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Abstract

With more than four million cases in Germany every year, influenza and acute upper respiratory tract infectious diseases (henceforth URTI) exhibit the highest number of reported doctor consultations. Although the direct treatment costs for URTI are comparably low, the indirect economic costs, due to work absences and productivity impairments of sick workers who remain at work (presentism), are far more compelling. In this paper, we estimate the effect of local URTI incidences as an exogenous shock to the production factor labor and thus on firm productivity. To quantify the URTI related shock on the production factor labor, we scrape a large number of weekly maps depicting the (local) URTI index across Germany, which are provided in the official influenza surveillance system. Measured by the length of the influenza season in German municipalities from 2003 to 2009, these data exhibit substantial seasonal as well as regional variation. In our main analysis, we estimate firm level production functions using data from the IAB Establishment Panel, a comprehensive German firm survey. In our main regression, we analyze total factor productivity differentials and their relationship with the local influenza intensity. We find sizeable negative effects of the URTI diseases on firm productivity. We attribute this effect to a combination of direct productivity losses caused by absences of sick workers as well as indirect productivity impairments due to presenteeism.

Zusammenfassung

Mit mehr als vier Millionen Fällen pro Jahr in Deutschland nehmen Influenza und akute Infektionskrankheiten der oberen Atemwege (URTI) die Spitzenposition unter den gemeldeten Arztbesuchen in Deutschland ein. Obwohl die direkten Behandlungskosten für URTI vergleichsweise niedrig sind, sind die indirekten wirtschaftlichen Kosten aufgrund von Fehlzeiten und Produktivitätseinbußen bei kranken Arbeitnehmern, die am Arbeitsplatz verbleiben (Präsentismus), weitaus bedeutsamer. In diesem Papier schätzen wir den Einfluss lokaler URTI-Inzidenz als exogenen Schock für den Produktionsfaktor Arbeit und damit für die Produktivität von Firmen. Um den Schock auf den Produktionsfaktor Arbeit zu quantifizieren, extrahieren wir aus einer großen Zahl an Karten aus dem offiziellen Grippe-Überwachungssystem den lokalen URTI-Index. Bezogen auf die Dauer der Grippesaison in deutschen Gemeinden von 2003 bis 2009 zeigen unsere Daten erhebliche saisonale und regionale Schwankungen. In unserer Hauptanalyse schätzen wir Produktionsfunktionen auf Unternehmensebene anhand von Daten aus dem IAB-Betriebspanel. In unserer Hauptregression analysieren wir Produktivitätsunterschiede und deren Zusammenhang mit der lokalen URTI-Intensität in einem Jahr. Wir finden erhebliche negative Auswirkungen von URTI auf die Produktivität von Unternehmen. Wir führen diesen Effekt auf eine Kombination aus direkten Produktivitätsverlusten durch Fehlzeiten kranker Mitarbeiter sowie indirekten Produktivitätseinbußen durch Präsentismus zurück.

JEL

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Keywords

flu, productivity, regional

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1 Motivation

The months from November until March are notoriously famous as flu season. In Germay, every year the incidences of acute infectious illnesses of the upper respiratory tract including influenza (henceforth URTI) account for the largest share of doctor consultations. The incidences of seasonal URTI vary from year to year in their timing, intensity and in their local occurrence. Also, the health impacts vary across demographic groups. In particular for children or the elderly population, influenza infections can be become life threatening diseases. For the core working population aged 20 until 60 years, however, URTI and influenza are tedious diseases from which adults usually recover after about one week. Regardless of their specific type, the total direct treatment costs of URTI infections are comparably low in high-income countries (see de Francisco et al., 2015). For instance, cost estimates related to URTI in the US range from $6 to $25 billion (Putri et al., 2018; Molinari et al., 2007). Due to the rapid occurrence and relatively short course of the disease, the indirect economic costs via the sheer volume of incidences and the related productivity losses are far more compelling. Bramley/Lerner/Sarnes (2002) attributes one third of the economic costs to actual work absences while two thirds are estimated to result from productivity loses caused by presenteeism, i.e. sick individuals with productivity impairments at work. Survey data for the US on workers who suffer from influenza suggest a decay in individual productivity of about one third (Dicpinigaitis et al., 2015). The costs of URTI in Germany are documented in various official statistics: with over seven million reported cases in 2012, URTI diseases account for the highest number of reported medical consultations in Germany. The average absence from work in 2012 of about seven days add up to a total volume of more than 47 million person days of sick leave (see Bundesministerium für Gesundheit, 2014). Typically, a firm can hardly adjust its human resources ad-hoc in response to clustered incidences of URTI induced absences, leading to a decrease in the production of goods and services of a firm. Empirical studies show the prevalence of presenteeism among workers Germany. According to a represenative survey of DAK-Gesundheit (2016), more than 50% of the workforce reported to have worked during the last 12 months despite suffering from an illness. The literature further highlights, that both volume and costs of presenteeism are higher for presenteeism in comparison to actual absences (see Oldenburg, 2012; Steinke/Badura, 2011).[1]

In the absence of large firm level data on sickness related absences and productivity impairments, we propose a new analytical approach. To the best of our knowledge, we are the first to exploit weekly (geographic) data from the official influenza surveillance system in Germany to analyze the empirical relationship between the URTI diseases in German municipalities and the productivity of firms. The nexus between firm productivity and URTI originates in the location of the firm and the fact that high intensity of local URTI represents an exogenous shock to the firm, operating via disproportionally high absences of employees and productiv-

[1] A comprehensive survey on presenteeism in Germany and other countries is Steinke/Badura (2011).

ity impairments at work due to presenteeism. Thus, our core identifying assumption is that local influenza outbreaks, as indicated by our URTI measure (see details below), represent an exogenous and random shock to firms. The intensity of local influenza is negatively correlated with productivity of firms located in the same municipality. Relying on this assumption enables us to estimate the causal effect of URTI on firm productivity.

A healthy labor force can be seen as a prerequisite for long-term investments into human capital accumulation Becker (1962), thus it is a driver for productivity growth. Empirically, the long term effects of illnesses on productivity focuses more on chronic diseases or large pandemic shocks (e.g., Percoco, 2016). In general, illnesses reduce individual productivity before as well as after the actual sickness period (Brouwer et al., 2002). To prevent pandemic outbreaks, influenza vaccinations are recommended for specific demographic groups or professions such as medial personnel or workers in the service industry with frequent customer contact (Maurer, 2009). The effectiveness of influenza vaccinations varies annually since the vaccinations are developed ex ante to protect against the seasonal influenza virus. In an extreme case, mutations of the virus during the season can render the vaccination ineffective. Overall, in 2012, the rate of all adults vaccinated against influenza was between 25 and 30 percent in West Germany and about 40 percent in East Germany. The German social security system and the statutory health insurance cushion the risk of illness. Sick-pay schemes cover up short-term interruptions of the input factor labor via influenza-like diseases. These schemes allow employees to nurse an URTI decease at home and to return to work more quickly. However, statutory sick-pay schemes also pose a significant threat of moral hazard. Empirical studies show that productivity gains through sick-day leave outweighs losses through presenteeism or moral hazard (Lohaus/Habermann, 2019; Pichler/Ziebarth, 2017). In any case, short-term and unforseeable incidences of URTI affect the volume of labor available to a firm, which typically impacts on short-term firm productivity.[2]

Based on official statistics or firm-level data, the effects through short-term absenteeism can hardly be investigated. The statutory health insurance system[3] in Germany is an admired institution built upon many different insurance companies with partly locally independent affiliated firms. This makes it merely impossible to set up a comprehensive database covering the number of doctor consultations with URTI illnesses by regions. Retrospective flu season surveys are very expensive to conduct. The official employment data in the social security system records statutory sick pay only after six weeks of absence due to sickeness. Hoever, the average duration of work absence related to URTI is only about seven days. The pension insurance system is limited to information about permanent occupational disability. Suffering from the same statistical issues on important public health matters, several

[2] Many studies rely on reported doctor consultations, which implies the estimated effects of URTI on productivity to be the lower limit of the actual effect. Though, there are other attempts to capture the true exposure in the population. Famously until 2015, Google Flu Trend established a flu monitoring based on search queries, which proved inadequate in pandemic outbreaks driven by people searched for information about the disease (Lazer et al., 2014; Butler, 2013; Cook et al., 2011).

[3] In 2015, 86 percent of the population in Germany were covered by the statutory health insurance.

countries established public health monitoring systems. In Germany, the Robert-Koch Institute (RKI) administers these comprehensive monitoring systems. The RKI is a federal public health management and research organization within the Federal Ministry of Health. The influenza working group within the RKI established a monitoring system of URTI, influenza-like viral illnesses and others following international epidemiological standards. An index documenting the (local) URTI situation in Germany draws on the voluntary reporting of 700 to 900 medical offices around Germany.

In our analysis, we propose a stepwise empirical approach in which we first estimate the total factor productivity (TFP) of a firm using a simple Cobb Douglas production function framework. In the second step, we regress the estimate of TFP on the local URTI intensity to obtain the causal effect of URTI on firm productivity. This relationship between URTI and TFP is operates via the production factor labor, which is an essential part of production functions and exposed to URTI shocks. Our findings suggest that influenza-like diseases - measured by their seasonal intensity -, indeed affect productivity differentials across firms. In our main specification, which controls for firm and regional heterogeneity, we find that a marginal increase in the intensity of the influenza season reduces the TFP of local firms by about 1.3 percentage (ceteris paribus).

The remainder of the paper is as follows: In section 2 we illustrate our theoretical motivation building on a production function framework. We present the data in chapter 3, followed by descriptive evidence in section 4. The results are presented in 5. Section 6 concludes.

2 Theoretical motivation & Empirical Approach

We investigate the effect of local URTI intensity on total factor productivity of a firm using a standard production function framework, firm level data and a rich set of controls to account for confounding factors. The basic rationale driving our research is that firms and their workforce by their location are exposed to the local influenza and URTI activity (standardized by the expected level of URTI in the location), which, at the annual level, leads to a relative shock on the production factor labor and the TFP of the firm. Given the epidemiology of the flu, we argue that the shock on the firm is exogenous because neither firms nor individuals can anticipate the local occurrence and seasonal timing of the flu. Also, neither firms nor workers are able to directly adjust their production function or their behavior in response to a local URTI shocks.

Following a standard production function approach, the quantity of output (Q) of a firm is expressed as a function of a set of different inputs available to a firm such as labor (L), capital (K) and other tangible or intangible factors (M) (e.g., land, intermediate goods, raw materials, knowledge). Mathematically, the basic relationship between inputs and outputs can be written as follows:

$$Q = f(L, K, M) \tag{2.1}$$

In our case, we assume only two inputs, labor and capital, which in a simple Cobb-Douglas production function equation with constant returns to scale are denoted as follows:

$$Y = AL^{\alpha}K^{1-\alpha} \tag{2.2}$$

In equation 2.2, Y represents output, L and K represent the production factors labor and capital and A the total factor productivity (TFP). α and β denote the output elasticities, which are determined by factors such as the production technology or organization of the firm. Capital and labor are to some extent substitutes and complements. The latter gives rise to potential scale economies. In the first stage of our analysis, we use the Cobb Douglas production function framework in a log linearized form to estimate TFP for each firm i in each year t using

OLS.[4]

$$ln(Y_{it}) = A_{it} + \alpha ln(L_{it}) + (1-\alpha)ln(K_{it}) + \psi_t \tag{2.3}$$

$$A_{it} = ln(y_{it}) - \widehat{ln(y_{it})} \tag{2.4}$$

Departing from these first stage estimates of TFP, in our second stage and main analysis, we regress A_{it} on the local flu intensity (FLU_{rt}), a set of firm level control variables (γ_{it}), municipality level controls (θ_{rt}), as well as on municipality (σ_r) and time (ϕ_t) fixed effects. The main regression equation is:

$$A_{it} = \beta FLU_{rt} + \gamma_{it} + \theta_{rt} + \sigma_r + \phi_t + \epsilon_{it} \tag{2.5}$$

With FLU_{rt} indicating the intensity of the flu season in year t to which the localized firm i is exposed, β represents our main effect of interest. Given the epidemiology of URTI, we argue that it is exogenous to the local firms and it affects the production factor labor randomly by reducing the volume of labor that the firm may utilize to produce goods and services. Assuming imperfect substitution of labor through capital and capital costs, URTI appears as an exogenous random shock to a firms' production function.

[4] Estimating TFP using OLS is likely to result in biased estimates because productivity and input choices are likely to be correlated, which results in an endogeneity problem. The literature proposes a number of ways to deal with these issues, e.g. by using firm fixed effects or instrumental variable approaches (see survey by Van Beveren (2012)).

3 Data

URTI data. To measure the local shocks on the production factor labor, we build on data provided by the Arbeitsgemeinschaft Influenza (influenza working group, AGI). This research community established a comprehensive public health monitoring system of the epidemiology of the influenza and other acute respiratory diseases in Germany following international epidemiological standards. From 2001, the Robert Koch Institute (RKI) administers and leads the project. The RKI is a public health management and research institute within the German Federal Ministry of Health. Among the main tasks of the RKI is safeguarding public health in Germany by providing empirical research and policy advice. The purpose of the AGI monitoring activities is to establish a comprehensive database for evidence-based health measures to prevent or combat URTI and influenza. The so-called ARE index that we use to construct our measure of local URTI intensity draws on the voluntary weekly reporting of 700 to 900 medical offices[5] spread across all German regions (see Figure A1)[6]. Starting from September through April on a weekly basis, the AGI publishes maps of the geographical distribution of the ARE index drawing on doctor consultations related to URTI. This index is standardized by the local supply and demand for medical treatment (i.e. demography, types of medical offices) and thus is readily adjusted to be used for regional comparisons (see Uphoff, 1998). An example of a weekly ARE index map is depicted in Panel (1) of Figure 1 (AGI Influenza, 2019). Towards constructing our URTI measure, which covers the influenza seasons 2003 until 2009 in all municipalities across Germany, we georeference the maps that are available as raster data and extract the color values for each pixel. The color scale ranges from 'blue' (local baseline level of URTI intensity) to 'red' (very high relative URTI intensity). We define five index categories based on the range of colors in the map. The highest levels of URTI, categories four and five (i.e. dark orange and red color), represent the class of high URTI intensity pixels, while we discard other categories. In the next step, we assign the URTI intensity (pixel data) to municipalities (vector data) using overlay methods in a geographical information system (GIS). We fully classify a municipality as high intensity URTI data point if at least 80 percent of the pixels that intersect with the municipal area fall into the categories four or five. We perform these steps for all weekly maps published by the RKI between 2003 and 2009. Departing from weekly data by municipality, we generate two indicators: First, the total weeks with extraordinarily high URTI intensity by municipality and calendar year. Second, the relative flu intensity, which is the percentage of weeks with extraordinarily high URTI intensity relative to the length of the influenza season in a calendar year.

[5] The number of responding medical offices varies annually and within each year due to local holidays or closings due to vacation. This variation, however is unlikely to be uncorrelated with the local incidences of URTI.

[6] The ARE index is derived from on data on doctor consolidations only. Therefore the actual population URTI activity might differ from the ARE index reported by the AGI. Notwithstanding, it is reasonable to assume a high correlation between URTI based on doctor consultations and the unknown population figure. From 2011, the calculation of the ARE index was adjusted using population survey data.

Firm level data. We use the IAB Establishment Panel survey (IAB-EP), one of the largest firm surveys in Germany to assess the effect of URTI on firm productivity. The IAB-EP is a standardized firm survey adminstered by the IAB that is conducted annually since the year 1988 (Fischer et al., 2009; Ellguth/Kohaut/Möller, 2014). The survey includes a set of questions that are relvant for our analysis and which were prepared following Umkehrer (2017). First, we exploit information on the production value, i.e. output of the firms as reported in the survey. Second, we use investment data (total investments, indicators for different types of investments) and perpetual inventory calculations to approximate the firm's capital stock in the absence of actual capital stock information in the survey (for a description of the methodology, see (Müller, 2008, 2010)). Using the link of the survey to other entirely register based establishment level data at the IAB, we enrich the survey with information on total employment, NACE industry codes and structural characteristics of the workforce (e.g., share of local workforce, age structure, education structure). These variables are measured on the reference date June 30 in each year and are used as control variables in our main regression (Equation 2.5). We estimate the production function (Equation 2.3) drawing on deflated[7] gross value added and capital stock information from the survey, as well as on the number of workers (count, full time equivalents) that were merged from the employment register. We also use NACE industry codes available from the register to restrict our analysis sample to manufacturing firms only.

[7] Deflation to the year 2010 using the producer price index information available from the Federal Statistical Office of Germany.

4 Descriptive Analysis

The intensity of URTI varies significantly from year to year. In the left panel of Table 1, we report the seasonal intensity in all German municipalities and in the right panel of the Table 1, the municipalities that are represented with at least one firm in our analysis sample. The flu season in 2009 stands out in our data with an average duration of the flu season, i.e. weeks of high URTI intensity of almost seven weeks (out of a maximum season length of 27 weeks). On the other end of the distribution are the the years 2004 and 2008, in which only few municipalities experienced remarkable local URTI activity peaks. Overall, our analysis sample (right panel) seems to follow the general pattern of all German municipalities (left panel). A temporal pattern that emerges is a bi-annual increase in the intensity of the flu season, i.e. a high intensity year is often followed by a low-intensity year. However, this pattern is likely to be caused by the splitting of self contained influenza seasons (September until March) into data structured by calendar year.

Table 1: URTI intensity (weeks with outstanding URTI activity) by year

	All municipalities					Municipalities in analysis sample				
	Mean	Std.dev.	Min.	Median	Max.	Mean	Std.dev.	Min.	Median	Max.
2003	2.30	1.07	0	2	6	2.27	1.03	0	2	6
2004	0.14	0.39	0	0	5	0.07	0.29	0	0	3
2005	4.92	1.50	0	5	9	4.91	1.19	0	5	9
2006	0.03	0.19	0	0	3	0.04	0.22	0	0	2
2007	2.88	1.87	0	3	8	3.64	2.13	0	3	8
2008	0.39	0.82	0	0	8	0.29	0.74	0	0	5
2009	6.84	2.14	0	7	18	6.70	2.08	1	7	15

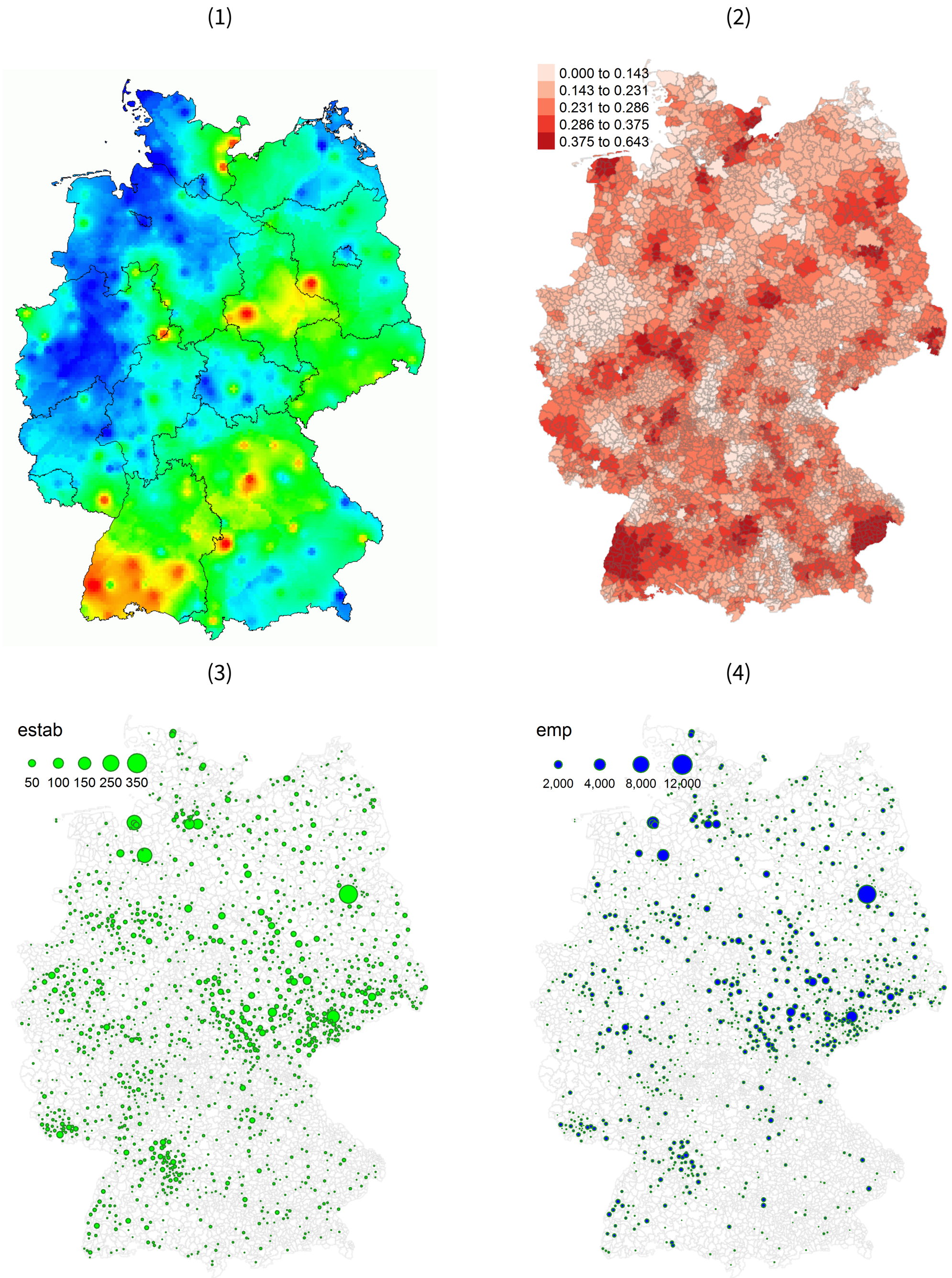
In Table 2, we describe all variables that are used in our main regression. First, we find that our TFP estimate is highly skewed, which is typical for productivity data (see Syverson, 2011). The other variables describe the controls at the municipality and at the firm level. For instance, municipality population density and demographics matter for the epidemiology URTI. Even more important for our analysis are the firm level controls, which include the median wage as a proxy for the labor productivity in the firm and a set of other structural characteristics of the workforce such as shares for the skill and age groups. Shares of skill groups capture the different types of jobs performed in the firm as well their complexity. With the level of complexity and the proportion of interactive tasks, the potential for substitution by technology varies significantly. The age structure of the workforce helps to account for demographic variation in the exposure to URTI. Moreover, there is a positive correlation between age and the length of sick-leaves due to URTI. In addition, firms that use more flexible work schemes such as overtime accounts are likely to cope better with pandemia outbreaks of the flu and sick leaves of workers. Health management measures might help firms to better mitigate URTI shocks or better prevent pandemic outbreaks among the workforce.

Table 2: Summary statistics

	Variable	Mean	Std.dev.	Min.	Median	Max.
TFP	TFP (baseline)	-0.011	0.696	-6.723	-0.006	3.993
	TFP (fixed-effects)	0.009	0.821	-5.260	0.046	4.139
Municipality	Commuter balance	1.145	0.556	0.302	0.968	4.920
	level Unemp. rate	0.089	0.042	0.010	0.084	0.228
	Share service sector	0.624	0.153	0.079	0.647	0.939
	Log(pop. density)	5.445	1.208	2.416	5.349	7.992
	Regional. share old	0.202	0.029	0.085	0.201	0.331
Firm level	Median wage	79.490	27.136	0	77.685	285.180
	Share old. emp.	0.275	0.122	0	0.265	1
	Share trainee	0.050	0.056	0	0.038	0.600
	Share mini.	0.064	0.109	0	0.020	0.960
	Share female	0.270	0.200	0	0.205	1
	Share high skilled	0.105	0.112	0	0.074	1
	Dum(1= overtime)	0.859	0.348	0	1	1
	Dum(1 = firm health)	0.659	0.474	0	1	1

In figure 1, we present four maps to outline our empirical approach. First, we present in panel (1) the base map on which our URTI intensity measure is built (see AGI Influenza, 2019). As an example, we depict the map of URTI in calendar week 8/2009. The values from the reporting medical offices (see Figure A1) are spatially smoothed using spatial statistics methods (Ordinary Kriging) and additional regional variables, which provide us with substantial regional variation. Our main indicator of local URTI intensity that was derived from the base map is depicted in map (2). It visualizes the geographical variation across municipalities in the normalized number of weeks per influenza season (calendar year) with outstandingly high URTI intensity. The map of year 2009 exhibits significant geographicial variation in the local URTI index. The flu season in this year stands out in our data as an untypically long and intense flu season (see Table 1). However, it is evident that the local hotspots of URTI are neither clustered geographically nor bounded by cities or urban agglomerations. As can be discerned from panel (3) and (4), the firms and the respective number of employees covered by our firm survey are distributed across all regions of Germany. Overall, our analysis sample achieves a comprehensive and (geographically) representative coverage of the spatial distribution of economic activity in Germany.

Figure 1: Maps of influenza intensity and establishments in Germany



Notes: The map shows the median commuting distance to the new job of all job seekers by municipality of residence in manually chosen distance categories. Municipalities with 'no obs.' emerge due to missing job matches in that region. Panel (1) shows the flu intensity (›ARE Praxisindex‹) in week 8, 2009. In panel (2) we visualize the relative season intensity by municipality (1 = 26 weeks of highest flu intensity according to the ›ARE Praxisindex‹). The regional distribution of establishments by municipality (panel (3)) as well as the employed in the establishments (panel (4)) of the IAB Establishment Panel Survey (analysis sample).

5 Regression Results

We analyze the effects of URTI on firm productivity using the panel data on municipalities[8] from the year 2003 until 2009. First, we present a baseline model documented in Table 3. Both indicators of URTI intensity show the expected negative relationship with TFP, i.e. if a municipality experienced a longer flu season, firms in these municipalities appear to have a lower productivity in this year. However, firm productivity appears as strongly affected by the regional economic conditions as well by a set of (observed) firm characteristics. We want to use the full annual variation in the intensity of URTI, thus we cannot use regional fixed effects to control for unobservable regional characteristics. In columns (3) and (4), we integrate a more comprehensive set of regional controls, which in turn, reduce the magnitude of the effect of the flu on TFP. Next, we plug in firm level control variables including the binary indicators from IAB-EP survey for the use of overtime schemes and active health measures. These two additional firm variables stand out from out results. Short-term flexibility in the use of labor in response to URTI appears as positively correlated with firm productivity (ceteris paribus). Furthermore, a firm can implement active health management measures. Such measures have direct costs, however, they might rather be visible in the well-being of the employees than in the productivity directly. Overall, after controlling for (observable) regional and firm variables, we still find a negative effect - although weakly significant - of local URTI intensity on the total factor productivity of the firm.

In the next step, we parse the estimation of the total factor productivity by adding several controls. In column (2) of Table 4, we estimated the TFP separately by industry, which only changes the results marginally. Further, we include year dummies in the TFP regression to account for the temporal variation in a firm's productivity. In column (4), we implement both model adjustments. Overall, we find only little variation in the main point estimate, as well as in the levels of statistical significance when using alternative TFP estimation approaches. Yet, the effect of the URTI intensity on productivity remains negative and statistically significiant. The magnitude of the coefficient as well as the precision of our point estimates increases after controlling for unobserved heterogeneity of the firm in the productivity estimation. The fit of our model also increases substantially by the factor of four.

In Table 5, we implement the count of weeks with high URTI intensity as our main regressor. The estimated coefficient obtained from the model is a semi-elasticity, i.e. an additional week of outstanding local flu reduces the TFP of a firm on average by 1.3 percent (see column 6). As the count represents also the mathematical basis for the relative URTI intensity, statistical significance and model fit follow the results of Table 3.

[8] Technically, we are looking at association of municipalities, often smaller towns and villages, cooperate with its neighbors, e.g., to save administration costs, however, still are independent.

Table 3: Baseline - Firm productivity effects of URTI

	Dependent Variable: Total Factor Productivity (TFP)					
	(1)	(2)	(3)	(4)	(5)	(6)
Rel. URTI intensity (0-1)	-0.600***		-0.361***		-0.256+	
	(0.158)		(0.138)		(0.166)	
Abs. URTI intensity (count)		-0.022***		-0.013**		-0.009+
		(0.006)		(0.005)		(0.006)
Commuter balance			-0.075***	-0.075***	-0.018	-0.018
			(0.028)	(0.028)	(0.030)	(0.030)
Unemp. Rate			-1.191***	-1.192***	-0.111	-0.111
			(0.403)	(0.403)	(0.482)	(0.482)
Share office worker			0.093	0.094	0.288***	0.288***
			(0.098)	(0.098)	(0.107)	(0.107)
Log(pop. density)			0.043***	0.043***	-0.015	-0.015
			(0.014)	(0.014)	(0.016)	(0.016)
Share old emp.			-0.437	-0.440	0.375	0.373
			(0.566)	(0.567)	(0.598)	(0.598)
Firm median wage					0.006***	0.006***
					(0.001)	(0.001)
Firm share old					0.121	0.121
					(0.122)	(0.122)
Share apprentice					-1.384***	-1.384***
					(0.260)	(0.260)
Firm share mini job					-0.715***	-0.715***
					(0.124)	(0.124)
Firm share female					-0.369***	-0.369***
					(0.079)	(0.079)
Firm share high skilled					0.081	0.081
					(0.161)	(0.161)
Dum (1 = add. hours)					-0.063*	-0.063*
					(0.035)	(0.035)
Dum (1 = firm health)					-0.148***	-0.148***
					(0.026)	(0.026)
R^2	0.009	0.009	0.028	0.028	0.131	0.131
N	10,479	10,479	10,469	10,469	7,520	7,520

Notes: All results are purged for year effects. The estimated TFP is controlled for establishment-year effects; Standard errors clustered at the municipality level in parentheses; Levels of statistical significance: + $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Firm productivity effects of URTI (weeks of high URTI intensity, relative)

	Dependent Variable: Total Factor Productivity (TFP)					
	(1)	(2)	(3)	(4)	(5)	(6)
Rel. URTI intensity (0-1)	-0.256+	-0.284+	-0.256+	-0.284+	-0.341**	-0.341*
	(0.166)	(0.182)	(0.166)	(0.182)	(0.164)	(0.178)
TFP est. by industry	N	Y	N	Y	N	N
year effects	N	N	Y	Y	N	Y
estab. fixed effects	N	N	N	N	Y	Y
R^2	0.131	0.064	0.126	0.066	0.356	0.474
N	7,520	7,520	7,520	7,520	7,520	7,520

Notes: All results are purged for year effects. Standard errors clustered at the municipality level in parentheses; Levels of statistical significance: + $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Firm productivity effects of URTI (weeks of high URTI intensity, count)

Dependent Variable: Total Factor Productivity (TFP)

	(1)	(2)	(3)	(4)	(5)	(6)
URTI intensity (count)	-0.009+	-0.010+	-0.009+	-0.010+	-0.013**	-0.013*
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.007)
TFP est. by industry	N	Y	N	Y	N	N
year effects	N	N	Y	Y	N	Y
estab. fixed effects	N	N	N	N	Y	Y
R^2	0.131	0.064	0.126	0.066	0.356	0.474
N	7,520	7,520	7,520	7,520	7,520	7,520

Notes: All results are purged for year effects. Standard errors clustered at the municipality level in parentheses; Levels of statistical significance: + $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusion

This research is the first to combine data on the epidemiology of the influenza and, more generally, acute infectious diseases of the upper respiratory tract (URTI) with comprehensive firm level survey data to assess the effect of influenza-like diseases on firm productivity in Germany. Statistical data originating in the statutory health insurance system are highly aggregated, which make them inadequate for such analysis. In linked employer-employee data as well as in firm data that are available for economic research, there is typically a lack of information on worker absences or productivity impairments due to sickness. Representative surveys are costly and unavailable, too. We circumvent these data issues by using epidemiological data on the geographical distribution of URTI from the official influenza surveillance system in Germany. Local URTI intensity measured in these data are highly correlated with the volume of worker absences due to sickness. Moreover, data on URTI are plausibly related to the phenomenon of presenteeism, which describes productivity impairments of sick workers who remain at work. Combining URTI data by municpality with firm level data, we approximate the exposure of firms to unforeseeable exogenous health shocks on their production factor labor. The line of argumentation via the geography of URTI holds in particular if firms predominantly draw on local workforce. The most severe economic impact is expected for pandemic URTI outbreaks in the municipality of the site and if the firm draws on local workforce only. To the best of our knowledge, we are the first to exploit data from the official influenza surveillance system AGI in labor market research. Our main results highlight the proposed nexus between the local flu intensity and firm productivity. Precisely, we find that TFP of a given firm decreases significancly with increasing length of the flu season in the municipality of the site. The average marginal effect, amounts to -1.3 percent. We argue that this estimate represents a negative causal effect of the local URTI intensity on productivity due to the epidemiology of the flu. After controlling for a large number of confounders, we assume the spatio-temporal pattern of the flu as quasi-random. We attribute the negative effect of URTI on productivity to the combination of absenteeism as well as to productivity impairments associated with presenteeism. While we are able to estimate the joint effect of both mechanisms on firm productivity, the aggregate data that are available to us do not allow to disentangle the two effects. Moreover, by its very nature, the two effects estimated using the information collected in the influenza surveillance system, provide only lower bounds of the true effect. This is because URTI data are based on doctor consultations rather than on actual absences, which would be a more precise volume of labor that is unavailable to the firm. Aggregate health insurance statistics show that individuals on sick leave due to URTI with doctoral visit are absent from work for about seven days. The distribution of our indicator, however, does not account for the large number and volume of shorter sick leaves of up to two working days without doctor consultations.

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