Uncertainty spillovers in Brazilian industry

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April 11, 2018

Abstract

This work aims to calculate uncertainty spillovers between sectors of the Brazilian transformation industry. We gathered monthly data from January 2006 to December 2017 on value added from *Confederação Nacional da Indústria* and employed the methodology of spillover indices from Diebold and Yilmaz (2009).

Keywords: Uncertainty, spillovers, Emerging markets.

JEL Codes: E32, E44, E5

1 Introduction

Today, economists and policy makers have a number of tools to analyze industry interactions in the real economy. For instance, the input-output analysis, derived from the works of Wassily Leontief, inspired in François Quesnay's *Tableau économique*, shows how an output from an industry can be an input to another. This work, however, focuses on dispersion effects, i.e., how fluctuations in industrial activities flows across industries, and that is our approach for a time-varying *uncertainty spillover*. But why should such spillovers exist? A compelling example is a highly vertical production chain. In this case, we have firms that convert raw materials into inputs to industries that produce final goods, and such industries must project their production of final goods based on an expectation of supply of this inputs. Hence, one can expect that shocks in early stages of the final good production should propagate along the chain. However, we must point out that improvements such as better inventory management methods and smaller general economic uncertainty should smooth this effect.

Finance also plays a crucial role. Firms must also be able to absorb this shocks, thus, access to credit should be taken into account. According to reports based on industry surveys [1], Brazilian industrial firms faced a recent tightening on credit. Data shows that other firm performance indicators follow a similar trend, showing that overall economic uncertainty also affects the financial channel.

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[1] Available at: https://static-cms-si.s3.amazonaws.com/media/filer_public/8d/2c/8d2c3f8e-4a6c-4c7c-8f7f-e652f5fe90a4/sondagem_industrial_dados_mpe_2014-2017.pdf

The majority of this studies so far turned their attention to aggregate economic growth volatility. In our study, we focus on segregation of economic performance in industrial activities. We argue that this research line is relevant: (i) to better understand the relationships between real sectors in face of exogenous shocks; and (ii) to provide an additional resource for policy makers to measure the effects of economic uncertainty at a more detailed level.

2 Theory and evidence

There is an existing literature that stress out the importance of investigating economic growth volatility beyond the usual aggregate measures. Comin and Mulani (2006) study aggregate and firm-level volatility in the U.S. economy, from 1950 to 2002, to find that while aggregate volatility shows a downward trend, firm-level data shows an upward trend. The author argues that while the effects of the Great Moderation are mentioned to explain the downward trend of aggregate volatility, they can't reasonably explain the movements at firm-level. Movements in aggregate economic growth volatility in the U.S. case were intimately linked, in addition to the Great Moderation effects, to a decline in employment and productivity shocks. Finally, the question is whether firms can internalize their own innovations that, according to Comin and Mulani (2006), "(...) can be easily patented and cannot be easily replicated or reverse-engineered".

Evidence shows that industrial activity is sensible to fluctuations in financial markets (Chiu et al., 2015). Manganelli and Popov (2015) finds that financial development not only reduces own sector volatility, but they also alter the capital allocation in direction of less volatile sectors of the economy. The authors base their findings empirically in 28 OECD countries. We can discuss how their results could be true in the Brazilian economy and its sectoral composition. Despite that, they show that both capital-intensive and labor-intensive sectors can benefit of greater financial development. The link between industry and finance is relevant in many ways, as policy makers and investors are always seeking for symptoms that precedes booms or busts, and how to proceed in moments of greater uncertainty. Similarly, Larrain (2006) finds that banks are able to reduce industrial output volatility, absorbing idiosyncratic risks. But credit must be counter-cyclical: while loans help reduce output volatility in recessions, they can increase volatility in expansions. This can be observed in developed countries, where financial intermediaries can provide services with fewer capital constraints.

Aren't industrial sectors less volatile just because they're larger? Manganelli and Popov (2015) argue that such mechanism could exist, but in fact once sector growth rates are uncorrelated, more finance won't help. One could argue that, because of lack of diversification in Brazilian industry, sector indicators should in fact be correlated. And how the present evidence relates to competitive and innovative sectors and activities, and what is the role of productivity and technological shocks? Imbs (2007) shows that there can be a positive correlation between economic growth and volatility in sector-level data, in the sense that fast-growing sectors are volatile because of high investment rates.

2.1 Risk sharing

In general, developed economies have a diversified productive structure. On the other hand, emerging economies have a greater degree of specialization. This affects how firms behave on the presence of exogenous shocks, according to Kalemli-Ozcan et al. (2003): while specialized economies resort to insurance markets, diversification is pursued via capital markets, and the general idea is to spread risk geographically. We should believe that finance plays a key role in how different sectors of industry can share risk. Economies specialize because of competitive advantages and greater returns to scale, and the main drivers of the Brazilian economy are agriculture and extractive mining, generating commodity exports. Following the findings of Kalemli-Ozcan et al. (2003), this suggest that we should find relevant risk sharing in specialized regions, however considering the fact that activities such as agriculture are dispersed along an extensive territory. But, while the authors consider risk sharing through regions, we consider between activities. We believe that firms that conduct high and low-risk activities should exchange insurance in capital markets, conditional to their ability to access them.

2.2 Brazilian industry

Recent history of industrialization in Brazil can be defined, according to Lamonica et al. (2011), in various stages: first, the development plans of the 1970's that resulted in fast economic growth and large foreign debts, followed by recession and high inflation in the 1980's, resulting in low development of the Brazilian industry. In this period, worker productivity remained stagnant, contributing to the so-called Brazilian lost decade. In the 1990's, liberalizing economic reforms resulted in foreign investment inflows and the reduction of the price of imported capital goods. The one-to-one parity between the U.S. dollar and Brazilian real raised the standard of competition between domestic and foreign goods. But still, high interest rates were still unfavourable to domestic investment.

What is the role of foreign capital in Brazilian industrialization? Arend (2015) point out that in the reforms of the 1990's, there were a large influx of foreign investments, that were mainly in financial markets. Overall, investments served to expand and improve sector with existing competitive advantages. There were little specialization in technology-intensive activities, which delayed the catching-up process of the Brazilian economy.

Reports of *Confederação Nacional da Indústria* (2017) [2] shows an overview of current Brazilian industrial activity: in July 2017, capacity utilization was 76,4%; manufactures balance of trade was -US$ 4,5 billion; the confidence index rose from 51,5 to 52,6 points (in a range from 0 to 100) in 12 months. In the last 5 years, indicators such as overall confidence, access to credit and employment declined, for a recovery trajectory in 2017. Our study should take into account this recent history, especially when calculating mean effects, as industrial activity experienced both downward and upward tendencies. **??** shows the Industrial Production Index from IBGE (the national statistics bureau) for capital goods, durable and non durable goods. Data are seasonally adjusted, spanning from January 2005 to August 2017, and its fixed base corresponds to year 2012. Data shows that, while the

[2] Available at: `https://static-cms-si.s3.amazonaws.com/media/filer_public/b0/89/b08980be-b415-4840-ba05-4c5931a46d03/industria_numeros_setembro_2017.pdf`

production of capital and durable goods are apparently co-integrated, non-durable goods were less volatile and decreased at a smaller rate.

3 Methodology

3.1 Data

In this work, we use data from *Confederação Nacional da Indústria* (CNI), that provides extensive data about key indicators of Brazilian transformation industry (industrial activity indexes, firm earnings, employment, capacity utilization, hours worked), for 22 activities, with monthly frequency ranging from January 2006 to December 2017. Our variables of interest will be the monthly variation of added value, for each sector. We narrow down the top 10 activities, as of 2017, in descending order, according to the importance of the sector (whose total sales is the dependant variable) in the overall economy, that is, the share of sales in total industry output, according to data from the *Pesquisa Industrial Mensal*, the Brazilian national industrial survey from IBGE. This is done as using the full sample does not give us enough degrees of freedom for the estimation of the empirical model. Also, it is known that the estimated variance components are affected by the order of the equations in the model. Additional orderings are tested using an algorithm from Kloessner and Wagner (2012).

Table 1: Descriptive statistics

Statistic	N	Mean	St. Dev.	Min	Max
Foods	114	162.23	41.61	83.90	249.30
Chemicals	114	127.82	23.51	84.50	181.20
Oil and biofuels	114	146.54	30.96	84.10	205.20
Vehicles	114	134.36	33.04	83.50	213.70
Steelworks	114	115.04	14.02	77.60	159.80
Mach. and equip.	114	165.80	45.59	82.90	253.00
Mining products	114	157.59	34.36	83.90	218.80
Metal products	114	128.77	20.64	86.30	199.80
Rubber and plastic	114	136.23	29.31	88.20	198.70
Paper and cellulose	114	149.37	44.08	86.90	266.00

3.2 Model

The empirical model is based on the *spillover index* from Diebold and Yilmaz (2009). In the article, the authors propose this method to construct a measure of interdependence among stock markets around the world. The model is based on a variance decomposition of a vector autoregression (VAR) model (e.g. a bivariate model):

$$\mathbf{y}_t = \mathbf{\Phi}\mathbf{y}_{t-1} + \mathbf{e}_t \tag{1}$$

The forecast error vector in period $t + 1$ will be:

$$\mathbf{e}_{t+1,t} = \mathbf{y}_{t+1} - \mathbf{y}_{t+1,t} = \mathbf{A}_0\mathbf{u}_{t+1} = \begin{bmatrix} a_{0,11} & a_{0,12} \\ a_{0,21} & a_{0,22} \end{bmatrix} \begin{bmatrix} u_{1,t+1} \\ u_{2,t+1} \end{bmatrix} \tag{2}$$

The variance-covariance matrix:

$$E[\mathbf{e}_{t+1,t}\mathbf{e'}_{t+1,t}] = \mathbf{A}_0\mathbf{A'}_0 \tag{3}$$

The variance decomposition allows to separate forecast errors according to the origin of shocks, whether they come from y_i or y_j. In other terms, the proportion of forecast errors caused by its own lagged variable or by the other variables in the system, in both ways; i.e. we can have shocks in y_i that affect the forecast error of y_j, or *vice-versa*. In this case, the total spillover effect will be $\mathrm{tr}(\mathbf{A}_h\mathbf{A'}_h)$.

Generalizing to a p-order, N-variate VAR model, with H steps ahead forecast, the spillover index S is defined as the ratio between the spillover and total forecast error:

$$S = \frac{\sum_{h=0}^{H-1}\sum_{i,j=1}^{N} a_{i,j}}{\sum_{h=0}^{H-1}\mathrm{tr}(\mathbf{A}_h\mathbf{A'}_h)} \tag{4}$$

The construction of this index results in an index matrix that points to the contribution of each sector to the forecast error of other sectors. Then, we can observe how uncertainty spreads out among the real sectors of the Brazilian economy. In practice, we have a first-order, 10-equation VAR. We standardize the variables in order to have mean zero and eliminate the constant vector, gaining additional degrees of freedom. This does not affect the estimates of the variance-covariance matrix.

4 Results

Table 2 presents the results of the empirical model. Each entry of the Table represent the percent contribution coming from the origin *(column)* sector to the forecast error of the destination *(row)* sector sales of shocks.

The empirical model reasonably predicts relationships that are expected, i.e. the sensitivity of the paper and cellulose sector to shocks coming from the chemical products sector, as such products are used in the productive process of paper, such as sodium hydroxide and sodium sulfide. Activities such as food (excluding beverages) manufacturing and the production of oil and biofuels appears to be highly influent, although the estimates for shocks coming from the food sector can be faced with skepticism, as no evident economic relationship appear to explain such high sensitivity of the vehicle manufacturing sector to shocks from the food manufacturing sector, in example. Nevertheless, other relationships are straightforward from the input-output perspective, such as the impacts of the mining products output in steelworks.

In addition, the last row present the external contribution of shocks from sectors other than those listed in the columns, defined as the ratio between the sum of all shocks in sector j minus its own contribution $a_{j,j}$ and the sum of all sectors in sector j. According to this metric, the three most exposed sectors to external shocks are (i) rubber and plastic products;

Table 2: Spillover table

Destination	Foods	Chemicals	Oil and biofuels	Vehicles	Steelworks	Mach. equip
	Origin					
Foods	90.1	3.5	0.8	0	1.3	0.5
Chemicals	0.9	79.7	1.8	0.2	3.4	1.7
Oil and biofuels	10.6	1.9	63.0	0.3	1.1	1.8
Vehicles	29.6	1.5	0.6	62.0	1.4	0.6
Steelworks	2.5	2.2	11.9	4.8	44.5	0.3
Mach. and equip.	13.2	3.5	13.5	0.8	4.1	53.0
Mining products	34.9	1.3	8.5	0.4	4.7	1.3
Metal products	17.4	6.2	11.8	0.3	3.6	2.9
Rubber and plastic	24.3	2.7	15.9	0.5	8.2	1.1
Paper and cellulose	20.2	6.6	0.7	1.1	5.0	3.0

(cont.)

Destination	Mining	Metal	Rubber and plastic	Paper and cellulose	External contrib.
	Origin				
Foods	1.6	0.3	1.7	0.2	9.9%
Chemicals	8.6	1.4	0.4	2.0	20.3%
Oil and biofuels	8.4	1.9	5.3	5.9	37%
Vehicles	2.3	0.3	0.2	1.6	38%
Steelworks	19.0	2.4	7.2	5.3	55.5%
Mach and equip	5.1	0.9	2.7	3.0	47%
Mining products	46.8	0.3	0.9	1.0	53.2%
Metal products	3.3	52.1	1.7	0.8	47.9%
Rubber and plastic	10.4	3.8	32.3	0.8	67.7%
Paper and cellulose	2.2	1.6	0.3	59.4	40.6%

Source: The authors.

(ii) steelworks and (iii) mining products. On the other hand, the three less exposed sectors are (i) foods; (ii) chemicals and (iii) oil products and biofuels. The last three sectors coincide as being the largest sectors in Brazilian transformation industrial activity.

5 Concluding remarks

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