Innovation, productivity, exports and the investment climate: A study based on Indian manufacturing firm-level data

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Abstract

In this paper, we use univariate instrumental estimations to study the interactions between firm-level innovation, exports and productivity in the Indian manufacturing sector. To differentiate incentives to innovate from the ability to innovate, we distinguish the inputs of innovation (R&D and training) from the outputs. Our findings highlight a virtuous circle between the three components of innovation, as well as between firms' R&D, innovation and exports. The productivity of Indian manufacturing firms is benefiting from this dynamics, as exports and innovation improve firms' TFP. With respect to the investment climate, our results suggest that differences in the environment of Indian companies contribute to their performance gaps. These results are all the more important in the context of the Make in India campaign and the weaknesses of India's business environment.

JEL classification: C31, C36, D22, L25, O12, O14, O30, O53

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A Study Based on Indian Manufacturing Firm-Level Data

1-Introduction

In the literature, the manufacturing industry is traditionally considered as the sector of most rapid growth through technical progress, innovation, externalities, knowledge spillovers and scale economies (Kaldor, 1966; Murphy et al. 1989). Improving productivity in manufacturing, especially, is recognized as an effective way of enhancing performance and catching up with other better performers, what is widely known as the convergence hypothesis (Howitt, 2000). Despite the recent surge of the services sector in Indian, the central role of the manufacturing industry has been reaffirmed by Aghion (2012) and Stiglitz et al. (2013) who believe that manufacturing remains the only realistic path to sustained growth for low-income, low-skilled, and labor-abundant countries, such as India.

Since 1991 in India, reform in the manufacturing sector has witnessed major policy changes. Industrial de-licensing and removal of restrictions on foreign investment have modified the profile of the sector considerably (Aghion et al., 2008). Trade policies have stimulated exports and imports since tariff rates have been reduced and quantitative restrictions on imports were by-and-large abolished (Topalova and Khandelwal, 2011). To encourage firms to innovate and conduct R&D, the government has developed a system of fiscal incentives and financial benefits (Unido, 2015). These reforms aimed at making the Indian manufacturing firms more efficient, technologically up-to-date and competitive. However, despite these policy changes, the share of the manufacturing sector at 16% of GDP in 2012 was still low compared to other Asian emerging countries[1], as well as exports and productivity (Gupta et al., 2008; Kathuria et al., 2014).

With the "National Manufacturing Policy" in 2012, and the "Make in India" campaign in 2014, the objectives are to enhance further the manufacturing industry so that the sector emerges as a new engine of growth to provide jobs to a large number of unemployed and under-employed workers. Poor quality of governance, the regulatory environment, deficiencies in physical, economic, and social infrastructure are reported as major reasons of the retarded industrial growth and the wide inter-state differences in the country (Mitra, et al., 2002, 2014; Lall and Mengistae, 2005; Gupta et al. 2008). The central policy agenda of these national-level programs is to address firms' constraints to unlock the potential of growth, innovation and competitiveness of the manufacturing sector[2.] By studying the interactions between firms' innovation, exports and productivity, this paper can be seen as a contribution to this debate.

This study relates to different strands of the literature. The role of trade in enhancing firms' performance has been the subject of extensive discussions (Balassa, 1988; Krugman, 1994).The issue has taken on added importance since the pioneering work of Bernard and Jensen (l995) that found exporting firms more productive, larger in size, more skill and capital intensive than non-exporting ones. On the theoretical front, some analysts argue that, due to the fixed-costs of exporting, the higher productivity of exporters reflects the self-selection of more efficient producers into highly competitive export markets (Melitz, 2003; Bernard and Jensen, 2004; as well as Haidar, 2012, and Mishra and Sharma, 2015 in the case of India). This "self-selection" model has however been challenged by others who stress that it is international trade, exporting especially, which improves firms' productivity through a learning process. This "learning-by-exporting" hypothesis has been illustrated by Clerides et al. (1998) and Aw et al. (2011), as well as Mitra, et al (2014) and Sharma (2017) in the case of India.

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1 This share was of 34% in Thailand, 32% in China, 31% in Korea and 24% in Indonesia in 2014.

2 http://dipp.nic.in/policies-rules-and-acts/policies/national-manufacturing-policy ;
http://www.makeinindia.com/home

Other studies focus on the relation between innovations and exports. Pioneer authors are Ito and Pucik (1993) who analyze this link in the case of Japan, and Lefebvre et al. (1998) of Canada. One strand of the literature pictures the "exporting-by-innovating" hypothesis. This is the case of Cassiman et al (2010) who illustrate that innovation increases the probability of exporting, with additionally an external effect enhancing productivity and exports of all the other firms. Van Beveren et al (2010) do not validate this link. Using instrumental variable, they depict the "self-selection into innovation" hypothesis by showing that it is exporting which is an incentive for firms to innovate. This is also the case of Sharma (2017) and Kale and Rath (2018b), for a small sample of firms, in India. Aghion (2018), however, highlights two opposite effects: as exporting extends market size, it fosters innovation by increasing innovation gains. But since it also toughens competition, only the most productive firms innovate.

Innovation has also been identified as a key channel to raise firms' productivity. Endogenous growth models explain that R&D, in addition to directly enhancing firms' performances through innovation, contributes to this process through their industry-wide spillover effect (Romer, 1986). Several studies describe the productive role of innovation (Hall, 2011 for a review of the literature), some of which supports the idea that firms self-select into innovation according to their productivity (Bustos, 2011; Aghion, 2018), others that it is innovation that boosts productivity (Aw et al., 2011). Two empirical approaches are mainly used. A major contribution can be found in Crépon et al. (1998), who propose a four-equation model and whose approach has been used in other studies (Griffith et al., 2006; Parisi et al., 2006). In the model, firms invest in knowledge inputs (R&D particularly), that are transformed into innovation outputs, that finally impact firms' productivity. Because firms' decisions are taken simultaneously, the model is solved as a system with Asymptotic Least Squares (ALS) to integrate the feedback effects at the various levels of the firms' decisions. Bustos (2011) however relies on sequential estimations for their empirical validations, the first stage predicted value of the endogenous variables being introduced in the following stages in a process less demanding than in Crépon et al. (1998).

In India, the literature on innovation initially focused on technology transfer. Numerous studies have quantified this source of technical progress, more easily accessible following the reforms of the 1990s (Kasahara and Rodrigue, 2008, Goldberg et al, 2010, Topalova and Khandelwal, 2011, Mitra et al, 2014). The technological success of some sectors, such as the pharmaceutical industry, automotive manufacturing and electronics (Kale and Little, 2007), have nevertheless revived the debate on the need to provide the country with its own innovation capabilities. The weakness of R&D activities, coupled with the lack of innovation data, made however the evaluations difficult. Some studies have shown a positive impact of research activities, although often weak, on the performance of branches or firms (Raut, 1995, Basant and Fikkert, 1996, Mishra and Sharma, 2015, Sikdar and Mukhopadhyay, 2018), while others did not (Mitra et al, 2014, Mishra and Sharma, 2015, Sharma, 2017). Few works, however, have focused on innovation itself. Kale and Rath (2018a) highlight its role in aggregate productivity, and Sharma (2017) and Kale and Rath (2018b) attempt to explain innovation by a number of factors. These studies are still very marginal and of very limited scope

In this study, we differentiate the incentives from the ability to innovate and distinguish the inputs of innovation from the outputs. Two innovation's inputs are considered: (i)-the implementation of a R&D program, (ii)-the implementation of a training program. The innovation's output follows the OECD-Oslo-manual, which defines 4 types of innovation: (i)-product, (ii)-process, (iii)-organisational, (iv)-marketing. Data are from the World-Bank-Enterprise-Surveys (WBES) conducted in India between June 2013 and December 2014. Each enterprise is interviewed once. The survey is stratified to ensure the representativeness of the sector. Several indicators describe productivity and exports as well.

The environment in which the firms operate, their investment climate, can also influence success in innovating, exporting and being productive. A main hypothesis in the literature is that a good environment facilitates the functioning of markets and reduces the transaction risks and costs associated with investing in, starting, operating and closing down a business. It can also create new opportunities (through trade, innovation or access to technology) and put competitive pressures on firms (World-Bank, 2004). Previous works have shown that the business environment is critical for firms' performance in developing countries (Dethier et al, 2008, for a review of the literature). Because India only ranked 130th out of 190 countries in 2015 in the World-Bank Ease-of-Doing-Business Index, important gains could be made by improving this environment. In this study, we define 9 categories: (i)-infrastructure, (ii)-information-and-communication technology (ICT), (iii)-human capacity, (iv)-access to financing, (v)-government relations, (vi)-security, (vii)-international openness/access to global knowledge, (viii)-agglomeration, (ix)-competition.

Several biases can distort the estimations of these relationships. Because of the interactions between the 5 variables of the system, there is a risk of reverse causality. A simultaneity bias can also result from the interactions between the investment climate and the firms' performances. Actually, while the investment climate can affect firms' innovation, productivity or exports, the reverse can be true. The most productive firms for example have probably more ease to adapt their environment to their needs. In addition, measurement errors are possible, especially for the opinion variables. These issues will be treated by using instrumental estimations.

Our results suggest a virtuous circle between R&D, innovation and exports of the Indian manufacturing firms. An innovative company would be tempted to engage into R&D, which in turn would materialise into more innovations (product innovation particularly). These innovations would increase firm exports, what would encourage the firm to undertake more R&D in return (and to innovate and export more consequently). Training is associated to the process. Trained workers would stimulate R&D, which in turn would materialize into innovation, then exports. Trained workers would also allow innovation directly (process, organizational and marketing particularly). These findings therefore highlight a virtuous circle between the 3 components of innovation: the 2 innovation inputs (R&D and training) and the innovation output.

Productivity seems to benefit from this dynamics. When considering Total Factor Productivity (TFP), exporting and innovating would increase the productivity of the firms, validating the learning-by-exporting hypothesis. The opposite would be partly true, since it is the least productive firms that would be willing to innovate (the most productive ones having less incentive to do so). However, we do not see any effect of the productivity of the firms on the level of exports (no self-selection into exporting), or on the decision to launch a R&D or training program.

With respect to the investment climate, our results suggest its importance in explaining firms' performance gaps. These results are robust to various proxies of innovation, productivity and exports, and to different indicators of investment climate, methods of estimations and bias corrections.

This study contributes to the literature in different ways. *First*, we define a broad concept of innovation by differentiating the inputs of innovation from the outputs. *Second*, R&D is not the only input of innovation. *Third*, we look at multiple interactions between our broad concept of innovation, exports and productivity and do not limit our research to one or two of them. *Fourth*, having access to an extensive dataset on Indian manufacturing firms, we control for a large number of variables. Particularly, we broaden the analysis to the firms' environment who can participate in the dynamics we study. *Fifth*, our topic of research rarely covers developing countries, for which data are limited. The study of India is of particular interest in line of its emerging nature and the recent "Make in India" campaign. *Sixth*, the robustness of our results is tested in several ways, not frequent in previous studies. Instrumental estimations allow us to address endogeneity at work in

the interactions, as well as linked to the nature of the investment climate data. Other issues are considered, such as measurement errors and multicollinearity.

The paper is organized as follows. In the second section, we introduce the WBES dataset and define our variables of interest. Based on the literature, the third section presents our system and specifies the interactions between firms' innovation (in the broad sense of the Oslo Manual), exports and productivity. Details on the equations and their estimation are given in section four. Section five exposes our results. Section six concludes with policy recommendations.

2-Presentation of the Data and Definition of the Variables

2.1-The World-Bank Enterprise Surveys (WBES)

The WBES questionnaire is organized in two parts. The first concerns general information on firms and their environment. The second provides data on costs and other accounting material[3].

In the first part, the questions are of two types. Most refer to information that can be verified ("objective" or quantitative questions), such as the State in which firms are located or the skilled workforce. Others are "subjective" or qualitative. Firms are expected to assess the obstacle that their environment represents.

How to handle the variables of opinion is a subject of debate (Dethier et al, 2008). These variables are subject to measurement errors since firms answer in different ways. Does their answer relate to their own environment, or to the "macroeconomic" environment? Aside these "anchoring" effects, some firms may be unable to distinguish what is due to their functioning, to what comes from outside. The respondent may also ignore some elements, or be influenced by their personality or cultural environment.

Another issue is endogeneity. Simultaneity is possible because competitive firms have most probably the possibility to modify their environment. A two way causality is thus possible. In the empirical part, we'll come back on how to handle these measurement errors and endogeneity issues (sections-2.4.1, 2.4.2).

2.2-The Indian Sample

The Indian survey includes 7130 registered private manufacturing firms of more than 5 employees, belonging to 27 States (out of 29) and one territory (out of 7) which represent more than 95% of the manufacturing wealth of the country. The sample is representative of the firms' universe and stratified by size, sector and State. We retained the sectors for which information was sufficient, and dropped the ones too specific or with a small number of observations. In total, our sample is constituted of 6249 firms belonging to 11 sectors (out of 20): (i)-food, (ii)-textile, (iii)-garment, (iv)-chemicals, (v)-rubber and plastics, (vi)-non-metallic products, (vii)-basic metal products, (viii)-fabricated metal products, (ix)-machinery and equipment, (x)-electronics, (xi)-transport machinery.

2.3-The Variables of the System

2.3.1-Training of Employees and Research and Development (R&D)

The WBES do not indicate the amounts allocated to R&D. Only a binary variable, which distinguishes enterprises that have spent on R&D is available. Since firms do not necessarily have the same vision of R&D, they are told that any approach with a creative aim and supposed to

3 http://www.enterprisesurveys.org

increase the stock of knowledge can be considered as R&D, what is a broad definition. About 36% of the Indian firms declare that they have undertaken R&D during the 3 years preceding the survey (Table-A1, Appendix-A), what is most probably overestimated because of this definition (Unido, 2015).

Similarly, the WBES have only one question dedicated to training. It is also a binary variable indicating if the firms have implemented a training program during the last 3 years. In the Indian sample, nearly 42% of the firms indicate that they have trained their workers (Table-A1, Appendix-A).

2.3.2-Innovation

The OECD Oslo Handbook distinguishes 2 types of innovations: (i)-"technological", which mainly refer to "product" and "process" innovations, (ii)-"non-technological", which include "organizational", "management" and "marketing" ones. The manual defines innovation not only as something new, but also as a significant change or improvement. Innovation can also be new for the firm alone, both definitions making innovation a broad concept.

The innovation related part of the WBES follows the Oslo Manual definition. On average, almost half of the firms answer that they have innovated during the 3 years preceding the survey (45% for "product", 47% for "process", 44% for "organisational" and 45% for "marketing", Table-A1, Appendix-A), a share that is most probably overestimated because of it broad definition. …

For the purpose of the study, we construct a variable representing the number of innovations and taking values from 0 to 4. This would mean that each type of innovation is equivalent, which is not necessarily true. That is why we'll also consider the 4 types of innovation individually, in order to test the effect of each separately.

2.3.3-Productivity

Several variables can be used to assess the productivity of the Indian manufacturing firms. Production levels in t and t-3 are available, and so is the number of permanent workers. For the present period, enterprises also provide their number of part-time/temporary workers, along with the contracts length and work duration. This information is used to convert temporary/part-time work in full-time equivalent. Enterprises are also asked to indicate the value of their capital (net book value), purchase of intermediate inputs and expenses in energy (electricity, fuel … Table-A1, Appendix-A).

This information has been used to compute several indicators:

(i)-The past (t-3) and present apparent labor productivity, calculated as the ratio of firms' sales to the total number of workers (permanent and temporary) for the present period, and to the number of permanent workers only for the past one (t-3).

(ii)-The current value-added per worker, or labor productivity, calculated as the difference between firms' sales and cost of intermediate inputs, on the total number of workers.

(iii)-The current TFP calculated as the residual of an estimated Cobb-Douglas production function (Appendix -B for estimations by sector).

2.3.4-Export

In the WBES, several questions concern firms export. Firms are asked if they export (directly or indirectly), how much, and for how long they had been exporting. We use the share of production exported (directly or

indirectly) as our variable of interest. In total, 20% of firms export on average 8.5 % of their production, directly or indirectly (Table-A1, Appendix-A).

2.4-The Control Variables

2.4.1-The Investment Climate

In the surveys, many questions concern the firms' environment, several of them covering similar topics. Based on the literature, we classify this environment into 9 categories: (i)-infrastructure, (ii)-information & communication technology (ICT), (iii)-human capacity, (iv)-access to financing, (v)-government relations, (vi)-security, (vii)-international openness/access to global knowledge (viii)-agglomeration, (ix)-competition. For each category, we take into account not only verifiable/quantitative information, but also questions of opinion to get a better picture of the overall environment. (Appendix-C).

In each category, several variables are correlated**.** Introducing all of them into the regressions would undermine the precision of the estimations. One solution could be to choose one variable for each category. However, the selected variables may not provide enough information, leading to a missing variable bias. For each category, we generate a composite indicator that has the advantage of incorporating a lot of information and describing the firms' environment more precisely.

As discussed in section 2.1, most investment climate variables are subject to endogeneity and measurement errors. The usual IV procedure cannot be used here because we do not have, for each variable, an instrument, exogenous in each of the 5 equations, and sufficiently correlated with the variable it represents. To limit endogeneity, we instrument all variables with a same set of exogenous ones[4]. This type of instrumentation has been shown to better address endogeneity than is the case in the literature (Nguyen et al., 2018).

2.4.2-Investment Climate Composite Indicators

Although different techniques of data analysis exist, we opt for the Principal Component Analysis (PCA) for its simplicity. We retain the most significant components which explain around 70% of the variance of the underlying variables. Any aggregation orders the variables in a certain way that can be questionable and sometimes does not make sense. It is the case of the infrastructure and government relation indicators that will not be used in the empirical analysis (section-4.3.).

We processed different composite indicators, based on different combinations of variables and including or not the subjective ones. Two versions of the same indicators are also proposed: one processed from the initial variables, another from their prediction after instrumentation (see previous section). Three types of investment climate variables are predicted: continuous, binary and obstacle variables (4-5 modalities in this case). The predictions were made respectively as linear combinations of the selected exogenous variables, based on probit, logit, or multinomial specifications. All the indicators were used to test the robustness of the results. .

2.4.3-The Characteristics of the Firms

In addition to investment climate, we consider several characteristics of the firms such as their age, size, partnership with a large company, belonging to an industrial association, sector and State (Table-A1, Appendix-A).

4 Instruments are: firm's age and size (proxied by the number of workers), production in t-3, manager experience , share of capital belonging to foreign companies**,** type of firm, belonging to a big enterprise, power and water shortages, States and sectors fixed-effects.

3-Presentation of the System

3.1-Training of Employees

Training can be a factor of innovation and be set up in this purpose (Cirera et al., 2016). Training can also aim at improving firms' productivity. Trained workers can be more efficient and organise better their work. They can make a better use of new equipment and handle better various situations (Bresnahan et al., 2002). Training can also have a direct effect on R&D (Crépon and Mairesse, 1993). It is the case if training is undertaken in view of starting R&D or to give managers a new strategic vision and encourage them to risk and innovate. Nevertheless, there is no reason to believe that training affects firm's exports, if not indirectly through innovation and/or productivity (Figure-1).

3.2-Research and Development (R&D)

The above hypotheses are true for R&D, with one exception: it is supposed that R&D has no direct effect on firms' productivity, in addition to exports. On the one hand, a company who invests in R&D may be willing to launch a training program, for example if skills for research are missing in the firm or outside, or to divulge and apply the results of the R&D (Cohen and Levinthal, 1989). On the other hand, the first aim of R&D is innovation, and it will be through innovation that R&D will eventually have an impact on productivity and/or export (Crépon et al., 1998; Parisi et al., 2006, Figure-1).

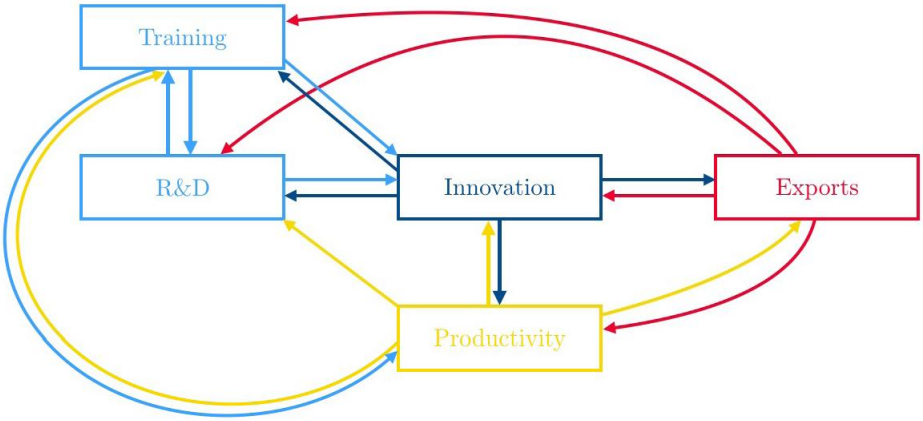
3.3-Innovation

Innovation, unlike training and R&D, can have a direct effect on the 4 other variables (Figure-1). Innovation can impact R&D and training. An innovative company may want to reinforce its advance by doing more R&D and training (Crépon et al., 1998; Bresnahan et al., 2002). The opposite can be true if a less innovative firm undertakes R&D and training to innovate more. In this case, it can be assumed that less innovating firms will first spend on training, less costly and risky than R&D, in order to invest in R&D afterwards. Innovation can also increase the productivity of a company (Griffith et al., 2006; Parisi et al., 2006). This is particularly true for "process" and "organizational" innovations (Griffith et al., 2006; Polder et al., 2010). Finally, innovation is also described as an incentive to export (the "exporting-by-innovating" hypothesis, (Cassiman et al., 2010), which may be the case for "product" and "marketing" innovations.

3.4-Productivity

A productive company, with adequate resources, is a priori more able to innovate (Bustos, 2011). This may not be the case however if, for example, the company is dominant in the market. On the contrary, a low-productive firm may want to innovate to catch-up with competitors, although it may not have enough resources for that. For these reasons, the effect of productivity on training, R&D and innovation is unsure. This uncertainty is due to the fact that the innovation equations reflect the ability to innovate, but also the incentive. The effect of productivity on exports seems clearer. It is expected to be positive (the "self-selection into exporting", Melitz, 2003; Bernard and Jensen, 2004) or insignificant, but never negative (Figure-1).

Figure-1: Presentation of the System



3.5-Exports

As with innovation, exports can have a direct (and positive) effect on the 4 other variables (Figure-1): productivity (the "learning-by-exporting" hypothesis, Clerides et al., 1998; Aw et al., 2011), R&D and training (as incentive especially), and innovation (the "innovating-by-exporting" or "self-selection into innovation" hypothesis, Van Beveren et al., 2010). However, as with productivity, because the equation of innovation does not allow dissociating the capacity from the incentive to innovate, the direction of the impact of exports on innovation (in the broad sense) is uncertain. Exports may provide financial resources or act as an incentive to innovate, in order to preserve or extend their market share. But exporting firms may not be willing to innovate if for example they are dominant in the export market.

3.6-Competition

Competition can influence firms' decision to innovate, spend on training and R&D, and be more productive (Crépon and Duguet, 1997; Ospina and Schiffbauer, 2010). There is no reason to think that domestic competition represents an incentive for firms to export. This effect is possible only indirectly, via innovation and productivity.

Among the 5 variables, productivity could directly influence the degree of competition, proxied by the number of competitors (Appendix-C). Since we have cross-section data, we'll consider competition as exogenous in all equations. Although a high productive firm can bring the least productive to leave the market, this mechanism takes time. Nevertheless, a more exogenous variable, the presence of informal firms, can be used (Appendix-C; Appendix-A, Table-A1). It is still possible that the competition of the informal sector pushes firms to perform better. However, if the informal "unfair" competition prevents them from innovating and being more productive, it will be possible to know which effect prevails (Ospina and Schiffbauer, 2010).

4-Estimation of the System

4.1-Estimation Methodology

If the interactions mentioned in section-3 are found in the Indian sample, OLS estimates are biased due to the endogeneity of the system variables. We choose instrumental estimations to correct the simultaneity bias. Multivariate instrumental **e**stimations are not always possible because of convergence issues. In addition, a single specification error is sufficient to "contaminate" the entire system. Potential problems can be encountered at finite distance and efficiency gains are possible in case of over-identification only. Finally, the exclusion-restriction conditions are not easy to verify, especially in a 5 equations system. If the 5 equations are estimated in an univariate mode, no causal link between the instrument and the variable instrumented is needed, a simple correlation is

sufficient[5]. In addition, because of the large number of control variables, the correlation between the 5 variables and the exclusion variables or instruments may not always be very high. Instruments can be weak in the sense of Staiger and Yogo (1997). This hypothesis will be tested in the empirical part and robust tests with weak instrumentation will be carried out. For all these reasons, we choose as in Bustos (2011) univariate estimations which provide more robust estimates, also in the case of weak instruments.

4.2-The Equations of the System

4.2.1-Equation of Training

The decision to start a training program can be influenced by undertaking R&D, innovation, export, productivity, and competition (section-3). The investment climate and characteristics of the firms also play a role in this decision (equation-1). To estimate the system, we need a variable correlated with training, exogeneous in all 5 equations, and excluded from the other 4 ones. We use the obstacle variable "access to skilled labor force" as instrument. One can think that the more a firm is constrained in its recruitment of skilled labor, the more it may decide to train its own workers. Since this variable is part of the "human capacity" indicator (Appendix-C), it has been excluded when processing the aggregate variable. The equation is as follows:

$$\text{Training}_i = \alpha_1 + \beta_{1;1}.\text{R\&D}_i + \beta_{1;2}.\text{Innovation}_i + \beta_{1;3}.\text{Productivity}_i + \beta_{1;4}.\text{Exports}_i + \delta_1.X_i + \gamma_1.Y_i + \mu_1.\text{Access-to-Qualified-Labor}_i + \lambda_1.\text{Competition}_i + \varepsilon_1 \quad (1)$$

where X and Y are the matrix of the investment climate variables and the individual characteristics of the firms respectively, α_1, $\beta_{1;1 \text{ to } 4}$, δ_1, γ_1, μ_1, λ_1: parameters to estimate, ε_1: error term, i: indicator of firms.

4.2.2-Equation of Research and Development (R&D)

Similarly, R&D is regressed on the other 4 variables, a set of control variables composed of competition, firms' investment climate and characteristics, and an instrument (equation-2). It is likely that the more difficult to obtain permits and licenses, the more difficult to patent an invention. We choose the obstacle variable "licenses and permits" as instrument. This variable will not be introduced in the other 4 equations, nor used as a proxy for government relation in all regressions. The equation is as follows:

$$\text{R\&D}_i = \alpha_2 + \beta_{2;1}.\text{Training}_i + \beta_{2;2}.\text{Innovation}_i + \beta_{2;3}.\text{Productivity}_i + \beta_{2;4}.\text{Exports}_i + \delta_2.X_i + \gamma_2.Y_i + \mu_2.\text{Access-to-Permits/Licenses}_i + \lambda_2.\text{Competition}_i + \varepsilon_2 \quad (2)$$

where X /Y are as defined before, α_2, $\beta_{2;1 \text{ to } 4}$, δ_2, γ_2, μ_2, λ_2: parameters to estimate, ε_2: error term, i: indicator of firms.

4.2.3-Equation of Innovation

In the innovation equation, we control for the other 4 variables, competition, the investment climate and characteristics of firms (equation-3). We choose "to have a foreign license" as instrument. Having a foreign license makes possible to use an invention from abroad and introduce something new at home. We make the reasonable assumption that this variable has no effect on the other 4 variables as it does not seem very correlated with them. The equation is as follows:

$$\text{Innovation}_i = \alpha_3 + \beta_{3;1}.\text{Training}_i + \beta_{3;2}.\text{R\&D}_i + \beta_{3;3}.\text{Productivity}_i + \beta_{3;4}.\text{Exports}_i + \delta_3.X_i + \gamma_3.Y_i + \mu_3.\text{Foreign-Licenses}_i + \lambda_3.\text{Competition}_i + \varepsilon_3 \quad (3)$$

5 It is then possible that the instrument is not one of the explanatory variables

where X/Y are as defined before, $\alpha_{3,}$ $\beta_{3;1 \text{ to } 4,}$ $\delta_{3,}$ $\gamma_{3,}$ $\mu_{3,}$ λ_{3} : parameters to estimate, $\varepsilon_{3:}$ error term, $_{i:}$ indicator of firms.

4.2.4-Equation of Productivity

We regress productivity on training, innovation, exports and control for competition, investment climate and firms' characteristics (equation-4). We exclude "output per worker in t-3" as instrument because of its strong auto-regressivity. We choose "stocks of capital and intermediate consumptions" instead. Since we control for the sectors, it makes it possible to distinguish the proper effect of these variables. Their exclusion from the other equations makes sense. In the R&D, training and innovation equations, the effect of equipment goes more likely through ICT, especially since we already control for sectors and firms size. In the export equation, effect of capital and intermediate consumptions, if any, passes through productivity, in addition to firms' size and sector that control for the effect of sectors'capital intensity. In one version however, we'll only use intermediate consumptions as instrument. The equation is as follows:

$$\text{Productivity}_i = \alpha_4 + \beta_{4;1}.\text{Training}_i + \beta_{4;2}.\text{Innovation}_i + \beta_{43}.\text{Exports}_i + \delta_4.X_i + \gamma_4.Y_i + \mu_{4.1}.\text{Capital}_i + \mu_{4.2}.\text{Intermediate-Consumption}_i + \lambda_4.\text{Competition}_i + \varepsilon_4 \quad (4)$$

where X/Y are as defined before,, $\alpha_{4,}$ $\beta_{4;1 \text{ to } 4,}$ $\delta_{4,}$ $\gamma_{4,}$ $\mu_{4.1 \text{ and } 2,}$ λ_{4} : parameters to estimate, $\varepsilon_{4:}$ error term, $_{i:}$ indicator of firms.

4.2.5-Equation of Exports

The variables of the export equation are innovation, productivity, investment climate and firms characteristics (equation-5). Two instruments are chosen: "to have an international quality certification" and "be located in an export zone". The second variable is certainly more exogenous than the first in the 5 equations. In addition, it does not seem correlated with the other 4 variables of the system. The equation is as follows:

$$\text{Exports}_i = \alpha_5 + \beta_{5;1.}\text{Innovation}_i + \beta_{5;2.}\text{Productivity}_i + \delta_{5.}X_i + \gamma_{5.}Y_i + \mu_{5.1.}\text{International-Quality-Certification}_i + \mu_{5\ .2}.\text{Export-Zone}_i + \varepsilon_{\ 5} \quad (5)$$

where X/Y are as defined before,, $\alpha_{5,}$ $\beta_{5;1 \text{ to } 4,}$ $\delta_{5,}$ $\gamma_{5,}$ $\mu_{5.1 \text{ and } 2,}$ λ_{5} : parameters to estimate, $\varepsilon_{5:}$ error term, $_{i:}$ indicator of firms.

4.3-Other Methodological Aspects: Instruments and Investment Climate Indicators

Univariate instrumental estimations require instruments to be exogenous in the equation in which they appear, and in the other **4** equations. Starting training or a R&D program, innovating, being productive and exporting must not have any effect on these variables. Having undertaken R&D and innovated during the last 3 years, for example, must not have a direct impact on having an international quality certification, what can be a strong assumption. Because there are two possible instruments for productivity and exports, it will be possible to verify, ex post, the exogeneity of these instruments through the Hansen test.

The variables used to compute the indicators of access to finance, ICT and security are those of Appendix-C. Human capacity, however, cannot include the variable "access to a skilled workforce". This variable serves as instrument in the training equation. Regarding the international openness indicator, the variables "to have a foreign licence" and "exports", are also excluded, the first because it is an instrument of innovation, the second, a main variable of the system. The variable used as proxy is the "rate of inputs from foreign origin".

Not all variables in the government relation indicator were used either. Many of these variables are difficult to interpret and of poor quality. We choose corruption via the "gifts when inspected" and obstacle variables as proxy for government relation, since corruption is seen as the main constraint faced by Indian companies (Table-A1, Appendix-A). The omission of most of the government relation variables does not seem prejudicial because we introduce size, State and sector fixed-effects in all regressions.

For the same reasons, no aggregate indicator of infrastructure is built. Electricity being, along with corruption and tax rate, one of the top 3 obstacles faced by the firms (Table-A1, Appendix-A), only the quality of the electricity network is considered. We choose the variable "generators" as a proxy for power outages, because it seems more reliable than the others.

Given that agglomeration can have two opposite effects (a positive effect linked to synergies between agents, and a congestion one due to lack of space and facilities), no aggregate indicator is constructed in this case either. We choose the city size and its square to capture the two opposite effects, as well as "to be located in an industrial zone" to proxy the agglomeration indicator.

In the next section, we present the results of univariate instrumental estimations when the Limited Information Maximum Likelihood (LIML) methodology is used. In addition to the 5 variables of interest, investment climate can also be endogenous. The results presented are those in which the investment climate variables are assumed to be exogenous (Table-D1, Appendix-D), and those using their predicted values to correct measurement errors and endogeneity, as explained in section 2.4.1 (Tables-D2-D3, Appendix-D). The results of the main tests are also reported in the tables.

The conclusions are not very sensitive to the way in which the investment climate is introduced and according to the composition of the aggregated indicators. They do not change much with the different proxy for innovation, productivity and export. Finally, since the form of heteroskedasticity is unknown, the estimated standard deviations are corrected according to White's method, which is preferable to clustering because it is controlled for States and agglomeration effects in the regressions.

5-Estimation Results[6]

5.1-Equation of Training

Undertaking R&D seems to be pushing Indian manufacturing firms to train their workers (Figure-2). On the contrary, there is a negative effect of innovation and exports. This result suggests that the low level of innovation and export encourage firms to train their workforce in order to innovate and export more. For poor performers, training is cheaper than R&D (section-3.3). For the best performers, the incentive for training is indirect, through, in both cases, R&D (see next section).

Productivity does not appear as an incentive for staff training, which suggests that training is part of another dynamics, related to R&D and innovation specifically. High or low productivity does not seem to be an incentive to launch a training program to innovate or be more productive.

The investment climate appears to be having a positive effect on the decision of Indian companies to train, especially human capacity, access to financing and to infrastructure (proxied by power supply). In a satisfactory environment, it is worth investing in training to reduce the skills gap and

6 Due to space constraint, we only present the results when using (i)-the number of different types of innovations (variable between 0-4) and its decomposition, (ii)-the labor productivity (LP) and total factor productivity (TFP), (iii)-the share of production exported (directly and indirectly).

innovate. These results are all the more important in the context of India's investment climate deficits.

5.2-Equation of Research and Development (R&D)

The results suggest that exports and innovation encourage Indian manufacturing firms to undertake R&D (Figure-2), which is more expensive than initiating a training program, a solution chosen by the least-innovative and least-exporting companies (see previous section). Similarly, the companies that train their workers are willing to engage in R&D, which highlights a virtuous circle between these two components.

Productivity, as for training, does not seem to play a role in the Indian manufacturing firms' decision to initiate R&D. Nor does the investment climate seem to be decisive, since only competition would stimulate R&D by Indian companies. The effect of the investment climate on R&D would therefore be indirect, through the incentive to train employees and innovation (see next section), for human capacity, infrastructure and financing in both cases.

5.3-Equation of Innovation

A trained workforce appears to be key to improving firms' innovation capacity (Figure-2). This is especially true for process, organizational, management and marketing innovations. R&D, on its side, stimulates primarily product innovation (Griffith et al. 2006; Polder et al., 2010). These findings highlight a virtuous circle between the 3 components of innovation: the 2 innovation inputs (R&D and training) and the innovation output. Training and R&D activities support innovation, which in return strengthens firms' R&D and training. These results are significant given the low investment in R&D by Indian manufacturing companies (Mitra, et al., 2014; Unido, 2015).

As with training and R&D, high productivity does not prove to be an innovation factor, which invalidates the self-selection into innovation hypothesis. It seems that the incentive to innovate comes mainly from R&D, training and the investment climate. Low productivity firms, however, seem ready to innovate to improve their performances, as shown in Table-D3 for TFP. Similarly, it seems that exporting firms do not self-select themselves into innovation. With regard to the business environment, human capacity, access to infrastructure and financing seem to count for innovation.

5.4-Equation of Productivity

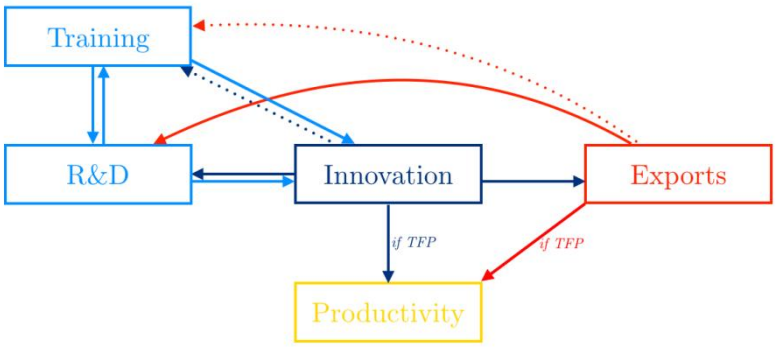
In the case of TFP (Table-D3), Indian manufacturing firms appear to benefit from a learning process when exporting, and from innovating in the case of marketing, management and organizational innovation (Polder et al., 2010; Figure-2). This result validates the "learning-by-exporting" hypothesis. With respect to training, the effect is indirect, through R&D and innovation.

The investment climate participates in the productivity gaps when the corresponding variables are instrumented by their predictions (Tables-D2-D3). This is the case for all aspects of the environment: human capacity, infrastructure, ICT, financing, international openness, corruption and security. This finding is all the more important given the deficit in the Indian business environment, where firms' productivity is low at the same time (Mitra et al, 2002-2014). Improving exports, innovation and the investment climate would therefore boost the productivity of the manufacturing sector.

The impact varies, however, depending on whether the investment climate variables are instrumented or not. This sensitivity, higher than that of the other 4 equations, should come from the simultaneity bias of investment climate variables, which can be high in the productivity

equation. Companies can only change their environment if they are productive and can afford it. Since we control for productivity in the other 4 equations, bias is less likely in these cases. This result justifies the instrumentation of the investment climate variables, in the productivity equation especially.

Figure-2: Main Estimation Results



An arrow represents a positive and significant effect, a dashed arrow a significant and negative effect

5.5-Equation of Exports

It does not appear that Indian companies "self-select themselves into exporting". This effect is not found in the Indian sample, since productivity does not seem to explain firms' exports (Figure-2).

The main determinants of exports are: innovation (product, management and marketing particularly), what validates the "self-selection into exporting" assumption of innovation, the investment climate, especially access to financing, to ICTs and to global knowledge (through the imports of intermediate goods specifically), have an international quality certification and be located in an export zone. These results are in line with the Make in India campaign which aims to strengthen the integration of the manufacturing sector into the global economy.

6-Conclusion and Policy Recommendations

The objective of this study was to identify the interactions between firms' innovation (in the broad sense of the Oslo Manual), exports and productivity in the case of the Indian manufacturing industry. Our results suggest the existence of a virtuous circle between R&D, innovation and exports, in which innovation plays a central role. Innovative firms would engage into R&D, which in turn would materialize into more innovations. Innovations would increase exports, which would encourage firms to undertake research (and innovate and export more consequently). Training is associated to the process. Trained workers would stimulate R&D, which in turn would materialize into innovation, then, into more exports. Trained workers would also allow innovation directly. These findings highlight a virtuous circle between the 3 components of innovation: the 2 innovation inputs (R&D and training) and the innovation output. These results are noteworthy because Indian manufacturing companies are known for not investing enough in R&D (Mitra, et al., 2014; Unido, 2015).

Innovation seems to be essential to export, as innovative firms would self-select themselves into exporting. Innovation also seems important for productivity, as it would increase firm-level TFP. These findings are all the more significant in the context of weak exports and low productivity in the Indian manufacturing sector (Mitra et al., 2002-2014). Helping the Indian manufacturing firms to innovate (in the broad sense of the Oslo Manual) would certainly contribute to the effort of the government to make this sector more productive and more integrated into the global economy. As

our results show, this could pass by an increased access to training, R&D and foreign licences, as well as through competition and the improvement of the investment climate, all these actions being part of the National Manufacturing Policy program and the Make in India campaign. This would also be important for the productive performances of the Indian manufacturing companies since our results highlight a learning process when exporting. Firm-level productivity would therefore be even more enabled if export rates were increased.

In addition to innovation, exports are sensitive to the investment climate, obtaining international quality certifications and be located in an export zone. All these results also go in the direction of the recent programs launched by the Indian governments to make of the manufacturing a sector of growth and competitiveness.

With respect to the investment climate, our results confirm its importance in explaining performance gaps between Indian manufacturing companies. This is true for productivity gaps for all dimensions of the investment climate. Improving human capacity, infrastructure (power supply especially), access to ICT and to financing, international openness, security and low corruption would enhance firms productivity. Furthermore, it looks like a better access to financing, ICT and global knowledge (through importing particularly) would help the Indian manufacturing companies to export more. Access to financing, infrastructure and human capacity would be of particular importance for the Indian manufacturing firms to innovate, both directly and through training. Finally, competition would incite firms to undertake R&D and be more productive.

The investment climate therefore appears to be an essential dimension of the innovation process in India. The investment climate also seems essential for enhancing productivity and exports, both directly and through innovation. Improving the investment climate would thus contribute to the performance of Indian manufacturing firms in a cumulative process. These results are all the more significant in light of the weaknesses in the Indian business environment, and the recent Make in India campaign which aims to make the manufacturing sector a new engine of growth, innovation and export in the country.

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Appendix A

Table A1: Descriptive Statistics of the Variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Sales (*LC*)	6843	3.94E+08	2.36E+09	3.00E+05	9.00e+10
Intermediate Inputs (*LC*)	6603	2.29E+08	1.54E+09	0	7.58e+10
Labor: Permanent (*nber*)	7018	107	303	3	8000
Labor: Temporary (*nber*)	6875	12	58	0	1500
Capital: Net book value (*LC*)	4673	6.23E+07	6.70E+08	0.00E+00	4.00e+10
Exports: Direct (*% sales*)	7019	1.2	8.6	0	100
Exports: Indirect (*% sales*)	7019	7.3	21.8	0	100
Exports: Tot (*% sales*)	7019	8.5	23.5	0	100
Product Innovation (*bin*)	7012	1.55	0.50	1	2
Process Innovation (*bin*)	7010	1.54	0.50	1	2
Organizational Innovation (*bin*)	7004	1.56	0.50	1	2
Marketing Innovation (*bin*)	7005	1,55	0,50	1	2
R&D (*bin*)	6996	1,64	0,48	1	2
Training (*bin*)	6983	1,59	0,49	1	2
Year of creation	7006	1994	14	1863	2013
Type of firm	6951	2,01	0,45	1	4
Part of a Large Firm (*bin*)	7019	1,80	0,40	1	2
Industrial Association (*bin*)	6993	1,05	0,21	1	2
Power Shortages (*bin*)	7014	1,34	0,47	1	2
Generator (*bin*)	7009	1,35	0,48	1	2
Water Shortages (*bin*)	6855	1,96	0,20	1	2
Electricity (*obst*)	7014	1,61	1,24	0	4
Transport (*obst*)	6996	1.12	1.03	0	4
E-mail (*bin*)	7013	1.12	0.33	1	2
Internet (*bin*)	7009	1.48	0.50	1	2
Cell phones (*bin*)	7015	1.05	0.23	1	2
Telecommunications (*obst*)	7015	0.43	0.76	0	4
Experience Manager (*years*)	7003	14.0	9.3	1	64
Education Workforce (*years*)	6841	9.8	1.9	5	20
Secondary School *(% workers*)	6847	47.5	29.9	0	100
Skilled Workforce (*obst*)	6970	1.02	1.07	0	4
Checking/ Savings Account (*bin*)	7006	1.02	0.15	1	2
Overdraft Facility (*bin*)	6951	1.37	0.48	1	2
Credit Line (*bin*)	6877	1.69	0.46	1	2
Financing (*obst*)	6986	1.15	1.14	0	4
Inputs Credit *(%)*	6912	51.3	32.4	0	100
Capital Financed by Banks *(%)*	6736	31.2	32.7	0	100
Tax Officials Inspection (*bin*)	6985	1.47	0.50	1	2
Regulations *(% time*)	6617	4.9	15.5	0	100
Gift when Inspected (*bin*)	3390	1.80	0.40	1	2
Tax Rate (*obst*)	7004	1.79	1.21	0	4
Tax Administration (*obst*)	7007	1.41	1.14	0	4
Labor Regulation (*obst*)	7004	1.15	1.05	0	4
Licenses & Permits (*obst*)	7000	1.10	1.10	0	4
Corruption (*obst*)	7006	2.25	1.30	0	4

Security *(% sales*)	4963	0.79	2.35	0	100
Losses Robberies *(% sales)*	4269	2.7	0.9	1	80
Losses Transit *(% value*)	6940	0.2	2.2	0	100
Crime (*obst*)	6960	0.57	0.85	0	4
Foreign cies *(% capital*)	7019	0.5	5.7	0	100
Foreign License (*bin*)	6961	1.90	0.30	1	2
Quality Certification (*bin*)	6964	1.50	0.50	1	2
Foreign Inputs (*%*)	6860	2.58	11.44	0	100
Business City (*bin*)	7019	1.22	0.41	1	2
Exporting Zone	6987	2.26	0.55	1	3
City Size	7019	3.06	0.94	2	5
Market Size	7012	1.80	0.57	1	3
Competitors (*nber*)	3247	50	296	1	1000
Informal Competition (*bin*)	6954	1.62	0.49	1	2
Informal Sector (*obst*)	6931	0.97	1.10	0	4

Source. Author' estimations.
Note: LC: local currency, *bin*: binary variables (Yes=1/ No=2), *obst*: obstacle variables (0= none to 4= very severe).

Appendix B

TABLE B1: Estimation Results of the Production Functions by Sector

	Manuf (Tot)	**Food**	**Textile**	**Garment**	**Chemicals**	**Plastic / Rubber**
Intermediate Consumption	0.69*** (51.37)	0.72*** (17.72)	0.65*** (17.65	0.61*** (9.94)	0.7*** (15.09)	0.71*** (16.12)
Labor	0.26*** (16.39)	0.23*** (4.46)	0.28*** (6.04	0.39*** (3.6)	0.27*** (4.63)	0.27*** (5.21)
Capital	0.08*** (10.04)	0.06* (2.26)	0.06*** (3.56)	-0.011 (-0.22)	0.078* (2.55)	0.076*** (3.82)
Intercept	3.6*** (24.55)	3.8*** (9.31)	4.6*** (10.36	6.6*** (6.1)	3.5*** (6.82)	3.4*** (6.88)
R2	0.922	0.931	0.925	0.885	0.936	0.93
Observations	4450	334	411	137	370	448

	Non Metalic Mineral Prod.	**Basic Metal**	**Fabricated Metal Prod**	**Machinery/ Equipments**	**Electronics**	**Transport Machinery**
Intermediate Consumption	0.67*** (17.11)	0.66*** (14.7)	0.74*** (19.85)	0.59*** (8.08)	0.75*** (18.22)	0.61*** (9.62)
Labor	0.31*** (5.48)	0.28*** (5.51)	0.21*** (4.79)	0.32*** (4.05)	0.21*** (4.71)	0.39*** (4.69)
Capital	0.065* (2.08)	0.11*** (4.68)	0.09*** (3.85)	0.16*** (4.57)	0.041' (1.69)	0.099*** (4.3)
Intercept	5.1*** (5.45)	3.6*** (7.37)	2.8*** (8.64)	3.9*** (5.46)	3.5*** (6.93)	4.4*** (6.28)

R2	0.887	0.934	0.937	0.903	0.933	0.903
Observations	317	444	412	436	373	354

Source. Author' estimations.
Note: Capital (*in log*). Labor (*in log*). Intermediate Consumption (*in log*). All regressions contain States fixed-effects. The regression for total manufacturing contains in addition sector fixed-effects. Production functions are estimated by a pool OLS. Heteroskedasticity-robust t-students are reported in parentheses. ***, **, *, and ' denote significance at the 0.1%, 1%, 5%, and 10% levels, respectively.

Appendix C

The Investment Climate Variables and Composite Indicators

Infrastructure quality

Although no aggregate indicator has been constructed, the quality of infrastructure can be defined by 5 variables:

(***a***)- Does the firm experiment power shortages? (*Yes=1/ No=2*)

(***b***)- Does the firm own or share a generator? (*Yes=1/ No=2*)

(***c***)- Does the firm experiment water shortages? (*Yes=1/ No=2*)

Obstacle for the operation of the enterprise caused by deficiencies in:

(***d***)-Electricity (*0 to 4*)

(e)-Transport (*0 to 4*)

The subjective information contained in the "obstacle" variables is supplemented by the more objective information incorporated into the "power", "water shortages " and "generator use" ones. According to the literature, "the use of generator" is considered as a proxy of power outages. Since electricity is one of the main constraints for Indian companies, we choose this variable as an indicator of infrastructure quality.

ICT availability

The ICT composite indicator (*ICT)* consists in 4 variables:

In its interaction with clients and suppliers, does the enterprise have access to:

(***a***)- E-mail? (*Yes=1/ No=2*)

(***b***)- Internet? (*Yes= 1/ No= 2*)

(c)- Cell phones? ((*Yes=1/ No=2*)

(***d***)- Obstacle for the operation of the enterprise caused by deficiencies in telecommunications (*0 to 4*).

Here too, we added the variable "obstacle" by 3 more objective variables: the use of email, Internet and cell phones. The 4 variables are inverted to enter the composite indicator (ICT).

Human capacity

The human capacity composite indicator (*H*) is represented by 4 variables:

(a)- Number of years of experience of the top manager (*years*).

(***b***)- Average number of years of education of a typical production worker (*years*).

(***c***)- Full time permanent workers who completed secondary school (*%*).

(***d***)- Obstacle for the operation of the enterprise caused by the access to a skilled workforce (*0 to 4*).

The variable "obstacle" is counterbalanced by the other 3 more objective. However, this variable will not be included in the composite indicator because it will serve as an exclusion variable in the Training equation.

Financing ability

The financing composite indicator (*Fin*) includes 4 to 6 variables:

(***a***)- Does the firm have a checking or savings account? (*Yes=1/ No=2)*

(***b***)- Does the firm have an overdraft facility? (*Yes=1/ No=2)*

(***c***)- Does the firm have a credit line? *(Yes=1/ No=2)*

(***d***)- Obstacle for the operation of the enterprise caused by the access to financing (*0 to 4*).

And eventually
(***e***)- Percentage of inputs purchased on credit *(%)*

(***f***)- Proportion of the firm's working capital borrowed from banks

The "obstacle" variable is counterbalanced by 3 to 5 more objective ones. All variables except "inputs purchased on credit" and "proportion of the working capital borrowed from banks" are reversed to enter into the composite indicator.

Government relation

No composite indicator could be constructed for this category as well. Government relationship was initially defined by 8 variables:

(***a***) Has the firm been inspected by tax officials? (*Yes=1/ No=2*)

(***b***) Percentage of time spent to deal with government regulations *(%).*

(***c***) Was a gift or informal payment expected or requested when inspected by tax officials? (*Yes=1/ No=2)*

Obstacle for the operation of the enterprise caused by:

(d) Tax rate (*0 to 4*).

(***e***) Tax administration (*0 to 4*).

(***f***) Labor regulation (*0 to 4*).

(***g***) Business licensing and operating permits (*0 to 4*).

(***h***) Corruption (*0 to 4*)

Despite the debate about the role of corruption in business performance, empirical evidence more often shows a negative impact of this factor. As corruption is the main constraint faced by Indian companies, it will be our indicator of the quality of government relations. The two variables gift to inspectors" and "obstacle" will be considered in the empirical part.

Security

The security composite indicator (*Crime*) is formed of 4 variables:

(***a***)- Percentage of total annual sales paid for security (%)

(***b***)- Losses due to robberies as percentage of total annual sales (%)

(***c***)- Losses in transit due to robberies as percentage of the value of the products (%)

(***d***)- Obstacle for the operation of the enterprise caused by crime (*0 to 4*).

The "obstacle" variable is counterbalanced by 3 more objective ones. All variables are inverted to enter the composite indicator.

International openness / Access to global knowledge

No composite indicator was constructed for "International openness" either. This category was defined by 5 variables:

- Share of capital belonging to foreign companies (%)

-Does this firm use technology licensed from a foreign-owned company, excluding office software? (*Yes=1/ No=2)*

-Does this firm have an international quality certification? (*Yes=1/ No=2)*

-Share of inputs from foreign origin (*%*)

The share of input from foreign origin is the only proxy used for this category.

Agglomeration

Agglomeration is defined by 2 variables:

-Is this firm located in an industrial zone? (*Yes=1/ No=2)*

-Size of the city in which this firm located (*0 to 4*)

The variable "size of the city" and its square (to capture the opposite effects of synergy and congestion), as well as being located in an industrial zone will be our agglomeration variables.

Competition

No aggregate indicator is built for Competition. The following variables are the proxies we use in the empirical part.

(***a***) Is the enterprise main market local (*1*), national (*2*) or international (*3*)?

(***b***) On the main market in which this firm operates, how many competitors does the firm have? (*number*)

(***c***) Does this firm compete against unregistered or informal firms? (*Yes=1/ No=2)*

(***d***) Obstacle for the operation of the enterprise caused by the presence of the informal sector (*0 to 4*).

Appendix D

TABLE D1: Estimation Results with Labor Productivity

(LIML with non-instrumented investment climate variables)

	Training^	**R&D^**	**Innovation^**	**Product Innovation^**	**Labor Productivity^**	**Exports^**	**Exports^**	**Exports^**
Training (*bin*)^		0.43**	3.15*	-0.9	-0.04			
		(3.16)	(2.00)	(-1.82)	(-0.14)			
R&D (*bin*)^	1.18***		-2.4	1.5**				
	(4.37)		(-1.27)	(2.93)				
Innovation (*0 to 4*)^	-0.19*	0.25***			0.15$	3.3		
	(-2.53)	(6.47)			(1.72)	(1.53)		
Product Innovation (*bin*)^							2.9	
							(0.39)	
Marketing Innovation (*bin*) ^								13.2$
								(1.68)
Labor Productivity (*log*)^	0.03$	-0.01	-0.06	0.01		0.48	0.59	0.31
	(1.77)	(-0.79)	(-0.74)	(0.36)		(0.89)	(1.07)	(0.55)
Exports (*%*)^	-0.008*	0.005*	0.007	-0.004	0.004			
	(-2.55)	(2.46)	(0.59)	(-1.00)	(1.48)			

Size (nbr) '	0.05	0.00	0.04	0.01	-0.36	5.8***	6.1***	5.96***
	(1.3)	(0.11)	(0.19)	(0.23)	(-1.58)	(3.35)	(3.36)	(3.47)
Age (years) '	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.01
	(1.34)	(-0.79)	(-1.11)	(0.7)	(1.5)	(0.83)	(0.94)	(0.26)
H_PCA"'	0.09***	-0.04	-0.116	0.07*	0.02	0.62	0.82	0.62
	(4,94)	(-1.71)	(-0.95)	(1,99)	(0,57)	(1,07)	(1,4)	(1,06)
Fin_PCA"'	0.11***	-0,05	-0,01	0,05	0,01	2.7***	3.3***	2.6***
	(4,49)	(-1.57)	(-0.06)	(1,15)	(0,22)	(3,62)	(5,11)	(3,51)
ICT_PCA"'	0.05**	-0.05	0,15$	0.05*	-0,03	0,85	1.3*	0,95$
	(2,59)	(-1.62)	(1,92)	(2,28)	(-1.53)	(1,4)	(2,2)	(1,74)
Generator (*bin*) "	0.07**	-0,02	-0,17	0,08$	0,02	0,15	0,30	0,47
	(2,84)	(-1.09)	(-1.17)	(1,92)	(0,61)	(0,21)	(0,4)	(0,66)
Imported Inputs (*%*)"	0,21$	-0,08	0,00	0,00	0,05	0.32***	0.32***	0.33***
	(1,64)	(-0.85)	(0,01)	(0,22)	(0,33)	(7,17)	(7,29)	(7,39)
Corruption (*bin*) "	-0,01	-0,01	-0,20	6,1	0,03	0,55	0,04	0,34
	(-0.30)	(-0.41)	(-1.07)	(1,05)	(1,14)	(0,51)	(0,04)	(0,33)
Security_PCA"'	-0,03	0,03$	-0,01	0.01	0.03	0.73	0.38	1.1
	(-1.59)	(1.95)	(-0.21)	(0.28)	(1.54)	(1.16)	(0.62)	(1.57)
Part Big Firm (*bin*) '	0.04	-0.01	-0.66**	0.12*	0.05	0.90	-0.46	1.2
	(1.18)	(-0.39)	(-2.83)	(1.96)	(1.23)	(0.72)	(-0.51)	(0.93)
Industrial Association (*bin*) '	-0.04	0.02	0.19	-0.07*	0.06**	-0.52	-0.19	-1.1
	(-1.60)	(1.45)	(1.57)	(-2.11)	(3.11)	(-0.70)	(-0.27)	(-1.22)
Industrial Zone (*bin*) "	-0.07		0.56**	-0.09	0.00			
	(-2.04)		(2.75)	(-1.57)	(-0.07)			
Size City (*0 to 4*) "	0.12**	0.07*	0.59$	-0.08	-0.05	-0.68	-0.33	-0.59
	(2.63)	(2.23)	(1.87)	(-0.96)	(-1.03)	(-0.56)	(-0.23)	(-0.48)
Size City (*square*) "	-0.05***	-0.03**	-0.22$	0.04	0.01	0.24	0.14	0.17
	(-3.52)	(-3.14)	(-1.89)	(1.32)	(0.74)	(0.67)	(0.32)	(0.48)
Competition (*bin*) "	-0.02	0.06**	-0.24**	0.01	0.03			
	(-0.85)	(3.29)	(-2.69)	(0.51)	(1.03)			
Access Qualified Work (*obst*)^^	-0.03**							
	(-2.67)							
Access Permis /Licences (*obst*)^^		0.03**						
		(2.96)						
Foreign Licence (*bin*)^^			0.75**	0.14*				
			(3.07)	(1.82)$				
Stock Intermed Conso (*log*)^^					0.003***			
					(4.76)			
Stock Capital (*log*)^^					0.00			
					(-0.40)			
Export Zone (*bin*)^^						22.5***	21***	23.3***
						(7.76)	(7.49)	(7.58)
Quality Certification (*bin*)^^						2.8***	2.9***	3.2***
						(3.58)	(3.78)	(4.05)
Intercept	-0.62	-0.06	7.43	-0.64	-2.2	-31.8	-28.9	-7.1
	(-0.43)	(-0.05)	(1.24)	(-0.35)	(-1.40)	(-0.69)	(-0.63)	(-0.15)
Observations	4393	4393	4280	4284	3171	4421	4425	4426
Hausman Test	0	0.00	0.01	0.00	0.01	0.14	0.64	0.11
Hansen Test	0.150	0.276	0.245	0.716	0.128	0.459	0.075	0.577
F-stat (Labor)	534	529	403	403	421	514	514	514
F-stat (Training)	.	13.3	12.0	12.0	9.9	.	.	.
F-stat (R&D)	13.5	.	10.0	10.1	.	.	.	.
F-stat (Innovation)	14.5	14.0	.	.	9.2	16.1	14.5	9.3
F-stat (Productivity)	70.3	71.3	73.7	73.6	.	76.4	76.5	76.4
F-stat (Exports)	16.9	17.4	16.5	16.6	13.4	.	.	.
Kleibergen-Paap Test	3.9	7.0	1.3	1.2	5.0	13.5	11.0	8.1

Source. Authors' estimations.

Note: ^Variables of the system (see section 2.3.1). ^^ Instruments of the variables of the system (see section 4.2). ʾCharacteristics of the firms (see section 2.4.3). ʾʾInvestment climate variables (see section 2.4.1 and *Appendix* C). ʾʾʾInvestment climate composite indicators (see section 2.4.2 and *Appendix* C). *Bin*: binary variables. *Obst*: obstacle variables. By construction, the expected sign of the investment climate variables and composite indicators is positive (except in the case of competition and size of the city where both sign can happen). All regressions contain State and sector fixed-effects. LIML: Limited Information Maximum Likelihood estimator. Heteroskedastic-robust t-students are into brackets: $ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001, respectively.

TABLE D2: Estimation Results with Labor Productivity

(LIML with instrumented investment climate variables)

	Training^	**R&D^**	**Innovation^**	**Product Innovation^**	**Labor Productivity^**	**Exports^**	**Exports^**	**Exports^**
Training (*bin*)^		0.41**	2.3***	-0.91	-0.07			
		(2.82)	(3.79)	(-1.43)	(-0.39)			
R&D (*bin*)^	1.4***		-0.67	1.4*				
	(4.56)		(-1.01)	(2.1)				
Innovation (*0 to 4*)^	-0.26*	0.25***			0.01	5.2**		
	(-2.27)	(6.83)			(0.09)	(2.65)		
Product Innovation (*bin*)^							11.9$	
							(1.82)	
Marketing Innovation (*bin*)^								21.4**
								(2.65)
Labor Productivity (*log*)^	0.00	0.00	-0.01	0.00		-0.36	-0.13	-0.72
	(-0.19)	(0.17)	(-0.27)	(-0.02)		(-0.60)	(-0.20)	(-1.11)
Exports (*%*)^	-0.008**	0.005**	-0.002	-0.006	0.00			
	(-2.79)	(2.95)	(-0.41)	(-1.00)	(-0.07)			
Size (*nbr*)ʾ	0.01	0.01	-0.02	0.10	-0.39	4.2*	3.9*	4.5*
	(0.39)	(0.39)	(-0.16)	(1.04)	(-1.59)	(2.44)	(2.28)	(2.59)
Age (*years*)ʾ	0.00	0.00	0.00	0.00	0.001$	0.01	0.02	-0.01
	(1.58)	(-1.14)	(-0.92)	(0.2)	(1.91)	(0.29)	(0.67)	(-0.51)
H_PCA ʾʾʾ	0.12***	-0.05	0.12	0.07	0.02	1.0	1.7$	0.81
	(3.47)	(-1.61)	(1.37)	(1.24)	(0.82)	(1.01)	(1.84)	(0.74)
Fin_PCAʾʾʾ	0.06*	-0.04	0.14	0.04	0.1***	1.9$	2.6**	1.9$
	(2.12)	(-1.59)	(1.64)	(0.69)	(4.54)	(1.94)	(3.07)	(1.95)
ICT_PCAʾʾʾ	0.01	0.00	-0.04	0.01	0.05***	1.0*	0.99*	1.1*
	(0.73)	(-0.07)	(-0.83)	(0.41)	(3.6)	(2.1)	(2.05)	(2.09)
Generator (*bin*) ʾ	0.16***	-0.05	-0.16	0.29	0.02	-1.4	-1.5	-0.84
	(5.37)	(-1.53)	(-1.48)	(1.8)$	(0.54)	(-1.58)	(-1.52)	(-0.97)
Imported Inputs (*%*)ʾ	0.36	0.03	-1.10	0.80	1.8**	0.69***	0.69***	0.71***
	(0.85)	(0.1)	(-0.89)	(0.85)	(3.91)	(5.06)	(4.98)	(5.1)
Corruption (*bin*) ʾ	0.03	0.00	-0.13	0.00	0.15*	2.3	2.1	1.9
	(0.42)	(-0.08)	(-0.80)	(-0.03)	(2.28)	(1.18)	(1.09)	(0.9)
Security_PCAʾʾʾ	-0.02	0.01	-0.07	-0.01	0.1***	1.4$	1.0	1.5$
	(-0.83)	(0.71)	(-1.17)	(-0.37)	(4.14)	(1.88)	(1.49)	(1.89)
Part Big Firm (*bin*) ʾ	0.04	0.01	-0.48	0.10	0.05	2.5*	0.59	3.1*
	(1)	(0.21)	(-4.73)	(1.09)	(1.58)	(2.03)	(0.64)	(2.16)
Industrial Association (*bin*)ʾ	-0.01	0.03	-0.16	0.08	0.17***	-0.75	-1.1	-1.2
	(-0.31)	(1.01)	(-1.56)	(0.98)	(4.13)	(-0.66)	(-0.94)	(-0.97)
Industrial Zone (bin) ʾ	0.01		0.32**	0.02	0.07$			
	(0.28)		(2,68)	(0,33)	(1,72)			
Size City (*0 to 4*) ʾ	0,00	0,05	0,71***	0,06	0,16*	-3,2	-3.2	-2,2
	(0,03)	(0,83)	(3.25)	(0,29	(2,01)	(-0.64)	(-1.05)	(-0.88)
Size City (*square*) ʾ	0,01	-0,01	-0,13**	0,00	-0,02	-3,0	1.3	0,08
	(0,54)	(-1.08)	(-2,58)	(-0.12)	(-1.23)	(-0.63)	-0,54	(0,13)
Competition (*bin*) ʾ	-0,04	0,05**	-0,26***	0,00	0,02			
	(-1.26)	(3,04)	(-4.49)	(0,03)	(1,18)			

Access Qualified Work (*obst*)^^	-0.05***							
	(-3.33)							
Access Permis/Licences (*obst*)^^		0.02**						
		(2.66)						
Foreign Licence (*bin*)^^			0.64***	0.16$				
			(5.34)	(1.86)				
Stock Intermed Conso (*log*)^^					0.002***			
					(3.63)			
Stock Capital (*log*)^^					0.00			
					(-1.15)			
Export Zone (*bin*)^^						24.2***	21.6***	25.5***
						(8.39)	(7.65)	(8.12)
Quality Certification (*bin*)^^						2.8***	3.0***	3.4***
						(3.84)	(4.19)	(4.56)
Intercept	-1.0	0.3	5.3	0.6	-2.2	-15.7	-22.2	24.0
	(-0.65)	(0.25)	(1.29)	(0.22	(-2.00)	(-0.31)	(-0.45)	(0.44)
Observations	5151	5188	4995	5005	3534	5227	5239	5236
Hausman Test	0	0	0	0.00	0.90	0.03	0.26	0.02
Hansen Test	0.81	0.13	0.47	0.65	0.32	0.92	0.07	0.99
F-stat (Labor)	459	454	370	388	408	528	528	528
F-stat (Training)	.	13.1	10.4	7.8	9.7	.	.	.
F-stat (R&D)	14.9	.	11.4	8.8	.	.	.	.
F-stat (Innovation)	18.0	17.0	.	.	9.2	18.74	18.53	10.4
F-stat (Productivity)	99	100	107	93	.	120	120	120
F-stat (Exports)	19.4	19.4	19.3	13.1	15.3	.	.	.
Kleibergen-Paap Test	3.4	9.1	1.6	2.6	7.1	17.8	15.6	9.6

Source. Authors' estimations.

Note: ^Variables of the system (see section 2.3.1). ^^Instruments of the variables of the system (see section 4.2). ' Characteristics of the firms (see section 2.4.3). '' Investment climate variables (see section 2.4.1 and *Appendix* C). ''' Investment climate composite indicators (see section 2.4.2 and *Appendix* C). *Bin*: binary variables. *Obst*: obstacle variables. By construction. the expected sign of the investment climate variables and composite indicators is positive (except in the case of competition and size of the city where both sign can happen). All regressions contain State and sector fixed-effects. LIML: Limited Information Maximum Likelihood estimator. Heteroskedastic-robust t-students are into brackets: $ p < 0.1. * p < 0.05. ** p < 0.01. *** p < 0.001 respectively.

TABLE D3: Estimation Results with Total Factor Productivity

(LIML with instrumented investment climate variables)

	Training^	**R&D^**	**Innovation^**	**Product Innovation^**	**TFP^**	**TFP^**	**Exports^**	**Exports^**	**Exports^**
Training (*bin*)^		0.09$	3.7*	-0.64	0.18	0.07			
		(1.66)	(2.45)	(-1.60)	(0.78)	(0.3)			
R&D (*bin*)^	3.5*		-1.8	0.9*					
	(1.98)		(-1.19)	(2.4)					
Innovation (*0 to 4*)^	-0.87$	0.3***			0.09		5.3$		
	(-1.78)	(6.63)			(1.33)		(1.65)		
Product Innov (*bin*)^^								24$	
								(1.65)	
Marketing Innov (*bin*)^									19$
									(1.65)
Market/ Orga Innov (*bin*)^						0.20$			
						(1.73)			
TFP (*log*)^	-0.04	0.05	-0.62$	-0.03			-2.0	-2.1	-0.82
	(-0.23)	(0.82)	(-1.70)	(-0.48)			(-1.01)	(-0.97)	(-0.35)
Exports (*%*)^	-0.017$	0.004*	0.009	-0.003	0.005*	0.006**			
	(-1.98)	(2.34)	(0.75)	(-1.00)	(2.52)	(2.78)			
Size (*nbr*) '	0.00	0.00	-0.01	0.01	0.01	0.01	0.47*	0.46*	0.52*
	(-0.18)	(0.67)	(-0.48)	(1.38)	(1.14)	(1.2)	(2.24)	(2.17)	(2.44)

Age (*years*) '	0.00	0.00	-0.01	0.00$	0.00	0.00	0.02	0.03	0.01
	(0.64)	(-0.04	(-1.41)	(-0.56)	(-0.16)	(-0.50)	(0.5)	(0.75)	(0.46)
H_PCA'''	0.27$	-0.08	0.19	0.06$	0.07*	0.06	1.2	0.84	1.5
	(1.8)	(-1.58)	(1.32)	(1.72)	(2.24)	(1.87)$	(0.79)	(0.49)	(1.08)
Fin_PCA'''	0.11	-0.04	0.25	0.04	0.17***	0.16***	2.0	1.7	1.4
	(1.06)	(-1.23)	(1.68)	(1.02)	(5.17)	(4.73)	(1.32)	(1.02)	(0.79)
ICT_PCA'''	-0.02	0.01	0.00	0.01	0.12***	0.12***	1.48*	1.56*	1.38*
	(-0.41)	(0.36)	(0.03)	(0.34)	(7.33)	(7.17)	(2.24)	(2.21)	(2.06)
Generator (*bin*) ''	0.25**	-0.05	-0.37	0.18**	0.06*	0.07*	-1.8	-2.0	-1.3
	(2.63)	(-1.57)	(-1.51)	(2.91)	(2.09)	(2.55)	(-1.42)	(-1.46)	(-1.20)
Imported Inputs (*%*)''	-0.01	0.00	-0.01	0.00	0.04***	0.04***	0.82***	0.77***	0.83***
	(-0.64)	(1.09)	(-0.28)	(0.87)	(7.57)	(7.57)	(4.26)	(3.86)	(4.23)
Corruption (*bin*) ''	-0.09	0.02	-0.11	0.03	0.19*	0.20**	2.9	3.0	3.7
	(-0.48)	(0.43)	(-0.38)	(0.38)	(2.54)	(2.64)	(1.13)	(1.08)	(1.42)
Security_PCA'''	-0.05	0.01	0.04	-0.02	0.11***	0.11***	0.77	1.09	0.30
	(-0.69)	(0.45)	(0.44)	(-0.71)	(5.3)	(5.2)	(0.83)	(1.08)	(0.33)
Part Big Firm (*bin*) '	-0.06	0.03	-0.33	0.03	0.09**	0.11**	2.3	2.1	3.1
	(-0.68)	(1.17)	(-2.49)	(1.02)	(2.68)	(2.84)	(1.48)	(1.4)	(1.6)
Industrial Association (*bin*) '	-0.04	0.02	-0.15	0.05	0.21***	0.21***	-1.5	-1.6	-1.3
	(-0.33)	(0.48)	(-0.87)	(1.25)	(6.11)	(6.05)	(-1.05)	(-1.03)	(-0.86)
Industrial Zone (*bin*) ''	0.11		0.35$	0.03	-0.04	-0.05			
	(0.84)		(1.86)	(0.74)	(-0.90)	(-1.00)			
Size City (*0 to 4*) ''	-0.295	0.15$	1.07**	0.02	0.16	0.18$	-1.0	0.35	-1.9
	(-0.88)	(1.81)	(2.61)	(0.15)	(1.51)	(1.67)	(-0.29)	(0.08)	(-0.57)
Size City (*square*) ''	0.068	-0.03$	-0.17*	-0.01	-0.01	-0.02	-0.02	-0.43	0.04
	(0.92)	(-1.70)	(-2.01)	(-0.41)	(-0.55)	(-0.72)	(-0.03)	(-0.46)	(0.05)
Competition (*bin*) ''	-0.209	0.07***	-0.08	0.01	0.04*	0.04*			
	(-1.53)	(3.82)	(-0.83)	(0.25	(1.96)	(2.15)			
Access Qualified Work (*obst*) ^^	-0.13$								
	(-1.78)								
Access Permis/Licenses (*obst*) ^^		0.02*							
		(2.34)							
Foreign Licence (*bin*) ^^			0.79**	0.05$					
			(2.85)	(1.78)					
Stock Intermed Conso(*log*) ^^					0.002$	0.003*			
					(1.91)	(2.11)			
Export Zone (*bin*) ^^							26.6***	27.5***	26.7***
							(6.94)	(6.86)	(6.78)
Quality Certification (*bin*) ^^							3.8***	3.2*	3.5**
							(3.51)	(2.54)	(3.06)
Intercept	0.40	-1.2	16.2*	1.6	6.6***	7.0***	-22.8	-47.1	-28.8
	(0.09)	(-0.84)	(2)	(0.85)	(4.22)	(4.49)	(-0.33)	(-0.62)	(-0.41)
Observations	3548	3570	3555	3560	3567	3569	3590	3597	3596
Hausman Test	0	0.00	0.00	0.00	0.01	0.01	0.11	0.44	0.10
Hansen Test	0.50	0.22	0.24	0.46	0.28	0.28	0.66	0.08	0.77
F-stat (Labor)	534	529	403	403	421	421	514	514	514
F-stat (Training)	.	13.0	11.0	9.1	9.5	10.0	.	.	.
F-stat (R&D)	13.9	.	11.0	9.1	.	.	.	.	.
F-stat (Innovation)	15.5	15.8	.	.	9.2	8.5	17.3	15.8	9.8
F-stat (TFP)	70.3	71.3	73.7	73.6	.	.	76.4	76.5	76.4
F-stat (Exports)	18.3	17.9	18.1	14.4	14.0	16.6	.	.	.
Kleibergen-Paap Test	3.5	7.9	1.5	2.3	6.5	7.8	14.9	14.3	9.2

Source. Authors' estimations.

Note: ^Variables of the system (see section 2.3.1). ^^ Instruments of the variables of the system (see section 4.2). 'Characteristics of the firms (see section 2.4.3). ''Investment climate variables (see section 2.4.1 and *Appendix* C). '''Investment climate composite indicators (see section 2.4.2 and *Appendix* C). *Bin*: binary variables. *Obst*: obstacle variables. By construction. the expected sign of the investment climate variables and composite indicators is positive (except in the case of competition and size of the city where both sign can happen). All regressions contain State and sector fixed-effects. LIML: Limited Information Maximum Likelihood estimator. Heteroskedastic-robust t-students are into brackets: $ p < 0.1. * p < 0.05. ** p < 0.01. *** p < 0.001 respectively.