

FEATURE ARTICLE





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ENTREPRENEURIAL QUALITY AND GROWTH POTENTIAL IN SINGAPORE

INTRODUCTION

Using machine learning techniques, success probabilities of newly founded firms are estimated, using firm specific features like experience and intellectual property ownership. These probabilities are aggregated to create two indices, the Entrepreneurial Quality Index (EQI) and the Entrepreneurial Cohort Potential Index (ECPI), to provide timely measures of entrepreneurial quality and growth potential of new firms in Singapore respectively.

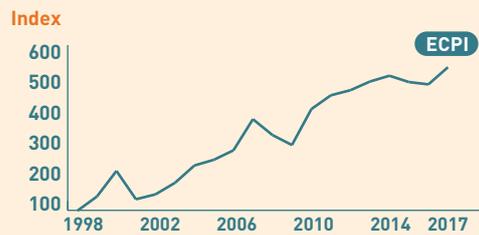


FINDINGS



► FINDING 1

The EQI, a measure of the average quality of new firms, rose from 1998 to 2000 alongside the recovery from the Asian Financial Crisis (AFC). Additionally, the pickup in entrepreneurial quality also coincides with the dot-com boom in the late 1990s. Following the peak in 2000, entrepreneurial quality has remained broadly stable from 2001 – 2017.



► FINDING 2

On the other hand, the ECPI, a measure of the growth potential of each new firm cohort, rose from 1998 to 2017, largely driven by the continued growth in the number of new firms formed each year.



► FINDING 3

Growth in the Entrepreneurial Cohort Potential Index displays a positive correlation with GDP growth.

KEY TAKEAWAY

The two new indices, when used in combination with existing statistics on business formation, provide us with a more holistic way to assess the current state of Singapore's entrepreneurial landscape. The strong correlation between GDP growth and the ECPI growth could be due to the positive signal that higher GDP growth conveys to entrepreneurs about the business environment, thereby encouraging more new firms to enter the market; and/or the increase in economic activity arising from the entry of new firms with growth potential.



EXECUTIVE SUMMARY

- This study aims to further our understanding of Singapore's entrepreneurial landscape through the construction of two measures of entrepreneurial quality and growth potential. First, using a dataset containing firm-level characteristics, we apply machine learning techniques to predict the probability that a new firm¹ will succeed, with success defined narrowly as being acquired or obtaining a listing on a public stock exchange. We also examine the characteristics (or features) of the new firms that are associated with success. In this regard, we find that features such as the cumulative number of years of experience that the founders of the new firm had in managing firms they previously founded, the exporting activity of the new firm, and the Intellectual Property (IP) ownership of the new firm are key features associated with success.
- Second, we average the predicted success probabilities of all new firms in a cohort (i.e., the new firms formed in a particular year) to derive the Entrepreneurial Quality Index (EQI) for the cohort. Doing so for every cohort of new firms since 1998, we find that the EQI and hence entrepreneurial quality has remained broadly stable in recent years. By multiplying the EQI of a cohort with the number of new firms in the cohort, we obtain the Entrepreneurial Cohort Potential Index (ECPI), which reflects the growth potential of each cohort of new firms. We find that the ECPI has shown an upward trend over the years, driven largely by an increase in the number of new firms formed every year. This suggests a steady increase in the growth potential of each cohort of new firms entering the market.
- We also find that growth in the ECPI has a positive correlation with GDP growth. This could be due to the positive signal that higher GDP growth conveys to entrepreneurs about the business environment, thereby encouraging more new firms to enter the market; and/or the increase in economic activity arising from the entry of new firms with growth potential.

The views expressed in this paper are solely those of the authors and do not necessarily reflect those of the Ministry of Trade and Industry or the Government of Singapore.²

INTRODUCTION

The Global Entrepreneurship Monitor (GEM) report³ in 2018 notes that the advent of new digital technologies and business models presents opportunities for budding entrepreneurs to start a business. In line with this, we have seen a rise in new firm formation in Singapore. Between 2008 and 2017, the number of new firms in Singapore grew by a robust 5.2 per cent per annum on average, with an average of 34,000 new firms entering the market per annum, more than twice the 14,000 recorded on average from 1998 to 2007. Singapore is also home to 4 out of 8 unicorns⁴ in Southeast Asia, namely Sea (formerly known as Garena), Razer, Lazada and Grab.

Given the important role that entrepreneurship plays in contributing to the dynamism of an economy, it is critical for us to assess the state of entrepreneurship in Singapore in a timely manner, so that the Government, industry and other stakeholders are better able to calibrate policies to create an environment that is conducive for innovation and entrepreneurship.

¹ For the purposes of this study, a new firm is considered as an entity that is newly founded/registered in a particular year. Only companies, limited liability partnerships and limited partnerships are analysed in this study.

² We would like to thank Yong Yik Wei and Kuhan Harichandra for their useful suggestions and comments. All remaining errors belong to the authors.

³ The GEM is a global survey that evaluates the entrepreneurial landscape of over 100 economies. For each economy, the GEM looks at the entrepreneurial behaviour and attitudes of individuals as well as the national context and how that impacts entrepreneurship.

⁴ Unicorns are high-tech startups valued at more than US\$1 billion. The other 4 unicorns are based in Indonesia (3) and Philippines (1).

While currently available statistics are able to provide a broad sense of Singapore's entrepreneurship landscape, they do not fully capture the quality and growth potential of the new firms formed. For instance, the monthly firm formation statistics reported by the Accounting and Corporate Regulatory Authority (ACRA) do not provide a sense of the growth potential of new firms, while other survey-based statistics such as those reported by the GEM are less timely and also do not track the entrepreneurial quality of new firms.

This study helps to plug the gap by developing measures of entrepreneurial quality and growth potential of new firms in Singapore through the application of machine learning techniques on firm-level data. We begin with a brief overview of the academic literature, followed by a description of the data and methodology used for our study. We then present the results before concluding.

LITERATURE REVIEW

To-date, only a few studies have examined the growth potential of firms and the determinants of their success. For instance, Belenzon et al. (2014) studied the performance of European firms and found that eponymous⁵ ventures generated, on average, returns on assets that were 3 percentage-points higher as compared to non-eponymous firms. Azoulay et al. (2018) used firm-level administrative data in the US and found that apart from eponymy, entrepreneurs with prior work experience closer to the specific industry of the startup⁶, and founders with longer experience in that industry, had substantially greater success rates, with success defined as the startup receiving venture capital financing or achieving a certain level of sales and employment growth. In addition, Wajzman et al. (2015) studied the impact of Intellectual Property (IP) ownership on firms in Europe, and found that SMEs and non-SMEs that owned IP had revenue per employee that was 32 per cent and 4.0 per cent higher than those that did not own IP respectively.

Our approach in this study is adapted from the approach taken by Guzman and Stern (2016). The authors defined successful startups⁷ in the US as those that were acquired or listed on a public stock exchange within 6 years of formation. Using the characteristics of the startups observed at the time of founding (e.g., the industry of the startup, whether the startup is an eponymous startup, whether the startup owned patent or trademarks, etc.), they ran a logistic regression to predict the probability of success of the startups. They found that characteristics such as eponymy and patent application were key predictors of success. In order to obtain measures of entrepreneurial quality and the growth potential of startups, the authors then aggregated the probabilities of success of the startups to form the Entrepreneurial Quality Index (EQI) and the Regional Entrepreneurial Cohort Potential Index (RECPI), with the latter measuring the growth potential of each cohort of startups within a particular geographical region in the US (e.g., state). Using the constructed RECPI, the authors found that it had a better correlation with GDP growth than traditional firm formation statistics.

DATA AND EMPIRICAL METHODOLOGY

The key dataset used in this study is derived from ACRA's business registry from 1998 to 2017. For each firm, the dataset from ACRA contains information on its characteristics such as the name of the firm, the number of founders associated with the firm, the position holders in the firm, and the industry of the firm. For a more comprehensive dataset, we also merged in datasets containing other pertinent firm-level characteristics such as patent ownership.

Similar to Guzman and Stern (2016), we define a new firm to be successful if it is acquired or obtains an Initial Public Offering (IPO) on a public stock exchange within 6 years from the time of formation.⁸ As the ACRA business registry does not include such data, we obtained information on the acquisition and IPO statuses of firms from the Bloomberg and Bureau van Dijk databases, and merged the information into our dataset.⁹

5 Eponymous firms are firms that are named after their founders.

6 Azoulay et al. (2018) defined startups as newly founded firms.

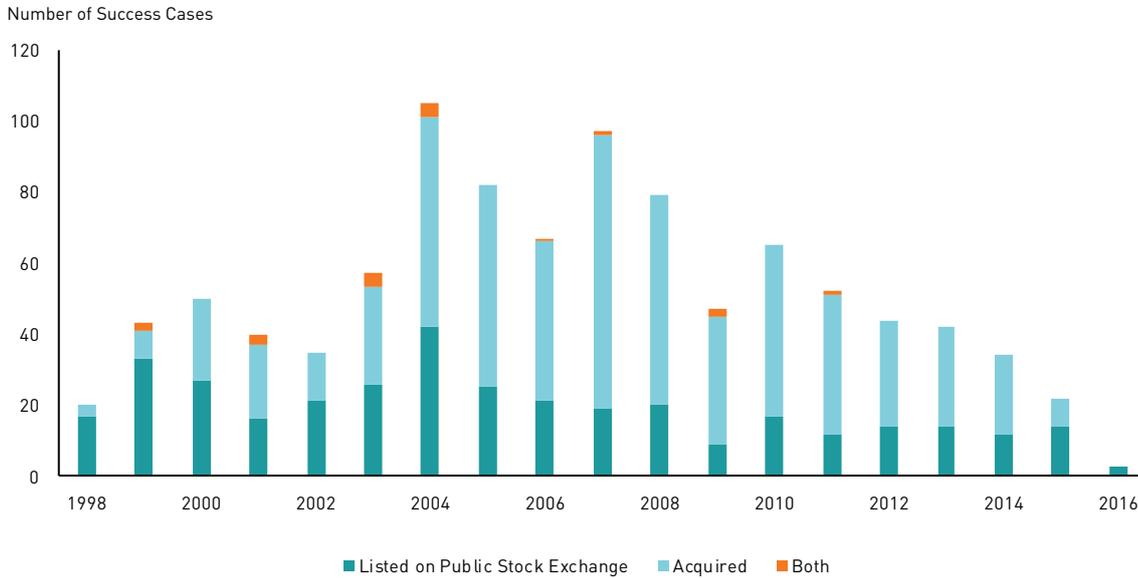
7 Similarly, Guzman and Stern (2016) defined startups as newly founded firms.

8 While there are other measures of a firm's success (e.g., performance-based measures such as revenue and profit growth, and other market-based measures such as receipt of venture capital funding and market valuation), acquisitions or listing on a public stock exchange are two of the most direct indicators of success and represent the market's endorsement of the firm's operations.

9 IPO data from the Bureau van Dijk database was merged into our primary database via the company UEN, while acquisition data from the Bloomberg database was matched via the name of each firm using a fuzzy matching algorithm.

Based on this narrow definition of success, the data shows that there were a total of 984 success cases in Singapore over the period of 1998 – 2017, out of more than 460,000 new firms formed during the period. Most of these cases were acquisitions between 2004 and 2008 (Exhibit 1).

Exhibit 1: Success Cases of New Firms by Type, 1998 – 2016



Notes:

1. "Both" refer to new firms that were acquired and subsequently listed on a public stock exchange.
2. There were no recorded success cases for new firms founded in 2017 due to the short runway.

Next, we select and engineer features from our dataset that can help to predict a new firm’s probability of success. In addition to considering firm-specific features proposed by Guzman and Stern (2016) such as a firm’s name and industry, we expand our feature list to include other firm-specific features such as a firm’s exporting activity as well as founder-specific features (e.g., the cumulative number of years of experience of founders in managing firms they previously founded). The key features included in our analysis are listed in Exhibit 2. For example, to obtain features like the cumulative number of years of experience of the founders, we sum up the total number of years of experience each member in the founding team of the new firm had spent managing firms they previously founded.

Exhibit 2: Firm- and Founder-Specific Features Considered

Firm-Specific Features	Founder-Specific Features
Industry of new firm*	Cumulative number of previous firms founded by the founders of the firm
Eponymous new firm*	Cumulative number of previous firms founded by the founders of the firm that had failed
Short names (name of new firm has less than 3 words, excluding terms like Private, Limited etc.)*	Cumulative number of years of experience managing firms previously founded by the founders of the firm
Entity type (e.g., company)*	Percentage of foreigners in founding team
Holding company*	
Management size (i.e., how many people are in charge of the firm)	
Domestic exports and re-exports	
IP ownership* (i.e., patents, trademarks, designs)	

Notes:

1. Features with a * refer to dummy variables.
2. Years of experience captures the additional dimension of how much time a founder stays in his/her role, as compared to the number of new firms founded.

Finally, to predict a new firm's probability of success, we employ a range of techniques, ranging from logistic regression model to other machine learning models such as gradient boosted trees, random forest, single-layer neural network and linear discriminant analysis. To evaluate which model best predicts firm success, we examine each model's Area Under Curve (AUC) of the Receiver Operator Characteristic (ROC) curve, and select the model with the highest AUC.^{10,11} We then use our selected model to generate a success probability for each new firm. In our final step, we aggregate the success probabilities of all new firms formed in a year to construct two economy-wide indices that can yield insights on how Singapore's entrepreneurial landscape has changed over time – the EQI and the Entrepreneurial Cohort Potential Index (ECPI):

- EQI: The EQI is constructed by taking a simple average of the predicted success probabilities of all new firms in each cohort (i.e., the new firms formed in a year). The index provides a measure of the entrepreneurial quality of a given cohort of new firms.
- ECPI: To holistically assess Singapore's entrepreneurial landscape, the ECPI combines both the quality and quantity measures of entrepreneurship. Specifically, the ECPI is obtained by multiplying the EQI of each cohort of new firms with the number of new firms in the cohort, and thus reflects the expected number of successful new firms in each cohort. This measure provides a sense of the growth potential of any given cohort of new firms in Singapore.

We construct the EQI and ECPI for every cohort of new firms between 1998 and 2017.

RESULTS AND DISCUSSION

Model Results and Features that Predict Success

In terms of the model that best predicts a new firm's success, we find that the gradient boosted trees model had the best predictive accuracy (i.e., an AUC of 0.84). In other words, this model was found to be best able to accurately predict successful new firms, even while minimising the number of falsely predicted success cases at the same time.

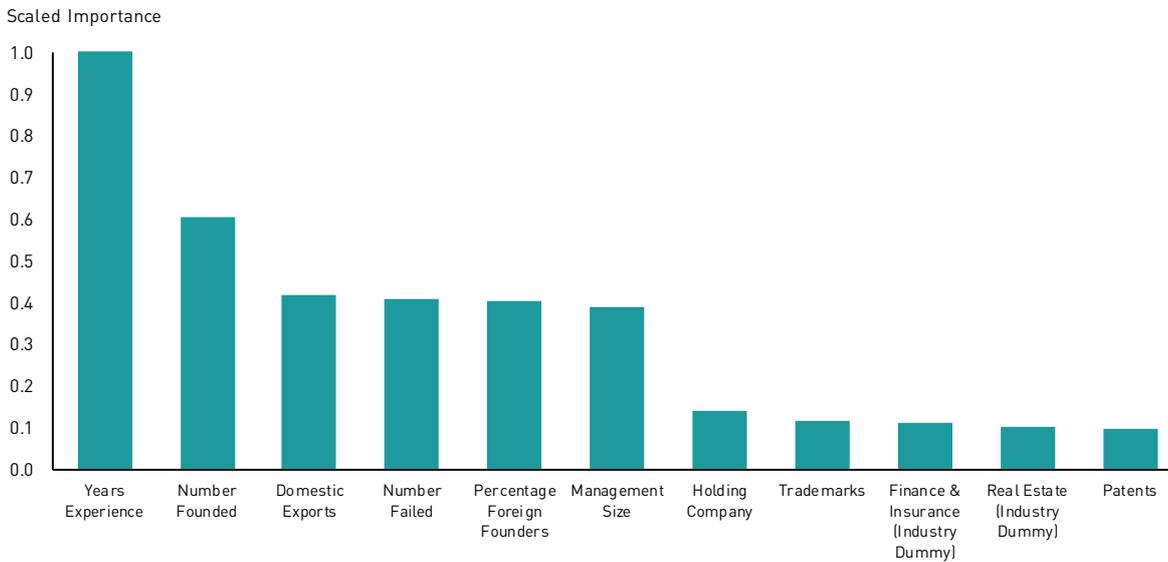
A variable importance¹² plot of the top features that contribute to the predicted probability of success using this model is shown in Exhibit 3. In particular, experience-based founder-specific features, viz. the cumulative number of years of experience of the founders of the new firm in managing firms previously founded and the cumulative number of firms previously founded by the founders emerged as the top 2 features. For firm-specific features, we find that a firm's exporting activity and the size of its management team are among some of the more important features that contribute to the likelihood of a new firm's success. The ownership of trademarks and patents is also associated with a higher likelihood of success.

¹⁰ To train our machine learning models, we first split the dataset into a training set and a testing set using random stratified sampling. Next, we tune the hyperparameters of each machine learning model using 10-fold cross-validations. Within each model, the combination of hyperparameter values that give the highest AUC under the ROC curve will be chosen.

¹¹ The ROC curve is a tool to evaluate the predictive accuracy of machine learning models. The curve plots the true positive rate (i.e., the percentage of new firms that are correctly identified as being successful) against the false positive rate (i.e., the percentage of new firms that are incorrectly identified as being successful) of each model. A model with high predictive accuracy will exhibit a high true positive rate while maintaining a low false positive rate at the same time. This predictive accuracy is calculated using the AUC of each model. An AUC closer to 1 signifies high predictive accuracy, while an AUC closer to 0.5 signifies low predictive accuracy.

¹² Variable importance represents the statistical significance of each feature in the data with respect to its effect on the prediction. The higher the scaled importance, the higher the importance of the feature in generating the prediction of success.

Exhibit 3: Variable Importance Plot



As the variable importance plot does not provide insights on how changes in the magnitude of each feature changes the probability of success, we also plot Partial Dependence Plots (PDPs)¹³ for some of the key features derived from the variable importance plot (Exhibit 4A and 4B).

Exhibit 4A: PDP for Cumulative Years of Experience Managing Previously-Founded Firms

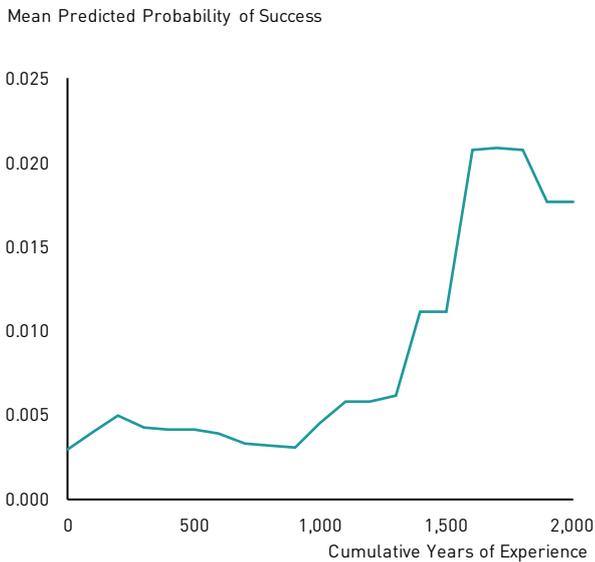
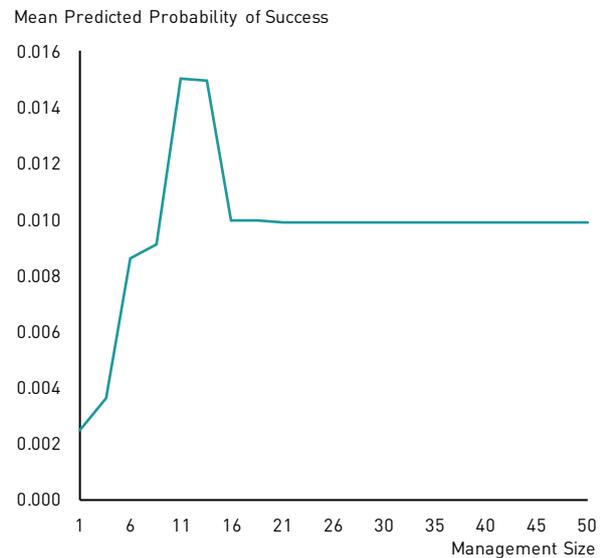


Exhibit 4B: PDP for Management Size



Based on the PDPs, a few salient observations can be made. First, in line with the results in the literature, more experience, as represented by a higher cumulative number of years of experience that founders had in managing previously-founded firms, led to higher predictions of success. Second, a larger management team improves the predicted probability of success, but only up to a certain point. This is similarly in line with the findings in the literature.

¹³ PDPs give a sense of the marginal effect of each feature on the prediction of success. In other words, it plots how changes in the value of the feature (x-axis) changes the mean prediction of success (y-axis), holding the values of the rest of the features constant.

Trends in EQI and ECPI

Exhibits 5A and 5B show the resulting EQI and ECPI for Singapore over the period of 1998 to 2017.¹⁴ Based on the EQI, entrepreneurial quality rose from 1998 to 2000 alongside the economy's recovery from the 1997 Asian Financial Crisis and the dot-com boom in the late 1990s. After peaking in 2000, entrepreneurial quality has remained broadly stable from 2001 – 2017, apart from a dip in 2009 during the Global Financial Crisis.

Driven by an increase in the number of new firms formed each year, the ECPI exhibits an upward trend over the period of 1998 – 2017. This reflects a steady increase in the growth potential of each cohort of new firms formed over the years. The rise in the ECPI coincides with an increase in the funding for, and interest in, entrepreneurship over the years. For example, Government initiatives such as the expansion of Block 71 into LaunchPad @ One-North, as well as the roll out of startup-focused grants such as the Startup SG Tech¹⁵ may have encouraged more individuals to embark on new ventures.

Exhibit 5A: EQI, 1998 – 2017

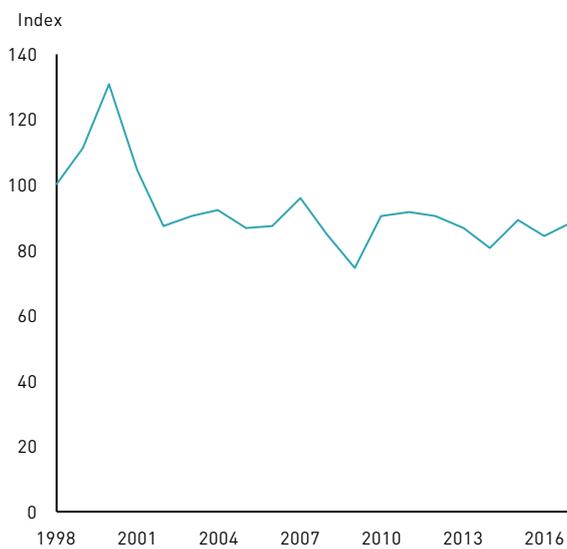
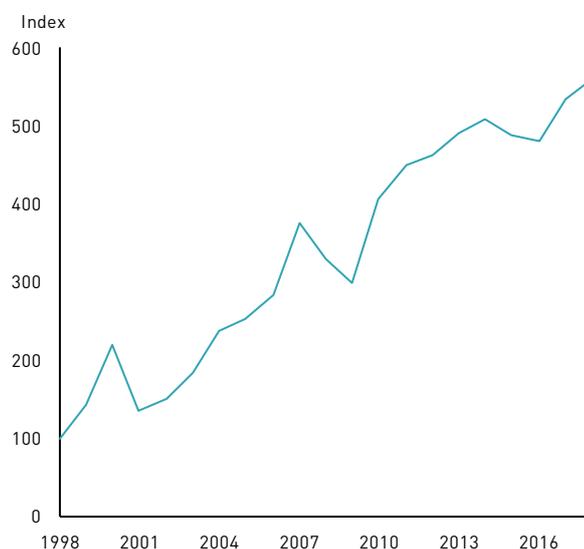


Exhibit 5B: ECPI, 1998 – 2017



We also find that the ECPI tracks economic growth, with ECPI growth exhibiting a positive correlation with GDP growth (0.63) over the 1999 – 2017 period (Exhibit 6). There could be two possible reasons for this. The first is the signal that GDP growth conveys to entrepreneurs. Specifically, higher GDP growth is likely to be seen as a sign that the economic environment is conducive for business activity, which may then encourage more firms to enter the market. Conversely, when GDP growth is negative or low, firms are deterred from entering the market. This reason is corroborated by the GEM report for Singapore (GEM, 2014), which found that perceived opportunities to start a business in the next 6 months had a positive and significant correlation with both entrepreneurial intent and startup experience. The second possible reason is that an increase in the number of new firms with growth potential entering the market is beneficial for economic activity, in turn resulting in higher GDP growth.

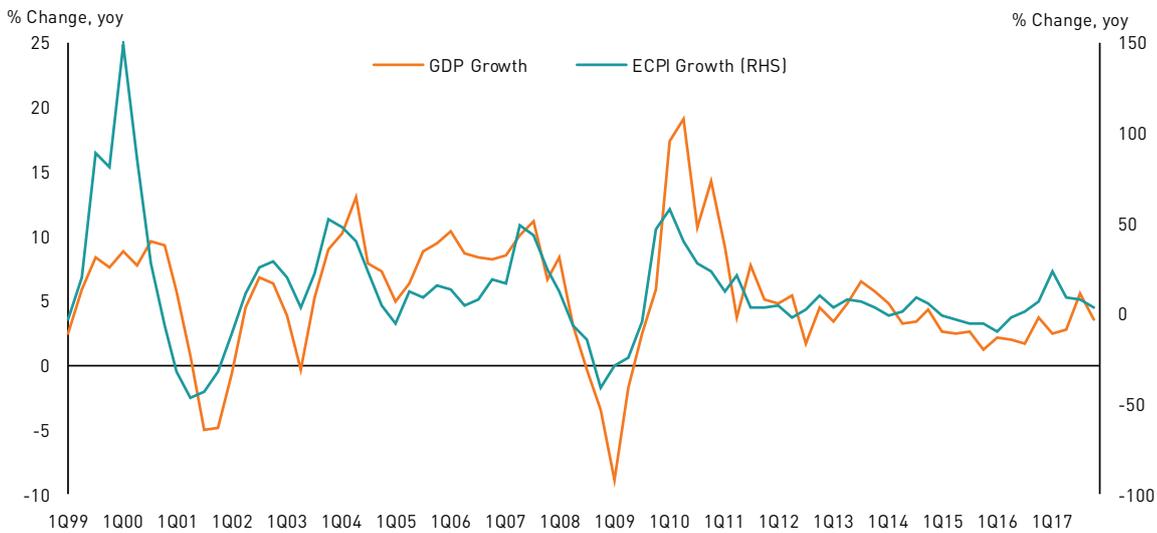
The above finding thus suggests that it is important to keep our macroeconomic environment healthy in order to foster a thriving entrepreneurial landscape. It also suggests that the Government should continue to ensure that our startup landscape remains vibrant. Indeed, the Government is committed to doing so in collaboration with ecosystem partners from the industry and research institutions. In particular, entrepreneurs as well as investors looking to invest in startups may tap on the wide range of financial and non-financial support from schemes under Enterprise Singapore's StartupSG umbrella and our ecosystem partners.¹⁶

¹⁴ EQI and ECPI were constructed based on predictions from a model that only utilised data that was available at the point of firm formation to ensure the timeliness of the indices.

¹⁵ The Startup SG Tech scheme implemented by Enterprise Singapore Group (ESG) provides early funding to help startups commercialise their proprietary technology products and services.

¹⁶ StartupSG was launched in 2017, with the goal of unifying and streamlining startup support schemes. The different startup schemes target different stakeholders within the startup ecosystem. For instance, StartupSG Founder is focused on first-time entrepreneurs, while Startup SG Investor supports investors looking to invest in startups.

Exhibit 6: ECPI and GDP Growth, 1Q99 – 4Q17



CONCLUSION

This study has furthered our understanding of Singapore's entrepreneurial landscape through the construction of two new measures – the EQI and ECPI. To construct these measures, we use firms' characteristics as inputs to our machine learning model in order to predict their probability of success. We find that experience-based features such as the cumulative number of years of experience that the founders of a new firm had in managing previously-founded firms are key features associated with a higher probability of success.

Averaging the predicted probabilities of success of new firms entering the market every year, we construct the EQI as a proxy for entrepreneurial quality. We find that the EQI and hence entrepreneurial quality has remained broadly stable in recent years, notwithstanding an increase in the number of new firms formed annually over the years. Driven by the increase in the number of new firms formed every year, the ECPI has shown an uptrend over the years, suggesting that the growth potential of each cohort of new firms has increased over the years.

Last but not least, we find that ECPI growth is positively correlated with GDP growth. This could be due to the positive signal that higher GDP growth conveys to entrepreneurs about the business environment, thereby encouraging more new firms to enter the market; and/or the increase in economic activity arising from the entry of new firms with growth potential. This suggests the importance of keeping the macroeconomic environment healthy in order to foster a thriving entrepreneurial landscape, and also the importance of ensuring that our startup landscape remains vibrant.

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