# Title registration for a systematic review: Interventions to promote technology adoption in firms

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## BACKGROUND

Implementing policies directed at promoting technological upgradation among firms has been embraced as a goal by governments and development agencies. In order to inform their actions, a reliable knowledge base is needed. This includes a systematic compendium of the already available evidence in this field and a map of the knowledge gaps that need to be filled. Our review will help fulfill this need.

Governments and development agencies have incorporated the promotion of firms' competitiveness into their priorities (World Bank, 2017; IADB, 2016) and recognized that the adoption of modern technologies is one of its drivers. Two reasons lie behind this interest in competitiveness in general and technological upgrading in particular: first, the expectation that improvements in firms' productivity will deliver benefits like higher employment, better wages and better working conditions at micro level and higher growth at aggregate level. Second, that the slowness, or even absence, of the process of technological adoption is due in part to market failures that call for public intervention, like externalities, imperfect information and coordination problems.

There is evidence that the market process alone is not enough to induce firms to adopt the best technologies among those available. The lack of technology adoption in cases in which the potential gains are clear have been observed in specific industries like textiles (Bloom et al, 2013) and soccer ball producers (Atkin et al, 2017). Foster, Haltiwanger and Syverson (2008) show that there is large heterogeneity in productivity even within narrowly defined industries, which can be interpreted as the consequence of the lack of technology adoption by the firms in the left tail of the distribution.

Despite this interest in promoting technology adoption by firms, the evidence regarding the effectiveness of interventions in this area is mainly focused on agriculture, leaving aside interventions in other sectors such as manufacturing or services. This knowledge gap is relevant given that efforts have been also directed to other sectors. Additionally, some of the challenges for technology adoption in agricultural and nonagricultural settings are different. As stated by Atkin et al (2017), in manufacturing, the obstacle posed by organizational conflict is more important than in the case of smallholder farmers. At the same time, risk aversion might play a less important obstacle in manufacturing than in agriculture because the level of production risk is lower and because the owners of manufacturing firms tend to be richer than farmers. Producing a systematic review that includes sectors other than agriculture will prove useful for policy making and for guiding the development of a research agenda to fill the knowledge gaps.

## OBJECTIVES

The objective of this review is to answer the following research questions:

1. To what extend do firm-level interventions affect technology adoption?
2. Is this effect heterogeneous across sectors, firm size or countries?
3. To what extend does technology adoption affect observable measures of productivity, output, unit cost, wages and employment?
4. Are these effects heterogeneous across sectors, firm size, countries, workers' skill level or workers' gender?

Questions 1 and 2 refer to the immediate impact of interventions to promote technology adoption. Questions 3 and 4 explore the subsequent impact of technology adoption on other economic outcomes. Answering questions 2 and 4 will bring attention to the heterogeneity of the main effects and to potential unintended impacts. For example, it is possible that the effect of technology adoption on wage is negative in some sector or type of firm even though its overall average effect is positive.

Note that all the review questions take the firm as the unit of analysis. The reference to wages and employment in question 3, refers to firm-level average and total level, respectively. Similarly, the reference to heterogeneity across workers' skill level and gender in question 4, means that we will summarize information about firm-level impacts on average wages and employment levels disaggregated by skill level and gender. Considering that some industrial surveys collect this type of firm-level disaggregated information, it is possible that some of the papers included in the review also report effects disaggregated in this dimensions.

## EXISTING REVIEWS

Systematic reviews about technology adoption are mostly focused on agricultural firms (Obayelu et al, 2017; Waddington et al, 2014; Silva et al, 2015). There has been little effort to do the same for other economic sectors, despite the recent publication of papers on technology adoption in manufacturing (Bloom et al, 2013; Atkin et al, 2017). Consequently, existing summaries of evidence for nonagricultural firms are almost all nonsystematic literature reviews. We comment about some of this nonsystematic reviews below.

Nonsystematic reviews on technology adoption by nonagricultural firms:

Herbert-Copley (1990) reviews case studies of technical change in manufacturing firms in the 80s in Latin America. In particular, he assesses the role of the nature of technology, market structure, government policy, firm characteristics and the location of the international technological frontier on the level of technology adoption. Even though it is interesting, the study is outdated and its geographic coverage is limited.

Keller (2004) reviews technology diffusion, but only across countries. This review leaves out cases that will be relevant for our review, like technology diffusion from advanced firms to backward businesses within a country. For obvious reasons, it also ignores more recent evidence. For example, one of the author's conclusions is that there is no evidence of exports being a driver of technology improvement. However, we know that recent experimental evidence has been produced pointing in that direction (Atkin et al, 2017b).

Coming from the information systems literature, Oliveira and Martins (2011) compile studies on the adoption of information technology at firm level. The authors do an interesting job classifying different papers according to the model they based their analysis on. However, their review does not attempt to compare their results or to try to extract general lessons from them.

Piza et al (2016) systematically review the evidence about the impact of businesses support services for small and medium enterprises (SME) in low and middle income countries (LMIC). Our review will complement their findings by broadening the types of countries and firms considered, and narrowing the type of intervention and outcomes to study. Including a broader set of firms is important because, even though SME are particularly relevant for outcomes like employment, larger firms are key for other important outcomes like exports. Considering also the experience of developed countries is warranted because active policies to promote technology adoption are widespread around the globe, not only in the developing world. The experience of these countries provides a knowledge collection relevant for policy making everywhere. Finally, our review's focus on technology adoption, leaving aside interventions aiming to affect other outcomes, will allow us to provide a sharper insight on the effectiveness of this kind of policy. The rationale for public intervention in this area includes the existence of knowledge spillovers and self-discovery (Hausmann and Rodrik, 2003), which are not present in the justification of other pro-business interventions, like formalization and access to working capital.

## INTERVENTION

The review will include interventions that explicitly attempt to induce adoption of a new technology by a firm. Following Foster and Rosenzweig (2010), we define *technology* as “the relationship between inputs and outputs”, and *technology adoption* as “the use of new mappings between input and outputs and the corresponding allocations of inputs that exploit the new mappings”. This definition of technology adoption is broad, including the overall production plan that firms implement (the recipe they use) as well as changes in the firm practices. Evenson and Westphal (1995) differenciate between these two concepts, calling technology to the former and technique to the latter. We subsume both under the term *technology*.

The word intervention should be considered as broadly defined, including public interventions, interventions carried out by private institutions (like NGOs), experimental variations deliberately induced by academic researchers trying to understand technology adoption, and quasi-experimental changes (including natural experiments) exploited in studies about technological change.

## POPULATION

The review will focus on firms. No requirement will be imposed on whether the firms are formal or informal, or whether they are located in developed or developing countries.

## OUTCOMES

We classify the relevant outcome variables in two groups: technological and economic. The technological outcomes are variables that reveal whether the firm has adopted a new technology. For example, an indicator variable that takes value one if the firms have adopted a new productive method or a number that indicates how many new practices have been incorporated. The economic outcomes are variables that are affected by technology adoption. These are variables in the second step of the causal chain. In particular, we consider observable measures of productivity[1], output, unit cost, wages and employment.

In this review, we only include studies on effects on economic outcomes if they also include effects on technological outcomes. In other words, a study on the impact of interventions on economic outcomes that does not include a variable on technology adoption will be excluded.

## STUDY DESIGNS

The review will focus on quantitative studies that attempt to establish causal relationships between interventions to promote technology adoption and actual adoption, and between this and firms' economic outcomes.

Regarding the unit of analysis, we require that the studies perform analysis at the level of the firm. This will leave out studies of technology adoption at country or region level.

With respect to the studies' methods, we will include quantitative analysis that explicitly address bias concerns. The randomized control trial is the gold standard to achieve this, however, in order to include as many studies as possible, we will also consider papers using propensity score matching, synthetic controls, difference-in-difference, instrumental variables, or regression discontinuity.

1 The expression *observable measures of productivity* leaves out residual measures like total factor productivity. Instead, we will focus on directly observable measures like output per unit of labor or the rate of production defects (lower rate means higher productivity).

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## ROLES AND RESPONSIBILITIES

- Content: All co-authors
- Systematic review methods: Ana, Tanay, David, Xavier
- Statistical analysis: David, Tanay
- Information retrieval: Tanay

## POTENTIAL CONFLICTS OF INTEREST

There are no conflicts of interest identified at this time.

## FUNDING

The study will be funded by the Competitiveness Policy Evaluation Lab (ComPEL) of the World Bank Group.

## PRELIMINARY TIMEFRAME

- Date you plan to submit a draft protocol: **15 February 2018**
- Date you plan to submit a draft review: **30 June 2018**
- Date you plan to submit the final draft review: **30 September 2018**

## DECLARATION

### Authors' responsibilities

By completing this form, you accept responsibility for preparing, maintaining, and updating the review in accordance with Campbell Collaboration policy. The Coordinating Group will provide as much support as possible to assist with the preparation of the review.

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