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TRADE AND INNOVATION: MATCHED WORKER-FIRM-LEVEL EVIDENCE

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ABSTRACT

This paper examines the relationship between globalization and innovation. To do so, it draws from data that match the full population of workers and private-sector firms in Finland tracking them from 1995 to 2009. To correct for endogeneity the paper considers variation in trade exposure from China during its entry to the world market using a fixed effects model. While the literature on trade and innovation has emphasized the role of firms in driving onshore innovation, the main conclusion of this research is that globalization increases the share of innovators within firms.

Keywords Trade, Innovation, China, Employment

JEL 033 F14 F16 J24 L60 L24

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I. INTRODUCTION

Consider the *iPod*. Its back panel states: "Designed by Apple in California, Assembled in China" (see Dedrick et al. 2010, Autor et al. 2016). In this paper, I study if this pattern is a more general result of globalization. That is, if the China shock—China's entry to the world market in the early 2000's—contributed to specialization in innovation.

In particular, I study if firms that were exposed to trade from China responded by increasing their investment in innovation. To do so, I use detailed worker-level longitudinal data on the full population of over 3 million Finnish workers and their employers. The paper focuses on China, because its accession to the WTO enables us to possibly identify the causal effects of increasing trade (see, for example, Autor et al. 2014, Bloom et al. 2015a)—that is, the causal impact of globalization on innovation.

In earlier literature, Bloom, Draca, and Van Reenen (2015a) argue that China's entry to the world market in early 2000's increased technological change and innovation in Northern Europe. *Firms*—and perhaps people—in Northern Europe seemingly specialized in innovative activity—say, design—while China offered a place for assembly.

And in a classic study, Dedrick, Kramer, and Linden (2010) track the production of the iPod from firms that design it in California to other firms that assemble it in China. Ali-Yrkkö, Rouvinen, Seppälä, and Ylä-Anttila (2011), in turn, literally follow the production of Nokia N95 mobile phone from its R&D in Finland to manufacturing in China back to consumers in Finland and throughout the world. From labor market perspective, it is remarkable that in these case studies, and in many others, the innovation happens in Northern countries while more routine manufacturing takes place in China. Our knowledge on the relationship of these two activities is, however, limited. The latter study also motivates our choice of data: the Finnish Longitudinal Employer–Employee Data consisting of the population of firms and workers in Finland. Using that data, I am able to measure the share of innovators in each firm affected by trade.

What we know from earlier studies, especially from Autor et al. (2013, 2014), is that for the workers that were most exposed to import competition the effect has been *negative*. That is, workers bore substantial costs as a result of the "shock" of rising import competition from China. But in this paper, we look at the potential *positive* impact of trade. While China's entry to the world market displaced certain workers in specific places and industries (Autor et al. 2013, 2014) the aggregate unemployment rate did not go up. That leaves the possibility that the *China shock* could have generated *new work*. And that is the topic of this paper.

Traditional economic logic tracing back to Smith (1776) says that trade is good—countries, firms, and people can do what they are good at and trade their services. But there is limited empirical evidence to confirm this. That is for two reasons. First, there have been only few, if any, natural experiments of trade. China's entry to the world market offers a reasonable candidate for such. Second, high-quality micro data has not been available. The Finnish register data, used in this paper, provides us with detailed measures both at the firm and at worker level. The contribution of this paper is to provide to a central topic more granular measurement than has previously been presented. It relates to the literature on labor market consequences of international trade (see, for example, Nilsson Hakkala and Huttunen 2016, Pekkala Kerr et al. 2016, Hummels et al. 2014, Goos et al. 2014, and Acemoglu and Autor 2011). But our main focus is on the firm-level innovation activity.

The structure of the paper is as follows: Section II describes the data, Section III specifies the empirical strategy, Section IV gives the results, Section V discusses the findings, and Section VI concludes.

II. DATA

This paper combines several detailed datasets. This section describes them. In short, the main variables are the innovator share at firm level and the trade exposure from China at the industry level, both from 1995 to 2009.

Firms and workers

Our base dataset is the Statistics Finland's Employer–Employee data, FLEED.[1] It contains the full population of firms and workers in Finland. The dataset enables tracking workers and companies over time; we can look at longer-term patterns in trade and innovation. The observation period for this study is 1995–2009, reported in 1995, 2000, and 2004–2009.

Statistics Finland constructed FLEED from a number of administrative registers. It has matched them together using unique identification codes both for workers and firms. These codes are available in the data. For each firm, FLEED also contains a NACE rev. 2 equivalent industry codes.[2]

Innovators

In order to capture to impact of globalization on innovation, I measure a specific aspect of innovation: the share of *innovators* in each firm. Innovators are identified by their occupation. Those occupations are designers, architects, engineers, scientists and similar occupations related to R&D. In specific, innovators are defined as workers in a group of "senior officials and employees in research and planning" following the 1989 Classification of Socio-Economic Groups. Table A1 in the Appendix provides the full list of occupations classified as innovators.

The main variable is defined as the amount of innovators in a firm divided by total employment in that firm. It measures the innovation intensity of the firm:

$$\text{INNOVATORS} = \frac{\text{EMP}^{\text{INNOVATORS}}}{\text{EMP}^{\text{TOTAL}}}$$

[1] FLEED is an acronym for Finnish Longitudinal Employer-Employee Data.
[2] This industry code is called TOL. I match 2008 version of it to ISIC rev.4 using concordance provided by Eurostat.

Traditional way of looking at innovation has been focused on firms and patents (see, for example, Bloom et al. 2015a, 2015b). But innovation is about people—it is the people who innovate. That is why I measure the amount of people who are making innovations. In other words, innovation is measured as an *activity*. At the same time, innovation becomes a labor market issue: how many people are working on new ideas instead of implementing the old?

This concept of innovators, and measuring innovation at the individual level, traces back to Florida (2012). Florida (2012) introduced the concept of *Creative Class* that broadly refers to innovators—people working in creative occupations, such as, researchers, designers, engineers, and artists.

But *a firm* could possibly be the *intermediate* through which trade exposure from China affects the labor market and individual people. That is why I measure firms' employment decisions. This kind of measure requires knowledge of firm-level employment structure—the data that we have here. The paper uses information only on firms with 10 or more workers in order to ensure the validity of our innovation measure. We also concentrate only on those industries that we have data on trade of goods.

As a descriptive statistic, Figure 1 illustrates the share of innovators in Finnish employment in our data from 1995 to 2009. Rise in the innovator share is remarkable. Within a relative short period of time the innovator share increased from 6.9 percent in 1995 to 10.0 percent in 2009. Descriptive evidence points out large variation between firms and industries.

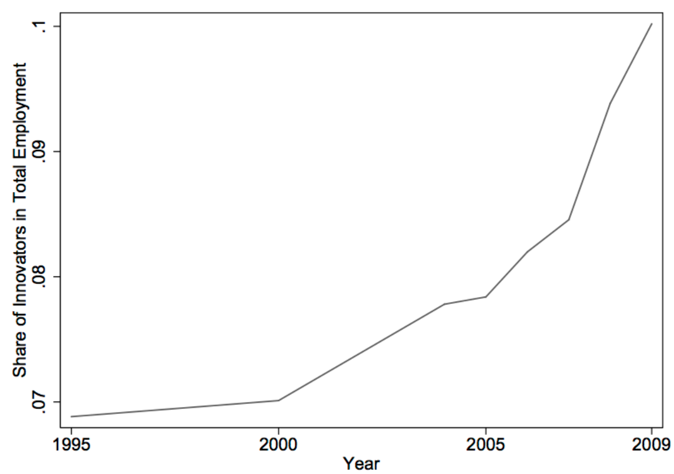

Figure 1: The share of innovators in total employment in Finland 1995–2009. Source: Statistics Finland.

Trade

The trade data comes from OECD's STAN Bilateral Trade Database. It is an international database of two-digit ISIC rev.4 industry-level information on all bilateral imports and exports of goods between any given pairs of countries. I use the industry codes in Statistics Finland's FLEED data in order to match the industry-level trade data. At the two-digit level, the match is uniquely defined.

The main explanatory variable is a measure of China's import share. It is defined as China's share in total imports in an industry:

$$\text{TRADE} = \frac{M^{\text{CHINA}}}{M^{\text{WORLD}}}$$

In the equation, M^{CHINA} is value of China's imports in a specific two-digit industry that contains several firms. M^{WORLD} is the same measure of world imports. The trade measure follows the "value share" approach outlined by Bernard, Jensen, and Schott (2002, 2006). It is used by Bloom et al. (2015a) and it is a static version of Autor et al. (2014) measure.

Figure 2 describes China's share of all imports in Finland. In 1995 only 1.6 percent of imports originated from China, but by 2006 this had increased almost six-fold to 9.4 percent. Descriptive analysis shows that the increase in China's imports also varied strongly across industries. Country-level patterns described in Figure 1 and 2 motivate the firm-level analysis on the relationship between trade and innovation activity.

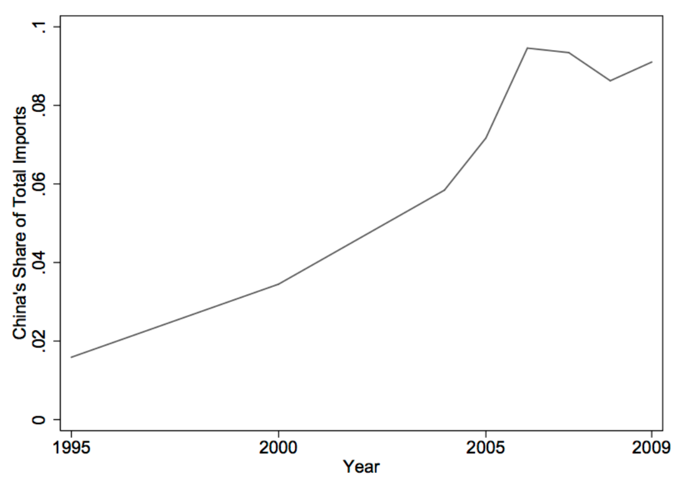

Figure 2: The share of China in total imports in Finland 1995–2009. Source: OECD.

III. METHODS

I analyze the relationship between trade, innovation and emergence of new work. To do so, I study China's import growth and firm-level innovation activity. The empirical models analyze employment in innovation at within-firm intensive margin. The other side of the model measures industry-level variation in exposure to Chinese trade.

The main equation is the following fixed effects model:

$$\text{INNOVATORS}_{\text{ijt+1}} = \beta_0 + \beta_1 \text{TRADE}_{\text{jt}} + f_{\text{i}} + \varepsilon_{\text{ijt}}$$

INNOVATORS is the share of people working in occupations related to R&D in firm *i*, which operates in industry *j*, at time *t*. TRADE is China's share of total imports in industry *j* at time *t*. Firm-level fixed effects are denoted by *f*. Lag length indicator *l* allows us to study time patterns in trade and innovation. Firm-level error term is denoted by ε_{ijt}.

The main strategy to address the endogeneity is simple: we consider imports from China from 1995 to 2009. During that time, China opened to the world market (see, for example, Autor et al. 2016 for a review on the identification strategy). The idea is that China's entry to the world market is close to an exogenous trade shock to a small country, such as, Finland (see, Autor et al. 2013, 2014, and 2016). The trade shock originated from China, not from Finland.

But unobserved factors may bias the observed relationship between trade and innovation. Fixed effects model provides an opportunity to control for at least some of these unobserved factors. Implicitly, the analysis aims to compare firms, some which of operate in industries subject to trade exposure from China and some of which do not. But the identification of causal relationship between trade and innovation is not perfect. Firms in industries that started to trade more with China may have increased or decreased their employment in innovation, but potential correlation need not be causal.

I account for the within-panel serial correlation in the firm-level error term ε_{ijt} by employing heteroskedasticity- and autocorrelation-robust standard errors developed by Arrellano (1987). The standard errors are also clustered at the firm level.

When estimating the models, I use the full population of Finnish firms in each year. But old firms disappear and new firms emerge. That is why the population size varies from year to year. The use of lag operator also reduces the amount of observations available depending on the lag length.

IV. RESULTS

Does trade induce innovation? Table 1 presents the main results. Column (1) explores the contemporaneous relationship between the share innovators and exposure to China's imports. The positive sign of the coefficient for the trade variable means that trade exposure from China was positively connected to innovation activity. More specifically, the coefficient 0.0561 means that a 1 percentage point increase in China's import share was associated with a 5 percentage point increase in the share of innovators in the affected firm. The trade variable coefficient is statistically significant at the 1% level. In short, we observe an immediate effect of trade on innovation.

But a stronger effect occurs later. Column (2) presents the estimation results for innovation five years ahead. The idea is to look at longer-term impacts of trade on innovation. A firm may have to adjust for the trade shock. We measure trade shock from China, for example, in 2004 and innovation in 2009. When we look at the relationship between future innovation and present trade the coefficients are larger than those previously reported. The coefficient of trade variable 0.1714 five years ahead is about three times larger than the instant relationship in the Column (1). Column (3) provides results estimated over nine-year response time. In that model we find a similar connection between trade exposure from China and innovation activity.

Note that the five-year time lag is the shortest time pattern we can reasonable observe; there is a gap between 1995 and 2000 and also between 2000 and 2004 in our data—a period when much of the variation in Chinese trade takes place.

Table 1: Innovation and trade.

	(1) INNOV.	(2) INNOV. t+5	(3) INNOV. t+9
TRADE	0.0561***	0.1714***	0.1643**
	(0.0075)	(0.0365)	(0.0807)
Firm fixed effects	yes	yes	yes
Observation period	1995–2009	1995–2009	1995–2009
Number of groups	8,380	4,203	2,766
Number of observations	33,250	7,990	4,072

Notes: The dependent variable, INNOV, denotes the share of people working in occupations related to R&D at the firm level. The explanatory variable, TRADE, is the China's share of total imports at the industry level. The full N = 33,250. The observation period is 1995–2009. All regressions include a constant and a full set of firm dummies. Robust standard errors are clustered by firm. Asterisks ** and *** denote statistical significance at 5% and 1% levels using a tow-sided test with standard errors of Arellano (1987). Data for firm-level innovation comes from Statistics Finland's FLEED database. Trade data is drawn from OECD's STAN Bilateral Trade database at the industry level.

V. DISCUSSION

In recent literature, China's emergence to the world market is pictured as a rise in competition—both for firms and for workers, and especially for workers that were similar to those in China. But traditional economic logic tracing back to Ricardo (1817), the theory of comparative advantage, says that an increase in the means of production—one country's entry to the factory of the world—could also benefit some workers. Trade allows countries, firms, and people to specialize in what they are good at.

The results of this paper provide a look at a one aspect if this. Seemingly, firms that were exposed to China's imports, or opportunities to engage in global value chains with China (as in Timmer et al. 2014 and Los et al. 2015), shifted their focus by employing more people working on innovation—that is, new ideas.

A contribution of this paper is to describe—on a granular level—a potential mechanism through which an economy adjusted to trade. Trade exposure from China at the industry level was associated with employment decisions at the firm level—a decision to specialize in innovation—that had an impact at the individual level.

But "why is it that they innovate after something bad has happened to them?" Bloom et al. (2015b) ask. Perhaps it is not that firms respond to *competition* with China, but to the possibilities to divide labor globally and specialize in specific aspects of production. The trade shock increases the possibilities of northern countries to concentrate on their comparative advantage—compared to China—in technology-, skill-, and innovation-intensive products and services.[3] The trade shock reduces the relative cost of the inputs used to innovate.[4]

And what we see in the data and related literature is that firms and people in China became specialized in manufacturing (Autor et al. 2014), while firms and people in northern countries became more innovation intensive. In specific, this shift is not limited to offshoring but includes shifting position in the global value chain (Baldwin 2012).

This idea is consistent with the finding of Bloom et al. (2015b) that increased competition from high-cost and high innovation intensive countries like Japan did not result in a similar increase in innovation. Those countries are in many ways similar to high-income European countries like Finland. Therefore there may have been less potential for specialization and smaller, if any, changes in the relative costs of innovation.

Just like workers work together with the machines (see, for example, Brynjolfsson and McAfee 2014 and Autor 2015) workers and firms work together *with* China's large labor force, not always *against* it. But Autor et al. (2013, 2014) emphasize that this adjustment has not been painless: globalization creates winners and losers. When two countries change their trading arrangements, some industries expand and some industries contract. The people that are in the contracting industry suffer. The people in the expanding industries gain.

[3] Comparative advantage can also be due to institutional factors (Nunn 2007).
[4] Bøler et al. (2015) propose a nuanced mechanism for this emphasizing the role of imported inputs. It is consistent with the findings of this paper.

This paper does not argue that increased trade exposure from China would have produced an offsetting increase in employment. It may not have.

Globalization—trade with China, in particular—has enabled innovations to be created. An example of this is the iPod that is assembled in China but designed in California. Low-cost manufacturing, manifested by increased share of Chinese imports in consumer goods, allowed, or even caused (Bloom et al. 2015a, 2015b) firms to specialize in innovation and employ people to do that. Without global trade, many existing innovations would have never been developed. And perhaps more importantly, by employing more innovators, firms may continuously produce more innovations and increase the long-run growth rate.

VI. CONCLUSION

This paper has analyzed the relationship between trade and innovation. In particular, I explored if firms responded to trade exposure from China by increasing their employment share in innovative occupations.

The motivation was that China's rapid entry to the world market in early 2000's provides an opportunity to study the impact of globalization on innovation. I used unique matched worker- and firm-level longitudinal data on the full population of over 3 million Finnish individuals and their employers and tracked them over time. I was interested in people working in occupations related to innovation. I called them innovators.

The main result is that those firms that were exposed to trade from China increased their employment share in innovative occupations. The effect was stronger within a longer response period. The results are in line with earlier literature by Bloom et al. (2015a, 2015b) but with a twist: I measure innovation at the worker level, as the people who make innovations. The paper provides a more granular measurement to this topic than has previously been presented. The results illustrate that innovation is linked to globalization.

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APPENDIX

Table A1: Innovators

ISCO08	Occupation
2111	Physicists and astronomers
2112	Meteorologists
2113	Chemists
2114	Geologists and geophysicists
2120	Mathematicians, actuaries and statisticians
2131	Biologists, botanists, zoologists and related professionals
2132	Farming, forestry and fisheries advisers
2133	Environmental protection professionals
2141	Industrial and production engineers
2142	Civil engineers
2143	Environmental engineers
2144	Mechanical engineers
2145	Chemical engineers
2146	Mining engineers, metallurgists and related professionals
2149	Engineering professionals not elsewhere classified
2151	Electrical engineers
2152	Electronics engineers
2153	Telecommunications engineers
2161	Building architects
2162	Landscape architects
2163	Product and garment designers
2164	Town and traffic planners
2165	Cartographers and surveyors
2166	Graphic and multimedia designers
2421	Management and organization analysts
2422	Policy administration professionals
2423	Personnel and careers professionals
2424	Training and staff development professionals
2631	Economists
2632	Sociologists, anthropologists and related professionals