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What drives high-growth? Characteristics of Australian firms

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Abstract

This paper estimates the impact of innovation and other business characteristics on turnover growth, paying particular attention to firms that show high growth in turnover.

In the United States, Europe and Australia, high-growth firms have contributed significantly to sales, employment and exports. Using unique unit record data and advanced panel data techniques, this is the first paper to examine the patterns, characteristics and determinants of high-growth firms in Australia. The paper focusses on the roles of innovation and research and development in driving turnover growth.

The paper finds that the type of innovation undertaken matters for growth. On average, innovation in goods and services or marketing contributes significantly to turnover growth, while process and organisational/managerial innovations do not. Having a strategic business focus on innovation also contributes to turnover growth.

The paper also finds that the impacts of innovation and research and development differ between high-growth firms and average firms. Goods and services innovations have a much greater impact for high-growth firms. The benefits of research and development are also skewed, with high-growth firms generating a substantially greater boost to turnover growth from increased research and development intensity compared to slower growing firms.

JEL Codes: C01, C21, C23, D8, D22, H, L6, L7, M13, O3, O4, O5
Keywords: High growth firms, innovation, firm growth, economic policy, firm-level data, quantile regressions, applied econometrics.

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The results of these studies are based, in part, on ATO data supplied by the Registrar to the ABS under A New Tax System (Australian Business Number) Act 1999 and tax data supplied by the ATO to the ABS under the Taxation Administration Act 1953. These require that such data is only used for the purpose of carrying out functions of the ABS. No individual information collected under the Census and Statistics Act 1905 is provided back to the Registrar or the ATO for administrative or regulatory purposes. Any discussion of data limitations or weaknesses is in the context of using the data for statistical purposes, and is not related to the ability of the data to support the ABR's core operational requirements.

Legislative requirements to ensure privacy and secrecy of this data have been followed. Only people authorised under the Australian Bureau of Statistics Act 1975 have been allowed to view data about any particular firm in conducting these analyses. In accordance with the Census and Statistics Act 1905, results have been confidentialised used to ensure that they are not likely to enable identification of a particular person or organisation

Key points

- **Understanding high-growth firms (HGFs) is especially important as these firms created most of the sales and value added in Australia over the past decade (Australian Innovation System Report 2016 and 2017).**
- **The proportions of Turnover HGFs have been declining since 2005. Between 2005 and 2014, the proportion of Turnover HGFs has declined from 17.6 per cent to 14.0 per cent of all firms.**
- **Turnover HGFs have generally become larger in terms of their turnover levels (i.e. annual sales revenue).**
- **Few firms can sustain outstanding rates of growth for long. More than half of HGFs end their high growth episode within four years.**
- **The average trajectory for HGFs seems consistent with the international findings that very high growth is more likely among young firms. Even though the average growth rate for HGFs declines as these firms age, the growth rate remains impressive for the first six years of life.**
- **Turnover HGFs tend to be distributed across all ages, although HGFs tend to be younger than non-HGFs.**
- **The type of innovation a firm undertakes matters for turnover growth. On average, innovation in goods and services or marketing has a positive and significant impact, while organisational/managerial or process innovations do not.**
- **For the average firm, goods and services innovation leads to a 3.3 percentage point increase in turnover growth, and marketing innovation leads to a 4.0 percentage point increase in turnover growth.**
- **The impact of innovation in goods and services is even more pronounced for HGFs. Innovation in goods and services leads to a 7.4 percentage point increase in turnover growth — almost double of that of an average firm.**
- **Even after accounting for the impact of innovation, having a strategic business focus on innovation has a compounding effect on turnover growth. Increasing the average firm's turnover growth by an additional 4.0 percentage points.**
- **HGFs also generate a tangibly higher benefit from having an innovation focus, amounting to 9.7 percentage points higher in turnover growth.**
- **The benefits of research and development intensity are skewed in favour of HGFs. R&D intensity has a significant and positive impact on turnover growth for firms with higher growth rates.**

1. Introduction

The economic literature has found that HGFs contribute significantly to employment, sales, exports and economic growth. This has been found for several countries, including Germany, the United States (US), Sweden, France, Finland and Canada (Coad and Hölzl 2012; Halabisky et al 2006; Moreno and Coad 2015; Schreyer 2000). Similarly, Australian Innovation System Reports (2016 and 2017) have found that while HGFs constituted a small proportion of all firms, they were responsible for creating most of the job, value added and sales growth in Australia between 2004–05 and 2011–12.

This paper is the first analysis of the patterns, innovation characteristics and determinants of Turnover HGFs in Australia. Although HGFs are the focus, the paper also studies the determinants of turnover growth for all firms. To the best of our knowledge, this is the first study to examine turnover growth determinants and the role of different types of innovation for Australian HGFs.

In this paper we use the Eurostat-OECD definition[1] which defines HGFs as those with average annualised growth greater than 20 per cent over a three year period. Growth can be measured by the number of employees or by turnover. For the purpose of this paper we focus on Turnover HGFs[2], which are firms that grew by more than 20 per cent per annum, over a three year period in turnover.

Section 2 provides a literature review, while the underlying data within the Business Longitudinal Analysis Data Environment (BLADE) is discussed in Section 3. Trends and characteristics are discussed in Section 4, while Section 5 talks about the methodology and Section 6 provides the results.

To preview the results, the paper finds that following the global financial crisis and the slowdown in the world economy, the proportion of HGFs has declined in Australia. Results show that most HGFs do not stay in the high-growth phase for long and that there is a lot of heterogeneity within the high-growth category.

The paper further finds that the type of innovation a firm undertakes matters for turnover growth. The results show that, on average, undertaking innovation in goods and services or marketing contributes significantly to turnover growth, while process or managerial innovations do not. For HGFs, innovation in goods and services has a much greater impact on turnover growth than for the average firm. Having a strategic business focus on innovation also contributes to turnover growth. This result is also strengthened for HGFs.

Lastly, the paper finds that improvements in turnover growth from research and development (R&D) are skewed, with HGFs receiving a substantially greater boost to turnover growth from increased R&D intensity than slower growing firms.

[1] Eurostat-OECD (2007), Eurostat-OECD Manual on Business Demography Statistics. Office for Official Publications of the European Communities: Luxembourg. Chapter 8, p.61

[2] Henceforth HGFs, unless mentioned otherwise.

2. Literature Review

A large volume of literature is dedicated to identifying the main determinants of firm growth. Although scholars have presented many theories, empirical studies show that these theories explain only a small fraction of the variation in firm growth rates. Indeed, early research theorised that firm growth is arbitrary and follows a 'random walk' (Gibrat 1931).

Having a major product to drive sales and having a marketing department have both been identified as important strategies for growth, at least for gazelles[3] (Parker et al. 2010).

Researchers have also identified institutional factors as being relevant to the creation of HGFs (Bravo-Biosca et al. 2013). Financial development, banking competition and institutions that foster contract enforcement support a more dynamic business environment, which can increase the proportion of HGFs in the population of firms. Some authors have also highlighted the importance of strong macroeconomic conditions as key drivers of firm survival and growth (Geroski et al. 2010).

There is also evidence that innovation may support high growth. Coad and Rao (2008) found that the effects of innovation on sales were amplified for fast-growing firms. However, they qualified this by stating that the relationship between innovation and sales growth is complex, making it hard to find a causal link between the two.

Regardless of such analytical challenges, there has been a strong policy interest in supporting HGFs. A major reason for the policy interest is their contribution to employment: although HGFs make up a small minority of firms, they contribute disproportionately to new job creation in an economy. In 2009, the United Kingdom (UK) National Endowment for Science, Technology and the Arts (NESTA) found that six per cent of HGFs (which it labelled as the 'vital six per cent') generated about half of all UK employment between 2002 and 2008 (Anyadike-Danes et al. 2009). NESTA also claimed that these firms were likely to be innovative, and that this was a source of their growth.

Henrekson and Johansson (2010) reviewed the empirical evidence on the role of HGFs as job creators. Their study showed that HGFs generate most of the jobs in an economy. They also found that HGFs are usually younger than other firms, vary in size and are present in all industrial sectors. However, empirical evidence suggests that it is hard for HGFs to sustain their high growth over time (Hölzl 2014).

Similar patterns have been observed in the US. Birch (1979) claimed that small businesses were responsible for a large portion of job creation in the US, but conversely, Haltiwanger et al. (2013) observed that after taking the firm's age into account, its size does not matter for job creation. Their paper further showed that young firms demonstrate high rates of both job creation and destruction. They found that while start-up firms account for only three per cent of all jobs, they are responsible for 20 per cent of job creation. However, 40 per cent of the jobs created by start-ups are lost due to firm exits. These authors further show that large, mature

[3] All enterprises up to five years' old with average annualised growth greater than 20% per annum, over a three year period, are considered gazelles.

firms are a major source of employment — firms that are more than 10 years' old and have more than 500 employees account for about 45 per cent of all jobs in the US private sector. Empirical evidence collected later has not found any relationship between net job growth rates and firm size within the manufacturing sector (Davis et al. 1996).

Despite the clear turnover growth and employment advantages of HGFs, it is difficult for policymakers to target them. Coad et al. (2014) suggested that it is impossible to predict which businesses will become HGFs. Shane (2009) warned policymakers against policies that simply encourage the creation of start-ups as a means to kick-start growth in stagnant economies, because 'the typical start-up is not innovative, creates few jobs and generates little wealth'. Indeed, a significant percentage of firms fail within three years (Criscuolo and Menon, 2015).

3. Data sources and creation

The data source for this paper is the Australian Bureau of Statistics' (ABS) Business Longitudinal Analysis Data Environment (BLADE). BLADE is a series of integrated, linked longitudinal datasets over the period 2001–02 to 2013–14. It is based on retrospectively reconciling the different reporting structures used in Australian Taxation Office (ATO) and ABS data to facilitate the linking of survey and administrative data for businesses, using Australian Business Registry (i.e. Australian Business Numbers (ABNs)) as a backbone.

The survey data used here is from two sources: the Business Characteristics Survey (BCS), and the Business Expenditure on Research and Development (BERD) Survey. The administrative data is sourced from the ATO and includes Business Activity Statement (BAS) and Pay-As-You-Go (PAYG) tax data. In addition, demographic information (such as firm age and industry classification) is derived by a combination of data from the ABS Business Register and historical ATO reporting patterns.

The BCS and the underlying administrative data used here covers the period from 2002 to 2013. The BCS is an annual survey and it is the vehicle for the ABS' Integrated Business Characteristics Strategy (IBCS). The strategy integrates the collection and quality assurance of data required for input into both the ABS Business Longitudinal Database (BLD) and the production of point-in-time estimates for the use of information technology, innovation and a broad range of other non-financial characteristics. Research and development (R&D) expenditure by businesses is taken from the Survey of Research and Experimental Development, Businesses. Prior to 2011–12, the R&D survey was a reduced-scope coverage census, in which all businesses that spent $100,000 or more on intramural R&D were included. In 2011–12, due to the steady increase in businesses undertaking R&D, the R&D survey was based on a random sample of businesses stratified by industry and expenditure on R&D.

To remove volatility and small sample bias, the paper removed all firms with less than five full time equivalent (FTE) employees. The robustness tests show that including smaller firms does not change the results qualitatively.

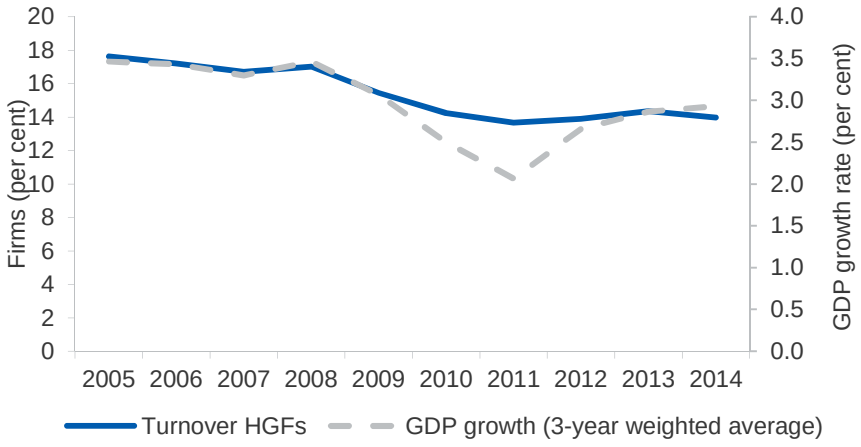
4. Trends, episodic nature and growth trajectories of HGFs.

4.1 Proportions of high-growth firms

The proportions of Turnover HGFs have been declining since 2005. Between 2005 and 2014, the proportion of Turnover HGFs has declined from 17.6 per cent to 14.0 per cent of all firms (Figure 4.1).

The decline in HGF proportions appears to coincide with the decrease in the GDP growth rate over the same period, suggesting there may be a two–way link. Given the disproportionate contribution of HGFs to value added such a connection may be expected to exist. The declining proportions of HGFs may be impacting on GDP growth, at the same time declining GDP growth may impact on the growth prospects of HGFs. This relationship may be worth investigating further if the correlation continues to hold into the future.

Figure 4.1: Turnover HGF proportions in Australia, with GDP growth rate comparison, 2005–14



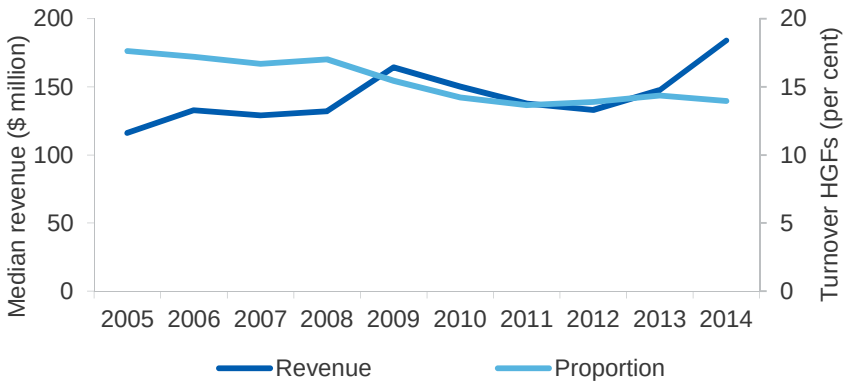
Notes: GDP growth rate is a 3–year moving average.

Source: ABS (2017) Business Longitudinal Analysis Data Environment (BLADE). Customised data analysis commissioned by the Department of Industry, Innovation and Science.

4.2 Size of high-growth firms

Despite their declining proportions, Turnover HGFs have generally become larger in terms of their turnover levels (i.e. annual sales revenue). In 2014, Turnover HGFs had a median turnover of $184.2 million, which is 45 per cent higher than in 2005, even after adjusting for inflation (Figure 4.2). When broken down by firm size (i.e. by employment), large HGFs drove the majority of this change over the period, with median turnover of large HGFs increasing from $108.9 million to $174.4 million (up 60 per cent). Small-sized HGFs increased their median turnover from $1.4 million in 2005 to $1.7 million in 2014 (24 per cent), and medium-sized HGFs increased their turnover from $6.0 million to $8.1 million (36 per cent). All estimates have been adjusted for inflation.

Figure 4.2: Median turnover and proportions of Turnover HGFs, 2005–14



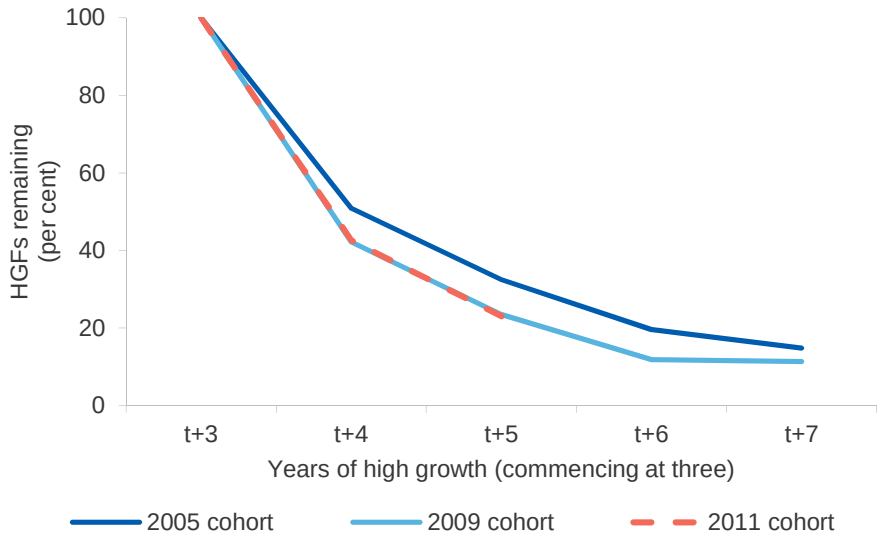
Notes: Turnover levels have been adjusted for inflation based on 2005 values.

Source: ABS (2017) Business Longitudinal Data Environment (BLADE). Analysis by Department of Industry, Innovation and Science.

4.3 The episodic nature of high firm growth

Few firms can sustain outstanding rates of growth for long. More than half of HGFs end their high growth episode within four years. After four years of high growth, 51 per cent of the 2005 cohort remained Turnover HGFs, and 42 per cent of the 2009 and 2011 cohorts remained HGFs (Figure 4.3). After seven years' of high growth, only 14 per cent and 11 per cent of Turnover HGFs from the 2005 and 2009 cohorts, respectively, were still growing fast enough to remain classified as HGFs.

Figure 4.3: Amount of time Turnover HGFs remain in high growth category, 2005–09, 2009–13 and 2011–13



Notes: t = Initial year of a firm's high growth episode, with t+3 being the year in which they were identified as a HGF.

Source: ABS (2017) Business Longitudinal Data Environment (BLADE). Analysis by Department of Industry, Innovation and Science.

4.4 Growth trajectories

This section first presents an analysis of the growth trajectory followed by the average high-growth firm in the period between 2002 and 2013. For comparison, the same analysis is undertaken for the non-HGFs. In this section we modify the definition slightly to analyse growth trajectories of HGFs as a group. All firms that achieved high growth during the sample period were all put in the high-growth firm category while all the remaining firms were put in the non-high growth category. To remove volatility from firms that enter the market for a short period the data was further cleaned. This included removing outliers, removing all firms born before 2002 and retaining only those firms with at least eight[4] years' of data.[5]

The growth trajectories look at the average as well as the spread of growth rates amongst HGFs and non-HGFs as separate groups, and how these change as firms age (where age is the time already spent in the market as an established business). Plotting the growth rates based on percentiles for both the groups, helps us understand the diversity of growth trajectories within the two groups.

Average high-growth firm growth rate

The average trajectory for HGFs seems consistent with the international findings that very high growth is more likely among young firms. Even though the average growth rate for HGFs declines as the firms age, the growth rate remains impressive for the first six years of life. It should be noted that the decline in growth rate is in turnover only, which is different from profitability. The average growth rates for HGFs remained substantially higher than that of non-HGFs, as they aged. Turnover growth trajectories for HGFs are given in Table 4.1 and Figure 4.4 based on firm age.

[4] This would remove younger/short-lived firms. These modifications were only done for this section to study growth trajectories.

[5] This was done to remove firms that only exist for a short period and then exit the market. As the samples are restricted to firms that survived for at least eight years, we cannot draw conclusions about the survival rates of HGFs versus non-HGFs from the current analysis.

Table 4.1: Annual turnover growth rates for HGFs and all other firms

	HGFs	Non-HGFs
Firm age (years)	Average (mean)	Average (mean)
4	83.3	5.6
5	23.4	0.1
6	11	–2.8
7	5	–2.8
8	4.9	–4.1
9	4.5	–3.9
10	2.8	–3.2
11	4.2	–4.3

Notes: The compound growth rates apply to the previous three-year period.

Source: Results based on data from the BCS, BLADE.

Heterogeneity within the HGFs' growth rates

The percentile breakdowns of the growth rates is given in Table 4.2. Here, we look at the spread of growth rates within each group, and how it changes as firms age. It should be noted that firms move between growth percentiles as they age. Therefore, Table 4.2 does not track the growth rates over time of the firms initially in the top or bottom percentiles. Instead, we track the change in the growth rates as a group.

We see evidence of an extremely large spread of initial growth rates (i.e. shortly after birth) among HGFs. As firm growth declines with age, this spread contracts. The 25th percentile still showed quite strong growth over their first four of years' of life, although they then started contracting afterwards. The 75th percentile experienced explosive growth in the first few years followed by a decrease in growth rates. The median trajectory is consistent with the average trajectory. However, the median tracks below the average, showing that the average is dragged upwards by a small number of extremely high performers.[6]

The growth rates for different percentiles among non-HGFs also showed variance (Table 4.2). The 75th percentile is remarkably distinct from the median and the bottom quartile, with a high growth rate initially, and then ongoing growth at a respectable rate. The 25th percentile showed decline from the initial years.[7] The median percentile showed modest growth in the first years and then started declining.

[6] Note that the HGF sample includes firms that satisfied the definition of high growth at least once, at any age. This analysis confirms that the high-growth period typically occurred early in firms' lifetime

[7] Rather than at later ages. However, it also shows that the idea of a single consistent growth path among HGFs is incorrect. At each age, HGFs show a wide range of growth rates (and especially wide range during their youth), although the spread between the top and bottom performers contracts as firms age

Analysing HGFs as a group also helps us to see the overall impact of HGFs on the whole economy. It should be mentioned that this section looked at growth rates of firms during the period of 2002–2013, a period that involved extraordinary macroeconomic conditions and global events including the mining boom, the global financial crisis, the decline of the mining boom and the slow-down in the Chinese economy. As these macroeconomic conditions are unlikely to be repeated, the growth trajectories for the Australian firms may be different in the coming years.

The idea that we can draw a clean boundary line between HGFs and non-HGFs is also challenged. Although the mean and median growth trajectories of the HGFs are clearly superior to those of the non-HGFs, the 25th percentile growth trajectory for HGFs is consistently worse than that of the 75th percentile for non-HGFs. This makes sense, given that our HGF category can include firms that recorded less than the required 20 per cent growth for much of their lives, as long as they satisfied the definition of high growth at least once. Conversely, our non-high-growth category can include firms that record persistent growth at, say, 19 per cent, but never satisfy the technical definition. The warning for policymakers is to be cautious about long-term growth expectations based on classifying firms by a rigid mathematical definition, as there is significant heterogeneity underneath the mean and median differences.

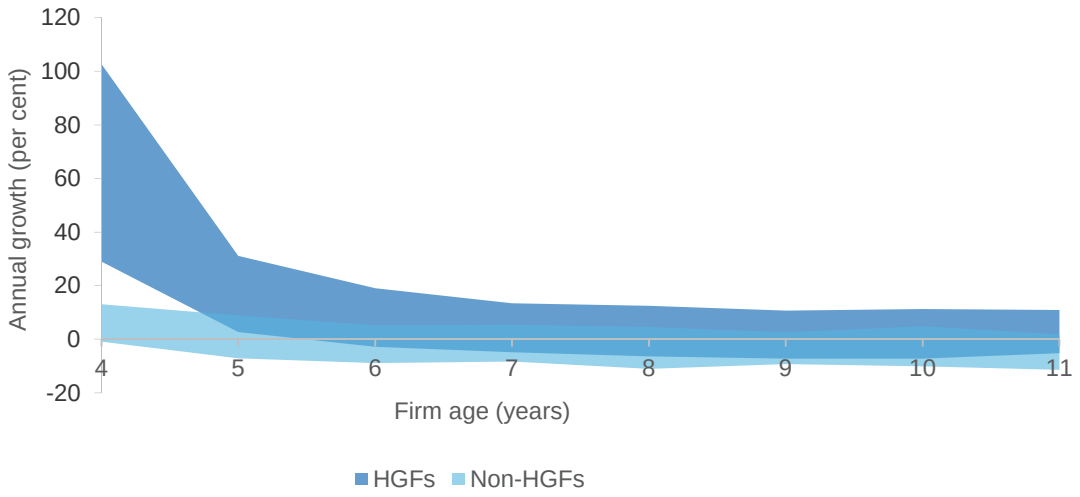
Table 4.2: Annual turnover growth rates for HGFs and all other firms

	HGFs			All firms		
Firm age (years)	25th percentile	50th percentile	75th percentile	25th percentile	50th percentile	75th percentile
4	28.9	55.2	102.7	–0.9	6.6	13.1
5	2.7	12.5	31.1	–7.1	2.9	8.8
6	–2.9	6.1	19.1	–8.9	–2.2	5.2
7	–4.9	2.1	13.4	–8.3	0	5.4
8	–6.4	1.5	12.4	–11	–3	4.6
9	–7.3	1.1	10.7	–9.3	–1.6	2.5
10	–7.3	0.9	11.2	–10.1	–1.6	4.9
11	–5.2	2.3	10.9	–11.4	–1.9	1.9

Notes: The compound growth rates apply to the previous three-year period.

Source: Results based on data from the BCS, BLADE

Figure 4.4: Growth profiles by quartile



Notes: The compound growth rates apply to the previous three-year period.

Source: Results based on data from the BCS, BLADE

4.5 Descriptive statistics

Based on descriptive statistics (Table 4.3) it seems that Australian HGFs comprise relatively younger firms, they invest more in capital and have a higher turnover. Here HGFs are defined as in the rest of the paper (except for section 4.4). Meaning that HGFs are defined as firms that are growing by more 20 per cent over a three year period. The basic idea is to compare the characteristics of firms that are in high-growth phase with firms that are not.

Table 4.3 compares the basic characteristics of HGFs and non-HGFs in Australia. Both categories show high variance over all the characteristics considered — which is usually typical of unit level data. The averages difference between the two groups tell an interesting story. Australian HGFs are approximately 1.9 years younger on average compared to the non-HGFs. The turnover of HGFs is more than 2.9 times greater than that of non-HGFs, and they have a larger wage bill.

HGFs' employees earn higher wages (by about 14 per cent). Paying more wages per employee may reflect that HGFs employ higher quality labour. Complementarity between extra capital and labour and high quality human capital is probably responsible for increased labour productivity amongst the HGFs average labour productivity (about 1.8 times higher than that of non-HGFs).

Table 4.3: Comparison of characteristics between HGFs and non-HGFs in Australia, 2002–2013

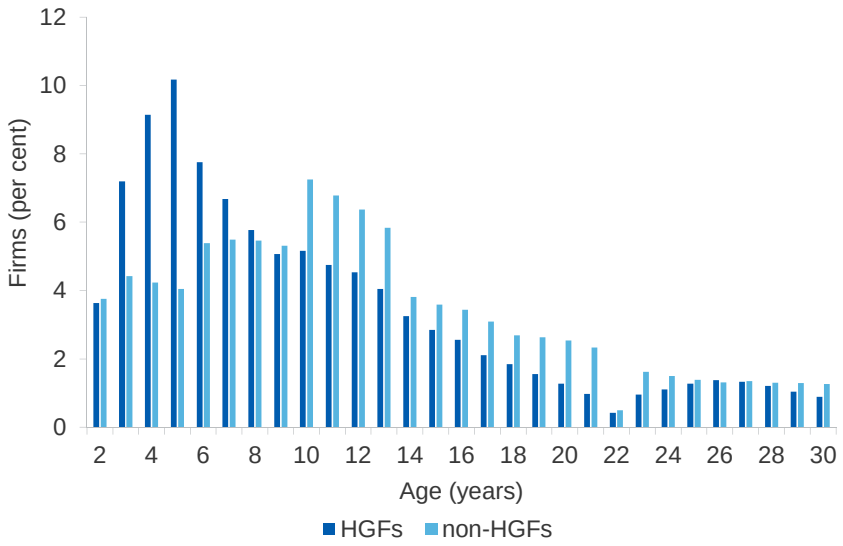
	HGFs			Non-HGFs		
	Mean	SD	Count	Mean	SD	Count
Age (years)	10.4	6.95	36042	12.3	6.95	105,504
Employees (FTE)	193	766.9	36,894	248	1,391	105,597
Headcount	304.2	1,237.4	36,879	386.4	2,403	105,582

Turnover ($millions)	319.2	11,242.1	36,852	110.5	1,540.5	97,065
Expenditure on wages ($millions)	10,600,000	96,200,000	36,882	11,500,000	88,700,000	97,962
Expenditure on wages per FTE ($)	47,593.9	222,911.7	36,882	41,771.8	98,567.3	97,962
Labour productivity	564,984	7,640,031	36,852	319,126.5	2,210,465	97,065
Labour productivity growth (%)	436	24,515.9	32,130	152.1	38,576	84,046

Source: The data in the above table was created using a pooled cross section of BLADE differentiating HGFs and non-HGFs — based on BCS data.

The international literature and the above sections on growth trajectories show that age is an important determinant for HGFs. As such, this section puts extra weight into examining the age dimension of the HGFs. The results find age of HGFs tend to be distributed across all ages, although HGFs between the ages of 3 and 8 were most common in the period from 2002 to 2013, compared to a range of 10 to 13 for non-HGFs (Figure 4.5). The median firm age of a Turnover HGF during the period was 8 years, compared to 11 years for non-HGFs. This is not surprising, given younger firms start from a lower base and have a greater capacity for growth than established firms. The most common age category for Turnover HGFs was around 5 years (i.e. they were aged 5 years in their first period of consecutive turnover growth).

Figure 4.5: The age of HGFs and non-HGFs, 2002–13



Notes: For HGFs, the chart shows a firm's age at the beginning of its high growth episode. A given firm that enjoys multiple high growth episodes can be counted multiple times. For a discussion on the persistence of individual HGFs, see Section 3.1. Top and bottom percentiles of the data are removed to preserve confidentiality.

Source: ABS (2017) Business Longitudinal Data Environment (BLADE), BCS data linked to firm-level financial data. Analysis by Department of Industry, Innovation and Science.

4.6 Innovation related descriptive statistics.

The proportions of all firms (classified by innovation status) in different growth categories is shown in Figure 4.6. For most types of innovation,[8] firms undertaking innovation are more common in the high and low-medium growth[9] categories and less common in the negative-growth category, compared to firms that do not innovate. Marketing innovation was the exception to this pattern, firms undertaking marketing innovation were more common in the low-medium growth category compared to the high-growth category.

This analysis hints at a possible positive correlation between innovation and firm growth in terms of turnover. It should be noted that even though we find a positive association between the various types of innovation and turnover growth, not all types of innovation have a causal interpretation. The econometric analysis shows that only innovation in goods and services and marketing have a positive and significant relationship with turnover growth. Causation is explored in greater detail in Section 5.

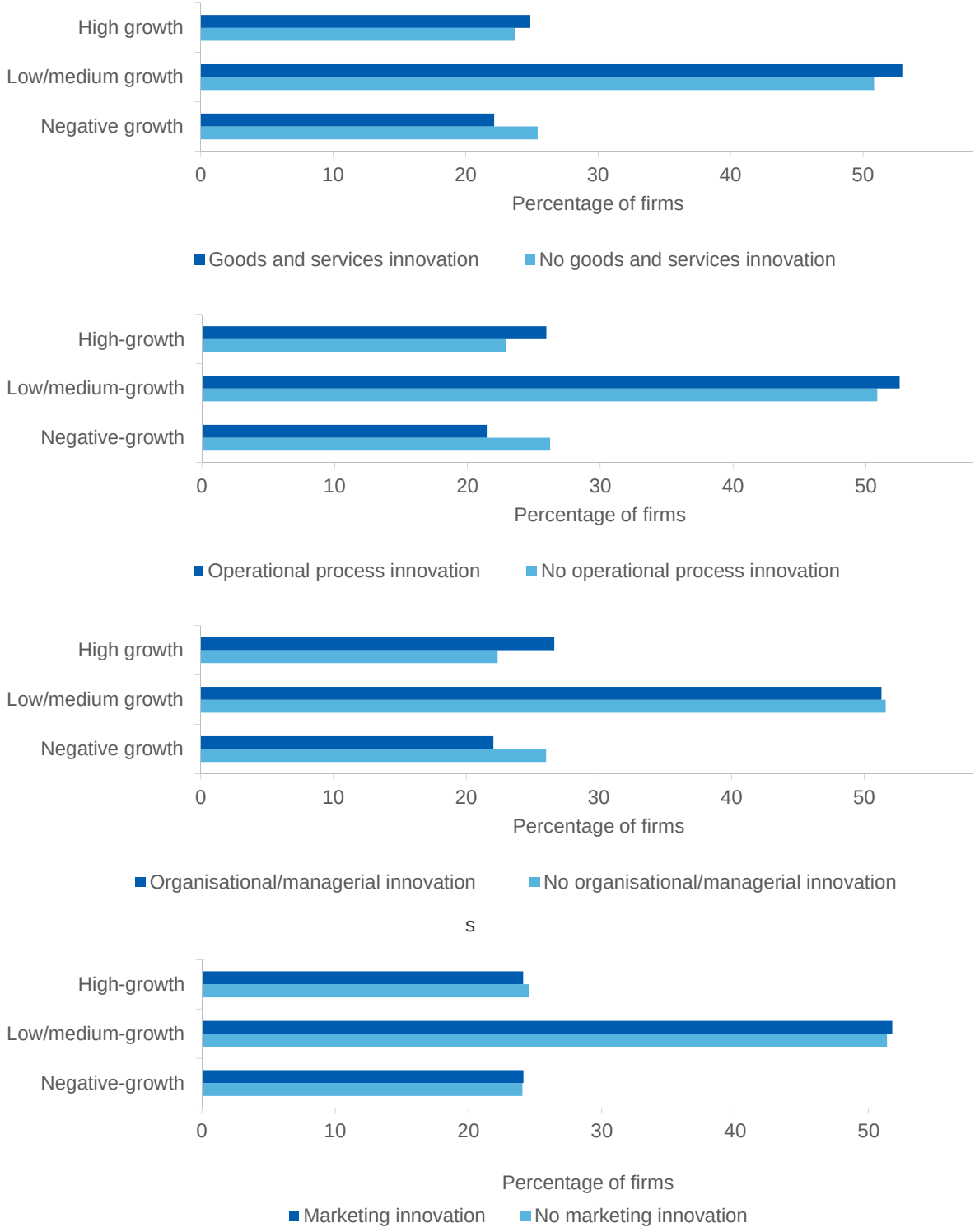
[8] Definitions of the various types of innovation are as follows:

- Good and services innovation: A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user-friendliness or other functional characteristics.
- Operational process innovation: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- Organisational/managerial innovation: A new organisational method in business practices, workplace organisation or external relations.
- Marketing innovation: A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

Source: OECD (2005), Oslo Manual: Guidelines for Collecting and Interpreting

[9] Growth categories are given in appendix B.

Figure 4.6: Innovation activity in firms, by turnover growth category and innovation type, 2005–06 to 2012–13



Source: ABS (2017) Business Longitudinal Analysis Data Environment (BLADE). Analysis by Department of Industry, Innovation and Science.

5. Econometric model

To study the determinants of growth we use Equation 1 using firm level data. The equation controls for relevant firm characteristics, including age, size, innovation, business focus and human capital variables.[10] This equation is similar to Coad and Rao (2008).

There are however, two major differences with Coad and Rao (2008). First, we study not only R&D but also several types of innovation, and second, we incorporate human capital (skills) and business focus variables — BCS based variables. The BCS provides rich information on firm characteristics, which we exploit to provide novel insights into the determinants of turnover growth.[11]

Equation 1

$$Growth_{i,t} = \alpha + \beta_1 Growth_{i,t-1} + \boldsymbol{\gamma I}_{i,t-1} + \boldsymbol{\vartheta B}_{i,t-1} + \boldsymbol{\vartheta H}_{i,t-1} + \boldsymbol{\beta X} + \gamma_t + \varepsilon_{i,t}$$

$\boldsymbol{I}$, $\boldsymbol{B}$ and $\boldsymbol{H}$ are respectively the innovation, business focus and human capital variables given in Equation 1. $\boldsymbol{X}$ is a vector of dummies for size, age and industry division. Macroeconomic conditions are captured by time dummies γ_t, and $\varepsilon_{i,t}$ is the error term. Lagged growth is included to clean up serial correlation.

Table 5.1: Variable names

Innovation variables.
Goods and/or services innovation
Operational process innovation
Organisational/managerial innovation
Marketing innovation
Business focus variables
Business focus — did this business focus on financial measures to a major extent when assessing overall business performance
Business focus — did this business focus on cost measures to a major extent when assessing overall business performance
Business focus — did this business focus on operational measures to a major extent when assessing overall business performance
Business focus — did this business focus on quality measures to a major extent when assessing overall business performance
Business focus — did this business focus on innovation measures to a major extent when assessing overall business performance

[10] Growth rates are expressed as fractions, so 10 per cent growth is recorded as 0.1. Plus annual growth rate is used as the dependent variable for the regressions.

[11] In its current form, the BCS only captures this information as binary variables. Nonetheless, the innovation variables convey useful information.

Business focus — did this business focus on human resources to a major extent when assessing overall business performance
Skill based variables
Skills used in undertaking core business activities — engineering
Skills used in undertaking core business activities — scientific and research
Skills used in undertaking core business activities — IT professionals
Skills used in undertaking core business activities — IT support technicians
Skills used in undertaking core business activities — project management
Skills used in undertaking core business activities — business management

Source: Department of Industry, Innovation and Science (2018)

The size and age variables are important because there has been significant debate about how these two variables influence firm growth (Haltiwanger et al. 2013). Section 4.5 also suggests that age has an important effect on a firm's turnover growth, with older age being associated with lower growth. Time dummies are used to control for macroeconomic conditions like the mining boom, the global financial crisis and the slow-down in commodities markets. Industry divisions are important to control for, because macroeconomic conditions have had varied effects on different industry divisions. We run Equation 1 separately for all firms and for HGFs.

To examine the effects of R&D we run the regression in Equation 2.

Equation 2

$$Growth_{i,t} = \alpha + \beta_1 R\&D\ intensity_{i,t-1} + \beta_2 Growth_{i,t-1} + \boldsymbol{\beta X} + \gamma_t + \varepsilon_{i,t}$$

Our dependent variable in Equation 2 is again the growth rate of turnover; $R\&D\ intensity_{i,t-1}$ is R&D expenditure divided by turnover; lagged growth is included to address serial correlation; and $\boldsymbol{X}$ is a vector of dummies for size, age and industry divisions.[12] Macroeconomic conditions are captured by time dummies γ_t, and $\varepsilon_{i,t}$ is the error term. We use data from the BERD and BCS databases. Data on R&D intensity is drawn from the BERD database, which gives information on the value of R&D expenditure and is a dedicated survey for quantifying R&D.[13]

5.1 Methodological issues and estimation

One of the main issues when estimating equations 1 and 2 is that there may be an unobserved time-invariant effect correlated with some of the independent variables. For instance, a firm may have innate abilities linked to its entrepreneurship, knowledge stock, innovation ability, history or culture that are

[12] The dummy variables for the regression are as follows. Size: 0 = "Missing/Non-employer"; 1 = "1 to 4 FTE"; 2 = "5 to 20 FTE"; 3 = "20 to 199 FTE"; 4 = "200+ FTE". Age: 1 = "0 to 5"; 2 = "6 Plus"; 3 = "Exit". Note that due to lags, the exit class is excluded. Industry divisions follow ANZSIC06.

[13] However, a drawback of the BERD data is that it only looks at larger firms that engage in more than $100 000 of R&D in a given year.

not controlled for. Let 'a' reflect this unobserved time-invariant effect, in which case the true data-generating process may be given by Equations 3 and 4.

Equation 3

$$Growth_{i,t} = \alpha + \beta_1 Growth_{i,t-1} + \boldsymbol{\gamma I}_{i,t-1} + \boldsymbol{\vartheta B}_{i,t-1} + \boldsymbol{\vartheta H}_{i,t-1} + \boldsymbol{\beta X} + \gamma_t + \mathrm{a} + \varepsilon_{i,t}$$

Equation 4

$$Growth_{i,t} = \alpha + \beta_1 R\&D\ intensity_{i,t-1} + \beta_2 Growth_{i,t-1} + \boldsymbol{\beta X} + \gamma_t + \mathrm{a} + \varepsilon_{i,t}$$

Given the unobserved time-invariant effect, ordinary least squares (OLS) may lead to inconsistent estimates. The paper therefore undertakes fixed effects (FE) regressions as the preferred methodology.

In addition, we use a similar methodology to Coad and Rao (2008) to study the impact of R&D on firms' output performance based on how firms are performing. Quantile regressions can be used to characterise the entire conditional distribution of a dependent variable (in this case, sales growth) given a set of independent variables (Buchinsky 1998; Coad and Rao 2008; Koenker and Bassett Jr 1978). To be precise, quantile regressions allow us to study how R&D intensity affects turnover growth based on how these firms are performing in terms of turnover growth. An added advantage of quantile regression is that it is robust to outliers.[14] A brief introduction to quantile regression is given in the appendix. Running the R&D equation (Equation 4), we obtain similar results to those in the literature: faster-growing firms benefit substantially more from undertaking R&D compared with firms that are not performing as well. Quantile regressions complement our overall results and show that high performing firms gain more from undertaking R&D. For robustness, FE regressions for high growth and all firms was also run.

The definition of innovation can vary amongst the participant of the survey, which can create a measurement issue. This is less of a problem with dedicated activities like R&D, which is an explicit activity in terms of expenditure. Questions based on innovation, such as where the BCS asks, 'Did the firm undertake a certain type of innovation?' can be prone to measurement error to an extent, partly reflecting the fact that different responders to the BCS will have different definitions of innovation. However, if the firm's ability to correctly identify innovation or appropriately fill out the BCS is likely to be linked to its overall ability, it can be controlled by the firm-level fixed effects.[15]

Lagging the right-hand-side variables is done to control for reverse causality emanating from sales growth. The literature, at the firm level usually uses 1 year lags.

Innovation is usually likely to impact firm growth within a year or two. However, for R&D, the effect may be delayed 2 to 3 years (Cohen, 2010). As such, robustness tests look at longer lags and results remain robust.

[14] Quantile regressions look at the whole distribution, so they are less affected by extreme values.

[15] Measurement error is problematic for innovation variables, which show very large confidence intervals for quantile regression results for most of the innovation variables in table 5.1. As such, FE estimates are again preferred.

6. Results

6.1 Types of innovation

This section analyses the impacts of various types of innovation on turnover growth. Table 6.1 gives the FE results.[16] As FE models control for firm-level effects, they are our preferred methodology. Further, regression results with variables capturing innovation, human capital and business focus[17] are our preferred estimates. As such, this section will focus on the results in columns 2 and 4 in Table 6.1.

The results yield several insights. First, the type of innovation undertaken matters. Only innovation in goods and services or marketing has a positive and significant impact on turnover growth for the average firm (columns 1 and 2). For the average firm, undertaking goods and services innovation results in 3.3[18] percentage points in higher turnover growth. Similarly, for the average firm, undertaking innovation in marketing leads to an increase in turnover growth of around 4.0 percentage points. Organisational/managerial and operational process innovations do not appear to impact turnover growth.[19]

Additionally, even after accounting for the effects of the specific innovations undertaken by a firm, having a business focus on innovation makes a further contribution to turnover growth. For the average firm, having an innovation focus increases turnover growth by a further 4.0 percentage points, additional to the increased growth thanks to the innovations themselves. The channels through which innovation strategy affects firm turnover is not clear, and more research is needed in this area. However, we can hypothesise a few channels that may be linking innovation strategy of a firm to turnover.

Firm strategy is formed by managers and the owners, so it may be that business strategy is associated with management/entrepreneurship capability of a firm. If so, it may be the case that that managers and entrepreneurs who set the business focus on innovation are innovative in terms of finding novels ways to increase turnover through different means, including contacts and networks (increasing turnover) or through innovative bargaining to reduce input costs, which can lead to an increase in turnover as well. Future research is needed to analyse the link between firm innovation strategy and turnover in more detail.

For HGFs, as noted, only innovations in goods and services impact growth. However, the growth boost to HGFs from goods and services innovation is almost double that received by the average firm, amounting to an increase of 7.3 percentage points in turnover growth. HGFs also generate a tangibly higher benefit from having an innovation focus, amounting to 9.7 percentage points higher

[16] OLS results are available on request.

[17] These variables, innovation, human capital and business focus are derived from respective questions from the BSC questionnaire that deals with skills, different types of innovation and key criteria that the business uses for assessing performance.

[18] Growth rates are expressed in decimal form, so 10 per cent growth is recorded as 0.1.

[19] There is some evidence based on OLS results that operational process innovation is also beneficial for firm growth.

turnover growth. Another difference between HGFs and non-HGFs is that marketing innovation does not seem to affect turnover growth for HGFs. It should be noted that after controlling for other factors, Science, Technology, Engineering and Mathematics (STEM) skills do not directly impact turnover growth. It is possible that STEM skills may have an indirect effect on innovation through increasing the likelihood of innovation itself.[20]

[20] Results do not change significantly if the dataset is increased to include all firms.

Table 6.1: Results on the impacts of different types of innovation, from FE and quantile regressions

	1	2	3	4
Independent variables	All firms — FE	All firms — FE	HGF — FE	HGF — FE
$Growth_{t-1}$	–0.192***	–0.266***	–0.230***	–0.282***
	(0.0317)	(0.0499)	(0.0325)	(0.0569)
Goods and/or services innovation	0.0348***	0.0332***	0.0523*	0.0737**
	(0.00955)	(0.0117)	(0.0275)	(0.0375)
Operational process innovation	0.0175*	–0.00505	0.00724	–0.0405
	(0.00992)	(0.0117)	(0.0245)	(0.0345)
Organisational/managerial innovation	–0.000515	0.0155	0.0239	0.0591*
	(0.00974)	(0.0107)	(0.0252)	(0.0331)
Marketing innovation	0.0452***	0.0397***	0.0412	0.0270
	(0.00916)	(0.0105)	(0.0255)	(0.0300)
Business focus — financial measures		–0.00161		–0.0639
		(0.0155)		(0.0418)
Business focus — cost measures		–0.00761		0.0434
		(0.0149)		(0.0410)
Business focus — operational measures		0.00270		0.0165
		(0.0134)		(0.0373)
Business focus — quality measures		–0.000995		–0.0393
		(0.0118)		(0.0354)
Business focus — innovation measures		0.0404***		0.0971***
		(0.0147)		(0.0363)
Business focus — human resources		0.00359		–0.0217
		(0.0142)		(0.0403)
Skills used in undertaking core business activities — engineering		0.0155		0.0235
		(0.0203)		(0.0525)
Skills used in undertaking core business activities — scientific and research		0.0175		0.0315

Table 6.1: Results on the impacts of different types of innovation, from FE and quantile regressions

	1	2	3	4
		(0.0184)		(0.0530)
Skills used in undertaking core business activities — IT professionals		0.0203		0.00180
		(0.0143)		(0.0433)
Skills used in undertaking core business activities — IT support technicians		–0.0112		–0.0340
		(0.0125)		(0.0410)
Skills used in undertaking core business activities — project management		0.00506		0.0276
		(0.0161)		(0.0376)
Skills used in undertaking core business activities — business management		0.00554		0.0306
		(0.0126)		(0.0412)
dummy_age_class_ 6 or more years	–0.0835***	–0.0940***	–0.0884	–0.169**
	(0.0269)	(0.0349)	(0.0624)	(0.0834)
dummy_size_20 to 200 FTE[21]	0.0379	0.0113	–0.0885	–0.120
	(0.0406)	(0.0541)	(0.0728)	(0.111)
dummy_size_ 200 plus FTE	–0.146***	–0.186***	–0.262***	–0.360**
	(0.0492)	(0.0698)	(0.0922)	(0.144)
Constant	–0.0812**	0.101*	0.577***s	0.580***
	(0.0392)	(0.0522)	(0.0734)	(0.108)
Observations	34,602	24,016	8,703	5,631
R-squared	0.044	0.057	0.099	0.117
Number of firms	12,569	10,368	4,191	3,098

Notes: *** p<0.01, ** p<0.05, * p<0.1

Time effects were included in calculations

Source: Results based on data from the BCS, BLADE.

[21] All the other dummy variables got dropped.

Table 6.1: Results on the impacts of different types of innovation, from FE and quantile regressions

6.2 R&D

The previous section looked at the impacts on turnover of innovation in goods and services, operational processes, organisational/managerial processes and marketing. This section studies the impact of a key input that can lead to innovation, namely R&D. The paper follows the literature and uses R&D intensity based on sales as a control variable. The R&D intensity is constructed from BERD data. Table 6.2 gives the OLS (columns 1 and 3), FE (columns 2 and 4) and quantile regression (columns 5 to 13) results. The quantile regressions complement our results for FE, showing that high-performing firms benefit more by increasing R&D intensity. The quantile regression results suggest important variations across different points in the conditional distribution of turnover growth rates. At the higher end of the distribution, R&D intensity has a significant and positive impact on turnover growth, while the lower end of the distribution experiences a negative impact. To give an idea of the estimates, for the 90th percentile, a one per cent increase in R&D intensity helps firms increase turnover growth by approximately 0.1 percentage points. There is a huge disparity between the growth benefits to HGFs and the rest of the distribution. The firms that are at the 90th percentile of the growth distribution benefit about 13 times more from increasing R&D intensity than the median firm.

Figure 6.1 depicts this information graphically. The solid line tracks the point estimates from the quantile regressions, and the shaded area shows the associated 95 per cent confidence intervals. The bold horizontal dashed line tracks the point estimates from the OLS regressions, while the dotted lines show the associated 95 per cent confidence intervals.

These results are similar to Coad and Rao (2008). Coad and Rao (2008) have suggested possible reasons why innovation, and thus possibly increasing R&D intensity, may have a negative impact on slower-growing or shrinking firms. This includes possible spinoffs from innovations and products. Further, they suggested that firms that innovate and fail may be commercially worse off than firms that do not innovate at all.

Columns 1 to 4 in table 6.2 give OLS and FE estimates for the whole sample and for HGFs. These results confirm that increasing R&D intensity helps to improve turnover growth, and that HGFs receive substantially greater growth benefits from R&D. Note that while the OLS results for HGFs are similar to those for the 90th percentile in the quantile regressions, the FE results suggest a substantially higher impact from R&D intensity. This suggests that HGFs may derive a greater growth advantage from R&D than suggested by the quantile regressions, however this paper focuses on the more conservative results.

OLS and FE results show that being an older firm (six or more years old) negatively impacts turnover growth. Some results, also point toward negative relationship between being a large firm (200 or more employees) and turnover growth. Both these factors may suggest that larger, mature firms are more likely to have exhausted most of their growth potential and the ‘low-hanging fruit’. However, these large, mature firms are typically also custodians of large market shares, value-added, research and development and economic activity.

Table 6.2 Impact on turnover growth of R&D intensity — OLS and FE

	(1)	(2zs)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Independent variables	All firms — OLS	All firms — FE	HGF — OLS	HGF — FE	Quatile 10th	Quatile 25th	Quatile 30th	Quatile 35th	Quatile 45th	Quatile 50th	Quatile 75th	Quatile 90th	Quatile 99th
$Growth_{t-1}$	–0.0338**	-0.0972***	–0.103***	–0.0705**	–0.0371**	–0.0260***	–0.0156***	–0.0133***	–0.0125***	–0.00948**	0.00747*	–0.0151***	–0.0621
	(0.0169)	(0.0207)	(0.0220)	(0.0299)	(0.0173)	(0.00574)	(0.00563)	(0.00494)	(0.00388)	(0.00424)	(0.00429)	(0.00544)	(0.0545)
ln_R&D_intensity	0.0290***	0.188***	0.0683***	0.326***	–0.0588***	–0.0174***	–0.0108***	–0.00526***	0.00200**	0.00625***	0.0336***	0.0814***	0.242***
	(0.00484)	(0.0125)	(0.00843)	(0.0263)	(0.00359)	(0.00130)	(0.00113)	(0.000990)	(0.000922)	(0.000993)	(0.00127)	(0.00247)	(0.0187)
dummy-size_20 to 200 FTE[22]	0.0589***	–0.0870***	0.00144	–0.179***	0.106***	0.0467***	0.0437***	0.0316***	0.0186***	0.0158***	–0.00920	–0.00423	0.0274
	(0.0113)	(0.0328)	(0.0209)	(0.0598)	(0.0202)	(0.00737)	(0.00647)	(0.00624)	(0.00488)	(0.00489)	(0.00644)	(0.0115)	(0.0828)
dummy-size_200 Plus FTE	0.121***	–0.287***	0.124***	–0.458***	0.0981***	0.0560***	0.0529***	0.0448***	0.0305***	0.0275***	0.0122	0.0727***	0.428***
	(0.0160)	(0.0474)	(0.0319)	(0.105)	(0.0236)	(0.00854)	(0.00747)	(0.00711)	(0.00573)	(0.00573)	(0.00745)	(0.0145)	(0.108)
Mining	0.0569		0.0748		–0.126	–0.0604*	–0.0304	–0.0240	0.00428	0.0191	0.126***	0.265***	1.221***
	(0.0467)		(0.0782)		(0.0806)	(0.0339)	(0.0246)	(0.0187)	(0.0168)	(0.0161)	(0.0228)	(0.0677)	(0.448)
Manufacturing	0.0276		–0.00802		0.174***	0.0250	0.0132	0.0107	0.00226	0.00571	–0.00402	–0.0661	–0.219
	(0.0346)		(0.0567)		(0.0502)	(0.0263)	(0.0186)	(0.0151)	(0.0119)	(0.0104)	(0.0107)	(0.0428)	(0.253)
Electricity, Gas, Water and Waste Services	0.0566		–0.00560		–0.0246	–0.0271	–0.0368*	–0.0272	–0.00643	0.00136	0.0581**	0.113*	0.757*
	(0.0509)		(0.0973)		(0.0800)	(0.0299)	(0.0198)	(0.0224)	(0.0160)	(0.0138)	(0.0238)	(0.0579)	(0.414)
Construction	0.0479		0.0159		0.0771	–0.00691	–0.00831	–5.17e–05	0.00695	0.0206	0.0698***	0.0730	0.127
	(0.0391)		(0.0605)		(0.0651)	(0.0282)	(0.0226)	(0.0173)	(0.0148)	(0.0150)	(0.0196)	(0.0452)	(0.257)
Wholesale Trade	0.0505		–0.0189		0.185***	0.0551**	0.0443**	0.0397**	0.0274**	0.0253**	0.00699	–0.0599	–0.121
	(0.0363)		(0.0627)		(0.0555)	(0.0268)	(0.0191)	(0.0157)	(0.0124)	(0.0106)	(0.0110)	(0.0433)	(0.262)
Retail Trade	0.0716		–0.00503		0.164	0.0579*	0.0510**	0.0605***	0.0483***	0.0587***	0.0617***	0.0210	–0.0641
	(0.0444)		(0.0801)		(0.105)	(0.0299)	(0.0207)	(0.0226)	(0.0165)	(0.0121)	(0.0153)	(0.0438)	(0.343)
Accommodation and Food Services	0.0720		–0.0523		0.0657	–0.0230	0.0292	0.0284	0.0106	0.0106	0.00134	0.0335	–0.342
	(0.0673)		(0.111)		(0.0737)	(0.0616)	(0.0768)	(0.0550)	(0.0162)	(0.0165)	(0.0341)	(0.0742)	(0.263)
Transport, Postal and Warehousing	0.143***		0.0972		0.193***	0.0839***	0.0596***	0.0575***	0.0505***	0.0587***	0.0447***	0.0399	1.335
	(0.0494)		(0.0989)		(0.0567)	(0.0278)	(0.0208)	(0.0186)	(0.0177)	(0.0135)	(0.0139)	(0.0845)	(1.851)
Information Media and Telecommunications	0.0560		–0.0122		0.205***	0.0837**	0.0765***	0.0635***	0.0612***	0.0633***	0.0424***	–0.0461	–0.104

	(1)	(2zs)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	(0.0422)		(0.0673)		(0.0520)	(0.0341)	(0.0203)	(0.0198)	(0.0187)	(0.0128)	(0.0146)	(0.0458)	(0.308)
Financial and Insurance Services	0.0368		0.0514		–0.0738	–0.00807	–0.0118	–0.00116	0.0154	0.0251*	0.0654**	0.129**	0.641
	(0.0457)		(0.0823)		(0.130)	(0.0329)	(0.0238)	(0.0172)	(0.0161)	(0.0144)	(0.0286)	(0.0525)	(0.457)
Rental, Hiring and Real Estate Services	–0.0173		0.0326		0.0351	–0.00635	0.00416	0.00465	0.00711	0.00994	0.0535	0.0239	–0.449
	(0.0652)		(0.107)		(0.0785)	(0.0388)	(0.0409)	(0.0184)	(0.0272)	(0.0277)	(0.0332)	(0.0620)	(1.512)
Professional, Scientific and Technical Services	0.000978		–0.0586		0.108**	0.0250	0.0254	0.0264*	0.0225*	0.0276**	0.0232*	–0.0386	–0.238
	(0.0354)		(0.0566)		(0.0528)	(0.0270)	(0.0195)	(0.0157)	(0.0124)	(0.0111)	(0.0120)	(0.0436)	(0.258)
Administrative and Support Services	0.0408		0.0334		0.143*	0.0109	0.00398	0.00109	0.00608	0.0140	0.0266	0.0135	–0.0393
	(0.0486)		(0.0770)		(0.0746)	(0.0310)	(0.0227)	(0.0192)	(0.0190)	(0.0166)	(0.0216)	(0.0709)	(0.486)
Arts and Recreation Services	0.0801		–0.0154		–0.00262	–0.0571	–0.00917	0.0649***	0.0167	0.0208	0.117	0.303	0.957***
	(0.108)		(0.182)		(0.284)	(0.165)	(0.119)	(0.0245)	(0.0127)	(0.0339)	(0.135)	(0.373)	(0.276)
Other Services	0.0127		–0.102		0.156**	0.00410	0.00677	0.0152	0.0107	0.0115	–0.0257	–0.106**	–0.321
	(0.0433)		(0.0828)		(0.0634)	(0.0316)	(0.0348)	(0.0240)	(0.0210)	(0.0140)	(0.0183)	(0.0502)	(0.281)
dummy_ age 6 plus	–0.0582**	–0.132***	–0.114***	–0.109	0.143***	0.0185	0.00388	–0.00404	–0.0304***	–0.0413***	–0.119***	–0.211***	–0.707***
	(0.0245)	(0.0441)	(0.0330)	(0.0701)	(0.0534)	(0.0167)	(0.0155)	(0.0127)	(0.0111)	(0.0125)	(0.0171)	(0.0273)	(0.187)
Constant	0.0530	0.823***	0.454***	1.221***	–0.939***	–0.261***	–0.181***	–0.112***	–0.00153	0.0471***	0.378***	0.876***	2.742***
	(0.0440)	(0.0516)	(0.0687)	(0.0870)	(0.0758)	(0.0313)	(0.0245)	(0.0200)	(0.0165)	(0.0166)	(0.0211)	(0.0517)	(0.318)
Observations	23,673	23,673	7,686	7,686	23,673	23,673	23,673	23,673	23,673	23,673	23,673	23,673	23,673
R–squared	0.010	0.096	0.052	0.185									
Number of firms		7,030		2,855									

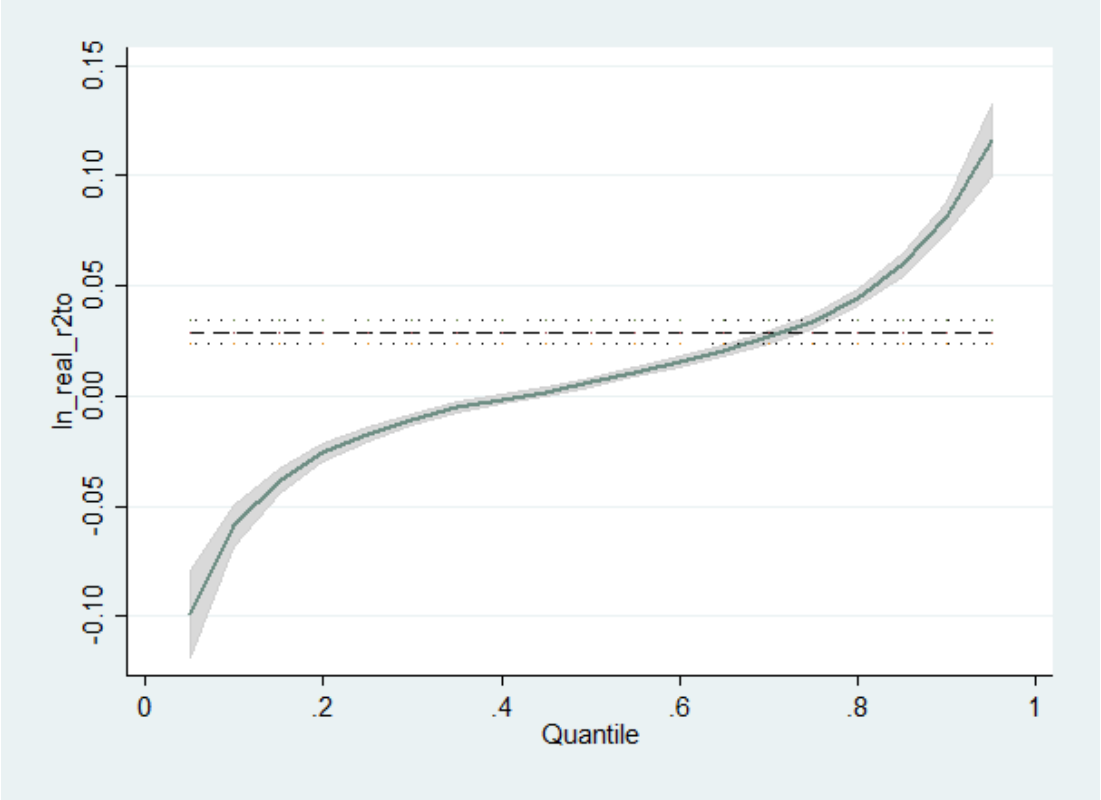
Notes: *** p<0.01, ** p<0.05, * p<0.1

Time effects were included in calculations

Source: Results based on data from the BERD database within BLADE.

[22] All the other dummy variables got dropped

Figure 6.1: Impact of R&D intensity on turnover growth (using BERD data)

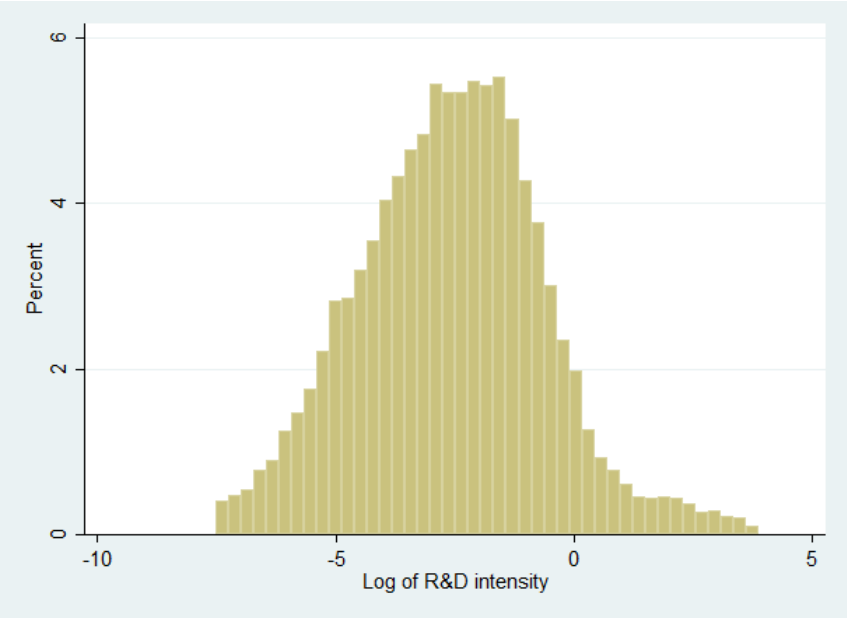


Source: Results based on the BERD database.

In general we find that firms with high R&D intensity have a higher return from R&D expenditure compared to low R&D intensity firms. There is a wide variation in R&D intensity among firms undertaking R&D (Figure 6.2). During the period from 2001–02 to 2012–13, the median firm undertaking R&D[23] spent about 8 per cent of its turnover on R&D expenditure and the distribution of R&D spending was skewed to the left. The bottom 10 per cent of the firms spent less than 0.5 per cent of their turnover on R&D expenditure, while the top 10 per cent of the firms spent more than 87 per cent of their turnover on R&D expenditure.

[23] Firms that spent more than $100,000 on R&D.

Figure 6.2: Distribution of R&D intensity (using BERD data)



Source: Results based on the BERD database.

The impact on turnover growth was larger for high R&D intensity firms compared to low R&D firms (Table 6.3). These results are based on two different methods of econometrics, OLS and FE (see Methodology 5). Results based on these methods show that the impact of R&D on turnover growth for high R&D intensity firms is between 5.9 to 7.3 times higher than for low R&D intensity firms.

Table 6.3 Impact on turnover growth – based on high and low R&D intensity — OLS and FE

	1	2	3	4	5	6
Independent variables	All firms — OLS	All firms — FE	High R&D intensity — OLS	High R&S intensity — FE	Low R&D intensity — OLS	Low R&D intensity – FE
Growtht–1	–0.0338**	–0.0972***	–0.0303	–0.0176	–0.0151	–0.0674**
	(0.0169)	(0.0207)	(0.0206)	(0.0257)	(0.0201)	(0.0305)
ln_R&D_intensity	0.0290***	0.188***	0.0681***	0.410***	0.00928**	0.0697***
	(0.00484)	(0.0125)	(0.0119)	(0.0306)	(0.00361)	(0.00783)
dummy-size_20 to 200 FTE	0.0589***	–0.0870***	0.0539***	–0.0411	0.0355***	–0.147***
	(0.0113)	(0.0328)	(0.0157)	(0.0441)	(0.0137)	(0.0448)
dummy-size_200 Plus FTE	0.121***	–0.287***	0.171***	–0.168	0.0564***	–0.356***
	(0.0160)	(0.0474)	(0.0370)	(0.174)	(0.0150)	(0.0564)
Mining	0.0569		0.0172		0.0449	
	(0.0467)		(0.0889)		(0.0412)	
Manufacturing	0.0276		0.00228		0.0517	
	(0.0346)		(0.0603)		(0.0330)	
Electricity, Gas, Water and Waste Services	0.0566		0.117		0.0326	
	(0.0509)		(0.149)		(0.0411)	
Construction	0.0479		–0.0131		0.0924**	
	(0.0391)		(0.0749)		(0.0361)	
Wholesale Trade	0.0505		0.0260		0.0667*	
	(0.0363)		(0.0644)		(0.0346)	
Retail Trade	0.0716		0.0452		0.0865**	
	(0.0444)		(0.0785)		(0.0425)	
Accommodation and Food Services	0.0720		0.106		0.0396	
	(0.0673)		(0.158)		(0.0566)	

	1	2	3	4	5	6
Transport, Postal and Warehousing	0.143***		0.212		0.117***	
	(0.0494)		(0.140)		(0.0374)	
Information Media and Telecommunications	0.0560		0.0147		0.110**	
	(0.0422)		(0.0697)		(0.0439)	
Financial and Insurance Services	0.0368		–0.00981		0.0534	
	(0.0457)		(0.0786)		(0.0491)	
Rental, Hiring and Real Estate Services	–0.0173		–0.119		0.0703	
	(0.0652)		(0.123)		(0.0507)	
Professional, Scientific and Technical Services	0.000978		–0.0340		0.0669*	
	(0.0354)		(0.0596)		(0.0348)	
Administrative and Support Services	0.0408		0.0262		0.0600	
	(0.0486)		(0.0750)		(0.0596)	
Arts and Recreation Services	0.0801		0.333*		–0.0664	
	(0.108)		(0.184)		(0.123)	
Other Services	0.0127		0.0381		–0.00620	
	(0.0433)		(0.0662)		(0.0552)	
Dummy_age 6 plus	–0.0582**	–0.132***	–0.0603*	–0.0771	0.000359	–0.0841
	(0.0245)	(0.0441)	(0.0313)	(0.0566)	(0.0274)	(0.0590)
			(0.0335)			
Constant	0.0530	0.823***	0.0265	0.637***	–0.0679	0.649***
	(0.0440)	(0.0516)	(0.0698)	(0.0521)	(0.0438)	(0.0856)
Observations	23,673	23,673	11,822	11,822	11,851	11,851
R–squared	0.010	0.096	0.018	0.139	0.011	0.058
Number of firms		7,030		4,173		4,020

Notes: *** p<0.01, ** p<0.05, * p<0.1. Time effects were included in calculations. Time dummies were included.

Source: Results based on data from the BERD database

7. Conclusion

Over the last decade, HGFs created most of the sales and value added in Australia (Australian Innovation System Report 2016 and 2017). This paper is the first detailed analysis of HGFs and their determinants of firm in Australia. The paper uses firm–level data based on BLADE to examine the patterns, characteristics and determinants of turnover growth among firms in Australia, with a focus on the roles of innovation and R&D.

The results yield intriguing and policy–relevant insights. The paper finds that the proportion of Turnover HGFs has declined in Australia. Between 2005 and 2014, the proportion of Turnover HGFs has declined from 17.6 per cent to 14.0 per cent of all firms. Results further show that most HGFs do not stay in the high–growth phase for long and that there is a lot of heterogeneity within the high–growth category.

Based on econometric results, the paper finds that the type of innovation a firm undertakes matters. Only innovations in goods and services and marketing have a significant positive impact on turnover growth for the average firm, while innovations in operational processes or organisational/managerial processes do not.

Innovations in goods and services is the only type of innovation that affects turnover growth among HGFs, but the growth benefits derived from this type of innovation is almost twice as much as all firms.[24] Business focus on innovation also affects turnover growth, independently of the impact of the innovations themselves, and having a business focus has a more pronounced impact for HGFs. This suggests innovation can boost turnover through channels besides the direct flow of benefits from materialised innovations.

The quantile regression results suggest notable variations across different points in the conditional distribution of turnover growth rates. At the higher end of the distribution, R&D intensity has a significant and positive impact on growth, while the lower end of the distribution is negatively impacted by R&D intensity. This shows that growth benefits from R&D are skewed in favor of HGFs. The results also show that R&D intensive firms benefit more from undertaking R&D than low R&D intensive firms.

HGFs are a challenge for policy makers they are hard to predict, and are episodic in nature. More than half of HGFs end their high growth episode within four years. After four years of high growth, 51 per cent of the 2005 cohort remained Turnover HGFs, and 42 per cent of the 2009 and 2011 cohorts remained HGFs.

Supporting innovation, R&D and creating conducive environment for business can augment firm growth and create more HGFs in the economy. Noting also, that since HGFs are in all sectors, so policy can be targeted at sectors with revealed comparative advantage in order to help these sectors reach a desired equilibrium of firm growth. At a more general level, policy options could be to help foster firm growth by removing bottle necks in terms of infrastructure and regulations, mitigate against market failures and invest in skills that will be essential for future industries.

[24] There was only partial evidence that organisational and managerial innovations affect turnover growth for HGF.

Appendix A: Quantile regression

Linear programming is used to minimise the following function for quantile regressions:

$$Q(\beta_q) = \sum_{i, y_i \geq X_{i\beta}}^{N} q|y_i - X_i' \beta_q| + \sum_{i, y_i < X_{i\beta}}^{N} (1-q)|y_i - X_i' \beta_q|$$

where q ranges between 0 and 1, and β_q denotes different choices of q for different values of β.

The estimator that minimises $Q(\beta_q)$ is an M–estimator with well–established asymptotic properties.

For a more detailed introduction of quantile regressions, see Cameron and Trivedi (2005).[25]

[25] Cameron AC and Trivedi PK (2005) *Microeconometrics: methods and applications*, Cambridge University Press.

Appendix B: Descriptive Statistics

In this paper we categorise high growth as 20 per cent or more compound average growth rate over three years. Medium, low and negative growth are categorized as 10–20 percent, 0–10 per cent and below zero percent compound growth rates over three years respectively (see chart below).

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