Firms, Destinations, and Aggregate Fluctuations*

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Abstract

This paper uses a database covering the universe of French manufacturing firms for the period 1990–2007 to provide a forensic account of the role of individual firms in generating aggregate fluctuations. We first decompose aggregate sales growth into its *intensive* and *extensive* components. The extensive margin of entering and exiting firms accounts for about 25% of the growth rate of total output in an average year, but the year-to-year variation in output growth is accounted for primarily by movements in the intensive margin. We next set up a simple multi-sector model of heterogeneous firms selling to multiple markets to motivate a theoretically-founded set of estimating equations that decompose firms' annual sales growth rate into different components. We find that the idiosyncratic firm components contribute substantially to aggregate volatility, mattering about as much as the country-level and sectoral components. The finding that idiosyncratic firm-level shocks appreciably affect aggregate volatility is evidence for the importance of large firms for aggregate fluctuations.

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1 Introduction

A long tradition in macroeconomics seeks to understand the microeconomic underpinnings of aggregate fluctuations. Starting with the seminal work of Long and Plosser (1983), an important line of research explores the role of sectoral shocks in generating aggregate fluctuations (see, e.g., Stockman, 1988; Horvath, 1998, 2000; Dupor, 1999; Foerster et al., 2011; Carvalho, 2009; Carvalho and Gabaix, 2010, among many others). The role of firms in the aggregate business cycle has received comparatively less attention. A recent contribution by Gabaix (2011) points out that because the firm size distribution is extremely fat-tailed, idiosyncratic shocks to individual (large) firms will not average out, and instead lead to aggregate fluctuations. A different strand of the literature models the relationship between the extensive margin – firms' entry and exit – and macroeconomic fluctuations (see, e.g., Alessandria and Choi, 2007; Bilbiie et al., 2007; Ghironi and Melitz, 2005). However, a comprehensive account of the role of aggregate, sectoral, and firm-level components at both the extensive and intensive margins in generating aggregate fluctuations is currently lacking.

This paper constructs a novel database covering the universe of French manufacturing firms' domestic sales and destination-specific exports for the period 1990–2007, and uses it to provide a forensic account of the contribution of (i) the intensive vs. extensive margins, and (ii) individual firms to aggregate fluctuations. To guide the empirical exercise, we set up a simple multi-sector model of heterogeneous firms in the spirit of Melitz (2003) and Eaton et al. (2011), and use it to show how firm sales to an individual market can be decomposed into aggregate, sector-specific, and idiosyncratic components. Relative to other empirical studies of the extensive margin (e.g., Dunne et al., 1988), and of the role of sectoral shocks (e.g., Stockman, 1988; Foerster et al., 2011) a novel aspect of our exercise is that we take explicit account of the sector- and firm-level participation in the export markets. Thus, in our analysis the concept of extensive margin encompasses both entry into the domestic, and into foreign markets. Similarly, aggregate and sectoral shocks are defined for each destination market.

We estimate the empirical model suggested by theory using a panel regression in which the unit of observation is the annual firm-destination growth rate of sales. Our findings can be summarized as follows. First, the idiosyncratic component accounts for the overwhelming majority (97%) of the sales variability across firms in the firm-destination panel regressions. Second, most of the variation in the idiosyncratic component is driven by destination-specific components, rather than the component that is common to all destination markets served by the firm. The destination-specific idiosyncratic component accounts for 68% of the variation, while 32% is accounted for by the firm common component. Our conceptual framework allows us to give an economic interpretation to the components we uncover. For instance, country-specific aggregate growth components reflect aggregate demand and exchange rate movements; sectoral components in a particular country reflect some combination of the relative demand in the sector and the relative costs of producing in that sector. Firm idiosyncratic components are also some combination of demand and cost shocks occurring at the firm level relative to the other firms in the sector. Our estimates suggest that the main source of volatility at the firm-level is related to the demand shocks a firm faces in each of its destination markets.

We next use the regression results to perform an aggregation exercise, which allows us to address several questions. First, we decompose the variance of total sales in the economy into the variance due to the extensive margin – firms entering and exiting – and the intensive margin – firms present in both periods selling less or more. Second, the aggregation exercise takes into account the distribution of firm size, and thus can be used to gauge the importance of firm-level idiosyncratic components for aggregate fluctuations. We find that the extensive margin makes a substantial contribution – roughly one-quarter – to the growth rate of aggregate sales. However, the variation in aggregate sales growth from year to year is much better accounted for by the movements in the intensive margin. In addition, we find that the firm idiosyncratic components contribute substantially to aggregate volatility. Their contribution is roughly similar in magnitude to that of the country-specific and sectoral components. We take this as evidence that large firms contribute to aggregate fluctuations, as first hypothesized by Gabaix (2011).

Finally, we perform an identical exercise for export sales only.[1] The analysis of the export subsample is motivated by two well-known facts: (i) aggregate exports are more volatile than GDP, and (ii) the largest firms tend to be exporters. Finally, as Canals et al. (2007) point out, international trade is very granular, both at the firm- and sector-destination level. We find that the idiosyncratic component contributes more to the volatility of exports, compared to overall sales.

This paper is related to several strands of the literature. The role of firm and sector level shocks in driving business cycles has received renewed attention in the empirical literature, starting with work examining the Great Moderation (see, for example, Comín and Philip-

[1] Though the trade literature has focused on the importance of the extensive margin, work by Bernard and Jensen (2004) show that the main driver of 1987–1992 export boom in the U.S.was the intensive margin.

pon, 2006; Davis et al., 2007). Jovanovic (1987) was an early theoretical contribution that showed how microeconomic shocks can impact the aggregate fluctuations. Gabaix (2011) shows how idiosyncratic shocks to firms can lead to aggregate fuctuations in an economy dominated by very large firms and provides empirical evidence for this phenomenon using U.S. data. Di Giovanni and Levchenko (2009a) extend this model to a multi-country framework, and provide cross-country evidence on its importance to differences in the magnitude of aggregate fluctuations across countries. Foerster et al. (2011) estimate a factor model on U.S. industrial production that incorporates input-output linkages, and find that sectoral shocks matter during periods of low volatility.[2] Empirical work on the role of sectoral shocks in a multi-country setting includes Stockman (1988) and Koren and Tenreyro (2007). In the open economy context, di Giovanni and Levchenko (2009b, 2010a) examine how sectoral shocks can impact countries' volatility and comovement.

Our work complements recent efforts in the quantitative literature to model the impact of the extensive margin on aggregate fluctuations. For instance, Ghironi and Melitz (2005), Alessandria and Choi (2007), Bilbiie et al. (2007), and Bergin and Corsetti (2008) use DSGE models to study the aggregate consequences of firm entry and exit into markets – the extensive margin. However, the empirical underpinnings of this literature currently lag behind the theoretical and quantitative models. First, due to data constraints existing work typically focuses on either entry into production or entry into exporting, but not both. Second, empirical papers presenting the stylized facts on the extensive margin focus on the medium- and long-run, and thus could miss potentially significant year-to-year dynamics. For instance, the classic paper by Dunne et al. (1988) uses the U.S. Census of Manufacturing over five-year periods. Similarly, Bernard et al. (2010) use data over five-year periods to present facts concerning the behavior of firms in switching products, which are used to motivate the quantitative studies of the extensive margin of varieties.[3] Besides potentially missing some of the year-to-year dynamics in entries and exits, these empirical exercises solely focus on the impact of extensive adjustments on the growth *level* while we are able to discuss their impact on aggregate *fluctuations*. In particular, we show that the correlation of entries and exits with aggregate fluctuations is low. This result can inform the debate in

[2]For theoretical work on sectoral linkages, see Horvath (1998), Horvath (2000), Dupor (1999), and Carvalho (2009).

[3]Unfortunately, our data does not allow us to measure changes in product or variety mixes of firms. Therefore, it is possible that some of the product switching discussed in Bernard et al. (2010) and emphasized in the work of Bilbiie et al. (2007) could in fact be picked up in our intensive margin. If one defines a variety as a firm sales to a given destination under a particular customs code, as is commonly done in the trade literature, it might be possible to measure the dynamics of varieties for exports. The main reason why we do not perform this exercise is that we do not have such information at the product level for domestic sales.

the macroeconomics literature on the impact of extensive margin adjustments on aggregate fluctuations.[4]

The rest of the paper is organized as follows. Section 2 begins by developing an accounting framework to decompose aggregate growth into the extensive and intensive components. It then presents a simple heterogeneous firms model that serves as a motivation for the empirical exercise. In the model, firm sales growth in each market can be decomposed into macroeconomic, sectoral, and idiosyncratic components. Given these results, it is possible to then derive a procedure to measure each components' contribution to *aggregate* volatility. Section 3 describes the datasets. Section 4 presents the main estimation results. Section 5 concludes.

2 Theoretical Framework

Total aggregate sales X_t by all French firms to all destinations are by construction given by: $X_t \equiv \sum_{f,n \in I_t} x_{fnt}$, where x_{fnt} is defined as the sales of firm f to market n in year t, and I_t is the set of firms f *and destinations* n being served at t. Thus, the unit of observation is a firm×destination pair, rather than a firm.[5] The growth rate of aggregate sales is then simply $\gamma_{At} = \ln X_t - \ln X_{t-1}$, by definition.

2.1 Intensive and Extensive Margins

Given the recent emphasis on the importance of the extensive margin in generating aggregate fluctuations (Bilbiie et al., 2007; Ghironi and Melitz, 2005), we first decompose the growth rate of aggregate sales into the intensive and extensive components. The intensive component at date t is defined as the growth rate of sales of firm-destination pairs that had positive sales in both year t and year $t-1$. The extensive margin is defined as the contribution to total sales of the appearance and disappearance of firm-destination-specific sales. The growth rate of total sales can be manipulated to obtain an (exact) decomposition

[4] For example, Lee and Mukoyama (2008), building on Hopenhayn and Rogerson (1993), study a DSGE model of industry dynamics with aggregate productivity shocks. They find no evidence of a "cleansing effect" during recessions, but find procyclical entry rates suggesting that the insulating effects of the entry margin dominate the impact of exits. Such work motivates the focus on entry rates (with exogenous exits) such as Bilbiie et al. (2007). Meanwhile, the model of Osotimehin and Pappadà (2010), building on Cooley and Quadrini (2001), examines the impact of exit decisions in the business cycle by focusing on credit market frictions.

[5] That is, suppose that there are two firms $f \in \{Renault, Peugeot\}$ and two markets, $n \in \{France, Germany\}$, and both firms sell to both markets, then $I_t = \{\{Renault, France\}, \{Renault, Germany\}, \{Peugeot, France\}, \{Peugeot, Germany\}\}$, and X_t is simply a summation over the sales of each firm and each destination.

into intensive and extensive components:

$$\begin{aligned}\gamma_{At} &\equiv \ln \sum_{f,n\in I_t} x_{fnt} - \ln \sum_{f,n\in I_{t-1}} x_{fnt-1} \\ &= \ln \frac{\sum_{f,n\in I_{t/t-1}} x_{fnt}}{\sum_{f,n\in I_{t/t-1}} x_{fnt-1}} - \left(\ln \frac{\sum_{f,n\in I_{t/t-1}} x_{fnt}}{\sum_{f,n\in I_t} x_{fnt}} - \ln \frac{\sum_{f,n\in I_{t/t-1}} x_{fnt-1}}{\sum_{f,n\in I_{t-1}} x_{fnt-1}} \right) \\ &= \tilde{\gamma}_{At} - \ln \frac{\lambda_t}{\lambda_{t-1}},\end{aligned} \tag{1}$$

where $I_{t/t-1}$ is the set of firm×destination pairs active in both t and $t-1$ (the "intensive" sub-sample of firms×destinations in year t) and λ_t (λ_{t-1}) is the share of output produced by this intensive sub-sample of firms in period t ($t-1$). Thus, the extensive margin calculation treats symmetrically entry into domestic production (a new firm appearing) and entry into exporting (an existing firm beginning exports to a particular destination n). Entrants have a one time positive impact on growth while exiters push the growth rate down, and the net impact is proportional to the share of entrants'/exiters' sales in aggregate sales.[6] Meanwhile, an observation only belongs to the intensive margin if an individual firm serves an individual destination in both periods.

One may also be interested in separating the extensive margin into firms entering production (the domestic extensive margin) and existing firms entering export markets. To set up this decomposition, let the destination index d refer to France (thus, the domestic sales), define I_{dt} to be the set of firms serving the domestic market in period t and define I_{xt} be the set of all firm×destination pairs active in period t in which the destination is not France – the set of export sales. By construction, $I_t = I_{dt} \bigcup I_{xt}$.[7] Similarly, let $I_{dt/t-1}$ be the set of domestic sales that is common across periods t and $t-1$, and let $I_{xt/t-1}$ be the set of corresponding export sales. Again, by construction $I_{t/t-1} = I_{dt/t-1} \bigcup I_{xt/t-1}$. Define the domestic and exporting equivalents of the extensive margin terms: $\lambda_{dt} = \frac{\sum_{f\in I_{dt/t-1}} x_{fdt}}{\sum_{f\in I_{dt}} x_{fdt}}$ and $\lambda_{xt} = \frac{\sum_{f,n\in I_{xt/t-1}} x_{fnt}}{\sum_{f,n\in I_{xt}} x_{fnt}}$. Then, straightforward manipulation leads to the following expression: $\lambda_t = \omega_{dt}\lambda_{dt} + (1-\omega_{dt})\lambda_{xt}$, where $\omega_{dt} = \frac{\sum_{f\in I_{dt}} x_{fdt}}{\sum_{f,n\in I_t} x_{fnt}}$ is the share of domestic sales in total sales of firms at time t. Using a Taylor expansion around $\lambda_{dt} = \lambda_{xt} = 1$ leads to the following decomposition:

$$\ln \lambda_t \approx \frac{\sum_{f\in I_{dt/t-1}} x_{fdt}}{\sum_{f,n\in I_{t/t-1}} x_{fnt}} \ln \lambda_{dt} + \frac{\sum_{f,n\in I_{xt/t-1}} x_{fnt}}{\sum_{f,n\in I_{t/t-1}} x_{fnt}} \ln \lambda_{xt}.$$

[6] This decomposition follows the same logic as the decomposition of price indices proposed by Feenstra (1994)

[7] Following the example above, $I_{dt} = \{\{Renault, France\}, \{Peugeot, France\}\}$, and $I_{xt} = \{\{Renault, Germany\}, \{Peugeot, Germany\}\}$.

The weight on the $\ln \lambda_{dt}$ is the share of domestic sales observations present in both t and $t-1$ in total sales present in both t and $t-1$. Plugging these into the extensive margin component of (1), we get:

$$\ln \lambda_t - \ln \lambda_{t-1} = \left(\frac{\sum_{f \in I_{dt/t-1}} x_{fdt}}{\sum_{f,n \in I_{t/t-1}} x_{fnt}} \ln \lambda_{dt} - \frac{\sum_{f \in I_{dt/t-1}} x_{fdt-1}}{\sum_{f,n \in I_{t/t-1}} x_{fnt-1}} \ln \lambda_{dt-1} \right) + \left(\frac{\sum_{f,n \in I_{xt/t-1}} x_{fnt}}{\sum_{f,n \in I_{t/t-1}} x_{fnt}} \ln \lambda_{xt} - \frac{\sum_{f,n \in I_{xt/t-1}} x_{fnt-1}}{\sum_{f,n \in I_{t/t-1}} x_{fnt-1}} \ln \lambda_{xt-1} \right)$$

Finally, if in addition the share of domestic sales *in the common set of sales observations* is roughly constant between t and $t-1$: $\frac{\sum_{f \in I_{dt/t-1}} x_{fdt}}{\sum_{f,n \in I_{t/t-1}} x_{fnt}} \approx \frac{\sum_{f,n \in I_{dt/t-1}} x_{fdt-1}}{\sum_{f,n \in I_{t/t-1}} x_{fnt-1}} \equiv \omega_{dt/t-1}$, then the expression above simplifies to:

$$\ln \frac{\lambda_t}{\lambda_{t-1}} \approx \omega_{dt/t-1} \ln \frac{\lambda_{dt}}{\lambda_{dt-1}} + (1 - \omega_{dt/t-1}) \ln \frac{\lambda_{xt}}{\lambda_{xt-1}}. \quad (2)$$

The first term on the right-hand side is the domestic extensive margin, while the second term is the foreign extensive margin.

2.2 A Motivating Model of Firm Sales Growth

To motivate the decomposition of the growth of firms in a given year into (i) firm-specific idiosyncratic, (ii) sectoral, and (iii) country ("macroeconomic") components, we consider a multi-sector heterogeneous firms model in the spirit of Melitz (2003) and Eaton et al. (2011). There are N countries indexed by n, and J sectors indexed by j. In country n, consumer within-period utility is Cobb-Douglas in the sectors $1, ..., J$:

$$U_{nt} = \prod_{j=1}^{J} \left(C_{nt}^{j} \right)^{\alpha_{nt}^{j}}, \quad (3)$$

where C_{nt}^{j} is consumption of sector j in country n at time t, and α_{nt}^{j} is a time-varying demand shock for sector j in country n. The Cobb-Douglas functional form for the utility function leads to the well-known property that expenditure on sector j is a fraction α_{nt}^{j} of the total expenditure in the economy: $Y_{nt}^{j} = \alpha_{nt}^{j} Y_{nt}$, where Y_{nt} is aggregate expenditure in country n at time t, and Y_{nt}^{j} is the expenditure in sector j.

Each sector j is a CES aggregate of Ω_{nt}^{j} varieties available in country n at time t, indexed by f:

$$C_{nt}^{j} = \left[\sum_{\Omega_{nt}^{j}} (\omega_{fnt})^{\frac{1}{\sigma}} C_{nt}^{j}(f)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \quad (4)$$

where ω_{fnt} is a time-varying demand shock for variety f in market n.

Sector j in country n is populated by $\bar{I}^j_{nt}$ firms. Each of these firms sells a unique CES variety, and thus has some market power. Firms also differ in productivity, with each firm characterized by a time-varying marginal cost a_{fnt}. It takes firm f a_{fnt} input bundles to produce one unit of its good in period t. The input bundle in sector j, country n and period t has a cost c^j_{nt}. Note that it can vary by sector, but not across firms within a sector. This input bundle can include labor costs and the cost of capital. It is well known that these firms will price at a constant markup over their marginal cost, and conditional on selling to market n, sales by a French firm f (i.e., residing in country d) to market n in period t are given by:

$$x_{fnt} = \omega_{fnt} \frac{\alpha^j_{nt} Y_{nt}}{\left(P^j_{nt}\right)^{1-\sigma}} \left(\frac{\sigma}{\sigma - 1} \tau^j_{nd} c^j_{dt} a_{fdt}\right)^{1-\sigma}, \tag{5}$$

where τ^j_{nd} is the iceberg cost of selling from France to country n in sector j, and we normalize $\tau^j_{dd} = 1$. This equation assumes that (i) τ^j_{nd} is sector-specific but does not vary over time (though that assumption can easily be relaxed, in which case the time variation in τ^j_{nd} will be absorbed in the demand shock), and (ii) the cost bundle c^j_{dt} and the marginal cost a_{fdt} may vary over time, but are not destination-specific.

2.3 Sales Decomposition

Sales to a single destination – say, domestic sales to France – then admit the exact decomposition into macroeconomic, sectoral, and firm-specific idiosyncratic components. In log differences/growth rates, equation (5) becomes:

$$\gamma_{fdt} = \delta_{dt} + \delta_{jdt} + \varepsilon_{fdt}, \tag{6}$$

where γ_{fdt} is the growth rate of sales of firm f to market d, $\delta_{dt} = \Delta\log Y_{dt}$ is the aggregate ("macroeconomic") shock to French demand, $\delta_{jdt} = \Delta\log\alpha^j_{dt} + (1-\sigma)(\Delta\log c^j_{dt} - \Delta\log P^j_{dt})$ captures the sectoral (country d-specific) demand and cost shocks; $\varepsilon_{fdt} = \Delta\log\omega_{fdt} + (1-\sigma)\Delta\log a_{fdt}$ is the firm-specific idiosyncratic demand and cost shock.

The same can be said of the sales to any other country $n \neq d$. In log differences/growth rates, the sales of firm f to any other (foreign) destination n are given by:

$$\gamma_{fnt} = \delta_{nt} + \delta_{jnt} + \varepsilon_{fnt}, \tag{7}$$

where γ_{fnt} is the growth rate of sales of firm f to some foreign market n, $\delta_{nt} = \Delta\log Y_{nt}$ is the aggregate ("macroeconomic") shock in market n, $\delta_{jnt} = \Delta\log\alpha^j_{nt} + (1-\sigma)(\Delta\log c^j_{dt} - \Delta\log P^j_{nt})$

is the sectoral (country n-specific) demand and cost shock; $\varepsilon_{fnt} = \Delta\log\omega_{fnt} + (1-\sigma)\Delta\log a_{fdt}$ is the firm-specific idiosyncratic demand and cost shock.

Equations (6) for the domestic French market and (7) for every foreign market can be estimated using data on domestic sales and destination-specific exports, respectively. These are the main estimating equations of the paper.

Estimating these for each destination market delivers a time series of aggregate ("macroeconomic") shocks, but more interestingly sectoral ($\delta_{jnt} = \Delta\log\alpha^j_{nt} + (1-\sigma)(\Delta\log c^j_{dt} - \Delta\log P^j_{nt})$) and idiosyncratic ($\varepsilon_{fnt} = \Delta\log\omega_{fnt} + (1-\sigma)\Delta\log a_{fdt}$) shocks. Examining these, it is immediate that both of these have a common component: the French sector-j cost shock $\Delta\log c^j_{dt}$ in the case of the sectoral shocks, and the firm-f productivity shock $\Delta\log a_{fdt}$. So, we can isolate the sectoral destination-specific and idiosyncratic destination-specific demand shocks by taking estimates of δ_{jnt} resulting from the destination-specific estimation, and further extracting the common component:

$$\delta_{jnt} = \delta^1_{jt} + \delta^2_{jnt}. \tag{8}$$

Where now δ^1_{jt} in this regression is the time effect, representing the sectoral cost shock that is common to all destinations: $\delta^1_{jt} = (1-\sigma)\Delta\log c^j_{dt}$, and δ^2_{jnt} is the residual, representing a destination-specific sectoral demand shock: $\delta^2_{jnt} = \Delta\log\alpha^j_{nt} - (1-\sigma)\Delta\log P^j_{nt}$.[8]

Same for the firm-specific shocks. Armed with the estimated series for ε_{fnt} for all destinations, we can run:

$$\varepsilon_{fnt} = \varepsilon^1_{ft} + \varepsilon^2_{fnt}, \tag{9}$$

Here, ε^1_{ft} is the time effect, which represents the firm idiosyncratic shock common to all destinations: $\varepsilon^1_{ft} = (1-\sigma)\Delta\log a_{fdt}$, and ε^2_{fnt} is the residual that captures the destination-specific demand shock: $\varepsilon^2_{fnt} = \Delta\log\omega_{fnt}$.[9]

The two-step approach of (i) running (7), and (ii) taking the resulting estimates, and running (8) and (9) leads to a comprehensive set of estimates of shocks that are affecting firms. Using these, we can examine the role of firm- vs. destination-specific shocks in the aggregate volatility.

[8]Specifically, we can estimate δ^1_{jt} as the time t average of δ_{jnt} over all destinations that are served by French firms in sector j.

[9]Specifically, we can estimate ε^1_{ft} as the time t average of ε_{fnt} for each firm that serves multiple destinations (including the domestic market).

2.4 Aggregate Volatility

We next use the estimated extensive, intensive, as well as country ("macroeconomic"), sector, and idiosyncratic components to perform several decompositions of aggregate fluctuations. The exercise is based on the standard deviation of aggregate output growth between 1991 and 2007, which by definition is equal to:

$$\sigma_A = \sqrt{\frac{1}{T-1}\sum_{t=1991}^{2007}(\gamma_{At} - \bar{\gamma}_A)^2}, \tag{10}$$

where γ_{At} is the growth rate of total sales between $t-1$ and t and $\bar{\gamma}_A \equiv \frac{1}{T}\sum_{t=1991}^{2007}\gamma_{At}$ is the mean growth rate over the sample period.[10]

2.4.1 Intensive and Extensive Margins

Using equation (1), the impact of the intensive and extensive margins on aggregate volatility then can be written as:

$$\sigma_A^2 = \tilde{\sigma}_A^2 + \sigma_\lambda^2 - 2\text{Cov}(\tilde{\gamma}_{At}, g_{\lambda t}), \tag{11}$$

where $g_{\lambda t} \equiv \ln \lambda_t/\lambda_{t-1}$ is the growth rate of λ, the extensive component of equation (1), $\tilde{\sigma}_A^2$ is the variance of the intensive margin growth rate $\tilde{\gamma}_{At}$, and $\text{Cov}(\tilde{\gamma}_{At}, g_{\lambda t})$ is the covariance between the two.

The volatility of total sales is the sum of three components: i) the volatility of output produced by incumbent firms, ii) the volatility of entries and exits during the sample period and iii) the (potential) covariance of the previous two components. A convenient feature of this decomposition is that it accounts for the impact of extensive margin adjustments on aggregate volatility in a very simple way.

2.4.2 Intensive Margin and Macroeconomic, Sectoral, and Firm-Specific Idiosyncratic Shocks

The intensive component of aggregate growth rate, $\tilde{\sigma}_A^2$, can be further decomposed into the macroeconomic, sectoral, and firm idiosyncratic components from the empirical model (6). The (intensive) aggregate growth rate of sales to all destinations can be written as:

$$\tilde{\gamma}_{At} = \sum_n w_{nt-1}\delta_{nt} + \sum_{j,n} w_{jnt-1}\delta_{jnt} + \sum_{f,n} w_{fnt-1}\varepsilon_{fnt}, \tag{12}$$

[10] To examine the patterns of aggregate volatility over time, below we also work with rolling five-year standard deviations, defined as $\sigma_{A,t} = \sqrt{\frac{1}{4}\sum_{\tau=t-2}^{\tau=t+2}(\gamma_{A\tau} - \bar{\gamma}_{At})^2}$, where $\bar{\gamma}_{A,t} \equiv \frac{1}{5}\sum_{\tau=t-2}^{\tau=t+2}\gamma_{A\tau}$.

where w_{nt-1} is the share of market n in the total sales of French firms, w_{jnt-1} is the share of sector j's sales to market n in total sales of French firms to all sectors and destinations, and w_{fnt-1} is the share of firm f's sales to destination n in total sales. Here, of course, the impact of imperfectly correlated sectoral and firm shocks comes through clearly: whereas the macroeconomic shock to domestic sales to France δ_{dt} has the weight of w_{dt-1}, which is about 75%, all the disaggregate shocks are weighted by the share of that sector×destination or firm×destination in total sales. Written this way, it is immediate why the literature has typically found only a limited role for sectoral shocks in aggregate fluctuations (see, most recently, the motivating exercise of Foerster et al., 2011): the weight on any individual sector×destination – w_{jnt-1} – is likely to be much smaller than the weight on the macroeconomic shock. However, this formulation also opens the door for idiosyncratic firm shocks to affect aggregate movements, irrespective of whether the sectoral shocks matter or not. This is the insight of Gabaix (2011): if the distribution of firm size is sufficiently fat-tailed – which is a statement about w_{fnt-1}'s – idiosyncratic firm shocks will be quantitatively important.

The role of sectoral and firm-idiosyncratic components for the aggregate growth rates can be further decomposed into the components common to all destinations served by sector/firm, and destination-specific components. Combining (7), (8), and (9), the growth rate of aggregate sales to all destinations can be written as:

$$\tilde{\gamma}_{At} = \sum_n w_{nt-1}\delta_{nt} + \sum_j \left(w_{jt-1}\delta^1_{jt} + \sum_n w_{jnt-1}\delta^2_{jnt} \right) + \sum_f \left(w_{ft-1}\varepsilon^1_{ft} + \sum_n w_{fnt-1}\varepsilon^2_{fnt} \right), \tag{13}$$

where w_{jt-1} is the share of sector j's sales in total sales by French firms to all markets, and w_{jnt-1} is the share of sales in sector j to market n in total sales, with firm-specific shares w_{ft-1} and w_{fnt-1} defined similarly. This expression captures the notion that while the common component of, say, a sectoral shock δ^1_{jt} cannot be diversified by selling to multiple markets, to the extent that some part of the sectoral shock is idiosyncratic to a particular destination (δ^2_{jnt}), it can be diversified across markets.

The variance of the intensive component of aggregate volatility $\tilde{\sigma}^2_A$ can be written as the combination of the variances and covariances of the aggregate, sectoral, and idiosyncratic shocks:

$$
\begin{aligned}
\tilde{\sigma}_A^2 = & \underbrace{\frac{1}{T}\sum_{t=1991}^{2007}\left(\sum_n w_{nt-1}\delta_{nt} - \frac{1}{T}\sum_{t=1991}^{2007}\sum_n w_{nt-1}\delta_{nt}\right)^2}_{Macroeconomic\ Volatility} \\
& + \underbrace{\frac{1}{T}\sum_{t=1991}^{2007}\left(\sum_{j,n} w_{jnt-1}\delta_{jnt} - \frac{1}{T}\sum_{t=1991}^{2007}\sum_{j,n} w_{jnt-1}\delta_{jnt}\right)^2}_{Sectoral\ Volatility} \\
& + \underbrace{\frac{1}{T}\sum_{t=1991}^{2007}\left(\sum_{f,n} w_{fnt-1}\varepsilon_{fnt} - \frac{1}{T}\sum_{t=1991}^{2007}\sum_{f,n} w_{fnt-1}\varepsilon_{fnt}\right)^2}_{Idiosyncratic\ Volatility} \\
& + COV,
\end{aligned}
\tag{14}
$$

where the term COV represents the covariances of the shocks from different levels of aggregation – that is, the covariances of macroeconomic with sectoral shocks, sectoral with idiosyncratic, and macroeconomic with idiosyncratic. The aggregation has to take into account the shares of markets (w_{nt-1}), sectors (w_{jnt-1}) and individual firms (w_{fnt-1}) in total sales.

The first term measures the volatility of "macroeconomic" shocks, that are common across all firms in all sectors of a particular destination market. If the geographical distribution of sales is roughly constant over time ($w_{nt-1} \approx w_n\ \forall t$), the first term can be re-written as:

$$
\begin{aligned}
\frac{1}{T}\sum_{t=1991}^{2007}\left(\sum_n w_{nt-1}\delta_{nt} - \frac{1}{T}\sum_{t=1991}^{2007}\sum_n w_{nt-1}\delta_{nt}\right)^2 = \\
\sum_n w_n^2 Var(\delta_{nt}) + \sum_n \sum_{n' \neq n} w_n w_{n'} Cov(\delta_{nt}, \delta_{n't}).
\end{aligned}
$$

The "macroeconomic volatility" is thus driven by the volatility of shocks affecting all firms selling goods in any given market ($Var(\delta_{nt})$) and the covariance of macroeconomic shocks across countries ($Cov(\delta_{nt}, \delta_{n't})$). Obviously, the importance of any country-specific shock in explaining aggregate volatility is increasing in the relative size of that market (measured by w_n): French shocks have more of an impact than shocks affecting firms selling goods in, say, Japan. In that sense, diversification of sales across markets helps reduce aggregate fluctuations. In the meantime, comovement across countries tends to amplify aggregate fluctuations: an increased synchronization of business cycles among EMU members might for instance drive French volatility up.

The second term in (14) measures the contribution of sectoral shocks to aggregate fluctuations. If sectoral weights are roughly constant over time ($w_{jnt-1} \approx w_{jn}\ \forall t$), the second term relates to the variance and covariance of sectoral shocks:

$$\frac{1}{T}\sum_{t=1991}^{2007}\left(\sum_{j,n} w_{jnt-1}\delta_{jnt} - \frac{1}{T}\sum_{t=1991}^{2007}\sum_{j,n} w_{jnt-1}\delta_{jnt}\right)^2 =$$
$$\sum_{j,n} w_{jn}^2 \mathrm{Var}(\delta_{jnt}) + \sum_{j,n}\sum_{j',n'\neq j,n} w_{jn}w_{j'n'}\mathrm{Cov}(\delta_{jnt},\delta_{j'n't}).$$

The sectoral volatility is thus driven by the shocks affecting each specific sector as well as the covariance of shocks across sectors and across markets within sectors. Here as well, the contribution of each sector to aggregate fluctuations is proportional to the size of that sector (w_{jn}): a country specializing in highly volatile sectors is likely to display large aggregate fluctuations (Koren and Tenreyro, 2007; di Giovanni and Levchenko, 2010a). Moreover, cross-sector correlations, operating via input-output linkages for instance, tend to increase aggregate volatility (see, e.g., di Giovanni and Levchenko, 2010b).

Finally, the third term in (14) measures the contribution of firms to aggregate fluctuations. If firm-level weights are constant over time ($w_{fnt-1} \approx w_{fn}\ \forall t$), which also implies that the extensive margin is not too important ($I_{t/t-1} \approx I\ \forall t$), the last term in (14) is related to the variance and covariance of idiosyncratic shocks:

$$\frac{1}{T}\sum_{t=1991}^{2007}\left(\sum_{f,n} w_{fnt-1}\varepsilon_{fnt} - \frac{1}{T}\sum_{t=1991}^{2007}\sum_{f,n} w_{fnt-1}\varepsilon_{fnt}\right)^2 =$$
$$\sum_{f,n} w_{fn}^2 \mathrm{Var}(\varepsilon_{fnt}) + \sum_{f,n}\sum_{f',n'\neq f,n} w_{fn}w_{f'n'}\mathrm{Cov}(\varepsilon_{fnt},\varepsilon_{f'n't}).$$

As in Gabaix (2011), the firm-level contribution to aggregate volatility is likely to be larger, everything else equal, if the distribution of sales across firms is more dispersed.[11] Furthermore, volatility also increases if the larger firms face more volatile shocks. Finally, a positive correlation of shocks across firms, for instance driven by vertical linkages, will increase the firm-level component of aggregate fluctuations.

Together with equation (10), equation (14) thus describes an economy where aggregate fluctuations are driven by multiple shocks, allowing for a general covariance structure

[11] In particular, if the idiosyncratic volatility is homogeneous across firms and shocks are not correlated, as assumed by Gabaix (2011), the firm-level component of aggregate fluctuations can be written as: $Var(\varepsilon) \times \sum_{f,n} w_{fn}^2$. Therefore, aggregate volatility is increasing with the Herfindahl index of individual sales, $\sum_{f,n} w_{fn}^2$.

between them. In particular, the decomposition allows us to measure the relative contribution of i) extensive adjustments, ii) macroeconomic shocks, iii) sector-specific shocks and iv) shocks to individual firms in the volatility of aggregate sales. Which component matters most quantitatively is an empirical question that we try to answer with our firm-level data.

3 Data Description

The analysis is performed on firm-level data describing domestic and export sales of French firms over the 1990–2007 period. The firm-level information is sourced from two rich datasets provided to us by the French administration. Both datasets can be merged together thanks to a unique *firm* identifier, called SIREN. We do not have any information at the *plant* level.

The first dataset, collected by the fiscal administration, gives balance-sheet information contained in the firms' tax forms. We restrict the analysis to firms in the manufacturing and service sectors. For those firms, the French tax system distinguishes three different regimes, the "normal" regime (called BRN for *Bénéfice Réel Normal*), the "simplified" regime (called RSI for *Régime Simplifié d'Imposition*) that is restricted to smaller firms, and the "micro-BIC" regime for entrepreneurs. The amount of information that has to be provided to the fiscal administration is more limited in the RSI than in the BRN regime, and even more for "micro-BIC" firms. Under some conditions, firms can choose their tax regime. An individual entrepreneur can thus decide to enroll in the "micro-BIC" regime if its annual sales are below 80,300 euros. Likewise, a firm can choose to participate in the RSI rather than the BRN regime if its annual sales are below 766,000 euros (231,000 euros in services).[12]

Throughout the exercise, "micro-BIC" firms are excluded, both because their weight in annual sales is negligible and because these data are complicated to harmonize with the rest of the sample. Most of the time, we also exclude RSI firms. In 2007, those firms represent less than 4% of total sales and about 11% of total employment. We however use the information contained in the RSI files to correct the data for a sample selection bias. Namely, the entry of a firm in the BRN file can either be interpreted as the result of a new firm being created or as the consequence of the firm switching from the RSI to the BRN regimes while growing. We use the information on the presence of firms in the RSI files to discriminate between these two interpretations. This helps refine the definition of "entries"

[12] Those thresholds are for 2010. They are adjusted over time, but marginally so.

and "exits" we use in the analysis. Since we do not have the information on micro-BIC firms, such correction for the selection bias would not be possible with the RSI files, which justifies neglecting them from the analysis.

The BRN sample covers 1,577,039 firms undertaking activities in 52 NAF sectors.[13] This represents around 30% of industrial and service firms but more than 90% of aggregate sales.[14] Of those firms, 208,596 belong to the manufacturing industry (22 NAF industries), which accounts for around 30% of aggregate sales. The dataset provides us with a detailed description of the firms' balance sheets, namely their total, domestic and export sales, their value added, as well as many components of their costs including the wages they pay, the primary material they buy, etc.

The information collected by the tax authorities is combined with firm-level export data provided to us by the French customs authorities. This individual database gives the (free on board) value each French firm exports to each of its destinations over a given fiscal year.[15] Merging these bilateral export flows with the balance sheets completes the dataset with information about the participation of firms in international markets and the geographical distribution of their foreign sales. In our sample, 18% of firms do export at some point in time (42% of manufacturing firms). In merging together the customs and balance-sheet data, there are a number of issues: i) we drop observations on firms that appear in the customs but do not appear in the BRN file (some of these firms may produce farming goods, which are not in the balance-sheet data); ii) a number of firms declare positive exports to the tax authorities but are not in the customs files. Since our procedure exploits the bilateral dimension of exports, and the customs data are the most reliable source of exporting information, we assume that those firms are non-exporters; iii) even when the

[13] "NAF", *Nomenclature d'Activité Française*, is the French industrial classification. Our analysis considers the level of aggregation with 60 sectors. We however merge together small sectors (in terms of the number of observations), namely tobacco and other food industries (NAF 15 and 16), all mineral products (NAF 13, 14 and 26), all combustible and fuel industries (NAF 10, 11, 12 and 23). We also neglect NAF sectors 95 (domestic services), and 99 (activities outside France). The NAF nomenclature has been created in 1993, as a replacement for the "NES" (*Nomenclature Economique de Synthèse*). Data for 1990-1992 are converted into the NAF classification using a correspondence table.

[14] We later neglect the banking sector because of important restructurings at the beginning of the 2000s that artificially add a large amount of volatility in the dataset. This sector represents less than 4% of total sales in 1990 but more than 25% at the end of the period.

[15] The customs data are quasi-exhaustive. There is a declaration threshold of 1,000 euros for annual exports to any given destination. Below the threshold, the customs declaration is not compulsory. Since 1993, intra-EU trade is no longer liable for any tariff, and as a consequence firms are no longer required to fill the regular Customs form. A new form has however been created, that allows keeping track of intra-EU trade. Unfortunately, the declaration threshold for this kind of trade flows in much higher, around 150,000 euros per year. A number of firms continue declaring intra-EU export flows below the threshold however, either because they do not know *ex-ante* that they don't need to, or because they delegate the customs-related tasks to a third party (e.g. a transport firm) that systematically fills the customs form.

firm is present in both the customs and the BRN data, the value of export sales is never the same in the two databases. We thus use the customs data to compute the share of each destination market in total firm exports and apply these shares to export sales provided in the BRN file.

With such micro-level data, it is not surprising that the set of individual growth rates we obtain is very noisy. In fact there are a number of reasons for the data to display important outliers. For instance, the BRN file does not provide any information on firms whose accounts are controlled by the fiscal administration during a given year. For these firms, the "Sales" variable is either zero or missing, which transmits into either extreme growth rates or artificial exits and re-entries around the year the firm is controlled. Also, firms that change their organizational structure in a given year, grouping activities together in different entities result in a number of large "exits." In a number of cases, firms decided to create new holding companies that pooled together the charges and benefits of all firms composing the group. The members of those groups, that before filled separate tax forms, disappeared from the fiscal files as a consequence.

In order for those extreme observations not to introduce noise in the estimation and aggregation exercise, we apply a trimming procedure. Namely, we neglect those individual growth rates in which sales are either double or half their previous year's value. Moreover, we consider as entries and exits into production those firms that enter the dataset for the very first time and leave it definitively. This neglects temporary "exits" that are probably induced by the firm not having to fill a fiscal form that specific year. Finally, we drop 0.5% of exit flows that correspond to the 99.5 percentile of the distribution of exiters' sales. This last trimming is meant to target those large, often publicly listed firms that were subject to mergers or acquisitions and thus artificially exited the sample. This data cleaning procedure produces a sample of firms whose total sales and export sales mimic aggregate activity quite well. Indeed, the growth rate of total sales in the final sample tracks the growth rate of GDP quite well (Figure 1), while the total export sales move with country exports over time (Figure 2).[16] Table 1 presents summary statistics for firm-level growth rates for the whole economy and the manufacturing sector, respectively. Growth rates tend to be higher for the average firm and more disperse across all firms in the manufacturing sector, but overall there is not a large difference between firms in the manufacturing sector relative to all firms in the economy.

[16] Note also that even given the limited time dimension of our sample, we are still able to pick up a cycle of the French economy, including the 1992–1993 and 2000–01 recessions and the acceleration of growth at the end of the nineties.

To cross-check the characteristics of entrants and exiters in our sample with existing literature, Table 2 presents the various statistics describing the entering and exiting firms, along the lines of the approach developed by Dunne et al. (1988). We present the average number of entering and exiting firms, their market share, and their relative size. About 17% of firms in any given year are entrants, representing on average 3.4% of total sales. The typical entrant is smaller, at about 18% of the size of an incumbent firm. About 15% of firms exit in a given year. The exiters are even smaller than entrants at less than 10% of average remaining firm, and representing less than 2% of total sales. These figures line up reasonably well with what Dunne et al. (1988) found for the U.S. if we convert our rates to a five-year basis.[17]

4 Empirical Results

4.1 The Extensive Margin

Table 3 presents the breakdown of the growth rate of aggregate sales into the intensive and extensive margins, while Figure 3 depicts the time series plots of the growth rates of total sales, intensive, and extensive margins, following equation (1).[18] Two striking features of these results stand out. First, the contribution of the extensive margin to the aggregate growth rate is noticeable. On average, about one quarter of the growth in aggregate sales is attributable to firms entering and exiting.[19]

Second, the correlations between the margins and the aggregate differ sharply. The intensive margin has a very high correlation with the aggregate sales growth, at 0.92 for the 1992–2007 sample period. By contrast, the extensive margin is much less correlated with the aggregate, with a correlation of 0.51. Though the extensive margin is substantial, the movements in the total sales growth are tracked much better by the intensive margin. Table 4 and the bottom half of Figure 3 repeat the exercise for domestic and export sales separately. The picture is broadly similar for domestic and export sales. The extensive margin contributes roughly the same on average to the growth of domestic sales and exports.

[17] Dunne et al. (1988) find values for the net entry rate between −0.003 and 0.068 depending on the period they consider. If we assume that our annual net entry rate is constant over the 1992–2007, and equal to the sample's mean net entry rate, 0.0116, this implies a five-year rate of 0.0594. The maximum rate annual rate, 0.14, is consistent with a five-year net entry rate equal to 0.93. Our lowest net entry rate, −0.11, is consistent with a five-year net entry rate of −0.44. Finally, if we let annual net entry rates vary over time, we find five-year values between −0.25 and 0.40.

[18] Throughout the analysis, we omit the first year (1991), for which the extensive component appears upward biased due to censoring.

[19] Errors in the data would introduce an upward bias in these numbers. Thus, they should be treated as an upper bound on the true impact of the extensive margin.

It is also clear that the intensive margin of domestic sales and exports tracks total domestic sales and exports, respectively, substantially less well than the corresponding intensive margin.

Next, we examine how the extensive margin breaks down into domestic entry and entry into export markets. The last two columns of Table 3 present the contribution of the domestic and exporting extensive margins to aggregate growth, while Figure 4 plots the domestic and exporting components of the extensive margin. It is clear that for aggregate growth, the domestic extensive margin matters more, accounting for 60% of the total extensive margin, and 17% of the aggregate growth rate on average. The cyclical properties of the domestic and exporting margins are very similar to the overall extensive margin, with a correlation with aggregate growth of 0.45 and 0.55, respectively.

All in all, our conclusion regarding the extensive margin's importance for aggregate growth is somewhat ambiguous. While the extensive margin does explain a substantial fraction of aggregate sales growth on average, it seems to be much less relevant for the year-to-year fluctuations. To illustrate this point most clearly, Figure 5 plots the rolling 5-year standard deviation of aggregate sales, the intensive margin, and the extensive margin. The extensive margin volatility is much lower than the aggregate, and tracks the movements in aggregate volatility less well than the intensive growth rate. Figure 6 presents a decomposition of the rolling 5-year variance into the intensive variance, extensive variance, and the covariance between the two, as in equation (11). The figure confirms the conclusion that the extensive margin variance contributes little. In addition, it illustrates that the covariance between the intensive and intensive component is also a minor part of the variance of total sales.

4.2 Macroeconomic, Sectoral, and Idiosyncratic Shocks at the Firm Level

Before assessing the impact of sectoral and idiosyncratic shocks on aggregate volatility, we present the importance of the different components for explaining the variation in sales growth at the firm×destination level. The top panel of Table 5 reports the relative standard deviation of the idiosyncratic firm×destination component, sector×destination, and aggregate destination-specific (macroeconomic) component. The last column reports the correlation of each component with the actual firm sales growth. The bottom two panels report the same statistics focusing on domestic and export firm sales only.

It is clear that at the level of an individual firm×destination, variation in sales growth is dominated by the idiosyncratic, rather than macroeconomic or sectoral components. The standard deviation of the idiosyncratic component is nearly the same as the standard deviation of actual sales growth, and the correlation is almost perfect. By contrast, the sectoral and macroeconomic components are much less volatile, and have much lower correlation with actual sales growth. These results are of course not surprising, and confirm the conventional wisdom that most shocks hitting firms are idiosyncratic.[20]

Whether the idiosyncratic or sectoral shocks that affect firm sales growth are common or destination-specific is less well understood. Table 6 presents the results of extracting the common firm- and sector components from destination-specific components, as in equations (8) and (9). It is clear that the sector- and firm-components that are common to all destinations are relatively insignificant compared to destination-specific shocks. The firm-common component has a relative standard deviation of 0.69 compared to the standard deviation of actual sales, while the destination component has a relative standard deviation of 0.83. The correlation with the actual is also higher for the destination-specific component of firm sales. For sectoral components, the results are even more stark: the common component has a relative standard deviation of 0.15 with the actual growth of the sector×destination shock, and a correlation of only 0.13. By contrast, the destination-specific sectoral component had a relative standard deviation of 0.99 and a correlation of 0.95. We conclude from this exercise that the destination-specific shocks at the firm and especially sector level are more important than the shocks common to all destinations.

4.3 Macroeconomic, Sectoral, and Idiosyncratic Shocks at the Aggregate Level

It is unsurprising that most of the variation in the growth rate of sales is accounted for by idiosyncratic shocks to firms, indeed to the destination-specific sales of those firms. This in itself does not mean that idiosyncratic firm shocks manifest themselves in aggregate fluctuations. To assess the importance of the different types of shocks for the aggregate, we must take into account the distribution of firm size, by decomposing the aggregate sales volatility as in Section 2.4.

Table 7 presents the results. Not surprisingly, the firm×destination component matters much less for the aggregate sales volatility than for the volatility of individual firm sales. However, its importance is non-negligible: the relative standard deviation of the idiosyn-

[20] A variance decomposition of the regression estimates for the firm-level growth rates indicates that 97% is solely explained by the idiosyncratic component while 3.5 and 2.4% of the variance are explained by the sectoral and macroeconomic components, respectively. Finally, −2.8% of the variance is due to negative comovements between the sectoral and macroeconomic components.

cratic component of aggregate sales is 0.48 compared to the actual sales volatility, and the correlation with the actual is 0.74. In fact, our results show that the idiosyncratic component is more important for aggregate fluctuations than the macroeconomic destination component, which has a relative standard deviation of 0.43 and a correlation of only 0.29. The sector×destination component turns out to be most significant, with a relative standard deviation and correlation both higher than the other two. The bottom panels of Table 7 checks the results on domestic sales to France only as well as export sales, confirming all the main conclusions.[21]

Figure 7 plots the 5-year rolling standard deviations of actual aggregate sales and the three components. Visually, macroeconomic, sectoral, and idiosyncratic shocks appear to have a similar level of standard deviation. If anything, over time the importance of the sectoral component decreases, such that by the end of the sample it has the same standard deviation of the idiosyncratic component, which stays roughly constant over the period. The variance decomposition obtained for the whole 1991–2007 period is given in the first column of Table 9, while Figure 8 decomposes the 5-year rolling variances of total sales into the three variance components and the covariance component, according to equation (14). This Table and this Figure underscore the importance of sectoral components, but show that they have been decreasing over time, and that the relative importance of firm×destination shocks is rising. It also shows that the covariance terms are important in a few years, but they are not always large, and are not systematic: sometimes they are positive, sometimes negative.[22] Note that for the full sample, the covariances between the macroeconomic, sectoral, and idiosyncratic components of aggregate volatility are not zero, in spite of the fact that in the firm-level estimations, the idiosyncratic component is by construction uncorrelated with sector and macro components. This comes about because of aggregation. While on un-weighted terms (equation (7)) the idiosyncratic shocks may be uncorrelated, it will not generically be the case that the weighted contributions of these shocks to aggregate growth (equation (12)) will be uncorrelated among each other. In the end, however, the covariances are not the predominant component of the aggregate variance. Added together, they account for only 10% of the aggregate variance for total sales.

[21] In addition to the positive influence of idiosyncratic shocks to aggregate fluctuations, the variance decomposition in Table 9 shows that the covariance of those shocks with the sectoral component further increases aggregate volatility.

[22] A deeper look at the data shows that the negative contribution of the covariance terms to the aggregate volatility at the beginning of the period is mainly due to negative comovements between the macroeconomic and sectoral components. Later, the positive covariance between idiosyncratic and sectoral components explains the positive contribution of covariance terms to the aggregate variance.

Next, we examine the relative importance of common and destination-specific components of the firm- and sector-level shocks for aggregate fluctuations. Table 8 presents the results. For aggregate movements, destination-specific shocks still predominate, but the relative importance of common shocks is higher compared to explaining individual firm sales. This is not surprising, since aggregation will naturally increase the importance of common shocks.

4.4 The Role of Large Firms

Thus far we have examined the contribution of the idiosyncratic components of all firms in the manufacturing sector to aggregate growth volatility. However, the "granular hypothesis" of Gabaix (2011) implies that the behavior of the upper tail of the firm distribution should be a sufficient statistic in explaining aggregate fluctuations. Therefore, following Gabaix (2011) we examine the contribution of the one hundred largest firms in our sample to the fluctuations in overall sales.[23]

Figure 9 presents the growth rate of total sales and of the sales of the one hundred largest firms in the manufacturing sector over time. As one can see, the growth rate of the one hundred largest firms tracks that of the aggregate quite well. Figure 10 plots the contribution of the largest firms to aggregate growth in each year, which averages 23% over the sample period. Figure 11 plots the rolling variance ot total sales, and the contribution of the 100 largest firms to this variance. Importantly, we calculate the volatility of the 100 largest firms based on their weights in total sales of all firms; therefore, we would expect this volatility to be less than that of total idiosyncratic volatility. The volatility of the largest firms in the economy moves virtually one-for-one with that of overall sales. The relative contribution of the largest firms to aggregate volatility is practically constant over time, and equals about one-third of the volatility of total sales. Finally, Figure 12 repeats the exercise on just the idiosyncratic component of both total sales and the sales of the largest firms. Similarly to the results on raw sales, the idiosyncratic fluctuations of the one hundred largest firms equal roughly one third of total idiosyncratic volatility over the sample.

[23] To simplify our analysis, we choose the one hundred largest firms that exist throughout the sample, unlike Gabaix (2011) who allows for these to change over his (longer) time series. Moreover, we use the results from our regressions using all firms, rather than re-running the regression on only the one hundred firms for comparability with our baseline results.

4.5 Export Sales

Next, we examine the behavior of aggregate exports on their own.[24] There are several reasons for examining export sales in particular: (i) the largest firms also tend to be exporters (particularly in the manufacturing sector); (ii) international trade is more volatile than overall output, and (iii) as emphasized by Canals et al. (2007), international trade is very granular, both at the firm- and sector-destination level.

Table 3 and Table 4 show that the extensive margin of exports is both higher on average and more volatile than for domestic and total sales. Furthermore, it is clear from Table 5 that the behavior of export sales does not differ dramatically from total or domestic sales at the firm level. However, in aggregation, as in Table 7, two observations jump out. First, the idiosyncratic component is more volatile than for domestic and total sales, while the sectoral component drops off. Second, the idiosyncratic component exhibits a strong comovement with aggregate exports.

Figure 13 presents the 5-year rolling volatility of aggregate exports and its three main components. The idiosyncratic component is quite large relative to the aggregate, while the sectoral and macroeconomic components are of comparable size to each other. It would therefore appear that the dynamics of the firm-destination component of aggregate export growth are more important in the fluctuations of exports. This fact is re-affirmed in Figure 14, which breaks down overall volatility into the three variance terms and the cumulative covariance term.

5 Conclusion

The importance of firm-level dynamics in explaining aggregate fluctuations has been highlighted in two distinct recent literatures. Specifically, one avenue of research has argued that the extensive margin of entering and exiting firms contributes an important part to the dynamics of an economy (Bilbiie et al., 2007; Ghironi and Melitz, 2005), while a second line of research highlights the importance of idiosyncratic shocks to large firms in generating aggregate fluctuations (Gabaix, 2011). However, the empirical evidence supporting these different theories is porous. We therefore construct a novel dataset, merging French domestic and export sales at the firm level over 1990–2007, to examine which channels are at work in generating aggregate fluctuations.

[24] Future work will delve more deeply into the firm-level behavior, such as potential gains from diversification across markets.

This paper begins by showing how aggregate sales growth can be decomposed into the extensive and intensive margins. We next propose a simple model, in the spirit of Melitz (2003) and Eaton et al. (2011), to motivate a regression framework that allows us to extract the macroeconomic, sectoral, and idiosyncratic components of a firm's sales to a given destination. These estimates are then aggregated up to explain the relative contribution of each component to the volatility of aggregate sales. Our main results can be summarized as follows. First, though the extensive margin contributes to approximately 25% of total annual sales growth, the variation in total sales is predominantly explained by movements in the intensive margin. Second, the idiosyncratic component contributes an important part to the fluctuations of the intensive margin sales growth for both total and export sales. Therefore, there appears to be evidence for the importance of shocks to large firms in generating aggregate fluctuations.

Our quantitative accounting exercise should not be thought of as structural. Rather, our goal was to provide some simple stylized facts to base theoretical models of aggregate fluctuations on. Based on these results, future work can add more structure to the analysis, such as allowing for a richer production structure (e.g., input-output linkages), or attempting to explicitly match our series of aggregate growth components to economic variables, such as exchange rate fluctuations.

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Table 1. Firm-Level Growth Rates: Summary Statistics

	Whole Economy			*Manufacturing Sector*		
	Mean	St. Dev.	Obs.	Mean	St. Dev.	Obs.
1991	0.0493	0.2726	463,204	0.0512	0.3181	136,741
1992	0.0362	0.2713	481,571	0.0465	0.3185	144,523
1993	0.0176	0.2709	421,575	0.0260	0.3188	122,539
1994	0.0452	0.2751	455,836	0.0664	0.3222	130,851
1995	0.0473	0.2705	569,202	0.0702	0.3184	162,390
1996	0.0330	0.2679	586,076	0.0449	0.3140	168,204
1997	0.0418	0.2674	625,264	0.0635	0.3159	176,297
1998	0.0582	0.2707	649,080	0.0715	0.3173	182,033
1999	0.0530	0.2682	657,805	0.0546	0.3156	183,495
2000	0.0704	0.2721	663,089	0.0817	0.3211	182,910
2001	0.0620	0.2692	654,808	0.0669	0.3199	181,221
2002	0.0428	0.2647	673,294	0.0410	0.3152	181,865
2003	0.0390	0.2639	694,433	0.0391	0.3116	182,365
2004	0.0507	0.2661	704,479	0.0578	0.3145	181,466
2005	0.0496	0.2672	717,856	0.0563	0.3150	180,732
2006	0.0574	0.2692	736,462	0.0701	0.3162	180,441
2007	0.0588	0.2727	746,183	0.0764	0.3175	177,377
Mean	0.0478	0.2694		0.0579	0.3170	

Notes: This table presents the summary statistics for the whole economy and our sample of manufacturing firms over 1991–2007.

Table 2. Entry and Exit Patterns: Manufacturing Sector

	Entry Rate	Exit Rate	Relative Sales Entrants	Relative Sales Exiters	Relative Size Entrants	Relative Size Exiters
1992	0.2684	0.1538	0.0354	0.0193	0.1155	0.1081
1993	0.1979	0.2015	0.0326	0.0276	0.1359	0.1126
1994	0.2794	0.1423	0.0452	0.0202	0.1452	0.1243
1995	0.1922	0.1353	0.0381	0.0203	0.1781	0.1323
1996	0.1806	0.1330	0.0367	0.0211	0.1830	0.1404
1997	0.2097	0.1184	0.0414	0.0150	0.1814	0.1135
1998	0.1605	0.1383	0.0235	0.0172	0.1290	0.1091
1999	0.1490	0.1377	0.0575	0.0174	0.3527	0.1107
2000	0.1485	0.1386	0.0360	0.0169	0.2169	0.1067
2001	0.1423	0.1498	0.0314	0.0157	0.1938	0.0904
2002	0.1276	0.1415	0.0263	0.0158	0.1815	0.0975
2003	0.1091	0.1493	0.0190	0.0146	0.1512	0.0846
2004	0.1137	0.1430	0.0335	0.0132	0.2612	0.0803
2005	0.1107	0.1503	0.0247	0.0126	0.1949	0.0723
2006	0.1053	0.1590	0.0122	0.0151	0.0986	0.0812
2007	0.0731	0.1912	0.0085	0.0176	0.0952	0.0760

Notes: This table presents entry and exit rates; entrant and exiter relative shares; and entrant and exiter relative size for firms in our sample over 1992–2007. We omit 1991 because of noise in entry rates, which biases the extensive margin upwards. The estimates are based on the definitions in Dunne et al. (1988).

Table 3. Aggregate Growth Rate: Intensive and Extensive Margins: Aggregate Sales

	Aggregate	Intensive	Extensive	Extensive Domestic	Extensive Exports
1992	0.0149	-0.0016	0.0165	0.0108	0.0057
1993	-0.0181	-0.0232	0.0050	0.0013	0.0037
1994	0.0705	0.0482	0.0223	0.0119	0.0103
1995	0.0549	0.0403	0.0145	0.0092	0.0054
1996	0.0236	0.0102	0.0133	0.0063	0.0069
1997	0.0590	0.0398	0.0192	0.0125	0.0066
1998	0.0486	0.0456	0.0030	0.0010	0.0020
1999	0.0738	0.0336	0.0402	0.0283	0.0119
2000	0.1119	0.0939	0.0180	0.0080	0.0100
2001	0.0501	0.0358	0.0143	0.0091	0.0052
2002	0.0154	0.0070	0.0083	0.0060	0.0023
2003	0.0072	0.0041	0.0032	0.0025	0.0007
2004	0.0646	0.0476	0.0169	0.0115	0.0054
2005	0.0201	0.0097	0.0104	0.0052	0.0052
2006	0.0302	0.0345	-0.0043	-0.0022	-0.0021
2007	0.0342	0.0488	-0.0146	-0.0103	-0.0043
Mean	0.0413	0.0296	0.0116	0.0069	0.0047
St. Dev.	0.0317	0.0276	0.0122	0.0083	0.0043
Corr. w/Agg.		0.9242	0.5068	0.4598	0.5509

Notes: This table presents the decomposition of the aggregate growth rate into the intensive and extensive margin components over 1992–2007. We omit 1991 because of noise in entry rates, which biases the extensive margin upwards. The decomposition detailed in the first three columns is based on equation (1). The last two columns refer to the decomposition (2).

Table 4. Aggregate Growth Rate: Intensive and Extensive Margins: Domestic and Export Sales

	Domestic sales			**Export sales**		
	Total	Intensive	Extensive	Total	Intensive	Extensive
1992	0.0115	-0.0024	0.0139	0.0269	0.0012	0.0257
1993	-0.0199	-0.0215	0.0015	-0.0116	-0.0295	0.0179
1994	0.0540	0.0383	0.0156	0.1275	0.0825	0.0450
1995	0.0580	0.0463	0.0117	0.0444	0.0203	0.0241
1996	0.0147	0.0064	0.0083	0.0534	0.0232	0.0302
1997	0.0447	0.0280	0.0167	0.1042	0.0776	0.0265
1998	0.0358	0.0342	0.0016	0.0872	0.0801	0.0071
1999	0.0757	0.0378	0.0379	0.0682	0.0214	0.0468
2000	0.1028	0.0919	0.0109	0.1371	0.0995	0.0376
2001	0.0537	0.0414	0.0123	0.0402	0.0204	0.0198
2002	0.0224	0.0144	0.0081	-0.0036	-0.0126	0.0091
2003	0.0033	0.0000	0.0033	0.0196	0.0170	0.0026
2004	0.0637	0.0488	0.0149	0.0674	0.0437	0.0237
2005	0.0096	0.0028	0.0068	0.0556	0.0333	0.0222
2006	0.0247	0.0276	-0.0029	0.0462	0.0548	-0.0086
2007	0.0273	0.0412	-0.0139	0.0530	0.0697	-0.0167
Mean	0.0364	0.0272	0.0092	0.0572	0.0377	0.0196
St. Dev.	0.0309	0.0269	0.0111	0.0416	0.0369	0.0175
Corr. w/Total		0.9361	0.5160		0.9071	0.4631

Notes: This table presents the decomposition of the aggregate growth rate into the intensive and extensive margin components over 1992–2007. We omit 1991 because of noise in entry rates, which biases the extensive margin upwards. These estimates are based on the decomposition (1) applied to aggregate domestic and export sales.

Table 5. Summary Statistics and Correlations of Actual Firm-Destination-Level Growth and Macroeconomic, Sectoral, and Idiosyncratic Components

	Total Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	Relative St. Dev.	Correlation
Actual	2,855,450	0.0586	1.0000	1.0000
Idiosyncratic	2,855,450	9.08E-11	0.9849	0.9849
Sectoral	32,576	-0.0098	0.5175	0.1093
Macroeconomic	1,955	0.0894	0.3261	0.0625
	Domestic Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	Relative St. Dev.	Correlation
Actual	1,245,160	0.0379	1.0000	1.0000
Idiosyncratic	1,245,160	1.55E-10	0.9905	0.9905
Sectoral	374	0.0130	0.1702	0.1274
Macroeconomic	17	0.0260	0.0556	0.0227
	Export Sales			
	(1)	(2)	(3)	(4)
	Obs.	Mean	Relative St. Dev.	Correlation
Actual	1,610,290	0.0745	1.0000	1.0000
Idiosyncratic	1,610,290	4.15E-11	0.9854	0.9854
Sectoral	32,202	-0.0100	0.4420	0.1204
Macroeconomic	1,938	0.0899	0.2778	0.0395

Notes: This table presents the average growth rate, standard deviations (relative to actual firm-destination-level growth), and correlations with the actual, for the three (non-aggregated) components of firm-destination-level growth: macroeconomic, sectoral, and idiosyncratic, over 1991–2007. These estimates are obtained by running the regression in equation (7). The overall variance decomposition of observed firm-destination growth rates in the sample covering total sales indicates that: i) 97% of the observed variance is explained by the idiosyncratic component, ii) 3.5% is explained by the sectoral component, iii) 2.4% is explained by the macroeconomic component, and iv) −2.8% is explained by the covariance between the sectoral and the macroeconomic components.

Table 6. Summary Statistics and Correlations of Idiosyncratic and Sectoral Growth and Components

	Idiosyncratic Component			
	(1)	(2)	(3)	(4)
	Obs.	Mean	Relative St. Dev.	Correlation
Firm	2,855,450	9.08E-11	1.0000	1.0000
Firm-Dest.	2,855,450	2.54E-12	0.8263	0.8263
Firm-Com.	1,257,994	0.0004	0.6891	0.5632
	Sectoral Component			
	(1)	(2)	(3)	(4)
	Obs.	Mean	Relative St. Dev.	Correlation
Sector	32,576	-9.77E-03	1.0000	1.0000
Sector-Dest	32,576	-8.48E-11	0.9906	0.9539
Sector-Com.	374	-0.0096	0.1473	0.1345

Notes: This table presents the average growth rates, relative standard deviations, and correlation coefficients, for the two components of (non-aggregated) sectoral and idiosyncratic firm-level shocks: the common and destination-specific components, over 1991–2007. These estimates are obtained by running the regressions in equations (8) and (9) for the sectoral and firm-level components, respectively. The overall variance decomposition of estimated idiosyncratic components indicates that: i) 68% of the observed variance is explained by the destination-specific component, while ii) 32% is explained by the component that is common across markets. For the estimated sectoral effects, i) 101% of the variance is due to destination-specific components, ii) 9% is attributable to the shocks that are common across markets, and iii) −10% is due to the negative covariance between the common and destination-specific components.

Table 7. Summary Statistics and Correlations of Aggregate Growth and Macroeconomic, Sectoral, and Idiosyncratic Components

		Total sales	
	(1)	(2)	(3)
	Mean	Relative St. Dev.	Correlation
Actual	0.0278	1.0000	1.0000
Idiosyncratic	-0.0195	0.4806	0.7397
Sectoral	0.0085	0.7079	0.7358
Macroeconomic	0.0388	0.4262	0.2900
		Domestic sales	
	(1)	(2)	(3)
	Mean	Relative St. Dev.	Correlation
Actual	0.0255	1.0000	1.0000
Idiosyncratic	-0.0130	0.5092	0.6350
Sectoral	0.0124	0.8047	0.7121
Macroeconomic	0.0260	0.4644	0.2231
		Export sales	
	(1)	(2)	(3)
	Mean	Relative St. Dev.	Correlation
Actual	0.0087	1.0000	1.0000
Idiosyncratic	-0.0095	0.5374	0.9071
Sectoral	-0.0009	0.4146	0.5399
Macroeconomic	0.0191	0.4936	0.5849

Notes: This table presents the average growth rates, standard deviations (relative to actual), and correlations with the actual, for the three components of aggregate growth: macroeconomic, sectoral, and idiosyncratic, over 1991–2007. These estimates are obtained from the aggregation equation (12), using regression results from estimating equation (7).

Table 8. Summary Statistics and Correlations of Idiosyncratic and Sectoral Growth and Components

	Idiosyncratic Component		
	(1)	(2)	(3)
	Mean	Relative St. Dev.	Correlation
Firm	-0.0195	1.0000	1.0000
Firm-Dest.	-0.0184	0.9163	0.6923
Firm-Com.	-0.0011	0.7556	0.4839
	Sectoral Component		
	(1)	(2)	(3)
	Mean	Relative St. Dev.	Correlation
Sector	0.0085	1.0000	1.0000
Sector-Dest.	0.0152	1.0035	0.8736
Sector-Com.	-0.0066	0.5036	0.2449

Notes: This table presents the average growth rates, relative standard deviations, and correlation coefficients, for the two components of sectoral and idiosyncratic aggregate shocks: the common and destination-specific components, over 1991–2007. These estimates are obtained from the aggregation equation similar to (12), using regression results from estimating equations (8) and (9).

Table 9. Variance Decomposition of Aggregate Growth

	Total Sales	Domestic Sales	Export Sales
Idiosyncratic Var.	0.3672	0.3875	0.3883
Sectoral Var.	0.5699	0.7201	0.1898
Macroeconomic Var.	0.1674	0.2261	0.1374
2* Cov. Idio/Sect.	0.1113	-0.0500	0.2739
2* Cov. Idio/Macro.	-0.0245	-0.0030	0.0810
2* Cov. Sect./Macro.	-0.1868	-0.2808	-0.0704
Aggregate Var.	6.22E-4	3.44E-4	0.72E-4

Notes: This table presents the decomposition of the variance of aggregate growth rates into its idiosyncratic, sectoral and macroeconomic components as well as various covariance terms, over 1991–2007. Each number (with the exception of the last row) is expressed in relative terms with respect to the overall variance of the aggregate growth rate. These estimates are obtained from the aggregation equation (14), using regression results from estimating equations (7), (8) and (9).

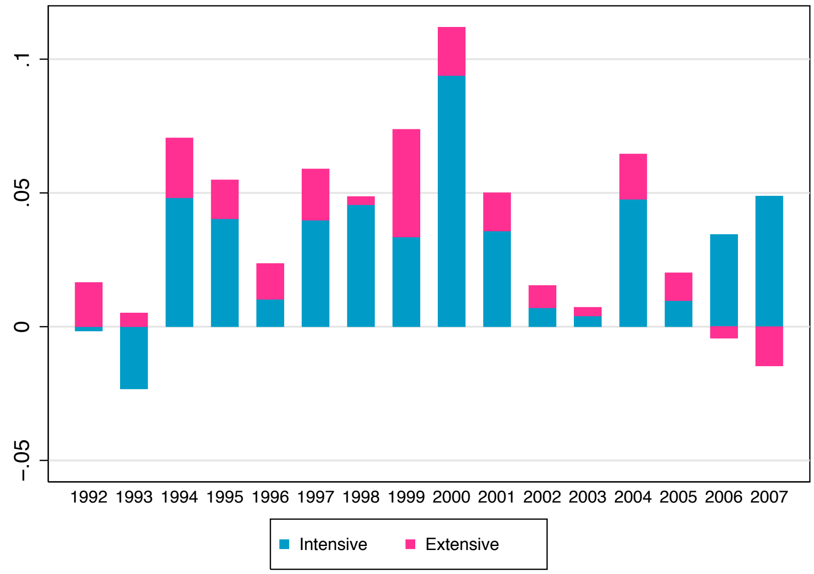
Figure 1. Aggregate Growth of Total sales, Value Added and GDP

Notes: This figure presents the time series of the growth rates of total sales, before-tax value added, and GDP sourced from the IMF International Financial Statistics.

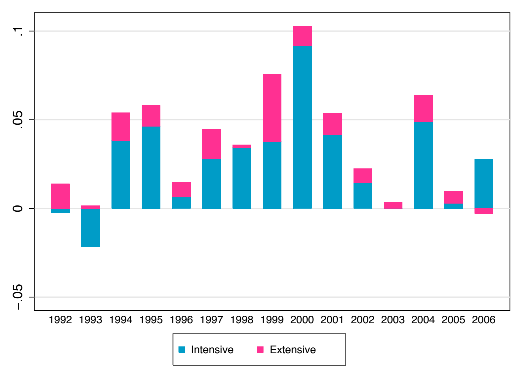
Figure 2. Aggregate Growth of Exports

Notes: This figure presents the time series of the growth rates of total exports in our data and total French exports sourced from the IMF International Financial Statistics.

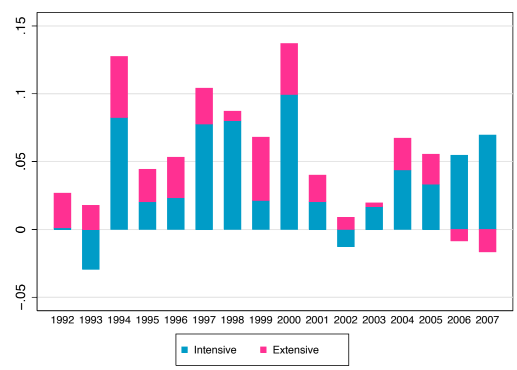
Figure 3. Intensive and Extensive Components of Sales



(a) Total Sales



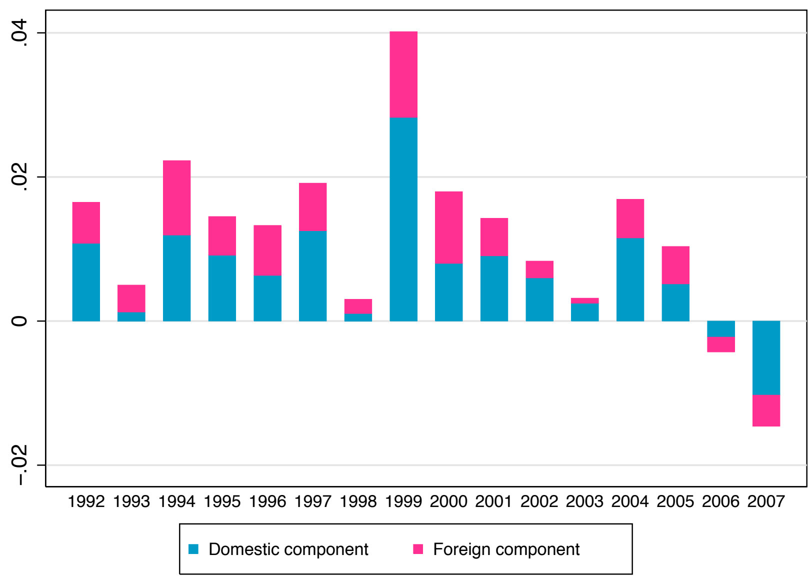
(b) Domestic Sales



(c) Export Sales

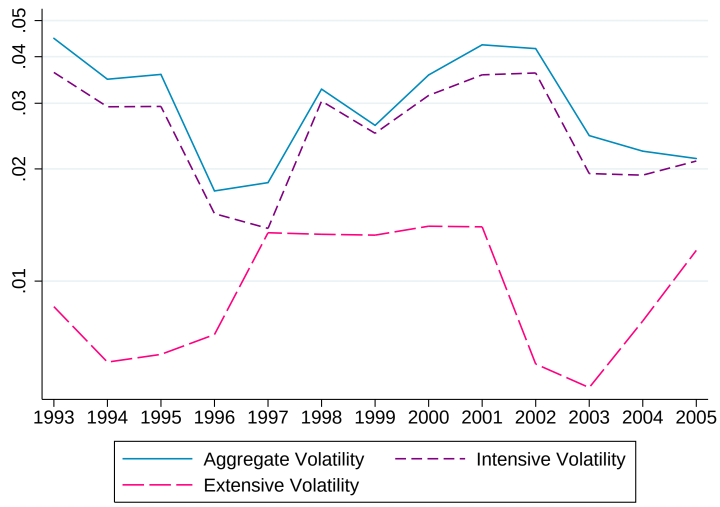
Notes: This figure decomposes the aggregate growth rate of total, domestic and export sales into an intensive component (growth rate of incumbent firms in each market) and an extensive component (attributable to the net effect of firms starting selling goods in a given market and firms exiting a given market). These estimates are based on the decomposition (1).

Figure 4. Extensive component of sales: Domestic and Foreign components



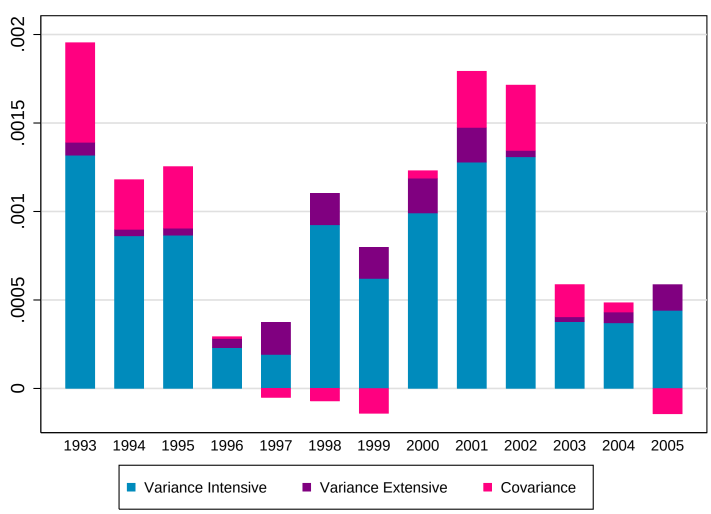
Notes: This figure decomposes the extensive component of the aggregate growth of total sales into a domestic and a foreign component. The domestic component corresponds to new firms starting producing and selling in France. The foreign component corresponds to firms starting exporting in a given market. These estimates are based on the decomposition (2).

Figure 5. Volatility of Aggregate, Intensive and Extensive Sales



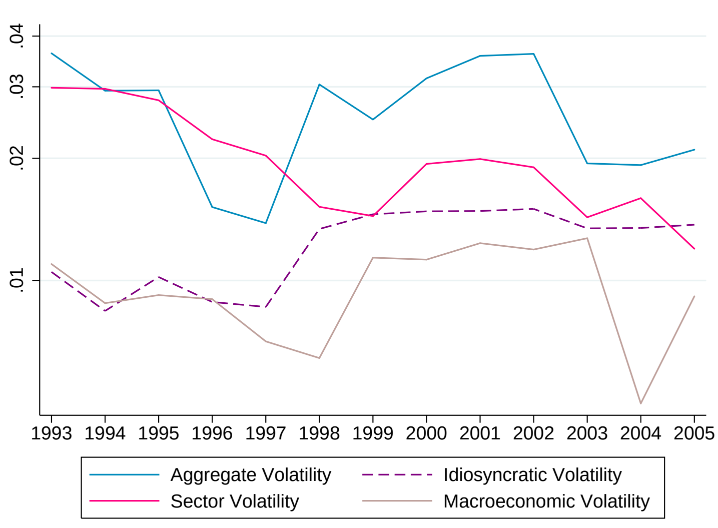
Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the standard deviation of the aggregate, extensive and intensive growth rates. These estimates are based on equation (11).

Figure 6. Decomposition of the Aggregate Volatility into an Intensive and Extensive Components



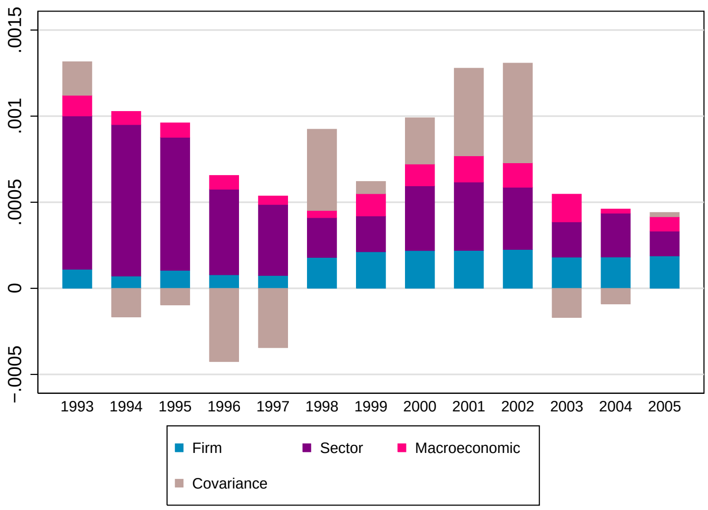
Notes: This figure presents the rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the aggregate volatility of total sales, together with its decomposition into an intensive component, an extensive component and a covariance term. These estimates are based on equation (11).

Figure 7. Volatility of Intensive Sales Growth and Their Components



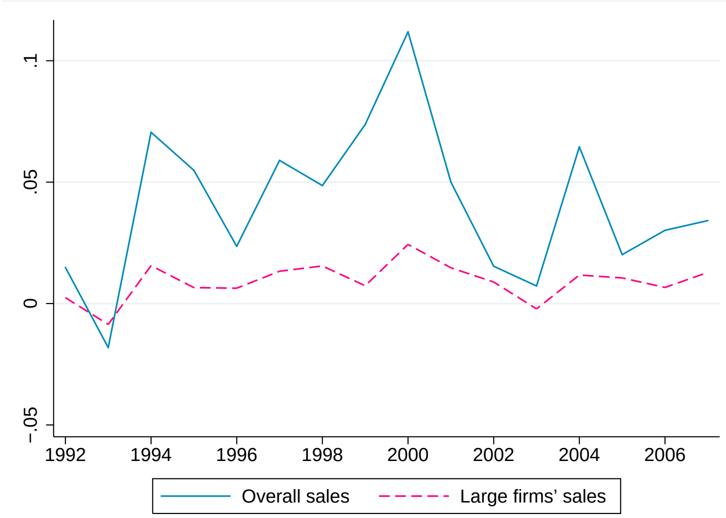
Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the standard deviation of the intensive growth rate and its components. These estimates are based on equation (14).

Figure 8. Decomposition of the Intensive Volatility into Firm-Specific, Sector-Specific, Country-Specific Components and a Covariance Term



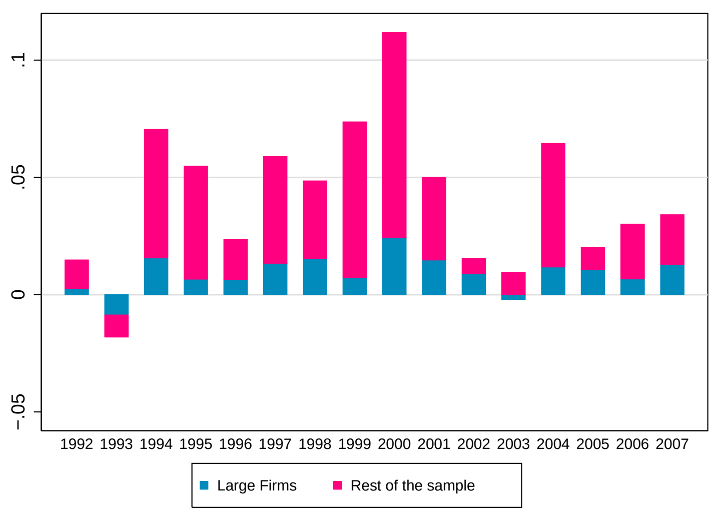
Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the volatility of intensive sales, together with its decomposition into a firm-specific, a sector-specific, a macroeconomic and a covariance term. The covariance term encompasses the covariances between i) the macroeconomic and the sectoral components, ii) the macroeconomic and the idiosyncratic components, and iii) the sectoral and the idiosyncratic components. Over the whole 1991–2007 period, these covariance coefficients (in relative terms with respect to the overall variance of sales) respectively equal −0.1868, −0.0245 and 0.1113 (see Table 9). These estimates are based on equation (14).

Figure 9. Aggregate and 100 Largest Firms Growth



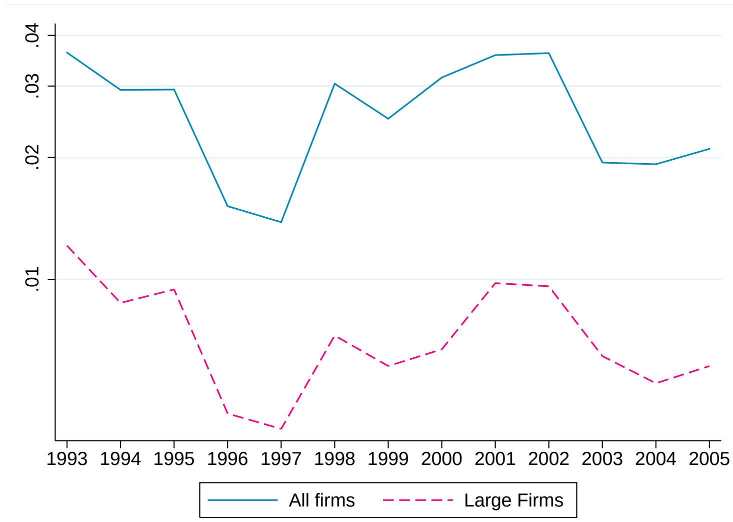
Notes: This figure presents total sales growth and the growth rate of the one hundred largest firms in the manufacturing sector.

Figure 10. Aggregate Growth Contribution of 100 Largest and Rest of Firms



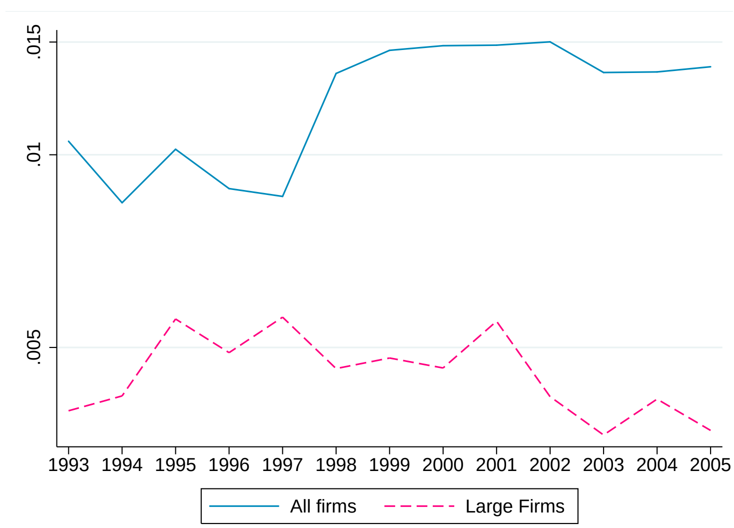
Notes: This figure presents the total sales growth contribution of the one hundred largest firms, as well as the rest of the firms in the manufacturing sector over 1992–2007. On average, the contribution of the largest firms is equal to 23% of the total sales growth.

Figure 11. Volatility of Intensive Sales Growth for All and the 100 Largest Firms



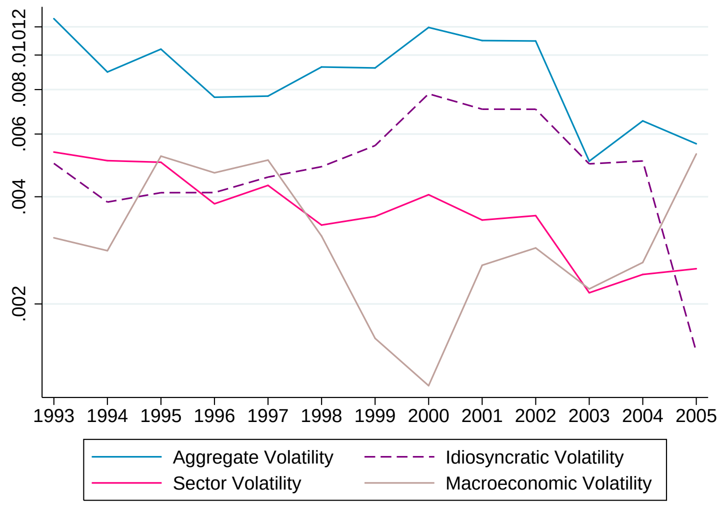
Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the volatility of intensive sales for all and the 100 largest firms in the manufacturing sector. The y-axis is in log scale.

Figure 12. Idiosyncratic Volatility for All and the 100 Largest Firms



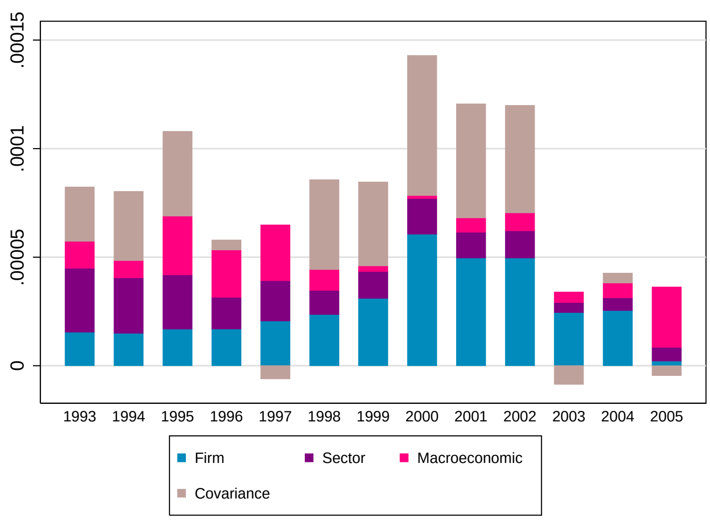
Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the idiosyncratic volatility for all and the 100 largest firms in the manufacturing sector. The y-axis is in log scale.

Figure 13. Volatility of Intensive Sales Growth and Their Components for Export Sales



Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the standard deviation of the intensive growth rate and its components for Export Sales.

Figure 14. Decomposition of the Intensive Volatility into Firm-Specific, Sector-Specific, Country-Specific Components and a Covariance Term for Export Sales



Notes: This figure presents rolling volatilities computed over 5-year windows. The figure illustrates changes over time in the volatility of intensive sales, together with its decomposition into a firm-specific, a sector-specific, a macroeconomic and a covariance term for Export Sales.