Competition, Technology, Innovation and Exports: Contemporary Theoretical Insights

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1 Introduction

In this essay, we discuss new theoretical insights in understanding certain enduring and emerging issues in the context of industrial organization and trade and more specifically on the role of competition in determining innovations and exports. Technology and finance are also critical in this context and hence are also included. Two major contributions are incorporating increasing marginal costs rather than working with constant marginal costs, as has been the universal norm with the models of industrial organization and explicitly including financial factors in decisions to export

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when firms face credit constraints. We discuss variety of results and provide intuitive outline of the theoretical models which have been referred. Several interesting infrequently answered queries are addressed.

Competition, technology and innovation are highly complex phenomena, and so is their interaction. In an oligopolistic set-up, generally the firms are faced with two choices, namely to form a collusion among themselves or to compete with each other. The literature has umpteen number of contributions where the said choices of the firms are analysed using game-theoretic models. Linear demand constant marginal cost framework has been extensively used. However, this framework shows that technology has no role to play as far as above-stated choices of the firms are concerned. Celebrated textbooks of Tirole (1988), Gibbons (1992), Shy (1996), Martin (2001), etc., show that the collusive is only driven by the discount factor.

However, altering the above framework by replacing the constant marginal cost assumption by increasing marginal cost offers very novel insights not only with regard to the final outcome of collusion or competition and welfare (Marjit et al., 2017) but also has implications for innovation (Misra, 2019) and export decision of the firms (Marjit & Ray, 2017). While Marjit and Ray (2017) analyse the export profitability of firms for a given level of technology and credit constraints, Misra (2019) addresses the issue of innovation incentives for firms with respect to the evolutionary dynamics of technology and competition.

The paper proceeds as follows. Section 2 reviews the literature pertaining to firms' choice of collusion or competition and then highlights the role played by technology in the said choice, while 2.1 reviews the literature pertaining to the innovation decision by the firms. Section 3 surveys the literature on the role of competition and technology on the export profitability of the firms and then also highlights the literature focusing on credit market and firm behaviour. Section 4 concludes.

2   Technology and Market Structures

In the context to the firms' decision to collude, until the very recent past in the literature, the critical discount factor determining the collusive or competitive outcome(s) was equal to a constant, $\frac{9}{17}$ (Gibbons, 1992). Studies addressing the firms' choice to collude or compete were using the linear demand constant cost framework, and the above stated result had been the generally accepted conclusion. We change the basic framework in the analysis of the firms' choice to collude or compete and derive significantly different results. We maintain the same linear demand but consider quadratic costs instead of the constant costs and conclude that technology improvement has the potential to alter market structures. These alterations in market structures have welfare and policy implications. We show that not only our results are very different from the ones in the literature but also our generalization of the analysis from the two-firm Cournot duopoly to the n-firms Cournot oligopoly gives a new set of results with regard to both the impact of technology on collusion and thus on market structures and also the act of innovation by the firms.

Firms take strategic decisions regarding collusion. Various considerations that the firms may have regarding their decision to collude could be but not limited to homogeneity/heterogeneity of the product, symmetries/asymmetries in costs, etc. The issue of collusion has been addressed from various perspectives like product differentiation (Deneckere, 1983; Wernerfelt, 1989; Chang, 1991; Ross, 1992; Symeonidis, 2002; Collie, 2006; Weibull 2006), asymmetric firms (Harrington, 1989) and cheap talks (Campbell, 1998; Miralles, 2010).

Deneckere (1983) analysed duopoly supergames with heterogeneity in goods. Working with a multi-product demand function in a repeated game set-up, he derived trigger strategy equilibrium in both Bertrand set-up (i.e. price setting supergames) as well as in Cournot set-up (i.e. quantity setting supergames). The degree of product differentiation is measured by an exogenously given parameter embedded in the demand functions. The least or the minimum discount factor supporting the maximum joint profit as a subgame perfect Nash equilibrium is a measure of the ease of collusion. This minimum discount factor is shown to be non-monotonically related to the substitutability between the goods. He found that when goods are very close substitutes or complements, trigger strategies of firms are more conducive to tacit collusion between the firms in supergames in Bertrand set-up (i.e. price setting supergames) as against in Cournot set-up (i.e. quantity setting supergames). However, the exact opposite happens, i.e. the situation is reversed, in case of moderate or poor substitutability between the goods. The welfare implications of his results are in contrast to those of the static situation where higher welfare always comes about by the Bertrand set-up (i.e. the price setting strategies) as against the Cournot set-up (i.e. the quantity setting game). It is suggested that the exact opposite welfare implications may come about for very close substitutes or complements.

In a simple supergame, Wernerfelt (1989) analysed tacit collusion in Cournot set-up with differentiated goods. In the context of optimal punishments, he analysed the effect of product differentiation on the maximum degree of tacit collusion, where the focus is on the analysis of conditions under which tacit collusion is easily brought about by production differentiation. He found that the net effects, which depend upon the temptation to cheat and the penalty effects, depending upon which dominates, could go either way.

Basing his paper on Hotelling's (1929) spatial competition framework, Chang (1991) analysed the relationship between the degree of product differentiation and the firms' ability to collude in price setting games, i.e. the Bertrand set-up. It is shown that the least or the minimum discount factor that is required to support the joint profits of the firms as a subgame perfect Nash equilibrium is a monotonically increasing function of the substitutability between the products; i.e. it monotonically increases as the products become better and better substitutes. This result is in contrast to the findings of Deneckere (1983) that the minimum discount factor is non-monotonically related to the substitutability between the goods. The optimal collusive price in Chang (1991) is shown to decline (and thus the joint profits cannot be supported) when the substitutability between the product increases. The paper's ultimate finding is that as the substitutability between the goods increases it is tougher for the firms to collude in price setting games.

Engaging with product differentiation and the stability of the cartel, Ross (1992) presented two models in which differentiated goods are being supplied by the cartels. Using a supergame-theoretic model of collusion, he analysed the effects on the stability of cartels that are brought about by the differing levels of product differentiation. The paper focused on how the increased product homogeneity has a positive impact on both, the benefits due to defection from a collusive agreement as well as the quantum of punishments following such defections. Results due to his supergame-theoretic analysis revealed that when finding an agreement is unproblematic, product differentiation may not hamper the stability of the cartel. The overall effect on the stability of the cartels, however, is not unambiguous. Finally, by making use of product differentiation model, contrary to the view from the literature, he shows that the stability of the cartels may be inversely related to product homogeneity; i.e. product homogeneity can diminish cartel stability.

Symeonidis (2002) also worked on cartel stability, but with multi-product firms. For a market which is horizontally differentiated, he examined the implications of the presence of multi-product firms on the stability of collusion. He found that in Cournot set-up (i.e. quantity setting supergames), for any arbitrarily given number of firms, the critical discount factor, above which collusion is rendered sustainable by means of trigger strategies by the firms, is an increasing function of the variety of goods produced by the firms. Thus, for a given number of firms, the critical discount factor increases as the number of varieties of goods produced by the firms increases. As a result, the likelihood of collusion diminishes. Generally, similar results come about in case of Bertrand set-up (i.e. price setting supergames) as well. However, these results may not hold in cases when the number of firms is small and the products are close substitutes.

Collie (2006) and Weibull (2006) worked with convex cost in their analysis of collusion by firms. Collie (2002) engaged with collusion in differentiated duopolies with quadratic costs (linear marginal cost) and compared the sustainability of collusion under Cournot and Bertrand duopoly with differentiated goods. He showed that if the marginal cost is sufficiently increasing, then for any degree of product substitutability, collusion is more easily sustainable in a Cournot set-up than in a Bertrand set-up. Weibull (2006) generalized the Bertrand model from linear cost to convex cost functions. He analyses price competition in both the static (one shot game) set-up, where the firms interact just once, and the dynamic (repeated game) set-up, where the firms interact repeatedly over and over again over uncertain future. He showed that there exists an interval of prices in equilibrium in both the static and the dynamic set-ups. He hinted that firms may earn huge profits and that their profits may be increasing in their production costs.

Considering the discount factors of the firms, with regard to collusion, Harrington (1989) analysed collusive behaviour of firms. Specifically, he investigated the collusive behaviour of the firms which are asymmetric in their discount factors. He developed a selection criterion which not only generates a unique collusive outcome but also respects the incentive compatibility constraints. This criterion leads to a unique collusive outcome in terms of output and prices. It is not important for the firms to have high discount factors for self-enforcing collusion; rather, what is important is

that the firms have long-run view. Optimal collusive outcome is characterized by a unique relationship between output quotas and the discount factors of the firms. At the equilibrium, there are strictly ordered output quotas and the firms with relatively low discount factor get a disproportionately high share of the market demand. Also, in the event of collusion, the firm's discount factor inversely impacts its output quota and its profits.

Campbell (1998) and Miralles (2010) analysed the issue of collusion through cheap talk. Campbell (1998) studied coordination and the self-enforcing collusion in simultaneous second-price auctions characterized by entry costs and focused on the ranking mechanism. Initially, the bidders indulge in pre-play communication whereby they publicly signal their rankings of the objects to be auctioned. Thereafter, each bidder decides as to in which auction she/he would participate. Finally, the bidder pays the entry cost and participates in the auction. Campbell (1998) worked with two-bidder case and showed that there always exists a full comparative cheap talk (a truthful ranking revelation) equilibrium. As the number of objects to be auctioned gets large, the above mechanism leads to asymptotically fully efficient collusion.

Miralles (2010) based his study on Campbell (1998). He extended and analysed the above-said mechanism with more than two bidders. He has two prominent results: namely, (1) an enhancement in the number of objects (to be auctioned) leads to a full comparative cheap talk equilibrium yielding asymptotically fully efficient collusion and (2) partial comparative cheap talk equilibrium always exists. Through numerical examples he also suggests that even in event of fewer objects to be auctioned, full comparative cheap talk equilibria are pretty common.

In analysis of collusion with the context of homogeneous goods with constant marginal cost, the main contributions are from Gibbons (1992), Martin (2001), Shy (1996) and Tirole (1988). They show that the existence of collusion or Cournot competition as the subgame perfect equilibrium (SPE) in an infinitely repeated game is independent of the level of technological advancement. Collusion is shown to depend only upon the magnitude of the discount factor(s) of the concerned firms.

Marjit et al. (2017) show that changing the assumption of constant marginal cost to increasing marginal cost drastically alters the result and has other interesting implications for cost reducing technological improvement. Specifically, they show that in an infinitely repeated game framework, technological improvement increases the critical discount factor, above which collusion is the SPE. Hence, as technology improves and reaches a certain level, the SPE market structure switches from collusion to Cournot competition generating additional welfare gains. So, the infeasibility of an alteration of market structure that is present under constant marginal cost set-up is removed by the increasing marginal cost assumption. Thus, they show as to how market structures can evolve with technological changes. As technology improves, it gets difficult to maintain collusion and hence innovation leads to competition. But potential does exist to explore opposite results when innovation leads to market concentration. This may happen when one party wins the R and D race, but, ex ante if the outcome is symmetric, i.e. all firms can win the race, with constant MC nothing really changes in terms of incentives to collude, but with increasing MC the result is different.

Lahiri and Ono (2004) focused on trade and industrial policy under international oligopoly. They deeply analysed the industrial and trade policies in a framework where many countries are involved with each other for the purposes of trade. Under the imperfect competition conditions, they analysed various trade policies, industrial policies and R&D subsidies in a market characterized by Cournot oligopolistic interdependence among the agents, in production. Their first chapter is closely related to our work. In this chapter, they analyse an oligopolistic industry having finite number of firms with asymmetric costs rendered by asymmetric technology levels. They categorized the firms as major (efficient) or minor (less efficient) firms. They showed that, at an average, the elimination of minor firms raises the efficiency of the firms, in terms of production, in the industry. It also increases the degree of oligopolistic market structure (the competition economics literature sees this as hampering of competition) leading to reduction in the aggregate output and increase in the price and thus, as a result, a reduction in the consumers' surplus. The authors showed that such an improvement in the efficiency in production over all enhances aggregate welfare and addresses the problem of misallocation of production by diverting/shifting production from the minor (less efficient) to major (efficient) firms. They suggest that a tax-cum-subsidy policy that favours major (efficient) firms and adversely affects the minor (less efficient) firms is better than a tax-cum-subsidy policy that favours the minor (less efficient) firms and adversely affects the major (efficient) firms as the former enhances aggregate welfare by correcting the problem of misallocation of production while the latter hampers aggregate welfare by distorting production by misallocating it.

Outsourcing at international level has grown significantly over the recent years. The literature has focused mainly on explaining the make or buy decision of the firms. However, not much has been said about the said (make and buy) decisions of the firms. Analysing cooperation among the final goods producers in the product market, Beladi and Mukherjee (2012) offered a new logic for bi-sourcing. By bi-sourcing, they refer to a situation when the producer of a final good engages in both buying the inputs from a seller from the input market and producing the input himself. They observed that the market structure with regard to inputs is the primary determinant of bi-sourcing. If the input market is perfectly competitive or if there are symmetric input suppliers engaged in Bertrand competition without capacity constraint, the price of input obtainable from the outside sellers would be low and equal to the marginal cost of production and thus there would not be any incentive for bi-sourcing and the firm would buy its input from outside. But, if the input market is imperfectly competitive then the market power of the outside input supplying firms enables them to charge a price higher than the marginal cost of production and thus the final good producing firm would produce some amount of input in-house along with buying from outside, i.e. bi-sourcing would emerge. They also showed that bi-sourcing (certain amount of in-house input production), even when the marginal cost of the in-house production of input is more than that of the outside input supplier, enhances consumers' welfare as against complete outsourcing the inputs to a firm with lower marginal cost of production.

Crucial insights with regard to the outcomes of international negotiations on enforcement of patents in the southern countries are provided by Mukherjee and Sinha (2013). They worked with a North–South trade model and analysed the impacts of the southern patent protection on the innovation, profits and welfare of the southern countries. They, in the presence of southern innovation, challenged the justification of the blanket approach for patent protection in the developing countries. Considering international negotiations for efficient global patent regime, they showed that patent harmonization is neither necessary nor sufficient. Their result that the stronger southern patent protection may not benefit the north contrasts that of Grossman and Lai (2004). There would always be cooperation between the firms as it would increase their profits through creation of monopoly and elimination of imitation in the industry through scrapping off the incentive of the firms to compete with each other. However, the overall impact on the aggregate welfare is not unambiguous and immediate due to the induced trade-off between the incentive for innovation and the higher market concentration. The cost of southern innovation and the degree of substitutability between the products are the main factors which drive the impact of the southern patent protection on both a country's and the world's welfare.

Motivated by empirical findings regarding joint venture breakdown, Marjit and Raychaudhuri (2004) worked with asymmetric capacity costs and joint venture buyouts. They developed a simple model, basing it on the asymmetric access to capital, synergy and the size of the market. Level of demand or the market size plays a significant role in their analysis. A low level of demand or a smaller market size leads to the formation of joint ventures, while a sufficient enhancement in the level of demand or the market size always breaks down the joint venture and leads to a buyout. Their model also predicts the likely effects of tariff polices. For instance, if a reduction in the tariff levels in an industry by the government results in a reduction in the demand levels or the market size faced by the existing firms. And thus, as a result in turn, their theory predicts that the stability of joint ventures should be enhanced.

The long-run implications of international outsourcing and R&D for the consumers are analysed by Marjit and Mukherjee (2008). They developed a simple Cournot oligopoly model with an innovator who is also the potential outsourcing firm and showed the effect of outsourcing on the investment on R&D. They showed that international outsourcing and the investment on R&D may be either substitutes of each other or complementary to each other. They showed that outsourcing increases the investment on R&D in both small and highly competitive product markets while it decreases the investment on R&D in large markets. However, if under exporting, the outsourced firm is very efficient technologically, then outsourcing would hamper consumer surplus through reduced investment on R&D. They suggest that in the event of skill differential among the workers, the outsourcing that reduces the investment in R&D will take place in the relatively low-skilled industry. Outsourcing would further depress the investment in R&D if the outsourcing of the unskilled jobs decreases the effective costs of the skilled workers through enhancing their efficiency as against the situation that outsourcing does not affect the effective costs of the skilled workers.

Analysing the impact of outsourcing of production on the magnitude and composition of the investment in R&D of the home country, Beladi and Mukherjee (2013) had

set up a model in which a multinational firm and a local firm compete in the developing country while producing heterogeneous or differentiated goods. They assumed that the cost of R&D does vary with outsourcing. They showed that outsourcing reduces the process R&D of the multinational firm in the large markets when the firm only conducts the process R&D. This happens due to the substitution effect between outsourcing and the process R&D. However, outsourcing emerges as a complement to product development when the multinational firm conducts both product and the process R&D, under certain conditions. However, this happens due to the complementary effect between outsourcing and product R&D. Thus, outsourcing emerges as a substitute to process R&D while a complementary factor to the product R&D. Their analysis hints that international outsourcing has disparate effects on process innovation and product innovation.

Continuing contributions to the long trending voluminous literature on technology transfer and patents in the developing world, two recent papers deal with restrictive policy and endogenous R and D and on patent rights, innovation and outsourcing in a vertical chain. Hong et al. (2016) extending Kabiraj and Marjit (2003) show that restrictive policy may facilitate technology transfer, but can hurt the country in the longer run by affecting innovations of the foreign firms. Beladi et al. (2016) argue for strong IPRs for increasing the incentive of the imitator to do R and D in the intermediate stage, leading to the more efficient outcome.

Bandyopadhyay et al. (2014) worked with international oligopoly, barriers to outsourcing and domestic employment. They, in an international oligopolistic set-up, where two developed nations produce a homogeneous good and compete with each other to sell the good in a third country, analysed as to how domestic employment is affected by the barriers to outsourcing. They showed that an outsourcing tax unambiguously makes the domestic labour cheaper, but the effect of the outsourcing tax on employment is not unambiguous. This happens due to strategic considerations. Considering international policy interdependence, they showed that a unilateral tax (subsidy) raises the domestic employment of the country; however, in Nash policy equilibrium, this may be counterproductive. They finally showed that both an increased product differentiation and a credit crisis worsen the employment effects of an outsourcing tax. Their results are robust in both, the Cournot and the Bertrand set-ups.

2.1   Innovation Incentives

Incentives to innovate have been analysed from various angles such as product differentiation, horizontal—Bester and Petrakis (1993) and vertical—Bonanno and Haworth (1998), profit incentives—(Yi, 1999; Delbono & Denicolò, 1990). This literature suggests that different measures of competition affect the firms' incentives to innovate in different ways.

Market structures and innovation have occupied the centre stage in the innovation literature since 1943 (Schumpeter's Capitalism, Socialism, and Democracy). The

'Schumpeterian trade-off'—perfectly competitive firms perform well in the sense of efficient allocation of resources (in the static sense) but poorly in terms of innovation, and have been dominant in many contributions (Sylos-Labini 1969; Scherer 1980; von Weizsacker 1980, Nelson & Winter, 1982; Kamien & Schwartz, 1982). Thus, the optimal market form seems to be the one having elements of monopoly.

However, later it was shown that perfect competition was more conducive to innovation than monopoly as there are more incentives for perfectly competitive firms to innovate as against a monopolist (Arrow, 1962). This is so because the monopolist already makes profits before innovation while the perfectly competitive firm just recovers its costs. Belleflamme and Vergari (2011) present a unified framework, whereby various sources of competition interact and shape the firm's incentives to innovate. They study the intensity of competition on innovation incentives and argue, in consonance of the existing literature (both, theoretical (Scherer (1967b), Barzel (1968), and Kamien and Schwartz (1972, 1976) and empirical (Mansfield, 1963; Williamson, 1965; Scherer, 1967a) that in contrast to the diametrically opposite and extreme cases of perfect competition and monopoly, the intermediate market forms may offer higher innovation incentives. However, they (Belleflamme & Vergari, 2011) qualify their findings by stating that different market forms create different incentives for innovation in different industries.

Tandon (1984) extends the Dasgupta and Stiglitz (1980) approach for analysis of the trade-off between static and dynamic efficiency. Optimal market structure or optimal degree of concentration is the main focus in answering the questions, '*are barriers to entry in addition to those created by R&D desirable?'* He finds the answer to be in the affirmative.

Traditional view suggests that entry of a firm in a market decreases the profit of the incumbent firms. However, introduction of R&D activities may lead to conclusions in contrast to the traditional view. Ishida et al. (2011) show that entry of a firm with a less efficient technology enhances both the R&D investment and the profit of the incumbent firms (which have a more efficient production technology). Entry in the presence of marginal cost differences decreases welfare in Cournot oligopoly set-up if the constant marginal cost of the entrant is sufficiently higher than those of the incumbents (Klemperer, 1988; Lahiri & Ono, 1988). Thus, this literature again is in contrast to the conventional view that entry enhances welfare, and may not hold in Cournot oligopoly set-up. There is also a part of the literature focusing on asymmetry due to differences in firm-level R&D capabilities. Interested readers may see Gallini (1992), Bester and Petrakis (1993), Mukherjee (2002), Mattoo et al. (2004) and Mukherjee and Pennings (2004, 2011).

Some studies have also shown that entry of firms may enhance the incumbent firms' profits. Working with a sequential move model in an asymmetric (marginal cost) Stackelberg set-up, Mukherjee and Zhao (2009) show that an inefficient follower (entrant) increases the profits of the incumbent firms (two) which, though, are heterogeneous in their efficiencies, but are relatively more efficient compared to the follower (entrant). However, similar results are also obtained by Coughlan and Soberman (2005), Chen and Riordan (2007), and Ishibashi and Matsushima (2009), but the difference is that they use simultaneous moved models.

Misra (2019) considers generalization of the increasing marginal cost linear demand model and shows that the profit of a colluding firm is always an increasing function of technological improvement; i.e. a cost reducing technological improvement always enhances an individual firm's profit under collusion. However, the same may not hold under Cournot competition; as in this situation, innovation may not be rewarding. The results indicate that cost reducing technological improvement: (i). unambiguously increases a firm's profit under collusion and (ii). increases a firm's profit under Cournot oligopoly iff there are at the most three firms in the market. Only if there are three or lesser firms, a cost-cutting technological improvement increases an individual firm's profit with certainty, else not. Thus, there would be conditional innovation by the firms, i.e. innovation contingent upon the number of firms in the market and the level of technology. Specifically, if the technology is already advanced and competition intensifies then firms would not innovate. This is very different from a Cournot model with constant marginal cost where cost-cutting innovation is always profitable. The author captures a dynamic interaction of technology with the possibility of innovation via the intensity of competition. It is shown that the intensity of competition and welfare may not have the usual (direct) relationship and 'monitored competition', wherein initially (at initial stages of innovation) competition is encouraged and then (at later stages of innovation) curtailed, to encourage innovation and thus welfare, as a suitable policy measure.

3   Exportability, Credit Market and Innovation

So far, the analysis is confined to the firms' behaviour in a domestic market leaving the possibility of export out of the purview. This section reviews the literature that concentrates on the export market along with domestic outlets. More specifically, the thrust is on two issues in the field, namely (a) the effect of competition and technology on export profitability of firms and (b) the role of credit market in the study of firm behaviour when export possibilities are allowed.

The central point of debate in the context of the role of 'competition' is whether the introduction of competitive forces in an otherwise restrictive economy would usher in economic development. The question is examined in the micro-context by way of evaluating the relationship between export profitability and competition. In this field, Clougherty and Zhang (2009) study the relationship between domestic rivalry and export performance on the basis of the world airline industry. Their paper develops a theoretical model with two markets—one domestic and the other international—dealing in a single industry. It highlights that the domestic rivalry enables domestic firms to improve and innovate the production process. As a result, they get a large share in the export market. In their paper, some measure of export performance (e.g. world market share, net exports, export revenue) is regressed on some measure of domestic rivalry (e.g. four-firm concentration ratio, Herfindahl–Hirschman index, instability in market shares) at the industry-wide level of analysis. Data from the world airline industry is used to test the impact of domestic rivalry on

export performance. A fixed panel-and-period effect regression model is used here,

$$
\begin{aligned}
\text{International} - \text{Market} - \text{Share}_{it} = {} & b_0 \\
& + b_{1*}(\text{International} - \text{Market} - \text{Share})_{it-1} \\
& + b_{2*}(\text{International} - \text{Market} - \text{Share})_{it-2} \\
& + b_{3*}(\text{Domestic} - \text{Competitors})_{jt} \\
& + b_{4*}(\text{Domestic} - \text{Market} - \text{Share})_{kt} \\
& + b_{5*}(\text{Domestic} - \text{Network})_{kt} + b_{6*}(\text{Merger})_{kt} \\
& + b_{7*}(\text{Foreign} - \text{Rivalry})_{kt} \\
& + b_{8*}(\text{Domestic} - \text{Competitor} - \text{Network})_{kt} \\
& + b_{9*}(\text{Home} - \text{Competitors})_{it} \\
& + b_{10*}(\text{International} - \text{Competitors})_{it} + \varepsilon_{it} + \alpha_i + \gamma_t
\end{aligned}
$$

where i indexes an airline's international country-pair market (433 of them), j indexes the nineteen countries, k indexes the thirty-seven airlines, t indexes time, αi represents the fixed panel-specific effect and γt captures the fixed period-specific effect.

Some studies in the literature focus extensively on the relationship of competitiveness and exports. In one of such studies by Barua, Chakraborty and Hariprasad (2010), an attempt is made to examine the interrelationships between entry and competitiveness in a consistent oligopolistic market framework. The basic theoretical model underlying the current empirical exercise is based on the segmented market hypothesis as put forward in a series of papers by Agarwal and Barua (1993, 1994, 2004). The main arguments of these papers are that entry liberalization would result in (a) increase in aggregate exports, (b) reduction in industrial concentration, (c) decrease in price-cost margin and (d) increase in social welfare. It is an empirical analysis on the basis of firm-level data for 14 sectors in India over 1990–2008. The model assumes that the firm behaves like a discriminating oligopolist between domestic and foreign markets. It is also assumed that the firms belonging to an industry produce a homogeneous product and all of them play the Cournot competition. From the first-order maximization condition of profit maximization subject to demand function, the price-cost margin is calculated. One of the central observations in the study is that the price-cost margin rises over the years 1990–1995 with the decline in concentration ratios. The paper concludes that India's liberalization results in lowering the concentration ratio and escalating the price-cost margin. This in turn signifies a better performance of export-oriented firms.

Das and Pant (2006) use a leadership model to underscore that the new industrial policy in India is not able to foster competition by facilitating the expansion of small firms. This is indicated by the calculation of markups. The model shows that the markups of small firms are higher than those of larger firms. The relevance of 'competition' evolves in various literatures including the paper of Das and Pant (2006). The issues of competitiveness, export intensity and productivity are empirically analysed through the estimation of markups in Barua, Chakraborty and Hariprasad (2010)

and Das and Pant (2006). Again, the paper by Clougherty and Zhang (2009) uses the concept of market shares to denote domestic rivalry. In their paper, the effect of domestic rivalry is studied using the Herfindahl index. The Herfindahl index as a measure of concentration is also adopted in Calkins (1983). On the other hand, the price-cost margin is used as a proxy for the degree of competition in Aghion et al. (2008), Martins et al. (1996) and Borg (2009). However, these indices of measuring the degree of competitiveness fail to account for the reallocation of market shares in the economy.

In the milieu of 'technology', a rich literature has been developed on the relationship between trade and technology, and the majority of them on the causation from former to latter. The argument is that by importing products and services that embody new technology, the host country is able to introduce foreign technology in home production. A number of studies identify these so-called R&D spillovers as one of the major benefits of trade. For example, Eaton and Kortum (1996) and Bernstein and Mohnen (1998) estimate R&D spillovers from the USA to Japan juxtapose to that from Japan to the USA and suggest the former's predominance. Coe and Helpman (1995) show that for 1971–90, R&D expenditures that G7 undertook yielded 30% gain in total factor productivity in smaller industrial countries. This study has, however, been modified/extended in many respects. Thus, a specification error in one of their regressions is identified, and also the measure of R&D spillovers is modified, by Lichtenberg and van Pottelsberghe de la Potterie (1996, 1998).

Perla et al. (2015) develop a model trade-induced technology diffusion in line with Perla and Tonetti (2014). Considering the prevalence of both backward and advanced technologies in the domestic economy, they show how under the scope of better export opportunities and the pressure of foreign competition, the domestic firms adopt better technology and thus speed up technology diffusion. Trade-induced technology upgradation is also discussed in Pavcnik (2002) and Holmes and Schmitz (2010).

Keller (2000) presents a model highlighting the pattern of a country's imports in intermediary goods as an important explanation of its growth of productivity. The underlying logic is that more a country imports from technological leaders, better would be the scope of technology diffusion. This theoretical position is found valid in an empirical test on eight OECD countries over the period 1970–1991. The paper also discusses the implication of its findings for developing countries.

There are a number of studies on the effects of trade on technology in the context of economic reforms in developing countries. Thus, for example, Muendler (2004) investigates Brazil's trade liberalization for 1990–93 and underscores that foreign competition enhanced the firm-level productivity significantly. The elimination of inefficient firms under competitive pressures also increased the industry's aggregate productivity. A related field of study is the assessment of the impacts of regional free trade agreement on the diffusion of technology. In this field, the study of Bustos (2011) seeks to find out the effect of MERCOSUR, a regional free trade agreement, on the advancement of technology by Argentinean firms during 1992–96. Treating technology and exporting choice, the study suggests that revenue addition by trade integration induces exporters to adopt better technology. In particular, its empirical

test shows faster technological upgradation for the industries that enjoyed higher tariff reductions in Brazil.

A number of studies are undertaken to relate the nature of trade and technological change to shed light on the emergence of wage gap in the industrialized nations (for the wage gap, see Reenen, 2011). Ekholm and Ulltveit-Moe (2001) develop in this field a model of imperfect competition with heterogeneous firms using modern and traditional technologies. High fixed costs are involved in the former with low variable costs. Remaining in the domain of intra-industry trade theory, the article shows that market integration expands the extent of market for individual firms and hence higher profitability for modern firms, relative to that for traditional firms. The consequent shift in technology dampens the wage rate for unskilled labour working in traditional sector. The question of trade-induced wage gap in the industrialized countries is also theoretically investigated in detail by Krugman (1985).

While the above literature assesses the impact of trade on technological development, some recent works discuss the impacts of technological development on trade. In this field, Marjit and Ray (2017) analyse the effects of competition and nature of technology on export profitability of firms in two different circumstances of 'price discrimination' and 'absence of price discrimination'. They use an oligopoly framework to closely determine the export incentive of firms in the midst of increasing competition and improving technology. They use firm-level data on India to support their theoretical underpinning. A fixed effect panel regression is used to empirically suggest the significant impact of technology (measured by the expense involved in capital–labour ratio) and competitiveness (measured by Herfindahl index and price-cost margin) on export profitability (measured by export earnings-to-sales ratio of firms) of firms. Results indicate that an increase in competition increases the export profitability of firms, when the nature of technology is 'good', in both the presence and absence of price discrimination. However, if technology is 'bad' it might or might not increase the export profitability. In the latter case, the paper highlights that in the presence of price discrimination there is a critical level of technology ($\bar{s}$) such that $s < (n-5)/2$. That is, below the threshold level exports appear to be profitable whereas it is not the case beyond the threshold level. The theoretical finding suggests that in the absence of price discrimination, at a given value of competitiveness, exports appear to be profitable for firms only if $s < (n-3)$. This condition for export profitability in the absence of discrimination implies that the market structure should consist of at least four firms.

In recent years, the issue of 'credit market' is discussed in the context of competition and trade. The focus of attention in many such studies is certainly imperfect competition—a field that is bolstered by the works on monopolistic competition by Krugman (1979, 1980) and Lancaster (1979, Lancaster 1980a, 1980b), and on oligopoly by Brander and Spencer (1981). These studies have initiated an immense volume of theoretical literature. There is a rich body of literature on the effects of credit constraints in the decision-making process of a firm. In an environment of credit constraints, Stiglitz and Weiss (1981) discuss about credit rationing as a screening device in the process of giving loan to the industries. However, the rejected borrowers may apply for loans at a higher interest rate. The paper identifies the case where the

interest rates equate the demand for loanable funds to the supply of funds. They demonstrate that the capital market may also be characterized by credit constraints because of the adverse selection problem. Their observation is that such constraints may take the form of limiting the number of loans that a bank provides, because imperfect information in the capital market leads to the failure of such financial instruments as increasing the interest rate, or else, scaling up the collateral requirements.

Kerr and Ramana (2009) argue that the credit constraint issue is all the more acute for new firms. The financial crisis of 2007–08 has exacerbated the problem of credit constraints, as it has further reduced the access to credit for many firms. In this context, Bandyopadhyay et al. (2014) develop a methodology for analysing the problem of credit constraints and employment in an oligopoly model. The central issue is, indeed, how credit-constrained firms can resolve the problems of insufficient credit.

Manova et al. (2011) highlight empirically that credit constraints restrict the international trade and affect the pattern of multinational activity. Their paper analyses the impact of credit constraints on firms' export decision and the pattern of FDI. Under these considerations, firm export is regressed on the interaction of proprietorship status of firms and the financial liability of sectors. The fixed effect regression is used in this context. Their paper includes two control variables, viz. the interaction of firms' size with the sectors' financial vulnerability and the interactions of firms' ownership status with the sectors' research and development, contract, physical capital and human capital intensity. Their paper is built on the assumption that, compared to manufacturers producing for the domestic market, exporting firms depend more on the external source of fund. This trend is explained by three factors. First, an entry into the global market necessitates extra expenses since the fixed trading costs are involved in studying the profitability of potential markets, market-specific investments, etc. Second, the cross-border shipping delivery requires longer time, which, in turn, heightens the working capital requirement for exporters. Third, the risks underlying transnational manoeuvres involve trade insurance for the exporters.

We should also refer here to Antras and Caballero (2009) which develops a general equilibrium model in a Ricardian continuum framework with heterogeneity of asset ownership. The paper clarifies the link between credit market imperfection and credit rationing, emphasizing that imperfections in the credit market can be characterized by credit rationing, though all of the borrowers with varying amount of assets may not face a binding credit limit.

Deardorff (2000) discusses the role of trade liberalization in service industries in stimulating trade in both services and goods. The paper identifies the role of trade in service in a model of international industrial fragmentation. In the presence of regulations and restrictions, the service costs of international fragmentation should be high. Trade liberalization in this field can, therefore, stimulate the fragmentation of production in both goods and services, thereby increasing the volume of international trade, as also the gains from trade. Deardorff (2000) argues that fragmentation allows countries to specialize in specific areas of production processes where they have

comparative advantages. Coordinating such comparative advantages internationally, the world economy can gain in terms of productive efficiency.

In the context of fragmentation, Matsuyama (2005) analyses the effects of credit constraints on the pattern of international trade in the North–South framework. He finds that the North, which enjoys a better credit market, specializes and exports in sectors that severely suffer from agency problems, whereas, in the presence of credit market imperfections, the South specializes and exports in those areas where such problems are less felt.

The issue of fragmentation is also discussed in Nocke and Thanassoulis (2014), Meisenzahl (2011) and Jones and Marjit (2001). Jones and Marjit (2001) confirm that the older generation would fail to survive without local protection due to inefficient technology. The older generation, therefore, resists the exposure to foreign culture and international fragmentation in production. They argue that an alliance of the members of the younger generation with the foreigners would promote local production in those fragments. The paper by Marjit et al. (2014) discusses the issue of fragmentation in output in the process of alleviating the problems of credit constraints. They consider two theoretical frameworks, viz. 'with production fragmentation' and 'without production fragmentation'. Their study uses the following incentive constraints for buyers and sellers, respectively, in the case of 'with fragmentation', respectively.

$$\frac{1}{2}P - \frac{1}{2}P^{\sim} + \frac{1}{2}P + \left(k - \frac{1}{2}\alpha\right)(1+r) > P - \alpha(1+r) + k(1+r)$$

$$\frac{1}{2}P^{\sim} + \left(k - \frac{1}{2}\alpha\right)(1+r) > P - \alpha(1+r) + k(1+r)$$

which indicate that it is profitable for a firm to produce in fragments in imperfect credit market.

Cetorelli and Peretto (2000) develop a dynamic general equilibrium model of capital accumulation where credit is intermediated by banks operating in a Cournot oligopoly. Credit market is split into two segments—one in which loans are screened and only high-quality entrepreneurs have access to credit and the other in which banks extend credit indiscriminately to all entrepreneurs. The paper establishes that, under certain plausible conditions, the market structure of the banking industry that maximizes the steady-state income per capita is neither competitive nor monopoly—it is an intermediate oligopoly.

The impacts of financial underdevelopment and credit constraints on export decision of firms are studied in Meisenzahl (2011), Matsuyama (2008) and Manova (2008). Meisenzahl (2011) uses a comprehensive data set on business credit decisions and contracts to examine the importance of financial constraints in the evolution of firm-size distribution. The paper adopts three measures of firm size to examine firms' decision on applying for credit, (i) number of employees, (ii) volume of sales and (iii) net worth. His empirical investigations establish that financial constraints can account for the evolution of firm-size distribution. In particular, firms without

access to credit are small and, hence, those firms exhibit a lower rate of growth in employment, although they are highly labour-intensive. Older firms, on the other hand, enjoy relatively greater access to credit. But they present low values for average leverage as well as for the net worth multiplier. In this regard, a model of financial constraints that Meisenzahl (2011) develops is capable of providing the explanation of these empirical findings. The policy implication of the study is this: small firms are subject to financial constraint though they enjoy higher productivity, and create more jobs; hence, by providing additional external finance, the productivity advantage of such firms can be harnessed, and also the generation of employment is maximized. Hence, the sanction of additional external finance to those firms is desirable from the welfare point of view.

Matsuyama (2008) investigates the macro-dynamics of credit market imperfection. His paper uses agents' utility function, the borrowers' objective function, profitability constraint and borrowing constraint to interpret the credit worthiness of borrowers. Matsuyama (2008) uses partial equilibrium model with homogenous agents to determine the aggregate capital stock available at the initial period. It is often argued that general equilibrium analysis of credit market imperfections fundamentally requires heterogeneous agents. But practically, credit market transactions can take place among homogeneous agents if there are some indivisibility constraints.

Manova (2008), however, examines the impact of liberalization in the equity market on the export behaviour of firms using panel data. His paper suggests that liberalization increases exports disproportionately more in those financially vulnerable sectors where more external funds are used, or fewer collaterizable assets are employed.

The nature of financial system in a country determines the export share of industries. The effect of financial development on export share has been studied in several papers. Beck (2003) argues both theoretically and empirically in a H-O framework that financially developed countries enjoy comparative advantages in those industries where the external source of finance is more predominant. Such countries have, therefore, higher export shares in those industries.

In Minetti and Zhu (2011), the impact of credit rationing on firms' export is evaluated. After controlling for productivity and other relevant attributes of firms, and also accounting for the endogeneity of credit rationing, the study estimates that the probability of opting for exports is lower by 39% for credit-rationed firms. The firm-level empirical analysis in this paper is closely related to Manova (2013) and Chaney (2016). While Manova and Chaney share the same view about the extensive margin of export, they hold divergent views about the effect of credit constraints on the intensive margin. However, Minetti and Zhu (2011) use a binary variable (C) that equals 1 if the firm faces credit rationing and 0 otherwise. They examine the effect of credit rationing on the probability of exporting using the following expression.

$$\pi_i^* = \alpha_1 + \beta_1 C_i + Z_i \gamma_1 + \varepsilon_i;$$

π_i^* represents the difference between firm i's operating profits when exporting and its operating profits when not exporting. This difference is determined by firm characteristics (e.g. productivity) and by credit constraints. C_i is a binary variable that equals 1 if firm i faces credit rationing, 0 otherwise; Z_i is a vector of controls for firm characteristics that may affect firm i's operating profits; ε_i captures the unobserved firm attributes and any other unknown factor that may also affect π_i^*. Their study suggests that credit rationing depresses domestic sales, and that firms with a high liquidity ratio are more likely to export. That is, the probability of opting for exports is higher for firms with a higher leverage ratio and lower cash flow. Credit rationing is found to have a statistically significant, negative effect on exporting.

Kapoor et al. (2012) also study the impact of credit constraint on exporting firms. Drawing reference from Melitz (2003), this paper argues that if causality runs from credit constraints to exports, financial sector reforms in emerging economies that improve the accessibility to credit for exporting firms can play a very significant role in promoting export-oriented growth in the economy. The paper exploits two exogenous policy changes in India that affected the availability of subsidized direct credit to small-scale firms. Using firm-level data from 1990 to 2006, it studies the behaviour of exporting firms on the basis of some key variables like total sales, total export earnings, total bank borrowing, etc. Difference-in-difference estimation strategy is used to estimate the causal impact of credit constraints on exporting firms.

In this context, we should refer to Banerjee and Duflo (2008) who focus on firms that are exporters in the manufacturing sector. In spirit with Banerjee and Duflo (2008), the study of Kapoor et al. (2012) suggests that when new firms are classified as belonging to the priority sector, both credit-constrained and credit-unconstrained firms would be willing to absorb more credit if it is cheaper than other sources of credit. A constrained firm would use this credit primarily to expand output/sales whereas an unconstrained firm would use this credit to substitute for other expensive sources of credit.

As an extension to these studies, Beladi et al. (2017) discuss the role of credit market imperfection in determining the export behaviour of an economy. Their paper highlights that credit rationing in the presence of asset inequality affects the level of production and the pattern of trade. Using a Ricardian general equilibrium framework, they prove that more equal asset distribution may reduce the output of the credit-intensive sector as redistribution to the bottom of the ladder fails to promote entrepreneurs. That is, in contrast to a conventional H–O–S model, their paper posits the possibility that an economy with relatively equal distribution of asset ownership might import capital or credit-intensive good and also export capital. The issue of export incentives is also investigated.

Marjit and Ray (2020) study export incentives of credit-constrained firms in the presence of credit rationing. They carve a relationship between the nature of technology, the degree of competition and the export incentive of a firm in an imperfect credit market. The theoretical and empirical findings suggest that the increase in the degree of competition increases the export profitability of firms, when only present period is concerned. But an increase in competition might not escalate the export profitability of firms, when both past and present time periods are considered in the

life cycle of a firm. The study shows that the role of competition is impacted by the intensity of capital accumulation and the initial level of wealth. Greater local competition before the entry of firms in the export market hurts export incentive by limiting cash flows and asset build-up. Thus, low domestic profit due to competition allows firms to look for export opportunities but lower cash flows hurt such incentives.

4 Concluding Remarks

A number of studies have discussed the issues of competition, technology and innovation in the context of firm behaviour. In an oligopolistic set-up, firms can either collude among themselves or else compete with each other. These choices of firms have been studied using the game-theoretic approach. However, technology occupies a crucial place in studying such behaviour of firms. Technological improvement alters market structure and provides export incentives to firms. The innovations should thereby have welfare implications where policy-makers are interested. Technological improvement that accompanies with a higher degree of credit market competition increases the export profitability of firms. But such an innovation improves firms' profitability in the domestic market only when 'monitored competition' prevails. However, introduction of credit market in such scenarios makes the subject more realistic. Indeed, the nature of credit market that firms are subject to determines the behaviour of firms in the global market. Thus, the issue of credit market imperfections (or credit rationing) that finds relevance in some recent papers can further be extended to other forms of market organizations.

Two major sets of results that have come out in recent times point towards the role of increasing costs in collusion and innovation of firms in oligopoly and credit market imperfection as an impediment towards exports. Finance and cost constraints both deter expansion of smaller firms and encourage domination of big players. The assumption of credit market perfection and linear costs both have deterred a healthy growth of the literature in trade and industrial organization.

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