Innovation in the Automobile Industry: How the Changing Face of Global Competition Affects Motor Vehicle Patenting

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There is much interest in how the increase in high valued added manufacturing in emerging economies is affecting established manufacturers in high income economies. One area of analysis is industry innovation. We analyze how innovation in the automobile industry has been impacted by competition in a North-South setting. North-South innovation models indicate that greater production by the South will encourage North companies to engage in more innovation to stay ahead of the new competition. In contrast, our analysis suggests that greater competition from auto manufacturers in the South results in less innovative output by manufacturers in the North.

INTRODUCTION

Automobile manufacturers from high income economies are facing increasing competition from manufacturers from low income economies. To illustrate, the China Association of Automobile Manufacturers reports that there are now more than 100 domestic auto manufacturers in the country, whereas there were only 18 in 2001; and the Society of Indian Automobile Manufacturers reports that vehicle production in India in 2011 was more than double that of 2006.

Competition, of course, can be in different forms such as price and after-sales service, but competition in the auto industry is also particularly intensive in regards to the quality and features of the vehicles. As a result, the auto industry historically has an extremely high level of innovation, including when measured by patenting.

In this paper we look at the patenting behavior of automobile manufacturers. Our focus is on auto manufacturers in countries with large, long-standing auto industries and how their patenting behavior is affected by increased competition from auto manufacturers in countries that are more recent entrants to the global auto industry. The “North-South” theory of product cycles indicates that as manufacturers in the south increase their production, manufacturers in the north will increase their rate of innovation in order to stay ahead of the new competition. It is this conclusion that we examine here with respect to the global auto industry.

The study holds relevance for understanding the impact that increased globalization has on business decisions dealing with technology and innovation. The changing nature of global competition, with heightened interconnections between both innovators and imitators, results in a growing emphasis on technological competition rather than just competition in price or quantity.

LITERATURE REVIEW

There is an extensive literature concerning the link between production in one country and innovation in another. Much of this research focuses on the acquisition of technology by reverse-engineering/learning from imported goods, or from knowledge spillovers from patents, R&D programs and research publications.

The role that imports play in innovation has been explored for both developed countries (see, for example, Coe and Helpman, 1995, and Keller, 2002) and developing countries (Schiff, Wang and Olarreaga, 2002, and Wang, 2007). Knowledge spillovers from research efforts in other countries is the focus of Jaffe, Trajtenberg, and Fogarty (2000), Hu and Jaffe (2003), and Simons and Isely (2010), for example.

Much of the current literature in this area is based on the endogenous growth theories of Romer (1990), Grossman and Helpman (1991a), and Aghion and Howitt (1992). Grossman and Helpman (1991b) extend their earlier work on quality ladders to develop a North-South theory of product cycles that indicates a positive effect on innovation in the North from competition in the South. It is this model that we empirically investigate here.

The way in which innovation is measured in the literature varies. Rather than using R&D expenditure (which measures the input to innovation) we follow the growing number of studies using patent data to measure the output of innovation (see, for example, Pavitt and Soete, 1997 and Jaffe, Fogarty, and Banks, 1998).

METHODOLOGY

Data

The time period for our study is 1998-2010. We obtain all our patent data from the U.S. Patent and Trademark Office's online patent database (http://www.uspto.gov), counting the number of granted U.S. patents from the patent classes 180 (Motor Vehicles) and 123 (Internal-Combustion Engines). Included in each patent's information is the country of origin of the patent's owner (assignee), which allows us to identify patents originating from North versus South firms. It can take several years for the USPTO to either grant or deny a patent application. So, to test if there is a significant effect from patents filed in 2010 that have not yet been granted, we run a specification of the base model with a 2010 dummy variable. Because this dummy is not significant, we do not include it in the specification of the model shown below.

We obtain data on Motor Vehicle R&D spending by company from the EDGAR database and convert into real 2000 values using the U.S. GDP Deflator (available at www.bea.gov). We obtain data on automobile production from the International Organization of Motor Vehicle Manufacturers website (www.oica.net). Our North firms are: Toyota, GM, VW, Ford, Nissan, Honda ("Big 6") – these consistently rank as the largest auto producers during the *entire* time period of our study *and* they consistently patent heavily in the U.S. Our South firms are other manufacturers as listed by OICA (e.g. Tata, Beijing Automotive, Hyundai etc.).

Model

We begin by modeling patenting as a Cobb–Douglas style production function:

$$PATENTS_{kt} = f(PRODUCTION_{nt} - PRODUCTION_{kt}, PRODUCTION_{st}, R\&D_{kt}, \text{year}) \qquad (1)$$

where

- Subscript k designates individual North firms, and t is years.
- $PATENTS_{kt}$ is the number of granted auto patents that were applied for in the U.S. in year t, where firm k is the assignee/owner.
- $PRODUCTION_{nt}$ is the natural log of auto production by all North firms in year t.

- $PRODUCTION_{kt}$ is the natural log of auto production by firm k in year t.
- $PRODUCTION_{st}$ is the natural log of auto production by all South firms in year t.
- $R\&D_{kt}$ is the natural log of firm k's spending on motor vehicle research and development in year t.
- Year is a trend variable

We formulate two versions of the basic model described above: One using auto production levels and the other using the percentage growth in auto production levels.

We try three different specifications for these models: Negative binomial, log-log, and Poisson. The results for both models are consistent for all three specifications. We report here only the results of the negative binomial specification for space considerations.

RESULTS

Table 1 gives the regression results for the two model specifications.

TABLE 1
REGRESSION RESULTS

	Model 1 Production	**Model 2** Production growth
R&D	-0.51 (2.11)*	0.04 (0.11)
NORTH PRODUCTION	1.33 (0.50)	
SOUTH PRODUCTION	-2.26 (1.45)	
NORTH GROWTH		-0.04 (0.44)
SOUTH GROWTH		-0.15 (2.62)**
YEAR	0.14 (1.30)	0.04 (3.20)**
CONSTANT	-250.37 (1.47)	-159.58 (3.22)**

Absolute value of z statistics in parentheses
* significant at 5%, ** significant at 1%.

Recall that our focus in this paper is to see if the patenting behavior of North firms is influenced by competition from firms in the South. In Model 1, the coefficient on South Production is negative, though not significant. A negative correlation here indicates that as firms in the South increase their auto production, patenting by the Big 6 North firms decreases. In Model 2, the coefficient on South Growth is negative and statistically significant at the 1% level. This indicates that as firms in the South increase their auto production more rapidly, patenting by the Big 6 North firms decreases. These results hold through all three regression specifications (negative binomial, log-log, and Poisson).

CONCLUSIONS

The above results indicate that we are unable to find any support for the traditional North-South innovation model which predicts that greater competition from the South will encourage North firms to innovate *more*. In contrast, our results indicate some support for the opposite conclusion – that greater competition from the South has a dampening effect on innovation by firms in the North.

The above finding seems to imply that, within the parameters of our study, the large North auto manufacturers do not treat South firms as true competitors, at least not as compared to their North rivals. What could explain this behavior? One possibility is that, through hubris or ignorance, North auto manufacturers have been slow to recognize the threat posed to them by rivals in the South. This has parallels in auto manufacturing history – for example, the recalcitrance of the U.S. "Big 3" to invest heavily in fuel efficient vehicles allowed Japanese manufacturers to capture a substantial share of the U.S. market when consumer tastes shifted in the 1970s and 80s.

Another possibility is that, while the thought process behind the traditional North-South model is valid, the difficulty is that increasing global economic integration has blurred the distinction between North and South. North companies increasingly produce in both the North and the South, and a growing number of joint ventures are between North and South companies rather than just North-North or South-South. This means that, although taking place in the South, some of the production that is labeled in our study as South may actually involve North manufacturers.

While the findings presented here do not allow us to identify the cause of the apparent contradiction with the North-South innovation model, it does open some avenues for us for future research.

REFERENCES

Aghion, P. & P. Howitt. (1992). A model of growth Through Creative Destruction. *Econometrica*, 60, 323-361.

Coe, D. & E. Helpman (1995) International R&D spillovers. *European Economic Review*, 39(5), 859-887.

Grossman, G., Helpman, E., (1991a). Quality ladders in the theory of growth. *The Review of Economic Studies*, 58, 43–61.

Grossman, G., Helpman, E., (1991b). Quality ladders and product cycles. *Quarterly Journal of Economics*,106, 557–586.

Hu, A. & Jaffe A. (2003) Patent citations and international knowledge flow: the cases of Korea and Taiwan. *International Journal of Industrial Organization*, 21(6), 849-880.

Jaffe, A., Fogarty, M., & B. Banks. (1998). Evidence from patents and patent citations on the iImpact of NASA and other federal labs on commercial innovation. *Journal of Industrial Economics*, 46(2), 193-205.

Jaffe, A., Trajtenberg, M., & M. Fogarty. (2000). Knowledge spillovers and patent citations: evidence from a survey of inventors. *American Economic Review Papers and Proceedings*, 90(2), 215-218.

Keller, W. (2002). Trade and the transmission of technology. *Journal of Economic Growth*, 7(1), 5-24.

Pavitt, K. & Soete L. (1997) International differences in economic growth and the international location of innovation. In Wolff, E. (ed.), *The Economics of Productivity, Vol. 1*. Cheltenham, UK: Edward Elgar Publishing.

Romer, P. (1990). Endogenous technological change. *The Journal of Political Economy*, 98, S78-S102.

Schiff, M., Wang, Y., & M. Olarreaga (2002) Trade-related technology diffusion and the dynamics of north-south and south-south integration. *World Bank Working Paper #2861*.

Simons, G. & P. Isely. (2010). The effect of offshoring on knowledge flows in the U.S. automobile Industry. *Economics of Innovation and New Technology*, 19(6), 553-568.

Wang, Y. (2007.) Trade, human capital and technology spillovers: an industry level analysis. *Review of International Economics*, 15(2), 269-283.