Innovation and International Competition: Evidence from Mexico*

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Abstract

How does trade liberalization that raises a country's import competition affect the innovative activity of its firms? We exploit the strong growth of Chinese exports resulting from China's entry into the World Trade Organization in 2001 as a competitive shock to, specifically, Mexican manufacturing firms. Innovation is captured through information on the adoption of detailed firm level production techniques such as just in time inventory methods, quality control measures, and job rotation among the Mexican firms. Our results indicate that China's rise in global trade did *not* affect by much Mexico's rate of innovation, which contrasts with the substantial gains that others have found in the case of bilateral liberalizations. At the same time, there is a striking heterogeneity in the responses across firms for different labor productivities, with productive firms innovating more and less productive firms innovating less, which leads to positive selection in that initial differences in firm performance are sharpened by the advent of new competition. We discuss the implications of these findings for theories of trade and innovation.

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1 Introduction

Trade liberalization that improves the access to a foreign market rarely encounter much domestic political opposition, if only because the foreign market opening means higher exports and employment for domestic firms. Economists have long supported the dismantling of trade barriers on efficiency grounds, long before it was shown that there are additional gains from foreign market access from the reallocation of firms' market shares and increased incentives to innovate, among others (Pavcnik 2002, Melitz 2003, Bernard et al. 2003, Aw, Roberts, and Winston 2007, Costantini and Melitz 2008, Verhoogen 2008, Lileeva and Trefler 2010, Bustos 2010). Given these benefits from improved foreign market access, it is natural to ask how they compare with the benefits from domestic market access improvements for foreign firms.

This paper addresses this question by examining innovation of Mexican firms in response to increased competition from China for the years 1998 to 2004. By becoming a member of the World Trade Organization (WTO) in 2001, China gained new market access to countries all over the world, and her already-high rates of export growth accelerated. By most accounts China's entry into world trade was the largest trade shock during the last 30 years.[1] Figure 1 shows the increasing presence of China on the world markets, with a particular steep slope in the years after 1998. For its part, Mexico was among the countries most strongly affected by China. Mexico had substantial overlap with China in terms of product range, and the location of Mexico next to the United States has made it particularly vulnerable to competition from China. In comparison to its imports from China, Mexico's exports to China over this period were trivial.

This setting yields an unparalleled opportunity to examine the innovative behavior of firms under the threat of competition. To be sure, innovation has many different aspects, and relatively little is known on which aspects are most important. Some emphasize inventory management, others the control of production processes, and some observers see workers as instrumental to innovation, while others focus on equipment (in particular, computers). The paper is bringing to individual evidence on these and other forms of innovation. Just-in-Time inventory techniques, for example, are among the key innovations Mexican firms could adopt when facing Chinese import competition. The first result of the paper is to provide a new look into the black box of innovation resulting from a major competitive shock.

Further, we show that innovation in our sample of Mexican manufacturing firms in response to Chinese competition did not change by very much over our sample period.[2] This is the

[1] See Winters and Yusuf (2007).

[2] Note that we use the terms firm and plant interchangeably here; the evidence below is at the level of the plant.

second result of the paper. It contrasts with the already noted findings of substantial gains for domestic firms in the case of foreign liberalizations or bilateral trade liberalizations. Relatively small Mexican innovation gains when Chinese exporters make inroads in Mexico while Mexican firms do not experience an effective market access improvement elsewhere likely reflect the overall reduction in the market size for Mexican firms. This is a Schumpeterian effect.[3]

Third, while the overall impact of Chinese competition was small, this masks a striking heterogeneous response across firms of different labor productivity. In a nutshell, productive firms innovate more in response to the China trade shock, while less productive firms innovate less. Because static performance differences translate into innovation choices in a way that amplifies initial differences, our result indicates that import competition sharpens the difference between strong versus weak performing firms. Put differently, this is a positive selection finding.

While high initial productivity makes it more likely that a firm will innovate in response to the China trade shock, there is no strong evidence that Mexican firms that innovate during China's WTO entry see smaller reductions in sales than is the case for non-innovating firms. Therefore, a market-size explanation for what drives innovation at the firm level does not find support from our results. Another explanation may be that productive firms innovate more than less productive firms in the presence of a competitive shock because the former have relatively more to gain from innovation than the latter, as in the 'escape competition' effect of Aghion et al. (2001).[4] In addition, we find evidence that innovation when market size is shrinking is more likely in foreign-owned firms and those that have a relatively skilled labor force.

A central question in international economics is the size of gains when countries liberalize their trade regime, and this paper sheds new light on the gains from innovation in this context. It has long been thought that trade liberalization may have major effects on innovation, and careful analysis of the detrimental impact of 'import substituting' trade strategies adopted by many less developed countries after World War II may have produced the first systematic evidence of this (Krueger 1975, Bhagwati 1978). We hope to make further progress by focusing on innovation at the firm level, along the lines of the recent literature on the behavior of firms in international trade that has produced a number of new major insights and facts.[5]

Our approach is distinct in two ways. First, we examine innovation in the sense of the adoption of specific firm techniques. The advantage of this is that it corresponds to the emphasis in

[3]Competition through its impact on market size reduces rents which are necessary to sustain innovation.

[4]Aghion et al. (2001) present a framework where more productive firms are closer to the technology frontier than productivity laggards, and entry of a foreign competitor close to the technology frontier will provide greater incentives to innovate for high- compared to low-productivity firms because conditional on innovation, a high-productivity firm can win out against the foreign competitor in a limit pricing contest whereas the low-productivity firm cannot.

[5]See Redding (2010) for an overview.

studies on how firms actually raise their economic performance, be it through quality control, inventory management, or generally 'lean' production. Such technology differences account for a large chunk of variation in economic performance across firms (Womack, Jones, and Roos 1991), and the extent to which trade liberalization affects the adoption of these technologies is bound to affect firm growth and the skill bias of its future labor demand. Although economists are increasingly turning to such direct measures (Bloom and Van Reenen 2007, Syverson 2010), in part because productivity, arguably the leading derived measure, picks up a whole set of additional factors that cloud the analysis,[6] they are still rare in studies of trade liberalization.[7] We are not aware of another study in which innovation is analyzed in terms of the adoption of specific firm techniques.

Second, we examine innovation responses to trade liberalization when the size of the market is not expanding but shrinking. The analysis is thus different from the recent argument that an expanding market size may lead to innovation because the firm's decision to innovate (or upgrade) is complementary to its decision to export (Yeaple 2005, Verhoogen 2008, Costantini and Melitz 2008, Atkeson and Burstein 2008, Lileeva and Trefler 2010, and Bustos 2010). Our focus on a shrinking market produces new insights because it focuses on firms' innovation choices that are unrelated to a general increase in firm scale, which makes it similar to some influential studies in industrial organization (see Holmes and Schmitz 2010).[8] From a policy perspective, the domestic innovation response to market access improvements at home may be no less important than the response to a bilateral liberalization.[9] A recent contribution on the impact of import competition on innovation is Bloom, Draca, and Van Reenen (2009). They show that the contribution of trade in generating wage inequality in rich countries is larger than generally presumed because increased imports from China caused European firms to increase their technology investments, raising the skill premium.[10]

The remainder of the paper is as follows. The following section 2 introduces our empirical

[6]Several of these factors have been highlighted in influential recent work, including market power (Foster, Haltiwanger, and Syverson 2008), product mix (Bernard, Redding, and Schott 2010, Mayer, Melitz, and Ottaviano 2010), and factor market distortions (Hsieh and Klenow 2010). Another measure of firm performance, namely changes in product range, is analyzed in Goldberg, Khandewal, Pavcnik, and Topalova (2009).

[7]The closest to our paper may be Schmitz (2005) who studies the abolition of restrictive work practices among North American iron ore producers threatened by Brazilian competition. Also see Lileeva and Trefler (2010) who show evidence on firm management changes among Canadian firms in terms of the use of computers; the latter are required for some of the firm techniques, such as just in time inventory.

[8]In addition, Aghion et al. (2009) and Javorcik et al. (2009) consider the impact of FDI on firm innovation, the former in response to policy reform in the UK, the latter in response to Wal-Mart's entry in Mexico.

[9]In addition, our analysis can shed new light on the innovation outcomes of other economic policies affecting competition in a zero-sum way, such as exchange rate intervention with imperfect pass-through.

[10]Other research on the impact of China's recent entry into global trade includes Utar and Torres Ruiz (2010) and Iacovone, Rauch, and Winters (2010). The latter examine the impact of China's trade on the market shares of firms and products in Mexico, which is complementary to our emphasis on innovation. Utar and Torres Ruiz (2010) study productivity changes among Mexican export processing firms (maquiladoras) using familiar methods. Such export processing firms are also included in our sample below.

approach. Our measures of innovation are defined in section 3, which also covers a general description of the data. All empirical results are discussed in section 4, while section 5 provides some concluding discussion.

2 Estimating innovation responses to changes in competition

The empirical approach is this paper is straightforward. We relate various plant-level outcome variables y_{ijt}, for example its adoption of Just in Time management techniques, to measures that capture the change in import competition, $comp_{ijt}$, Mexican plants have face been facing through China's emergence on world markets

$$y_{ijt} = \beta_0 + \beta_1 comp_{ijt} + \gamma X + u_{ijt}, \tag{1}$$

where i indexes the plant, j the 2-digit industry, and t time;[11] the term X is a vector of other observable determinants of y_{ijt} including time and industry fixed effects, and u_{ijt} is an error term. There are a number of generic problems in estimating this equation, including endogeneity, that will be addressed below. If β_1 can be consistently estimated, it represents the mean impact of competition on the outcome variable. Theory indicates that this can be positive or negative; for example, if the escape-competition effect dominates, it will be positive, whereas if the Schumpeterian rent dissipation effect is particularly strong, it will be negative.[12]

We are particularly interested in whether the relationship between innovation and competition on the one, and market share and competition on the other hand depends on characteristics of the firm. Our main focus will be on the technological capability of the firms, which will be labor productivity (measured as sales divided by employment). Below we will examine whether the impact of intensified competition varies with the labor productivity of the firm. This leads to the following specification:

$$y_{ijt} = \beta_0 + \beta_1 comp_{ijt} + \beta_2 q_{ijt} + \beta_3 \left(q_{ijt} \times comp_{ijt}\right) + \gamma X + u_{ijt}, \tag{2}$$

where q_{ijt} is the labor productivity of the firm in the initial period. If firms are differentially affected by competition, β_3 will be different from zero, and specifically, if larger firms innovation more in response to intensified competition, then $\beta_3 > 0$. Given that some of our variables, in particular Just in Time production and other management information systems, are limited

[11] We will be exploiting changes between the years $t = 1998$ and $t = 2004$.

[12] See Bloom, Draca, and van Reenen (2009) for more discussion of the different theories that are relevant here.

dependent variables that take on only values of zero or one, in future work we will not only use linear regressions but also probit models.

Before we specify our estimation equations and show the results, the following section gives an overview of our data sources.

3 Data

In this article we use data provided by *Instituto Nacional de Estadística y Geografía* (INEGI), a Mexican statistical agency. We use their annual surveys of manufacturing plants from the years 2005 and 1999, which cover information on plants in the years 2004 and 1998. These surveys of the *Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitación* (ENESTyC), provide information on a large range of plant characteristics, such as technology, employment and salaries. The survey includes all Mexican plants with more than 100 employees, and uses a sampling procedure that ensures representativeness to include smaller firms. The data attaches a unique identified to each plant that remained the same over time. Thus we are able to match the survey answers for some plants across time.

While we are interested in the response of Mexican firms to Chinese competition, we recognize that Chinese market share gains in Mexico are potentially endogenous to the performance of the Mexican firms themselves, and the estimated coefficients may therefore not be consistent. To address this issue, we employ information on Chinese market share gains in the United States instead of Chinese gains in Mexico over this period. By exploiting evidence on the competitive strength of China in a different, much larger though closely related market, we are more plausibly examining an exogenous shock to the Mexican manufacturing sector. This approach also lets us examine specifically the performance of Mexican firms that export to the United States. These firms may be losing domestic market share in Mexico through competition from China at the same time when they lose export market shares in the United States.

Our measure of import competition is based on the change in the imports from China in the United States, relative to all US imports, for narrowly defined industries.[13] We merge the survey information with the well known international trade data from COMTRADE employing the concordance of Iacovone, Rauch, and Winters (2010). This links the Mexican plant data at the six-digit level (CMAP 6) to the COMTRADE trade data according to the Harmonized System (HS) classification.

[13] We are in the process of adding policy measures–the change in tariffs–for a subset of industries as additional measures of changes in import competition.

We use a number of innovation variables in the analysis. Each corresponds to a specific technique that defines the firm's technology. In the following we will provide an overview of these techniques.

Just in Time (JIT):[14] An administrative process tool that follows the philosophy of eliminating wasteful elements in the production chain, most notably inventories, by making use of modern developments in distribution and logistics management. Its implementation follows typically elements such as (i) elimination of unneeded operations, (ii) minimization of time for necessary operations, (iii) elimination of unneeded transportations, (iv) minimization of necessary transportations, (v) eliminate non-operator inspections, (vi) eliminate delays, (vii) eliminate work-in-progress storage and (viii) minimize raw materials and finished goods storage. In consequence, by this system the arrival of production inputs is ideally organized such that they are delivered in the moment in which they are needed. Similarly, only demanded goods are produced, in a way that they are ready to ship at the time when they ought to. This production process reduces storage costs to the minimum. In addition, by the production synchronizes with demand, thus there are no costs arising from overproduction.

Statistical quality control: The questionnaires by INEGI specify that in this question the surveyor asked for the installation of any system of quality assurance, by which products are cross checked along certain check points on the production chain if their quantity and quality matches predefined standards.

Total quality management (TQM): The main idea of TQM is that quality is built into production by achieving zero defects along the production chain. It is not a specific measure, but rather an approach that integrates a group of concepts. TQM seeks to establish (i) the provision of high quality products or services to satisfy consumers through a continuous improvement process, (ii) the achievement of high quality in products and processes at low costs, and (iii) the management of total quality through involvement of all employees, measurement of progress and communication of results. Typically such quality improvement measures evaluate quality of products and services, as well as processes and organizational infrastructures.

Equipment reorganization: In this question INEGI asked explicitly if the plant undertook a reorganization of machinery or equipment with the aim to either achieve more efficient production lines or to reduce the probability of work risks, thereby reducing downtime.

Job rotation: Internal rotation of employees, such that employees can develop different skills in various areas of production. In addition, employees learn to understand many dimensions of the firm and the production process, which allows them to make better decisions at their own

[14] See International Encyclopedia of Business & Management (1996).

departments. The system also may lead to increased communication across various different departments of the firm.

In addition to these variables, the surveys also cover variables that measure technology investment inputs, such as R&D expenditures, investments towards worker training, and other activities affecting the technological capabilities of the firm (such as technology purchases, equipment purchases, and indicators of process and product innovation). In the following analysis the focus will be mostly on the adoption of specific firm techniques, for reasons discussed in the introduction.

We now turn to our estimation results.

4 Estimation results

In table 1 we describe sum statistics on innovation adoption before 1998, and in the period from 1998 to 2004. 15 percent of plants in our sample introduced Just in Time before 1998, and 14 more percent of the remaining plants introduced this system in the years 2000-2004, making Just in Time the least popular innovation we study. On the other hand, the most popular innovations were statistical control and continuous control, which were used by 40 and 50 percent of plants respectively before 1998, with new introductions of around 20 percent of the remaining plants from 2000 to 2004.

Table 2 gives additional descriptions of the main variables we consider in this paper. Sales of plants in our sample increased considerably in the six years studied, from 311 to 540 thousand pesos, while total employment for the plants in our sample decreased in mean and median. The share of expenditures spent on R&D was relatively low in both years, with the median plant not spending on research in both years, which is typical for large samples of firm level data.

For the other variables in this panel we have information on the introduction of innovations from the 2004 survey. Thus we can distinguish introduction between 2000 and 2004, and before 2000. This includes the following variables: The production chain system "just in time", introduction of quality control or total quality control measures, equipment reordering, and job rotation systems and the presence of worker training programs. All these variables show a substantial activity in the number of introductions of innovations during the period 2000-2004, also compared to firms who had these innovations installed in 2000.

To estimate the effect of competition from China on innovation activity of plants we rely in all tables on a simple estimation strategy that uses a straight forward competition measure and relies on useful control variables we have in the panel. The equation we estimate in table 3 is of the form:

$$y_{ij2004} = \beta_0 + \beta_1 \Delta comp_{ij} + \gamma X + \eta_j + \epsilon_i j, \quad (3)$$

where y_{ij2004} is an innovation outcome variable of plant i in two digit industry j in the year 2004, β_0 a constant, $\Delta comp_{ij}$ a measure of competition from China, y_{ij1998} a control for the initial value of the outcome variable, X a matrix of control variables such as controls for the age of a plant, the distance to the border, a control variable for plants in Mexico City, and eta_j a matrix of two digit industry controls. Throughout the reported results we apply robust standard errors, which we typically cluster at six digit industry level (the level at which competition varies). We interact the competition measure with initial labor productivity of plants, because we expect the response of innovation activity to increased competition to vary with productivity.

To measure competition from China with the variable $\Delta comp_{ij}$ we compute the share of imports from China in all imports in the United States in 2004 and 1998. Our competition measure is the difference between these two shares. As noted above, we are concerned that the observed degree of import penetration of China in Mexico is endogenous. One possibility is that Chinese firms make greater inroads into the Mexican market whenever the Mexican competitors are particularly weak. Therefore, the Chinese import share in the United States is considered as an alternative measure of competition as well, to which we will refer as the US competition measure. China's export success in the US market Chinese exports to the US are positively correlated with Chinese exports to Mexico, but the US imports are less likely to be subject to reverse causality.

For the first five variables in Table 3 we have information of the year in which a plant introduced innovation measures. The outcome variable in these columns is a dummy that indicates if the innovation was introduced between the years 2000 and 2004. We restrict the table to plants that did not have the respective innovation introduced already in the year 1998. In addition we use two digit industry fixed effects, and cluster standard errors at the level at which competition varies (six digit industry level). The first outcome variable we test is the introduction of the production system "Just in Time". The measure of competition we use does not give significant results for any of the outcome variables we test, with the exception of sales. This suggests that on average the Chinese competition by the way we measure it did not seem to have a significant impact on the innovation activity of plants. Typically the results remain unchanged if we use the difference of import shares directly.

The coefficients on most control variables do not show coefficients that are statistically different from zero. Our measure for the distance to the US border does not give significant coefficients, and neither does the control for plants in Mexico City. Both suggests that in this specification technology transfer is equally efficient for plants at distance from the United States, and outside of the capital. Similarly the two control variables for the age of plants are not significantly different from zero, but also for these we started without a clear prior on what to expect.

In Table 4 we include a measure of labor productivity, and interact it with competition, to investigate asymmetric effects for plants of different productivity. The equation we estimate in the following tables is of the form:

$$y_{ij2004} = \beta_0 + \beta_1 \Delta comp_{ij} + \beta_2 \Delta comp_{ij} q_{ij1998} + \beta_3 q_{ij1998} + \gamma X + \eta_j + \epsilon_i j, \qquad (4)$$

where q_{ij1998} is a measure of labor productivity in 1998. In Table 4 we include again two digit industry fixed effects and control variables for age, distance to the US and a Mexico City control. The coefficients on the competition measure, and competition interacted with initial labor productivity must be interpreted together to understand the marginal effect of competition on the introduction of our innovation measures. In the first column we estimate again the probability that a plant introduces "Just in time" between 2000 and 2004. We find that this probability is negative for low productivity plants, but larger and positive for high productivity plants. This same pattern is visible for the introduction of total control, equipment reordering, job rotation and quality control, however for total control and quality control with less significance. This observation is consistent with other papers in this area that find an asymmetric effect that favors productive plants (see Iacovone, Rauch, Winters 2010).

Given that all outcome variables of interest in table 4 are dummy variables, we re-estimate the table using probits in table 5. We report marginal effects. For all five outcome variables, the probit suggests coefficients with similar signs and significance. Also magnitudes are close to those estimated with the linear probability model.

Table 6 considers magnitudes of the effects we find. We find that our empirical model suggests that between one (equipment re-organization) and 13 (job rotation) percent of innovation introductions can be explained through competition. If we consider the subsample of high productivity plants alone, this number increases up to between four and 18 percent.

In Table 7 we split the data into two samples with high and low labor productivity, defined as initial labor productivity above and below its median. This has the advantage of approaching the question of heterogeneous innovative response in a less parametric way. We find that whenever the coefficients of the two samples are significantly different, the coefficient for the high sample is larger. In addition we observe that the coefficient on competition is always positive in the high productivity sample, and always negative in the low productivity sample, despite not always being statistically significantly different from zero. This table stands in contrast with table 3 that did not display significant results of this specification for the full sample, and demonstrates the importance of considering asymmetric effects. Figure 2 displays the marginal effects estimated in table 7 with 90 percent confidence intervals of these coefficients.

Finally, table eight considers maquiladora plants by introducing an additional interaction to table 5. The interaction of competition with a maquiladora indicator is negative whenever it is significantly different from zero, which counterbalances the positive effect from competition alone. This suggests that maquiladora plants experience smaller marginal effects from competition on innovation, and may highlight that these plants have more experience with a high competition market.

To test the robustness of our competition measure, we re-estimate the results from table 7 with different measures for Chinese competition, and graph coefficients and 90 percent confidence intervals for each. The bars in (a) show our preferred estimate, using the difference of import shares as measure of Chinese competition in the US. Again we find that the marginal response of competition from China is positive for large plants, and negative for small plants. In (b) we replace this measure with the initial level of competition, and obtain largely similar results. In the bars displayed in (c) and (d) we repeat the exercise with Chinese imports in Mexico, measured as difference and level respectively. Confidence intervals are wider, and thus significance reduced, but the effect remains largely the same. Finally in (e) and (f) we replace the competition measure with a dummy variable that indicates if the difference of import shares was above or below median competition. Again we find a similar interpretation.

To summarize, from our analysis so far it appears that in the face of new import competition, the differences across firms in terms of their innovative behavior–their forward looking activity–are magnified relative to differences across firms in terms of current sales.

We now turn to some concluding discussion.

5 Conclusions

Innovation is a broad term that includes many different phenomena, which might not be all effected in the same way by competition. In this study we are able to analyze the impact of competition on several distinct measures of innovation. We find that the incentives to adopt new management systems such as Just in Time is much stronger for larger than for smaller firms. Moreover, our results looking at these variables are sharper than for less direct measures of firm technology, such as R&D expenditures, TFP, or the share of highly skilled workers. These results underline the usefulness of opening the black box of firm technology and employ information on directly observable features of technology in quantitative analyses.

The Schumpeterian hypothesis that monopolists have a greater incentive to innovate than firms facing tough competition has been revisited by new theory and empirical results finding that more competition may on balance actually increase the rate of innovation. In our analysis of the impact of China's emergence as a force in international trade, we find that the rate of innovation of Mexican plants tends to fall, not rise. This may be specific to the shock we are analyzing, which is extraordinary in many respects. At the same time, there is strong evidence that larger firms tend to innovate more than smaller firms in the face of new competition. Import competition is thus a force that sharpens the difference between strong-performing and weak-performing firms, a result that is in line with the more qualitative body of research on countries' foreign trade strategies that has been accumulated since World War II.

Our study shows that while innovation rates vary strongly in response to intensified competition, there is less evidence for a reallocation of market shares in our analysis compared to other studies. In part this may be because by focusing on continuing plants we do not account for exit in our analysis.[15] Another explanation might be that it takes more time than is covered by our sample for market shares to substantially change; in that case, however, the market share changes may also be in part due to the differential rates of innovation. While our study has generated some new results, it clearly remains a major challenge to distinguish the static and dynamic effects of changes in import competition.

In our study of how different types of innvation differ in their response to innovation, we are limited to the measures included in the surveys at hand. Further studies might highlight other outcome variables, such as wages, destinations, product introduction or changes of management practices.

[15]Another reason might be that we control for the general reversion-to-the-mean effect in our analysis by including initial size.

References

[1] Aghion, P., R. Blundell, R. Griffith, P. Howitt and S. Prantl (2009), *The Effects of Entry on Incumbent Innovation and Productivity*, Review of Economics and Statistics, vol. 91, no. 1, pp. 20-32.

[2] Atkeson, Andrew and Ariel Burstein, *Pricing to Market, Trade Costs, and International Relative Prices*, American Economic Review, December 2008

[3] Aw, Bee Yan, Mark Roberts and Daniel Yi Xu, "R&D investments, exporting and the evolution of firm productivity, American Economic Review: Papers & Proceedings 2008, 98:2, 451–456

[4] Bernard, Andrew, Jonathan Eaton, J. Bradford Jensen and Samuel S. Kortum, *Plants and Productivity in International Trade*, American Economic Review, 93(4), 2003

[5] Bhagwati, J. (1978), *Anatomy and Consequences of Exchange Control Regimes*, Ballinger.

[6] Bloom, N., M. Draca and J. Van Reenen (2009), *Trade Induced Technical Change: The Impact of Chinese Imports on Innovation, Diffusion and Productivity*, mimeo, Stanford University.

[7] Bloom, N. and J. Van Reenen, *Measuring and Explaining Management Practices Across Firms and Countries*, The Quarterly Journal of Economics 122: 1351-1408.

[8] Bustos, Paula, "Trade Liberalization, Exports and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinean Firms", American Economic Review, 2010

[9] Costantini, James A., and Marc J. Melitz, "The Dynamics of Firm-Level Adjustment to Trade," in The Organization of Firms in a Global Economy, Elhanan Helpman, Dalia Marin, and Thierry Verdier, eds. (Cambridge, MA: Harvard University Press, 2008).

[10] De Loecker, J. (2007), *Do exports generate higher productivity? Evidence from Slovenia*, Journal of International Economics, vol. 73, no. 1, pp. 69-98.

[11] Erdem E. and J. Tybout, (2003), *Trade policy and industrial sector responses: using evolutionary models to interpret the evidence*, in Susan Collins and Dani Rodrik, eds., Brookings Trade Forum 2003, Washington, DC.: The Brookings Institution.

[12] Fernandes, A., *Trade policy, trade volumes and plant-level productivity in Colombian manufacturing industries*, Journal of International Economics, Vol. 71.

[13] Fernandes, A. and C. Paunov, (2010), *Does Trade Stiumlate Innovation? Evidence from Firm-Product Data* OECD Development Centre Working Papers 286, OECD, Development Centre.

[14] Goldberg, P., A. Khandelwal, N. Pavcnik and P. Topolova (2009), *Trade Liberalization and New Imported Inputs,* forthcoming, Quarterly Journal of Economics

[15] Iacovone, L., F. Rauch and L. Winters (2010), *Trade as Engine of Creative Destruction*, mimeo, The World Bank.

[16] "International Encyclopedia of Business & Management", Routledge Publishing, New Fetter Lane, London, 1996

[17] Javorcik, B., W. Keller, and J. Tybout (2008), "Openness and Industrial Responses in a Wal-Mart World: A Case Study of Mexican Soaps, Detergents and Surfactant Producers", World Economy, December 2008.

[18] Keller, W. and S. Yeaple, (2009), *Multinational enterprises, international trade, and productivity growth: firm-level evidence from the United States*, The Review of Economics and Statistics, vol. 91, no. 4, pp. 821-831.

[19] Krueger, A. (1978), *Liberalization Attempts and Consequences*, NBER.

[20] Lileeva, A., and D. Trefler (2010), "Improved Access To Foreign Markets Raises Plant-Level Productivity...For Some Plants", Quarterly Journal of Economics August 2010, 1051-1099.

[21] Melitz, M. (2003), *The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity*, Econometrica, Vol. 71, No. 6 (Nov., 2003), pp. 1695-1725.

[22] Muendler, M. (2004), *Trade, Technology, and Productivity: A Study of Brazilian Manufacturers, 1986-1998* University of California at San Diego Economics Working Papers.

[23] Pavcnik, N. (2002), *Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants*, Review of Economic Studies.

[24] Topalova, P., and A. Khandewal (2010), "Trade liberalization and Firm productivity: The Case of India", forthcoming, Review of Economics and Statistics.

[25] Verhoogen, Eric, "Trade, Quality Upgrading and Wage Inequality in the Mexican Manufacturing Sector," Quarterly Journal of Economics, 123 (2008), 489–530.

[26] Womack, J., D. Jones and D. Roos (1991), *The machine that changed the world*, New York: Harper Collins.

[27] Yeaple, Stephen, *A Simple Model of Firm Heterogeneity, International Trade, and Wages*, Journal of International Economics, 2005, 65(1): 1-20.

	% adopted by 1998	# of firms	% new adopters 2000-04	#of firms
Just in Time	15.4	334	13.7	251
Statistical Control	43.7	947	23.5	287
Quality Control	33.5	726	24.7	356
Eq. Re-Ordering	40	867	26	338
Continuous Control	49.8	1079	27.2	296
Job Rotation	24.5	531	18.2	298

Table 1: Innovation: Summary Statistics. Total Number of Firms: 2167

	Period	Mean	Median	Std Dev
Total Sales	1998	311936	85000	1463649
	2004	540591	144519	2315503
Employment	1998	376.56	228	583.392
	2004	341.071	210	491.992
Labor training	1998	0.833	1	0.373
	2004	0.719	1	0.449
R & D (%)	1998	0.085	0	3.009
	2004	1.676	0	34.951
Foreign Ownership	1998	16.267	0	35.41
	2004	16.844	0	35.41
Exporter Status	1998	0.61	1	0.488
	2004	0.579	1	0.494
Intermediates from Asia	1998	0.025	0	0.157
Intermediates from China	1998	0.691	0	4.69

Table 2: Labor training is a dummy variable that indicates the presence of any labor training efforts of firms, R&D measures the share of expenditures for R&D, foreign ownership measures the share of capital from outside Mexico, exporter status is a dummy variable equal to one for exporters, intermediates from Asia indicates by firms if Asia was origin of any intermediates, intermediates from China reports the percent of intermediate imports from China.

	(1) Just in Time	(2) Quality control	(3) Total control	(4) Equipment reordering	(5) Job rotation
Competition	-0.177	-0.009	-0.0416	-0.231	0.057
	(0.166)	(0.946)	(0.748)	(0.134)	(0.680)
Distance to US	-0.013	-0.029	0.005	0.005	-0.009
	(0.488)	(0.166)	(0.782)	(0.802)	(0.642)
Mexico city	-0.020	-0.039	0.007	-0.004	-0.021
	(0.299)	(0.116)	(0.730)	(0.825)	(0.383)
Age $<$ 5 years	0.042	-0.0245	0.005	-0.017	0.002
	(0.144)	(0.482)	(0.877)	(0.549)	(0.943)
Age $<$ 10 years	-0.006	-0.007	-0.0313	-0.0005	-0.028
	(0.750)	(0.779)	(0.157)	(0.984)	(0.254)
Observations	1900	1900	1900	1900	1900
R-squared	0.034	0.107	0.167	0.143	0.063

Table 3: Includes industry fixed effects at the CMAP2 level. The p-values are based on robust and clustered standard errors at the CMAP 6 level.

	(1) Just in Time	(2) Quality control	(3) Total control	(4) Equipment reordering	(5) Job rotation
Competition	-0.541***	-0.314	-0.473	-0.694**	-0.380*
	(0.179)	(0.268)	(0.300)	(0.270)	(0.212)
Competition x Labor	0.667**	0.595*	0.854*	0.742**	0.859***
prod. in 1998	(0.265)	(0.351)	(0.481)	(0.346)	(0.290)
Labor prod. in 1998	-0.0379	-0.0414	-0.0272	-0.0412	-0.0783***
	(0.0273)	(0.0356)	(0.0471)	(0.0313)	(0.0295)
Distance to US	-0.0181	-0.0516	0.00654	0.00399	-0.0197
	(0.0224)	(0.0342)	(0.0385)	(0.0325)	(0.0246)
Mexico City	-0.0220	-0.0545	0.0153	-0.00254	-0.0270
	(0.0222)	(0.0358)	(0.0418)	(0.0309)	(0.0322)
Age $<$ 5 years	0.0487	-0.0361	-0.00299	-0.0282	0.00262
	(0.0349)	(0.0490)	(0.0606)	(0.0437)	(0.0406)
Age $<$ 10 years	-0.00970	-0.0128	-0.0589	-0.00164	-0.0364
	(0.0244)	(0.0387)	(0.0440)	(0.0414)	(0.0324)
Constant	0.286*	0.602***	0.258	0.289	0.356**
	(0.148)	(0.220)	(0.249)	(0.203)	(0.160)

Table 4: Includes industry fixed effects at the CMAP2 level. The p-values are based on robust and clustered standard errors at the CMAP 6 level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Just in Time	Just in Time	Quality control	Quality control	Total control	Total control	Equipment reordering	Equipment reordering	Job rotation	Job rotation
	OLS	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS	Probit
Competition	-0.541***	-0.532**	-0.314	-0.390	-0.473	-0.575*	-0.694**	-0.749***	-0.380*	-0.473**
	(0.179)	(0.216)	(0.268)	(0.254)	(0.300)	(0.339)	(0.270)	(0.256)	(0.212)	(0.218)
Competition x Labor	0.667**	0.697**	0.595*	0.656*	0.854*	0.889*	0.742**	0.760**	0.859***	0.838***
prod. in 1998	(0.265)	(0.284)	(0.351)	(0.354)	(0.481)	(0.502)	(0.346)	(0.363)	(0.290)	(0.300)
Labor prod. in 1998	-0.0379	-0.0431	-0.0414	-0.0465	-0.0272	-0.0342	-0.0412	-0.0527*	-0.0783***	-0.0794***
	(0.0273)	(0.0264)	(0.0356)	(0.0354)	(0.0471)	(0.0464)	(0.0313)	(0.0303)	(0.0295)	(0.0295)
Distance to US	-0.0181	-0.0221	-0.0516	-0.0490	0.00654	0.00777	0.00399	-0.00147	-0.0197	-0.0168
	(0.0224)	(0.0203)	(0.0342)	(0.0311)	(0.0385)	(0.0372)	(0.0325)	(0.0317)	(0.0246)	(0.0245)
Mexico City	-0.0220	-0.0209	-0.0545	-0.0593*	0.0153	0.0214	-0.00254	-0.0103	-0.0270	-0.0307
	(0.0222)	(0.0227)	(0.0358)	(0.0360)	(0.0418)	(0.0423)	(0.0309)	(0.0303)	(0.0322)	(0.0295)
Age < 5 years	0.0487	0.0418	-0.0361	-0.0464	-0.00299	-0.00563	-0.0282	-0.0355	0.00262	-0.00246
	(0.0349)	(0.0336)	(0.0490)	(0.0498)	(0.0606)	(0.0589)	(0.0437)	(0.0428)	(0.0406)	(0.0395)
Age < 10 years	-0.00970	-0.00987	-0.0128	-0.0123	-0.0589	-0.0662	-0.00164	-0.00703	-0.0364	-0.0368
	(0.0244)	(0.0238)	(0.0387)	(0.0382)	(0.0440)	(0.0433)	(0.0414)	(0.0420)	(0.0324)	(0.0319)
Observations	1604	1604	1250	1250	951	951	1136	1136	1429	1429

Table 5: Probit vs. OLS. For the probits marginal effects are reported. The standard errors are based on robust and clustered standard errors at the CMAP 6 level.

	Mean Competion	Observed adoption	% explained by by comp	Comp Coeff High LP	Observed adoption for High LP	Fraction explained by comp for High LP
Job Rotation	0.38	0.18	0.13	0.49	0.17	0.18
Stat. Control	0.32	0.24	0.08	0.42	0.22	0.11
Just in Time	0.16	0.14	0.07	0.28	0.14	0.12
Qual. Control	0.25	0.25	0.06	0.35	0.24	0.09
Contin. Control	0.23	0.27	0.05	0.33	0.29	0.07
Re-Organization	0.03	0.26	0.01	0.16	0.26	0.04

Table 6: Import competition and innovation: Some magnitudes.

	(1) Just in Time	(2) Just in Time	(3) Quality control	(4) Quality control	(5) Total control	(6) Total control	(7) Equipment reordering	(8) Equipment reordering	(9) Job rotation	(10) Job rotation
Competition	0.278	-0.657***	0.352	-0.451	0.331	-0.499	0.156	-0.822***	0.485**	-0.322
	(0.221)	(0.209)	(0.281)	(0.304)	(0.359)	(0.312)	(0.274)	(0.270)	(0.238)	(0.244)
Distance to US	-0.0457	0.0120	-0.0266	-0.0727	-0.0239	0.0330	0.0237	-0.0235	-0.0318	-0.0154
	(0.0352)	(0.0274)	(0.0497)	(0.0475)	(0.0534)	(0.0510)	(0.0465)	(0.0518)	(0.0316)	(0.0419)
Mexico City	0.00850	-0.0495*	-0.0495	-0.0505	0.0593	-0.00678	-0.00695	0.00402	0.0400	-0.0976**
	(0.0373)	(0.0261)	(0.0528)	(0.0440)	(0.0701)	(0.0492)	(0.0465)	(0.0433)	(0.0424)	(0.0385)
Age $<$ 5 years	0.0637	0.0383	-0.0448	-0.0248	-0.0128	0.00344	-0.0539	-0.00448	0.00226	-0.000182
	(0.0469)	(0.0562)	(0.0574)	(0.0806)	(0.0769)	(0.0854)	(0.0569)	(0.0750)	(0.0515)	(0.0714)
Age $<$ 10 years	0.0215	-0.0380	-0.0532	0.0416	-0.102*	-0.0141	-0.00241	0.0101	0.00942	-0.0995**
	(0.0378)	(0.0358)	(0.0461)	(0.0541)	(0.0587)	(0.0646)	(0.0494)	(0.0611)	(0.0431)	(0.0453)
Constant	0.399*	0.116	0.405	0.737**	0.420	0.0946	0.115	0.472	0.335	0.348
	(0.226)	(0.177)	(0.311)	(0.305)	(0.340)	(0.331)	(0.299)	(0.326)	(0.204)	(0.267)
Productivity	High	Low	High	Low	High	Low	High	Low	High	Low
Observations	838	766	642	608	472	479	604	532	775	654
R-squared	0.024	0.028	0.039	0.019	0.036	0.025	0.043	0.039	0.023	0.028

Table 7: Separate high and low productivity plants. The standard errors are based on robust and clustered standard errors at the CMAP 6 level.

	Just in Time	Stat. Control	Quality Cont	Total Cont	Re-Organization	Job Rotation
Competition	-0.490***	-0.145	-0.307	-0.468	-0.651**	-0.342
	(0.00500)	(0.590)	(0.251)	(0.130)	(0.0153)	(0.113)
Comp x Labor Productivity 98	0.631**	0.473	0.591*	0.851*	0.709**	0.835***
	(0.0175)	(0.234)	(0.0946)	(0.0844)	(0.0410)	(0.00491)
Labor Prod 98	-0.0352	-0.0443	-0.0411	-0.0267	-0.0395	-0.0764**
	(0.192)	(0.217)	(0.248)	(0.572)	(0.208)	(0.0107)
Comp x Maquiladora	-3.619**	-1.017	-0.313	-0.668	-2.458**	-2.635***
	(0.0187)	(0.562)	(0.776)	(0.449)	(0.0103)	(0.00597)
Maquiladora	0.449***	0.358	-0.0493	0.143	0.203*	0.403***
	(0.00666)	(0.199)	(0.757)	(0.412)	(0.0918)	(0.00899)
Observations	1,604	1,065	1,250	951	1,136	1,429
R-squared	0.023	0.015	0.017	0.020	0.034	0.024

Table 8: This table shows differential effects for maquiladoras. P values displayed in parantheses. The p-values are based on robust and clustered standard errors at the CMAP 6 level.

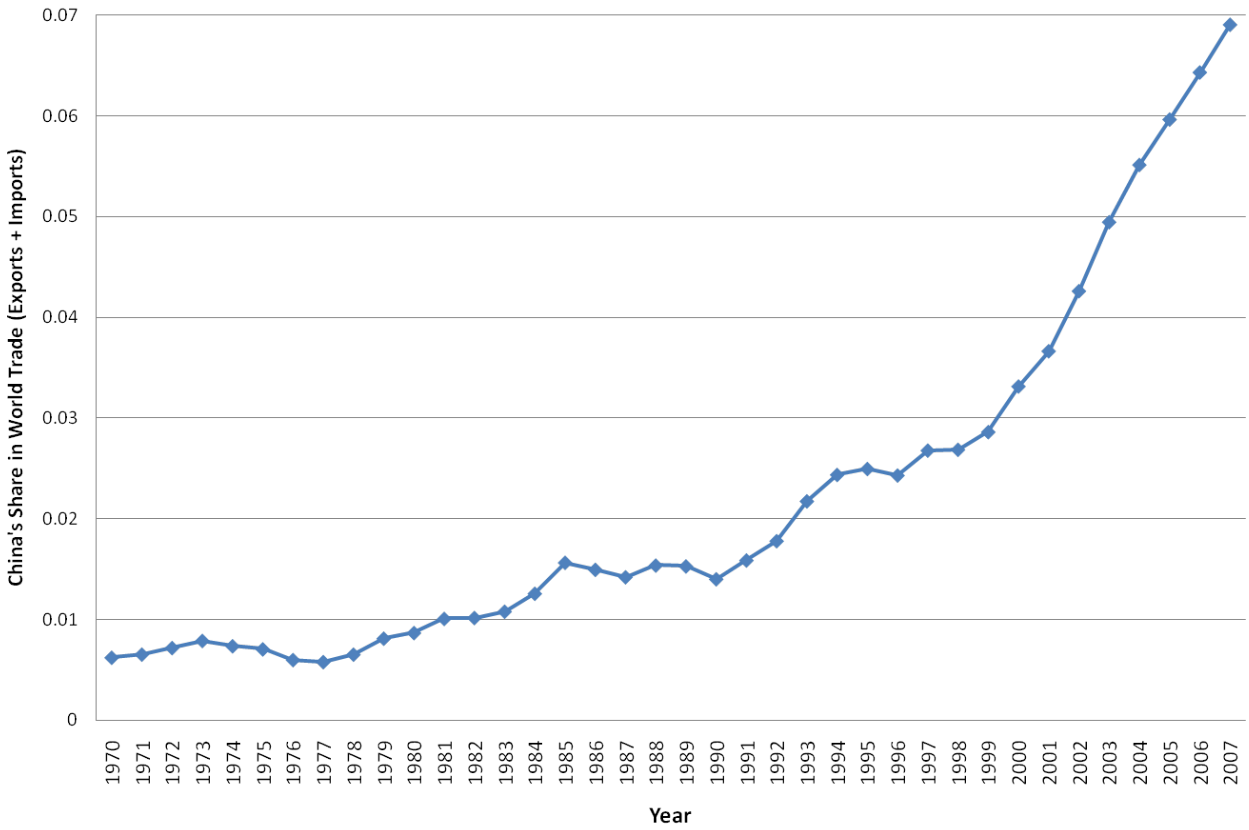

Figure 1: The Shock: China's Rise in World Trade

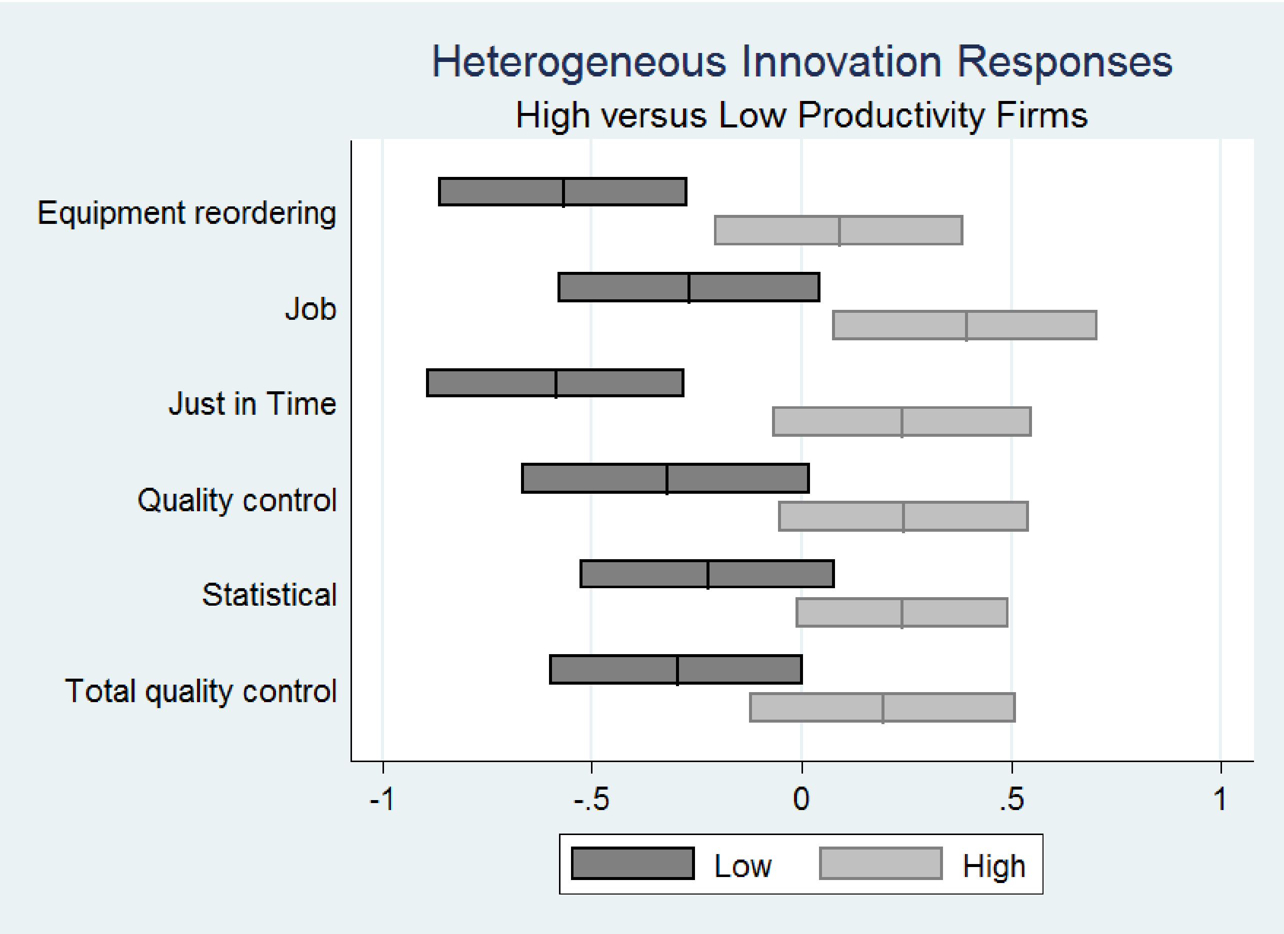

Figure 2: Productivity measured by labor productivity above (high) or below (low) mean.

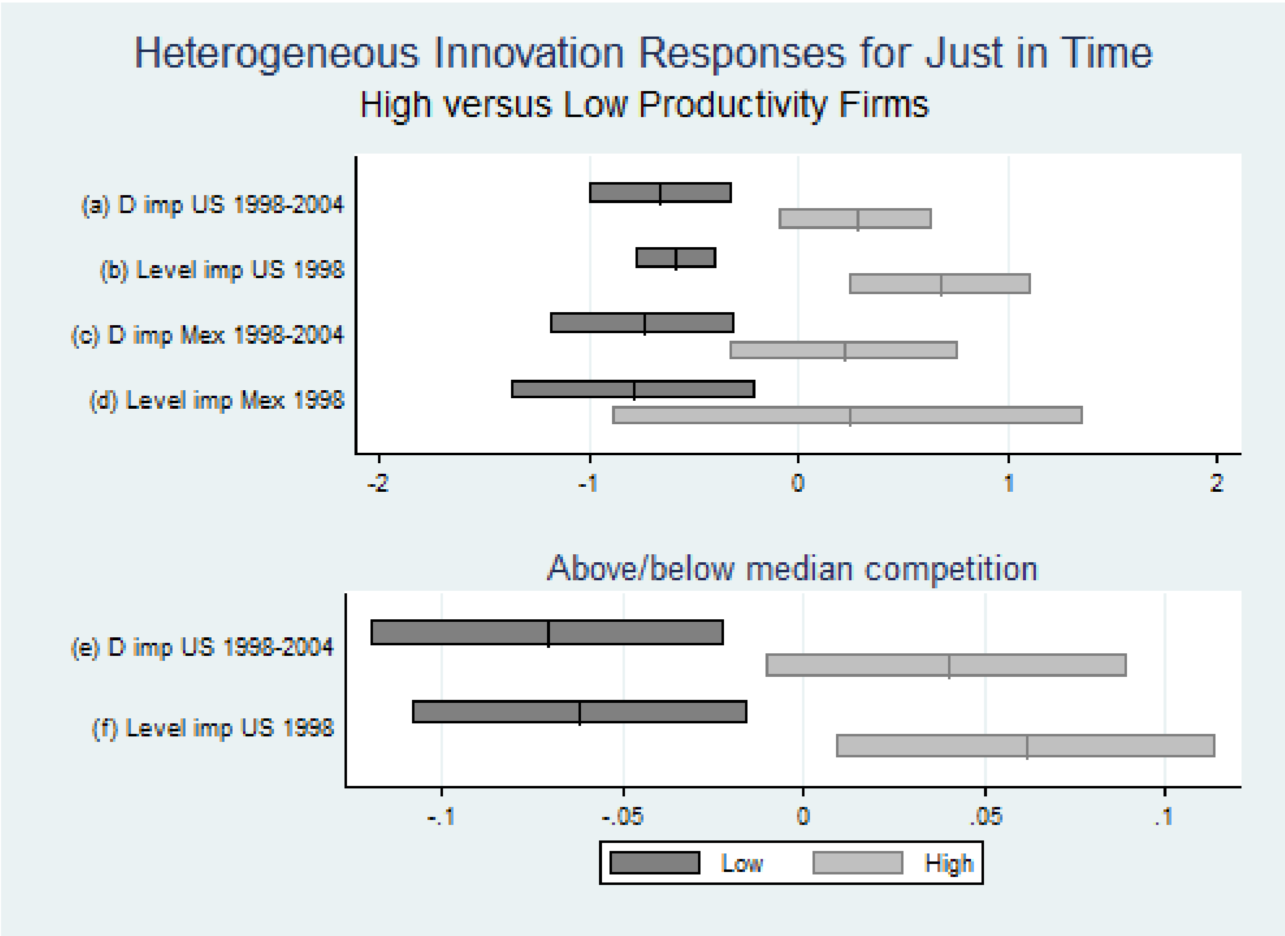

Figure 3: Productivity measured by labor productivity above (high) or below (low) mean.