High-Tech Entrepreneurial Trends in the Austin MSA

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> "The rate of new entrepreneurs varies widely across metros. Austin ranked No. 1 in this category, with 600 new entrepreneurs for every 100,000 adults [in 2016]."
>
> —Kauffman Foundation's website, August 25, 2016.

Introduction

The previous report submitted to the Kauffman Foundation[2] depicts *general* trends in the Austin entrepreneurial ecosystem since the 1960s based on data from the Texas Secretary of State (SOS). These data illustrates two important trends. First, they display an explosive growth of entrepreneurial activity beginning in 2010—a trend that matches recent Kauffman Foundation rankings of Austin as the top metropolitan area in start-up density in the United States.[3] Second, they show entrepreneurial activity slowing down during national recessions in line with observations in previous studies (Guzman and Stern, 2016).

A group of researchers from MIT led by Professor Scott Stern note that a central challenge in the measurement of entrepreneurship is accounting for the variation in entrepreneurship quality across firms (Guzman and Stern, 2015a, 2015b, and 2016). More specifically, they are referring to the type of entrepreneurship that seems likely to be associated with overall economic performance. Citing Hurst and Pugsley (2011), they note that policymakers and theory often treat entrepreneurs

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[2] Echeverri-Carroll and Oden (2016). *Preliminary Assessment of the Factors That Led Austin to Become a High-Tech Entrepreneurial City*. Kauffman Foundation #2.

[3] The Austin-Round Rock MSA comprises Bastrop, Caldwell, Hays, Travis, and Williamson counties.

as a homogeneous group (at least from an *ex ante* perspective), but entrepreneurs seem to be very heterogeneous in terms of the ambition and potential of their ventures. Although quality indicators can vary, this report defines quality entrepreneurs not based on individual characteristics (e.g., entrepreneur's ambitions) or startup's characteristics (e.g., fast growth) but on the start-up's contributions to local economic development. More specifically, it argues that high-tech start-ups, defined as those in innovative industries, contribute disproportionately more to local economic development than non-high-tech start-ups.

In *The Geography of Jobs*, Moretti (2012) notes that a handful of cities with the "right" industries and a solid base of human capital keep attracting good employers and paying high wages, while those at the other extreme, cities with the "wrong" industries and a limited human capital base, are stacked with dead-end jobs and low wages. He notes that this Great Geographical Divergence has its origins in the 1980s when U.S. cities started to be increasingly defined by their residents' level of education. The cities where the "right" industries tend to agglomerate and talented workers tend to migrate are usually called high-tech cities.

Innovative activity tends to be more spatially concentrated than industrial activity (Audretsch and Feldman, 1996), and Research and Development (R&D), a proxy for innovative activity, is more spatially concentrated than employment (Carlino et al., 2012). This is so because the benefits of agglomeration to firms—earlier defined by Marshall (1890) and more recently by others (Storper, 1995, 2013)—apply doubly so to clusters of innovative activity (Carlino and Kerr, 2014). In particular, these innovative spatial clusters are sites of technological learning and localized knowledge spillovers, the most important input in innovation processes (Jaffe and Trajtenberg, 2002; Feldman, 1994, 2003). Innovative activities have then an incentive to agglomerate because knowledge externalities depend on spatial proximity.

Cortright and Mayer (2001) find that in most high-tech cities, high-tech employment is concentrated in only a few industry segments. What benefits do high-tech industrial clusters bring to a region? Moretti (2012) elaborates on at least two of these benefits. The first and perhaps least understood regional benefit is the multiplier effect of wages in high-tech jobs on wages in low-tech jobs. The second regional benefit is the cross fertilization of ideas and know-how that makes hotbeds of innovative industries unrivaled as entrepreneurial centers, however costly the local land and labor. Indeed, Delgado et al. (2010) find that industries located in regions with strong clusters (i.e., a large presence of other related industries) experience higher growth in new business formation and start-up employment. Finally, industrial clusters of innovative firms are vital to regional growth (Carlino and Kerr, 2014).

Austin has been ranked consistently among the most entrepreneurial cities (Kauffman Foundation, 2016) and among the top high-tech cities (Milken Institute, 2015) in the United States. The previous report submitted to the Kauffman Foundation presents data on Austin's specialization in three clusters of high-tech industries: computers, semiconductors, and software (Echeverri-Carroll and Oden, 2016). There is, however, a void of studies on both general and quality entrepreneurial growth trends in Austin. This report fills this void by presenting new data on the number of quality or high-tech start-ups in the Austin–Round Rock metropolitan area since 1990. It accomplishes this task in several sections.

Section one uses registration data from the Texas Secretary of State to identify Austin business establishments registered in Delaware from 1960 to 2015, a proxy for local start-ups that have received venture capital funding—an entrepreneurship quality indicator. Section two compares general entrepreneurial trends from National Establishment Time Series (NETS) and the Texas Secretary of State (SOS). Section three presents NETS data on the number of total high-tech start-ups in Austin from 1990 to 2010 and by industry during the same period. Section four describes the steps in matching establishment names and location (ZIP code) in NETS and SOS in order to explore similarities and differences among these two databases that have become important sources of data on regional entrepreneurship activity. The final section enumerates some of the main conclusions from this analysis and discusses future research.

Measuring Quality Entrepreneurial Trends with Texas SOS Data

Guzman and Stern (2016) noted that a practical requirement for any growth-oriented entrepreneur is business registration—as a corporation, partnership, or limited liability company. As they explained it, although it is possible to found a new business without registration (e.g., sole proprietorship), the benefits of registration are substantial. These include limiting liability, tax benefits, and the ability to issue and trade ownership shares. Limited liability companies must register with a secretary of state in order to take advantage of these benefits, as the act of registering the firm triggers the legal creation of the company. Therefore, the business registration records reflect the population of businesses that adopt a form that is a practical prerequisite for growth—one proxy for entrepreneurship quality.

Guzman and Stern (2016) find that corporations are more likely to grow than start-ups organized under other legal structures, and firms registered under Delaware jurisdiction (instead of the local jurisdiction) are also more likely to grow. Delaware registration (or jurisdiction) is preferred by business establishments seeking more certainty in corporate law and is required by many venture capitalists (Guzman and Stern, 2015b). Moreover, as Carmelo Gordian,[4] a local lawyer specializing in helping business establishments to register with the Texas Secretary of State, explains, a history of legal precedent outlining the specifics of directors' and shareholders' rights has established the Delaware courts as the gold standard for corporate governance.

We focus on for-profit business establishments that are registered under the legal form of corporations, limited partnerships, and limited liability companies. It is important to note that establishments that are sole proprietorships or general partnerships are not required to file with a secretary of state; therefore, the SOS data does not include most sole proprietorships. Following the work of Guzman and Stern (2015a, 2015b, 2016), we used business registration records from the Texas Secretary of State to study entrepreneurial trends in Austin.[5] We included businesses

[4] Interview with Carmelo Gordian on September 27, 2016.
[5] Guzman and Stern (2015a, 2015b, and 2016) provide a rich and detailed overview of these data in the data appendix of their publications.

founded in Austin as well as those founded in Austin but registered in Delaware. As already indicated, venture capital investors often prefer to finance firms governed under Delaware law. In a manner similar to Guzman and Stern (2015a, 2015b), we restrict our sample of private and public entities registered with the Texas SOS to those satisfying one of the following:

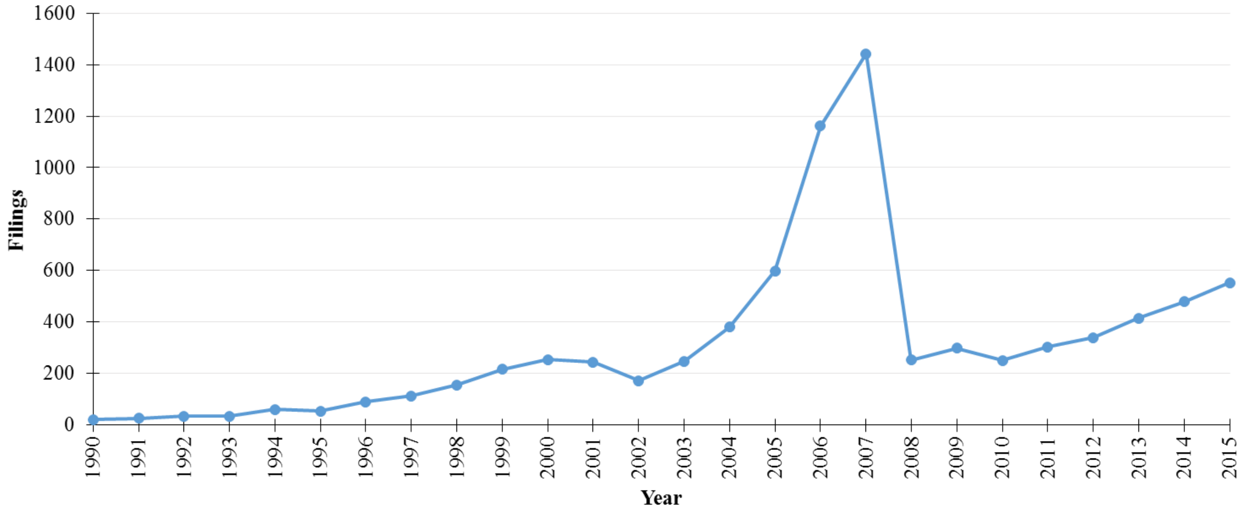
(i) A for-profit establishment with its principal office in the Austin–Round Rock MSA ZIP codes (see Appendix B for list of ZIP codes);

(ii) A for-profit establishment registered in Delaware with principal office in the Austin–Round Rock MSA ZIP codes.

Our sample of start-ups in the Austin metro includes 214,861 unique filings[6] with the Texas SOS and in Delaware between 1 January, 1960, and 31 December, 2015, with a primary address in an Austin ZIP code. One indicator of entrepreneurial quality is the number of start-ups that receive venture capital funds. It is important to note that usually firms funded by venture capitalists are high-tech, but not all high-tech firms are funded by venture capital, as angel investors are also an important component of the capital available to start-ups. There were 8,354 Austin start-ups registered in Delaware from 1960 to 2015. However, most of these registrations (98 percent) occurred after 1990. Figure 1 shows venture-capital-backed start-ups registered in Delaware with principal address in an Austin MSA ZIP code between 1990 and 2015. Particularly striking is the rapid increase of registrations in Delaware after the dot-com bust and before the Great Recession in 2008. There is a steep upward trend for this proxy of venture-capital-backed start-ups from 2010 to 2015 in line with Austin's recent rankings as the number one entrepreneurial city in the United States. We note that this trend, however, is much more moderate than the trend for new Austin-based establishments registered in Texas as reported in the previous Kauffman Foundation report (Echeverri-Carroll and Oden 2016).

[6] Each entity that registers with the SOS is assigned a unique filing number that represents the establishment. If there are multiple filings for a given entity (i.e., a legal amendment to the entity's file such as a change of legal structure, addition of an officer, name change, etc.), the same unique filing number is associated with each.

Figure 1
Number of for-profit, Delaware establishment filings in Austin, 1990-2015.



Source: Texas Secretary of State.
Notes: For-profit firms include corporations, LLCs, and LPs.

Comparing Austin's Entrepreneurial Trends Using NETS and SOS Data

The National Establishment Time Series (NETS) is a product of Walls and Associates resulting from a collaboration with Dun and Bradstreet (D&B). According to Neumark et al. (2005), D&B strives to identify and assemble information on all business establishments[7] through a massive data-collection effort including more than 100 million telephone calls from four calling centers each year as well as obtaining information from legal and court filings, newspapers and electronic news services, public utilities, U.S. Secretaries of State, government registries and licensing data, payment and collections information, company filings and reports, and the U.S. Postal Service. Particular efforts are devoted to identifying the birth and death of establishments. For every establishment identified, D&B assigns a Data Universal Numbering System (DUNS) number as a means of tracking the establishment. According to Neumark et al. (2005), the DUNS has become the standard means of tracking businesses, having been adopted by many government agencies in the United States and internationally since around 1990. NETS data covers essentially

[7] They stress the importance of having access to the population of establishments, not just samples.

all establishments (whether entrepreneurial or not) in the United States and specific regions using data from the D&B archives (Neumark, Zhang, and Wall, 2005). We have access to an extract of this data set that covers all business establishments that were located in the Austin–Round Rock metropolitan area between 1990 and 2012.

NETS provides many variables (over 350) associated with each establishment (Walls & Associates, 2013). However, only the following variables are of particular importance in identifying the birth of new establishments and the industry to which they belong: first year of the establishment (FirstYear), ZIP code of establishment location at first year (ZIPCode_First), last type of location (EstCat—single location, headquarters, branch), and industry classification for each year (NAICS—primary industry classification code).

Previous studies have found a high reliability of NETS data in capturing new business establishments. Neumark et al. (2005) find a correlation of 0.87 between start dates reported in NETS and the start date reported by the company website (75 percent corresponded exactly, 88 percent within one year, 92 percent within two years) for biotechnology establishments in California. Moreover, Newmark et al. (2011) note that earlier D&B data were criticized for reporting higher aggregate employment levels and capturing business births poorly. With the current NETS database, constructed using more recent D&B data, they find that overestimation of aggregate employment is not a serious concern and underestimation of establishments births is largely invalid for U.S. data.

For establishments that existed before 1990, NETS records 1989 as the establishment's first year of existence. Additionally, NETS data for the previous year are reported as data for the following year. For instance, NETS 2013 data include establishments created through the end of 2012, not those created in 2013. We restrict our sample to establishments that reported a first year between 1990 and 2012.[8] We impose additional restrictions to increase the probability that an

[8] Neumark et al (2005) removed NETS observations for 1990 and 1991, as D&B drastically improved its methodology for data collection in 1992. We chose to retain these years, as they do not show a divergence from the trends seen in the SOS data discussed in section two.

establishment's birth is indeed entrepreneurial, not an out-migration relocation or expansion of an existing firm. All establishments in NETS are classified as being a headquarters (having a child establishment), a branch (having a parent establishment), or stand-alone (having neither a parent nor a child establishment). We remove branch establishments, as these cannot be entrepreneurial by definition.

Choi, Robertson, and Rapasingha (2013) noted that publicly provided firm-level data, namely the Quarterly Census of Employment and Wage (QCEW) and Business Dynamics Statistics (BDS), deviate significantly below NETS in terms of number of establishments. They attribute this disparity to several interrelated reasons. One main reason suggested is that the QCEW and BDS exclude establishments not subject to state unemployment insurance (UI) programs, including sole proprietorships (Choi et al., 2013). NETS also counts the owner of the business as an employee regardless of the existence of a payroll record for the establishment. Because the SOS data does not include self-proprietors, as indicated earlier in this report, we need to exclude sole proprietors from NETS, as do Choi et al. (2013), in order to compare it with SOS data.

Like Choi et al. (2013), we also need to remove not-for-profit establishments (e.g., religious or charitable organizations, etc.), government establishments, and subcontractors. The legal status variable (LegalStat: G = proprietors, H = partnership, I = corporation, J = non-profit) in NETS would have potentially allowed us to identify sole proprietors and non-for-profit establishments. However, this variable has 248,382 missing cases, which means that for about 70 percent of the establishments, the legal status is not reported in our Austin–Round Rock total sample. We follow the Choi et al. (2013) methodology to estimate sole proprietors by excluding establishments with only one employee in their first year in NETS.[9] Moreover, we delete the relatively few establishments whose variable legal status identifies them as self-proprietors or non-profit establishments. We then delete establishments with NAICS codes that Choi et al. (2013)

[9] Choi et al. (2013) also excluded establishments with two employees. However, we decided to only remove establishments with one employee for two reasons. First, if we removed the establishments with two employees we will end up removing some limited partnerships which are part of the SOS data. Second, start-up trends from NETS deviate significantly from SOS start-up trends when we exclude establishments with two employees.

suggest identify government, subcontractors, and non-profit organizations.[10] We also take into consideration that the last two years in NETS are less reliable due to sampling procedures, so we restrict our period of analysis to 1990 to 2010.[11] In sum, our NETS sample of 138,889 start-ups in Austin for the 1990–2010 period fulfills the following criteria:

(i) First year is between 1990 and 2010 with a first address ZIP code included in the Austin-Round Rock MSA;

(ii) Establishment is not categorized as a branch;

(iii) Establishment does not have a non-profit legal status;

(iv) Establishment is not government-owned or a subcontractor;

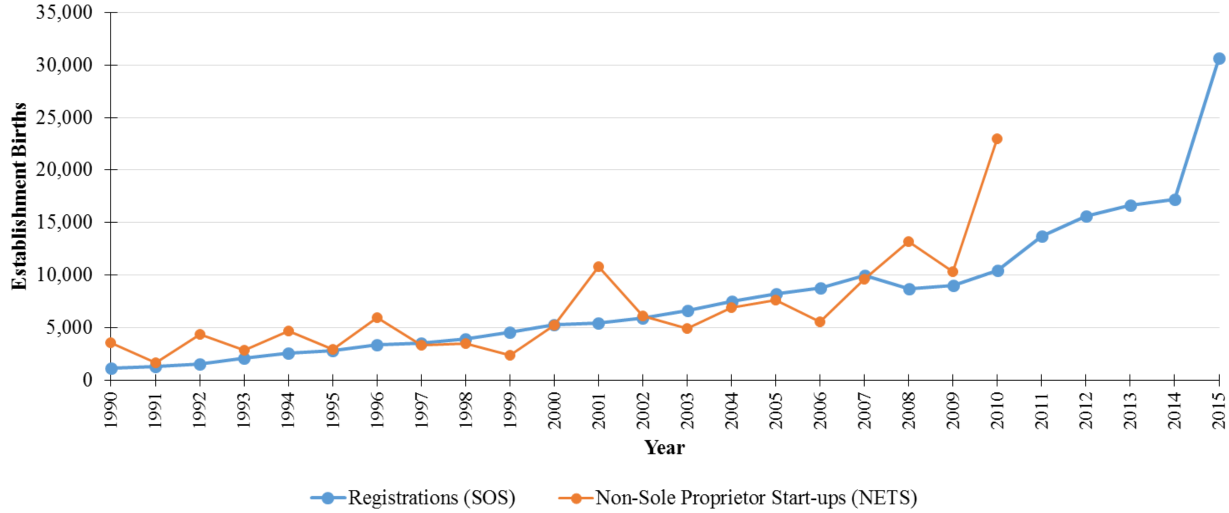
(v) Establishment is not a sole proprietorship by employment or legal status.

Figure 2 compares start-up trends in the Austin metropolitan area from 1990 to 2010 using NETS and SOS data. Particularly noticeable is that the number of Austin start-ups (excluding sole proprietors) in NETS is much higher (138,889) than those find in the SOS data (112,931) for the 1990–2010 period. It means that we have 25,958 more start-ups in NETS than in the SOS database. Second, it is important to note that in spite of size differences the two databases show similar upward trends in the number of start-up births in Austin from 1990 to 2010. Also noticeable is the fact that data from the SOS depict a smooth trend, while NETS data display stronger ups and downs particularly in recent years.

[10] NAICS: 92, 8131, 4821, 6111, 1141, 8141, and 11.

[11] We understand that only one-third of the NETS data is annually revised. Because NETS data from the three most recent years are still in a period of revision, we remove data for years 2013, 2012, and 2011.

Figure 2
Business registrations and entrepreneurial establishment births in Austin, 1990-2015.



Source: SOS and NETS.
Notes: For-profit firms in SOS include corporations, LLCs, and LPs. Non-sole proprietor start-ups in NETS satisfy criteria 1-5. NETS revises data for three years after collection.

High-Tech Start-up Trends in Austin Using NETS

The SOS data does not allow us to study establishment births in Austin by industry. In contrast, NETS data allow us not only to study establishments' births but also to differentiate them by the type of industry to which they belong. As discussed in the introduction, we are interested in finding quality establishments or those that contribute more to regional growth. We refer to establishments that are skill-intensive or high-tech, pay high wages and compete globally through innovation. More specifically, high-tech establishments are those in high-tech industries, but what are high-tech industries?

Hecker (2005) points out there is no single definition of high-technology industries (or establishments); however, there is wide agreement on their general characteristics. In particular, he cites a report from the Office of Technology Policy (1982) describing high-technology firms as those engaged in the design, development, and introduction of new products or innovative manufacturing processes through the systematic application of scientific and technical knowledge.

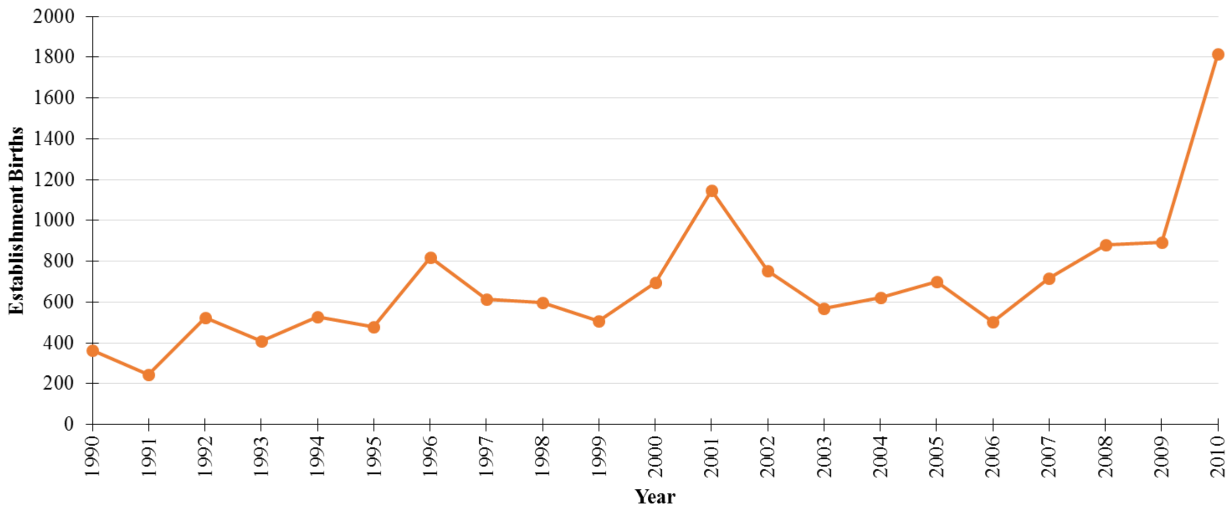
To classify industries by their relative innovativeness, studies have used a large variety of proxies for innovation (Chapple et al., 2004). However, in most academic studies, high-tech industries are those with a large proportion of workers in scientific, technical, or technology-oriented occupations (Hadlock et al., 1991; Hecker, 1999, 2005; Luker and Lyons, 1997; Markusen et al., 1986; Yu, 2004).

Studies define four Standard Occupational Classification (SOC) categories as technology-oriented: engineers, life and physical scientists, computer professionals and mathematicians (except actuaries), and engineering, computer, and scientific managers. Workers in these occupations need in-depth knowledge of theories and principles of science, engineering, and mathematics (Hecker, 1999, 2005). Such knowledge is generally acquired through specialized post–high school education, ranging from an associate degree to a doctorate, in some field of technology. Using data on employment by occupation, Hecker (1999, 2005) finds which NAICS categories are relatively intensive in technology-oriented workers and classifies them as high-tech. As noted by Decker et al. (2015), Hecker's definition of high-tech industries has become standard in the literature. To use Hecker's (2005) definition of high-tech industries, we crosswalked his 46 four-digit, 2002 high-tech NAICS codes to 198 six-digit, 2012 high-tech NAICS codes.[12]

NETS provides the annual industrial classification of an establishment by its primary 2012 NAICS code at the six-digit level of specificity. We classify an establishment as high-tech based on its first reported NAICS code in NETS (variable name: NAICS) and whether it fits Hecker's list of high-tech NAICS. Our focus in this report is on total high-tech entrepreneurial trends and those in the top high-tech sectors in Austin. Figure 3 shows the number of new high-tech entrepreneurial establishments in Austin from 1990 to 2010. It depicts the steady growth of high-tech start-ups in the 1990s, a slowdown after the dot-com bust in 2000, and an acceleration after the 2008-2009 Recession.

[12] See table 1 in Appendix A for a complete list of the high-tech NAICS codes.

Figure 3
High-tech start-ups in Austin, 1990-2010.



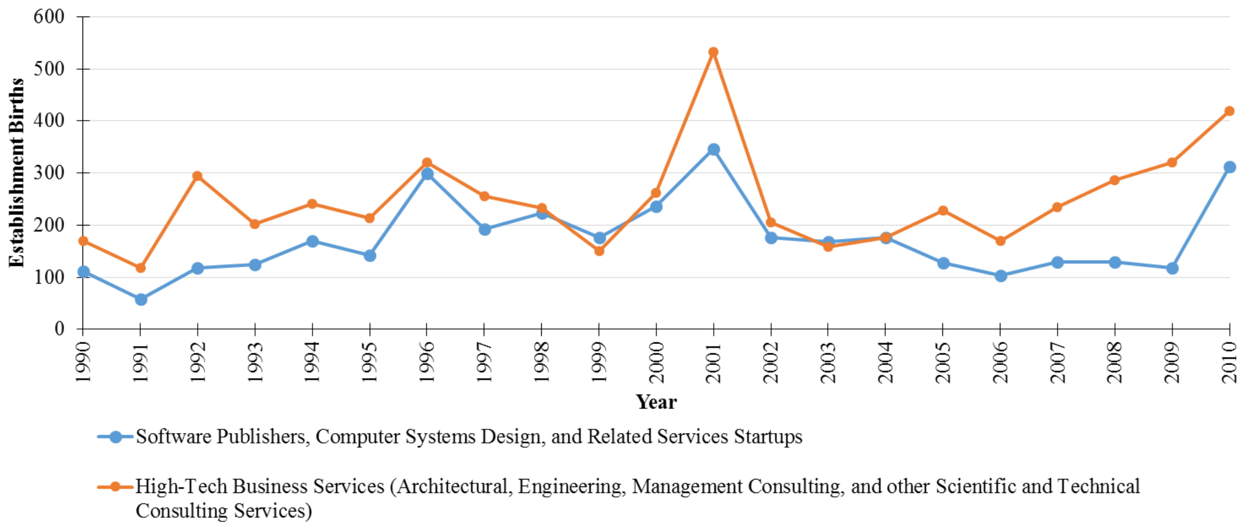
Source: NETS.
Notes: Start-ups are non-sole proprietors satisfying criteria 1-5. NETS revises data for three years after collection. See appendix A for high-tech definition.

As described in the previous Kauffman Foundation report (Echeverri-Carroll and Oden, 2016), Austin specializes in three high-tech traded sectors: computer and semiconductor manufacturing and software. The first two are traded sectors defined mainly by large global high-tech firms that experience high international competition. Creating a new computer or semiconductor manufacturing facility is very expensive relative to a software start-up. Thus, most of the high-tech entrepreneurial activity in the city is dominated by one traded sector, software. This sector has benefited from many technological advances (e.g., cloud computing, open source software, etc.) that have significantly reduced the cost of creating a new start-up as well as new technologies that have reduced the cost of reaching a global market (e.g. Internet) (Echeverri-Carroll and Oden, 2016).

We use industry-level data from NETS (excluding sole proprietors) to study entrepreneurial trends in high-tech sectors. The number of new start-ups in the computer and semiconductor manufacturing sectors has stayed constant in a range of 20 to 40 per year between

1990 and 2010. In contrast, as figure 4 shows, total start-up births in the software industry have ranged from 100 in 1990 to as many as 300 in 2001 and more than 150 per year after 2010.[13] It is also important to notice the significant increase in software start-ups between 2009 and 2010, which grew at a rate of 165.2 percent from 2009 to 2010. As discussed in the previous report, the software sector has surpassed the semiconductor and computer manufacturing industry in terms of full-time employment indicating the increasing specialization of Austin in this industry and the increasing importance of this sector for the local economy.

Figure 4
Software and high-tech business services start-ups in Austin, 1990-2010.



Source: NETS.
Notes: Start-ups are non-sole proprietors satisfying criteria 1-5. NETS revises data for three years after collection. See appendix A for high-tech and ICT sector definitions.

As expected the vast majority of high-tech start-ups are in non-traded service activities—those that depend on the local market and therefore their existence is dependent on the vitality of the traded sector (Moretti 2013). Particularly striking has been the accelerated growth of the high-

[13] The NAICS codes that define the software sector are selected from previous studies that examine all high-tech sectors or specifically the Information and Communications Technology (ICT) or software sectors (Saxenian, 1994; Rosenthal and Strange, 2004; Bessen and Hunt, 2007; Spigel, 2013; Osman, 2015). The NAICS codes that define any of the other high-tech sectors are based on Osman (2015) and table A1 from Echeverri-Carroll et al. (2016).

tech business service sector which includes professional services such as architecture, engineering, management consulting, and other technical consulting services. Indeed, as Figure 4 shows, the business service sector has grown steadily, generating more than 150 new start-ups per year in Austin since 1992.

What Type of Startups Are not in the SOS Data?

SOS and NETS databases are two of the primary sources of data on new establishments at the regional level. The significance of these databases is that they are not samples but they capture the population of startups. As already noted, there are 25,958 more start-ups in NETS than in the SOS database. We do not know the demographic characteristics of this group of start-ups. Do they belong to the same industry? Do most of them show a different start year than a legal registration year? The only possible overlapping variable between the two databases is the name of the business establishment. Although there are statistical packages that facilitate name matching processes, their usefulness is limited in cases where there is a large deviation on names.

The exercise of matching names in NETS and SOS is complex because many establishment names in the NETS database do not exactly match establishment names in the SOS database. These are some examples: Accelrted Dgital Solution, Inc. (NETS) versus Accelerated Digital Solutions, Inc. (SOS); Doner John & Assoc. (NETS) versus John Doner & Associates, Inc. (SOS). Differences could be due to a variety of reasons such as misspelling, use of abbreviations, registration under different names in each database, etc. We have then to use both manual and approximated matching methods (using statistical software) in our matching exercise.

Approximate matching is conducted using fuzzy matching techniques. These techniques are used to identify pairs of words that have a high probability of being the same, despite not being 100 percent matches. We use the COMPGED function in SAS as our fuzzy matching tool. The

COMPGED function compares two string variables[14] and returns a value (COMPGED score) based on the measure of dissimilarity[15] between the two strings. The COMPGED function gives a high value if the strings are highly dissimilar and a low value if the strings are almost alike (e.g., an exact match will return a value of 0). We can then identify pairs with the highest probability of being actual matches by choosing low COMPGED scores and then manually verify whether they are valid matches. However, it should also be noted that when comparing two lists of string variables, the COMPGED function will return values for every possible pair of variables that can be formed between the two lists (e.g., if there are 100 names in list A and 200 names in list B, the COMPGED function will score all 20,000 possible pairs). The scoring of every possible pair of names for big data sets such as ours is computationally time consuming and can also result in a huge number of invalid pairs with low COMPGED scores. Since each pair with a low COMPGED score might not be an actual match (e.g., the pair Technologies Unlimited Inc. and Technology Unlimited Inc. has a low COMPGED score since the company names are almost alike, yet they are different companies), the resulting data set of pairs resulting from the COMPGED function needs to be verified manually, making the process very complex.

To make the name matching process manageable, we focus only on start-ups in the software services subsector (excluding non-sole proprietors) in our Austin sample for the 1990–2010 period. This results in a subset of 3,642 software establishments to be matched against 112,931 SOS records in Austin between 1990 and 2010. We selected the software services subsector because of its importance to Austin's start-up ecosystem and the local economy. We perform this matching process in several stages (please follow them in figure 5).

A prerequisite for the matching process is cleaning the establishment name variable in NETS and the entity name variable in SOS of extraneous spaces, special characters (e.g., #,!?$ etc.), and words that do not add value to the matching process (e.g., "Inc.," "Ltd.," "LLC," " Corporation," etc.). In the first matching stage, we use a SAS code to find exact matches between

[14] A string variable is a variable that can contain letters, numbers, and other characters.
[15] The measure of dissimilarity is obtained by computing the number of deletions, insertions, or swaps needed to transform one of the strings being compared into the other string (sometimes referred to as the Levenshtein distance).

the establishment name in NETS and the entity name in the SOS data set. We find 1,349 exact name matches, leaving us with 2,293 establishments remaining to be matched.

In the second stage we utilize a SAS command (Proc SQL) which allows us to select a set of establishment pairs that fulfills the following two requirements: the COMPGED scores are below an arbitrarily low threshold value and the ZIP code of each establishment pair is the same in NETS and SOS databases. We manually verify the quality of matching in the resulting pairs in order to identify valid matches. We repeat the process with a higher threshold value for the COMPGED score. We observe that in most cases of valid matches, the establishment names differed by extraneous spaces between words, letters missing in words (e.g., Intelligent Automation Systems Inc. versus Intellgent Automtn Systems Inc.), or because the company name in one database was a shorter version of the corresponding name in the other database (e.g., Leosoft Inc. versus Leo Soft Inc.; Isquare-R Inc. versus Isquare Inc.; Shokwave Software Inc. versus Shokwave Inc.). We identified 85 establishments that are cross-listed with the same name in the two databases using this method. We are then left with 2,208 unmatched establishments.

In the third stage, we observe that of the 1,349 exact matches we obtained in the first stage, 749 establishments (55.5 percent) did not have matching ZIP codes in the SOS data set, so we decided to continue the matching process based only on the establishment name without imposing the restriction of an exact match on establishment ZIP code. We repeat the stage-two process to obtain pairs with the highest probability of being valid matches. We were able to find 38 additional valid matches between the two data sets and are now left with 2,170 unmatched establishments.

Certain establishments in NETS have registered with SOS under a slightly different name—e.g., Zunke Network Solutions (SOS) versus Zunke Associates (NETS). Therefore, they could not be captured using the COMPGED function. In such cases, even though the establishment names share a portion that is exactly the same, COMPGED calculates the score for the entire string and gives high scores in these cases, which is misleading. To account for this problem, we use the INDEX function in SAS in the fourth stage of the matching process. The INDEX function is used to find a substring of characters (e.g., zunke) within character strings of establishment names (e.g., zunke associates). The INDEX function maps the substrings in one database with the strings in the other database. It searches strings from left to right, looking for the occurrence of the specified substring. When a pair of matching names occurs, it gives a non-zero value. If the substring is not found within any letter string (establishment name), it gives a zero value. The resulting list of pairs with non-zero values is verified manually to ascertain whether they are valid matches or not. We find 32 valid matches between the establishment names and entity names using this procedure. We are left with 2,138 establishments that remain unmatched at the end of stage four.

We ran out of possibilities to continue finding matches using software and needed to rely on manual matching. To facilitate this process, we selected a random sample of 500 out of the 2,138 remaining establishments and cross-checked it using publicly available information from the Texas Comptroller of Public Accounts. This organization provides information on establishments' registration with the Texas Secretary of State. We checked at the Comptroller's Website whether the 500 NETS establishments were registered under different names in the SOS records according to this organization (e.g., DroidCloud Inc. in NETS data is registered as Hypori Inc. in the SOS database). We were able to identify three such establishments, leaving us with 2,135 unmatched establishments.

Why could we not find matching names for 497 establishments of our random sample of NETS establishments in the SOS? We found several reasons:

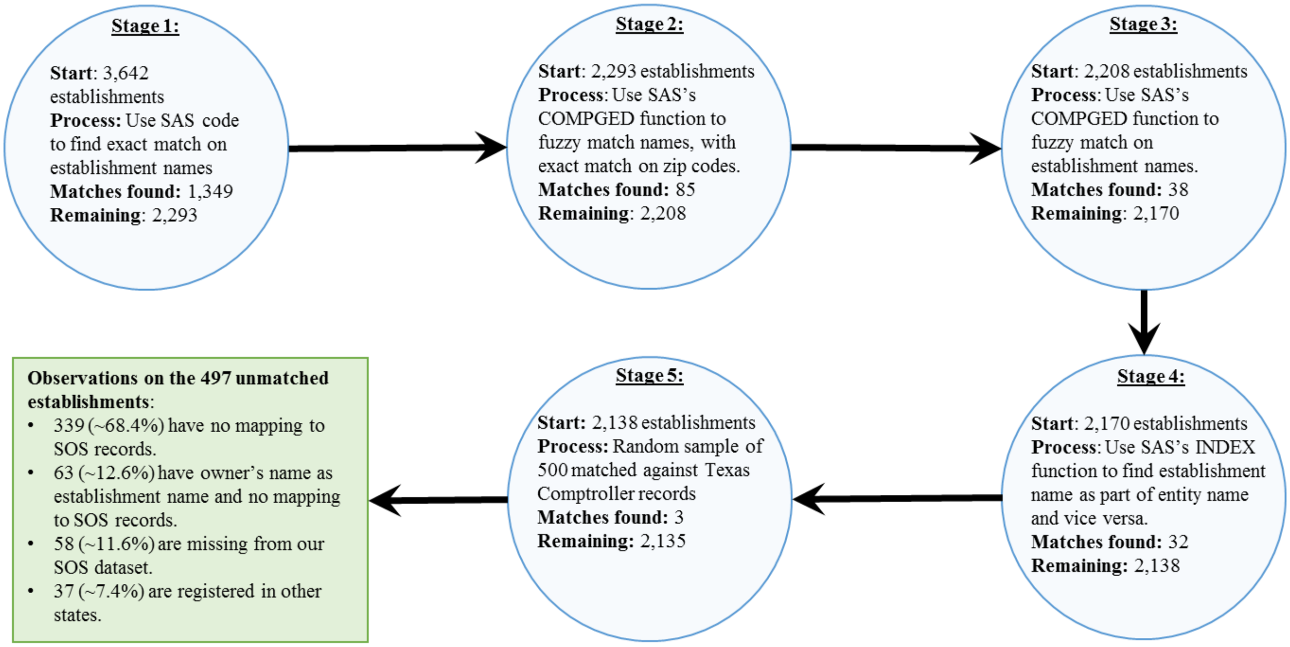
- We find 63 records (12.6 percent of cross-checked records) in the NETS data set that have the owner's name as the establishment name (e.g., Anderson James R, Benjamin D Connor). No corresponding matches could be found in the SOS data in such cases. It is quite possible that the owners register with the SOS with a different official name.
- 58 records (11.6 percent of cross-checked records) in the NETS data set have corresponding SOS filing numbers (according to the Texas Comptroller of Public Accounts records) but are missing from our SOS database. According to the Texas Comptroller records, these establishments were born in Austin between 1990 and

2010, have primary establishment addresses in the Austin MSA, and are registered in either Texas or Delaware. This suggests that we might not have gotten a complete list of business establishments from the Texas Secretary of State.

- 37 records (7.4 percent of cross-checked records) in the NETS data set are establishments that have an Austin address in the NETS data but are registered in other states different from Texas and Delaware.
- 339 records (68.4 percent of cross-checked records) in the NETS data set are establishments for which no corresponding SOS record could be found using both our SOS data set and the Texas Comptroller records.

We need to ask for registration data from the Texas Secretary of State for business registered in other states besides Texas and Delaware (7.4% of the cases). We also need to ask the Texas SOS why we did not get all companies registered in Texas o Delaware (11.6% of the cases). However, the most important explanation for unmatched names in the two databases (68 % of the cases) is the fact that the establishment is missing from the SOS database. Using the richness of information available in the NETS database, we will continue to explore the demographic characteristics of the missing software business establishment. We think that this exercise will contribute to the entrepreneurial literature by evaluating the limitations and possibilities of measuring entrepreneurial quality based on two different databases.

Figure 5
Matching procedure for SOS and NETS.



Source: Authors' calculations, SOS, and NETS.

Conclusions

The Kauffman Foundation has recently ranked Austin as the number-one entrepreneurial city in the United States. We use new data from the Texas Secretary of State to estimate all start-ups in Austin from 1960 to 2015. Two trends are particularly striking. First, Austin consistently generated new establishments during the entire period. Second, the city displays an explosive growth of entrepreneurial activity starting in 2010 in line with its top rankings in entrepreneurial activity among U.S. metropolitan areas. Following the MIT group, this report maintains that it is important to study quality entrepreneurs and focuses on industries associated with good paying jobs and local economic growth. The reports presents new NETS data on innovative or high-tech start-ups as an indicator of entrepreneurship quality. To our knowledge, it is the first time that data are used to document the growth of high-tech start-ups by industry in the Austin metropolitan area.

NETS data allow identification of the establishment's industry for our Austin sample from 1990 to 2010. Results show an accelerated growth of high-tech start-ups, especially before the 2000 dot-com bust; a slowdown of growth after this recession; and sped-up growth after the Great Recession in 2008. These trends are for the most part consistent for new establishments from both NETS and the SOS databases. Two sectors have been responsible for most of the high-tech entrepreneurial activity in the city, software and business services (including professional services such as architecture, engineering, management consulting, and other technical consulting services).

Software start-ups have grown consistently since at least 1990. But, they grew especially rapidly after 2006 due to new technologies, in particular, cloud computing and open-source innovations that have made creating a software start-up easier and less costly as well as the Internet that has facilitated access to global markets. This rapid growth also coincides with an explosion of co-working spaces and incubators in the city that have enabled the diffusion of knowledge of how to create new software start-ups. Particularly important has been the creation of Capital Factory in 2009, which has become the de facto community of entrepreneurs with an average of 1,000 entrepreneurial events a year that bring, on average, 50,000 participants, and prospects to have 100,000 participants next year.[16]

Finally, this report notes that in spite of close similarities in start-ups growth trends between the SOS and the NETS data, there are 25,958 more start-ups in NETS than in the SOS database. We then question what type of start-ups are not in the SOS database? We conducted a pilot exercise to try to match names for 3,642 software establishments in NETS with 112,931 start-up names in the SOS data. We were able to match 41.37 percent (1,507) of establishments, mostly using SAS matching codes. To try to understand why we could not match 58.63 percent (2,135) of these establishments, we selected a smaller sample of 497 of the unmatched software establishments to check them manually. We found that most of these NETS establishments (68 percent) were simply not in the SOS database. Future research will use the richness of business establishment data (e.g.,

[16] Interview with Josh Baer, Capital Factory founder on September 16, 2016.

available in NETS industry, employment, sales, year started) to studying the demographic characteristics of the start-ups that are not in the SOS data. Evaluating limitations and possibilities of measuring entrepreneurial quality based on two different large databases is an important contribution to the entrepreneurship literature.

Appendix

A. High-Technology Industries and Information and Communication Technology Sector Definitions

Our definition of the ICT sector is a subset of the 198 six-digit, 2012 high-tech NAICS codes cross walked from Hecker's (2005) 46 four-digit, 2002 high-tech NAICS codes. These five ICT subsectors are:

(i) Semiconductor and electrical equipment manufacturing;

(ii) Computer and related equipment manufacturing;

(iii) Software, computer systems design, and related services;

(iv) Commercial equipment wholesalers and telecommunication related services;

(v) Other high-tech business services.

These subsectors are explicitly defined by 69 six-digit 2012 NAICS codes listed in table 1. The categorization of the software sector comes from definitions in Osman (2015), Spigel (2013), Bessen and Hunt (2007), Rosenthal and Strange (2006), and Saxenian (1994). The categorization of the other four sectors is based on Osman (2015) and table A1 in Echeverri-Carroll et al. (2016).

Table 1: High-Tech 2012 NAICS Codes (6-digit)		
Sub-Sector Title	**2012 NAICS Industry**	**2012 NAICS Code**
Semiconductor & Electrical Equipment Manufacturing	Semiconductor Machinery Manufacturing	333242
	Bare Printed Circuit Board Manufacturing	334412
	Semiconductor and Related Device Manufacturing	334413
	Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing	334416
	Electronic Connector Manufacturing	334417
	Printed Circuit Assembly (Electronic Assembly) Manufacturing	334418
	Other Electronic Component Manufacturing	334419
	Blank Magnetic and Optical Recording Media Manufacturing	334613
	Software and Other Prerecorded Compact Disc, Tape, and Record Reproducing	334614
	Power, Distribution, and Specialty Transformer Manufacturing	335311
	Motor and Generator Manufacturing	335312
	Switchgear and Switchboard Apparatus Manufacturing	335313
	Relay and Industrial Control Manufacturing	335314
	Storage Battery Manufacturing	335911
	Primary Battery Manufacturing	335912
	Fiber Optic Cable Manufacturing	335921
	Other Communication and Energy Wire Manufacturing	335929
	Current-Carrying Wiring Device Manufacturing	335931
	Noncurrent-Carrying Wiring Device Manufacturing	335932
	Carbon and Graphite Product Manufacturing	335991
	All Other Miscellaneous Electrical Equipment and Component Manufacturing	335999
Computer & Related Equipment Manufacturing	Electronic Computer Manufacturing	334111
	Computer Storage Device Manufacturing	334112
	Computer Terminal and Other Computer Peripheral Equipment Manufacturing	334118
	Optical Instrument and Lens Manufacturing	333314
	Telephone Apparatus Manufacturing	334210
	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	334220
	Other Communications Equipment Manufacturing	334290
	Audio and Video Equipment Manufacturing	334310
	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	334513
	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	334515
	Other Measuring and Controlling Device Manufacturing	334519
Software, Computer Systems Design, & Related Services	Software Publishers	511210
	Custom Computer Programming Services	541511
	Computer Systems Design Services	541512
	Computer Facilities Management Services	541513
	Other Computer Related Services	541519
	Data Processing, Hosting, and Related Services	518210
Commercial Equipment Wholesalers & Telecommunication Related Services	Photographic Equipment and Supplies Merchant Wholesalers	423410
	Office Equipment Merchant Wholesalers	423420
	Computer and Computer Peripheral Equipment and Software Merchant Wholesalers	423430
	Other Commercial Equipment Merchant Wholesalers	423440
	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers	423450
	Ophthalmic Goods Merchant Wholesalers	423460
	Other Professional Equipment and Supplies Merchant Wholesalers	423490
	Wired Telecommunications Carriers	517110
	Wireless Telecommunication Carriers (Except Satellite)	517210
	Satellite Telecommunications	517410
	Telecommunications Resellers	517911
	All Other Telecommunications	517919
	Internet Publishing and Broadcasting and Web Search Portals	519130

Sub-Sector Title	2012 NAICS Industry	2012 NAICS Code
Other High-Tech Business Services	Architectural Services	541310
	Landscape Architectural Services	541320
	Engineering Services	541330
	Drafting Services	541340
	Building Inspection Services	541350
	Geophysical Surveying and Mapping Services	541360
	Surveying and Mapping (except Geophysical) Services	541370
	Testing Laboratories	541380
	Administrative Management and General Management Consulting Services	541611
	Human Resources Consulting Services	541612
	Marketing Consulting Services	541613
	Process, Physical Distribution, and Logistics Consulting Services	541614
	Other Management Consulting Services	541618
	Environmental Consulting Services	541620
	Other Scientific and Technical Consulting Services	541690
	Research and Development in Biotechnology	541711
	Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)	541712
	Research and Development in the Social Sciences and Humanities	541720
All Other High-Tech Industries	Timber Tract Operations	113110
	Forest Nurseries and Gathering of Forest Products	113210
	Crude Petroleum and Natural Gas Extraction	211111
	Natural Gas Liquid Extraction	211112
	Hydroelectric Power Generation	221111
	Fossil Fuel Electric Power Generation	221112
	Nuclear Electric Power Generation	221113
	Solar Electric Power Generation	221114
	Wind Electric Power Generation	221115
	Geothermal Electric Power Generation	221116
	Biomass Electric Power Generation	221117
	Other Electric Power Generation	221118
	Electric Bulk Power Transmission and Control	221121
	Electric Power Distribution	221122
	Petroleum Refineries	324110
	Asphalt Paving Mixture and Block Manufacturing	324121
	Asphalt Shingle and Coating Materials Manufacturing	324122
	Petroleum Lubricating Oil and Grease Manufacturing	324191
	All Other Petroleum and Coal Products Manufacturing	324199
	Petrochemical Manufacturing	325110
	Industrial Gas Manufacturing	325120
	Synthetic Dye and Pigment Manufacturing	325130
	Other Basic Inorganic Chemical Manufacturing	325180
	Ethyl Alcohol Manufacturing	325193
	Cyclic Crude, Intermediate, and Gum and Wood Chemical Manufacturing	325194
	All Other Basic Organic Chemical Manufacturing	325199
	Plastics Material and Resin Manufacturing	325211
	Synthetic Rubber Manufacturing	325212
	Artificial and Synthetic Fibers and Filaments Manufacturing	325220
	Nitrogenous Fertilizer Manufacturing	325311
	Phosphatic Fertilizer Manufacturing	325312
	Fertilizer (Mixing Only) Manufacturing	325314
	Pesticide and Other Agricultural Chemical Manufacturing	325320
	Medicinal and Botanical Manufacturing	325411
	Pharmaceutical Preparation Manufacturing	325412
	In-Vitro Diagnostic Substance Manufacturing	325413
	Biological Product (except Diagnostic) Manufacturing	325414
	Paint and Coating Manufacturing	325510
	Adhesive Manufacturing	325520
	Printing Ink Manufacturing	325910
	Explosives Manufacturing	325920
	Custom Compounding of Purchased Resins	325991
	Photographic Film, Paper, Plate, and Chemical Manufacturing	325992
	All Other Miscellaneous Chemical Product and Preparation Manufacturing	325998
	Power Boiler and Heat Exchanger Manufacturing	332410

Sub-Sector Title	2012 NAICS Industry	2012 NAICS Code
All Other High-Tech Industries	Metal Tank (Heavy Gauge) Manufacturing	332420
	Metal Can Manufacturing	332431
	Other Metal Container Manufacturing	332439
	Industrial Valve Manufacturing	332911
	Fluid Power Valve and Hose Fitting Manufacturing	332912
	Plumbing Fixture Fitting and Trim Manufacturing	332913
	Other Metal Valve and Pipe Fitting Manufacturing	332919
	Ball and Roller Bearing Manufacturing	332991
	Small Arms Ammunition Manufacturing	332992
	Ammunition (except Small Arms) Manufacturing	332993
	Small Arms, Ordnance, and Ordnance Accessories Manufacturing	332994
	Fabricated Pipe and Pipe Fitting Manufacturing	332996
	All Other Miscellaneous Fabricated Metal Product Manufacturing	332999
	Food Product Machinery Manufacturing	333241
	Sawmill, Woodworking, and Paper Machinery Manufacturing	333243
	Printing Machinery and Equipment Manufacturing	333244
	Other Industrial Machinery Manufacturing	333249
	Photographic and Photocopying Equipment Manufacturing	333316
	Other Commercial and Service Industry Machinery Manufacturing	333318
	Industrial Mold Manufacturing	333511
	Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	333514
	Cutting Tool and Machine Tool Accessory Manufacturing	333515
	Machine Tool Manufacturing	333517
	Rolling Mill and Other Metalworking Machinery Manufacturing	333519
	Pump and Pumping Equipment Manufacturing	333911
	Air and Gas Compressor Manufacturing	333912
	Measuring and Dispensing Pump Manufacturing	333913
	Elevator and Moving Stairway Manufacturing	333921
	Conveyor and Conveying Equipment Manufacturing	333922
	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	333923
	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	333924
	Power-Driven Handtool Manufacturing	333991
	Welding and Soldering Equipment Manufacturing	333992
	Packaging Machinery Manufacturing	333993
	Industrial Process Furnace and Oven Manufacturing	333994
	Fluid Power Cylinder and Actuator Manufacturing	333995
	Fluid Power Pump and Motor Manufacturing	333996
	Scale and Balance Manufacturing	333997
	All Other Miscellaneous General Purpose Machinery Manufacturing	333999
	Electromedical and Electrotherapeutic Apparatus Manufacturing	334510
	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	334511
	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	334512
	Totalizing Fluid Meter and Counting Device Manufacturing	334514
	Analytical Laboratory Instrument Manufacturing	334516
	Irradiation Apparatus Manufacturing	334517
	Automobile Manufacturing	336111
	Light Truck and Utility Vehicle Manufacturing	336112
	Heavy Duty Truck Manufacturing	336120
	Motor Vehicle Body Manufacturing	336211
	Truck Trailer Manufacturing	336212
	Motor Home Manufacturing	336213
	Travel Trailer and Camper Manufacturing	336214
	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	336310
	Motor Vehicle Electrical and Electronic Equipment Manufacturing	336320
	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	336330
	Motor Vehicle Brake System Manufacturing	336340
	Motor Vehicle Transmission and Power Train Parts Manufacturing	336350
	Motor Vehicle Seating and Interior Trim Manufacturing	336360
	Motor Vehicle Metal Stamping	336370
	Other Motor Vehicle Parts Manufacturing	336390
	Aircraft Manufacturing	336411
	Aircraft Engine and Engine Parts Manufacturing	336412
	Other Aircraft Parts and Auxiliary Equipment Manufacturing	336413

All Other High-Tech Industries	Guided Missile and Space Vehicle Manufacturing	336414
	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	336415
	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	336419
	Motorcycle, Bicycle, and Parts Manufacturing	336991
	Military Armored Vehicle, Tank, and Tank Component Manufacturing	336992
	All Other Transportation Equipment Manufacturing	336999
	Pipeline Transportation of Crude Oil	486110
	Pipeline Transportation of Natural Gas	486210
	Pipeline Transportation of Refined Petroleum Products	486910
	All Other Pipeline Transportation	486990
	Monetary Authorities-Central Bank	521110
	Securities and Commodity Exchanges	523210
	Offices of Bank Holding Companies	551111
	Offices of Other Holding Companies	551112
	Corporate, Subsidiary, and Regional Managing Offices	551114
	Facilities Support Services	561210
	Executive Search Services	561312
	Consumer Electronics Repair and Maintenance	811211
	Computer and Office Machine Repair and Maintenance	811212
	Communication Equipment Repair and Maintenance	811213
	Other Electronic and Precision Equipment Repair and Maintenance	811219

B. ZIP Codes That Define the Austin–Round Rock MSA

The following 135 ZIP codes define the Austin–Round Rock MSA, comprising Bastrop, Caldwell, Hays, Travis, and Williamson counties. The ZIP code to MSA (or CBSA) crosswalk is taken from the U.S. Department of Housing and Urban Development (HUD: https://www.huduser.gov/portal/data sets/usps_crosswalk.html). The geographical county composition of the Austin–Round Rock MSA did not change in 2000 or 2013 (Geffen 2003, Texas Workforce Comission).

78602, 78612, 78616, 78617, 78621, 78650, 78653, 78659, 78662, 78941, 78942, 78953, 78957, 78959, 78610, 78616, 78622, 78632, 78640, 78644, 78648, 78655, 78656, 78661, 78662, 78666, 78953, 78959, 78130, 78610, 78619, 78620, 78623, 78640, 78652, 78656, 78663, 78666, 78667, 78676, 78736, 78737, 78738, 73301, 76574, 78610, 78612, 78613, 78615, 78617, 78620, 78621, 78634, 78640, 78641, 78642, 78645, 78652, 78653, 78654, 78660, 78663, 78664, 78669, 78691, 78701, 78702, 78703, 78704, 78705, 78708, 78709, 78710, 78711, 78712, 78713, 78714, 78715, 78716, 78718, 78719, 78720, 78721, 78722, 78723, 78724, 78725, 78726, 78727, 78728, 78729, 78730, 78731, 78732, 78733, 78734, 78735, 78736, 78737, 78738, 78739, 78741, 78742, 78744, 78745, 78746, 78747, 78748, 78749, 78750, 78751, 78752, 78753, 78754, 78755, 78756, 78757, 78758, 78759, 78760, 78761, 78762, 78763, 78764, 78765, 78766, 78767, 78768, 78772, 78774, 78778, 78779, 78799, 76511, 76527, 76530, 76537, 76573, 76574, 76577, 76578, 78605, 78613, 78615, 78621, 78626, 78627, 78628, 78630, 78633, 78634, 78641, 78642, 78646, 78660, 78664, 78665, 78673, 78674, 78680, 78681, 78682, 78683, 78717, 78727, 78728, 78729, 78750, 78759.

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