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The Belgian business-to-business transactions dataset 2002-2021

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Abstract

This paper provides an updated overview of the network of Belgian business-to-business transactions from 2002 to 2021, building on the previous vintage of the dataset which covered 2002-2014. Leveraging data from VAT client lists, we establish a comprehensive and cohesive database detailing the values of transactions between non-financial corporations in Belgium. This database encompasses all sectors, ranging from primary industries, manufacturing and utilities to construction, business services and other services. With its unmatched breadth at the level of individual firms and panel dimensionality, the dataset facilitates diverse research inquiries in areas such as industrial organisation, international trade, and network theory. To give readers a clearer picture, this paper also highlights several key insights about the Belgian network. Due to the confidential nature of the data, access to this dataset is restricted to NBB staff members.

Keywords: Firm-Level Analysis, networks, VAT transactions, firm-to-firm linkages.

JEL Codes: C67, C81, L23.

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Non-technical summary

Over the past decade, the growing accessibility of microdata has propelled firm-level analysis to the forefront, making it more feasible than ever. Drawing from raw data from annual VAT client lists submitted to the Belgian tax authorities, we now have access to transaction-level data, ushering in a new era for both empirical exploration and foundational theories in areas such as firm theory, international trade and network theory. As far as we are aware, the Belgian transaction dataset stands out due to its extensive business-to-business coverage, its panel structure, and the depth of information it provides on both buyers and suppliers.

This paper presents the latest vintage of the National Bank of Belgium's (NBB) business-to-business (B2B) transactions database, highlights its potential research applications, and provides an in-depth account of its development. The updated database spans the years 2002-2021 and, unlike its predecessor, now comprises exclusively transactions where both the supplier and buyer are non-financial corporations. Nevertheless, its scope remains extensive, capturing transactions across diverse sectors — from primary industries, manufacturing and utilities, to construction, business services and other services. The final dataset is an unbalanced panel consisting of 215.8 million yearly business-to-business transaction records in euros, offering a thorough representation of transactions between non-financial corporations.

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INTRODUCTION

Over the past decade, the growing accessibility of microdata has propelled firm-level analysis to the forefront, making it more feasible than ever. Drawing from raw data from annual VAT client lists submitted to the Belgian tax authorities, we now have access to transaction-level data, ushering in a new era for both empirical exploration and foundational theories in areas such as firm theory, international trade and network theory. As far as we are aware, the Belgian transaction dataset stands out due to its extensive business-to-business coverage, its panel structure, and the depth of information it provides on both buyers and suppliers.

A first vintage of the Belgian dataset, covering the 2002-2014 period, was released in 2015 and is described in Dhyne *et al*. (2015). This dataset has already been used in a number of papers, which explore, among other issues, the (in)direct exposure of Belgian businesses to imports and exports (Dhyne, Duprez, 2017, Dhyne *et al*., 2021, Dhyne *et al*., 2023); the heterogeneity of firm size in production networks (Bernard *et al*., 2022); the responses of firms and the impacts on workers of foreign demand shocks to domestic production networks (Dhyne *et al*., 2022); raising productivity across the supply chains of superstar firms (Amiti *et al*., 2023); the importance of input entry and exit in driving economic growth (Baqaee *et al*., 2023); the potential bias when using a common-scale intermediate inputs price deflator in the estimation of productivity (Cherchye *et al*., 2022); and the formation of production networks (Dhyne *et al*., forthcoming).

This paper presents the latest vintage of the National Bank of Belgium's (NBB) business-to-business (B2B) transactions database, highlights its potential research applications, and provides an in-depth account of its development. The updated database spans the years 2002-2021 and, unlike its predecessor, now comprises exclusively transactions where both the supplier and buyer are non-financial corporations. Nevertheless, its scope remains extensive, capturing transactions across diverse sectors — from primary industries, manufacturing and utilities, to construction, business services and other services. The final dataset is an unbalanced panel consisting of 215.8 million yearly business-to-business transaction records in euros, offering a thorough representation of transactions between non-financial corporations.

Due to the confidential nature of the data, access to this dataset is restricted to NBB staff members. For further information on research projects making use of NBB B2B data, please contact the NBB.

NBB B2B data can be merged with business-specific information from several other sources. For instance:

- the NBB's annual business accounts, which offers insight into value added, employment, wages, capital stock and several financial variables;
- the National Accounts Institute (NAI) register, which provides data regarding the sector and location of a firm;
- the NBB's international trade statistics database, which includes details on exports and imports;
- the VAT returns submitted to the Belgian tax administration for a given year, which provide information on turnover, input consumption, and investment;
- the National Social Security Office database on social security declarations, which provides data on employment and wages.

The structure of the paper is as follows. In Section 1, we describe the various data sources used. In Section 2, we delve into the processes and methods of inquiry applied and the decisions made while developing the final dataset. In Section 3, making use of the dataset itself, we present several stylised facts that illustrate the organisation of the production network in Belgium, drawing insights from this distinct element of the data.

1. DATA

As mentioned above, the objective of this paper is to present a unique dataset that provides information on the organisation of the production network in Belgium. The NBB B2B transactions dataset not only covers almost all bilateral business relationships between Belgian firms, but also records the value of transactions in euros. The final dataset contains more than 960,000 businesses, and more than 219 million transactions over a 20-year period. It is built from four raw data sources: the annual VAT client lists sent to the Belgian tax authorities, VAT returns submitted to the Belgian tax authorities, the NBB's annual business accounts, and the NAI register. The resulting dataset is a network representation of the Belgian economy, covering the entire Belgian private sector, with all industries included. The final dataset contains five main variables: (i) the reference year, (ii) the VAT identification number of the supplier, (iii) the VAT identification number of the buyer, (iv) the gross annual transaction value from annual VAT client lists, and (v) the corrected transaction value, where necessary (see section 2.2 below).

1.1 VAT CLIENT LISTS

The main source of information for the NBB B2B transactions dataset is the annual VAT client lists from Belgian businesses for the period 2002 to 2021. This raw dataset contains 341.9 million observations from the twenty years covered and includes the annual transaction value (in euros) between two businesses. Every business registered and liable for VAT must file an annual list of its VAT-liable Belgian customers with the tax authorities. Only filers that are fully exempt from VAT under Article 44 of the Belgian VAT Code do not have to submit such a list. In the case of multiple plants or establishments under the same VAT identification number, the list is presented in the form of a single file for that number. The list contains the reference year of the return, the VAT number of the supplier (the business submitting the list), the VAT number of each buyer, the annual transaction value of the supplier vis-à-vis each buyer, and the amount of VAT applied to this annual aggregate. Annual transaction values are calculated based on all invoices sent to a given buyer in a given calendar year.

All amounts must be declared by the supplier, even if no VAT was due for any reason, when the annual transaction value with a given buyer is greater than or equal to €250. In the event of a credit note or a negative adjustment, the amount must be shown with a negative sign, even if the amount is less than €250. Each business must submit its list by 31 March of the year following the reference year, using the online INTERVAT application. Administrative penalties are levied for an incorrect or incomplete list, to guarantee the quality of the data collected.

It should be noted that the data we use come from the original client lists submitted to the VAT authorities. These data do not include revisions or corrections made by the tax authorities during auditing or late returns. We therefore also provide a corrected transaction value, the methodology for which is explained below. We also apply certain selection criteria using three other datasets, which we will now present.

1.2 VAT RETURNS

We use VAT returns as our second source of information. These contain information on a firm's total sales and purchases, including domestic and international transactions and sales to final consumers, and must be submitted online via INTERVAT by all VAT-registered businesses. In the case of multiple plants or establishments under one VAT number, the return is submitted as a single file for that number. Certain businesses are exempt from the obligation to file VAT returns: (i) micro-enterprises with an annual turnover of less than €5 580 per calendar year (however, they are obliged

to submit annual VAT client lists) and (ii) VAT-registered businesses that are exempt from VAT (they do not have to submit annual VAT client lists either, and in turn cannot recover VAT). Almost all such exempt entities are self-employed persons. Each business must submit its return by the twentieth day of the month following the reporting period, either monthly or quarterly, depending upon certain thresholds.[1] Businesses with no turnover relating to the reporting period must file a "nil return".

The submission of these returns is compulsory, and they enable the tax authorities to determine the amount of value added tax due based on sales and purchases data contained in the returns. Businesses are then required to pay the balance to the authorities (or are reimbursed). The returns show the value of sales excluding VAT and the VAT invoiced, which must be paid to the tax authorities. In addition to sales, VAT returns also record purchases of goods, services and capital goods (and the deductible VAT associated with these purchases). They are extremely reliable for three reasons. Firstly, a fine can be levied for failure to comply with the reporting obligation. Secondly, the tax authorities can easily check the consistency between the amount excluding VAT and the amount of VAT. Lastly, as businesses are also required to submit a client list (see above), it is possible to cross-reference sales and purchases. Given their quality and integrity, VAT data are an essential source of microdata for the production of national accounts statistics.

1.3 ANNUAL BUSINESS ACCOUNTS (BALANCE SHEETS)

The annual business accounts provide an overview of a firm's financial position, detailing its assets and liabilities, as well as its workforce (payroll and employment) and, for large firms, turnover and intermediate inputs.

1.4 NAI REGISTER

The register is used by the NAI to compile official statistics for Belgium. Each VAT number/year pairing is assigned an institutional sector (S.11: non-financial corporations, S.12: financial corporations, S.13: general government, S.14: the self-employed (households), S15: non-profit institutions serving households), an NIS code for the location of the activity, and a NACE code (NACE rev. 2, five digits) for the sector of activity.

2. SETTING UP THE NBB B2B TRANSACTIONS DATABASE

As mentioned above, the latest vintage of the NBB B2B database extends the observation period to 2021. However, it is not a mere extension of the 2002-2014 database presented in Dhyne, Magerman, Rubinova (2015), as it departs from the first vintage in terms of coverage and data cleaning.

2.1 SAMPLE SELECTION

The first vintage of NBB B2B covered all bilateral transactions involving Belgian VAT-registered businesses. To comply with new privacy protection rules, transactions involving self-employed persons as suppliers or buyers were excluded from the new vintage. We also decided to remove

[1] Businesses with an annual turnover (excluding VAT) of more than €2.5 million are required to complete a monthly return (for deliveries of fraud sensitive goods and services, the threshold is €250 000). Annual turnover is based on sales over the preceding twelve months.

transactions involving financial institutions, public institutions, and non-profit associations from the production network. As a result, the new dataset covers only bilateral transactions between Belgian non-financial corporations. The classification of VAT numbers into one of these categories follows the NAI register (see above). In addition, only transactions equal to or greater than €250 are retained, as this is the statutory threshold for mandatory reporting. This selection procedure leaves 215.8 million observations in the final dataset, out of the 341.9 million observations in the annual VAT client lists. This represents 63% of the number of transactions and 84% of the total amount in euros in the VAT client lists.

The dataset covers transactions between non-financial corporations in all sectors, from agriculture, manufacturing, public services and construction to business services and other services. This gives us a complete overview of transactions between non-financial corporations.

2.2 DATA CLEANSING

The raw data from the VAT client lists do not include any revisions or corrections made by the tax authorities during auditing, or any late returns. To detect outliers, we checked the consistency of individual transactions with the total amounts of sales or purchases declared by businesses in their VAT returns or annual accounts. It should be noted that the raw data are always retained in the database. Any corrected amounts are, therefore, an additional variable.

To check the quality of the individual files, we merged the B2B client lists with both the annual VAT returns and annual accounts of each business, which provided us with total annual sales, total consumption of inputs (materials or services) and total capital expenditure. Across the entire database, 96.7% of observations, or 208.7 million transaction flows, were found to be consistent for both buyers and suppliers. For the remaining 3.3% (7.1 million transaction flows), corrections to individual flows and/or totals had to be applied. As we shall see, in most cases the total was corrected, while individual flows remained unchanged. The detailed methodology and corrections applied are set out in detail below.

We considered that the B2B sales of a business were consistent with its total sales if the sum of the sales declared by firm *i* in the B2B client list was less than or equal to the total sales declared by that firm, either in its VAT return or in its annual accounts,[2] with a tolerance of 10%. Similarly, we considered a firm's expenditure to be consistent if the sum of its purchases was less than the sum of its material inputs and consumption of services reported in the VAT return or annual accounts and its total purchases of capital goods reported in the VAT return, plus 10%. In sum, a firm's B2B sales or B2B purchases are consistent if:

$$\sum_{j=1}^{n_i} sales_{ij;t} \leq 1.1 \underbrace{Max\{Sales\_VAT_{i;t}; Sales\_AC_{i;t}\}}_{tot\_sales_{i;t}}$$

and

$$\sum_{i=1}^{n_j} sales_{ij;t} \leq 1.1 \underbrace{(Max\{Inputs\_VAT_{j;t}; Inputs\_AC_{j;t}\} + Invest\_VAT_{j;t})}_{tot\_purchases_{j;t}}$$

where:

- $sales_{ij}$ represents the sales of firm i to firm *j*;
- n_i represents the number of Belgian B2B clients of firm *i*;
- n_j represents the number of Belgian B2B suppliers of firm *j*;
- *Sales_VAT* represents the total sales reported in the VAT returns;

[2] If sales are declared in both the VAT returns and the annual accounts, the largest value is used.

- *Sales_AC* represents the total sales reported in the annual accounts;
- *Inputs_VAT* represents the total input consumption (materials and services) reported in the VAT returns;
- *Inputs_AC* represents the total input consumption (materials and services) reported in the annual accounts;
- *Invest_VAT* represents the total purchases of capital goods reported in the VAT returns;
- *t* is the time index.

2.3 CORRECTION OF INCONSISTENT TRANSACTION FLOWS

A series of step-by-step corrections were made to achieve 100% consistency between B2B transactions and totals, on both the buyer and supplier sides. Each step is clearly identified in the dataset.

Step 1: Correcting outliers in the totals

To control for outliers in the totals, we compared a firm's totals in year *t* to the average of its totals in years *t*-2, *t*-1, t+1, and t+2, where available. If the total observed was less than 85% of the corresponding moving average and if the transactions observed in the network were less than 150% of this moving average, then the total for year *t* was replaced by the sum of the transactions observed in the B2B network or

$$New\_tot\_sales_{i;t} = \sum_{j=1}^{n_i} sales_{ij;t} \quad if \quad tot\_sales_{i;t} < 0.85\,\overline{tot\_sales}_{i;t} \;\; and \;\; \sum_{j=1}^{n_j} sales_{ij;t} \leq 1.5\,\overline{tot\_sales}_{i;t}$$

and

$$New\_tot\_purchases_{j;t} = \sum_{i=1}^{n_j} sales_{ij;t} \quad if \quad tot\_purchases_{j;t} < 0.85\,\overline{tot\_purchases}_{j;t} \;\; and \;\; \sum_{i=1}^{n_i} sales_{ij;t} \leq 1.5\,\overline{tot\_purchases}_{j;t}$$

After correcting the totals, consistency was reassessed and established for a further 2.4 million transactions (one third of inconsistent flows).

Steps 2 to 7: Correcting transactions if larger than total sales

If a transaction between *i* and *j* is greater than 1.1 times the total sales of firm *i,* the value of the flow is divided by 10, i.e.

$$new\_sales_{ij;t} = 0.1\, sales_{ij;t} \quad if \; sales_{ij;t} > 1.1 \; tot\_sales_{ij}$$

After each iteration, consistency was checked against the new values and consistent flows were frozen. After six iterations, no individual flow was found to be greater than 1.1 of total sales for firm *i*. These steps resulted in the correction of 1.3 million transactions.

Steps 8 to 15: Correcting transactions using moving averages

By calculating the average sales between firm *i* and firm *j* in *t*-2, *t*-1, *t*+1, *t*+2 and the average total sales of firm *i* over the same period, we adjusted the individual transactions using the following formula:

For step 8:

$$new\_sales_{ij} = \frac{\overline{tot\_sales}_{i;t}}{tot\_sales_{i;t}} sales_{ij} \quad if\ sales_{ij;t} > 10\ \overline{sales}_{ij;t}$$

For step 9:

$$new\_sales_{ij} = \frac{\overline{tot\_sales}_{i;t}}{tot\_sales_{i;t}} sales_{ij} \quad if\ sales_{ij;t} > 5\ \overline{sales}_{ij;t}\ \ and\ sales_{ij;t} \geq 1{,}000{,}000$$

For step 10:

$$new\_sales_{ij} = \frac{\overline{tot\_sales}_{i;t}}{tot\_sales_{i;t}} sales_{ij} \quad if\ sales_{ij;t} > \overline{sales}_{ij;t}$$

For step 11:

$$new\_sales_{ij} = \frac{\overline{tot\_sales}_{i;t}}{tot\_sales_{i;t}} sales_{ij} \quad if\ \frac{\overline{tot\_sales}_{i;t}}{tot\_sales_{i;t}} < 0.5$$

Between each step, consistency was reassessed on the basis of new implicit sales. These four additional steps resulted in the correction of 0.7 million flows. Steps 12 to 15 use the same correction formulas but total purchases instead of total sales. These additional steps resulted in the correction of 0.6 million flows.

Step16-17: Correcting total sales if all flows are consistent from the buyer side and total purchases if all flows are consistent from the supplier side

If the B2B sales of firm *i* are not consistent but the purchases are consistent for all customers, the total sales of firm *i* were adjusted to introduce consistency.

$$new\_tot\_sales_{i;t} = \sum_{j=1}^{n_i} sales_{ij;t} \quad if \quad \sum_{k=1}^{n_j} sales_{kj;t} < 1.1\ tot\_purchases_{j;t}\ \ \forall\ j = 1, \dots, n_i$$

Similarly, the total purchases of firm *j* were adjusted to introduce consistency if the sales of all suppliers were consistent:

$$new\_tot\_purchases_{j;t} = \sum_{i=1}^{n_j} sales_{ij;t} \quad if \quad \sum_{k=1}^{n_i} sales_{ik;t} < 1.1\ tot\_sales_{i;t}\ \ \forall\ i = 1, \dots, n_j$$

1 million flows were made consistent via these last two steps.

Step18: Adjusting totals of the remaining flows to introduce consistency

A final step introduced consistency by adjusting total sales and/or total purchases of the remaining 1 million inconsistent flows.

By applying the above steps, all flows and totals were rendered consistent. Complete consistency was achieved by correcting 0.3% of all individual flows. The total sales of 0.4% of firms were corrected while the total purchases of 3.1% of firms were corrected.

3. STYLISED FACTS

Now we present several stylised facts that illustrate the organisation of the production network in Belgium, drawing insights from this distinct element of the data.

3.1 THE NUMBER OF DOMESTIC B2B TRANSACTIONS HAS BEEN STEADILY GROWING

The number of transactions in the NBB B2B dataset has grown steadily, at an average rate of 3% over the observed period: from 7.8 million in 2002 to 13.9 million in 2021 (see Figure 1). The increase is seen every year, with two notable exceptions: the financial crisis of 2008 and the COVID-19 crisis of 2020. The total value of transactions rose from €237 billion in 2002 to €562 billion in 2021. This is more than twice the GDP of the non-financial corporate sector, which was €274 billion in 2021.

Figure 1. Number of transactions in the NBB B2B dataset (in millions)

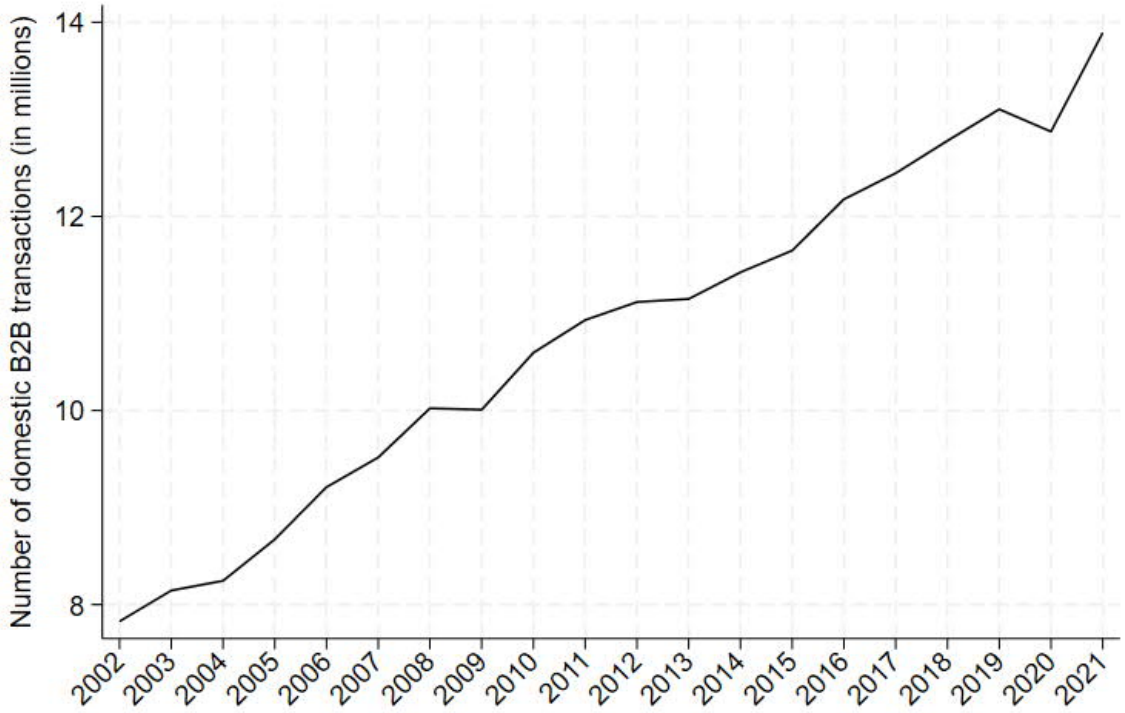
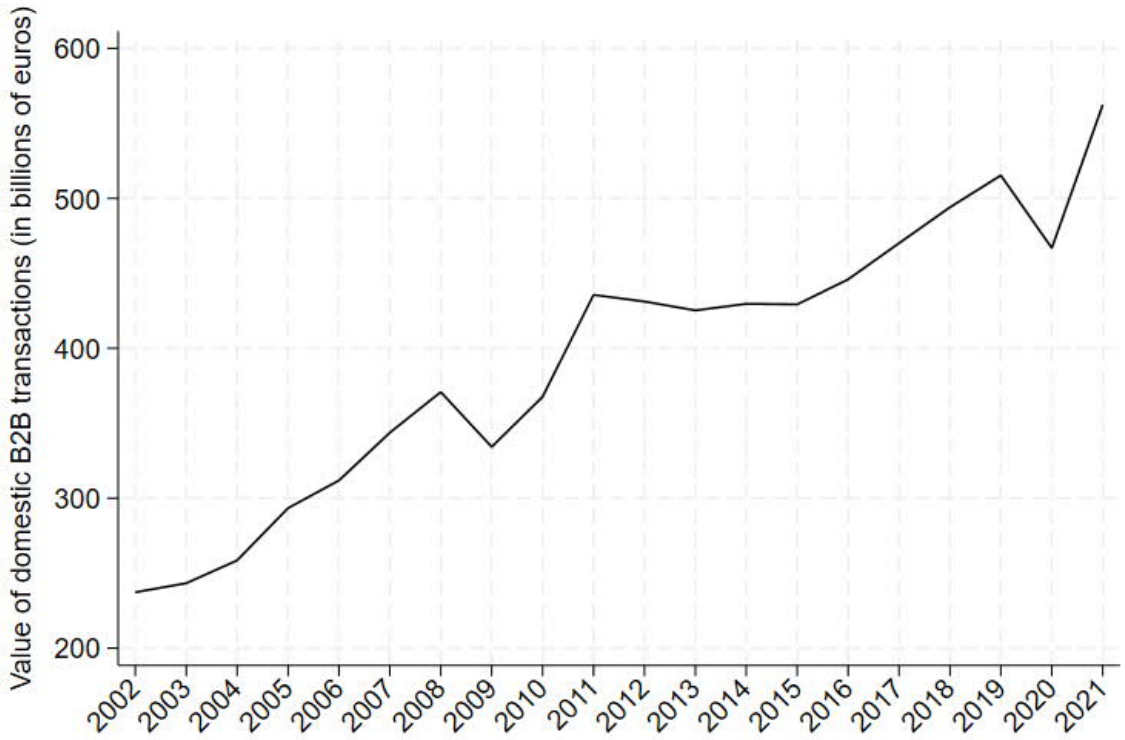


Figure 2. Value of transactions in the NBB B2B dataset (in euro billions)



3.2 THE NETWORK IS HIGHLY SKEWED

The average value of the transactions recorded in the dataset is €36 456, but the distribution is clearly skewed, with a standard deviation of €3.2 million (see Table 1). It should be noted that the threshold for reporting annual transactions in VAT client lists is €250. The number of buyers for each company and, similarly, the number of its suppliers, once again show a highly asymmetric distribution. The average number of a firm's business customers in any given year is 36, with a standard deviation of 336. Even up to the 90th percentile, a company has only 63 customers in the Belgian economy. The number of suppliers is less skewed: the mean is 26, with a standard deviation of 55 and a median of 12.

Table 1. Summary statistics

			Percentiles				
	Mean	SD	10th	25th	50th	75th	90th
Transactions (in euro)	36456	3178858	358	613	1607	5751	24131
Number of buyers	36	336	1	2	5	17	63
Number of domestic suppliers	26	55	2	5	12	29	58

The main suppliers and buyers play an important role in the network. For example, 63% of domestic network sales are to the top buyer in 2019, and 87% of domestic network sales are to the top five buyers (see Figure 3). 49% of domestic network inputs are purchases from the top supplier, and 84% of domestic network inputs are purchases from the top five suppliers (see Figure 4).

Figure 3. Percentage of sales to top buyers (2019)

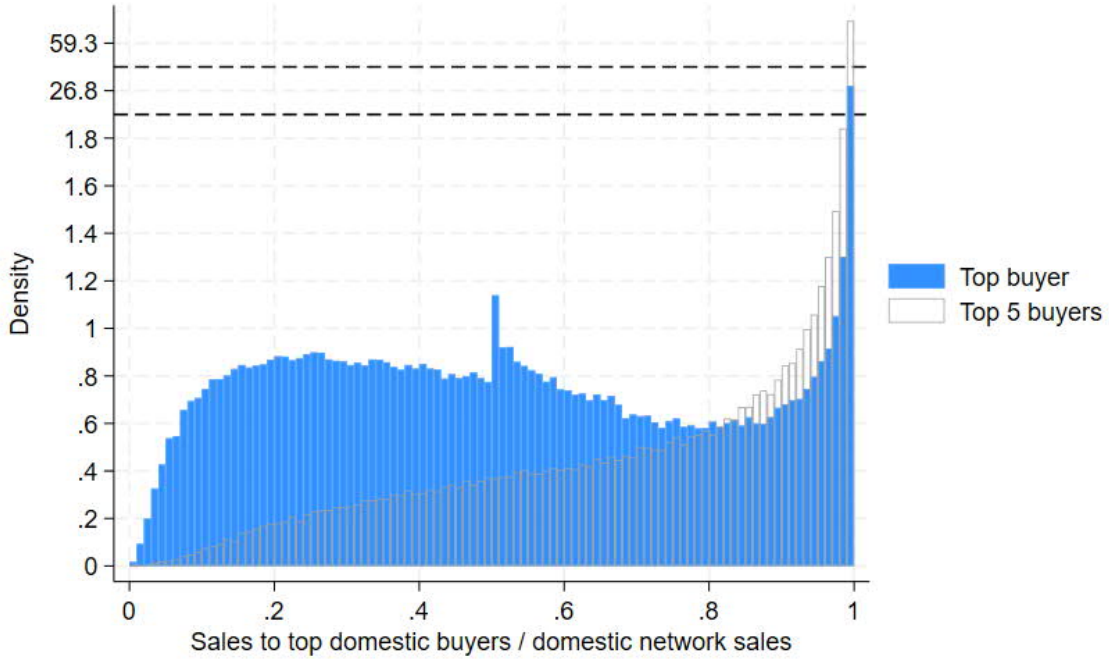
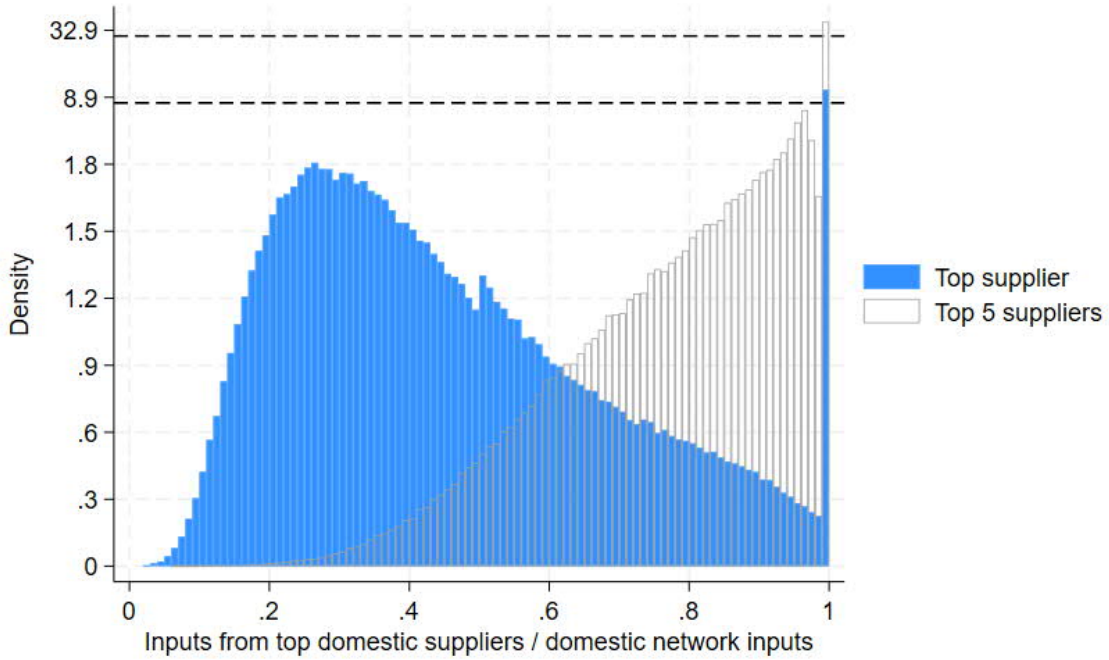


Figure 4. Percentage of expenditure on top suppliers

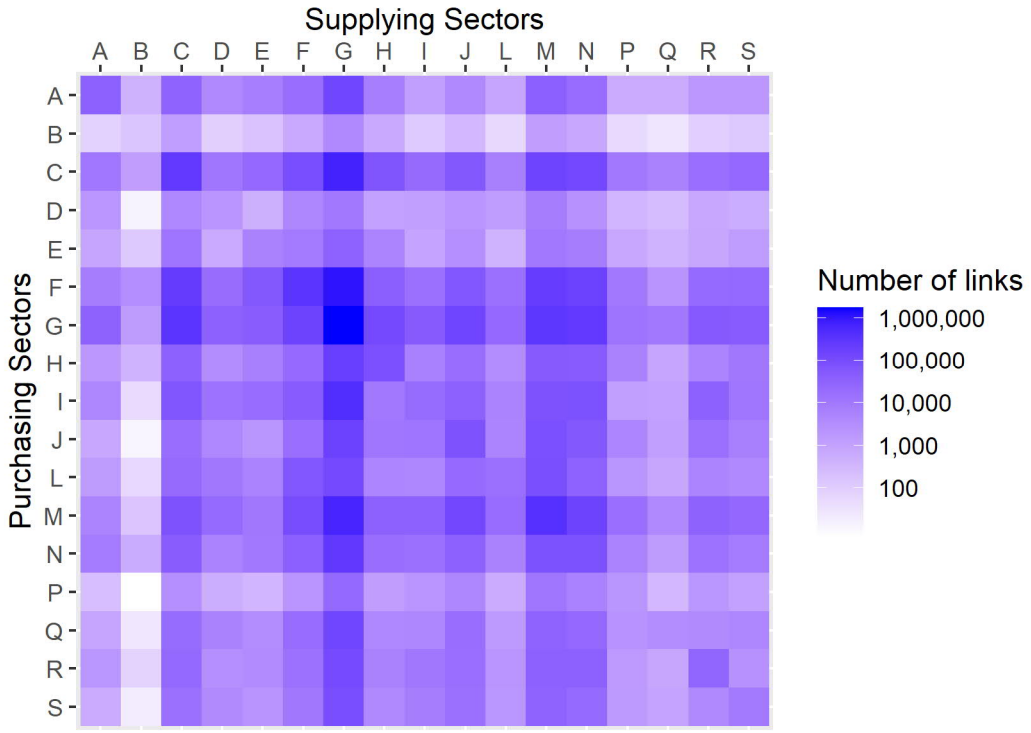


3.3 WHOLESALERS AND RETAILERS ARE KEY NODES IN THE NETWORK

The trade sector, whether wholesale or retail, plays a crucial role in the production network (see Figure 5). The number of transactions is highest in this sector, for both suppliers and buyers. The picture (not shown here) is similar in terms of transaction values. Of course, purchases or sales in the trade sector include the value of goods and services bought or sold. This is the main difference with the input-output table, which describes the value of transactions between sectors. In these

tables, the output of the trade sector corresponds to the services it provides by selling goods to consumers and other businesses. It is not the value of the goods and services sold, but rather the value added by sales services.

Figure 5. Number of transactions between sectors



Note: Agriculture, forestry and fishing (A), Mining and quarrying (B), Manufacturing (C), Electricity, gas, steam and air conditioning supply (D), Water supply; sewerage; waste management and remediation activities (E), Construction (F), Wholesale and retail trade (G), Transportation and storage (H), Accommodation and food service activities (I), Information and communication (J), Financial and insurance activities (K), Real estate activities (L), Professional, scientific and technical activities (M), Administrative and support service activities (N), Public administration and defence; compulsory social security (O), Education (P), Human health and social work activities (Q), Arts, entertainment and recreation (R), Other service activities (S).

4. TRADE IS MOSTLY LOCAL

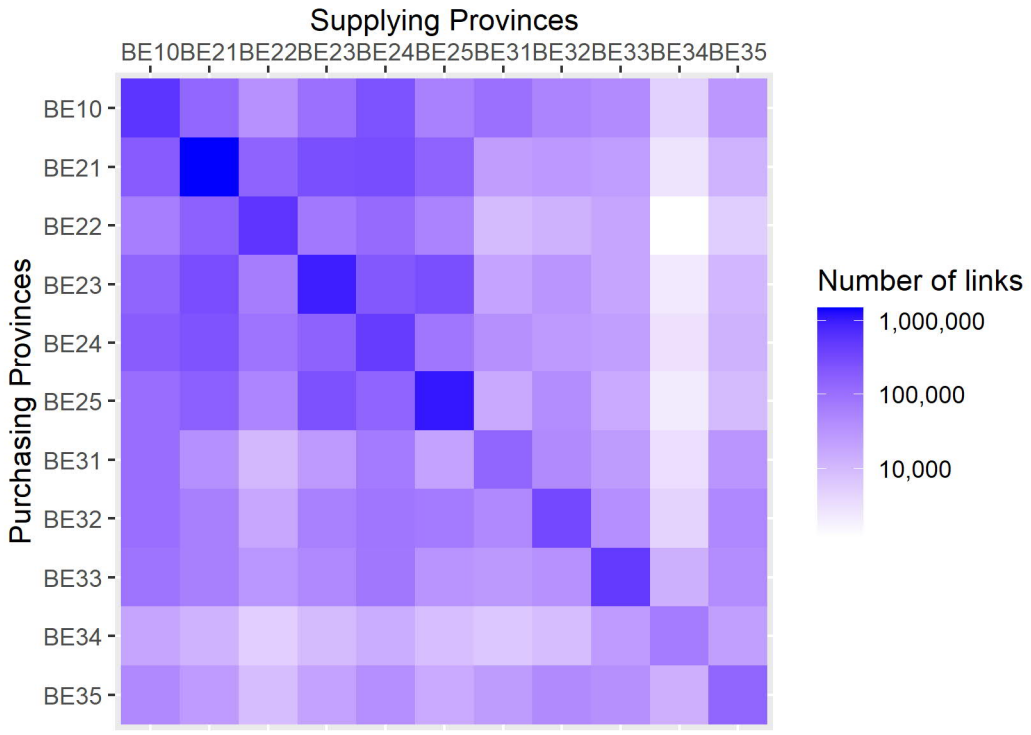
Most transactions (47.5%) involve two trading partners located in the same NUTS2 region (see Figure 6) (43.3% in value terms). Belgium provides an interesting setting for the study of gravity, as trade frictions are expected to be very low. Belgium is a very small country,3 with the longest distance between two cities being 277 km. It is also very densely populated, with more than half a million businesses in a geographical area of no more than 30 000 km2. Nevertheless, the number of links is much higher within NUTS2 than between NUTS2.[4]

The NUTS3 map in Figure 7 also shows that the capital, Brussels, and the district of Antwerp record the highest number of flows.

3 Moreover, Belgium has a very dense transportation infrastructure (155 000 km of roads, 3 500 km of railways and 2 000 km of waterways) and no natural geographical obstacles such as lakes or mountains that could hamper trade between firms.

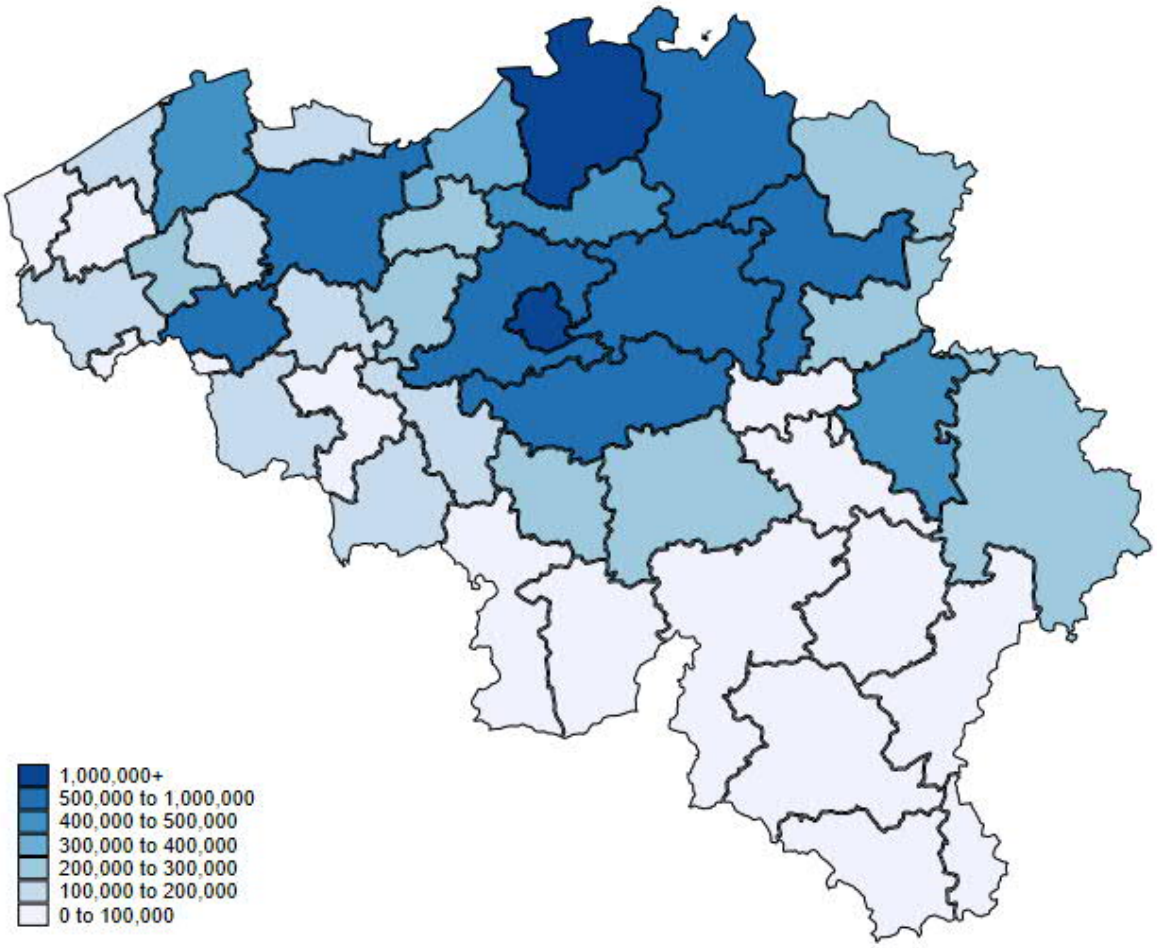
4 We found a similar pattern for values.

Figure 6. Number of transactions between NUTS2 (2019)



Note: Brussels (10), Antwerp (21), Limburg (22), East Flanders (23), Flemish Brabant (24), West Flanders (25), Walloon Brabant (31), Hainaut (32), Liège (33), Luxembourg (34), Namur (35).

Figure 7. Number of incoming transactions (2019)



5. THE NETWORK EXHIBITS A HIGH CHURN RATE

The one-year survival rate, i.e., the percentage of links from year *t* that still exist in year *t*+1, is less than 50% each year (see Figure 8). The links that do not survive are relatively small, as shown by a much higher survival rate when weighted by transaction value. Interestingly, the percentage of long-lasting relationships remains relatively high and increases over time (see Figure 9). At the end of the sample period, more than 25% of the transactions carried out in year *t* survive into years *t*+1, *t*+2 ... and *t*+5. Once again, this survival rate is much higher for large transactions.

Figure 8. Transaction survival rate on a short-run horizon
(proportion of links in year *t* that survive to year *t*+1)

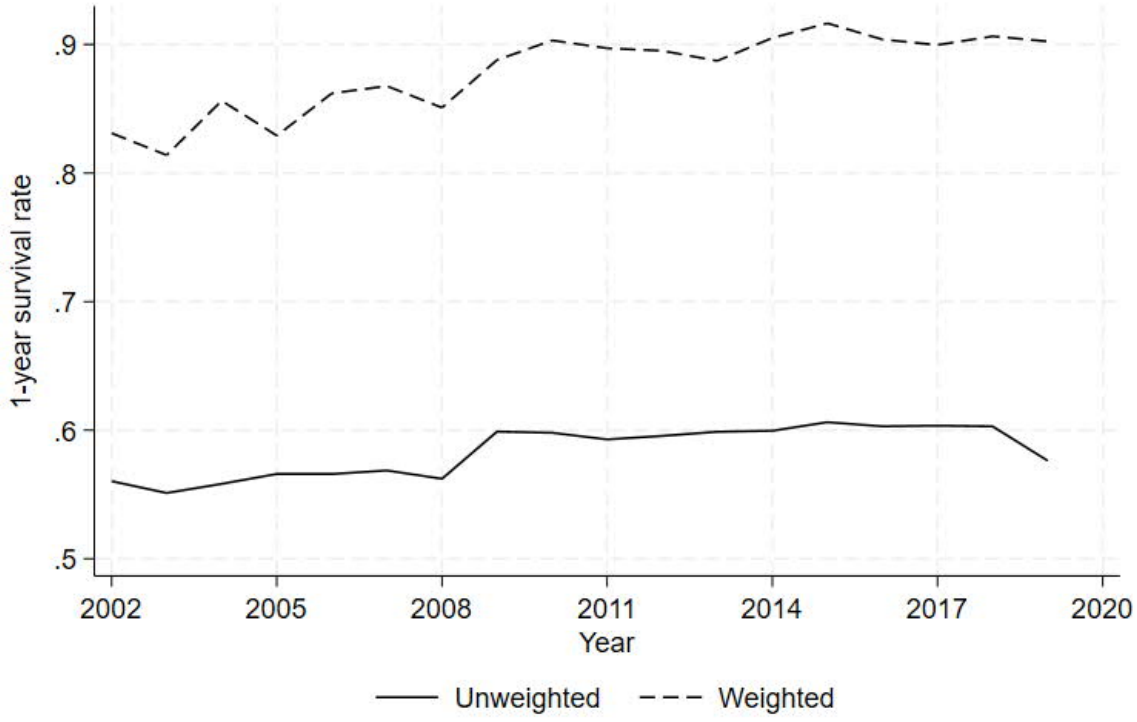
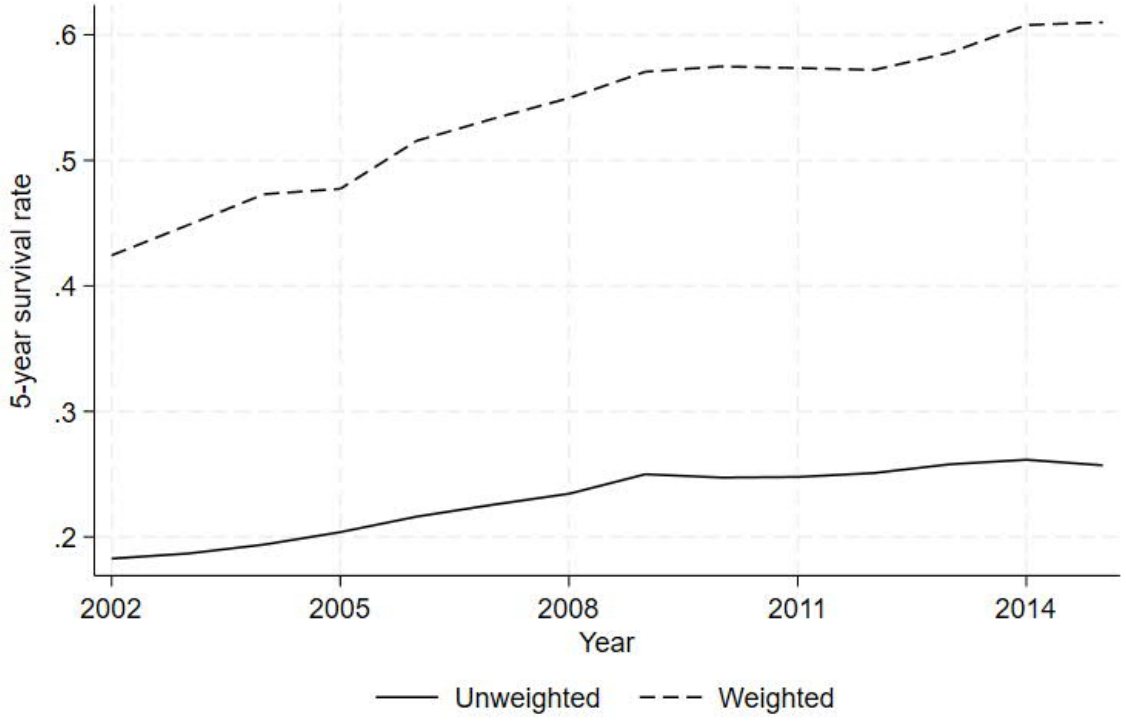


Figure 9. Transaction survival rate on a longer-run horizon
(proportion of links in year *t* that survive in year *t*+1 through to year *t*+5)



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