Do business groups help or hinder technological progress in emerging markets? Evidence from India

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Abstract:

Business groups, which are ubiquitous in emerging market economies, balance the advantages of characteristics such as internal capital markets with the disadvantages such as inefficient internal distribution of resources and suppression of technological and other forms of innovativeness. In this paper, we examine, in the Indian context, whether business group affiliation provides an advantage over unaffiliated (or private independent) firms with respect to technological progress, which lies at the heart of wider economic growth and prosperity. Our results suggest that while business group affiliation did provide an advantage over private independent firms at the start of the sample period (2000), this advantage was more than offset by the turn of the century. We discuss the implications of our results for economic growth rates in emerging market economies.

Keywords: Business groups; Technological progress; India

JEL code: D24, L21, L22, O12

1. Introduction

It is now well understood that business group affiliated firms can account for a significant proportion of private sector firms in emerging market economies. Their existence has been justified in many different ways. For example, it has been argued that if capital markets are informationally imperfect then there is scope for business groups to come into existence (Ghatak and Kali, 2001; Kali, 2003). Indeed, if capital markets are imperfect, internal accruals of firms may be the dominant source of funds for investment. In such cases, existing firms with internal accruals are in a better position to start new business ventures (Riyanto and Toolsema, 2008), resulting in the formation of business groups. Similarly, business groups may be the optimal outcomes of environments where contract enforcement is costly (Kali, 1999), i.e., where they are optimal organisational structures that minimise transactions cost (Granovetter, 1995).[1] Similarly, business groups can result from expansions of businesses into unrelated industries, in contexts such as late-industrialising countries where expansion of business activities is much more dependent on ability to use contacts than on other capabilities of the firms (Kock and Guillen, 2001).

The literature highlights the advantages of resource sharing within business groups; it may result in greater innovation and higher productivity in group affiliated firms, in part by weakening the relationship between a firm's liquidity and its investment in innovation (Keister, 1998; Belenzon and Berkovitz, 2010; Hsieh et al., 2010). However, it also indicates that, as postulated above, the context matters significantly. For example, group affiliated firms are likely to be more innovative in contexts where institutions are weak (Chang et al., 2006), i.e., where the benefits from mutual insurance or internal resource sharing are quite high. Choi et al. (2011) find a strong positive impact of business group affiliation on patent registration in China. By contrast, if business groups foster moral hazard either by providing safety nets or by restricting competition, innovation is adversely affected. Mahmood and Mitchell (2004)[2] find that while business groups in Korea and Taiwan may provide innovation infrastructure, innovation intensity has an inverted-U relationship with the market share of business groups. Further, the peak of this inverted-U curve is reached early if there are alternative sources of innovation infrastructure.

[1] Some researchers have expressed discomfort with the view that business groups are an optimal response to market imperfections and weak institutions. They have sought alternative explanations for the existence of this organisational form, e.g., in important historical events and subsequent path dependence (Carney and Gedajlovic, 2003), and in inimitable capability of firms and entrepreneurs for repeated market entry (Guillen, 2000). However, market imperfections and institutional weaknesses continue to be the dominant explanation for existence of these groups.

[2] See also Mahmood and Lee (2004).

Over the past two decades, emerging economies have experienced significant changes in their economic and institutional environments. To a lesser or greater extent, they have embraced market oriented reforms and have attempted to remove distortions in their product, and factor (particularly capital) markets (e.g., Kim, Bae and Bruton, 2012). There has also been an attempt at improving the ease with which contracts can be enforced and, more generally, at reducing the transactions cost of doing business in these countries. The 2012 *Doing Business* report of the World Bank concludes that "more and more economies are focusing their reform efforts on strengthening legal institutions such as courts and insolvency regimes and enhancing legal protections of investors and property rights. This shift has been particularly pronounced in low- and lower-middle-income economies where 43% of all reforms recorded by *Doing Business* in 2010/11 focused on aspects captured by the getting credit, protecting investors, enforcing contracts and resolving insolvency indicators" (p. 1). The market imperfection and weak institutions based rationale for existence of business groups, therefore, is rapidly disappearing.

Can we then argue that business groups continue to be optimal organisational structures on account of other advantages that they bestow on the affiliated firms? In particular, do they offer an advantage by way of mutual insurance of the affiliated firms (see Aoki, 1984, 1988), thereby enabling group affiliated firms to take risk, which is an important component of innovation and entrepreneurship that encompasses structural changes in the way in which firms are organised and how they formulate and execute strategy? Or does mutual insurance largely results in moral hazard on the part of the weaker firms within the groups and a suppression of (technology related) innovation and (wider) innovativeness among the stronger firms?[3] The literature suggests that, with the exception of the Japanese *keiretsu*, there is little empirical evidence from other contexts in support of the mutual insurance hypothesis (Khanna and Yafeh, 2007). On the other hand, there is evidence to suggest that families in control of business groups do indeed maximize the payoff of the group as a whole, often quashing productive activities of some of the member firms to protect obsolete investment in other member firms (Morck and Yeung, 2003). Further, stronger firms support weaker group members through debt guarantees, equity investment and internal trade, one consequence of which is that profitable group members may have to forego profitable investment opportunities (Chang and Hong, 2000).

[3] The moral hazard can directly be the consequence of expectations on the part of the weaker group members that they would be bailed out if they perform poorly, and also on account of the expectation that business groups may be capable of restricting competition through political lobbying or by way of control over key resources or by way of their size relative to other firms.

Profit is often redistributed from stronger to weaker firms to ensure group survival (Estrin, Poukliakova and Shapiro, 2009). And group firms might suffer from over expansion and over diversified into business area that is outside their competitive advantage (Khanna and Yafeh, 2007). The performance and innovativeness of business groups (and hence their affiliates) may, therefore, depend on whether or not the benefits of mutual insurance and resource sharing, which decrease over time, outweigh (or get outweighed by) the costs associated with moral hazard and suppression of innovativeness among group affiliated firms.[4] Seo, Lee and Wang (2010), for example, find that performance of business groups in China has declined over time, at least partly on account of serious agency costs associated with these groups.

In this paper, we contribute to this literature by examining differences in technical change of group affiliated firms and unaffiliated firms. The context of our analysis is India, where business groups are ubiquitous (Khanna and Yafeh, 2007), and yet where we find a large number of unaffiliated firms across a wide range of industries which can act as comparators.[5] We posit that if mutual insurance and resource sharing results in greater innovativeness, whether related to product improvement though internally developed and externally sourced technology or through better organizational structure and strategy formulation, this should be reflected in greater technical change for group affiliated firms. By the same token, if technical change is lower for group-affiliated firms, this is arguably on account of moral hazard and hindrance of among group affiliated firms. Further, if the advantages of mutual insurance and resource sharing declines with strengthening of local institutions, and if indeed institutions and strengthened over time, this should result in reduction of productivity differential between group affiliates firms and unaffiliated firms over time, even if business group affiliated firms have an initial advantage. Our results suggest that, in the Indian context, business group affiliation was associated with higher technological progress relative to unaffiliated or private independent firms in the immediate aftermath of the reforms of the early to mid 1990s, but this advantage of business group affiliates was more than offset by the turn of

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[4] It is now well established in the wider literature on business groups that with reduction in market imperfections and improvement in institutional quality, group affiliated firms may indeed lose their advantage over unaffiliated firms. Bhaumik, Das and Kumbhakar (2012) find that group affiliated firms in India experienced less financing constraints at the turn of the century, but this advantage vis-a-vis unaffiliated firms was reversed during the first decade of the twenty first century, as reforms reduced inefficiency in the Indian credit and capital markets. Similarly, Zattoni et al. (2009) find that while business groups in India outperformed other firms in a weak institutional environment, this superiority in performance disappear with reduction in market imperfections and improvement in institutional environment.

[5] By contrast, the literature on the business group-innovation-productivity link in emerging markets is almost entirely focused on Korea, Taiwan and China.

the century. Our result is consistent with those reported in other recent papers on Indian business groups, e.g., about the waning advantage of their internal capital markets.

The rest of the paper is structured as follows: In Section 2, we briefly discuss the research methodology and the data. In Section 3, we discuss the regression results. Finally, Section 4 reflects on the implications of the regression results and concludes.

2. Research methodology and data

The growing literature on productivity and its growth in emerging market economies has largely focused on the role of competition, ownership and financial development in fostering productivity growth (Ayyagari et al., 2010; Gorodnichenko et al., 2010). At the same time, it is well understood that there are three different courses of productivity growth, namely, improvement in firm level efficiency (e.g., through implementation of processes that minimise of wastage of inputs), scale efficiencies and, of course, technological change.[6] Of these, greater risk-taking is perhaps associated with activities that are associated with technological change -- investment in research and development, acquisition of new technology and associated changes to products and/or production processes -- than with the other drivers of productivity growth. We, therefore, focus largely on the impact of business group affiliation on technological progress. However, we also examine the impact of this affiliation on efficiency change, which is an important component of TFP growth, and on TFP growth itself.

The stochastic frontier approach to model production functions facilitates the decomposition of (total factor) productivity growth into technological change, change in the efficiency with inputs are converted into outputs, and change in scale efficiency. Following Aigner, Lovell and Schmidt (1977) and under the assumption of translog functional form the stochastic frontier of an individual firms *i* at time *t* can be represented as follow:

$$lnY_{it} = \beta_0 + \sum_{n=1}^{N} \beta_n lnX_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{j=1}^{N} \beta_{nj} lnX_{nit}\, lnX_{jit} + \sum_{n=1}^{N} \beta_{tn} t lnX_{nit}$$

$$+\beta_t t + \frac{1}{2}\beta_{tt} t^2 + v_{it} - u_{it} \quad (1)$$

[6] Girma and Gorg (2006), for example, demonstrate that productivity gains observed in firms that are acquired by multinationals is largely on account of changes in technical efficiency and not in the scale of operations.

$i = 1,2, \dots I, t = 1,2, \dots T$, *N=3*.

where Y_{it} denotes the output produced by firm *i* at time period *t*, X_{nit} denotes the inputs (in this case labour (*l*), capital (*k*) and materials (*m*), i.e., *N* = 3) of firm *i* at time *t*, v_{it} represents the normally distributed *iid* error term with zero mean and positive variance, and u_{it} denotes firm *i*'s positive and half-normally distributed inefficiency at time *t*.

To utilise the panel structure of our data set in this study we adopt the true fixed effect panel stochastic frontier model specification as suggested by Greene (2003). We assume the firm level heterogeneity affects a firm's production process in a time invariant fashion, but that it is independent of firm-level time-varying technical efficiency.[7] This setting is preferred in contexts (such as emerging market economies) where there is considerable heterogeneity in firm size, such that production capacity of firms might vary significantly and yet be unrelated to the efficiency of the firms. Equation (1) is therefore written as:

$$lnY_{it} = \beta_0 + \alpha_i + \sum_{n=1}^{N} \beta_n lnX_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{j=1}^{N} \beta_{nj} lnX_{nit}\, lnX_{jit} + \sum_{n=1}^{N} \beta_{tn} t lnX_{nit}$$

$$+\beta_t t + \frac{1}{2}\beta_{tt} t^2 + v_{it} - u_{it} \quad (2)$$

where α_i denotes the time invariant firm specific factors that would affect firm level output but not the technical efficiency. The model is estimated using maximum likelihood estimation (MLE).

Once the parameters of the translog production function are estimated, following Jondrow et al. (1982) the inefficiency parameter u_{it} can be predicted as follows:

$$\hat{E}[u_{it}|\varepsilon_{it}] = \frac{\sigma_\varepsilon}{1+\lambda^2}\left[\frac{\phi(z_{it})}{1-\Phi(z_{it})} - z_{it}\right]$$

[7] While it is well understand that firm specific heterogeneities could affect firm production, in the literature there is still no uniform framework on how such heterogeneity should be treated in stochastic frontier estimation. Schmidt and Sickles (1984) assume that the firm specific heterogeneity can be treated a fixed effect to be included in firm level inefficient. Similarly, in Kumbhakar (1990), Pitt and Lee (1982) and Battese and Coelli (1988, 1992, 1995), it is captured by a time invariant random inefficiency term. The models by Schmidt and Sickles (1984), Kumbhakar (1990), and Pitt and Lee (1982) has been criticised for assuming firm level inefficiency to be time invariant. Whilst the monotonic decaying inefficiency with respect to time period as assumed by Battese and Coelli (1995) has also been contended as been restrictive and could lead to extreme results (Greene 2005). Further, Greene (2003) has pointed out that the alternative specification of a time-invariant firm specific factor in firm level efficiency is extremely challenging to be accurately estimated with volatile likelihood function even under the most favourable scenarios. This makes the identification of the key parameters difficult.

$$\varepsilon_{it} = v_{it} - u_{it}, \ \ \sigma_{\varepsilon} = \sqrt{(\sigma_v^2 + \sigma_u^2)}, \lambda = \frac{\sigma_u}{\sigma_v}, z_{it} = \frac{\varepsilon_{it}\lambda}{\sigma_{\varepsilon}}$$

Here, $\phi(.)$ and $\Phi(.)$ denote the density and CDF function, respectively, evaluated at z_{it}. Conditional estimates, of u_{it}, in turn, enables us to estimate technical efficiency level of each firm during each year of the sample period:

$$TE_{it} = Exp\left(-\hat{E}[u_{it}|\varepsilon_{it}]\right) \ (3)$$

This, in turn, enables us to decompose total factor productivity (TFP) into efficiency change (EC), technical progress (TC) and scale change (SC) (Coelli et al., 2005). EC represents the improvement in TFP that results from improvement in pure technical efficiency, when compared with a constant returns to scale (CRS) production frontier, while SC represents the improvement in TFP caused by scale change.[8] Finally, TC on the other hand represents technological progress made by the firm between the period *t* and *s*. Specifically, EC, TC and SC between time periods *t* and *s* can be written as:

$$EC = \frac{TE_{it}}{TE_{is}} \ \ (4)$$

$$SC = exp\left\{\frac{1}{2}\sum_{n=1}^{N}[e_{nis}SF_{is} + e_{nit}SF_{it}]ln\left(\frac{X_{nit}}{X_{nis}}\right)\right\} \ (5)$$

$$TC = exp\left\{\frac{1}{2}\left[\frac{\partial lnY_{is}}{\partial s} + \frac{\partial lnY_{it}}{\partial t}\right]\right\} \ (6)$$

where $SF_{is} = \frac{(e_{nis}-1)}{e_{nis}}$, $e_{is} = \sum_{n=1}^{N} e_{nis}$ and $e_{nis} = \frac{\partial lnY_{is}}{\partial X_{nis}}$. Malmquist TFP index is the geometric mean of these three components.

Using equation (2), we estimate translog production functions for 11 NIC 3-digit Indian industries for the 1999-2010 period. The data are taken from the *Prowess* database that is available from the Centre for Monitoring the Indian Economy. This widely used database[9] included information on sales, labour cost, capital stock and material cost that are required to estimate equation (2).[10] It also includes information about

[8] The value of SC would be 1 if firm *i* is producing under CRS, whilst be larger than 1 under increase returns to scale and be less than 1 under decreasing returns to scale.

[9] See, for example, Bertrand et al. (2002), Gopalan et al. (2007), Bhaumik, Das and Kumbhakar (2012), and Dharmapala and Khanna (2012).

[10] Other empirical exercises that use *Prowess* for production function estimation use the same measures of output and inputs; see, e.g., Mandal and Madheswaran (2009), Mitra and Sharma (2011) and Kim and Saravanakumar (2012). One limitation of this data set is that it requires the use of labour cost as a proxy for labour input in production function estimations. However, as noted by Fox and Smeets (2011), even aside from the fact that in some contexts wage bill is the only available proxy for labour input, "[a] wage bill specification is also attractive because the explanatory power of human capital variables in wage regressions can be low, suggesting unmeasured worker characteristics are also

group affiliation of firms, indicators of other forms of ownership such as MNE subsidiaries, first year of operation and industry affiliation. The descriptive statistics of the sample of firms for each of these industries is reported in Table 1. After dropping observations with missing values, we are left with a sample of 31.671 firm years.

INSERT Table 1 about here

The parameter estimates of the stochastic frontier model enables us to generate measures of EC, TC and SC as in equations (4)-(6). Next we transform the estimated annual EC, SC and TC into chain-linked indices based on the initial year. The logged differences of the linked indices between two years represent the percentage growth rate in EC, SC and TC, and the percentage change of the growth in TFP equals the sum of growth rate in EC, SC and TC as in Coelli et al. (2005). We then estimate the following regression models, to examine the impact of group affiliation on percentage change in TC (TC from here on):[11]

$$P_{it} = c_0 + b_i + b_1 Group_i + b_2 Foreign_i + b_3 Z_{it} + b_4 t + b_5 t * Group_i + b_6 t * Foreign_i + Ind_i + e_{it} \quad (7)$$

where P_{it} denotes TC. $Group_{it}$ is an indicator variable that equals one if firm *i* is a business group affiliate and zero otherwise. $Foreign_{it}$ is the indicator variable for foreign ownership which takes the value of one if majority of a firm's share is controlled by foreigner(s). Z_{it} includes the other control factors such as size and age of the firm.[12] Ind_i represents industry dummies at 2-digit industry level. We also control for investment in research and development (R&D) and off-the-shelf acquisition of technology that are often more important in the context of emerging market economies. Since the impact of these investments may

important determinants of labor quality. Further, the wage bill using monthly salaries better weights the contributions of part-time and full-time workers than do measures like the number of workers." They also find that "the wage bill is potentially a more accurate measure of input quality than the detailed human capital measures."

[11] We also estimate the model with EC (reported in Appendix) and TFP growth (unreported) as the dependent variable, but the focus of the discussion in the rest of the paper is largely change in TC.

[12] In the production function, our proxy for output is total sales. Hence, in Equation (7), we should ideally use some other measure of size. However, *Prowess* does not include information on employment (our proxy for labour input is the employee wage bill). We, therefore, use as our control for firm size a dummy variable that equals 1 if the total sales of the firm is larger than industry average, and 0 otherwise.

vary across industries, we interact them with the industry dummy variables, which are also included in Z_{it} in some of the estimations we performed. To control for changes in the institutional environment on account of incremental policy initiatives, we also include a time trend t in the model.[13] To explore the possible changes of institutional environment on the effect of group affiliation on firm productivity growth we include an inter-action term between time trend t and group affiliation indicator. Furthermore, we also examine the evolution process of the impact of foreign ownership on TC and other variables of interest. e_{it} denotes the *iid* error and b_i denotes firm specific random effect to be controlled in panel regressions.[14] We estimate equation (7) above using time series-cross section pooled OLS (with cluster adjustment for possible correlations across firm i over time) and panel random effects model. Further, to accommodate possible correlation between explanatory variables and the individual random effect, we also the Hausman-Taylor estimator.

Our regression framework enables us to directly compare the impact of business group affiliation on TC（and EC and TFP growth), relative to those of the unaffiliated firm. The interaction between the time trend and the dummy variable for group affiliation, in turn, enables us to examine the changing impact of group affiliation on TC (and EC and TFP growth) over time. Note that market-oriented and institution improving economic reforms were initiated in India in the early 1990s (Rodrik and Subramanian, 2004; Bhaumik, Gangopadhyay and Krishnan, 2009). Recapitulate also that we posit that improvements in market efficiency and institutional quality reduces the benefits of intra-group mutual insurance and resource sharing, such that in such a reformed environment costs associated with group affiliation might outweigh their benefits. Given that these reforms take a few years to have an impact on firm performance, therefore, we expect group affiliated firms to have an edge over unaffiliated firms with respect to TC (and TFP growth)

[13] For other examples of this approach, see Bhaumik and Dimova (2004) and Bhaumik, Das and Kumbhakar (2012). It can be argued that a time trend may also capture other dynamics. Specifically, if either the group or the non-group firms have a higher level of technical ability to begin with, its technical change over time may be slow, under the assumption that in the long run laggard firms catch up such that there is a convergence. However, this line of argument is untenable. First, there is no evidence to support the argument that except perhaps in some "old" sectors like textiles technology has reached a steady state to which laggard firms can converge. Second, while there may be relative laggards and front runners in a developing country context, it is likely that both these sets of firms are far removed from the global technology frontier such that both these sets of firms have considerable scope to experience technical change over a relatively short period of time. Finally, our estimates of technical efficiency of group-affiliated and non-group firms during the first two years of the sample period indicates that the difference in the average technical efficiency levels is not statistically significant.

[14] Since group affiliation and foreign ownership are firm specific and time invariant in our dataset the adoption of fixed effect panel regression method would obstruct the accurate estimation of the coefficients for these two key variable. Hence the use of random effect panel model to estimate Equation (7).

during the early years of our sample period, and we expect this advantage to decline (or even get reversed) during the later years of this period.

The empirical results are reported and discussed in Section 3.

3. Regression results

The estimates of the translog production function for each of the sectors is reported in Table 2. While it is difficult to interpret individual coefficient estimate for translog production functions, the computed values of returns to scale, reported in the last row of the table, suggests that the estimates are reasonable. The returns to scale for each of these industries is close to 1, which is consistent with the evidence about returns to scale in the wider literature, and it is also consistent with past estimates of returns to scale in the Indian context (e.g., Bhaumik and Kumbhakar, 2012).

INSERT Table 2 about here.

Next, using the methodology proposes by Coelli et al. (2005), we compute productivity growth for each of these 3-digit industries over the 2000-2010 period, and decompose it into its components, namely, SC, TC and EC. These are reported in Figure 1. Since the focus of our analysis is the difference between business group affiliated firms -- which may have historically been more suited to the economic and business environments in emerging market economies but whose advantage may have waned over time -- and unaffiliated or private independent firms, we separately report productivity growth and the contribution of its components for these two types of firms. The figures suggest the following: (a) There is considerable heterogeneity in productivity growth across industries. However, for many of the industries, positive and significant productivity growth is noticed for both types of firms, indicating that there might be significant industry effects. (b) While the importance of TC relative to EC in total percentage changes of TFP differ significantly across industries, by and large, TC is the more important driver of productivity growth than EC.

INSERT Figure 1 about here.

Recapitulate that business group affiliation, which trades off the advantages of resource sharing with the disadvantages of agency conflicts, inefficient intra-group resource allocation and innovativeness suppression, is expected to have the greatest impact on the technological change component of productivity growth, which involves the greatest extent of risk taking. Hence, we compare the 2000-2010 TC for business group affiliated and private independent firms in three different ways. To begin with, we use the stylized t-test. Next, we take into consideration the possibility that the distributions of TC are non-normal, and hence use the nonparametric Wilcoxon-Mann-Whitney rank-sum test instead. Finally, we use the Kolmogrov-Smirnov test where the null hypothesis is that the two samples are drawn from the same underlying population. The test statistics and their significance levels are reported in Table 3, and they suggest that there is significant difference between technological change over the 2000-2010 period, between the group affiliated firms and private independent firms, for most of the industries.

INSERT Table 3 about here.

As mentioned earlier, we formally test the impact of business group affiliation on technology change using Equation (7), which we estimate using cluster adjusted OLS, random effects panel and Hausman-Taylor estimators. The regression estimates are reported in Table 4. In each case, we estimate two different specifications. To begin with, we regress year-on-year TC on a set of industry dummies, a time trend that controls for secular changes in the institutional environment, and dummy variables for business group affiliation and foreign ownership. Private domestic firms that are unaffiliated to business groups are the omitted ownership category. To understand how the impact of ownership changes over time, we interact the time trend with business group affiliation and foreign ownership. The estimates of this specification are reported in columns (1), (3) and (5). Next, we control for other firm specific effects such as firm size and firm age. The estimates of this augmented specification are reported in columns (2), (4) and (6).

INSERT Table 4 about here.

The regression estimates indicate that technological change in India is, to a significant extent, driven by industry level factors that could include domestic and international competition, changes in regulations, and technology shocks that periodically hit industries. Most of the industry dummy variables have statistically significant coefficients. The estimates of the augmented specification in columns (2), (4) and (6) also indicate that TC is inversely related to firm size and firm age. Given that larger firms may have greater resources for investment in innovation (see Bartelsman and Doms, 2000) but may also have longer agency chains within the organization, resulting in managerial weaknesses and slower adoption of technology,[15] the inverse relationship between firm size and TC is plausible. [16] Similarly, given that older firms in India were more likely to have strategic inertia and were therefore more likely to find it difficult to adapt to the post-liberalization environment, and given that the average age of the firms in our sample is 23.25 years, the negative relationship between firm age and TC is plausible as well. Finally, the time trend variable has a positive and significant coefficient, and the implication in our context that TC is augmented by incremental reforms that reduce institutional weakness gradually is quite sensible. Importantly, the signs and significance of these estimates are robust across the choice of the estimator.

The focus of this paper, of course, is the impact of business group affiliation on TC, and here we notice something quite interesting., The business group affiliation dummy itself has a positive and significant coefficient, while the interaction between this ownership dummy and the time trend has a negative and significant coefficient. In other words, during the first year of the sample period (namely, 2000), business group affiliated firms experienced greater TC than private independent firms. However, within a short time, this advantage of business groups was eroded and by the third (or even second) year of the sample period TC in business group affiliated firms lagged that in private independent firms.[17] This is consistent

[15] Bloom, Sadun and Van Reenen (2009) and Acemoglu et al. (2007), for example, suggest that decentralization in firm structure helps to improve new technology adoption and productivity. It is not unreasonable to assume that decision-making process in most Indian firms, even those unaffiliated with business groups, is fairly centralised on account of factors such as family ownership.

[16] Indeed, as pointed out by Syverson (2011), empirical evidence about this relationship is hardly conclusive.

[17] Consider, for example, the panel random effects estimates. In the column (4), the group affiliation dummy has a coefficient of 0.13 while the interaction between this dummy and the time trend has a coefficient of -0.05. In other words, by the third year of the sample period (i.e., when value of the time trend variables equals 3), the interaction term dominates the secular impact of the group affiliation dummy. Similarly, the Hausman-Taylor estimates reported in column (6) indicate that the interaction term (-0.06) starts dominating the group affiliation dummy (0.21) from the fourth year of the sample period.

with available evidence about the erosion of advantage of business group affiliated firms in India with respect to financing constraints, over roughly the same time period (Bhaumik, Das and Kumbhakar, 2012).

INSERT Table 5 about here.

An important weakness of the specifications reported in Table 4 is that they do not include any measure of R&D which is believed to have a significant impact on TC. While the R&D-TC relationship may not be strong in emerging market economies, on account of difficulties with absorption of technology, among other things, it is nevertheless important to examine whether our results with respect to business group affiliation is affected by the inclusion of R&D in the specification. We, therefore, control for R&D as a robustness check and the estimates are reported in Table 5. In column (1), we control for internal R&D, scaled by total sales of the firms. Further, since the impact of R&D on firm-level TC can differ by industry, we include in the specification interactions between the R&D-to-sales ratio and the industry dummies (e.g., RD131 is the interaction between the R&D-to-sales ratios of firms and the dummy for industry 131). Since R&D is not widespread in emerging market economies, and technology is often purchased off the shelf, through licensing arrangements etc, in column (2), we control for the ratio of off the shelf technology purchase to sales and industry dummies.[18] Finally, in column (3), we include the controls for both in-house R&D and off the shelf purchase of technology. Since the estimates reported in Table 4 are robust across the choice of estimators, in Table 5 we report the estimates of the panel random effect model alone.[19]

The results indicate that neither in-house R&D nor externally procured technology has a significant impact on firm-level TC. This is not particularly surprising, given the emerging market context, and is consistent with the recent literature on the impact of technological innovation on firm performance in India (Bhaumik, Estrin and Mickiewicz, 2012). More importantly, for our purposes, the result with respect to the impact of business group affiliation on TC is unaffected. The results reported in Table 5 continue to show that while business group affiliation may have been advantageous at the start of the sample period, within a

[18] In our sample, only 14% of the firms reported R&D expenditure, another 15% purchased technology off the shelf through licensing etc, and 7% of the firms both invested in R&D and purchased technology off the shelf.
[19] The Hausman-Taylor estimates are reported in Appendix A1.

short period of time the tables had turned and TC was higher, on average, in private domestic firms than in business group affiliated firms.

In Appendices A2 and A3, we report the regression models that have EC as the dependent variable, instead of TC. The results suggest that EC is indeed driven by factors that are different from those that influence TC. For example, while TC is unaffected by R&D and off the shelf technology procurement, these variables affect EC significantly. In the context of our paper, however, we note that there is no statistically significant difference in the impact of business group affiliation and private independent firms on EC. In results that are not reported in this paper, we re-estimate the regression models with TFP growth as the dependent variable. The estimates for these regression models suggest that, much like in the case of TC, which is the dominant component of TFP growth in our sample of industries (Figure 1), the initial advantage of business group affiliation is soon more than offset, and from the fourth year in the sample period TFP growth in private independent firms exceed that in business group affiliated firms.

4. Discussion and concluding remarks

Business groups are ubiquitous in emerging market economies, and it has been argued in the literature that they are an optimal response to weak institutions and missing markets for resources such as capital and managerial talent. As the economic and business environments in these economies change with reforms and liberalization, an important question that has to be addressed is whether these organisational forms help or hinder economic progress in the new environment. For example, recent research suggest that affiliation with business groups and their internal capital markets do not guarantee insurance against financing constraints (Bhaumik, Das and Kumbhakar, 2012). Similarly, globalization of labour markets and provide fast growing emerging market firms access to global managerial talent, including returning expatriates (Song, 1997; Zweig, 2006). Yet, as the competitive advantage of business groups gets eroded, their internal agency problems and strategic may persist. These groups may, of course, acquire new resources and capabilities to prospect (Yiu, Bruton and Liu, 2005) to overcome organisational inertia (Hannan and Freeman, 1984), and hence whether they help or hinder economic progress in the new economic or business environment remains and open empirical question.

In this paper, we examine, in the Indian context, whether business group affiliation provides an advantage over unaffiliated or private independent firms with respect to technological progress, which lies at the heart of wider economic growth and prosperity. Our results suggest that while business group affiliation did provide an advantage over private independent firms at the start of the sample period (1997), this advantage was more than offset by the turn of the century. To recapitulate, the Indian economy was subjected to significant reforms to the real sector (e.g., end of the licensing system and greater import competition) and the capital market during the first few years of the 1990s, leading to a reduction in the transactions cost of doing business. It is not unrealistic to draw the conclusion, therefore, that with economic reforms and liberalization, the *average* business group (or the average firm affiliated to a business group) may have progressively weaker impact on economic growth than its private independent counterparts. If significant presence of business groups within industries act as entry barriers for young (and hence potentially innovative) firms (Mahmood and Lee, 2004), then the overall cost of the persistence of business groups could be higher still.

While the caveats associated with generalizing any one set of empirical results remain relevant, our analysis suggests that within emerging market economies there may be natural limits to enhancing structural growth rate through top-down policy measures. While government initiatives and legislations may change the macro-institutional environment in which firms operate, firms themselves may find it difficult to adapt in ways that can enable them to make the best possible use of the new economic and business environment. At the same time, on account of their historical control over scarce resources, these firms may prevent the entry of more nimble and innovative new firms whose structures and actions are optimal for the new environment. The ability of emerging market economies to sustain high rates of growth over prolonged periods of time, therefore, depends as much on the changes in the nature of the organisations that are engaged in production as on the ability of the governments to reduce or eliminate institutional weaknesses.

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Table 1: Summary statistics

NIC code	Description	Sales		Labour cost		Capital		Material		
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Observations
107	Manufacture of other food products	1214.41	2943.72	124.82	305.10	707.38	2073.15	257.52	829.85	3194
131	Spinning, weaving and finishing of textiles	952.13	2248.96	109.06	238.14	600.44	2139.04	259.81	658.83	3697
139	Manufacture of other textiles	1094.93	2769.89	113.29	272.17	697.91	1990.40	259.40	680.16	2195
201	Manufacture of basic chemicals, fertilizer and nitrogen compounds	2390.57	7148.75	137.99	404.15	1451.82	4980.00	915.64	4376.94	3508
202	Manufacture of other chemical products	2356.04	9400.61	161.69	631.94	593.61	2009.60	819.88	4331.84	2311
210	Manufacture of pharmaceuticals, medicinal chemical and botanical product	1594.61	4150.78	189.79	568.77	658.12	1752.74	495.00	1409.97	3562
222	Manufacture of plastics products	880.34	2277.76	53.35	127.62	412.95	1199.05	148.58	403.61	2632
239	Manufacture of non-metallic mineral products n.e.c.	3302.15	9230.52	194.10	468.70	2105.10	6235.18	1418.37	4155.16	1801
241	Manufacture of basic iron and steel	4925.45	24588.50	337.47	2846.78	2637.20	13111.59	1101.91	4663.36	3520
282	Manufacture of special purpose machinery	1385.91	3694.42	153.04	392.52	325.92	890.86	203.45	591.14	1804
309	Manufacture of transport equipment n.e.c.	2369.90	8465.18	182.22	413.74	658.97	1742.88	285.96	931.34	3447
	All industries	2070.80	9926.72	163.13	1025.54	1005.36	5191.43	549.38	2746.02	31671

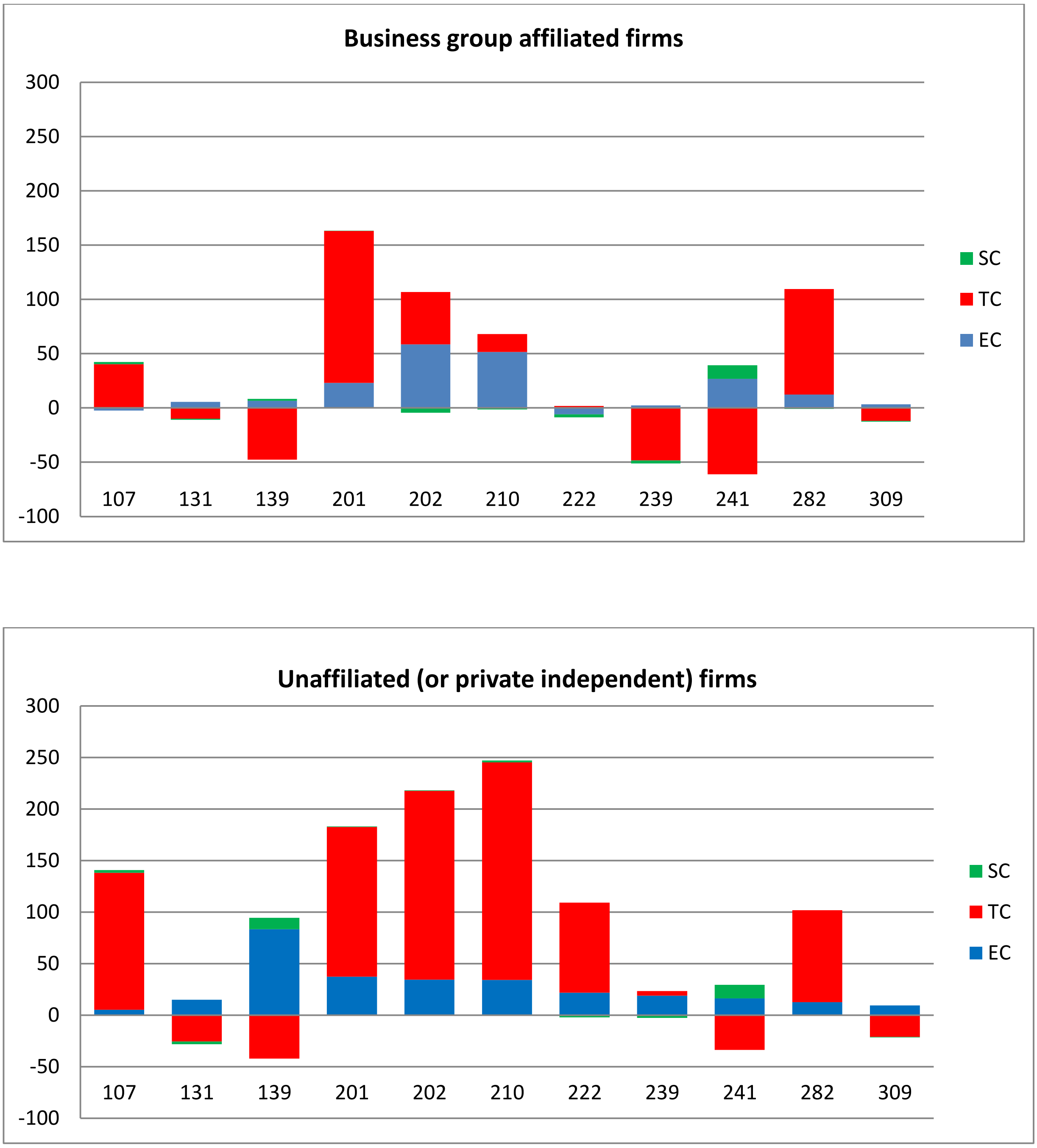
Note: All values in millions of Rupees

Table 2: Parameter estimation from stochastic frontier, 1999 and 2010

NIC Code	107 Manufacture of other food products	131 Spinning, weaving and finishing of textiles	139 Manufacture of other textiles	201 Manufacture of basic chemicals, fertilizer and nitrogen compounds	202 Manufacture of other chemical products	210 Manufacture of pharmaceuticals, medicinal chemical and botanical product	222 Manufacture of plastics products	239 Manufacture of non-metallic mineral products n.e.c.	241 Manufacture of basic iron and steel	282 Manufacture of special purpose machinery	309 Manufacture of transport equipment n.e.c.
β_k	0.437**	0.279**	0.464**	0.289**	0.140**	0.287**	0.216**	0.093**	0.306**	0.282**	0.425**
	(0.174)	(0.009)	(0.019)	(0.014)	(0.018)	(0.014)	(0.016)	(0.021)	(0.013)	(0.019)	(0.016)
β_l	0.106**	0.281**	0.144**	0.095**	0.191**	0.279**	0.223**	0.324**	0.266**	0.526**	0.375**
	(0.023)	(0.010)	(0.022)	(0.019)	(0.022)	(0.022)	(0.022)	(0.022)	(0.015)	(0.022)	(0.021)
β_m	0.537**	0.349**	0.345**	0.520**	0.557**	0.397**	0.514**	0.535**	0.281**	0.275**	0.242**
	(0.018)	(0.010)	(0.022)	(0.015)	(0.017)	(0.018)	(0.015)	(0.027)	(0.014)	(0.017)	(0.018)
β_{kk}	0.085**	0.062**	0.024**	-0.006	-0.051**	-0.001	-0.113**	-0.164**	-0.033**	0.018*	0.003
	(0.009)	(0.004)	(0.007)	(0.006)	(0.008)	(0.006)	(0.008)	(0.009)	(0.005)	(0.008)	(0.008)
β_{ll}	0.094**	0.083**	-0.022+	0.030*	-0.065**	-0.028*	0.039**	-0.129**	-0.091**	0.184**	-0.028+
	(0.017)	(0.007)	(0.013)	(0.014)	(0.013)	(0.012)	(0.017)	(0.011)	(0.007)	(0.014)	(0.015)
β_{mm}	0.096**	0.040**	0.055**	0.024**	0.041**	0.044**	0.055**	-0.077**	-0.115**	0.047**	0.051**
	(0.006)	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.013)	(0.004)	(0.007)	(0.006)
β_{kl}	-0.012	0.029**	0.180**	-0.048**	0.174**	0.158**	0.059**	0.140**	0.108**	-0.099**	0.258**
	(0.019)	(0.007)	(0.013)	(0.016)	(0.015)	(0.014)	(0.018)	(0.019)	(0.010)	(0.018)	(0.017)
β_{km}	-0.063**	-0.039**	-0.019	0.152**	0.004	-0.045**	0.170**	0.172**	0.013+	0.120**	-0.079**
	(0.011)	(0.007)	(0.012)	(0.010)	(0.011)	(0.011)	(0.012)	(0.017)	(0.007)	(0.013)	(0.015)
β_{lm}	-0.224**	-0.155**	-0.204**	-0.181**	-0.113**	-0.146**	-0.227**	0.056**	0.108**	-0.218**	-0.195**
	(0.019)	(0.011)	(0.017)	(0.012)	(0.014)	(0.013)	(0.017)	(0.021)	(0.008)	(0.017)	(0.018)
β_t	-0.585**	-0.143**	-0.203**	-0.400**	-0.082*	-0.221**	-0.086*	-0.336**	-0.441**	-0.344**	0.023
	(0.038)	(0.020)	(0.042)	(0.030)	(0.041)	(0.033)	(0.036)	(0.038)	(0.032)	(0.038)	(0.028)
β_{tt}	0.538**	0.113**	0.051	0.455**	-0.022	0.148**	0.072	0.244**	0.224**	0.324**	-0.055
	(0.049)	(0.024)	(0.054)	(0.036)	(0.051)	(0.042)	(0.046)	(0.049)	(0.038)	(0.049)	(0.035)
β_{tk}	-0.003	0.037**	-0.099**	0.030**	0.052**	0.062**	0.019	0.008	0.015	-0.102**	-0.002
	(0.014)	(0.007)	(0.014)	(0.010)	(0.015)	(0.012)	(0.013)	(0.014)	(0.009)	(0.014)	(0.012)
β_{tl}	-0.049**	0.003	0.144**	-0.033*	0.104**	0.032+	-0.028	-0.079**	-0.046**	0.046*	0.083**
	(0.019)	(0.009)	(0.018)	(0.015)	(0.019)	(0.018)	(0.019)	(0.017)	(0.010)	(0.019)	(0.016)
β_{tm}	0.013**	-0.023**	-0.036**	0.005	-0.143**	-0.122**	-0.033**	0.044**	-0.006**	0.044**	-0.063**
	(0.014)	(0.007)	(0.016)	(0.010)	(0.012)	(0.013)	(0.011)	(0.017)	(0.009)	(0.013)	(0.014)
RTS	1.079	0.909	0.953	0.904	0.889	0.963	0.952	0.953	0.853	1.084	1.042

Standard errors in parentheses
+ p<.10, * p<.05, ** p<.01
Note: Authors' estimation using fixed stochastic frontier method proposed by Greene (2003) (see equation (3)).

Figure 1: Rate of change in the components of TFP growth, 2000-2010



Note: From authors' own calculation.
National Industry Code (NIC) on the horizontal axis.

Table 3: Comparing technological change of business group affiliated and private independent firms

NIC code	Description	t-test (1)	Wilcoxon-Mann-Whitney rank-sum test (2)	Kolmogorov-Smirnov (3)
		8.18**	14.56**	0.28**
107	Manufacture of other food products	(0.00)	(0.00)	(0.00)
		- 7.38**	- 7.34**	0.16**
131	Spinning, weaving and finishing of textiles	(0.00)	(0.00)	(0.00)
		2.85**	3.19**	0.010**
139	Manufacture of other textiles	(0.00)	(0.00)	(0.01)
		2.19**	3.58**	0.10**
201	Manufacture of basic chemicals, fertilizer and nitrogen compounds	(0.01)	(0.00)	(0.00)
		1.19	- 1.25	0.07
202	Manufacture of other chemical products	(0.12)	(0.21)	(0.06)
		4.61**	12.42**	0.29**
210	Manufacture of pharmaceuticals, medicinal chemical and botanical product	(0.00)	(0.00)	(0.00)
		9.17**	13.44**	0.37**
222	Manufacture of plastics products	(0.00)	(0.00)	(0.00)
		11.68**	11.43**	0.25**
239	Manufacture of non-metallic mineral products n.e.c.	(0.00)	(0.00)	(0.00)
		17.06**	18.13**	0.35**
241	Manufacture of basic iron and steel	(0.00)	(0.00)	(0.00)
		1.42**	6.85**	0.22**
282	Manufacture of special purpose machinery	(0.16)	(0.00)	(0.00)
		- 4.20**	- 3.21**	0.07**
309	Manufacture of transport equipment n.e.c.	(0.00)	(0.00)	(0.00)

Notes: From authors' own calculation.

** indicates significant at 1% significant level, which indicates the hypothesis of no difference between group and non-group firms in terms of their TC growth rate can be rejected with 99% confidence.

p-value within parentheses.

(1) reports the t-test for equality of TC growth rate between group and non-group firms in India.

(2) reports the Wilcoxon-Mann-Whitney rank-sum test for equality of TC growth rate between group and non-group firms in India.

(3) reports the Kolmogorov-Smirnov test for equality of TC growth rate between group and non-group firms in India.

Table 4: Impact of group affiliation on technology change

	Cluster adjusted OLS		Panel Random Effect		Hausman-Taylor	
	(1)	(2)	(3)	(4)	(5)	(6)
Group	0.06+	0.15**	0.07**	0.13**	0.14+	0.21**
	(0.03)	(0.04)	(0.02)	(0.02)	(0.08)	(0.08)
Foreign	-0.00	0.07	0.01	0.06+	0.11	0.16
	(0.04)	(0.04)	(0.04)	(0.04)	(0.15)	(0.15)
Time Trend	0.08**	0.08**	0.07**	0.08**	0.09**	0.09**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Time Trend*Group	-0.05**	-0.05**	-0.05**	-0.05**	-0.06**	-0.06**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Time Trend*Foreign	-0.06**	-0.06**	-0.06**	-0.06**	-0.08**	-0.08**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
Large		-0.23**		-0.18**		-0.16**
		(0.02)		(0.01)		(0.05)
Firm Age		-0.003**		-0.003**		-0.005**
		(0.001)		(0.0004)		(0.00)
Industry effect	YES***	YES***	YES***	YES***	YES***	YES***
Constant	-0.62**	-0.47**	-0.51**	-0.37**	-0.49**	-0.35**
	(0.05)	(0.06)	(0.03)	(0.04)	(0.09)	(0.11)
N	27717	27658	27717	27658	25344	25289

Robust standard errors in parentheses

+ p<.10, * p<.05, ** p<.01

Base industry is manufacture of other food products (NIC 107).

Note: OLS is estimated with clustered standard error at individual level to control for possible individual heterogeneity. The results reported are estimated for 2000 to 2010. The dependent variable is chain linked change rate in technology changes (TC).

Table 5: Robustness check: including R&D and off shelf technology purchase as control variable (panel random effects)

	(4a)	(4b)	(4c)
Group	0.17**	0.16**	0.17**
	(0.03)	(0.03)	(0.03)
Foreign	0.11**	0.12**	0.11**
	(0.04)	(0.04)	(0.04)
Time Trend	0.09**	0.09**	0.09**
	(0.01)	(0.01)	(0.01)
Time Trend*Group	-0.06**	-0.06**	-0.06**
	(0.01)	(0.01)	(0.01)
Time Trend*Foreign	-0.07**	-0.07**	-0.07**
	(0.01)	(0.01)	(0.01)
Large	-0.19**	-0.19**	-0.19**
	(0.01)	(0.01)	(0.01)
Firm Age	-0.003**	-0.003**	-0.003**
	(0.00)	(0.00)	(0.00)
R&D	-1.51		-1.51
	(1.08)		(1.09)
Off the shelf technology		0.15	0.15
		(1.24)	(1.24)
Industry effect	YES***	YES***	YES***
R&D × Industry	YES***		YES***
Off the shelf technology × Industry		YES***	YES***
Constant	-0.47**	-0.47**	-0.47**
	(0.05)	(0.05)	(0.05)
N	25289	25289	25289
Sigma_u	0.95	0.95	0.95
Sigma_e	1.67	1.67	1.67
Rho (fraction of variance due to *u*)	0.24	0.24	0.24
F-statistic	174.81***	55.94***	226.33***

Robust standard errors in parentheses
+ p<.10, * p<.05, ** p<.01
Base industry is manufacture of other food products (NIC 107).
Note: The results reported are estimated for 2000 to 2010. The dependent variable is chain linked change rate in technology changes (TC). The F test is for joint significance of R&D or/and off the shelf technology and their interaction terms with industry dummies.

Appendix A1: Robustness check: including R&D and off shelf technology purchase as control variable (Hausman-Taylor)

	(6a)	(6b)	(6c)
Group	0.21**	0.21**	0.21**
	(0.08)	(0.08)	(0.08)
Foreign	0.16	0.16	0.16
	(0.15)	(0.15)	(0.15)
Time Trend	0.09**	0.09**	0.09**
	(0.01)	(0.01)	(0.01)
Time Trend*Group	-0.06**	-0.06**	-0.06**
	(0.01)	(0.01)	(0.01)
Time Trend*Foreign	-0.08**	-0.08**	-0.08**
	(0.02)	(0.02)	(0.02)
Large	-0.16**	-0.16**	-0.16**
	(0.05)	(0.05)	(0.05)
Firm Age	-0.005**	-0.005**	-0.005**
	(0.001)	(0.001)	(0.001)
R&D	-0.67		-0.69
	(6.74)		(6.74)
Off the shelf technology		-2.16	-2.15
		(2.97)	(2.97)
Industry effect	YES***	YES***	YES***
R&D × Industry	YES***		YES***
Off the shelf technology × Industry		YES***	YES***
Constant	-0.35**	-0.34**	-0.34**
	(0.11)	(0.11)	(0.11)
N	25289	25289	25289

Robust standard errors in parentheses
+ p<.10, * p<.05, ** p<.01
Base industry is manufacture of other food products (NIC 107).
Note: The results reported are estimated by Hausman-Taylor estimator for 2000 to 2010. The dependent variable is chain linked change rate in technology changes (TC). The F test is for joint significance of R&D or/and off the shelf technology and their interaction terms with industry dummies.

Appendix A2: Impact of group affiliation on efficiency change (panel random effects)

	(4a)	(4b)	(4c)
Group	0.03	0.02	0.02
	(0.04)	(0.04)	(0.04)
Foreign	0.06	0.05	0.05
	(0.08)	(0.08)	(0.08)
Time Trend	0.03**	0.03**	0.03**
	(0.00)	(0.00)	(0.00)
Time Trend*Group	-0.01	-0.00	-0.01
	(0.00)	(0.00)	(0.00)
Time Trend*Foreign	-0.02*	-0.02*	-0.02*
	(0.01)	(0.01)	(0.01)
Large	-0.24**	-0.23**	-0.23**
	(0.03)	(0.03)	(0.03)
Firm Age	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
R&D	1.55*		1.56*
	(0.73)		(0.71)
Off the shelf technology		-0.22	-0.21
		(0.39)	(0.39)
Industry effect	YES***	YES***	YES***
R&D × Industry	YES***		YES***
Off the shelf technology × Industry		YES***	YES***
Constant	-0.16**	-0.14**	-0.14**
	(0.04)	(0.04)	(0.04)
N	25289	25289	25289
Sigma_u	0.99	0.97	0.96
Sigma_e	0.88	0.87	0.87
Rho	0.55	0.55	0.55
F-statistic	85.09**	144.01***	229.28***

Robust standard errors in parentheses

+ p<.10, * p<.05, ** p<.01

Base industry is manufacture of other food products (NIC 107).

Note: The results reported are estimated for 2000 to 2010. The dependent variable is chain linked change rate in efficiency changes (EC). The F test is for joint significance of R&D or/and off the shelf technology and their interaction terms with industry dummies.

Appendix A3: Impact of group affiliation on efficiency change (Hausman-Taylor)

	(6a)	(6b)	(6c)
Group	0.03	0.03	0.03
	(0.05)	(0.05)	(0.05)
Foreign	0.14	0.12	0.12
	(0.10)	(0.10)	(0.10)
Time Trend	0.03**	0.03**	0.03**
	(0.00)	(0.00)	(0.00)
Time Trend*Group	-0.01	-0.00	-0.01
	(0.00)	(0.00)	(0.00)
Time Trend*Foreign	-0.02*	-0.02*	-0.02*
	(0.01)	(0.01)	(0.01)
Large	-0.25**	-0.24**	-0.23**
	(0.03)	(0.03)	(0.03)
Firm Age	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
R&D	1.89		1.85
	(3.97)		(3.92)
Off the shelf technology		-0.05	-0.05
		(1.72)	(1.71)
Industry effect	YES***	YES***	YES***
R&D × Industry	YES***		YES***
Off the shelf technology × Industry		YES***	YES***
Constant	-0.23**	-0.21**	-0.21**
	(0.08)	(0.08)	(0.08)
N	25289	25289	25289

Robust standard errors in parentheses
+ p<.10, * p<.05, ** p<.01
Base industry is manufacture of other food products (NIC 107).
Note: The results reported are estimated by Hausman-Taylor estimator for 2000 to 2010. The dependent variable is chain linked change rate in efficiency changes (EC). The F test is for joint significance of R&D or/and off the shelf technology and their interactions with industry dummies.

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