Industry rates of return in Korea and alternative theories of competition: equalising convergence versus tendential equalisation

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Abstract

This paper considers convergence and equalisation in industry profit rates in the Republic of Korea in the period of 1970–2015, from the perspective of alternative paradigms of competition – classical and neoclassical. Two measures of profitability are estimated: average rate of profit based on the total capital stock in the economy, and incremental rate of profit (IROP) based on the concept of regulating capital. It is shown that little convergence in industry rates of profit occur when the former measure is used, while almost complete equalisation of IROP is achieved. The classical-type equalisation takes place in particular capital accumulation and competitive settings in Korea, characterised by the prominent role of diversified conglomerate firms, the capital flows within conglomerates, investment coordination by the state, and the fast pace of capital accumulation and renewal).

Keywords: Convergence, gravitation, average profit rate, incremental profit rate, unit roots

JEL Classification: B5, C22, L0, L60, L70, L90

Introduction

The dynamics of the profit rates at industry level is a salient topic in economics for a variety of reasons: the rate of profit serves as an indicator of the overall health and vitality of individual industries; it highlights the pace of technological progress and industrial change; and it is a key regulator of competition, of the speed and direction of capital investment across the firms and sectors, and of the degree of capital mobility.

The possibility of a reduction of profit rate differentials between industries is discussed in the neoclassical economic theory, while the tendency of the equalisation of profit rates between industries is observed in classical economics. In both instances, the process is likely driven by the movement of capital to more profitable activities and uses. D'Orlando (2007) and Tescari and Vaona (2014) thus define two alternative paths along which industry profit rates may evolve: 'convergence towards long period positions', when the initial difference in the level of profit rates between individual industries is reduced over time, as capital flows to the industries with higher rates; and 'the random oscillation of actual magnitudes around their long-period counterparts', or oscillation of profit rates around some stable level. Convergence of profit rates is thus related to the gravitation of profit rates, albeit the latter concept is a more restrictive, as far as the dynamics of profit rates are concerned.

The purpose of this paper is to examine these convergence and gravitation tendencies among industry profit rates in the Republic of Korea in the period of 1970–2015. More specifically, we identify two

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alternative views on profit rate differentials: equalising convergence in profit rates as per the neoclassical paradigm of competition, and the tendential equalisation of profit rates as per the classical paradigm.

This choice of the Korean economy for empirical analysis is dictated by three factors: firstly, the majority of studies focus on profit rate dynamics in developed economies, while consideration of the convergence or gravitation process in developing or transition economies is missing. Secondly, the Korean economy has undergone a rapid transformation over recent decades, specifically experiencing a rapid rise in manufacturing industries, implying large-scale flows of capital across the economy. Thirdly, the manufacturing sector in South Korea is dominated by diversified conglomerates (chaebols) and is characterised by high degrees of concentration (Chung, Yang, 1992; Lee, 2014), likely affecting profit rate dynamics.

The paper adopts two alternative measures of the rate of profit: average rate of profit, based on all vintages of capital available in the economy, and IROP, conceptualised as returns on the most recently invested capital (regulating capital) and considered a better representation of the rate of return on capital (Shaikh, 2016). The former measure is considered appropriate for analysing of the equalising convergence and tendential equalisation hypotheses, while the latter is suitable for analysis of the tendential equalisation hypothesis. Another methodological novelty of this paper is its adoption of a sequential testing procedure, utilising a number of unit root tests to determine the presence of convergence. This contrasts with previous empirical work that relies on early-generation unit root tests, autoregressive procedures, or inverted trend models that tend to bias the results.

The paper is structured as follows: Section 2 presents a brief review of the literature pertaining to the theoretical and empirical aspects of industry rates of return convergence. Section 3 considers the methodological approach to the analysis of convergence. Empirical results are provided in Section 4, while Section 5 contains concluding remarks.

Literature review

Classical economics conceptualises competition as a rivalry process aimed at ensuring business survival. Technological and organisational innovation are seen as indispensable means to achieving higher market shares, cutting costs and reducing prices, and thereby guaranteeing survival. In turn, capital investment is means of financing innovation, while the rate of profit is the outcome of the competitive process and a determinant of further capital investment (Shaikh, 1982; Tsoulfidis, Tsaliki, 2011: 1-2).

Another outcome of the competitive process is equalisation of profit rates at industry, regional, and possibly international levels (albeit not at intra-industry levels among firms operating within the same line of business). Classical economists (Smith, 1976; Ricardo, 1975; Marx, 1981) explain the mechanism of profit rate equalisation as follows: in the presence of high profit rates in a particular industry, capital seeking higher profit is invested, leading to supply increases, and decreases in output price, gross operating surplus, and profit. The opposite mechanism operates in industries with low profit rates, with equalisation forces operating in both industry types. The equalisation process concerns both capital and product markets and is denoted by Flashel and Semmler (1990) as a cross dual dynamic process, with the chain of effects being as follows: profit rate differentials → inflow or outflow of capital → excess supply or demand on product markets → variation in prices, profits and profit rates and so on. The adjustments at industry level are seen to be driven by inflows and outflows of production factors (capital and labour), rather than the entry or exit of the firms.

The equalisation of profit rates does not mean equality of profit rates in a mathematical sense or a general equilibrium, but rather tendential equalisation manifested in the long-term and based on turbulent fluctuation and crisscrossing of individual industries' profit rates around the average profit rate, with positive or negative deviations from the mean being offset in the long-run. The points where profit rate differentials dissipate are thereby not equilibrium states, but rather centres of gravity or points of attraction (Semmler, 1984), the tendential equalisation being thus synonymous with gravitation (Shaikh (2016: 260) indicates that centres of gravity may be moving over time as well).

In contemporary economic theory, this classical conceptualisation of competition as a dynamic process is adopted in the Schumpeterian, evolutionary, and Austrian schools (Schumpeter, 1934, 1950; Nelson, Winter, 1982; Kirzner, 1978; 1987), which place entrepreneur and entrepreneurship as agents in charge of innovation and exploitation of profit opportunities.

Neoclassical and mainstream theories of competition tend to view competition as a state rather than a process, with different states (monopoly, oligopoly, perfect, and monopolistic competition) corresponding to varying degree of industry concentration, barriers to entry, sunk costs, and demand elasticities, resulting in profit rate differentials and persistence (Bain, 1951; Kamerschen, 1969; Mancke, 1974; Gschwandtner, 2012). The later theorising focuses on dynamic and interactive aspects of competition (Spence, 1981; Bajari et al, 2007), determinants of firms' heterogeneity and profit rate persistence (Griliches, 1986; Haltiwanger et al., 2007; Mueller, 1986), and the extent of market imperfections (Galbraith, 1967; Stigler, 1971), among other issues.

The dynamics of profit rates in neoclassical theorising are viewed as a transition towards a perfectly competitive state (*equalising convergence*). Profit rate differentials dwindle over time, with those in individual industries converging to competitive rates, unless barriers to entry and market imperfections persist or external shocks cause further deviations from the competitive level. In this latter case, the persisting profit differentials could indicate a certain degree of market (monopoly) power. In contrast to the classical view, the adjustment is driven by firms' entry or exit. Depending on the perfectionist or imperfectionist view of the actual markets and industries (such as Chicago versus Harvard theories of industrial organisation and anti-trust policy), the speed of equalising convergence may vary, but a priori there are no grounds to envisage instantaneous adjustment (indeed, Canarella et al. (2013) hypothesise profit hysteresis, or the permanent deviation of profit rates from the mean).

Overall, while both classical and neoclassical theories of competition agree that profit rate disparities exist and bring in perturbations and adjustments in the economy (profit rate differential causing changes in industry output through capital flows or variation in the number of firms), the specific adjustment mechanisms and outcomes differ. In classical theories, the competitive process is ongoing and profit rate differentials persist, but offset each other in the long-run and at macroeconomic (rather than industry) level. In neoclassical theory, the profit rate differentials associated with imperfectly competitive states disappear in the long run, with industry profit rates converging to competitive profit rate levels, with outcomes seen in the individual industries. Thus, the verification of the two alternative hypotheses (*neoclassical equalising convergence* and *classical tendential equalisation*) is warranted.

An empirical analysis of industrial rates of profit falls into two broad categories: the studies of profit rates persistence based on firm-level data, and studies of profit rates convergence and equalisation based on the industry profit rates data available from national accounts.

In the former category, studies are conducted of sets of firms in the USA, Germany, and France (Geroski and Jacquemin, 1988), Canada (Khemani and Shapiro, 1990), the USA (Waring, 1996), the UK (Cubbin and Geroski, 1990), Germany (Schohl, 1990), and Japan (Odagiri and Yamawaki, 1986; Maruyama and Odagiri, 2002), among others. These studies use the autoregressive procedure $\pi_{it} = \alpha_i + \beta_i \pi_{it-1} + \varepsilon_{it}$ for the firms' normalised profit rate π_{it} and establish a high degree of profit persistence. Certain evidence of profit rate persistence is confirmed in the studies that employ univariate (UK firms by Goddard and Wilson, 1999; Indian firms by Kambhampati, 1995) or panel unit root tests (Turkish firms by Yurtogly, 2004; Danish firms by Bentzen et al., 2005; Brazilian firms by Resende, 2006), or more advanced econometric techniques (US firms by Gschwandtner, 2012 and Canarella et al., 2013; Ukrainian firms by Stephan and Tsapin, 2008).

Of particular interest are the studies of firms' profit rates in developing economies (Glen et al., 2001, 2003). Both studies include profit rates data for large manufacturing firms in Brazil, India, Jordan, Korea, Malaysia, Mexico, and Zimbabwe in the period of 1980–1995, using a combination of Augmented Dickey-Fuller (ADF) test (in univariate or panel settings) and the autoregressive model, and systematically reject the unit root hypothesis (implying a high degree of persistence) in all of the economies, indicating that profit persistence in developing economies is lower than in developed ones, while the speed of adjustment of excess profits is higher. These results are in contrast to the findings of Resende (2006), which consider the Brazilian context and point to high degree of persistence, due to a low degree of rivalry and firm turnover, as well as lax implementation of anti-trust policies and lack of independency of anti-trust authorities.

The second category of studies uses profit rates data pertaining to all firms in the economy and obtained from the national accounts. The studies in this category derive profit rates measures that are consistent with economic theories of competition, thus average and IROP, or the profitability of the total or recently invested capital. This contrasts with firm-level studies that derive profit rates from firms' balance sheets and income statements, along company accounting lines (return on equity and assets, and profit margin on sales).

The studies that use average rate of profit tend to establish high degrees of persistence of profits and low degrees of convergence; namely, the study of the Greek (Droucopoulos and Lianos, 1993; Lianos and Droucopoulos, 1993) and Turkish (Bahce and Eres, 2012) manufacturing industries that apply autoregressive procedures or linear trend models, and the study of industrial and regional profit differentials in Canadian manufacturing (Rigby, 1991) that apply the autoregressive model. The study of

13 manufacturing industries in France, Germany, Italy, the UK, and the USA use regression models with sector- and time-specific effects and correction for serial correlation by Glick and Ehrbar (1988) likewise point to the persistence of differentials and the lack of equalisation. The study of the US non-financial economy, based on average rate of profit and using descriptive statistics methods, by Duménil and Lévy (2002), confirms capital mobility across industries and gravitation around mean value. However, the findings do not apply to capital intensive industries. Finally, the study of US manufacturing industries by Zacharias (2001) identifies non-stationarity in most profit series (and hence no possibility of convergence), albeit without co-movement in individual profit rates.

The studies that derive incremental profit rates identify low degrees of persistence and high degrees of tendential equalisation in the Greek and Turkish industries (Tsoulfidis, Tsaliki, 2011; Bahce and Eres, 2012). The incremental profit rates adjusted for capacity utilisation and capital depreciation also gravitate in US manufacturing (Tescari, Vaona, 2014). On the other hand, the recent research by Vaona (2011) that employs a nonlinear trend model and applies SURE and an exactly median unbiased (EMU) estimator to deal with serial and cross-sector correlations does not identify either convergence or gravitation in average or IROP in a set of OECD economies. In New Zealand and Taiwan (Vaona, 2013), the evidence of convergence or gravitation is incomplete.

The apparent contradictions regarding the presence or absence of profit persistence, convergence, and equalisation are likely to be resolved when multiple testing procedures are considered, sequential analysis is performed, the national accounts data (all firms, rather than a limited set) are examined, the inter- rather than intra-industry competition is considered, and alternative profit rate measures are derived.

Studies of profitability in Korea are limited to the analysis of level and determinants of profit rates economy-wide, rather than at the industry level (Jeong, 2007; Hart-Landsberg et al, 2007; Grinberg, 2011). In contrast, an analysis of competition in the Korean economy considers several related issues. In terms of the value of concentration ratios, the Korean level is conventionally seen as very high (Chung, Yang, 1992; Lee, 2014), although Jwa (2002) points out that the ratios have been overestimated. The extent of the monopoly was measured by Choi (1988) and Yoon (2004), both reporting high welfare losses due to this. According to Yoon (2004), based on a study of 223 listed companies (all of which are chaebol affiliates) in 1990–1998, welfare losses amounted to 4.03–7.56% of the gross value of shipments. Choi (1988) reports losses equal to 3.94% of GNP.

Regarding the economic and institutional determinants of competition and the nature of the competitive process, analyses point to interrelated and frequently conflicting tendencies. Glen et al. (2001), Amsden (1989), and the World Bank (1993) identify a high degree of rivalry between Korean firms. This rivalry results in profit persistence lower than in developed economies and firm turnover rates higher than in developed economies (Glen et al., 2003: 476). The causes of the phenomenon were the less sophisticated demand and production processes, and hence low sunk costs; fast economic and market growth, accommodating a larger number of firms; the development of institutions providing assistance to firms, conditional on performance targets (Amsden, 1989; Joh, 2004), this being an indirect way of fostering competition; and the presence of conglomerate firms that bring in economies of scale and scope and facilitate entry by newcomers.

It is arguable whether Korean manufacturing continues to be characterised by low sunk costs and by the production of unsophisticated goods. It was likewise possible that the growth of existing firms (meeting growing market demand) occurs side-by-side with growth in the number of firms. The export competitiveness of Korean manufacturing has improved, but it is debatable whether capital investment decisions by conglomerates tend to lead to positive profit outcomes and inter-industry flows of capital to profit rate equalisation, and whether conglomerates (through their relationships with government and financing institutions) constitute a barrier to exploitation of economies of scale and scope by newcomers.

The institutional and policy context was, to a certain extent, antithetical to competition. According to Singh (2014: 9-10), competition policy has been subordinated to industrial policy, with its focus on assisting growth and technological change and achieving productivity gains, rather than allocative efficiency, low consumer prices, and low profits (which could compromise private investment and growth). Chang (1994) argues that provision of subsidies to chaebols was frequently coordinated to prevent excessive competition and overcapacity. The competitive forces of international markets are limited too for extended periods, as attested to by import and foreign exchange controls and other protectionist measures (Singh, 2014: 15). Singh (2014: 14) highlights a plethora of deliberate distortions created by the state, including controls over multinational investment and foreign ownership, government encouragement of a variety of cartel arrangements in the product markets, promotion of conglomerate enterprises through mergers, as well as outright administrative guidance of enterprises. Joh (2000) likewise mentions sluggish Schumpeterian creative destruction, particularly in the 1990s, resulting from lengthy bankruptcy procedures, legislative hurdles to implementing hostile takeovers, and mergers and acquisitions by foreign firms. The result was low turnover among the largest plants and businesses.

Methodology

General approach

Two measures of profit rate are considered. First, the average profit rate is defined as the ratio of net operating surplus ($NOPS$) to net capital stock ($CAPN$), $\pi_t = \frac{NOPS_t}{CAPN_t}$. Second, $IROP$ is defined as the ratio of the change in aggregate profits to the lagged investment (the change in current profits over the previous period investment), $IROP_t = \frac{\Delta P_t}{I_{t-1}}$.

This analysis of IROP is justified by Shaikh (2008, 2016), Tsoulfidis and Tsaliki (2005), and Botwinick (1993). The current total capital stock includes multiple vintages and results from a series of investments, many of which were made years ago. Since more recently invested capital is likely to be more productive and to deliver greater mass of profits, it is advantageous to examine the profitability of the recently installed capital (Shaikh, 2016: 65). This investment of new capital (regulating capital) is seen as a driving force of tendential equalisation (Shaikh, 2016: 67), setting the rhythm of capital accumulation (Tsoulfidis, Tsaliki, 2011: 27), and the recently installed capital represents the best generally reproducible conditions of production in any industry (Shaikh, 2016: 265). From an econometric perspective, we expect that the average rate of profit may contain unit root, as is calculated from variables in all levels, while IROP may have stationarity properties due to the numerator being expressed in the first differences.

Regarding the measurement of the profit rate differential, two alternative metrics are available. Mueller (1986) and Kambhampati (1995) define profit rate differential as the difference between profit rate in a particular industry and the average profit rate in the total economy, $\prod_{it} = \pi_i(t) - \overline{\pi_i}(t)$, where π_i and $\overline{\pi_i}$ are industry- and economy-wide rates of profit respectively in period t . We, following Duménil and Lévy (2002), conceptualise profit rate differential as relative profit rate, the ratio of the industry's profit rate, and the average rate of profit in the total economy, $\prod_{it} = \frac{\pi_i(t)}{\overline{\pi_i}(t)}$. The $\overline{\pi_i}$ is the weighted average profit rate, where weights are calculated as the ratio of industry's gross output to the gross output in the whole economy.

The paper considers two related hypotheses. First, we look at the possibility of neoclassical equalising convergence of the relative profit rates, calculated from average profit rates in individual industries. Second, we look at the possibility of classical tendential equalisation of the relative profit rates, calculated from average profit rates in individual industries, or of relative profit rates calculated from IROP in individual industries.

Specifically, we consider three possible outcomes:

1) Relative profit rate series exhibit unit roots (stochastic trends): This indicates the absence of equalising convergence or tendential equalisation, as series fluctuate randomly and no prediction may be made about their future levels.

2) The relative profit rate series are trend stationary: Equalising convergence may take place if the direction of the trend is towards the level when $\pi_i(t) = \overline{\pi_i}(t)$ and $\prod_{it} = 1$, or when individual profit rates revert to the economy-wide profit rate. When series are trend stationary but the direction of the trend is away from the level when $\pi_i(t) = \overline{\pi_i}(t)$, the divergence is present and individual profit rates move away from the economy-wide profit rate. Alternatively, when the trend is directed to some other level ($\prod_t < 1$ or $\prod_t > 1$), the industry likely has a certain degree of market power that prevents convergence with the economy-wide profit rate.

3) The relative profit rate series are stationary (in linear or nonlinear fashion) around zero or non-zero mean: This suggests a classical tendential equalisation, with relative profit rate series fluctuating persistently around (rather than converging to) economy average profit rate.

In line with Canarella et al. (2013: 77), we note that stationarity implies mean reversion. Specifically, stationarity is a prerequisite for mean reversion, while not every stationary process is mean reverting. Neoclassical economic theory tends to consider equalising convergence as mean reversion (in this paper, the trend is directed towards the economy-wide mean), while the classical paradigm considers tendential equalisation as mean stationarity. For the purpose of results interpretation, we consider mean stationarity as evidence of equalising convergence when average profit rates are used to calculate relative profit rates, and as evidence of tendential equailsation when IROP are used.

While several previous studies (Geroski and Jacquemin, 1988; Glen et al., 2001, 2003) use firm-level data to estimate profitability of the firms (specifically, profit margin on sales), the industry aggregation is warranted due to the following: 1) the prominent role of diversified conglomerates that stretch multiple industries and the flows of investment within the same firm operating in different lines of business (Clifton, 1977); and 2) the possibility of profit rate equalisation at the industry level when individual firms face varying production conditions, use heterogeneous technologies, and have varying business strategies (Salter, 1969; Duménil, Lévy, 1993: 154; Vaona, 2010).

The scope of this study is confined to the capitalist segment of the economy (the sample includes agriculture, forestry and fishing, mining, manufacturing, utilities, construction, transport and storage, accommodation, information and communication, and finance and insurance: a total of 19 industries). Thus, we exclude real estate activities, public administration and defence, education, health and social work, personal services, and arts and recreation. In these sectors, production is driven, to some extent, by not-for-profit motives, is undertaken for personal gain rather than exchange in the market, or takes place in the public realm.

Previous studies have excluded finance and insurance activities from profit rate calculation, due to the inherent difficulties in separating the real and financial aspects of profitability in financial firms (Duménil, Lévy, 2004), specifically as a result of the lack of data on financial debts and assets. On the other hand, the exclusion of finance and insurance, as well as other non-manufacturing industries, introduce bias in the study of convergence and equalisation of profit rates (Vaona, 2012: 8). Thus, in line with Vaona (2010, 2011, 2012), we provide estimates of profit rates by including the finance and insurance sector, completing a robustness check by excluding this sector.

The study covers 1970–2015, which includes a period of rapid growth in the 1970s, a more moderate growth in the 1980s, the Asian Financial Crisis of 1997, a recovery period, and a period of slower growth in the 2000s.

Model

Following Endres (2014) and Stolbov (2015), we adopt a sequential procedure that relies on using a number of unit root tests. This is necessary given the frequent contradictions between test results, and the possibility of non-linearities (particularly when profit rate differentials change sign or experience reversals). In addition, the models typically employed in the analysis of profit rate convergence and gravitation have certain shortcomings: the autoregressive procedure ($\prod_{it} = \alpha_i + \beta_i \prod_{t-1} + \varepsilon_{it}$) becomes inappropriate when large outliers or moving-average processes are present, while bias towards convergence is present when profit rate differentials are modelled as a hyperbolic function of time ($\prod_{it} = \alpha_i + \beta_i \frac{1}{t} + \varepsilon_{it}$). In this latter case, the coefficient of the inverted trend is influenced more strongly by the behaviour of profit rate differentials in the earlier years, while the constant is influenced more by the differentials in the later years (Kambhampati, 1995: 354; Odagiri, Yamawaki, 1986).

The testing procedure is as follows. The Brock-Dechert-Scheinkman (BDS) two-tailed test for nonlinearity in series is conducted (Brock et al, 1987; Chu, 2003). The BDS test is conducted on the first difference of the relative profit series and is based on the correlation integral,

$$C_{\varepsilon,m} = \frac{1}{N_m(N_m - 1)} \sum_{i \neq j} I_{i,j;\varepsilon}$$

where m is the embedding dimension to convert time series to the m-dimensional vectors with overlapping entries $x_1^m, ..., x_{N-m}^m$, i and j are the added pairs of points to calculate the integral, and $I_{i,j;\varepsilon} = 1$ if $\left\| x_i^m - x_j^m \right\| \leq \varepsilon$ and $I_{i,j;\varepsilon} = 0$ otherwise.

With series being independent and identically distributed random variables, $C_{\varepsilon,m} \approx \left[C_{\varepsilon,1} \right]^m$ and quantity $\left[C_{\varepsilon,m} - \left(C_{\varepsilon,1} \right)^m \right]$ being asymptotically normally distributed with zero mean and variance $V_{\varepsilon,m}$, the BDS test statistic is,

$$BDS_{\varepsilon,m} = \frac{\sqrt{N} \left[C_{\varepsilon,m} - \left(C_{\varepsilon,1} \right)^m \right]}{\sqrt{V_{\varepsilon,m}}}$$

The null hypothesis of independent and identically distributed residuals (linear dependence) is rejected when the BDS statistic is greater or smaller than the specified critical value.

If the BDS test concludes that series are linear, the conventional unit root tests are then performed, as shown below. If, in contrast, non-linearity is present, the two non-linear unit root tests are run: the Kapetanios-Shin-Snell (KSS) test and the Sollis test (Kapetanios et al, 2003; Sollis, 2009).

The KSS test considers the exponential smooth transition autoregressive (ESTAR) process:

$$\Delta \prod_t = \gamma \prod_{t-1} \left\{ 1 - \exp\left(-\theta \prod_{t-1}^2 \right) \right\} + \varepsilon_t$$

Given that γ is not identified under the null hypothesis of linear unit root ($\theta = 0$), a first-order Taylor series approximation to ESTAR yields an auxiliary non-linear autoregressive equation,

$$\Delta \prod_t = \delta \prod_{t-1}^3 + \varepsilon_t$$

with augmenting terms to correct serial correlation:

$$\Delta\prod_t = \delta\prod_{t-1}^3 + \sum_{i=1}^{n}\eta_i\Delta\prod_{t-1}$$

The significance of δ is examined based on the corresponding t-ratio. The null hypothesis is the non-stationarity of the series ($\delta = 0$), implying no mean reversion and convergence, while the alternative hypothesis is non-linear stationarity ($\delta < 0$). In line with Kapetanios et al. (2003: 364), we conduct test on raw, de-meaned, or de-trended series (in the latter two cases, when the series likely contain a non-zero mean or trend).

The Sollis test is based on the asymmetric ESTAR (AESTAR) model:

$$\Delta\prod_t = G(\gamma_1, \prod_{t-1})\{S_t(\gamma_2, \prod_{t-1})\rho_1 + (1 - S_t(\gamma_2, \prod_{t-1}))\rho_2\}\prod_{t-1} + \sum_{i=1}^{k}k_i\Delta\prod_{t-i} + \varepsilon_i$$

where $G(\gamma_1, \prod_{t-1}) = 1 - \exp(-\gamma_1\prod_{t-1}^2)$, $\gamma_1 \geq 0$, and $S_t(\gamma_2, \prod_{t-1}) = \{1 + \exp(-\gamma_2\prod_{t-1})\}^{-1}$, $\gamma_2 \geq 0$.

Following the Taylor approximation, the auxiliary equation is obtained:

$$\Delta\prod_t = \delta_1\prod_{t-1}^3 + \delta_2\prod_{t-1}^4 + \sum_{i=1}^{n}\eta_i\Delta\prod_{t-1}$$

Similar to KSS, the null hypothesis is non-stationarity ($\delta_1 = \delta_2 = 0$). The test is likewise conducted on the raw, de-meaned, and de-trended series.

If KSS and Sollis tests reject the null hypothesis, we conclude that series are globally stationary, but nonlinear. If the two tests reject the alternative hypothesis, it is determined that series are linear but seemingly non-stationary. In this case, the conventional unit root tests are run to confirm the presence of unit roots.

For these linear and non-stationary series, the possibility of the presence of structural breaks is considered using Bai-Perron test for structural breaks (Bai, Perron, 1998: 74). The global optimisation procedure for identifying the number of unknown breaks is employed.

The multiple regression model is estimated:

$$\prod_t = x_t^{'}\beta + z_t^i\delta_j + \mu_t$$

where j is the number of regimes, $t = T_{j-1} + 1, ..., T_j$, $T_0 = 0$, $T_{m+1} = T$ (breaks are unknown), and x and z variables are those whose parameters are regime-invariant and regime-specific respectively.

The sum of squared residuals for the model is minimised as:

$$(\hat{T}_1,\ldots,\hat{T}_m) = \arg\min_{(\lambda_1,\ldots,\lambda_m)\in\Lambda_\varepsilon} S_T(T_1,\ldots,T_m)$$

where minimisation takes over all partitions with $T_i - T_{i-1} \geq h = T_\in$.

The obtained estimates of $\hat{\beta}\left(\{T_j\}\right)$ and $\hat{\delta}\left(\{T_j\}\right)$ are used in the double maximum tests ($UD\max$ and $WD\max$), where the null hypothesis of no structural break is tested against the alternative hypothesis of unknown number of breaks, provided that the upper bound for break numbers is M . Two alternative bounds are set as $M = 2$ and $M = 5$, and the results of the test with the former bound are reported.

If the Bai-Perron test does not establish any breaks, it is concluded that series are non-stationary without breaks. If the Bai-Perron test for structural breaks confirms at least one break, the unit root tests with structural breaks are performed: initially, the Lumsdaine-Papell (LP) test with two structural breaks, and (if one of the trend breaks is not significant in LP test) the Zivot-Andrews (ZA) test with single break (Zivot, Andrews, 1992; Lumsdaine, Papell, 1997). For both ZA and LP tests, the most general specification with intercept and trend is tried first, and if either trend or intercept are not significant, the more restrictive version of the test (without either trend or intercept or both) is used. As a result of ZA and LP tests, it is determined that series are either stationary with a single or two breaks, or are non-stationary.

For those series deemed linear, the ADF test is first performed. In line with the recommendations of Endres (2014), the sequential procedure is adopted. The most general specification is tried:

$$\Delta\prod_{it} = \alpha_i + \beta_i \prod_{it-1} + \gamma_i t + \lambda_i \sum_{i=1}^{n} \Delta\prod_{it-n}$$

where β_i is the coefficient if the error-correction term, γ_i is the trend coefficient, and Δ is the difference operator. If the null hypothesis of unit root is rejected, the series are considered trend-stationary. Alternatively, if the null hypothesis is not rejected, the series are seen as containing unit root. In this case, the auxiliary regression

$$\Delta\prod_{it} = \alpha_i + \gamma_i t + \lambda_i \sum_{i=1}^{n} \Delta\prod_{it-n}$$

is run to determine whether trend is statistically significant ($\gamma \neq 0$). If $\gamma = 0$, the specification with constant but no trend is performed:

$$\Delta\prod_{it} = \alpha_i + \beta_i \prod_{it-1} + \lambda_i \sum_{i=1}^{n} \Delta\prod_{it-n}$$

The acceptance of the null hypothesis would indicate stationarity around the constant; the acceptance of the null hypothesis would imply unit roots. To confirm the significance of the constant, the regression

$$\Delta\prod_{it} = \alpha_i + \lambda_i \sum_{i=1}^{n} \Delta\prod_{it-n}$$

is run. If $\alpha = 0$, the ADF specification with no trend and constant is tried (as with other specifications, the null hypothesis is stationarity around zero mean and the alternative is unit root):

$$\Delta\prod_{it} = \beta_i \prod_{it-1} + \lambda_i \sum_{i=1}^{n} \Delta\prod_{it-n}$$

In addition to the ADF statistic, the paper also considers the persistence coefficient defined as $\varphi = \beta + 1$, where if $\beta \to -1$ and φ is low, the low degree of persistence, high degree of convergence and mean reversion are indicated (high degree of persistence if $\beta \to 0$).

The Bai-Perron test for structural breaks, as well as the LP and ZA tests, are performed to distinguish between stationarity with breaks and non-stationarity. Given the size and power problems of the ADF test, the Kwiatkowski–Phillips–Schmidt–Shin (KPSS), Phillips-Perron (PP), and Elliott, Rothenberg and Stock DF-GLS unit root tests are executed (Phillips, Perron, 1988; Kwiatkowski et al., 1992; Elliott et al., 1996).

In the LP and ZA tests, the breaks are determined endogenously, the null hypothesis of unit root with drift and no breaks is tested against the alternative hypothesis of trend stationarity with single or two breaks. The null hypothesis is rejected when the t-statistic of the lagged term coefficient exceeds the tests' critical values. The general specification LP test model (which is the extension of ZA test) is,

$$\Delta\prod_t = \mu + \beta_t + \theta DU1_t + \gamma DT1_t + \omega DU2_t + \psi DT2_t + \alpha \prod_{t-1} + \sum_{t=1}^{k} c_t \Delta\prod_{t-1} + \varepsilon_t$$

where $DU1_t$ and $DU2_t$ represent breaks in in the intercept, and $DT1_t$ and $DT2_t$ represent breaks in the trend, the lag length k is selected using general-to-specific procedure. $DU1_t = 1$ if $t > TB1$ and zero otherwise, $DU2_t = 1$ if $t > TB2$ and zero otherwise, $DT1_t = t - TB1$ if $t > TB1$ and zero otherwise, $DT2_t = t - TB2$ if $t > TB2$ and zero otherwise.

The standard panel unit root tests are performed to complement univariate unit root tests (Barbieri, 2006). Specifically, two panels are considered: the encompassing panel containing relative profit series for all industries, and a smaller panel that includes series that were stationary according to all univariate tests. The panel tests included the Levin-Lin-Chu t-test and the Breitung t-test (that assume common unit root process and unit root as a null), and Im-Pesaran-Sin W-statistic, ADF-Fisher χ^2 and PP-Fisher χ^2 (individual unit root processes and unit root as a null). The Hadri Z-statistic was also estimated (stationarity as a null hypothesis).

Finally, a dynamic of the dispersion coefficient for the relative profit series is considered and the relevant linear and nonlinear unit root tests and the linear trend model are estimated. The coefficient is defined as,

$$\sigma_t = \frac{1}{n}\left(\sum_{i=1}^{n}\left(\frac{\Pi_i^t - \overline{\Pi^t}}{\overline{\Pi^t}}\right)^2\right)^{1/2}$$

$$\overline{\Pi^t} = \frac{1}{n}\sum_{i=1}^{n}\Pi_i^t$$

where $\overline{\Pi^t}$ is the weighted average of the relative profit series.

Data sources

The relevant series for the estimation of the average rate of profit were obtained from the OECD STAN Industrial Analysis database: the net capital stock at current replacement costs (CAPN code), compensation of employees (LABR code), net operating surplus and mixed income (NOPS code), and gross output in current prices (PROD code). To calculate the incremental rate of profit, the data from the WORLD KLEMS database (2014 release) was used: gross value added at current basic prices (VA code), labour compensation (LAB code), and nominal investment (VI code). The former two series were obtained from the relevant output and labour file, while the latter series were sourced from the capital file. All variables were measured in Korean won and in current prices (given that relative prices of output and capital affect profit rates and that inflation has positive effects on profit and accumulation process, deflation and measurement in constant prices would render estimates non-informative). The OECD STAN data covers the period of 1970–2015, while the EU KLEMS data covers the period of 1970–2012.

Empirical results

The profit rate series for individual industries are plotted in Figure 1. It is apparent that profit rates in all industries (with the exception of coke and refined petroleum production and fabricated metal production) have been declining. The largest declines from the highest profitability levels in the 1970s were experienced in agriculture, forestry and fishing, and construction. This reflects the structural transformation of Korea’s agriculture-based economy to an industrial economy, and the infrastructure build-up in the 1970s. The lowest rates of profit in 1970–2015 were observed in transportation and storage, electricity, gas and water supply, and information and communication, reflecting the high degree of capital intensity in these industries (in the case of electricity, gas, and water supply, the rates were negative in some of the years). Overall, the tendential decline of profit rates (particularly quickly in the 1970s) is in line with previous studies by Grinberg (2011), Jeong (2007), and Hart-Landsberg et al. (2007). The decline in capital productivity (driven by capital intensity growth in excess of labour productivity growth) was seen to be a dominant factor in profit rate decline.

It also appears that convergence towards a lower profit rate is seen across the economy, with the distance between profit rates shrinking. This view is misleading, however, when relative profit rates are examined (Figure 2). In each industry, the relative profit appears to fluctuate around a stable mean (the spike in the relative profitability of the coke and refined petroleum products is prominent in the mid-1980s, presumably due to the fall of oil prices in that period, but this does not dramatically change the broad pattern).

The dynamics of the dispersion coefficient confirm the visual observation. The value of the coefficient fluctuated in a narrow range, between 0.14 and 0.17. The lowest values are observed in 1970–8 and 1997–05 (0.14 and 0.15 respectively), indicating tighter gravitation of profit rates. According to Duménil and Lévy (2002: 432), tighter gravitation of profit rates is likely observed during the periods of accelerated investment and steady technological improvements (in the Korean economy during the 1970s). On the other hand, the higher profit rate dispersion corresponding with the recovery from the Asian crisis of 1997 (and manifest in the greater heterogeneity of firms) is not observed in Korea, with the values of the dispersion coefficient in 1997 and 1998–2000 not dramatically different to the average values. Overall, the visual representation of the dispersion coefficient over the years (Figure 3) suggests the absence of any significant trends, and thereby the absence of convergence of profit rates.

Figure 1 – Average rates of profit

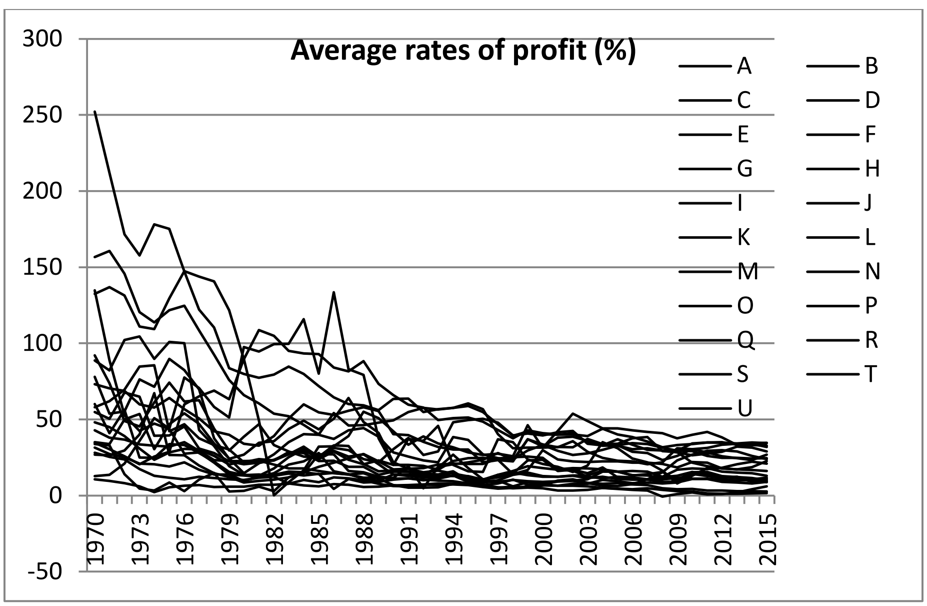


Figure 2 – Relative average rates of profit

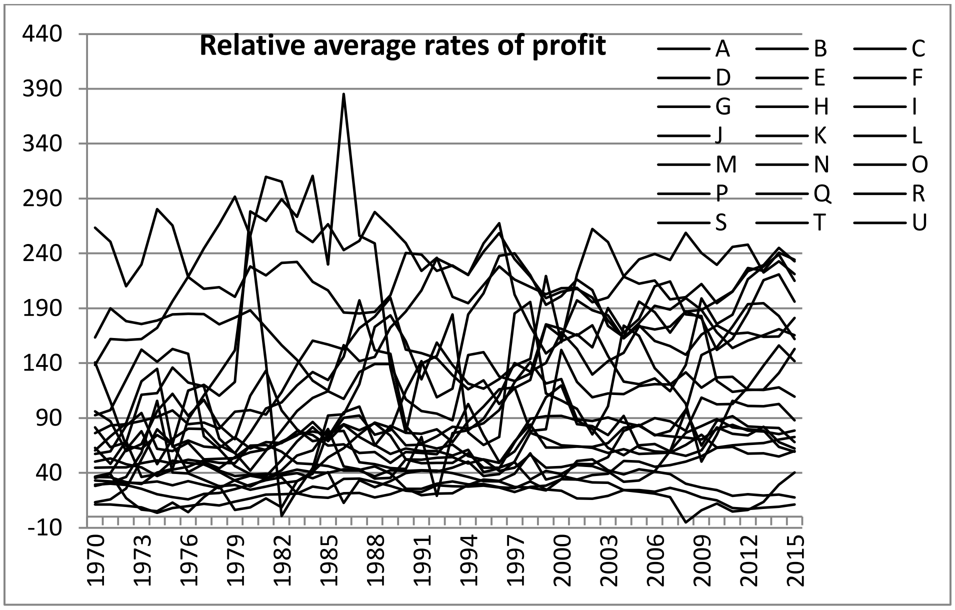
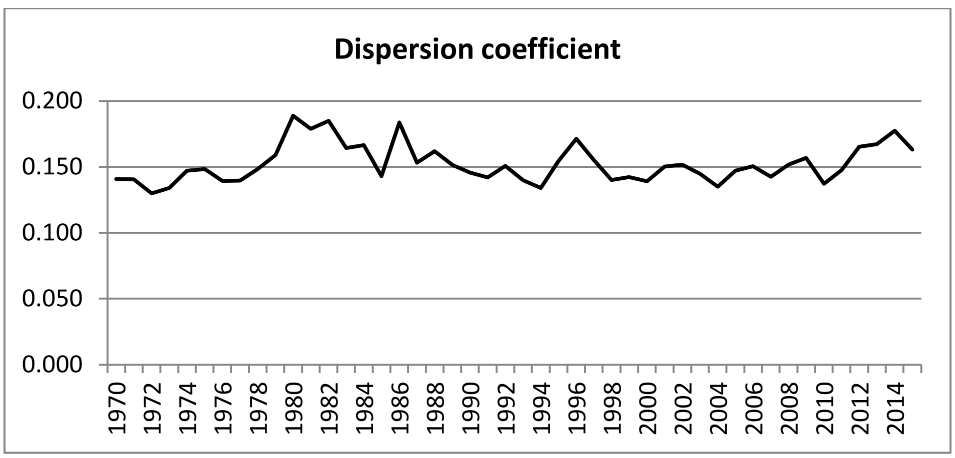


Figure 3 – Dispersion coefficient (for relative average rates of profit)



The BDS test was performed (Table 1). The test results indicate that non-linearities are likely to be present in the relative average profit rate series in the following industries: agriculture, forestry and fishing; mining and quarrying; food products, beverages and tobacco; wood and paper products and printing; basic metals; transport equipment; accommodation and food service activities; and financial and insurance activities. In all other industries, the relative profit rates likely experience linear dynamics.

Table 1 –BDS test results (relative average rates of profit)

Industry		k=2		k=3		k=4		k=5		k=6	
		z-stat	p(z-stat)	z-stat	p(z-stat)	z-stat	p(z-stat)	z-stat	p(z-stat)	z-stat	p(z-stat)
Agriculture, forestry and fishing	A	0.836	0.403	1.665	0.096	2.401	0.016	2.137	0.033	2.551	0.011
Mining and quarrying	B	-2.068	0.039	1.860	0.063	1.897	0.058	1.934	0.053	2.085	0.037
Food products, beverages and tobacco	C	3.645	0.000	3.897	0.000	3.830	0.000	3.431	0.001	2.903	0.004
Textiles, wearing apparel, leather	D	-0.759	0.448	0.101	0.920	0.561	0.575	0.342	0.732	-0.003	0.998
Wood and paper products, and printing	E	-1.889	0.059	-2.082	0.037	-2.286	0.022	-2.495	0.013	-1.900	0.057
Coke and refined petroleum products	F	0.213	0.831	0.489	0.625	0.607	0.544	0.445	0.656	0.471	0.637
Other non-metallic mineral products	G	2.201	0.028	1.682	0.093	1.026	0.305	0.273	0.785	0.173	0.863
Pharmaceutical products	H	0.794	0.427	0.773	0.440	0.617	0.537	-0.048	0.961	0.199	0.843
Rubber and plastics products	I	-0.401	0.689	-0.441	0.660	0.164	0.870	0.157	0.875	-0.211	0.833
Basic metals	J	2.387	0.017	2.065	0.039	2.005	0.045	1.884	0.060	2.157	0.031
Fabricated metal products	K	0.727	0.467	1.274	0.203	1.190	0.234	1.032	0.302	1.074	0.283
Electrical, electronic and optical equipment	L	0.149	0.881	0.516	0.606	1.461	0.144	2.133	0.033	2.628	0.009
Machinery and equipment n.e.c.	M	0.078	0.938	1.368	0.171	1.699	0.089	1.879	0.060	2.100	0.036
Transport equipment	N	3.021	0.003	2.199	0.028	2.054	0.040	2.231	0.026	2.101	0.036
Furniture; other manufacturing	O	0.407	0.684	0.895	0.371	0.960	0.337	0.706	0.480	0.452	0.651
Electricity, gas and water supply	P	1.211	0.226	-0.391	0.696	-0.647	0.518	0.507	0.612	0.167	0.868
Construction	Q	-1.103	0.270	0.478	0.633	0.130	0.896	0.205	0.838	0.162	0.872
Transportation and storage	R	-0.411	0.681	0.151	0.880	0.312	0.755	0.263	0.793	-0.429	0.668
Accommodation and food service activities	S	1.829	0.068	2.042	0.041	2.686	0.007	2.844	0.005	2.615	0.009
Information and communication	T	0.127	0.899	0.527	0.599	1.228	0.220	1.382	0.167	1.226	0.220
Financial and insurance activities	U	3.558	0.000	2.947	0.003	2.397	0.017	2.026	0.043	1.589	0.112

Note. k represents maximum correlation dimension. The distance $\mathcal{E}$ is specified as a fraction of pairs.

For those industries where non-linearities are identified, KSS and Sollis non-linear unit root tests were conducted. As shown in Table 2, average profit rates in basic metals and in transport equipment were non-linear stationary under all three specifications of KSS and Sollis tests. Other industries demonstrate ambiguous patterns, with both non-linear stationarity and unit roots being likely. In this case, the series (together with series that were linear according to the BDS test) were tested using linear unit root tests. We note that the Sollis test tends to identify a larger number of cases of stationarity in relative profit rates than the KSS test, and the greater number of stationarity cases are observed with de-meaned and de-trended data.

Table 2 – KSS and Sollis nonlinear unit root tests' results (relative average rates of profit)

Industry		KSS						Sollis					
		(1)		(2)		(3)		(1)		(2)		(3)	
		T-stat		T-stat		T-stat		F-stat		F-stat		F-stat	
Agriculture, forestry and fishing	A	-0.516	0	-2.873	0	-2.836	0	4.266	0	4.048	0	4.046	0
Mining and quarrying	B	-0.160	3	-0.357	2	-0.608	2	0.618	2	1.251	2	0.670	2
Food products, beverages and tobacco	C	-0.335	1	-2.840	0	-4.893	0	0.652	1	4.201	0	13.561	0
Wood and paper products, and printing	E	-0.078	0	-1.098	0	-2.367	0	0.507	0	1.091	0	3.335	0
Other non-metallic mineral products	G	-0.602	0	-2.918	0	-2.615	0	5.416	0	4.935	0	4.020	0
Basic metals	J	-2.492	0	-4.875	3	-5.484	0	24.075	3	18.286	3	14.881	0
Machinery and equipment n.e.c.	M	-1.580	0	-2.143	0	-2.363	0	4.709	0	3.778	0	2.736	0
Transport equipment	N	-4.501	0	-3.824	0	-3.802	0	9.907	0	14.832	0	13.673	0
Accommodation and food service activities	S	-0.685	0	-2.287	0	-2.294	0	0.920	0	4.554	1	5.494	3
Financial and insurance activities	U	-1.117	0	-1.835	0	-3.383	0	2.537	0	2.297	0	5.593	0

Note. Specifications (1), (2) and (3) represent tests run on the raw, de-meaned, and de-trended series respectively. Each specification includes a number of augmenting lags.

According to the ADF test (Table 3), at a 5% significance level, the relative average profit rates are trend stationary in food products, beverages, and tobacco, and in electrical, electronic, and optical equipment. At a 10% significance level, the relative average profit rates are trend stationary in textiles, wearing apparel, leather and related products; fabricated metal products; and financial and insurance activities. In agriculture, forestry and fishing, average profit rates are stationary around constant at a 10% significance level. In all other industries, unit roots are observed.

The visual observation suggests that relative profit rate in wood and paper products, pharmaceutical products, construction, and information and communication industry likely see linear trends. The ADF test was thus also run with linear trend as a deterministic component, albeit without changing conclusions: all four series appeared to contain the unit root. While a sequential selection of deterministic terms point to zero constant in several cases (coke and refined petroleum products, other non-metallic mineral products, rubber and plastics, furniture and other manufacturing, and electricity, gas and water supply), we report results of a unit root test with a non-zero constant, in line with visual observation.

Table 3 – Linear unit root tests' results (relative average rates of profit)

Industry		ADF				PP			ERS GLS			KPSS		
		DF_τ			φ	Adj t-stat			t-stat			LM-stat		
Agriculture, forestry and fishing	A	-2.635	C	0	0.805	-2.644	C	3	-1.338	C	0	0.134	C	5
Mining and quarrying	B	-1.186	C	2	0.926	-1.311	C	8	-0.836	C	2	0.676	C	5
Food products, beverages and tobacco	C	-3.701	CT	0	0.573	-3.599	CT	1	-2.976	CT	0	0.186	CT	4
Textiles, wearing apparel, leather	D	-3.378	CT	3	0.700	-1.813	CT	3	-2.313	CT	1	0.152	CT	5
Wood and paper products, and printing	E	-1.290	C	0	0.920	-1.266	C	2	-0.512	C	0	0.806	C	5
Coke and refined petroleum products	F	-2.592	C	0	0.753	-2.508	C	4	-2.005	C	0	0.159	C	5
Other non-metallic mineral products	G	-2.217	C	0	0.812	-2.217	C	0	-1.580	C	0	0.457	C	5
Pharmaceutical products	H	-1.579	C	0	0.864	-1.579	C	0	-1.510	C	0	0.556	C	5
Rubber and plastics products	I	-1.765	C	0	0.886	-1.739	C	1	-0.969	C	0	0.597	C	5
Fabricated metal products	K	-3.411	CT	0	0.649	-3.316	CT	1	-2.567	CT	0	0.189	CT	4
Electrical, electronic and optical equipment	L	-3.681	CT	0	0.518	-3.584	CT	5	-3.649	CT	0	0.096	CT	1
Machinery and equipment n.e.c.	M	-2.305	C	0	0.779	-2.421	C	3	-2.319	C	0	0.263	C	5
Furniture; other manufacturing	O	-2.555	C	0	0.728	-2.724	C	1	-2.379	C	0	0.075	C	3
Electricity, gas and water supply	P	-1.635	C	0	0.854	-1.816	C	2	-1.428	C	0	0.199	C	5
Construction	Q	-2.147	C	0	0.820	-2.264	C	2	-1.525	C	0	0.663	C	5
Transportation and storage	R	-1.835	C	0	0.838	-1.835	C	0	-1.578	C	0	0.385	C	4
Accommodation and food service activities	S	-1.766	C	0	0.866	-1.957	C	2	-1.685	C	0	0.133	C	5
Information and communication	T	-1.161	C	0	0.915	-1.291	C	4	-0.952	C	0	0.611	C	5
Financial and insurance activities	U	-3.290	CT	0	0.581	-3.356	CT	3	-3.378	CT	0	0.048	CT	2

Note. C and CT indicate alternative deterministic terms – constant, and constant plus trend. φ represents persistence coefficient. ADF and ERS GLS tests include augmenting lags, while PP and KPSS tests include a bandwidth.

Table 4 – Zivot-Andrews (ZA), Lumsdaine-Papell (LP) and Bai-Perron (BP) tests' results (relative average rates of profit)

Industry		Zivot-Andrews test				Lumsdaine-Papell test					Bai-Perron test				
		T-stat	Break			T-stat	Break 1	Break 2			UDMax		WDMax		Break (UDMax)
Agriculture, forestry and fishing	A					-7.231	1980	2000	CT	3	28.527	2	33.901	2	1976, 1991
Mining and quarrying	B	-4.263	1993	C	2						108.605	2	129.062	2	1994, 2003
Food products, beverages and tobacco	C					-8.079	1985	1997	CT	0	50.448	1	50.448	1	1998
Textiles, wearing apparel, leather	D	-6.209	2008	C	3						247.478	1	247.478	1	2009
Wood and paper products, and printing	E	-4.773	2003	CT	1						94.519	2	112.323	2	1983, 2009
Coke and refined petroleum products	F					-7.099	1985	1991	CT	0	104.422	2	124.092	2	1980, 1989
Other non-metallic mineral products	G	-5.170	1990	CT	0						126.602	2	150.449	2	1980, 2004
Pharmaceutical products	H					-5.853	1989	1999	CT	0	68.090	2	80.916	2	1997, 2009
Rubber and plastics products	I					-6.133	1986	1998	CT	4	117.844	2	140.041	2	1983, 2009
Fabricated metal products	K					-5.831	1991	2001	CT	0	77.755	2	92.402	2	1996, 2008
Machinery and equipment n.e.c.	M					-6.920	1982	1999	CT	3	23.889	2	28.388	2	1977, 1995
Furniture; other manufacturing	O					-5.420	1985	1995	CT	2	10.597	2	12.593	2	1984, 1990
Electricity, gas and water supply	P					-3.217	2003	2009	T	0	63.661	2	75.653	2	1981, 2007
Construction	Q	-4.504	1990	C	1						115.499	2	137.255	2	1998, 2010
Transportation and storage	R	-3.928	2008	C	1						101.459	1	101.459	1	2010
Accommodation and food service activities	S					-5.423	1986	1993	CT	1	15.354	2	18.246	2	1991, 2003
Information and communication	T					-6.128	1982	2000	CT	4	59.656	2	70.894	2	1986, 2009
Financial and insurance activities	U					-4.742	1981	2008	C	1	623.899	2	741.420	2	1976, 1999

Note. C and CT indicate alternative deterministic terms – constant, and constant plus trend. ZA and LP tests include augmenting lags. UDMax and WDMax indicate the number of selected breaks.

This does not alter the findings: with both types of deterministic terms, the series follows unit root. Given that stationarity is detected in only six out of 19 cases, the value of persistence coefficient is high on average: above 0.90 in three industries, between 0.70 and 0.89 in another 12 industries, and between 0.50 and 0.69 in another four industries. No value of persistence coefficient below 0.50 is observed.

We thereby conclude, based on the ADF test, that in the majority of cases (13 of 19), mean reversion of the relative profit rate is unlikely, while high persistence of relative profit rates (and hence profit rate differentials) is common.

According to the PP, ERS GLS, and KPSS tests (Table 3), the unit roots are also widespread: at 5% significance, both ADF and PP tests indicate unit roots in 17 series out of 19, ERS GLS test in 14 series, and KPSS test in nine series. Electrical, electronic, and optical equipment are the only industries where relative profit is stationary, according to all tests.

The Bai-Perron test, as well as ZA and LP tests (Table 4), were conducted for all series that were considered likely to contain the unit root (in effect, all series except electrical, electronic, and optical equipment that were stationary according to four unit root tests, and basic metals and transport equipment that were non-linear stationary as per KSS and Sollis tests). According to the Bai-Perron test, breaks were identified in all cases (making the use of LP and ZA tests justified), with break times being rather uniformly distributed across the study period. The LP test identifies trend stationarity, with two breaks in agriculture, forestry, and fishing; food products, beverages and tobacco; coke and refined petroleum products; and machinery and equipment not elsewhere specified. The ZA test identifies trend stationarity with one break in other non-metallic mineral products, and stationarity around constant with one break in textiles, wearing apparel, and leather.

Overall, based on all of the tests conducted, unit roots in relative profit rates were present in 14 industries, non-linear stationarity in two industries (basic metals, and transport equipment), linear stationarity with up to two breaks in three industries (food products, beverages, and tobacco; coke and refined petroleum products; machinery and equipment not elsewhere specified), and linear stationarity with one break in one industry (other non-metallic mineral products).

The results of the panel unit root tests (Table 5) confirm the findings. When a full sample – consisting of all series – is considered, unit roots are identified by the LLC and Hadri tests (specification with intercept, and with intercept plus trend). When smaller samples – consisting of the series deemed stationary under univariate tests – are considered, unit roots are identified by the Breitung tests (specification with intercept plus trend) and by the Hadri test (both specifications).

Table 5 – Panel unit root tests' results (relative average rates of profit)

Test	Statistic	Prob.	Cross-sections	Obs.	Statistic	Prob.	Cross-sections	Obs.
	Constant				Constant + trend			
Full sample								
Levin, Lin & Chu t*	-0.700	0.242	21	941	-1.253	0.105	21	939
Breitung t-stat					-3.960	0.000	21	918
Im, Pesaran and Shin W-stat	-2.792	0.003	21	941	-3.891	0.000	21	939
ADF - Fisher Chi-square	73.147	0.002	21	941	79.959	0.000	21	939
PP - Fisher Chi-square	74.914	0.001	21	945	80.094	0.000	21	945
Hadri Z-stat	18.003	0.000			7.743	0.000		
Heteroscedastic Consistent Z-stat	12.304	0.000			6.447	0.000		
Small sample								
Levin, Lin & Chu t*	-3.199	0.001	4	180	-3.337	0.000	4	180
Breitung t-stat					-1.188	0.117	4	176
Im, Pesaran and Shin W-stat	-4.260	0.000	4	180	-4.262	0.000	4	180
ADF - Fisher Chi-square	34.621	0.000	4	180	31.556	0.000	4	180
PP - Fisher Chi-square	32.493	0.000	4	180	30.446	0.000	4	180
Hadri Z-stat	3.223	0.001			3.077	0.001		
Heteroscedastic Consistent Z-stat	3.212	0.001			3.132	0.001		

In contrast to the relative profit rates calculated using all available capital (in effect, average profit rate), the IROP demonstrates turbulent equalisation: the IROPs of individual industries fluctuate around mean values (non-zero in the majority of cases). As shown in Figure 4, both positive and negative deviations from the weighted-average economy-wide IROP are observed, with the magnitude of deviations increasing in the post-Asian Crisis period (after 1997). The dispersion coefficient is below 0.5 for most of the period, except a number of years between the 1990s and the 2000s (Figure 5).

Figure 4 – Relative rates of profit (IROP)

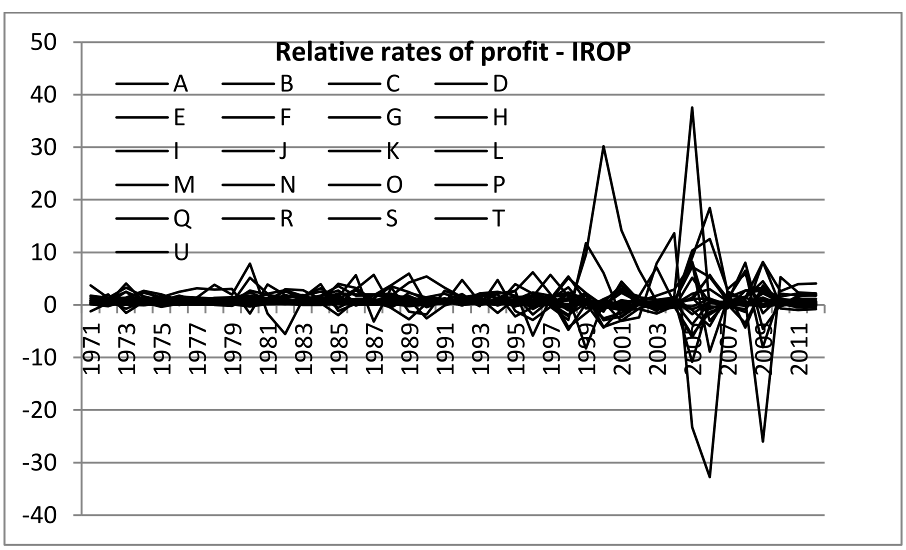
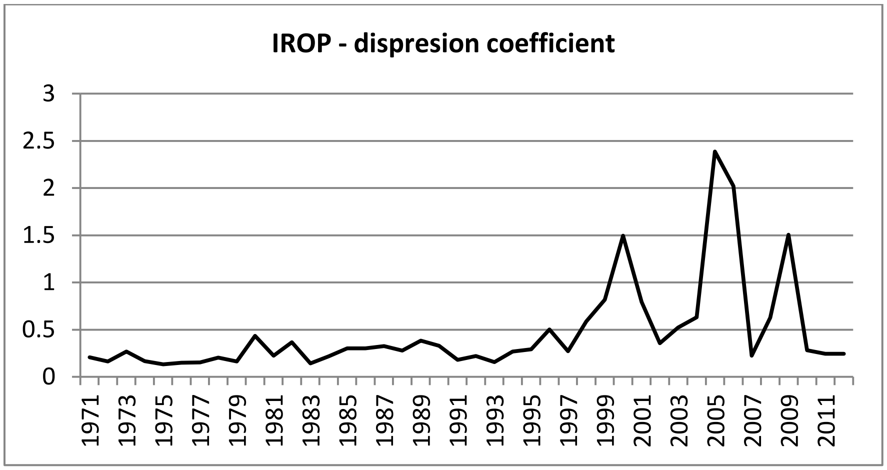


Figure 5 – Dispersion coefficient (IROP)



The BDS test identifies linearities in six IROP relative profit series: agriculture, forestry and fishing; mining and quarrying; food products, beverages, and tobacco; textiles, wearing apparel and leather; machinery and equipment not elsewhere specified; and furniture and other manufacturing (Table 6). KSS and Sollis tests implemented on raw IROP relative profit series indicate nonlinear stationarity in all cases except wood and paper products and printing; rubber and plastics products; electrical, electronic and optical equipment; transportation and storage; and information and communication (Table 7). According to conventional unit root tests (ADF, PP, ERS GLS, and KPSS), the IROP relative profit series (for cases where linearity is identified by BDS or non-stationarity is identified by KSS and Sollis tests) is stationary under all three alternative specifications. Table 7 presents the results of these tests under specification with non-zero constant.

As a final step, we consider the dynamics of dispersion coefficient for both average and IROP (Table 8). For the average rate of profit, given certain variations of the coefficient during the period of rapid economic development in the 1970s, two periods are examined: the full period covering 1970–2015, and the shorter period of 1980–2015. In 1970–2015, the coefficient did not see any significant linear trend, while in 1980–2015, the trend was significant, but positive (in effect, dispersion was not attenuating, implying no convergence in relative profit rates). The nonlinear unit root tests were conflicting: while KSS points to the absence of stationarity, Sollis tests indicate non-linear stationarity. The conventional unit root tests indicate a mix of unit roots (with a high degree of persistence) and stationarity patterns. We thereby conclude that, for the dispersion coefficient, the evidence of mean reversion or convergence is limited.

Regarding the dispersion coefficient for IROP, it remained relatively stable until 1997, and fluctuated substantially in 1997–2012, albeit returning to the mean value. Given significant outliers in the latter period and potential estimation problems (heteroscedasticity of residuals), we considered the value of dispersion coefficient prior to 1997. KSS and Sollis tests indicate non-linear t. ADF, PP, ERS GLS, and KPSS tests (implemented with constant) confirm the finding. The trend coefficient is insignificant, implying that no significant movements upwards or downwards are observed in IROP relative rates (in line with tendential equalisation hypothesis).

Table 6 – BDS test results (IROP)

Industry		k=2		k=3		k=4		k=5		k=6	
		z-stat	p(z-stat)	z-stat	p(z-stat)	z-stat	p(z-stat)	z-stat	p(z-stat)	z-stat	p(z-stat)
Agriculture, forestry and fishing	A	-0.176	0.860	-0.248	0.804	-0.310	0.757	-0.368	0.713	-0.425	0.671
Mining and quarrying	B	0.000	1.000	0.455	0.649	1.004	0.315	0.679	0.497	-0.003	0.998
Food products, beverages and tobacco	C	-0.276	0.783	-0.177	0.860	-0.575	0.565	-1.246	0.213	-0.716	0.474
Textiles, wearing apparel, leather	D	0.699	0.484	0.977	0.329	1.444	0.149	0.854	0.393	0.007	0.994
Wood and paper products, and printing	E	1.404	0.160	1.937	0.053	1.821	0.069	1.822	0.068	1.594	0.111
Coke and refined petroleum products	F	1.874	0.061	1.565	0.118	2.127	0.033	0.427	0.669	1.200	0.230
Other non-metallic mineral products	G	2.138	0.033	1.350	0.177	1.894	0.058	0.580	0.562	1.282	0.200
Pharmaceutical products	H	1.683	0.092	1.679	0.093	2.012	0.044	1.784	0.075	2.126	0.034
Rubber and plastics products	I	0.686	0.493	1.130	0.258	2.090	0.037	1.328	0.184	1.819	0.069
Basic metals	J	-0.292	0.771	-0.394	0.693	0.411	0.681	-1.703	0.089	-0.936	0.349
Fabricated metal products	K	2.905	0.004	2.518	0.012	2.042	0.041	2.122	0.034	1.973	0.049
Electrical, electronic and optical equipment	L	0.713	0.476	1.974	0.048	2.530	0.011	3.129	0.002	3.309	0.001
Machinery and equipment n.e.c.	M	-0.108	0.914	0.958	0.338	0.943	0.346	0.642	0.521	0.212	0.832
Transport equipment	N	2.207	0.027	3.088	0.002	3.232	0.001	2.538	0.011	1.706	0.088
Furniture; other manufacturing	O	0.108	0.914	-0.710	0.478	-0.318	0.751	-0.867	0.386	-0.498	0.619
Electricity, gas and water supply	P	2.223	0.026	2.524	0.012	2.638	0.008	1.599	0.110	0.445	0.657
Construction	Q	0.263	0.792	1.653	0.098	1.880	0.060	1.828	0.068	1.224	0.221
Transportation and storage	R	1.793	0.073	1.255	0.210	1.835	0.067	0.877	0.380	1.360	0.174
Accommodation and food service activities	S	0.893	0.372	1.494	0.135	1.837	0.066	1.159	0.247	1.381	0.167
Information and communication	T	1.482	0.139	2.732	0.006	3.569	0.000	4.202	0.000	5.023	0.000
Financial and insurance activities	U	3.072	0.002	3.121	0.002	2.936	0.003	2.675	0.008	2.528	0.012

Note. k represents maximum correlation dimension. The distance $\mathcal{E}$ is specified as a fraction of pairs.

Table 7 – Linear and non-linear unit root tests' results (IROP)

Industry		KSS		Sollis		ADF				PP		ERS GLS		KPSS	
		T-stat		F-stat		DF_{τ}			φ	Adj t-stat		t-stat		LM-stat	
Agriculture, forestry and fishing	A					-6.032	0	C	0.035	-6.206	4	-6.015	0	0.531	4
Mining and quarrying	B					-5.483	8	C	-4.756	-6.665	2	-6.739	0	0.187	2
Food products, beverages and tobacco	C					-6.432	0	C	-0.030	-6.432	3	-6.452	0	0.075	3
Textiles, wearing apparel, leather	D					-4.584	0	N	0.312	-4.547	1	-4.616	0	0.126	2
Wood and paper products, and printing	E	0.513	4	20.286	0	-6.219	3	C	-1.237	-9.493	26	-6.246	3	0.281	26
Coke and refined petroleum products	F	-4.803	0	14.029	0										
Other non-metallic mineral products	G	-3.560	0	12.770	0										
Pharmaceutical products	H	-6.386	0	27.082	0										
Rubber and plastics products	I	-1.799	2	1.612	2	-7.487	0	C	-0.187	-7.487	0	-7.583	0	0.143	3
Basic metals	J	-4.738	2	34.548	2										
Fabricated metal products	K	-2.250	0	3.696	0										
Electrical, electronic and optical equipment	L	-1.250	3	0.781	3	-6.996	1	C	-0.235	-5.118	21	-7.087	1	0.500	41
Machinery and equipment n.e.c.	M					-4.875	0	N	0.254	-4.990	3	-5.237	0	0.064	3
Transport equipment	N	-4.057	0	10.355	0										
Furniture; other manufacturing	O					-5.588	0	C	0.120	-5.584	1	-5.041	0	0.226	2
Electricity, gas and water supply	P	-2.567	4	24.017	1										
Construction	Q	-2.721	1	3.933	2										
Transportation and storage	R	-0.109	4	13.673	0	-5.935	0	C	0.040	-5.993	3	-5.997	0	0.112	3
Accommodation and food service activities	S	-3.880	0	7.397	0										
Information and communication	T	-0.068	0	27.964	0	-6.141	1	C	-0.485	-7.064	4	-6.455	0	0.180	5
Financial and insurance activities	U	-3.123	0	5.423	0										

Note. C and N indicate alternative deterministic terms – non-zero constant, and zero constant. φ represents persistence coefficient. KSS, Sollis, ADF and ERS GLS tests include augmenting lags, while PP and KPSS tests include a bandwidth. KSS and Sollis tests are performed on raw series.

Table 8 – Tests on the dispersion coefficient

Test	Average rate of profit						IROP		
	Full sample			1980-2015			1971-1996		
BDS	3.351		NL	5.781		NL	-2.150		NL
	(0.001)			(0.000)			(0.032)		
KSS	-0.254	0	NS	-0.876	0	NS	-2.837	0	NLS
Sollis	6.010	0	NLS	6.037	0	NLS	5.358	0	NLS
ADF$_c$	-3.572	0	ST	-2.830	1	UR	-4.070	0	ST
ADF$_{c+t}$	-3.537	0	ST	-2.386	1	UR			
ERS-GLS$_c$	-3.371	0	ST	-2.478	0	ST	-4.094	0	ST
ERS-GLS$_{c+t}$	-3.540	0	ST	-3.335	0	ST			
PP$_c$	-3.519	3	ST	-3.782	4	ST	-4.119	2	ST
PP$_{c+t}$	-3.490	3	UR	-3.564	4	ST			
KPSS$_c$	0.097	4	ST	0.331	3	ST	0.409	2	ST
KPSS$_{c+t}$	0.104	4	ST	0.210	3	UR			
ZA	-4.862	0	UR	-4.782	0	UR			
	1987			1977					
Trend model	0.001			-0.003			0.004		
	(0.594)			(-1.342)			(1.290)		

Note. NL, NS, NLS, ST and UR indicate non-linearity, non-stationarity, non-linear stationarity, stationarity, and unit root respectively. t-statistics are contained in parentheses. All tests except BDS and trend model include relevant augmenting lags and bandwidth.

Table 9 (Appendix) summarises the findings and shows the likely presence of tendential equalisation in incremental profit rates, and the absence of equalising convergence in average profit rates. We also consider estimation of the rates of profit by excluding the finance and insurance sector (not reported but available upon request). This did not fundamentally affect the results – the only minor difference was non-linear stationarity in electrical, electronic, and optical equipment. The principal pattern of no convergence in average rates of profit and tendential equalisation in IROP is confirmed.

Conclusion

This paper considers convergence and gravitation of profit rates at the industry level in South Korea in the 1970–2015 period. It specifically contrasts alternative paradigms of industry competition (classical and neoclassical) and two alternative representations of profit rates' dynamics – equalising convergence and tendential equalisation. Two measures of profit rates are used: average rate of profit (return on the total capital stock) and IROP (return on regulating capital, the most recently invested capital).

Against the background of a falling economy-wide rate of profit, the profit rate differentials (calculated based on average rate of profit) do not attenuate and no reduction in differential is observed. The relative average rate of profit (as a proxy for profit rate differential) does not exhibit mean reversion in the majority of cases. In 13 cases, the relative average rate of profit contains unit root; in effect, it fluctuates randomly. In only four cases, the relative average rate of profit is trend stationary and the convergence towards economy-wide average rate of profit takes place. In three cases, the relative average rate of profit fluctuates around the mean. Specifically, the value of the mean is below the economy-wide average rate of profit. Persistence of industry profit rates at low (or at times negative) levels was common in Korea, particularly prior to the 1998 crisis (Joh, 2000). The lack of monitoring by financial institutions, corporate governance failures, and bailouts of failing businesses by the government encouraged sub-optimal investment in unprofitable projects and the provision of subsidised credit at rates below the prevailing market interest rates. Notwithstanding this phenomenon, in a number of industries (particularly those where unit root was identified), the relative average rates of profit were high, confirming earlier studies on the extent of monopoly power in the Korean economy (Choi, 1988; Yoon, 2004). Additional estimates were performed by excluding finance and insurance activities from profit rate calculations, but this did not fundamentally alter the results. Overall, the convergence towards perfectly competitive states and the reduction of profit rate differentials, as per the neoclassical hypothesis, are observed in rare cases.

We note that, from a methodological point of view, the use of average rates of profit may be inappropriate in the Korean context. Over the whole period (and particularly in the 1970s and 80s), Korea was characterised by rapid technological change and fast pace of capital accumulation and the obsolescence of old capital stock (in many instances, deliberately implemented by the government to foster productivity gains and growth), implying that older vintages of capital stock were less productive and less relevant for production and that IROP, based on regulating capital, is a better measure of profitability. Where IROP (returns on regulating capital) is concerned, the equalisation tendencies are well observed: in all cases, the relative IROP (a proxy for profit rate differentials) fluctuates around the mean. The fluctuation is turbulent, in line with the classical hypothesis, as evidenced by a greater number of nonlinearities in the series.

The finding of intense competition and turbulent profit rate equalisation along classical lines may reconcile the opposing view of Korean competitive landscape: on one hand, the high degree of monopoly power, the low rate of firm turnover, and the dominance of chaebols in total output, assets and sales; and on the other hand, the fierce competition among chaebols in export and domestic markets, the competition among chaebols for credit and government support instruments, and competition within chaebols.

In this setting, some of the impediments to competitive process, earlier identified by Vaona (2011), may thus be removed. For instance, while profit persistence and profit rate differentials are, to a certain extent, affected by high adjustment costs when adopting best practice production methods, the turbulent competitive dynamics – as per the classical hypothesis – foster timely adoption of the best production methods and speed up the learning process, a fact well documented by Amsden (1989).

On the other hand, future research should examine whether the high degree of competition – as per the classical view and documented in this paper – is compatible with the dominance of chaebols for the following reasons. 1) The free flow of information about profit opportunities and hence fast flow of capital is ensured within chaebol, but the flow of information to outsiders and newcomer firms may not be guaranteed. 2) The credit rationing and allocation of credit for profitable ends is facilitated in chaebols, but the outcomes of such allocations are not always optimal, while newcomers may suffer a lack of credit that may compromise their entry decisions.

We also note that in an economy where investment is planned and assisted by the government, and where profit rate adjustments occur through the movement of capital between and within firms rather than through firms' turnover, the documented dynamics of industry profit rates are a mere manifestation of investment decisions made to supplement industrial policy decisions, frequently to the detriment of competition. The study of profit rate convergence will thus necessarily become subordinate to the analysis of investment decisions and of the effects and outcomes of such decisions made by business conglomerates and the government, which orchestrate and coordinate investment processes.

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Table 9 – Summary of findings

Industry		Average rate of profit								IROP						
		BDS	KSS, Sollis	ADF	PP	ERS GLS	KPSS	ZA, LP	Overall	BDS	KSS, Sollis	ADF	PP	ERS GLS	KPSS	Overall
Agriculture, forestry and fishing	A	NL	NS	UR	UR	UR	ST	TSB	UR	L		ST	ST	ST	ST	ST
Mining and quarrying	B	NL	NS	UR	UR	UR	UR	UR	UR	L		ST	ST	ST	ST	ST
Food products, beverages and tobacco	C	NL	NS	ST	ST	UR	UR	TSB	ST	L		ST	ST	ST	ST	ST
Textiles, wearing apparel, leather	D	L		UR	UR	UR	UR	SLB	UR	L		ST	ST	ST	ST	ST
Wood and paper products, and printing	E	NL	NS	UR	UR	UR	UR	UR	UR	NL	NS	ST	ST	ST	ST	ST
Coke and refined petroleum products	F	L		UR	UR	ST	ST	TSB	ST	NL	NLS					ST
Other non-metallic mineral products	G	L		UR	UR	UR	ST	TSB	ST	NL	NLS					ST
Pharmaceutical products	H	L		UR	UR	UR	UR	UR	UR	NL	NLS					ST
Rubber and plastics products	I	L		UR	UR	UR	UR	UR	UR	NL	NS	ST	ST	ST	ST	ST
Basic metals	J	NL	NLS						ST	NL	NLS					ST
Fabricated metal products	K	L		UR	UR	UR	UR	UR	UR	NL	NLS					ST
Electrical, electronic and optical equipment	L	L		ST	ST	ST	ST	UR	ST	NL	NS	ST	ST	ST	ST	ST
Machinery and equipment n.e.c.	M	L		UR	UR	ST	ST	TSB	ST	L		ST	ST	ST	ST	ST
Transport equipment	N	NL	NLS						ST	NL	NLS					ST
Furniture; other manufacturing	O	L		UR	UR	ST	ST	UR	UR	L		ST	ST	ST	ST	ST
Electricity, gas and water supply	P	L		UR	UR	UR	ST	UR	UR	NL	NLS					ST
Construction	Q	L		UR	UR	UR	UR	UR	UR	NL	NLS					ST
Transportation and storage	R	L		UR	UR	UR	ST	UR	UR	NL	NS	ST	ST	ST	ST	ST
Accommodation and food service activities	S	NL	NS	UR	UR	UR	UR	UR	UR	NL	NLS					ST
Information and communication	T	L		UR	UR	UR	UR	UR	UR	NL	NS	ST	ST	ST	ST	ST
Financial and insurance activities	U	NL	NS	UR	UR	ST	ST	UR	UR	NL	NLS					ST

Note. NL, L, NS, NLS, UR, ST, TSB, and SLB indicate non-linearity, linearity, non-stationarity, non-linear stationarity, unit root, stationarity, trend stationarity with break(s), and stationarity around constant with break(s) respectively.