Examining the Trajectory of Competitive Advantage with Financial Ratios

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The ambiguity between competitive advantage and firm performance prohibits replication of success. Yet, a recent study indicates that firm performance reveals its own causes, that is, one could infer the sources of the competitive heterogeneity from performance related financial ratios. By developing a hierarchical linear model of individual growth with financial ratios, the present study examined the underlying factors driving the competitive heterogeneity for the semiconductor industry during the period of 2003 to 2007. Results show that companies in the advanced countries have advantage on cost leading from bargaining power against suppliers. This advantage, however, has been decreasing over time. Furthermore, companies in the newly industrialized countries have generated increasing advantage in lower administrative cost and R&D expenditures during the study period.

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1. Introduction

The resource-based view (RBV) has been taking the lead in explaining the intra-industry performance differences, that is., competitive heterogeneity (Hoopes, Madsen and Walker, 2003). However, much of the RBV work has focused on resource bundles, such as culture (Barney, 1986) and other socially complex resources (Barney, 1991; Barney 1997). Other than RBV, much of the more modern work on fit and organizational alignment (Porter, 1996; Sigglekow, 2001; 2002), including the work on NK analysis (Levinthal, 1997), concerns bundles of activities (or resources) as the source of competitive advantage. The problem is that resource and activity bundles are notoriously hard to dismantle since they include complex linkages, complementarities (Milgrom and Roberts, 1990; 1995) and tacit dimensions (Nelson and Winter, 1982). Variants of the RBV, such as the knowledge-based view (Kogut and Zander, 1992) and the dynamic capabilities literature (Eisenhardt and Martin, 2000; Teece, Pisano and Shuen, 1997) have the same problem in interpreting the sources of competitive advantage since all resources are embedded, interconnected, or tacit. These bundles of resources are not only hard to unpack but also are very difficult to test the prediction that such resources provide a competitive advantage or affect sustained firm performance.

Except the RBV, Miles and Snow (1984) and Miller (1986; 1996) connect broad archetypes or configurations to performance. In addition, following the work of Milgrom and Roberts (1990; 1995), many empirical studies showed evidences that complementarities provide advantages (e.g. Ichniowski Shaw, and Prennushi, 1997). As a further step, Peteraf and Reed (2007) brought management into managing bundles of capabilities and showed that this can lower firm costs (or create value). The RBV and the Dynamic RBV (Helfat and Peteraf, 2003) or Dynamic Capabilities (Teece, Pisano and Shuen, 1997) are advancing by following the archetype/configuration-performance framework.

To tackle the system fallacies in the strategic thinking (Priem and Bultler, 2001a; 2001b), Tang and I (Tang and Liou, 2010) suggest extending the causal relation between competitive advantage and superior performance to a strategy-configuration-performance causal series. We suggest using resource configuration to find out which potential routes to competitive advantage yield long-term payoffs in performance and profitability given a specific context, and which resource bundles really matter. We then built the resource configuration model with financial ratios and identified three dimensions of resource bundles (i.e., relationship advantage, management capability, and knowledge management) for the competitive advantage of the global semiconductor industry. Our study parameterizes the packed resource bundles and thus provides a practical approach to infer the sources of competitive advantage. The resource configuration approach in our previous study was static comparative. To reveal the dynamic feature of competitive advantage, this paper uses hierarchical linear model of individual growth (individual growth model) to identify the time trend of those resource bundles and managing capabilities contributing to the sustained competitive advantage in a specific period.

2. Literature Review

Sustainable competitive advantage is defined as "above-average performance in the long run" (Porter, 1985:11), with the amount of time defining the "long run" not specified. There is increasing strategic theorists believed that sustained competitive advantage is not feasible at firm level in a hypercompetitive, high-velocity, hyper-turbulent, and chaotic environments (e.g., Brown & Eisenhardt, 1998; D'Aveni, 1994; Eisenhardt and Martin, 2000; Hamel, 2000; Dawai, 2004). As the advantage of entry barriers and low cost might erode in a short term, the firm can only pursue temporary or a series of competitive advantage. To tackle the competitive dynamics, the speed and aggressiveness of firm actions determine the effectiveness of a firm's position and movements.

Dynamic capabilities are defined as the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly-changing environments (Teece et al., 1997). The dynamic resource configuration model proposed by the present study investigates which resource bundles and managing capabilities contribute to the trajectory of competitive advantage in a specific period. One of problem associating with analysis of competitive advantage is that neither the traditional long-term sustainable argument nor the short-term temporary view of competitive advantage specifies the time span for observing competitive advantage. The proposed study examines the trajectories of competitive advantage within industry for a period of five years from 2003 to 2008. The market was in an upward trend from 2003 to the third quarter of 2007 and started falling at the end of 2007 when the United States housing bubble collapsed and the global financial crisis followed. Examining the growth trajectories of individual firm helps us to identify those resource bundles and capabilities contribute the most to the competitive advantage during this business cycle.

3. Methodology

Recent decades, major advance has been made in methodology for analyzing individual-level developmental trajectories to analyze the stability and change over time. One of the main branches of methodology is hierarchical modeling (Bryk and Raudenbush, 1987, 1992; Goldstein, 1995). Individual growth models refer to statistical models for longitudinal data that allow each individual in the sample to have distinct over-time trajectories of change (Figure 1). These patterns of change are summarized in relatively few parameters. The parameters in turn are modeled as functions of other variables. In hierarchical modeling, individual variation in developmental trajectories, which are commonly called growth curves, are captured by a random coefficients modeling strategy. The Hierarchical linear approach is also called "multilevel analysis", "random regression models", "growth-curve analysis" or "empirical Bayes-estimation".
The growth mixture modeling approach is a useful method for fully capturing information about interindividual differences in intra-individual change (the trajectory) taking into account unobserved heterogeneity (different groups) within a larger population (Muthén, 2004). A trajectory defines the developmental course of a behavior/measure (e.g., employment of resources or capabilities) over time. Trajectories, however, are not deterministic functions of time. External events may deflect a trajectory. For example, the impact of strategies or the employment of resources and capabilities on trajectories of competitive advantage might vary in different industries.
Mixture models have been used for modeling unobserved heterogeneity in a population. Consider the two-level growth model, for time point t and individual i:

Level 1 growth model (the trajectory):

$$\boldsymbol{Y_{ti}} = \beta_{0\boldsymbol{i}} + \beta_{1\boldsymbol{i}}(\boldsymbol{TIME})_{\boldsymbol{ti}} + \sum_{\boldsymbol{j}=1}^{\boldsymbol{J}} \beta_{\boldsymbol{tji}} \boldsymbol{a_{tji}} + \boldsymbol{v_{ij}} \text{, where } \boldsymbol{v_{it}} = \boldsymbol{N}(0, \sigma^2)$$

Level 2 growth factor (variation among individuals):

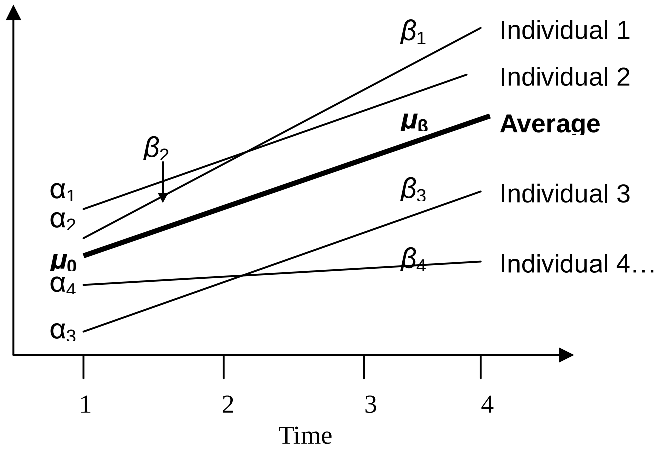

Figure 1 Fitted growth trajectories for individuals

$$\begin{aligned} \beta_{0i} &= \pi_{00} + \sum \pi_{0i} \boldsymbol{x}_i + \mu_{0i} \\ \beta_{1i} &= \pi_{10} + \sum \pi_{1i} \boldsymbol{x}_i + \mu_{1i} \\ \beta_{2i} &= \pi_{20} + \sum \pi_{2i} \boldsymbol{x}_i + \mu_{2i} \end{aligned} \text{, where } \begin{pmatrix} \pi_{0i} \\ \pi_{1i} \\ \pi_{2i} \\ \vdots \\ \pi_{Ji} \end{pmatrix} \sim \boldsymbol{N}\left[\begin{pmatrix} 0 \\ 0 \\ 0 \\ \vdots \\ 0 \end{pmatrix} \times \begin{pmatrix} \tau_{00}\ \tau_{01}\tau_{02}\ldots\tau_{0J} \\ \tau_{10}\ \tau_{11}\tau_{12}\ldots\tau_{1J} \\ \tau_{20}\tau_{21}\tau_{22}\ldots\tau_{2J} \\ \vdots \\ \tau_{J0}\tau_{J1}\tau_{J2}\ldots\tau_{JJ} \end{pmatrix} \right] \quad (2)$$

…

where
Y_{ti} = the outcome of individual company over time (e.g., financial performance)
TIME = time-related variable (time scores) (e.g., 2003-2007)
a_{jti} = the jth time-varying covariate (e.g., resource and capability related financial indicators)
x_i = time-invariant covariate (e.g., industry type, governance institution)

β_{0i}, β_{1i} and β_{2i} are random intercepts and slopes varying across individuals. The residuals v_{ij}, μ_{0i}, μ_{1i}, and μ_{2i} are assumed normally distributed with zero mean and uncorrelated with *Time*, *a* and *v*. The Level 2 residuals μ_{0i}, μ_{1i}, and μ_{2i} are possibly correlated but uncorrelated with *v*. The variances of *v* are typically assumed equal across time and uncorrelated across time. However, these restrictions on residuals can be relaxed. The model may alternatively be expressed as a mixed linear model relating *y* directly to a_1, a_2, and *x* by inserting (2) into (1). Analogous to a two-level regression, when either a_{ti} or β_{2ti} varies across *i*, there is variance heteroscedasticity for *y* given covariates and therefore

not a single covariance matrix for model testing.
The combined form is

$$\boldsymbol{Y_{ti}} = \left[\pi_{00} + \pi_{10}(\boldsymbol{TIME})_{\boldsymbol{ti}}\right] + \left[\mu_{0i} + \mu_{1i}(\boldsymbol{TIME})_{\boldsymbol{ti}} + \boldsymbol{v_{ij}}\right]$$

The multilevel, random effects model presented above can be seen as a latent variable model, where the random effects β_{0i}, β_{1i} and β_{2i} are latent variables. The latent variables β_{1i} and β_{2i} are called growth factors and are of key interest in growth model.
Model (1) and (2) have two contradictory assumptions. On one hand, it allows individual differences in development over time because the growth intercept β_{0i} and growth slope β_{1i} vary across individuals, resulting in individually varying trajectories for Y_{ti} over time. The heterogeneity is captured by random effects (i.e., continuous latent variables). On the other hand, it assumes that all individuals are drawn from a single population with common population parameters. Growth mixture modeling relaxes the single population assumption to allow for parameter differences across unobserved subpopulations. This is accomplished using latent trajectory classes (i.e., categorical latent variables). This implies that instead of considering individual variation around a single mean growth curve, the growth mixture model allows different classes of individuals to vary around different mean growth curves. The combined use of continuous and categorical latent variables provides a very flexible analysis framework (Muthén, 2004).
In Compustat database, firms in the semiconductor and related devices industry (Standard Industrial Classification code 3674) primarily engaged in manufacturing semiconductors and related solid-state devices.
Important products of this industry are semiconductor diodes and stacks, including rectifiers, integrated microcircuits (semiconductor networks), transistors, solar cells, and light sensing and emitting semiconductor (solid-state) devices. In the North American Industry Classification System (NAICS) code, these firms are classified in Semiconductor and Related Device Manufacturing (#334413).The semiconductor/IC industry has developed several highly dependent partitions over the years, with firms dealing in intellectual property (e.g., NXP and IBM), integrated circuit design (e.g., Qualcomm and NVIDIA), wafer foundry (e.g., TSMC, Taiwan Semiconductor Manufacturing Corp.), and IC assembly (e.g., Advanced Semiconductor Engineering).
This industry shows moderate average annual growth of sales (12.0%) during the past five years. The four-firm concentration rate decreased dramatically from 44.20% to

27.05%. The serious competitions come from commoditization of chip prices, and lower barriers to entry into the industry for start-ups (e.g., SMIC).

There are 423 companies included in the class of semiconductor and related devices industry in the Compustat database. The sample contains only those companies with at least three years of complete data or a lifespan longer than three years. The samples do not include any companies with one or more financial indicators (excluding return on invested capital) more than three standard deviations from the industry mean. None of these outliers are extraordinary performers. The final data set contains 471 companies located in advanced countries and 378 in newly industrialized countries (NICs).

The annual growth of the economic value added over invested capital (EVA/IC) measures the productivity of unit invested capital of the firm and was taken as the proxy of competitive advantage. EVAs is defined as the net operating profits less adjusted taxes (NOPLAT) over the dollar cost of capital (WACC, weighted average cost of capital, times IC, invested capital).

$$EVA = NOPLAT - WACC \times IC$$

The financial ratios revealing the resource configuration of the firm (Tang and Liou, 2010) are used as the time variant variables at the first level of the model to examine the trajectory of growth in the semiconductor industry. The time invariant predictors at the second level include scale and the synthetic company rating measured by times interest ratio. For model fitting, the sample is divided into two groups according to the country type (advanced and newly industrialized countries) where the companies locate.

4. Discussion of Findings

Table 1 shows the estimates of the individual growth model. Firms based in the newly industrialized countries (NICs) had a significant growth pattern (0.016; $p < 0.001$) over time during 2003-2007. However, growth pattern of firms based in advanced countries are not significant during the same period. For the past two decades, the semiconductor industry has developed a global setting Capital investment, labour, and production often differ from one nation to the next, but semiconductor markets are hierarchical. The high labour and capital equipment costs in the production of semiconductors create a niche for foundries in NICs. The fabrication-plant chip-design semiconductor companies create

Table 1 Results from the individual growth model

Effect	Advanced countries	NICs
Intercept	0.220	0.053
Time	–0.008	**0.016*** **
Rating	–0.002	0.002
Time*Rating	–0.001	0.001
Scale	–0.011	0.005
Cash turnover	0.000	0.000
Accounts receivable turnover	–0.005	0.002
Inventory turnover	0.000	0.000
Property, plant and equipment turnover	0.000	0.001
Accounts payable turnover	0.001	0.001
Cost of goods sold / sales	**–0.106** **	0.039
R&D expenditure / sales	–0.093	0.103
Selling, general and administration expenses	–0.084	0.071
Tax / sales	–0.006	0.003
Time*Accounts receivable turnover	0.002	0.001
Time*Inventory turnover	0.000	0.000
Time*accounts payable	0.000	0.000
Time*cost of goods sold / sales	**–0.046*** **	0.000
Time*R&D expenditure / sales	0.100	**0.013*** **
Time*Selling, general and administration expenses / sales	0.047	**0.051*** **

schematics for chips but outsource the manufacturing to semiconductor foundries. Focusing resources on core business, large companies in advanced countries (including Motorola and Intel) have outsourced most of their components and products to foundries in NICs such as TSMC. As a result, companies in the semiconductor industry are highly interdependent—each has to ally with both upstream and downstream members of the industry. Competitive heterogeneity from bundles has thus become insignificant except cost leadership in production. The present study might be advanced by including more time invariant predictors in the growth model.

For the semiconductor companies based in advanced countries, the ratio of cost of goods sold over sales (COG/sales) is the only factor showing significant contribution (–0.106; $p < 0.05$) to the growth other than time. However, the effects of the cost leading on growth have been decreasing over time. On the contrary, the effects of lower administrative cost on competitive advantage were increasing over time for semiconductor firms based in NICs. In addition, the percentage of research and development expenditures over sales also shows an increasing impact on growth.

Among the three resource bundles identified from static comparative approach in Tang and my previous study (2010), only one of the upstream relationship advantage indicators (COGS/sales) has a significant effect on growth for semiconductor firms based in advanced countries. This result shows that the bargaining power against suppliers is the major competitive advantage over time in this high variant industry. Neither of the resource bundles related to bargaining power against customers or management capability of physical assets show significant contribution to the individual growth in this industry.

5. Conclusion

Following our (Tang and Liou, 2010) previous research in revealing the causes of competitive advantage from financial performance, the present study use the mixture individual growth model to identify the trajectory of competitive advantage in the semiconductor industry from 2003 to 2007. Results show that (1) while companies in the NICs have significant growth over time, those in the advanced countries have insignificant growth pattern during the study period; (2) companies in the advanced countries generate competitive advantage from lower cost of goods sold, which indicate a stronger bargaining power against suppliers; however, this cost advantage have been decreasing; and (3) companies in the newly industrialized countries have generated increasing advantage in lower administrative cost and R&D expenditures, which is the advantage of followers. The mixture model used in present study contains only few time invariant predictors. It might be advanced if more time invariant predictors are included in the growth model.

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