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The Role of Individual Firms in Aggregate Fluctuations: Evidence from Hungary*

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This paper investigates the role of activities by Hungarian firms in generating aggregate fluctuations for the time period 2000–2013. The paper decomposes aggregated sales volatility into a macro-sectoral and firm-specific component and finds that shocks to individual firms contribute significantly to aggregate fluctuations. The relative contribution of idiosyncratic shocks to sales volatility at the aggregate level is 55.5 per cent for the whole economy and 56.4 per cent for the manufacturing sector. The main mechanism through which firm fluctuations manifest themselves in aggregate fluctuations is input–output linkages.

Journal of Economic Literature (JEL) codes: E32, F12, F14, F41

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1. Introduction

Individual firms seem to play an important role in generating business cycles. A new wave of recent research has uncovered that idiosyncratic shocks to firms do not average out at the country level, and most importantly, they contribute largely to aggregate fluctuations (*Gabaix 2011; Acemoglu et al. 2012; Di Giovanni et al. 2014*). Is this result also true for Hungary, a small economy but one of the most open in the world? Or do firm-level fluctuations wash out at the aggregate level and macro- and sectoral-level shocks shape the business cycle instead?

This paper investigates whether shocks to individual firms in Hungary manifest themselves in aggregate fluctuations. To address this question, closely following the methodology of *Di Giovanni et al.* (*2014*), I first decompose yearly firm-level sales growth rates into an idiosyncratic and macro-sectoral component. Idiosyncratic shocks are calculated as the deviation of firm growth from the sectoral average growth in each year and capture any event that affects firm growth independently

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from country and sector-level shocks. Second, I aggregate firm-level sales growth and its idiosyncratic and macro-sectoral component to the country level by weighting the individual components by their contribution to total sales. Finally, I compute the standard deviation of the aggregated components and analyse the relative standard deviation of the idiosyncratic and macro-sectoral component to aggregate sales growth volatility.

According to the results, at the firm level the vast majority of shocks hitting firms are idiosyncratic, whereas the macro-sectoral component plays a relatively less important role in explaining firm sales growth. Interestingly, those idiosyncratic shocks do not wash out at the country level. In addition, the relative standard deviation of the firm-specific component is strikingly high: 55.5 of aggregate fluctuations can be explained by idiosyncratic shocks for the whole economy and 56.4 per cent regarding the manufacturing sector. These results are robust for different growth and trimming definitions and also for incorporating heterogeneous reaction to shocks.

The paper distinguishes two main channels through which individual firms can alter aggregate sales volatility. First, *Acemoglu et al.* (*2012, 2017*), *Carvalho* (*2014*) and *Barrot and Sauvagnat* (*2016*) emphasise the linkage channel, according to which idiosyncratic shocks to individual firms through input-output linkages are also able to generate aggregate fluctuations. A shock, hitting an upstream or downstream partner, propagates and is amplified in the production network, eventually causing sizable aggregate effects. Second, according to Gabaix (2011), idiosyncratic shocks to firms cannot average out since the firm size distribution is too fat-tailed (granularity hypothesis): some firms contribute such a large share to GDP growth that shocks to those giants can shape the business cycle.[1] As for Hungary, evidence suggests that idiosyncratic shocks manifest themselves in aggregate fluctuations through the linkage channel: its relative contribution to the aggregated idiosyncratic component is around three times more important than the granularity channel.

For a long time, most economists did not study the differences across firms, but focused mainly on differences across countries and industries in order to understand aggregate fluctuations. It is well-documented that idiosyncratic shocks to a single sector can have sizable aggregate effects (*Long and Plosser 1983; Stockman 1998; Koren and Tenreyro 2007a; Carvalho and Gabaix 2013*). Recently, the increased quality and accessibility of firm-level data has turned attention towards to individual firms. Recent studies, starting with the seminal work of *Melitz* (*2003*), have uncovered that firms are surprisingly heterogeneous even within narrowly defined industries and markets, motivating research on the role of individual firms in generating business cycles. *Gabaix* (*2011*) demonstrated theoretically and

[1] Consider the case of Finland’s Nokia or South Korea’s Samsung, for instance. Nokia contributed around 25 per cent to Finland’s GDP growth over the period 1998–2007, and the performance of Samsung is also of great significance for the economic success of South Korea.

empirically that firm-level shocks do not necessarily average out at the country level if the economy is "granular" enough: using US data he showed that the top 100 firms have sizable effects on the GDP dynamics. *Di Giovanni et al*. (*2014*) used a wider data base of French firm-level balance sheet and customs information and argued that firm-level fluctuations manifest themselves in aggregate volatility with a relative standard deviation of 80 per cent. Findings are similar to Sweden (*Friberg and Sanctuary 2016*) and Belgium (*Magerman et al. 2016*) as well.

Nevertheless, there is still little empirical evidence on individual firms generating aggregate fluctuations. The main motivation of the paper is to contribute to the emerging applied literature on the role of individual firms in aggregating business cycles. To the best of my knowledge, this is the first paper providing empirical evidence on the role of individual firms on business cycles on Hungarian firm-level data. One might think that the contribution of firm fluctuations to the business cycle is less important in Hungary since, compared to the aforementioned examples, the Hungarian economy is smaller and more open, implying that the country is more exposed to foreign shocks and hence the importance of idiosyncratic shocks are much more moderate and macro-sectoral fluctuations play a higher role in aggregate volatility.[2] Indeed, in Hungary macro-sectoral shocks matter more (with a relative standard deviation of 70 per cent) compared to France (53 per cent) and Sweden (58 per cent), but firm-level fluctuations are still very important (56.4 per cent).

The remaining part of the paper is structured as follows. *Section 2* introduces the econometric model to decompose firm sales growth rates into a macro-sectoral and idiosyncratic component and analyses the contribution of those components to aggregate sales growth volatility. *Section 3* provides data description, *Section 4* summarises the main results and finally, *Section 5* concludes.

2. Econometric implementation

Closely following *Di Giovanni et al*. (*2014*), I first decompose the firm-level yearly sales growth rates γ_{ft} into a macro-sectoral and idiosyncratic component:[3]

$$\gamma_{ft} = \delta_{jt} + \varepsilon_{ft}, \tag{1}$$

[2] According to the World Bank (http://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?end=2013&start=1960), Hungary was the 13th most open economy in the world in 2013: the sum of exports and imports accounted for 165 per cent of GDP, whereas for France the trade openness measure was 59 per cent, for Sweden 83 per cent and for Belgium 162 per cent. As for a GDP comparison: compared to Hungary, the economy of Belgium is 3.7 times larger, the Swedish economy is 4 times larger and the French economy is 20 times larger.

[3] Due to data restrictions, I cannot use exactly the same estimation procedure as *Di Giovanni et al.* (*2014*), who had data on export sales at the destination level for the firms and decomposed firm sales growth rates into an industry-destination and an idiosyncratic component, since I do not have information on destination-level exports.

where δ_{jt} denotes the industrial average growth rate, encompassing macro-sectoral demand and cost shocks, and ε_{ft} is the idiosyncratic shock component that is simply the deviation of firm-level sales growth rate from the industrial average growth rate.[4]

The ultimate purpose of the paper is to assess the impact of firm-specific shocks ε_{ft} on aggregate fluctuations. To do so, I first calculate the aggregate sales growth rate γ_{At} as the weighted sum of the macro-sectoral and idiosyncratic growth rates:

$$\gamma_{At} = \Sigma_j \, w_{jt-1}\delta_{jt} + \Sigma_f \, w_{ft-1}\varepsilon_{ft} \, , \tag{2}$$

where w_{jt-1} is the share of sector j's and w_{ft-1} is the share of firm f's sales in total sales. Note that if we want to quantify the relative contribution of the idiosyncratic component to aggregate sales growth volatility, the use of time-varying weights complicates the analysis since we cannot disentangle the effect of the time-varying sectoral and firm-level sales shares and the associated growth components. Instead, one can fix weights for a certain period τ and work with the following stochastic process:

$$\gamma_{At|\tau} = \Sigma_j \, w_{j\tau-1}\delta_{jt} + \Sigma_f \, w_{f\tau-1}\varepsilon_{ft} \, , \tag{3}$$

where weights $w_{j\tau-1}$ and w_{ft-1} are fixed over time at their $\tau - 1$ values combined with period t shocks.

Next, I compute the variance of the stochastic process $\gamma_{At|\tau}$, which is denoted by $\sigma^2_{A\tau}$ and decompose it into the variance of the idiosyncratic and macro-sectoral component:

$$\sigma^2_{A\tau} = \sigma^2_{J\tau} + \sigma^2_{F\tau} + \text{COV}_\tau, \tag{4}$$

where $\sigma^2_{J\tau} = \left(\Sigma_j w_{j\tau-1}\delta_{jt}\right)$ denotes the volatility of the aggregated macro-sectoral component, $\sigma^2_{F\tau} = \left(\Sigma_f w_{f\tau-1}\varepsilon_{ft}\right)$ is the firm-specific volatility, and $\text{COV}_\tau = \text{Cov}\left(\Sigma_j w_{j\tau-1}\delta_{jt}, \Sigma_f w_{f\tau-1}\varepsilon_{ft}\right)$ is the covariance of shocks from different levels of aggregation.

2.1. Estimation

The estimation procedure involves two steps. In the first stage, firm-level sales growth rates are decomposed into a macro-sectoral and an idiosyncratic part, and then in the second stage, those three terms are aggregated to the macro-level using the respective fixed industrial and firm-level weights. Finally, I compute the relative standard deviation of the aggregated macro-sectoral and idiosyncratic component to aggregate sales growth volatility.

[4] For a motivating heterogeneous firm model framework, see *Annex A*.

The macro-sectoral shock δ_{jt} is the average growth rate of sales of all firms selling in sector j. The firm-specific shock ε_{ft} is simply computed as the deviation of γ_{ft} from δ_{jt}, or putting it differently, as the residual in a regression of firm sales netting out industry-year fixed effects.

The estimator for $\sigma^2_{F\tau}$ is the sample variance of the T realisations of the time series $\Sigma_f w_{f\tau-1}\varepsilon_{ft}$ while the estimators for $\sigma^2_{A\tau}$ and $\sigma^2_{J\tau}$ are the sample variances of the realisations of $\gamma_{At|\tau}$ and $\Sigma_j w_{j\tau-1}\delta_{jt}$ respectively. The framework of *Di Giovanni et al*. (*2014*) allows for cross-sectional and time dependence in the data-generating process, but nevertheless jointly stationarity for ε_{ft} and δ_{jt} – variables describing growth rates – is assumed. In order to be comparable with other findings in the literature, the results are always presented in terms of relative standard deviations ($\sigma_{F\tau}/\sigma_{A\tau}$).

3. Data description

The analysis uses balance sheet information of Hungarian firms with double-entry bookkeeping collected by the National Tax and Customs Administration of Hungary (NAV) over the 2000–2013 period. It contains in total 434,956 firms including 45,211 firms in the manufacturing sector during the time period analysed. *Figure 1* shows that the aggregated real sales growth in the data, although it is slightly more volatile, follows the Hungarian business cycle and hence our database represents the economy of the country well.

To construct real sales growth rates at the firm level, I first deflated sales using 2-digit sector-specific output deflators provided by the Hungarian Central Statistical Office (HCSO) and then calculated the sales growth rates γ_{ft} as the log difference between the real sales level of two consecutive years.[5] Since I do not have information on mergers and acquisitions, I trimmed the data at the bottom and top 1 per cent level of sales growth rates.[6]

Table 1 presents means and standard deviations of firm-level real sales growth rates for the whole economy and for the manufacturing sector. The weighted average real sales growth rate during the sample period was –3.78 per cent (–1.63 per cent) for the whole economy (manufacturing firms), due to the huge negative impact of the recession on sales in 2009 (see *Figure 1*), whereas the unweighted average yearly firm-level real sales growth rate was 2.46 per cent (0.08 per cent) with a standard deviation of 0.6085 (0.5446). The difference between the weighted and unweighted average growth rates can be explained by the faster growing small firms (*Haltiwanger 1997*). Large firms fluctuate less: moving up on the firm size percentile

[5] The robustness of the results to different growth definitions is presented in *Section 4.4*.
[6] See the exact cut-off values in *Annex B* and the robustness of results to different trimming cut-off values in *Section 4.4*.

Figure 1
Growth of aggregate sales and GDP growth

Note: This figure plots the time series of the growth rate of real GDP and aggregate real sales growth over the period 2001–2013.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

ladder, firms tend to have lower levels of growth volatility and the largest 100 and 10 firms are even more stable. These findings also hold for France (*Di Giovanni et al. 2014*) and Sweden (*Friberg and Sanctuary 2016*).[7] According to average square root of the *Herfindahl index* (*0.0667*), sales in Hungary are more concentrated than in France (0.0301) or in Sweden (0.055). The difference in concentration ratios is even greater for the manufacturing sectors.[8] The higher concentration implies that the Hungarian economy is more "granular", and that idiosyncratic shocks to large firms have the potential to manifest themselves in aggregate fluctuations through the fat-tailed firm size distribution.

[7] Volatility levels for Hungary are higher due to the more permissive trimming cut-off values.
[8] See the distribution of firm size and firm sales growth in *Annex B*.

Table 1
Description of firm-level yearly real sales growth

	Whole economy	Manufacturing
	Mean	
Weighted	–0.0378	–0.0163
Unweighted	0.0246	0.0008
	Standard deviation	
Average	0.6085	0.5446
0–20 size percentile	0.8387	0.7789
20–40 size percentile	0.6038	0.5572
40–60 size percentile	0.5380	0.4799
60–80 size percentile	0.4963	0.4210
80–100 size percentile	0.4210	0.3559
Top 100	0.3952	0.3387
Top 10	0.2815	0.2489
Average Herfindahl index	**0.0667**	**0.1630**

Note: This table presents means and standard deviations of firm-level yearly real sales growth γ_{ft} *for the whole economy and for the manufacturing sector. Sales percentiles are constructed on a yearly base. HHI is the Hirschman–Herfindahl index of the total firm sales shares.*

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

Table 2 summarises means and volatility levels of yearly industry-level real sales growth rates and sectoral importance for each 2-digit NACE industry. Industries with the top-five sales shares are: wholesale and retail trade; electricity, gas, steam and hot water supply; sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel; manufacture of radio, television and communication equipment; manufacture of motor vehicles and trailers. Industries are heterogeneous in both growth rates and volatility. Among the industries with a share of at least 1 per cent, the fastest growing ones were: financial intermediation (9.02 per cent); manufacture of radio, television and communication equipment (5.68 per cent); manufacture of rubber and plastics products (4.93 per cent); and manufacture of (electrical) machinery (4.39 per cent). While the post and telecommunications (–2.35 per cent), the construction (–1.69 per cent), the sale, maintenance and repair of motor vehicles and motorcycles (–1.11 per cent) and the wholesale trade sector (–0.84 per cent) underperformed relatively. The sectors construction, financial intermediation, manufacture of fabricated metal products, and real estate activities were the most volatile, whereas the food products and beverages, chemicals, coke, refined petroleum products manufacturing; the retail trade and post and telecommunication sector had the most stable growth path.

Table 2
Descriptive statistics at industry level

Code	Division definition	Mean	St. Dev.	Share	# firms
51	Wholesale trade and commission trade	–0.84%	0.2354	17.91%	40,716
52	Retail trade, except of motor vehicles and motorcycles	0.72%	0.1686	7.08%	54,376
40	Electricity, gas, steam and hot water supply	3.40%	0.1771	5.81%	545
50	Sale, maintenance and repair of motor vehicles and motorcycles	–1.11%	0.2240	5.64%	16,903
32	Manufacture of radio, television and communication equipment	5.68%	0.2349	5.30%	1,031
34	Manufacture of motor vehicles, trailers and semi	2.77%	0.1951	5.23%	375
45	Construction	–1.69%	0.3357	4.87%	47,862
74	Other business activities	3.30%	0.2694	4.47%	77,117
15	Manufacture of food products and beverages	–0.72%	0.1717	4.44%	5,036
23	Manufacture of coke, refined petroleum products and nuclear fuel	2.45%	0.1511	3.78%	10
24	Manufacture of chemicals and chemical products	3.27%	0.1716	2.82%	730
64	Post and telecommunications	–2.35%	0.1532	2.61%	1,631
65	Financial intermediation, except insurance and pension funding	9.02%	0.2753	2.32%	1,031
01	Agriculture, hunting and related service activities	0.25%	0.2460	2.22%	10,339
28	Manufacture of fabricated metal products, except machinery and equipment	2.19%	0.2733	2.07%	7,463
70	Real estate activities	0.24%	0.2727	2.06%	27,971
63	Supporting and auxiliary transport activities; activities of travel agencies	2.55%	0.2216	1.84%	4,968
60	Land transport; transport via pipelines	3.08%	0.1922	1.84%	10,799
29	Manufacture of machinery and equipment n.e.c.	3.91%	0.2309	1.74%	3,794
25	Manufacture of rubber and plastics products	4.93%	0.2168	1.47%	2,055
31	Manufacture of electrical machinery and apparatus n.e.c.	4.39%	0.2215	1.46%	1,115
72	Computer and related activities	2.65%	0.2541	1.25%	16,654
92	Recreational, cultural and sporting activities	0.57%	0.2052	0.96%	12,835
26	Manufacture of other non	–1.36%	0.2165	0.96%	1,811
66	Insurance and pension funding, except compulsory social security	–1.05%	0.2103	0.90%	97
55	Hotels and restaurants	1.02%	0.1872	0.83%	21,282
22	Publishing, printing and reproduction of recorded media	–5.73%	0.1963	0.82%	7,349
27	Manufacture of basic metals	–6.94%	0.2438	0.67%	332
21	Manufacture of paper and paper products	–2.16%	0.1590	0.47%	541

Table 2
Descriptive statistics at industry level

Code	Division definition	Mean	St. Dev.	Share	# firms
62	Air transport	3.09%	0.1754	0.44%	102
85	Health and social work	8.82%	0.1777	0.43%	16,385
90	Sewage and refuse disposal, sanitation and similar activities	3.92%	0.2159	0.41%	1,134
20	Manufacture of wood and of products of wood and cork	–2.13%	0.2154	0.39%	3,161
36	Manufacture of furniture; manufacturing n.e.c.	1.30%	0.2244	0.37%	3,565
33	Manufacture of medical, precision and optical instruments, watches and clocks	0.98%	0.2400	0.34%	1,684
67	Activities auxiliary to financial intermediation	–7.20%	0.2619	0.31%	6,324
16	Manufacture of tobacco products	6.17%	0.1589	0.28%	5
17	Manufacture of textiles	–7.16%	0.2192	0.28%	1,329
41	Collection, purification and distribution of water	0.85%	0.0984	0.28%	350
71	Renting of machinery and equipment and of personal and household goods	2.39%	0.2404	0.26%	2,091
35	Manufacture of other transport equipment	4.21%	0.2651	0.24%	289
18	Manufacture of wearing apparel; dressing and dyeing of fur	–9.67%	0.2248	0.20%	2,717
02	Forestry, logging and related service activities	–0.21%	0.1556	0.17%	1,881
19	Tanning and dressing of leather; manufacture of luggage, handbags and footwear	–1.35%	0.2238	0.15%	549
73	Research and development	7.61%	0.2769	0.14%	2,287
80	Education	2.35%	0.2607	0.13%	7,277
93	Other service activities	1.81%	0.1669	0.12%	5,392
37	Recycling	–4.65%	0.2462	0.12%	263
11	Extraction of crude petroleum and natural gas	7.15%	0.3139	0.12%	34
14	Other mining and quarrying	–0.56%	0.2816	0.11%	433
61	Water transport	–0.22%	0.2196	0.03%	117

Note: This table presents the average industry-year level growth $\frac{1}{T}\sum_{t=2000}^{2013}\delta_{jt}$ *and its standard deviation. Industries are ranked by "Share" referring to the share of an industry in total sales.*

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

4. Results

This section describes the main results. First, I show that the bulk of the aggregated volatility is due to the intensive margin after decomposing sales growth rate volatility into an extensive and intensive margin component (*Section 4.1.*). Second, I describe the firm-level results (*Section 4.2.*), and then I aggregate the components at the country level to summarise the contribution of the firm-specific and macro-sectoral component to aggregate sales volatility (*Section 4.3.*). *Section 4.4.* checks the robustness of the results using a different definition of firm-level sales growth and trimming rules and different methodology to compute idiosyncratic shocks. Finally, *Section 4.5.* investigates the possible mechanisms through which idiosyncratic shocks can manifest themselves in business cycles.

4.1. Decomposition of total firm sales into intensive and extensive margin

Following *Di Giovanni et al.* (*2014*), total aggregate sales X_t by all firms in period t are defined as $X_t \equiv \Sigma_{f \in I_t} x_{ft}$ where x_{ft} is the sales of firm f in year t, and I_t denotes the set of firms f and output industries j at t. First, I decompose the growth rate of aggregate sales into intensive and extensive components. The intensive component at t is defined as the growth rate of sales of firms that had positive sales in both year t and year $t-1$, whereas the extensive margin is the contribution to total sales of appearance and disappearance of firm sales. The exact decomposition of the log-difference growth rate of total sales is the following:

$$\tilde{\gamma}_{At} \equiv \ln \Sigma_{f \in I_t} x_{ft} - \ln \Sigma_{f \in I_{t-1}} x_{ft-1} = \ln \frac{\Sigma_{f \in I_{t/t-1}} x_{ft}}{\Sigma_{f \in I_{t/t-1}} x_{ft-1}} - \left(\ln \frac{\Sigma_{f \in I_{t/t-1}} x_{ft}}{\Sigma_{f \in I_t} x_{ft}} - \ln \frac{\Sigma_{f \in I_{t/t-1}} x_{ft-1}}{\Sigma_{f \in I_{t-1}} x_{ft-1}} \right) = \gamma_{At} - \ln \frac{\pi_{t,t}}{\pi_{t,t-1}}, \quad (5)$$

where $I_{t/t-1}$ is the set of firms active in both t and $t-1$, and $\pi_{t,t}$, $\pi_{t,t-1}$ are the share of output produced by this intensive sub-sample of firms in period t and $t-1$.Using equation (5) the impact of intensive and extensive margins on aggregate volatility can be expressed as:

$$\tilde{\sigma}_A^2 = \sigma_A^2 + \sigma_\pi^2 - 2\mathrm{COV}\left(\gamma_{At}, g_{\pi t}\right), \quad (6)$$

where $g_{\pi t} = \ln(\pi_{t,t}/\pi_{t,t-1})$ is the extensive margin component of equation (5), σ_π^2 is its variance, σ_A^2 is the variance of the intensive margin growth rate γ_{At}, and Cov(γ_{At}, $g_{\pi t}$) is the covariance between the two terms. Intuitively, the volatility of total sales consists of three elements: the volatility of sales of incumbent firms, the volatility of entries and exits during the sample period and the potential covariance between them.

Although 34.5 per cent of the firm-year observations belong to the extensive margin (of which 15.7 per cent are entering, 15.1 per cent are exiting and 3.7 per cent are reentering firms), according to *Table 3*, the majority of sales volatility is due to the intensive margin. Its contribution to sales volatility is 86 per cent (97 per cent), whereas the relative standard deviation of the extensive margin is only 23 per cent (20 per cent) for the whole economy (manufacturing sector). In both cases, the covariance between the intensive and extensive margin is negligible. These findings are similar to France and confirm the choice of conducting the analysis on the intensive margin.

Table 3
Contribution of extensive and intensive margins on sales volatility

	Whole economy		Manufacturing	
Variables	St. Dev.	Rel. SD	St. Dev.	Rel. SD
Aggregated growth rate	0.0733	1	0.0855	1
Intensive margin	0.0628	0.8575	0.0828	0.9683
Extensive margin	0.0171	0.2341	0.0168	0.1961

Note: This table presents the standard deviations of the intensive and extensive margins, in absolute and relative terms with respect to the actual aggregated real sales growth rates, for the whole economy and for the manufacturing sector over the period 2000–2013.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

4.2. Properties of shocks at firm level – the first stage

First, I investigate the properties of the components of firm-level sales growth rates γ_{ft}. Following equation (1), we can express sales growth rates as the sum of a macro-sectoral δ_{jt} and an idiosyncratic growth rate ε_{ft}. *Table 4* presents summary statistics of the mean and standard deviation of firm-level real sales growth rates and its components, along with the correlation coefficient of the idiosyncratic and macro-sectoral component with firm-level sales growth rates for the whole economy and for the manufacturing sector.

Table 4 strengthens the previous findings that shocks hitting firms are mostly idiosyncratic: the error term ε_{ft} plays the most important role in explaining firm-level sales growth γ_{ft} rates (*Haltiwanger 1997; Di Giovanni et al. 2014; Castro et al. 2015; Friberg and Sanctuary 2016*). Both for the whole economy and for the manufacturing sector, the correlation between firm-level sales growth rates and its idiosyncratic component is very close to one. The macro-sectoral component is less volatile and also less correlated with firm growth, but compared to the French data the correlation is slightly higher which is not a surprise after seeing that the

Hungarian economy is more concentrated. *Table 4* implies that firm performance is driven by more firm-specific characteristics, such as demand shocks to the certain variety produced by the firm, productivity shocks or managerial skills, rather than country-specific or industry-specific shocks, i.e. seemingly similar firms within the same industry exhibit substantially different behaviour: in the fast-growing industries, a large share of firms experience substantial declines, whereas, in declining sectors many firms grow rapidly.

Table 4

Description of firm-level real sales growth rates and their firm-specific and macro-sectoral components

Variables	Obs.	Mean	St. Dev.	Correlation
Whole economy				
Firm-level Sales Growth Rates	1,561,644	0.0246	0.6085	1.0000
Idiosyncratic growth component	1,561,644	0.0000	0.6040	0.9926
Macro-sectoral component	700	0.0340	0.1611	0.1216
Manufacturing sector				
Variables	**Obs.**	**Mean**	**St. Dev.**	**Correlation**
Firm-level Sales Growth Rates	213,146	0.0008	0.5446	1.0000
Idiosyncratic growth component	213,146	0.0000	0.5387	0.9891
Macro-sectoral component	332	0.0058	0.1705	0.1470

Note: The idiosyncratic growth component ε_{ft} is the deviation of the yearly firm-level sales growth rate γ_{ft} from Lotte the macro-sectoral component of growth δ_{jt}.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

4.3. Role of firm-specific shocks in generating aggregate fluctuations – the second stage

After having demonstrated in the previous section that the variation in firm-level sales growth is mainly caused by idiosyncratic shocks, the next question is whether the idiosyncratic component of firm growth also has an impact on aggregate fluctuations.

The relative contribution of the idiosyncratic part is calculated as the time average of the ratio of the standard deviations of the aggregated firm-specific component and aggregated sales growth on the intensive margin:

$$\sigma_{F\tau}^{rel} = \frac{1}{T}\sum_{\tau=2001}^{2012}\frac{\sigma_{F\tau}}{\sigma_{A\tau}}. \quad (7)$$

The average relative standard deviation of the macro-sectoral component is computed in the same manner:

$$\sigma_{J\tau}^{rel} = \frac{1}{T}\sum_{\tau=2001}^{2012}\frac{\sigma_{J\tau}}{\sigma_{A\tau}}. \quad (8)$$

Table 5 presents the main results. The time average of the relative standard deviation of the aggregated firm-specific component is 56.5 per cent (56.9 per cent), whereas the average relative contribution of the macro-sectoral component is 69.5 per cent (73.1 per cent) for the whole economy (manufacturing sector).[9] At the country level, the relative importance of macro-sectoral shocks has increased, while the contribution of idiosyncratic shocks has declined, but over time the aggregated impact of the firm-specific component is far from negligible and has a relative importance similar to the macro-sectoral shocks. Compared to the findings of *Di Giovanni et al.* (*2014*), the estimated overall impact of firm fluctuations is lower in Hungary (56.5 per cent) than in France (80.1 per cent), whereas the relative contribution of macro-sectoral factors is higher (69.5 per cent versus 52.9 per cent), which can be a consequence of the much higher trade openness of Hungary that makes the economy more vulnerable to macro-sectoral shocks.

Table 5
Aggregate impact of firm-specific shocks on aggregate volatility

	Whole economy		**Manufacturing sector**	
	St. Dev.	**Relative SD**	**St. Dev.**	**Relative SD**
Firm-level Sales Growth Rates	0.0838	1.0000	0.0967	1.0000
Idiosyncratic growth component	0.0464	0.5554	0.0540	0.5642
Macro sectoral component	0.0566	0.6950	0.0702	0.7311

Note: This table presents the average standard deviation of the aggregated firm-specific $\frac{1}{T}\sum_{\tau=2001}^{2012}\sigma_{Ft}$, *macro-sectoral component* $\frac{1}{T}\sum_{\tau=2001}^{2012}\sigma_{J\tau}$ *and the aggregate sales growth volatility* $\frac{1}{T}\sum_{\tau=2001}^{2012}\sigma_{A\tau}$ *in absolute and relative terms –* $\sigma_{F\tau}^{rel} = \frac{1}{T}\sum_{\tau=2001}^{2012}\frac{\sigma_{F\tau}}{\sigma_{A\tau}}$ *and* $\sigma_{J\tau}^{rel} = \frac{1}{T}\sum_{\tau=2001}^{2012}\frac{\sigma_{J\tau}}{\sigma_{A\tau}}$, *respectively.*

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

[9] See *Figure 3* in *Annex B* for the time series of the standard deviations of the aggregated sales growth rates ($\sigma_{A\tau}$) and its firm-specific $\sigma_{F\tau}$ and macro-sectoral $\sigma_{J\tau}$ component defined as in equation (4) for the whole economy.

4.4. Robustness

Note that so far I have calculated idiosyncratic shocks simply as the deviation of the yearly firm-level sales growth from the corresponding sectoral growth. However, firms can react heterogeneously to different shocks: larger and older firms have the experience to smooth shocks affecting sales. Also, as *Vannoorenberghe* (*2012*) found, firms involved in international trade can hedge domestic and foreign shocks by switching across markets if those shocks are not perfectly correlated. Moreover, exporters, older and larger firms are also more productive and hence those firms, by using more sophisticated production technologies, have a better chance to adjust to a shock. Location also matters: local labour market conditions, infrastructure or savings of local people may have an impact on firm growth as well.

To control for heterogeneous response to shocks and for location, I re-estimate the idiosyncratic growth component ε_{ft} as follows:

$$\gamma_{ft} = X_{ft} + d_{jt} + d_{rt} + \varepsilon_{ft} \tag{9}$$

I regress sales growth rates γ_{ft} on a set of firm covariates X_{ft} including age, the logarithm of total sales at time $t-1$ as a proxy for firm size, and the export share of sales. Also, I net out industry-year fixed effects d_{jt} as before and I control for transitory regional-level local shock by adding region-year fixed effects d_{rt}. The first row of *Table 6* indicates that, surprisingly, the contribution of idiosyncratic shocks to aggregate sales growth volatility is virtually the same after controlling for local time-varying effects and heterogeneous response to shocks of firms by netting out size, age and export openness. The relative standard deviation of aggregated firm fluctuations is 54.4 per cent (56.5 per cent) for the whole economy (manufacturing sector) compared to the baseline results of 55.5 per cent and (56.4 per cent), respectively.

Table 6
Aggregate impact of firm-specific shocks on aggregate volatility – robustness

	Whole	Manufacturing
Heterogeneous response to shocks	0.5441	0.5647
By different sales growth definitions		
symmetric growth rates	0.5491	0.5668
"classic" growth rates	0.7041	0.6373
By different cut-off rules		
1	0.5554	0.5642
5 per cent	0.5532	0.6228
10 per cent	0.5536	0.6200
Trimming rule of Di Giovanni et al. (2014)	0.5231	0.6173

Note: The table reports averages of the relative standard deviation of the firm-specific component $\frac{1}{T}\sum_{\tau=2001}^{2012}\frac{\sigma_{F\tau}}{\sigma_{A\tau}}$ for the whole economy and for the manufacturing sector. Idiosyncratic shocks are calculated for "Heterogeneous response to shocks" using equation (9). Symmetric growth rates are calculated as $\gamma_{ft} = (X_t - X_{t-1})/(X_t + X_{t-1})/2$. The "classic" measure of sales growth is computed as $\gamma_{ft} = (X_t - X_{t-1})/X_{t-1}$. The different cut-off rules are: sales growth rates above and below the top 1 per cent, 5 per cent and 10 per cent. The rule of Di Giovanni et al. (2014) deletes growth rates below –50 per cent and 100 per cent.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

I also experiment with other definitions of firm growth. It can be argued that measuring firm-level growth as the log difference of sales may be misleading since smaller firms experience higher growth in absolute value hence the log differences become an imprecise proxy for growth (*Kalemni-Ozcan et al. 2014*). To check whether the growth definition modifies the main results I use two additional measures. The first one follows *Davis* (*2006*) and is calculated as $\gamma_{ft} = (X_t - X_{t-1})/(X_t + X_{t-1})/2$. In particular, it yields a measure that is symmetric around zero and bounded between –2 and 2, affording an integrated treatment of births, deaths, and incumbents. The "classic" measure of sales growth is simply computed as $(X_t - X_{t-1})/X_{t-1}$. Results with the symmetric measure are almost exactly the same as the baseline relative contributions: 54.9 per cent versus 55.5 per cent for the whole economy and 56.7 per cent versus 56.4 per cent for the manufacturing sector. With the classic growth measure, however, the relative contribution of idiosyncratic shocks to aggregate volatility is even more pronounced: 70 per cent (64 per cent) for the whole economy (manufacturing sector). This is not a surprise taking into account that the majority of the firms are micro and small firms, with high and volatile average growth at the intensive margin (see *Table 1*) and the log difference method possibly underestimates the contribution of individual firms.

Results are also robust to different cut-off rules: sales growth rates above and below the top 1 per cent, 5 per cent and 10 per cent.[10] The relative contribution of the firm-specific component varies between 55 per cent and 58 per cent (52 per cent and 62 per cent) for the whole economy (manufacturing sector). Without dropping any firm-year observations, those values are higher, as expected: 71.4 per cent (78 per cent).

Note that these criteria for outlier treatment are far more permissive compared to those used by *Di Giovanni et al.* (*2014*), who dropped observations with a growth rate higher than 100 per cent and lower than –50 per cent.[11] Nevertheless, I find it unreasonably restrictive to apply these to the Hungarian data. The cut-off rule of *Di Giovanni et al*. (*2014*) would result in losing one third of the observations, mainly the fast growing micro and small firms (25 per cent of the firm-year growth rates are higher than 100 per cent, and more than 8 per cent of the observations have a growth rate of less than –50 per cent). Also, there is no reason to exogenously employ the trimming rule of French data on the Hungarian data, due to the structural differences between the two economies. Another additional difference in my outlier treatment is that I do not drop manufacturing (service) firms with annual sales that are less than EUR 766,000 (EUR 231,000).[12] Employing the trimming rule of *Di Giovanni et al*. (*2014*), we can compare the French results to the Hungarian results: In France, idiosyncratic shocks have a higher relative importance in generating business cycles than in Hungary. The relative standard deviation of firm fluctuations is 80.1 per cent (68.9 per cent) in France, whereas in Hungary idiosyncratic shocks contribute with a relative standard deviation of 52.3 per cent (61.7 per cent) to aggregate sales growth volatility for the whole economy (manufacturing sector). Once again, the main reason beyond the differences could be the huge difference in relative trade openness between the two countries: Hungarian firms face a higher risk of being exposed to foreign shocks and hence idiosyncratic shocks to firms matter less for aggregate fluctuations. But still, their contribution is far from negligible and has a similar impact in terms of magnitude compared to macro-sectoral disturbances.

4.5. Mechanisms through which idiosyncratic shocks manifest themselves in aggregate fluctuations

After having demonstrated that idiosyncratic shocks do matter in generating business cycles, the next step is to understand the underlying mechanisms through which firm-level fluctuations shape aggregate sales growth volatility. Is it due to

[10] See the precise values of real sales growth at firm-level for the cut-off values in *Annex B*.

[11] *Friberg and Sanctuary* (*2016*) trimmed sales growth above 200 per cent and below –50 per cent for the sake of the comparability with the results with *Di Giovanni et al.* (*2014*), however, note that the latter cut-off rule is more permissive and hence one cannot directly compare the two results.

[12] The reason for dropping those observations in *Di Giovanni et al*. (*2014*) was the unsuccessful matching between balance sheet and trade data, a problem I do not face.

the "granular" firm-size distribution that the performance of some giant firms has a huge impact on the whole economy of the country or are shocks propagating and being amplified through input-output linkages? To distinguish the channels, I decompose the aggregated firm-fluctuation component $\sigma^2_{F\tau}$ into a variance and covariance component:

$$\sigma^2_{F\tau} = \Sigma_f w^2_{ft-1} Var\left(\varepsilon_{ft}\right) + \Sigma_g \Sigma_f w_{gt-1} w_{ft-1} \text{Cov}\left(\varepsilon_{gt}, \varepsilon_{ft}\right), \quad f \neq g. \tag{10}$$

According to equation (10), the volatility of the aggregated idiosyncratic shocks encompasses two channels. The first one is the variance of individual shocks, which is called after *Di Giovanni et al.* (*2014*) the DIRECT term and is driven exclusively by the firm-size distribution, and the covariance of shocks across firms (second term), which I will refer to as the LINK component. The former captures the effect of the distribution of the shocks to firms on aggregate volatility, while the latter captures the contribution of firm-to-firm linkages, i.e. the effect of business partnership (or rivalry) between firms according to which a shock hitting a certain firm also has an effect on other firms in its network, and/or time-invariant and transitory local shocks, such as independent events to a certain group of firms in the same location having an impact on their sales growth.

Table 7 clearly shows that the idiosyncratic-shock component is mainly driven by the LINK component, whereas the DIRECT channel plays a negligible role in aggregate fluctuations. The LINK component explains around 88 per cent of the average variance of the aggregated firm-specific, whereas the DIRECT component only 16 per cent if one estimates idiosyncratic shocks by using equation (1).[13] These findings are similar to the results of *Di Giovanni et al.* (*2014*) with the slight difference that in France the link component more closely follows the firm-specific component, as the French economy is less concentrated and thus large firms have even less chance to shape aggregate fluctuations.

By controlling for heterogeneous firm response to shocks and common local shocks to firms operating in the same geographical area, according to equation (9), the findings are similar, with a slight decrease of the relative importance of the LINK component (84 per cent) and a moderate increase in the DIRECT component (18 per cent). These results suggest and strengthen the recent findings of *Barrot and Sauvagnat* (*2016*), according to which firm-level shocks propagate through vertical and horizontal connections between firms: shocks to input providers have an impact on downstream partners, and the other way around, a troubled (a growing) output buyer negatively (positively) affects the sales of the upstream partner. Seemingly, even if the Hungarian economy is "granular", shocks to large firms cannot generate

[13] See *Figure 4* in *Annex B* for the time series of the channels.

business cycles on their own, but firm-to-firm linkages do: idiosyncratic shocks affecting firms can be amplified causing sizable aggregate effects.

Table 7
Impact of the DIRECT and LINK component on the aggregated firm-specific component

	(1)		(2)	
	Variance	**Rel. Var.**	**Variance**	**Rel. Var.**
Aggregated idiosyncratic component	0.0022	1.0000	0.0020	1.0000
DIRECT	0.0004	0.1632	0.0004	0.1843
LINK	0.0019	0.8837	0.0017	0.8439

Note: This table presents the average variance of the aggregated firm-specific $\frac{1}{T}\sum_{t=2001}^{2012}\sigma_{F\tau}^2$ and its DIRECT and LINK component computed as in equation (10) in absolute and relative terms – $DIRECT_{rel}=\frac{1}{T}\sum_{t=2001}^{2012}\frac{DIRECT_\tau}{\sigma_{F\tau}^2}$ and $LINK_{rel}=\frac{1}{T}\sum_{t=2001}^{2012}\frac{LINK_\tau}{\sigma_{F\tau}^2}$, respectively. In the first specification, idiosyncratic shocks to firms are estimated following equation (1), while in the second one as in equation (9).

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

5. Conclusions

The aim of the paper was to analyse the role of Hungarian firms in generating aggregate fluctuations. The analysis quantifies the impact of idiosyncratic shocks on aggregate sales growth volatility and found that – at the individual level – it was mostly idiosyncratic shocks that hit firms and that macro-sectoral factors play a relatively smaller role. This result simply implies that deviation from sectoral growth varies substantially across firms: many of them were growing despite the recession and during booms one can also find numerous declining firms.

Interestingly, in contrast to the decades-old common wisdom that idiosyncratic shocks average out at the macro level, the second-stage results of the paper indicate that firm-level shocks are also capable of shaping the business cycle; moreover, they make a very high relative contribution to the aggregated sales growth volatility. Even though Hungary is one of the most open economies of the world and is exposed to sizable foreign and sectoral shocks, almost 50 per cent of the aggregate sales volatility is due to firm-level fluctuations, events that affect firm performance independently of macro-sectoral components.

Evidence suggests that the large contribution of firm-specific factors to aggregate fluctuations is driven by firm-to-firm linkages: shocks to a single firm can propagate and be amplified through production networks. The fat-tailed firm-size distribution plays a relatively less important role in generating business cycles. Although Hungarian sales are quite concentrated, the results also imply that – on its own – the performance of large firms has a moderate impact on aggregate volatility.

The surprisingly high importance of firm-level shocks in generating business cycles underlines the necessity of future research on understanding the determinants of firm-level disturbances. Quantifying the sources of firm-level fluctuations would provide valuable insight for policymakers as well.

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Annex A. The model: A multi-sector heterogeneous firm framework

This section presents a simple multi-sector heterogeneous firm model in the spirit of *Di Giovanni et al*. (*2014*) to motivate the decomposition of aggregate sales growth into a macro-sectoral and firm-specific component.[14] Consumers derive utility from the following Cobb-Douglas function:

$$U_t = \prod_{j=1}^{J} \left(C_{jt}\right)^{\varphi_{jt}}, \tag{11}$$

where C_{jt} is consumption of sector j at time t, and φ_{jt} is a time-varying demand shock for sector j. Let Y_t denote aggregate expenditure at time t, and Y_{jt} the expenditure in sector j. By using the Cobb-Douglas utility function, expenditure on sector j is a fraction φ_{jt} of total expenditure: $Y_{jt} = \varphi_{jt} Y_t$.

Sectors are CES aggregate of ω_{fjt} varieties f available at time t:

$$C_{jt} = \left[\Sigma_{f \in \Omega_{jt}} \left(\omega_{fjt}\right)^{\frac{1}{\theta}} \left(C_{ft}\right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta-1}{\theta}}, \tag{12}$$

Where ω_{fjt} is a time-varying demand shock for variety f.

In this model framework, each firm sells a unique variety within sector j and hence has some market power. Firms are also heterogeneous in productivity denoted by a time-varying unit input requirement a_{ft} having a cost of c_{jt} in sector j at period t. The input bundle can have cost of labour and capital, respectively. In this manner, sales by a firm is given by:

$$x_{ft} = \omega_{fjt} \frac{\varphi_{jt} Y_t}{P_{jt}} \left(\frac{\theta-1}{\theta} c_{jt} a_{ft} \right)^{1-\theta}, \tag{13}$$

where P_{jt} is the price level in sector j at time t.

The sales growth rate γ_{ft} of firm f between time t−1 and time t is in log difference form:

$$\gamma_{ft} = \tilde{\delta}_t + \tilde{\delta}_{jt} + \varepsilon_{ft}, \tag{14}$$

where $\tilde{\delta}_t = \Delta \log Y_t$ is the aggregate ("macroeconomic") shock to demand, $\tilde{\delta}_{jt} = \Delta \log \varphi_{jt} + (1-\theta)(\Delta \log c_{jt} - \Delta \log P_{jt})$ captures the sectoral demand and cost shocks, and $\varepsilon_{ft} = \Delta \log \omega_{ft} + (1-\theta)(\Delta \log a_{ft})$ is the firm-specific demand and cost shock.

[14] The difference between my approach and that of *Di Giovanni et al.* (*2014*) is that – because of data restrictions – I decompose total (domestic plus export) firm-level sales growth rather than firm destination-level sales growth since I do not observe the export destinations.

However, note that I cannot estimate the macroeconomic $\tilde{\delta}_t$ and industrial component $\tilde{\delta}_{jt}$ separately without further restrictions. But my goal is similar to *Di Giovanni et al*. (*2014*) in the sense that ultimately I am not interested in investigating the impact of those two components, but rather the firm-specific shocks on aggregate sales volatility. Finally, I encompass macro and industrial shock into a macro-sectoral shock $\delta_{jt} = \tilde{\delta}_t + \tilde{\delta}_{jt}$ and use the following equation for estimation:

$$\gamma_{ft} = \delta_{jt} + \varepsilon_{ft}. \quad (15)$$

In this manner, idiosyncratic shocks ε_{ft} are estimated as the deviation of firm-level sales growth rates γ_{ft} from the industrial average growth rates δ_{jt}.

Annex B. Extra tables and figures

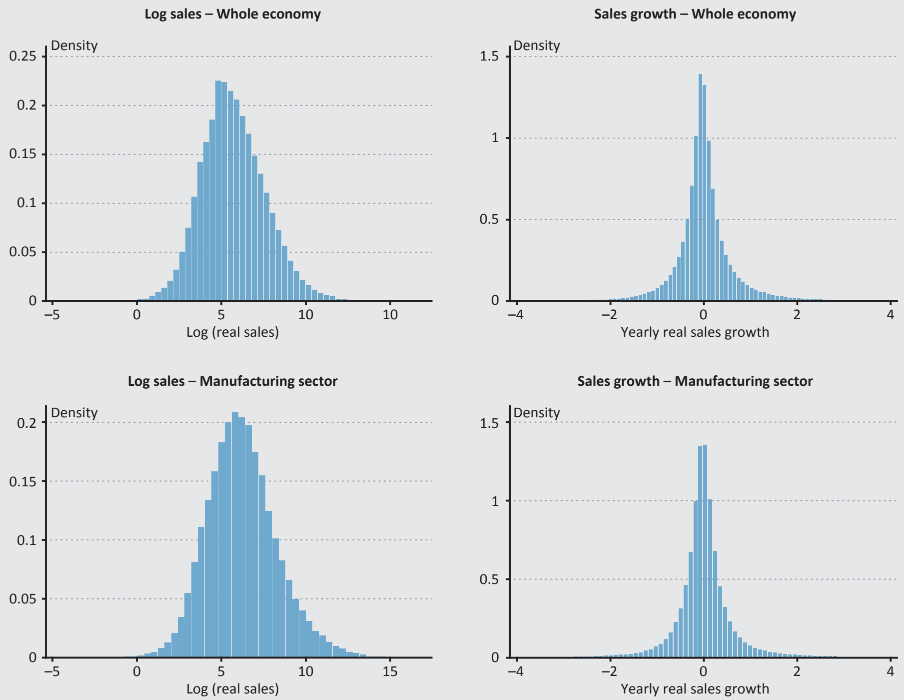
Table 8
Top and bottom real sales growth cut-off values

	Whole economy		Manufacturing	
percentiles	**bottom**	**top**	**bottom**	**top**
1%	–2.0574	2.7523	–1.7836	2.3081
5%	–0.9282	1.2185	–0.8255	0.9515
10%	–0.5813	0.7158	–0.5377	0.5688
25%	–0.2258	0.2418	–0.2288	0.2067
50%	–0.0079		–0.0159	

Note: This table presents the top and bottom percentiles of firm-level real sales growth rate used for outlier treatment.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

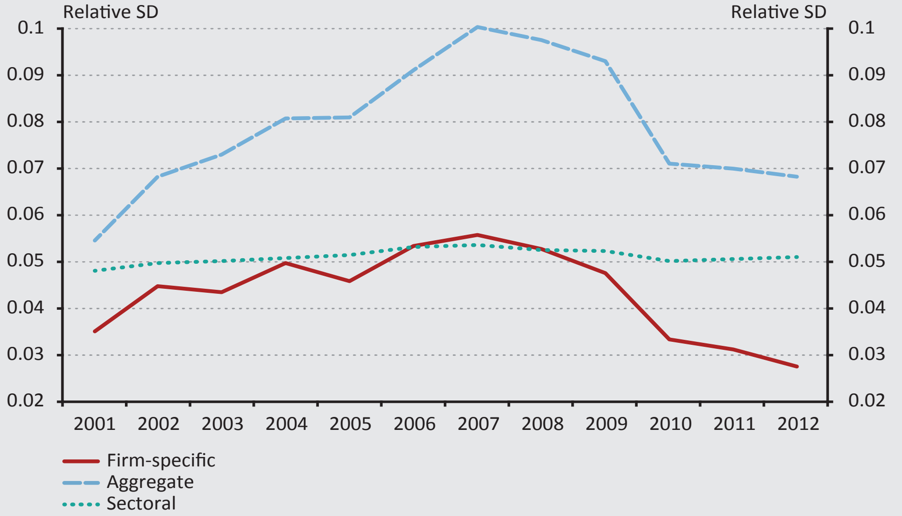
Figure 2
Distribution of sales and yearly sales growth rates



Note: This figure presents the distribution of the logarithm of average real sales (first column) and the yearly growth rate of real sales at the firm level (second column) for the whole economy (first row) and for the manufacturing sector (second row).

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

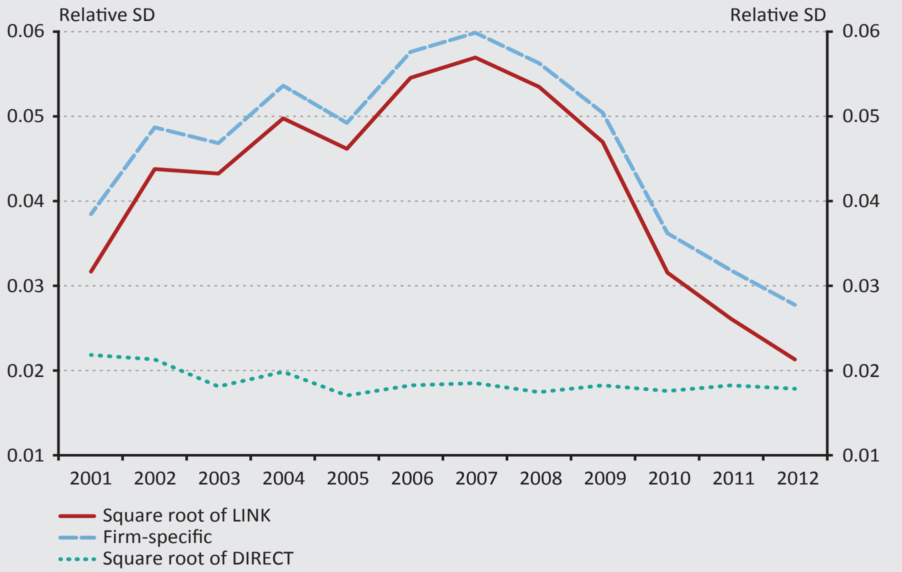
Figure 3
Aggregate sales growth fluctuation and its components



Note: This figure plots the time series of the aggregated sales growth volatility $\sigma_{A\tau}$ and its firm-specific $\sigma_{F\tau}$ and macro-sectoral component $\sigma_{J\tau}$ over the period 2001–2012.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).

Figure 4
Contribution of individual volatilities and covariance terms to firm fluctuations



Note: This figure presents the decomposition of aggregated firm-level fluctuations $\sigma_{F\tau}$ into the square root of the DIRECT and LINK component following equation (10) over the period 2001–2012.

Source: Computation based on the data of the National Tax and Customs Administration of Hungary (NAV).