



Research and Publication

WORKING PAPER SERIES

WP NO: 2017/02/EC

Dr. Meghna Dutta

**Intra-country Technology
Transfer**

**GOA INSTITUTE OF MANAGEMENT
PORIEM, SATTARI,
GOA 403505**

Intra-country Technology Transfer

Meghna Dutta*

Goa Institute of Management

and

Sugata Marjit

Centre for Studies in Social Sciences, Calcutta

Abstract: Production fragmentation is an important decision for firms. The decision becomes even more imperative because with the decision to fragment the production process is intertwined the decision to transfer technology. This paper models the transfer of technology from a formal manufacturing firm to a low cost firm which do not have the technology to produce the whole good. We show that the wage differential plays an important role in deciding technology transfer. However, if there is a threat of entry by a foreign firm, the decision of the formal sector domestic firm changes significantly wherein, technology transfer then becomes the dominant strategy.

Keywords: Technology transfer, FDI, symmetric duopoly, outsourcing

JEL Classification: L24, O33

*Address for Correspondence:

Goa Institute of Management,

Poriem, Sattari, Goa 403505

Email- 86meghna@gmail.com

1. Introduction:

The decision of technology transfer is of outmost importance to a firm when it decides to fragment its production process. The decision of whether to outsource and the location of outsourcing remains imperative because with the decision to fragment is intertwined the decision of technology transfer. The important identified avenues of technology diffusion is through international trade, FDI and outsourcing (Borensztein *et. al.*, 1998, Glass and Saggi, 2002). However, most of the literature on technology transfer actually looks into inter-country knowledge diffusion and intra-country knowledge transfer remains less dealt with. Studies have found that in the developing countries, the question of intra-country knowledge transfer attains a different dimension due to the presence of the low cost informal sector. Beladi *et. al.*, (2016) found FDI coming into domestic formal firms, transmitted through technology spillover, leads to significant increase in the gross value added for several industries located in the informal sector. This presence of the low cost informal firm which is out of purview of formal laws and regulations obfuscates the issue of technology transfer because it has the potential to positively impact the formal sector suppliers' competitiveness. Therefore, given the increasing trend of production reorganization between the formal and the informal sector, it will be interesting to see how transfer of technology takes place between these two sectors. Furthermore, we attempt to model the impact of regulations on informalisation. Broadly, the paper, discusses how FDI can induce intra-country transfer of technical know-how between domestic firms. More specifically, we try to assess whether technology diffusion is a dominant strategy for high cost domestic firms when faced with a threat of entry from a foreign firm. Section 2 discusses the existing literature, section 3 develops the model, the results of a government penalty policy for collaborating with a smaller "informal" firm is presented in section 4 and Section 5 concludes.

2. Existing Literature

The area of intra country knowledge transfer remains less dealt with. Maiti and Marjit (2008) argued that with an increase in the prospect of getting a better price in the international market, the inclination of the formal sector producers become more marketing and sales oriented and production activities are subcontracted to informal sectors¹. Beladi *et al.*, (2016) observed an increased organized-unorganized outsourcing relation which is directly borne out by the interactions between FDI and the level of technology existing in the sectors thereby implying that, as FDI flows into the organized sector, which is the primary beneficiary, spillovers to the unorganized sector remain significant. The relative increase (decrease) in organized (unorganized) labour cost is a strong driver of production outsourcing and hence of technology transfer.

As firms increasingly relocate to the less developed countries, to ensure that local inputs meet their stringent quality standards and specifications, foreign affiliates often provide the local suppliers not just with guidelines but sometimes also with assistance in raising their technological capabilities. Such assistance tends to be more prominent in developing countries, and the knowledge transfer has had a positive impact on the suppliers' competitiveness (UNCTAD, 2001). Foreign affiliates therefore, is found to diffuse their advanced technology and skills to domestic suppliers with whom they have direct and indirect dealings. In particular, backward linkages between foreign affiliates and domestic firms remain important channels of technology dissemination.

Kabiraj and Sinha (2011) analysed outsourcing decision of a firm for a key input in the production of a final good to an independent input supplier even though the firm has an option of producing the key input in-house at a lower cost with a better technology. They found that for smaller technology gap with the independent input supplier, the firm outsources and for larger technology gap it produces the input in-house for itself and for its rivals. However, when ownership advantage is the unique possession of some knowledge, firms wishing to exploit this knowledge in a foreign market generally decide against arm's length transaction because selling the information, or sharing the information with a foreign firm to which the foreign firm has outsourced work, might lead it to lose,

¹ However, unlike Maiti and Marjit (2008), we do not consider trade with a foreign firm in this paper.

at least in part, its monopoly advantage (Ethier, 1986). Multinational companies, in many cases were found not to have an interest in transferring knowledge to and supporting innovation in foreign affiliates beyond what is needed for their production process or product. In the case of joint ventures with foreign firms, transfer of knowledge to local firms and dissemination in local economy are even more limited unless local firms have a long history of using the foreign technology and accumulating such technology through license agreements or other technology use arrangements (UNCTAD, 2010).

The problem of contractual incompleteness also have an effect on technology transfer (Marjit, 2008). Such problems might arise from the fact that the transferor may transfer an obsolete or insignificant technology or the licensee may not pay the fee after obtaining the technology or may resell it. Marjit and Mukherjee (1998, 2001) shows that these moral hazard type of problems can be solved if firms form joint ventures through equity participation. However, Mukherjee (2003) have argued that even though joint ventures lead to higher profit generation thereby encouraging the foreign firm to transfer relatively better technology, joint ventures can reduce the welfare of a host-country by reducing the number of technology transfers and creating higher market-concentration. Marjit *et. al.* (2000) studies the profitability of technology transfer and horizontal mergers between two asymmetric firms in a multifirm Cournot oligopoly showing that if there is only one technologically advanced firm and one or many technologically backward firm(s), a profitable technology deal between two asymmetric firms exists if and only if the collaborating firms are close in terms of their initial technology levels. In a work, Marjit (1990) show a firm with better technology will sell technology to its less efficient competitor because it would help them both to share a larger collusive profit. The author showed that if total profits rise after the transfer, both firms benefit from the deal, and transfer of technology takes place even if the perfectly collusive outcome is not achieved. Kabiraj and Marjit (1993) have examined the hypothesis whether the technological leader will transfer the best technology to its competitor or not. On the other hand, Kabiraj and Marjit (1992) had discussed the possibility of higher price being associated with superior technology. Marjit (1989) considered the case when transfer of technology from a technology leader to a follower is induced by potential threat of imitation and showed that given the threat of cheating, the leader would impose conditionalities on sale of technology, otherwise there will not be any sale of superior technology.

3. *The Model*

We consider a single good, the production of which can be carried out in two stages. The first stage is completed using a technology β and the second stage uses a technology α . Since, α represents an advanced technology, the cost of production with this technology is less. There are two types of production units in the economy, a formal firm which has access to α and many other small production units who do not have access to α . The latter group of firms can also produce at a lower wage w_I compared to the formal sector wage (w_F), owing to regulations². This higher wage, however, is not a skill premium for the formal sector workers; they are paid a higher wage only because of regulations³. The smaller production units work for the formal firm wherein, they produce the initial stage of the output with the technology β . The formal firm then uses this output, adds value to it using α and sells it. The.

Inverse demand functions faced by both type of production units are:

$$P = a - q \tag{1.1}$$

Cost function of the F firm is:

$$C_F(q) = \alpha w_F q + \beta w_I q \tag{1.2}$$

Cost function of the I firm is:

$$C_I(q) = \beta w_I q \tag{1.3}$$

where, q is the total output produced.

given,

$$w_F > w_I, \text{ and } \alpha < \beta$$

²The smaller production units that we talk of can be thought of as informal sector firms. However, the results holds good for any firm which do not have access to the technology to produce the finished goods and can produce at a lower cost.

³This rationale for higher formal sector wage can be due to the presence of labour unions, or due to conformation to government regulations as wage floors. The existence of higher formal sector wages has been

The profit of F when it is the sole seller of the final good is⁴:

$$\pi_F^M = \frac{(a - \alpha w_F - \beta w_I)^2}{4} \quad (1.4)$$

The formal firm now has two options; it can transfer technology α to I which was working for it so that I can produce the entire good at a lower cost. F can then buy from I and sell the final product in the market. Else, the formal firm can choose not to transfer technology to I . If it decides not to transfer technology, it retains the monopoly profit. However, if it decides to transfer α , in subsequent periods, the smaller firm; who now has got access to α , might become a potential competitor for F , in which case, they will both earn duopoly profit in the final good market.

Under duopoly (denoted by superscript D), the formal firm's output is:

$$q_F^D = \frac{a + \alpha w_I - 2\alpha w_F - \beta w_I}{3} \quad (1.5)$$

and the I firm's output is:

$$q_I^D = \frac{a + \alpha w_F - 2\alpha w_I - \beta w_I}{3} \quad (1.6)$$

Comparing (1.5) and (1.6) we have:

$$q_I^D > q_F^D$$

That is, in duopoly, I produce more compared to the F firm. This is commensurate with the idea that the high cost firm produces less in duopoly. Also, the output of the firms depend on the wage difference paid by the two firms F and I .

The profits under duopoly are:

proven empirically and theoretically by Heckman and Hotz (1986), Tansel (1999), and Gong and Van Soest (2002), Badaoui *et al.* (2007).

⁴ The superscript M denotes monopoly situation.

$$\pi_F^D = \frac{(a + \alpha w_I - 2\alpha w_F - \beta w_I)^2}{9} \quad (1.7)$$

$$\pi_I^D = \frac{(a + \alpha w_F - 2\alpha w_I - \beta w_I)^2}{9} \quad (1.8)$$

If the wage paid by the smaller firm⁵ is too high (close to the formal wage), the domestic formal firm remains the monopoly. Whereas, if this wage is too low, say at some \underline{w} , then the subcontracted firm clearly has an advantage over the parent formal firm. Therefore, it would be beneficial for the formal firm to transfer α to I against a lump-sum fee and let I produce the entire good.

So, if $w_F > w_I$, the joint profit of the two firms is:

$$\pi_F^D + \pi_I^D = \frac{2[a - w_F(\alpha + \beta)]^2}{9}$$

Similarly, if $w_I = \underline{w}$ the joint profit of the two firms:

$$\pi_F^D + \pi_I^D = \frac{2[a - \underline{w}(\alpha + \beta)]^2}{9}$$

Comparing $(\pi_F^D + \pi_I^D)$ at different levels of w_I with π_F^M , we have:

$$(\pi_F^D + \pi_I^D \Big|_{w_I = \underline{w}}) > \pi_F^M > (\pi_F^D + \pi_I^D \Big|_{w_I = w_F}) \quad (1.9)$$

Differentiating the joint profit function w. r. t. w_I we have:

$$\frac{\delta(\pi_F^D + \pi_I^D)}{\delta w_I} < 0$$

⁵ For simplicity we call this the informal wage, but it can mean a lower wage offered by a formal sector firm too.

⁶ At $w_F = w_I$, there is no economic reason for transfer of technology to the smaller firms, so there is only monopoly profit by the domestic formal firm.

That is, the joint profit function is monotonically falling.

So, it intersects the π_F^M curve once. This gives us the threshold level of informal wage. For any $w_I > w^*$ the formal firm will not transfer technology to the subcontractor. If the informal wage is too low, it is beneficial for the formal firm to transfer technology to the subcontractor against a lump-sum fee. Whereas, if the informal wage is closer to the formal wage, we have a symmetric duopoly. This level of total duopoly profit (profit of the formal and the informal firm taken together) is lower than the profit of the formal firm earned under monopoly (Fig 1). Thus, in the range a , the formal firm will transfer technology to the subcontractor, however, in the range b , it will not.

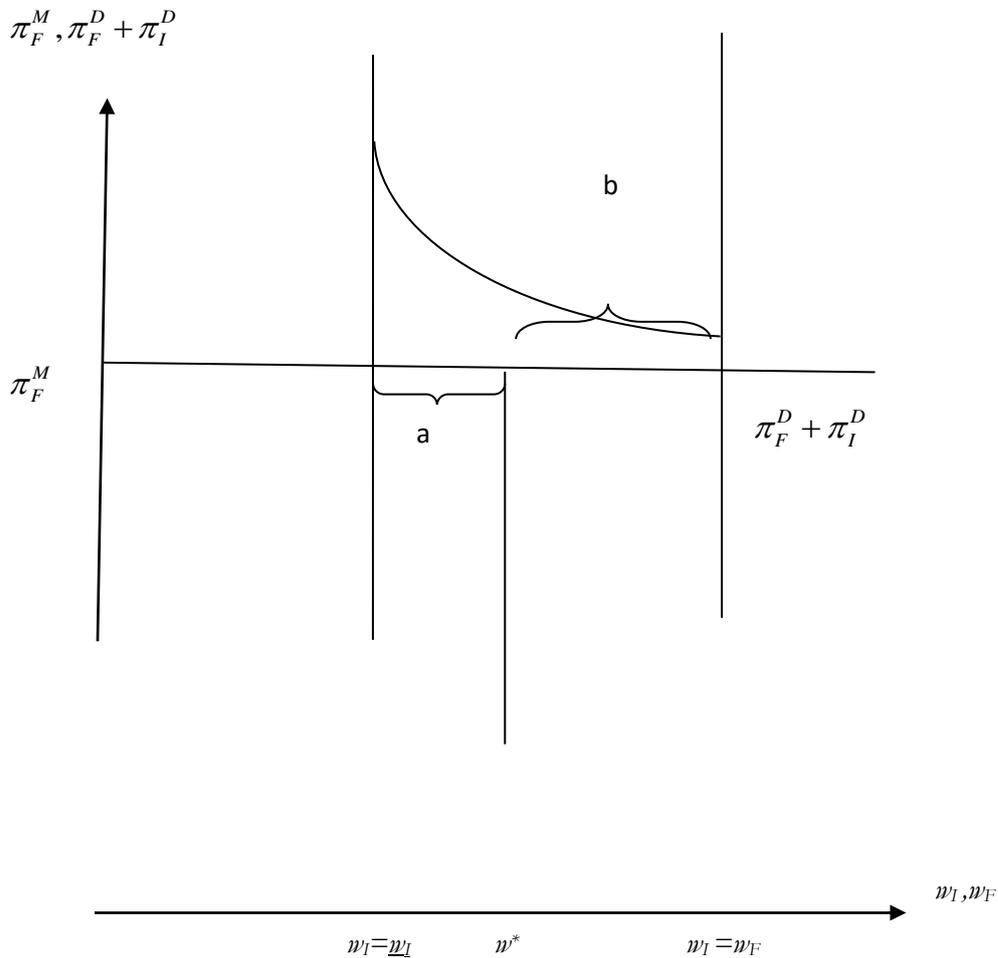


Fig 1: The relation between wages and joint profit

Solving for w^* , we have:

$$w^* = \frac{a + \alpha w_F}{(2\alpha + \beta)}$$

Proposition 1 *In a closed economy with one formal and many informal firm, transfer of technology from the formal firm to the informal firm depends on the difference between the formal and informal wage.*

3.2 Entry of a Foreign Firm

Now let a foreign firm F^* enter the home market with technology $\alpha^* < \alpha$. Being in the formal sector it has to pay w_F to its workers.

The cost function of the foreign firm is:

$$C_{F^*}(q_{F^*}) = \alpha^* w_F q_{F^*} + \beta w_F q_{F^*} \quad (1.10)$$

If the domestic firm do not transfer technology to I , there will be two firms; F and F^* . In this case, the profits of the firms are:

$$\pi_F = \left(\frac{a - 2\alpha w_F - \beta w_F + \alpha^* w_F}{3} \right)^2 \quad (1.11)$$

$$\pi_{F^*} = \left(\frac{a - 2\alpha^* w_F + \alpha w_F - \beta w_F}{3} \right)^2 \quad (1.12)$$

However, in the first stage, the domestic formal firm has already transferred technology to the subcontractor for a range of wages. The foreign firm has difficulty in transferring technology to the informal firms since it involves costs to identify such production units, training the workers, ensuring quality standards and inefficiencies because of incompleteness of contracts. Incompleteness of contracts together with weak enforcement can also lead to trademark infringement or piracy⁷.

However, being “local”, the local domestic firm is in a better position to identify a more productive

⁷ See Hart (1988), Banerjee *et. al.* (2008) for incompleteness on contract and enforcement and copyright infringement.

informal firm. It is also easier for the domestic formal firm to transfer technology to the I firm and ensure quality standards are maintained. So, the domestic formal firm will definitely transfer α to the informal firm. As the three of them produce, we have a three firm Cournot setup. So, the profit becomes:

$$\pi_{F^*} = \left(\frac{a + \alpha w_I + 2\beta w_I + \alpha w_F - 3\alpha^* w_F - 3\beta w_F}{4} \right)^2 \quad (1.13)$$

$$\pi_I = \left(\frac{a - 3\alpha w_I - 2\beta w_I + \alpha w_F + \alpha^* w_F + \beta w_F}{4} \right)^2 \quad (1.14)$$

$$\pi_F = \left(\frac{a + \alpha w_I - 2\beta w_I + \alpha^* w_F - 3\alpha w_F + \beta w_F}{4} \right)^2 \quad (1.15)$$

Clearly,

$$(\pi_{F^*} + \pi_I) > (\pi_F)$$

That is, as the foreign firm comes in, the total profit of the domestic formal firm if it did not transfer technology to the I firm is less than the sum of total profit that it would earn if it transferred technology to I and there are three firms producing. Therefore, with the entry of the foreign firm, transferring technology becomes the dominant strategy of the domestic formal firm.

However, ex-post technology transfer the F and the I firm will not merge following Salant *et al.* (1983) by which exogenous mergers may reduce the endogenous joint profits of the firms that are assumed to collude.⁸ Therefore, in a symmetric oligopoly, with 3 firms, if 2 firms merge together and form a single firm so that the three-firm oligopoly is converted to a two firm duopoly, the profit of the new firm will be smaller than the joint profits of the two firms that merged. Therefore, they will not merge. In fact with initially two firms, one firm would like to break into two because those 2 firms will earn more than the single firm. In the process the left out firm will lose.

In our case, the joint profits of the F and I firm becomes:

⁸ Similar results have been derived in Lahiri and Ono (1988) and Cave (1980).

$$\pi_F + \pi_I = \left(\frac{a + \alpha w_I - 2\beta w_I + \alpha^* w_F - 3\alpha w_F + \beta w_F}{4} \right)^2 + \left(\frac{a - 3\alpha w_I - 2\beta w_I + \alpha^* w_F + \alpha w_F + \beta w_F}{4} \right)^2 \quad (1.16)$$

However, had the F firm and the I firm merged, their profit functions would be⁹:

$$\pi_{IF} = \left(\frac{a - 2\alpha w_I - 2\beta w_I + \alpha w_F + \beta w_F}{3} \right)^2 \quad (1.17)$$

Comparing the joint profit and the merged profits of the domestic firms we have:

$$(\pi_I + \pi_F) > \pi_{IF}$$

Nonetheless, such breakup by the domestic firm may not be allowed by the law since, the breaking up into two firms by the domestic formal firm can deter the entry of foreign firm. So, eventually the foreign firm goes out of business keeping only the domestic formal firm which can act as a monopoly¹⁰. So, if breaking up of the firm is considered “illegal” because it reduces competition, then the domestic firm will transfer technology to the smaller firm for all range of wages and the above results will hold. If the I firm has the same level of marginal cost with the local formal firm, their joint profits will be greater than the single firm. Here there is an added incentive because the effective MC is lower for the informal firm. So, even if break ups are not allowed legally, the formal-informal deal through technology transfer will achieve the same outcome.

Proposition 2 *If there is a threat of entry from a foreign firm, the domestic formal firm will tend to transfer technology to the informal firm for all wage levels.*

4. Levying penalty for collaborating with low cost ‘informal’ firm:

Now we consider there is a penalty levied on both the formal domestic firm and the foreign firm for dealing with the low cost ‘informal’ firm as such firms often do not abide by government

⁹ The values for the merged firm are denoted by the subscript IF .

¹⁰ For example, the Competition Commission in India works to prevent unfair methods of business practices that are anticompetitive.

regulations. Let there be a probability z that the foreign firm gets caught collaborating with the I firm in which case a penalty μ is imposed on it. Therefore, the cost to the foreign firm if caught is:

$$C_{F^*} = \alpha^* w_F q_{F^*} + (1 + z\mu)\beta w_I q_{F^*} \quad (1.18)$$

and the cost to the domestic formal firm would be:

$$C_F = \alpha w_F q_F + (1 + z\mu)\beta w_I q_F \quad (1.19)$$

Solving, we have:

$$\pi_{F^*}^* = \left(\frac{a + \alpha w_F - 2\alpha^* w_F - (1 + z\mu)\beta w_I}{3} \right)^2$$

$$\pi_F = \left(\frac{a - 2\alpha w_F + \alpha^* w_F - (1 + z\mu)\beta w_I}{3} \right)^2$$

Given $\alpha > \alpha^*$, the foreign firm's profit are more than that of the domestic formal firm. If the penalty on both F and F^* for collaborating with the I firm is similar then the penalty that the foreign firm has to pay if it is found to be collaborating with the I firm is less than the profit it will earn from collaboration. Thus, it will collaborate with the I firm and the domestic formal firm loses out due to higher costs.

Such a set up can be related to the recent e-commerce industry in developing countries as India. In the e-commerce industry, formal domestic firms often collaborate jointly with smaller low cost firms from whom they source the product. However, if the space is opened up to foreign firms, it is possible that the foreign firm will collaborate with the domestic low cost firms and put the domestic formal firms at a disadvantage.

5. Conclusion

It has been observed that in most developing countries there has been an increased proliferation of low cost firms who lack the technical know-how to produce the finished output. Studies have also shown that such firms mostly work as subcontractor for formal firms. Here we have shown that when

the production of the good can be broken up into at least two stages, the high cost firm will outsource to the low cost firm. However, the formal firm will transfer the advanced technology to the low cost firm only for a range of informal wage. Beyond this range, there will not be any transfer of technology since the high cost firm's monopoly profit is greater than its joint profit.

The situation, though, changes when a foreign firm enters with a better technology. Then the domestic high cost firm transfers technology to the low cost domestic firm for the entire range of wages. In fact, the domestic high cost and low cost firm will not merge but will continue to play Cournot. We also explore the possibility where collaborating with the low cost "informal" firm is penalized and found that since the penalty to be paid is less than the profit from transferring, the foreign firm will collaborate with the low cost domestic firm and the domestic formal firm loses out.

References

- Badaoui, E., Strobl, E. and Walsh, F. (2007), "The Formal Sector Wage Premium and Firm Size", IZA Discussion Paper 3145.
- Banerjee, D., Banerjee, T. and Raychaudhuri, A. (2008), "Optimal Enforcement and Anti-copying Strategies to Counter Copyright Infringement", *Japanese Economic Review*, Vol. 59, No. 4, pp. 519 – 535.
- Beladi, H., Dutta, M. and Kar, S. (2016), "FDI and Business Internationalization of the Unorganized Sector: Evidence from Indian Manufacturing", forthcoming, *World Development*.
- Borensztein, E., Gregorio, J. De, and Lee, J. W. (1998), "How Does Foreign Direct Investment Affect Economic Growth?," *Journal of International Economics*, Vol. 45, pp. 115-135.
- Cave, J. (1980), "Losses due to Merger", Federal Trade Commission Working Paper.
- Ethier, W. J. (1986), "The Multinational Firm", *The Quarterly Journal of Economics*, Vol. 101, pp. 805-833
- Glass, A. J. and Saggi, K. (2002), "Multinational Firms and Technology Transfer", *Scandinavian Journal of Economics*, Vol. 104, pp. 495–513.
- Gong, Xiaodong and Arthur Van Soest (2002), "Wage Differentials and Mobility in the Urban Labour Market: A Panel Data Analysis for Mexico" *Labour Economics*, Vol. 9, pp. 513-529.
- Hart, O. (1988), "Incomplete Contracts and the Theory of the Firm", *Journal of Law, Economics and Organization*, Vol. 4, No. 1.
- Heckman, James J., and V. Joseph Hotz, (1986), "An Investigation of the Labor Market Earnings of Panamanian Males: Evaluating the Sources of Inequality", *Journal of Human Resources*, Vol. 21, pp. 507-542.
- Kabiraj, T. and Marjit, S. (1992), "Transfer or Not to Transfer the Best Technology Under Threat of Entry - The Case of Price Competition", in B. Dutta *et al.*, (ed.), *Game Theory and Economic Applications*, Springer-Verlag, Berlin.
- Kabiraj, T. and Marjit, S. (1993), "International Technology Transfer Under Potential Threat of Entry - A Cournot-Nash Framework", *Journal of Development Economics*, Vol. 42, pp. 75-88.

Kabiraj, T. and Sinha, U. B. (2011), "Strategic Outsourcing with Technology Transfer", Centre for Development Economics Working Paper No. 203.

Lahiri, Sajal and Ono, Yoshiyasu, (1988), "Helping Minor Firms Reduces Welfare," *Economic Journal*, Royal Economic Society, Vol. 98, No. 393, pp. 1199-1202.

Maiti, D. and Marjit, S. (2008), Trade Liberalization, Production Organization and Informal Sector in the Developing Countries", *The Journal of International Trade and Economic Development*, Vol. 17, No. 3, p. 445-53.

Marjit, S. (1989), "A Strategic Theory of Technology Transfer", CNCR Discussion Paper No. 88-11, Pennsylvania State University, University Park.

Marjit, S. (1990), "On a Non-Cooperative Theory of Technology Transfer", *Economics Letters*, Vol. 33, pp. 293-98.

Marjit, S. (2008), *International Trade and Economic Development – Essays in Theory and Policy*, OUP, New Delhi.

Marjit, S. and Mukherjee, A. (1998), "Technology Collaboration and Foreign Equity Participation: A Theoretical Analysis, *Review of International Economics*, Vol. 6, pp. 142-50.

Marjit, S. and Mukherjee, A. (2001), "Technology Transfer under Asymmetric Information: The Role of Equity Participation", *Journal of Institutional and Theoretical Economics*, Vol. 157, No. 2.

Marjit, S., Kabiraj, T. and Mukherjee, A. (2000), "Bilateral Agreements in a Multi Firm Industry - Technology Transfer and Horizontal Merger, *Pacific Economic Review*, Vol. 5, No. 1, pp 77-87.

Mukherjee, A. (2003), "Foreign Market Entry and Host-Country Welfare: A Theoretical Analysis", Globalisation, Productivity and Technology Research Paper Series 2003/08, University of Nottingham.

Salant, Stephen W., Switzer, Sheldon, Reynolds, Robert J. (1983), "Losses from Horizontal Merger: The Effects of an Exogenous Change in Industry Structure on Cournot-Nash Equilibrium", *The Quarterly Journal of Economics*, Vol. 98, No. 2, pp. 185-199.

Tansel, Aysit, (1999), "Formal versus Informal Sector Choice of Wage Earners and their Wages in Turkey", Economic Research Forum Working Paper No. 9927.

UNCTAD (2001), “World Investment Report: Promoting Linkages”, United Nations Conference on Trade and Development, Geneva.

UNCTAD (2010), “Foreign Direct Investment, the Transfer and Diffusion of Technology, and Sustainable Development”, United Nations Conference on Trade and Development, Geneva.