Web Appendix for “Who Creates Jobs? Small vs. Large vs. Young”

By

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This web appendix includes background material and supplementary results from the paper “Who Creates Jobs? Small vs. Large vs. Young”. It is organized as follows. Section I shows how we handle M&A activity when computing job flow measures. Section II provides notation and equations underlying our net growth, job creation, job destruction, job creation from entry and job destruction from exit measures. Also, included is a discussion of the relationship between firm and cell-level measures. Section III provides a description of the longitudinal business data we use for our analysis and compares and contrasts these data with alternative longitudinal business data. Section IV provides information on the firm and establishment-level growth rate distributions for our data. Section V provides information about regression to the mean. Section VI shows patterns of job creation and destruction by firm size and firm age. Section VII has a discussion of robustness and sensitivity analysis. Many different issues are explored in this section including the use of establishment vs. firm level controls, showing results controlling for industry and year effects, showing that the results on components of growth (continuers, entry and exit) sum to the overall effects in our analysis and comparing the results in the main text with fully saturated models to two way models without interactions.

Please note that throughout the text of this appendix we adopt the convention of referring to tables and figures in “Who Creates Jobs? Small vs. Large vs. Young” by the same number as in the paper. Tables and figures in this appendix have a “W” prefix.

1 Any opinions and conclusions expressed herein are those of the author(s) and do not necessarily represent the views of the U.S. Census Bureau. All results have been reviewed to ensure that no confidential information is disclosed.
I. Example showing how we handle M&A activity in our firm growth measures

An example of how we handle M&A activity is provided in this section. The graphic in the left panel of Figure W.1 describes the period $t-1$ to period $t$ dynamics for twelve hypothetical establishments owned by 8 hypothetical firms. The patterns reflected in the example are typical of the patterns one sees in actual establishment and firm dynamics datasets such as the LBD. The right hand panel gives the results of calculating job flow measures at the firm and establishment level of aggregation.

In this example, establishments 1, 2, 4, 5, 9, 11 and 12 are continuers. Establishments 3, 8 and 10 are deaths and establishments 6 and 7 are births. Establishment 2 is divested from firm A and acquired by firm B. A new firm, C, enters with establishment 7 and firm D dies by shutting down its only establishment (8). Firm B opens a new establishment (6), firm E closes one of its establishments (10), and firm G changes ownership and becomes firm H.

Using the formulas provided in the paper, we compute the firm-level net growth rates two ways: first, using firm-level data without correcting for M&A activity and second, using the employment-weighted establishment-level data that only incorporates organic growth. The latter is the approach we employ in the paper. Looking at the resulting rates in the lower right of Figure W.1, we see that the implied net growth rates are equal across the two methods for all firms but firms A, B, G and H. Firms experiencing M&A activity (A and B) will have inflated absolute net growth rates when computed using the first method. Similarly, firm-level computations in the presence of pure ownership changes using the first method will result in spurious job creation and destruction due simply to the transfer of ownership of the affected establishment(s). For example, using the first method, firm A is assigned a decrease in employment of 130 or just over 25% of current size employment. If instead, we compute the
firm net growth rates as the weighted sum of the establishment rates, firm A has a decrease in employment of 30 workers of just over 6%. This is the net of the increase in 50 employees at establishment 1 and the loss of 80 employees from the shutdown of establishment 3. Note that the decrease in employment at establishment 2 is assigned to firm B since it is the controlling firm in period \( t \). Firm B then is assigned a net change in employment of 45 or 17% of current size employment. Finally, in the case of a simple change in ownership where firm G is bought out by firm H, the only affected establishment (12) grows by 18%, but the first method approach results in values of -2 and 2.

Computing firm growth rates building up from establishment-level growth rates produces consistent measures that are robust to ownership changes which is important when we want to compare across industries, geographic entities and firm or establishment size and age categories. More fundamentally it also has strong implications for how we interpret the different margins of adjustment. The bottom panel of Figure W.1 makes the point. It decomposes aggregate net growth into growth coming from firm birth and death events as well as from continuing firms. Measures that fail to account for the effects of M&A activity will overestimate employment changes from these margins.

**II. Measurement of Net Growth, Gross Job Creation and Destruction at the Establishment-Level, Firm Level and cell-level.**

Measures of job creation and destruction at the establishment level are given by:

\[
JC_{it} = \max(g_{it},0)
\]

\[
JD_{it} = \max(-g_{it},0)
\]

Where \( g_{it} \) is the establishment level employment growth rate as defined in the paper. Job creation from entry at the establishment level is given by:

\[
JC_{it} = \max(g_{it},0) \times I\{g_{it} = 2\}
\]
where $I$ is an indicator variable equal to one if expression in brackets hold, zero otherwise, and $g_{it} = 2$ denotes an entrant. Similarly job destruction from exit at the establishment level is given by:

$$ JD_{it} = \max(-g_{it}, 0) \cdot I\{-g_{it} = 2\} $$

where $g_{it} = -2$ denotes an exit.

Using these measures it is straightforward to generate aggregate measures of job creation and destruction as well as job creation and destruction from entry and exit, respectively (at any level of aggregation) given by:

$$ JC_{t} = \sum_{i} (X_{it}/X_{t}) \max\{g_{it}, 0\} $$

$$ JD_{t} = \sum_{i} (X_{it}/X_{t}) \max\{-g_{it}, 0\} $$

$$ JC_{Cont_{t}} = \sum_{i \in c} (X_{it}/X_{t}) \max\{g_{it}, 0\} $$

$$ JD_{Cont_{t}} = \sum_{i \in c} (X_{it}/X_{t}) \max\{-g_{it}, 0\} $$

$$ JC_{Entry_{t}} = \sum_{i} (X_{it}/X_{t}) I\{g_{it} = 2\} \max(g_{it}, 0) $$

$$ JD_{Exit_{t}} = \sum_{i} (X_{it}/X_{t}) I\{g_{it} = -2\} \max(-g_{it}, 0) $$

Given these definitions, the following simple relationships hold:

$$ g_{t} = JC_{t} - JD_{t}, \ JC_{t} = (X_{ct}/X_{t})JC_{Cont_{t}} + JC_{Entry_{t}} \ and $$

$$ JD_{t} = (X_{ct}/X_{t})JD_{Cont_{t}} + JD_{Exit_{t}} $$

where $JC_{Cont}$ and $JD_{Cont}$ are job creation and job destruction for continuing establishments respectively. Note they are defined here only over the range of continuing establishments so that the share of employment accounted for by continuing establishments needs to be used in aggregation.
We can also define job creation and destruction starting from the firm level in a manner analogous to the relationships above. As with net changes in the presence of M&A activity, appropriate care must be used in considering the relationship between establishment-level and firm-level employment gross rate patterns. But even after focusing on only organic growth, there are inherent differences in firm and establishment-level gross rates of creation and destruction. Firms that are expanding (including firm entrants) contribute to firm-level gross job creation and firms that are contracting (including firm exits) contribute to firm-level gross job destruction. But a firm that is expanding may have some contracting (or exiting) establishments and a firm that is contracting may have some expanding (or entering) establishments. As such, gross job creation and destruction is inherently greater when summed up from establishment-level net changes than when summed up from firm-level net changes. In a closely related way, we note that firm entry implies that there must be establishment entry as an entering firm is identified as a new firm with all new establishments but the converse does not hold. Similarly, firm exit implies that there must be establishment exit but the converse does not hold.

The establishment-level and firm-level data can be aggregated to the cell-level “s” for any definition of cell “s”. The following relationships hold:

\[ g_{st} = JC_{st} - JD_{st}, \quad JC_{st} = (X_{act} / X_{st})JC_{Cont_{st}} + JC_{Entry_{st}} \]
\[ JD_{st} = (X_{cst} / X_{st})JD_{Cont_{st}} + JD_{Exit_{st}} \]

These relationships imply that one can decompose overall net growth into its continuer, job creation from entry and job destruction from exit components at the cell-level:

\[ g_{st} = (X_{st} / X_{i})g_{cst} + JC_{Entry_{st}} - JD_{Exit_{st}} \]
III. Description of Business Datasets

Table W.1 describes main features of alternative longitudinal business dataset currently available for the analysis of business dynamics. We do not intend to be exhaustive and simply describe three different datasets currently used to conduct analysis describing the whole private non-farm economy; specifically, 1) the Bureau of the Census Longitudinal Business Database (LBD), 2) the Bureau of Labor Statistics Longitudinal Database (LDB), and 3) the Walls and Associates National Establishment Time Series (NETS) Database.

A. The Census Bureau’s Longitudinal Business Database

The LBD is an annual establishment level dataset covering all non-farm private employer business in the U.S. that file payroll and income taxes with the IRS. The LBD is used to generate gross job and establishment flows in the Business Dynamics Statistics (BDS) data series. The Census Bureau’s Business Register (BR) supplies the underlying data and serves as the sampling frame for Census establishment surveys. Sourced from mandatory administrative employer filings (quarterly payroll and income employer tax reports) the BR is enhanced with Economic Census data as well as other Census collections to identify employment and payroll for the establishment and firms associated with those employer filings. An establishment is the physical location where business is conducted. The firm is the legal entity with the operational control. Firms can and often have complex structures spanning multiple establishments, geographies, industries and subsidiaries.

The Census Bureau is able to identify parent firms with operational control from a variety of sources. A key source is the Company Organization Survey (COS). The COS is conducted

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2 Employers file payroll and income taxes based on the Employer Identification Number (EIN) assigned to them by the IRS. The EIN is a tax reporting unit and does not necessarily correspond to the meaningful economic units of interest to the Census Bureau. The EIN can represent a whole business or a single establishment of a large multi establishment firm depending largely on how firms choose to report their operations. The EIN represents the firm as well as the establishment only for single establishment firms.
every year for firms over 250 employees and every 5 years for all firms covered by the Economic Census. In addition large single-establishment firms suspect of having become multi-establishment firms are also surveyed.\(^3\) The COS is designed to track the structure of firms and any changes taking place.\(^4\) However, many of these (particularly small single to multi transitions) are only identified during a more comprehensive Census year. The LBD incorporates this information after every Census along with additional administrative and survey data so that the timing of establishment openings and closings is as accurate as possible.

The LBD starts in 1975 and currently runs through 2009. In 2009 alone there were over five million active employer firms and close to 7 million active establishments in the non-farm private sector. Firm identifiers in the LBD are assigned by the Census Bureau based on the following criteria. When a new entity is detected via administrative sources (e.g., the filing for a new EIN, filing of payroll taxes, etc.), the Census determines whether it is part of an existing firm or it is a new firm using a mix of administrative and survey data. The Company Organization Survey is the most important source of survey data but some updates come from annual surveys of businesses. Administrative sources include the SS4 and 851 which also allow linking new EINs to existing companies as well as BLS multiple worksite report flags which allow the Census to flag multi-establishment firms not identified through other means. On occasion and particularly for single establishment firms reorganizations and changes in legal form might lead to a new firmid for what is in fact a continuing business unit. To minimize the number of spurious births and deaths from these events Census uses name and address matching for all deaths and births in a year as well as across consecutive years. All new firms are assigned a unique firm identifier when they are first identified and are deemed not part of some parent

\(^3\) We term these “single to multi” transitions.
\(^4\) Small, single establishment firms are not surveyed in the annual report since the establishment and firm are one and the same.
firm. Changes in ownership, reorganizations or single to multi transitions can lead to the creation of a new firmid. Specifically, a reorganization that results in a new legal entity (e.g. as a result of a merger or a change in the legal form of organization) will generate a new firmid. When a company changes their firmid the old firmid is retired and not used again. Partial divestitures or acquisitions that do not result in a new legal entity do not spawn a new firmid.

The age of the firm is assigned based on the age of the oldest establishment at time of birth of a firmid. The firm ages naturally after that so that the acquisition of an older establishment does not change the age of the acquiring firm. Similarly the divestiture or closure of existing establishments does not lead to changes in the age of the firm even if the oldest establishments are the ones closing or being divested. This definition of age also clearly implies that a new firmid that emerges from change in organization will not be classified as a startup or firm birth. Similarly, the disappearance of a firmid from some change in organization will not be classified as a firm exit. Information about the LBD can be found at http://www.census.gov/ces/dataproducts/bds/index.html.

B. The Bureau of Labor Statistics’ Longitudinal Database (LDB)

The LDB is a quarterly establishment level dataset covering all public and non-farm private employer business in the U.S. The data are reported by employers to comply with State unemployment insurance tax requirements. Approximately 98% of employees on nonfarm payrolls are covered under unemployment insurance programs. The underlying data serves as the sampling frame for BLS establishment surveys and is used to generate gross job flows in the Business Employment Dynamics (BED) data series. Sourced from mandatory administrative filings the LDB is enhanced with Multiple Worksite Reports used to collect separate employment and wage data for each establishment owned by employers with multiple locations.
within a state. An establishment is an economic unit, such as a factory or store, which produces goods or provides services. Every multi-establishment employer with ten or more employees in secondary physical locations covered by one UI account is requested to provide establishment level data. Employers in the LDB can and often have complex structures spanning multiple establishments, geographies, industries and subsidiaries within a State.

A firm in the LDB is defined at an administrative taxpayer ID level at the level of the Federal Employer Identification Number (EIN). As such, business entities under common operational control but having different EINs will not be considered to be part of the same firm in the LDB (unlike the Census LBD). Analysis of the Census LBD shows that there are many firms (under the operational control definition used by Census) that have multiple EINs – especially those firms that are operating in multiple states. It is common for firms that operate in multiple states to use different EINs for activity in different states.

This definition of a firm in the LDB implies that the tabulations by firm size in the LDB will have the limitation that multi-EIN firms that are in fact quite large may be classified in smaller size classes. This definition also implies that when an existing business opens up new establishments with new EINs this will be classified as a firm startup when in fact it should be classified as new establishments of existing firms.

The LDB starts in 1990 and currently runs through 2010. In 2010 alone there were over 120 million jobs covered by the UI system. Within a given state, firms in the LDB are identified based on their UI account number while establishments are identified through the “reporting unit” number. Changes in ownership or reporting configurations (i.e. single to multi establishment transitions or vice versa) within state are identified via predecessor and successor

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5 Internal Census estimates show that using EIN as a measure of firm size underestimates the employment share of business with more than 500 employees by over 10% (from roughly 51% to just over 45%.)
numbers. The predecessor number is the UI account of the establishment that previously owned
the establishment. The successor number is the UI account of the establishment that will take
over the establishment in the event of either a change in ownership or a change in reporting
configuration. Not all successor-predecessor links are captured in the data so after matching on
UI account number and matching on predecessor and successor numbers both within and across
quarters, a third step is undertaken to link the establishment level microdata across quarters using
a probability based match using name and address that attempts to identify two establishments by
comparing births in the current quarter to deaths in the previous quarter. Note that the UI
account number is state-specific so that the definition of the “national” firm in the LDB is based
on the EIN as discussed above. Information about the LDB can be found at
http://www.bls.gov/bdm/.

C. The National Establishment Time Series (NETS) Database

The NETS database is an annual establishment level dataset covering public and private
businesses. The NETS database is constructed from 20 “snapshots” taken every January since
1990 of all active Dun and Bradstreet- Dun’s Market Identifiers (DMI) establishments. Covered
businesses include sole-proprietors and the self-employed. The file contains basic company data,
executive names and titles, corporate linkages, DUNS® Numbers, organization status on over 26
million U.S. business locations, including public, private, and government organizations.
Corporate affiliation information is available.

Public domain documentation on how firms and establishments are identified in the
NETS data is limited. The DMI file is extracted from D&B’s global database of millions of
businesses. Data is collected and maintained by a large staff of business analysts through daily
in-person and telephone interviews; county, state, and federal government sources; third party sources; business trade tape exchange programs; and large-volume mailings.

All of these sources are used to identify new businesses. But it remains unclear how accurately D&B captures startups as in the Census LBD and the BLS LDB. In the Census and BLS data, the first payment of payroll and UI taxes in a quarter triggers the tracking of a new business entity that has employees (and note that the first payment of business taxes enables Census to track new non-employer businesses in a similar fashion). Historically, D&B first noted a new business when it applied for credit. Armington and Odle (1982), among others, showed that this had severe limitations. As D&B has added more sources for tracking business startups (as well as for continuing business activity), these limitations have undoubtedly been reduced. However, recent studies using D&B data still raise questions about the coverage of startups and young businesses in the D&B data on which NETS is based (see, e.g., Acs et. al. (2008)).

These many different sources are also used in the NETS data to track changes of ownership, and records the establishment’s death if it occurs. Information on how this is accomplished is scarce but involves a multi-stage process, the most important steps of which include merging the data files, imputing data when not reported, eliminating duplicate records and merging records on establishments for which the DUNS number changes. Information about the NETS database and the D&B DMI can be found at http://www.youreconomy.org/nets/?region=Walls and http://mddi.dnb.com/mddi/story.aspx

IV. The Firm-Level and Establishment-Level Growth Rate Distributions

It is useful to understand the features of the growth rate distributions for both establishments and firms in the US economy. Figure W.2 displays distributions of the DHS
growth rates used in the paper. The upper panels of Figure W.2 show the unweighted distributions and the lower panels the employment weighted distributions of average annual establishment and firm level net employment growth over the 1992-2005 period. Several patterns stand out. First, the U.S. economy is extremely dynamic with large numbers of establishments and firms opening and closing at any given time – the masses at -2 (deaths) and 2 (births). At both the firm and the establishment levels, about 20 percent of establishments or firms are either entering or exiting in any given period. The unweighted distributions of firm and establishment growth rates look quite similar since the unweighted distributions are dominated by the large number of single unit establishment firms that tend to be small. The lower panels show somewhat different patterns for the firm and establishment growth distributions especially for entry and exit. The pace of employment-weighted establishment entry and exit is not surprisingly higher than the pace of employment-weighted firm entry and exit.

Second, beyond the role of entry and exit, in the weighted distributions there is substantial mass of employment at firms and establishments growing more rapidly than 15 percent per year and a substantial mass of employment at firms and establishments contracting more rapidly than 15 percent per year. The implication, along with the patterns of entry and exit, is that a large fraction of job creation is accounted for by high growth firms and establishments and a large fraction of job destruction is accounted for by rapidly contracting and exiting firms and establishments.

Third, high churning in the economy is combined with substantial inertia. Figure W.2 shows that approximately 30 percent of establishment-year and firm-year records in the LBD exhibit no change in net employment from one year to the next. The share of jobs at
establishments characterized by zero employment growth account for approximately 13 percent of all jobs an indication that these establishments tend to be small. The share of jobs at firms with zero net growth rates account for about 7 percent indicating that some of these less dynamic establishments are part of larger firms that do exhibit net changes.

It is interesting there is this much inertia at an annual frequency. Using BLS data, Davis, Faberman and Haltiwanger (2006) report that about 80 percent of establishments have zero net employment change at a monthly frequency and about 30 percent of employment is at establishments that have zero employment change at the monthly frequency.

V. Evidence on Regression to the Mean

It is useful to examine the serial correlation properties of net growth rates by firm size to provide perspective on why the choice of size classification methodology matters so much especially for the smallest businesses. Figure W.3 shows estimated serial correlation patterns for continuing firms using both the base size and current size classification methods.6 We focus on continuing firms since serial correlation is more of an issue for such firms.7 Interestingly, there is negative serial correlation in all size categories. This reflects the presence and importance of transitory shocks. That is, growth one year tends to be at least partially reversed the following year. However, it is also clear that the regression to the mean effects are more important for small businesses consistent with the view that small businesses face a higher variance of transitory (idiosyncratic) shocks. The negative correlation shows roughly similar patterns across size class methodology but a steeper decline in the absolute correlation with size class for our preferred measure.

VI. Job Creation and Destruction Patterns by Firm Size and Firm Age

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6 The figure plots the correlation between net growth in period t and t-1 by size class.
7 The patterns using all firms are very similar.
The paper focuses on describing patterns of net job creation by firm age and firm size and for different margins (continuers, entrants, and exits). For background purposes, we now also show the underlying patterns of gross job creation and destruction by firm age and firm size.

Figure W.10 shows the patterns of job creation and destruction rates for firms and establishments by firm age. Interestingly, the patterns look quite similar at the firm and establishment levels although the magnitudes are somewhat higher at the establishment-level. This is not surprising given that the latter also captures within-firm creation and destruction across establishments in the same firm. \(^8\) It is apparent that, at both the firm and establishment-level, volatility is higher at young firms as the pace of creation and destruction falls monotonically by firm age with or without size controls. Controlling for firm size has relatively modest effects. The most apparent effects are in the relationship between job destruction and firm age. Here we observe that controlling for firm size tends to reduce the rate of decline of job destruction with firm age especially when using current size controls.

We now turn to the patterns of job creation and destruction by firm size. The upper panel of Figure W.11 shows the patterns for firm-level creation and destruction and the lower panels the patterns for establishment-level creation and destruction. We find that whether or not one controls for age effects and for both size class methods, job destruction tends to decline with firm size. However, the patterns for job creation are more sensitive to controlling for firm age. Job creation falls especially rapidly with firm size when not controlling for firm age but this effect largely disappears with firm age controls. These results highlight the asymmetry in job creation and destruction patterns for small firms. Controlling for age, small firms are more likely to destroy jobs but are not more likely to create jobs.

\(^8\) The establishment-level creation and destruction rates are only necessarily higher than the analogous firm-level creation and destruction rates at the unconditional means (reported for the 16+ group). For the other groups, industry and year controls may be different at the establishment and firm level so this pattern need not hold.
Turning to the establishment-level patterns, we find higher establishment-level job creation (and to a lesser extent job destruction) rates at larger firms once controls for firm age are included. The implication is that, abstracting from firm age effects, establishments at large firms create jobs at a faster rate than establishments of small firms and that the establishments of large firms are not necessarily less volatile than the establishments of small firms.

The analysis of the creation and destruction margins again highlights several important points for the job creation debate. First, the symmetry in job creation and destruction patterns for young firms and establishments; that is, young firms and establishments have relatively high rates of job creation and destruction which translate into high number of jobs being simultaneously created and destroyed in the economy as shown in Figure 1. Second, the asymmetric response in job creation and destruction patterns for small firms. Small firms, once we account for the effects of age, do not have particularly high rates of job creation but relatively high rates of job destruction. Third, when we turn to establishment-level measures of volatility, establishment volatility is larger at large firms than small firms once we control for firm age.9

VII. Robustness and Sensitivity Analysis

A. Net Growth and Firm Size: Controlling for Firm vs. Establishment Age

The Census Bureau invests considerable time and resources identifying the enterprise units with operational control over particular establishments; that is, the firm. Most datasets identify establishments but are not able to link establishments that belong to the same firm (or only identify part-firms). This raises questions as to whether establishment characteristics can be used as a reliable proxy for firm characteristics and whether one would obtain similar results. Figure W.4 compares the impact of controlling for firm vs. establishment age in exploring the

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9 When we aggregate employment to the level of the firm we net out within firm patterns of establishment job creation and destruction. The exception of course is for single unit firms where firm and establishment will net the same measures.
relationship between firm size and net growth. Controlling for establishment age has much less impact than controlling for firm age. When only controlling for establishment age, the results for base year size still show an inverse relationship between firm size and net growth. This contrasts with the patterns in Figure 2 that show that there is no longer a monotonic relationship between net growth and size (base year) when controlling for firm age. The results for average size show that small firms have a higher relative growth rate compared to large firms when controlling for establishment as opposed to firm age.

B. Results Excluding Large Firms

As another robustness check, we explore the sensitivity of the results summarized in Figure 2 of the main paper to the inclusion of the very large firms in the analysis. Figure W.5 shows that the impact of controlling for firm age eliminates any systematic relationship between firm size and net growth even when restricting to firms less than 500 employees. Figure W.6.1 shows that the pattern of up or out dynamics of young firms is also robust to restricting the sample to firms with less than 500 employees.

C. Results with controls for Base Year Size

Figures W.6.2 through W.9 show the analogous results in Figures 4, 5, 8 and 9 but also including the results using base year size effects as opposed to the average size effects summarized in the paper. The figures show that the patterns by firm age are largely robust to including size controls or not, and regardless of whether base year or average size effects are included.

D. Two Way Fully Saturated Dummy Models vs. Two Way Models Without Interactions

The specifications considered in the main text are two way dummy variable models with interactions. As emphasized by Heckman and MaCurdy (1985), Woolridge (2002) and Angrist and Pischke (2009), using fully saturated models is one way to avoid boundary and related
econometric issues with bounded dependent variables when using OLS. Such models by construction yield estimates that are means for the cells defined by the dummy variables (so it is a fully non-parametric approach). In that respect, the fully saturated model estimates can be alternatively calculated directly as the cell means and will be the same regardless of using firm or cell based data.

More formally, as emphasized by Angrist and Pischke (2009), the conditional expectation function $E(y|X)$ is a linear function of X if X is a fully saturated set of dummies. As Angrist and Pischke show in Theorem 3.1.4, if the conditional expectation function (CEF) is linear then the population regression yields exactly the CEF. The classic case for the CEF to be linear is, of course, when y and X are jointly normally distributed. But another case is when X is a fully saturated set of dummies. Angrist and Pischke note Theorem 3.1.4 holds regardless of the distribution of y, so it, therefore, applies to cases when y is a limited or bounded dependent variable. They denote this as “justification 1” for using OLS.\(^{10}\) Note in our application that the employment-weighted fully saturated model yields exactly the employment-weighted cell means for the fully saturated size and age classes. It is precisely the employment-weighted cell means that need to quantify the contribution of firms of different sizes and ages to aggregate net employment growth.

In this section, we compare the partial effects that we report in the main text from those that emerge from estimating a two way model without interactions. The latter is potentially subject to econometric concerns but has the advantage of being transparent and permits estimates for

\(^{10}\) Angrist and Pischke (2009) also provide other justifications for using OLS even when the conditional expectation is not linear including in cases where y is a limited or dependent variable. They note that OLS is the best linear predictor of the dependent variable and in like fashion that OLS is the best linear approximation to the conditional expectation function even when the CEF is non-linear (see the discussion on pages 37-38). Based on these arguments and the limitations of non-linear methods that require additional assumptions they advocate the use of OLS in a wide variety of cases. These additional justifications provide support for the two way models without interactions we consider in this section.
more detailed firm size and firm age categories. We don’t take advantage of this here but have in earlier drafts of the paper.

Figures W.12 and W.13 shows the partials for firm size controlling for firm age equivalent to Figures 2 and 3 in the paper using the results from the main text (fully saturated) and the results for the two way model without interactions. It is evident that the results are very similar using either approach. The implication is that the inferences drawn in the paper regarding the impact of controlling for firm age on net growth (and its components) are very similar using a 2 way model with or without interactions.

Figures W.14 and W.15 repeat the equivalent exercise for Figures 4 and 5 from the main text. There are some slightly larger quantitative differences between the two approaches but the basic patterns also remain very similar. We find an up or out dynamic for young firms regardless of which approach is used.

The main text uses the fully saturated models since such specifications are fully robust to econometric concerns. The 2-way models without interactions yield quite similar results and have, as noted, advantages in terms of transparency and being parsimonious. The latter lends itself to considering additional factors and controls in the analysis although appropriate caution is called for given the potential econometric concerns.

We note that the primary limitation of a 2-way model without interactions is that it can yield predictions outside the bounded range of the dependent variable indicating at least some degree of misspecification. In practice, we have found that the predicted value of the net growth for firm age=0 is close to 2 but not exactly 2 for the 2-way models without interactions. Moreover, there is some modest variation in predicted values across firm size classes in the 2-

11 Huber et. al. (2012) raise econometric concerns in this context and suggest an alternative approach. Their approach may have particular merit for some richer applications of firm dynamics where fully saturated models are not feasible or practical.
way models without interactions. In contrast, as is evident from Table W.2, the predicted value of the net growth for firm age = 0 is exactly equal to 2 for all firm size classes. Even though the 2-way model without interactions yields some modest variation in predicted values of net growth across firm size classes, we note that by construction the employment-weighted average prediction of the net growth rate at firm age = 0 across firm size classes is exactly equal to 2. We also note that the modest variation in predicted values for firm age = 0 across firm size classes is further mitigated when we consider a 3-part approach as discussed in the next section. That is, in estimating a 2-way model without interactions separately for net growth for continuers, job creation from entry and job destruction from exit, we obtain predicted values (results available upon request) for firm age = 0 very close to 2 for the job creation from entry component. The firm age = 0 is not relevant for the other two components.

Putting the pieces together, we find very similar results for the impact of firm size controlling for firm age (and vice versa) whether using a 2-way model without interactions or the fully saturated approach. The former approach is transparent and parsimonious but has at least some degree of misspecification evident at the boundaries. The latter approach is more general but given that it requires a full set of interactions does have some practical limitations. In addition, we note that one way to mitigate the limitations at the boundaries for the 2-way model without interactions is to use a 3-part approach estimating effects separately for continuers, job creation from entry and job destruction from exit.

E. Components vs. Total Effects (or a three-part model vs Integrated Model)

The estimates in Table 2 of the main paper as well as, for example, Figure 2 provide estimates of the relationship between overall net growth and firm size and firm age. As is evident from the discussion in the main text, the overall net growth rate can be decomposed into
the net growth from continuers, the job creation from entry and the job destruction from exit. This section shows that this is indeed the case by computing components and contrasting their sum total to the aggregated estimate. To make this more explicit, note that for cell “s”, the following holds:

\[
g_{st} = \frac{E_{st} - E_{st-1}}{X_{st}} = \frac{E_{cst} - E_{cst-1}}{X_{st}} + \frac{E_{nst}}{X_{st}} - \frac{E_{xst-1}}{X_{st}}
\]

where \(E_{st}\) is employment for cell “s” in period t, \(X_{st} = 0.5 \times (E_{st} + E_{st-1})\), \(E_{cst}\) is employment for continuing firms in cell “s” in period t (continuing between t-1 and t), \(E_{nst}\) is employment from entering firms in cell “s” in year t (by entering we mean firms with zero employment in period t-1 and positive employment in period t), \(E_{xst-1}\) is the employment of exiting firms in cell s from t-1 (exiting here is going from positive to zero employment). In measuring and defining \(E_{st-1}\) it is critical to emphasize that this is the employment in period t-1 of the firms (or establishments) that are in cell “s” in period t. That is, this is based on the same set of firms or establishments in period t-1 and t so that these measures are not subject to the “size distribution fallacy” discussed in Davis, Haltiwanger and Schuh (1996) wherein misleading inferences can be generated by considering cell based totals of establishments classified by firm size (or firm age) across years as establishments can change firm size and firm age classifications. The first term on the RHS of the above expression captures the contribution from continuing firms, the second term captures the contribution of job creation from entry and the third term captures job destruction from exit. The three terms can be expressed alternatively in terms of firm specific growth rates as:

\[
\frac{E_{cst} - E_{cst-1}}{X_{st}} = \frac{X_{cst}}{X_{st}} g_{cst} = \frac{X_{cst}}{X_{st}} \sum_{f \in s, c} \frac{X_{ft}}{X_{cst}} g_{ft}
\]
Where $X_{cst} = 0.5 \times (E_{cst} + E_{cst-1})$,

$$\frac{E_{nst}}{X_{st}} = \sum_{f \in s} \frac{X_{ft}}{X_{st}} g_{nft}$$

$$\frac{E_{cst-1}}{X_{st}} = \sum_{f \in s} \frac{X_{ft}}{X_{st}} g_{xft}$$

Where

$$g_{ft} = \frac{E_{ft} - E_{ft-1}}{X_{ft}}, X_{ft} = 0.5 \times (E_{ft} + E_{ft-1})$$

$$g_{nft} = \begin{cases} 2 & \text{if } g_{ft} = 2 \\ 0, & \text{otherwise} \end{cases}$$

$$g_{xft} = \begin{cases} 2 & \text{if } g_{ft} = -2 \\ 0, & \text{otherwise} \end{cases}$$

Here $E_{ft}$ is employment for firm $f$ in period $t$. From these relationships, it can be seen that the contribution from continuers can be measured directly from the cell level data or can be measured by taking employment-weighted ($X$-weighted) average of firm-level net growth rate for continuing firms. Note there is a difference between the contribution of continuers to the net growth rate of the cell and the net growth rate of continuers for the cell. The contribution takes into account the employment share of continuers.\(^{12}\) For the job creation from entry component or job destruction from exit component this can again be measured directly from cell based data or can be generated as employment-weighted averages of firm-level indicators of entry and exit.

\(^{12}\) Note that it may seem more natural to calculate job destruction from exit using only firms with firm age greater than zero since job destruction from exit must be identically equal to zero for firm ages equal to zero. Such an approach is perfectly acceptable and even desirable for some specifications. But in taking this approach a similar employment share adjustment as with continuers must be made in this case in aggregating components.
These relationships help integrate the findings in the main paper. First, consider these components for size class cells without controlling for age. Overall effects for firm size on net growth are reported in Table 2 and Figure 2.A of the main paper, effects of firm size on net growth for continuers are reported in Figure 2.A, and job destruction by firm exit is reported in Figure 3. To make this exposition easier, the components from the noted figures are reproduced here and we also include the job creation from firm entry in this analysis as well.

Figure W.16 shows the components of net growth by firm size. Note that this is a one way fully saturated model in firm size. The net (overall) differs non-trivially from net continuers for smaller size classes. The difference of course is driven by the role of job creation from entry and job destruction from exit. Job creation from entry is concentrated in the smaller size classes. So is job destruction from exit but job creation from entry exceeds job destruction from exit in the smaller size classes. These components are constructed to be additive in a manner consistent with the above equations. In many ways, these basic tabulations are at the heart of the results in the main text. That is, the inverse overall relationship between net growth and size is being driven entirely by the contribution of entry. Note that for continuers we observe a mild positive relationship between net growth and size. For exit, there is a strongly inverse relationship between size and net growth. So from continuers and exits alone, one would expect a positive relationship between net growth and size (recall sign convention here that we subtract job destruction from exit). Figure W.17 shows that the components add up to the overall consistent with the equations above. For this fully saturated one way model, this is an identity.

We now turn to the same exercise using our estimates controlling for firm age effects. Figure W.18 shows the overall (from Figure 2.A of paper), continuers (Figure 2.B of paper), job destruction from exits (Figure 3), and job creation from entry. Figure W.19 shows that the
components sum up to the total consistent with the above even in this case where we control for firm age. Given that we are using the partials from a two way model, this outcome is not an identity but Figure W.19 shows that there is a very tight empirical relationship between the estimated net overall and the weighted sum of the components. While not shown here, we also note that this pattern holds for the two way models without interactions.

It might be surprising there is any residual variation in “entry” after controlling for firm age. But entry here refers to a firm transiting from zero to positive activity. There is a small amount of such transitions especially for small firms even after initial entry at firmage=0.

These results highlight that even after controlling for firm age it is obviously important to take into account both continuers and exits in computing overall net growth rate for the cell. The overall relationship with size differs for continuers given the role of exits (and the modest role of “entry” for firm age>0).

We now turn to showing related patterns by firm age. First we show the results for firm age only (no firm size controls). We show results for firm age>=1. Figure W.20 shows the net overall and components by firm age. Figure W.21 shows that the components add up to the net overall. Since this is a fully saturated one way model this is not surprising since this is identity. In these results, we note that there is some very modest entry for firm age>0. The “up or out” dynamic of young firms emphasized is apparent in these basic tabulations. It is apparent that the relationship between net for continuers is very different than net overall. This reflects the offsetting effects of a very strong inverse relationship of net growth with firm age for continuers with the accompanying very high exit rate from job destruction from exit.

Finally we now show the patterns by firm age controlling for firm size (using current average size classes). Figure W.22 shows the net overall and components by firm age with firm
size controls. Figure W.23 shows that the components up add to the total. Since these are based on the partials from the 2 way model with interactions, this result is not simply reflecting an identity. Even though it is not an identity, the relationship between the net overall and the sum of the components is very tight. While not shown, it is also the case there is a tight relationship between the net overall and net from the weighted sum of the components when using the 2 way model without interactions.

The “up or out” dynamic of young firms is even stronger once we control for firm size. That is net growth rate is inversely related to firm age but job destruction from exit is also inversely related to firm age. As before, it is important to take both components into account (along with modest role for entry for firm age>0). Overall net growth patterns differ from net growth for continuers since by construction it incorporates the contribution of continuers, entry and exit.

In sum, this section shows that the components add up to the overall net growth effects for all specifications. This implies that we could have obtained the overall with a 3-part components approach. That is, we could have just estimated the continuers, job destruction from exit and job creation from exit components separately and then post-estimation added up the components. The appropriate interpretation of the overall is that it reflects all components. The advantage of the employment-weighted DHS growth rates is that the decomposition of overall net growth into components is straightforward.

F. Controlling for Industry and Year

Figures W.24 through W.27 are the analogues to Figures 2 through 5 from the main text but controlling for industry and year effects. It is apparent that the results in Figures 2 through 5 are robust to controlling for industry and year effects.
References


### Establishment Structure and Firm Dynamics for Eight Hypothetical Firms

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<th>Establishment Dynamics</th>
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Aggregate Net Growth: 0.0442

From Births: 0.1885

From Deaths: -0.0677

From Continuers: -0.0766

Net Growth Rate: 0.0442
Figure W.2 Employment Growth Distributions: Weighted and Unweighted
Figure W.3: Serial Correlation in Firm Employment Growth by Firm Size for Continuing Firms
Figure W.4  Controlling for Establishment Age Instead of Firm Age
Figure W.5  Robustness of Figure 2 to Using Firms With only Less than 500 employees
Figure W.6.1 Robustness of Up or Out Dynamic to Firms Less than 500 employees

Panel A: Net Employment Growth of Continuing Firms

Panel B: Job Destruction from Exit
Figure W.6.2: The Relationship between Net Employment Growth and Firm Age

Panel A: Net Growth Rate for All Firms

Panel B: Net Growth Rate for Continuing Firms
Figure W.7: Firm Exit by Firm Age
Figure W.8: Establishment Entry and Exit by Firm Age

Panel A: Job Creation from Establishment Entry

Panel B: Job Destruction from Establishment Exit
Figure W.9: Establishment Entry and Exit by Firm Size

Panel A: Job Creation from Establishment Entry

Panel B: Job Destruction from Establishment Exit
Figure W.10: Job Creation and Destruction at the Firm and Establishment Level by Firm Age
Figure W.11: Job Creation and Destruction at the Firm and Establishment Level by Firm Size
Figure W.12 Effects of Firm Size on Net Overall Growth and Net Growth For Continuers, Controlling for Firm Age (With and Without Interaction Effects)

Panel A: All Firms

Panel B: Continuing Firms
Figure W.13 Effect of Firm Size on Job Destruction from Exit Controlling for Firm Age (With and Without Interactions)
Figure W.14 Effect of Firm Age on Net Overall Growth and Net for Continuers, Controlling for Firm Size (With and Without Interaction Effects)

Panel A: All Firms

Panel B: Continuing Firms
Figure W.15 Effect of Firm Age on Job Destruction from Exit Controlling for Firm Size (With and Without Interactions)
Figure W.16 Components of Net Growth by Firm Size Class (Current(avg) Firm Size Classes)

Figure W.17 Comparison of Net Overall and Net from Sum of Components
Figure W.18 Net Overall and Components by Firm Size Classes (Avg Size), Controlling for Firm Age

Figure W.19 Overall and Sum of Components by Firm Size Class (Avg Size), Controlling for Firm Age
Figure W.20 Net Overall and Components by Firm Age

Figure W.21 Overall and Sum of Components for Firm Age
Figure W.22  Net Overall and Components by Firm Age, with Firm Size Controls

Figure W.23  Net Overall and Sum of Components by Firm Age, Controlling for Firm Size
Figure W.24: The Relationship between Net Growth and Firm Size (Controlling for Industry and Year Effects)

Panel A: All Firms

Panel B: Continuing Firms Only
Figure W.25: Firm Exit by Firm Size (Controlling for Industry and Year Effects)
Figure W.26: The Relationship between Net Employment Growth and Firm Age (Controlling for Industry and Year Effects)

Panel A: All Firms

Panel B: Continuing Firms Only
Figure W.27: Firm Exit by Firm Age (Controlling for Industry and Year)
Table W.1: Characteristics of LBD and similar longitudinal datasets

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<th>Dataset name</th>
<th>Microdata</th>
<th>Units</th>
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<th>Source Data</th>
<th>Coverage</th>
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<th>Firm Age</th>
<th>Years Covered</th>
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Table W.2 Estimates of Overall Net Growth by Firm Size and Firm Age for 1-way and 2-way Fully Saturated Models

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Table W.3 Estimates of Net Growth for continuers by Firm Size and Firm Age for 1-way and 2-way Fully Saturated Models

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