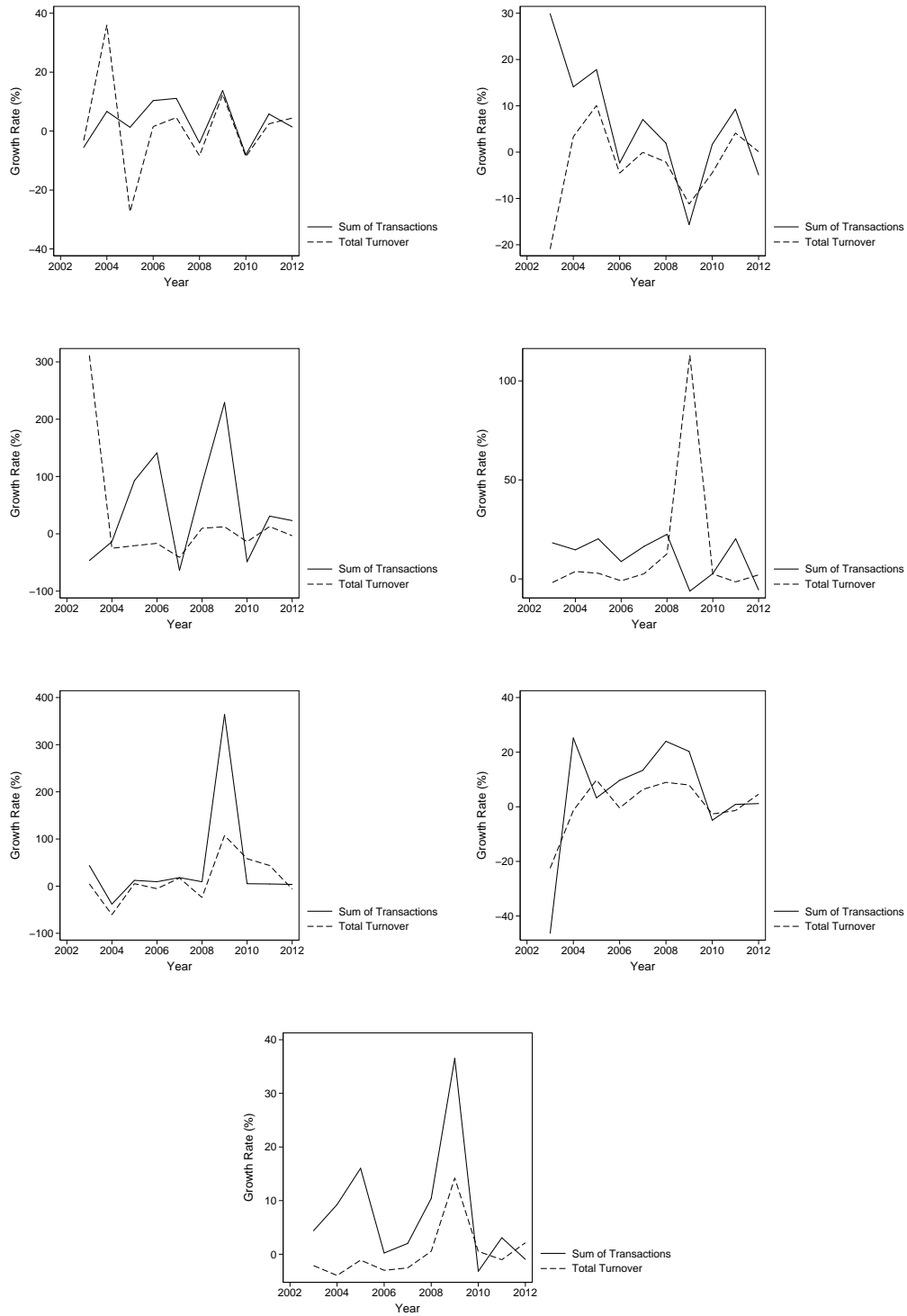


Figure 6: Growth rates of turnover and aggregate sales in Services: Remaining Sectors.



## Appendix C - Comparison VAT listings, annual accounts and National Accounts.

Table 6: Comparison enterprise turnover across databases (in billions of euro).

Year	Total transactions	Total turnover	National Accounts
2002	191	550	556
2003	195	552	561
2004	217	617	598
2005	233	665	628
2006	252	732	675
2007	279	775	716
2008	268	754	751
2009	251	674	692
2010	251	710	750
2011	270	765	808
2012	260	783	820

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Registered office: boulevard de Berlaimont 14 – BE-1000 Brussels  
[www.nbb.be](http://www.nbb.be)

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Layout: Analysis and Research Group  
Cover: NBB AG – Prepress & Image

Published in October 2015