Productivity and wage effects of an exogenous improvement in transport infrastructure: accessibility and the Great Belt Bridge

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Abstract

In this paper, we study the short-run effects of a large and very localized discrete shock in the quality of transport infrastructure, viz. the opening of the Great Belt Bridge connecting the Copenhagen area with a neighbouring island and the mainland of Denmark. We analyse the effect of the opening of the bridge on the productivity of firms as well as on wages. In both cases, we assume the effect operates via changes in accessibility after opening of the bridge, and we estimate the distance decay parameter of the accessibility index simultaneously with the effect of accessibility on productivity and wages, controlling for firm or worker fixed effects. We find large productivity effects for firms located in the regions near the bridge, especially for relatively small firms in the retail industry. We estimate elasticities of wages and productivity with respect to accessibility that are of similar magnitude, but a much larger distance decay effect is found for wages than for productivity. Significant wage effects are observed for workers even in industries where productivity did not improve. Moreover, the results suggest that the wage effects are to some extent driven by improved labour market matching.

Keywords: production functions, productivity, accessibility, agglomeration, transport infrastructure.

JEL Classification: D2, H54, O18, R4, R12.

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1 Introduction

One effect of improvements in transport infrastructure is that they reduce the importance of physical distance. This has several implications. At a very basic level, better transportation possibilities reduce production and logistic costs per unit (Shirley and Winston, 2004; Datta, 2012; Li and Li, 2013). They also open possibilities for better matches between supply and demand on output as well as input markets (see, for example, Helsley and Strange (1990)).[1] Moreover, improved transportation infrastructure facilitates knowledge spillovers through formal and informal contacts, contributing to agglomeration benefits associated with proximity to other actors (Duranton and Puga, 2004; Rosenthal and Strange, 2004; Puga, 2010; Gaubert, 2018).

Unsurprisingly, economists have intensively studied the implications of transport infrastructure for economic performance. One strand of literature focused on analyzing marginal improvements of existing networks in developed economies, like the upgrading of existing roads to highways or the addition of segments to existing networks (see, for instance, Graham (2007a,b); Holl (2012, 2016); Fretz et al. (2017); Gibbons et al. (2019)). Another recently emerging literature concentrated on the economic effects of constructing new transport infrastructure from scratch, mainly emphasizing their large impact in developing countries. Examples include the railroad network built in colonial India (Donaldson, 2018), the introduction of Bogota's TransMilenio Bus Rapit Transit system (Tsivanidis, 2019), the development of the Chinese highway network (Baum-Snow et al., 2020), and the construction of a number of bridges across a river in rural Nicaragua (Brooks and Donovan, 2020). With the exception of Ahlfeldt and Feddersen (2017), who analyze in detail the effects of a new high speed rail connection between Cologne and Frankfurt in Germany, few studies focus on an improvement in a single link in an existing network.

In this paper we consider a rare example of a large-scale and highly localized project that considerably improved the quality of the transportation network in a developed country. More specifically, we estimate the productivity and wage effects of the opening of the Great Belt Bridge in Denmark; the bridge connecting much better connected Zealand (where Copenhagen, the Danish capital, is located) with the neighboring island of Funen and, indirectly, with mainland Denmark and the rest of Europe.[2] The bridge, which became

[1] Dauth et al. (2018) provide empirical evidence that assortative matching of high productivity workers and jobs is facilitated by large labor markets.

[2] Politically, a major argument in favor of the bridge was the belief that this might shift the focus in the rest of Denmark from Hamburg to Copenhagen. Moreover, it was hoped that the new infrastructure might stimulate development in Funen, now that it would be better connected to the capital region. Arguments

operational in 1998, replaced an existing ferry service, reducing travel times between Zealand and all other parts of Denmark by 24 minutes. This is quite substantial compared to an average travel time between all combinations of Danish municipalities of 2 hours and 23 minutes. The improvement was also exceptionally localized: only trips that have to pass the Great Belt are affected by it. The project thus provides a unique opportunity for studying the impact of a large (rather than marginal) improvement in transportation infrastructure on one particular network link in the context of an advanced economy.

The availability of register data allows us to construct a large panel of individual firms, covering the whole country and a variety of production sectors. State-of-the-art techniques for estimating production functions that control for correlation between input levels and unobserved firm-specific productivity have been developed by Olley and Pakes (1996), Levinsohn and Petrin (2003), Wooldridge (2009) and Ackerberg et al. (2015). As physical output figures are often unavailable, studies applying these methodologies (a recent example is Holl (2016)) typically use firm revenues as output indicator. This is somewhat less than desirable, because revenues are affected by price as well as quantity changes. We deal with this issue by adopting the methodology developed by De Loecker (2011), which assumes monopolistically competitive markets to take the effect of price setting behavior into account.[3] Moreover, we avoid the identification problem emphasized by Ackerberg et al. (2015) by using the Generalized Method of Moments (GMM) technique proposed by Wooldridge (2009).

To capture the effect of the bridge we estimate an index of accessibility at the level of individual municipalities prior to and after the opening of the bridge. The index is defined as the weighted sum of employment in surrounding locations, where the weights are a decreasing function of the 'distance' to the bridge, captured by travel time. The 'distance decay' parameter of the accessibility index is estimated jointly with the effect of changes in accessibility on firms' productivity to identify the productivity effect of the bridge. The model is estimated by nonlinear least squares; we resolve endogeneity issues by using an appropriate instrument for accessibility and employing the control function approach (see Blundell and Powell (2003) and Wooldridge (2015)). We provide estimates of the productivity effects of the bridge not only at the aggregate level, but also at the regional and sectoral level.

While productivity is arguably the real focus of interest in economic research on agglom-

against its construction were that it was too expensive, that it would stimulate car driving, and that it generates unemployment among ferry-workers.

[3] De Loecker (2011) develops a method to integrate demand effects into the estimation of firm-level productivity effects, and he uses the model to study the effect of trade liberalization in the Belgian textile industry. The model allows distinguishing 'revenue' from 'physical' productivity. He finds that trade liberalization has much smaller productivity effects when demand-side effects are incorporated into the analysis.

eration benefits, many studies have focused on wages. There is no doubt that changes in wages and productivity are to some extent related, as there is substantial evidence that productivity increases raise input prices (see, among others, Greenstone et al. (2010); Donaldson and Hornbeck (2016); and Gibbons et al. (2019)). Still, there are good reasons to believe that the implications of improved transport infrastructure on wages and productivity can be quite different. First, better transportation possibilities may facilitate efficient allocation of workers to jobs (Helsley and Strange, 1990). This mechanism probably results in higher wages for the better matched workers as well as higher productivity for the firms concerned. However, this labor market matching effect on productivity and wages is limited to the local labor market surrounding the bridge, whereas other impacts of the bridge on productivity (for example, the decline in logistics costs) may operate over larger distances. Second, the firms experiencing higher productivity will often increase the demand for labor for workers with the skills most relevant in their production process. With competitive labor markets for these skill types, this raises wages in all firms using these types of workers, even in firms where productivity has not increased. In sum, this suggests that wages may be affected by the opening of the bridge even in industries where productivity is not.

We analyze the effect of the bridge on wages throughout the country using detailed data on wages before and after opening of the bridge.[4] The impact of the bridge is again captured via its impact on accessibility. We estimate Mincerian wage regressions using wage data for almost two million individual workers, allowing for worker and sectoral fixed effects. Estimating the model for different subsamples gives insight into the role of the labor matching argument mentioned above.

The paper contributes to the literature in several ways. It reports the impact of a substantial change in the transportation network of a well-developed country due to a large investment in one particular network link; such cases have seldom been studied. In contrast with several earlier studies we find no significant effects on productivity in manufacturing but highly significant effects for services. These effects concentrate in smaller firms and are most pronounced in regions close to the bridge. Moreover, although the effect of improved accessibility on productivity and wages is of the same order of magnitude for the country

[4] Our data do not allow us to study a number of other equilibrium effects. For example, location patterns of firms and households may change (Baum-Snow, 2007; Michaels, 2006; Redding and Turner, 2015; Tsivanidis, 2019). Locations that strongly benefit from the transport cost reduction may attract firms from elsewhere (see Coughlin and Segev, 2000; Ghani et al., 2016), and it may generate a number of startups of new firms Holl (2004). Other locations may become less desirable and lead to firms disappearing or going out of business. Since the pioneering studies of Krugman (1991) and Krugman and Venables (1995) we know that the general equilibrium effects of changes in transportation costs can be large.

as a whole, we find that the regional effects on productivity and wages are substantially different: wage effects are much more sensitive to distance to the bridge; moreover, they manifest themselves also in industries where productivity remained unchanged, including manufacturing. On the one hand, these findings suggests that wage effects are to some extent highly localized and restricted to the regions close to the bridge, with strong distance decay effects when moving away from the new infrastructure. On the other hand, however, there appears to be a wider ranging effect that is less sensitive to distance. Finally, the empirical analysis of wages provides strong support for the hypothesis that the opening of the bridge contributed to improved labour market matching.

The structure of the paper is as follows. In Section 2 we review related literature dealing with the economic effects of improved transport infrastructure. We discuss the methodology in Section 3. We explain how we estimated productivity, we describe in detail the construction of our accessibility index and how it was used to estimate the effect of the opening of the bridge on productivity. Section 4 reports on the data used in the empirical analysis. The next two sections give the empirical results. In Section 5 we discuss the estimation results capturing the impact of the bridge on productivity at the aggregate, regional and sectoral level. Section 6 focuses on the estimated effect of the bridge on wages. A final section concludes.

2 Related recent literature

There is a large literature on the economic effects of highway investments. However, much of this literature does not use firm-level data, and it mainly emphasizes local and regional outcomes; relevant references include, among many others, Chandra and Thompson (2000), Faber (2014) and Ghani et al. (2016). A number of papers do use firm-level data and, as we do, they explicitly focus on the productivity effects of extensions of the transport infrastructure. However, the huge majority of these papers study the effect of marginal extensions in the highway network, typically using the changes in area market potential measures to capture the local impact of the highway (for example, see Graham, 2007a,b; Holl, 2012; Fretz et al., 2017).

Closest in spirit to the current paper are Holl (2016) and Gibbons et al. (2019). Holl (2016) studies the effects of freeway accessibility on the productivity of Spanish manufacturing firms, exploiting variation over time related to the construction of the network. She first estimates firm level total factor productivity using the approach suggested by Levinsohn and Petrin (2003). In a second step she estimates the relationship between productivity and access to the highway system using instrumental variable methods to deal with possible endogeneity in the highway access variable. She finds strong productivity effects. Doubling the distance to the nearest highway ramp reduces productivity by 1.3-1.7%. The productivity effect is not just due to agglomeration effects of higher density of economic activity, but a significant direct effect is identified as well. The productivity-enhancing effects are higher in urban than in rural areas, and they appear to be largest in typical manufacturing industries. Finally, highways are found to attract new firms to its vicinity.

Gibbons et al. (2019) considered the effects of incremental improvements in the UK highway network on firms' productivity and employment. They measure exposure to road improvements using changes in a continuous network-based index of accessibility at a detailed small scale, based on the calculation of optimal travel times. They study only treated places, that are areas very close to the changes in the network, identifying their model by changes in the intensity of treatment. The accessibility measure they use is interpreted as a treatment indicator and they note that the effect can realize through better access to output markets, intermediate input markets or workers or through reduced travel times in general. They find that a 1% increase in accessibility raises employment by 0.3-0.4%. Incumbent firms loose employment while the positive effect is generated by new firms. They further find positive effects of accessibility on productivity.

As in Holl (2016), our analysis allows to capture both sectoral and spatial heterogeneity in productivity and in the productivity effects of transport improvements. In line with Gibbons et al. (2019), we use the change in an 'accessibility' measure (see the definition of our index below) defined at the local level to capture the effect of the opening of the bridge. Contrary to both papers, however, we consider a single location-specific but very large infrastructural improvement, not a continuous expansion of the highway network. In this sense, our paper also relates to Ahlfeldt and Feddersen (2017). They study the agglomeration effects of the opening of the high speed rail line between Cologne and Frankfurt. To avoid endogeneity problems they exploit the particular institutional setting that generates variation in transport costs that can be considered exogenous to the level of economic development. Their results show that under some specific conditions peripheral regions benefit from better connections to core regions.

Many studies of agglomeration effects and transportation improvements use an index of accessibility which is defined as the weighted sum of employment in surrounding locations, where the weights are a decreasing function of travel time (see, for instance, Lucas and

Rossi-Hansberg (2002), Hanson (2005) and Redding and Rossi-Hansberg (2017)). Below, we follow their lead and relate the changes in productivity and wages to the change in such an accessibility index due to the opening of the Great Belt bridge.

3 The effect of the bridge on productivity and wages: empirical strategy

In this section, we describe our empirical strategy to estimate the effect of the opening of the bridge on the productivity of firms and on workers' wages throughout the country. We first discuss how total factor productivity was estimated for individual firms. Then we explain in detail the construction of our accessibility index and the role of the bridge on travel time and accessibility changes. Finally, we present the empirical model used to estimate the effect of accessibility and the opening of the bridge on productivity and wages.

3.1 Estimating Total Factor Productivity (TFP)

The current state of the art to estimate firms' total factor productivity has been initiated by Olley and Pakes (1996) and Levinsohn and Petrin (2003). They derive productivity measures from estimated production functions that control for unobserved productivity shocks through investment or intermediate inputs, respectively. Assuming a Cobb-Douglas production function, the Levinson-Petrin approach starts from the following estimation equation:

$$y_{i,t} = \alpha_l l_{i,t} + \alpha_k k_{i,t} + \alpha_m m_{i,t} + \omega_{i,t} + u_{i,t} \tag{1}$$

where $y_{i,t}$ denotes the log of output of firm i in year t, and l, k, m are the logs of the quantities of labor, capital, and intermediate inputs, respectively. The α's are coefficients to be estimated. The model accounts for two types of error. The first of these, ω, is a productivity shock that reflects aspects of the production process that are unobserved by the researcher and are potentially correlated with labor or capital. The second error term, denoted u, is a standard i.i.d. component.

Capital and the unobserved productivity shock are state variables, while labor and the intermediate inputs are assumed to be freely variable in each period. The demand for intermediate inputs is a function of the two state variables: $m_{i,t} = m_t(k_{i,t}, \omega_{i,t})$. Levinsohn and Petrin (2003) show that under plausible conditions the demand for intermediate inputs is increasing in the unobserved productivity shock $\left(\frac{\partial m_t}{\partial \omega_{i,t}} > 0\right)$. This function can therefore be inverted, and it follows that the right-hand side of the above equation can be reformulated as the sum of the labor term $\alpha_l l_{i,t}$, an unknown function φ_t of the two state variables, and the second error term:

$$y_{i,t} = \alpha_l l_{i,t} + \varphi_t(k_{i,t}, \omega_{i,t}) + u_{i,t}. \tag{2}$$

This equation is estimated by OLS using a third-order polynomial to approximate φ_t. The results are then used to find estimates of α_k and α_m applying the (moment) conditions that capital and the previous period's demand for intermediate inputs are independent of the most recent innovation in productivity. With these results at hand, an estimate of the natural log of total factor productivity can be computed as:

$$t\hat{f}p_{i,t}(= \hat{\omega}_{i,t}) = y_{i,t} - (\hat{\alpha}_l l_{i,t} + \hat{\alpha}_k k_{i,t} + \hat{\alpha}_m m_{i,t}) \tag{3}$$

Although output is the correct dependent variable when estimating the above relation (2), this is usually not reported in the data available to the researcher. In practice only revenues or turnover are typically known; i.e., the product of the output and the firm-specific price is known, but the individual components are unobserved. In terms of the model presented so far, the firm's output $y_{i,t}$ is therefore unobserved, only its revenue $r_{i,t} = p_{i,t}y_{i,t}$ is, where $p_{i,t}$ is the price per unit of the firm's output. This price is also not observed: available price information is usually limited to price indices referring to more broadly defined industries to which the firm belongs. Our data set is no exception; we use information about firm's total revenues, deflated by these crude price indices, as measure for the firms' outputs. The implication is that price differences occurring at a relatively low level – within the broad sectors for which the price indices are published – are not adequately measured. This could bias the measurement of productivity. For example, we argued above that the bridge over the Great Belt could increase productivity, but it may also lead to more competition from firms in other locations; this may in turn affect firms' output prices and the demand for their product. Relying on deflated sales using a broad price index will therefore result in productivity estimates that to some extent also reflect price and demand variation.

One can improve upon using revenues deflated by a broad sectoral price index by taking into account the demand side of the market (De Loecker, 2011). This approach requires that broadly defined industries can be divided into a number of industry segments, assumed to be monopolistically competitive. Each firm i is assumed to produce a variety of the product within such an industry segment s. Consumer preferences for varieties of a product within industry s are of the CES-type. The price of firm i is unknown, but at the level of industry

s a price and quantity index, denoted as $p_{s,t}$ and $q_{s,t}$, respectively, are available. De Loecker (2011) then shows that the relevant equation to obtain estimates of the production function is:

$$(r_{i,t} - p_{s,t}) = \beta_l l_{i,t} + \beta_k k_{i,t} + \beta_m m_{i,t} + \beta_s q_{s,t} + \omega^*_{i,t} + \xi^*_{i,t} + u_{i,t} \tag{4}$$

The variable on the left-hand side is the firm's revenue deflated by the price index for industry s (note that variables are in logs). The inputs in the production process now appear with a different coefficient, β_h, $h = l, k, m$ that can be shown to equal α_h multiplied by the firm's markup. The output of industry s appears as an additional variable and its coefficient β_s can be shown to equal the Lerner index. Similarly, the productivity shock $\omega^*_{i,t}$ equals $\omega_{i,t}$ multiplied by the markup and $\xi^*_{i,t}$ is a demand shock multiplied by the Lerner index. De Loecker (2011) shows that the methodology of Levinsohn and Petrin (2003) can, with appropriate modifications, be applied to obtain estimates of total factor productivity. As mentioned above, this requires that industries can be subdivided into a number of segments. See below for details.

In our empirical work we implement the approaches of both Levinsohn and Petrin (2003) and De Loecker (2011) to estimate productivity. However, to address the identification problem highlighted by Ackerberg et al. (2015), we use the generalized method of moments procedure proposed by Wooldridge (2009).[5]

3.2 Accessibility and the opening of the bridge

As mentioned, we capture the effect of the bridge on productivity and wages indirectly through its effect on travel times and accessibility of locations throughout Denmark. The accessibility index we use captures the proximity of a given location to other locations; it has its roots in the literature on agglomeration economies.[6] Although the literature offers various different indicators (see Rosenthal and Strange (2001, 2004) and Melo et al. (2009)), it has become standard to use the distance-weighted sum of employment in surrounding locations (see Lucas and Rossi-Hansberg (2002), Spiekermann et al. (2015) and Redding and Rossi-Hansberg (2017)). We follow a similar methodology but use travel time instead of distance. More specifically, our indicator A is computed for each municipality as the weighted sum of

[5] Ackerberg et al. (2015) show that for many data generating processes the moment conditions underlying the first-stage estimating equation in the procedures used by Levinsohn-Petrin fail to identify the labor coefficient, and they propose a two-step procedure to avoid this problem. Wooldridge (2009) shows that the moment conditions can easily be implemented in a Generalized Method of Moments (GMM) framework. The moment restrictions are written in terms of two equations with the same dependent variable, where the set of instruments differs across equations.

[6] Our accessibility index takes the market potential form suggested by Harris (1954).

full time equivalents (FTE's) in all municipalities. The value of A for municipality m in year t is:

$$A_{m,t} = \sum_{m'} FTE_{m',t} e^{-\delta d_{m,m',t}} \tag{5}$$

where the summation runs over all municipalities m' and d denotes distance measured in travel time minutes between municipalities. This measure basically captures, for each municipality, the 'proximity' of workers in other municipalities. A similar measure was used in (Dekle and Eaton, 1999, see their equation (1)), (Ahlfeldt and Feddersen, 2017, their equation (4.2)) and in (Lucas and Rossi-Hansberg, 2002, p. 1448). Hanson (2005) also uses an analogous index to model locations' proximity to consumer markets.

As the effect of the bridge is measured through the change in travel times between municipalities, the 'decay' parameter δ captures how far-reaching the effects of the bridge extend. Of course, economic theory does not offer much guidance on how narrowly or how broadly such regional effects should be measured. This suggests that the common practice of using the accessibility measure in (5) with a predetermined value of δ may suffer from misspecification of the range of the investigated effect.[7] We therefore estimate δ jointly with the effect of accessibility on productivity or wages.

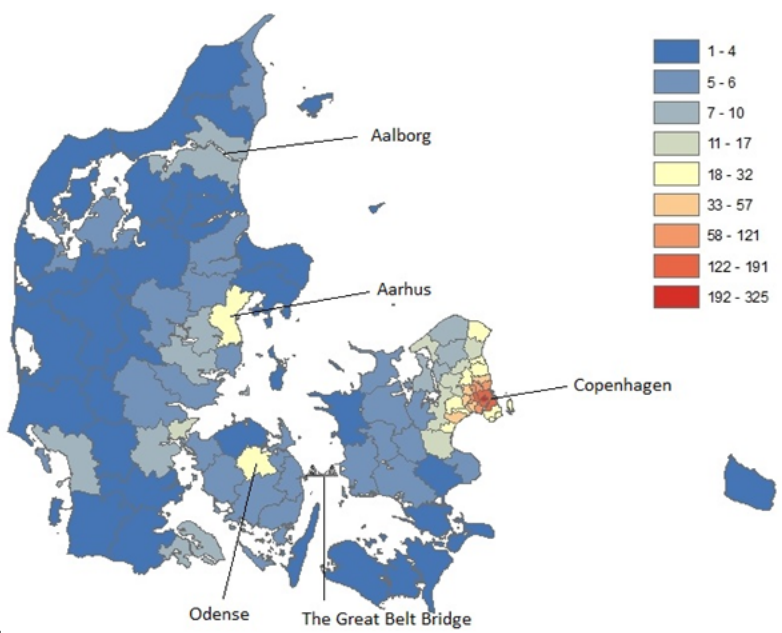
At this point it may be useful to make the bridge project, its implications for travel times and the potential impact on firms a bit more concrete. To do so, consider Figure 1 which gives the geographical distribution of firms together with the precise location of the new bridge. Economic activity is concentrated in a few (relatively) large urban areas around the four largest cities. It turns out that the Great Copenhagen Area accounts for about 19.2% of all firms in our sample.[8] Other larger cities, i.e., Aarhus, Aalborg and Odense, account for another 10.2% of the total number of firms. The new bridge (which, in fact, consists of two bridges plus a railroad tunnel) replaces the historical ferry route between the islands Zealand and Funen. Zealand is the large island on the right where Copenhagen is located. Funen is clearly visible in the middle of the figure; the main city on the island is Odense.

The information on individual firm location is combined with the available data on FTE's (full time equivalents) from Statistics Denmark. Data on travel times between all 98 Danish municipalities are available from the Danish National Traffic Model for the year 2002 (Rich et al., 2010). They are derived using the complete road network structure including all minor roads, forbidden turns and one-way restrictions. The average mean travel time between

[7]See Ciccone and Hall (1996), Graham et al. (2010), and Ahlfeldt and Feddersen (2018) for studies estimating the distance decay parameter.

[8]The municipality of Copenhagen in itself accounts for 6.9% of all firms.

Figure 1: Number of firms per km^2 in 1995 (municipal level)



municipality pairs is 143 minutes, with standard deviation 82.6; the minimum is 4.1 minutes and the maximum is about 6 hours (357 minutes).[9]

The 18 km long Great Belt Bridge clearly links the eastern and western parts of Denmark. It opened in June 1998.[10] The bridge is open 24 hours a day, 365 days a year. The new infrastructure obviously affects the travel times between municipalities on opposite sides of the bridge; it does not affect travel times between municipalities on the same side. Moreover, although there is a toll on the new bridge, it is broadly equal to the price of a ferry crossing prior to the opening of the bridge, so that the change in travel time is the only major effect of the bridge on travel costs.

Our data consist of a panel over the period 1995-2002, covering a few years before and a few years after the opening of the bridge. Very detailed information on actual travel times is available for 2002, and we capture the effect of the opening of the Great Belt Bridge by adding, for travel times before 1998, 24 minutes for all links that cross the Great Belt. This corresponds to the difference between the travel time across the Great Belt by ferry and the free flow travel time for a motor vehicle crossing the bridge.[11] Since using the ferry

[9]The mean travel time within a municipality is different from zero. This implies that the diagonal in the O-D travel time matrix is not a vector of zeros.

[10]The Danish parliament adopted the Construction Act for the Great Belt link in June 1987. Construction work began in August 1990.

[11]We thus ignore other changes in the road network apart from the opening of the new bridge. Other changes in the road network over the period considered were very small. As a robustness check, in the empir-

also implied some waiting time and uncertainty under bad weather conditions, this is a conservative way of dealing with the impact of the bridge on travel times.[12]

3.3 Estimating the impact of the bridge on productivity

To estimate the impact of the bridge on firm productivity, we regress the firm- and year-specific estimates of the log of total factor productivity $\hat{tfp}_{i,t}$ on the log of the accessibility, denoted $a_{m(i),t}$:

$$\hat{tfp}_{i,t} = \gamma_{i,0} + \gamma_1 a_{m(i),t}(\delta) + \gamma_t + \varepsilon_{i,t}. \tag{6}$$

In this equation $m(i)$ denotes the municipality in which firm i is located. Note that we have made the dependence of a on the distance decay parameter δ explicit. By treating δ as one of the parameters to be estimated we allow the range of the effect of the Great Belt bridge on productivity to be determined by the data. It is estimated jointly with the effect of accessibility on productivity, see below. The intercept $\gamma_{i,0}$ in (6) is firm-specific. Since we have panel data for firms, we can control for all differences in productivity that remain constant over time using firm-fixed effects. This allows us to deal in a general way with the concern that the level of firm productivity may be correlated with the level of accessibility, for instance because firms in Copenhagen tend to be more productive than those in Jutland. Finally, γ_t captures time-fixed effects.

There are three issues that deserve further discussion when estimating the relation between accessibility and productivity as given by (6). First, a typical concern in studies analyzing the effect of infrastructural improvements is that these are often realized in response to existing bottlenecks in the network, raising serious concerns about endogeneity. For example, if the timing or the location of highway or rail extensions is selected according to trends and locational patterns in economic development, the improvements are not random, causing correlation between accessibility and the error term $\varepsilon_{i,t}$. Not surprisingly, therefore, previous studies on the productivity effects of highway or rail extensions have devoted much attention to possible endogeneity issues (see, among many others, Holl (2016), Ahlfeldt and Feddersen (2017), Gibbons et al. (2019), Fretz et al. (2017)). However, by focusing on one localized huge investment in new infrastructure this particular endogeneity argument is in the setting of the current paper less of a concern. There are good arguments why neither the location nor the timing of the bridge are likely to be endogenous. It was situated where

ical work below we include changes in the distance to the nearest highway ramp as additional information.

[12] The bridge is in general uncongested. It seldom happens, but particularly severe weather can affect traffic on the bridge.

the distance between the islands it connects was shortest on the exact same location where a ferry service had been operating for several centuries.[13] Moreover, the timing of the opening of the bridge can be considered exogenous as well. It was heavily dependent on the political situation of the moment; moreover, the scale of the project, the long construction time and the technical challenges involved made it hard to predict the opening date of the bridge with precision.[14] It is very unlikely that it was affected by economic developments on either side of the bridge.

However, given the way we constructed the accessibility index, there is a second issue that deserves attention. Although in some regions changes in accessibility are dominated by the opening of the bridge, they also depend on the complete distribution of the evolution of local employment, see expression (5) above. Ideally, identification of the impact of the bridge should come from changes in travel times only. If changes in local productivity are associated with changes in local employment and the latter strongly affect the accessibility index, this may lead to correlation between changes in productivity and in accessibility that are not informative about the impact of the bridge.[15] Alternatively, suppose the bridge was constructed in response to an (expected) increase in employment, then this might lead to reverse causality. To cope with these issues, when estimating (6) we instrument the accessibility index (5) by an alternative accessibility index that artificially eliminates all variability except that which is due to the opening of the bridge. A similar procedure was used recently by, for example, Ahlfeldt and Feddersen (2017) and Tsivanidis (2019).[16]

[13] The first documented regular "vessel" route crossing the Great Belt was introduced in 1624. In the 18th century, the connection was improved both for passenger and delivery (post) services, and new vessels were operating the service. In the early 19th century, the link was serviced by steam-operated ships. Note that as early as 1858 there was a proposal to connect the two Danish islands Zealand and Funen. An engineer A.F. Tscherning proposed a tunnel under the Great Belt.

[14] In 1936 the first bridge-idea (a bridge with railway and road) came up, but the project was not realized due to the Second World War. In 1948 an expert group was appointed in order to explore the possibilities for a Great Belt bridge. In 1965 the Danish government offered an award for the best bridge project. It announced 4 winners of the competition in 1967. However, due to political difficulties, the oil crises, and a number of new analyses, the bridge project was postponed again. The Danish parliament finally adopted the Construction Act for the Great Belt link in June 1987. Construction work began in August 1990. The bridge opened in 1998.

[15] Although some of these employment changes also may have been the result of the opening of the bridge, not all of them are. For example, there was a positive trend in employment throughout Denmark in the period we considered, so that some increases in local employment were likely to be unrelated to the effect of the bridge. Of course, pure trends will be reflected in the year-fixed effects, but our coefficient on accessibility reflects the impact of the bridge as well as those of the remaining changes in the employment distribution across municipalities.

[16] Tsivanidis (2019) models population and employment as a function of Commuter Market Access (CMA). As CMA depends on employment, he instruments an index of CMA by a similar index holding employment fixed. Ahlfeldt and Feddersen (2017) also used a similar employment-fixed type of index in their analysis of the German high speed rail link to purify accessibility from employment changes.

More specifically, our instrument uses the same specification as (5), but keeps employment in all municipalities throughout Denmark fixed at its 1995 value.[17] This ensures that the calculated change in accessibility between 1995 and 2002 only reflects the impact of the travel time changes due to the bridge. In this way, the instrument 'purifies' the accessibility effect on productivity from changes that are potentially unrelated to the opening of the bridge. We report all the estimation results when the accessibility index given in expression (5) is instrumented with the 'constant employment' accessibility index.

A third issue to be discussed is the estimation of the proximity decay parameter δ. To estimate it jointly with the effect of accessibility on productivity, we substitute (5) in (6) to obtain the nonlinear relation:

$$\hat{tfp}_{i,t} = \gamma_{i,0} + \gamma_1 log\left(\sum_{m'} FTE_{m',t} e^{-\delta d_{m,m',t}}\right) + \gamma_t + \varepsilon_{i,t}. \tag{6bis}$$

Since non-linear least squares does not combine well with two-stage least squares, the most popular way to use instrumental variables, we use the control function approach (see Blundell and Powell, 2003; Wooldridge, 2015), in which potential endogeneity is taken into account by adding the residual of the 'first-stage' equation as an additional explanatory variable to (6bis). For details, we refer to online appendix A.

3.4 Estimating the impact of the bridge on wages

To estimate the impact of the bridge on wages, we have data available on the wages of individual workers. Denoting the log of the observed wage of worker j in year t as $w_{j,t}$ we use a similar specification as (6):

$$\hat{w}_{j,t} = \varphi_{j,0} + \varphi_1 a_{m(j),t}(\delta) + \varphi_t + \eta_{j,t}. \tag{7}$$

In this equation, $\varphi_{j,0}$ and φ_t capture worker and time fixed effects, respectively. Here as well we estimate the distance decay parameter jointly with the other parameters using non-linear least squares and the control function approach mentioned above. We do not impose any relationship between the size or range of the impact of the bridge on productivity and on wages.

[17]Formally, the instrument is defined for municipality m in year t as: $A_{m,t} = \sum_{m'} FTE_{m',1995} e^{-\delta d_{m,m',t}}$.

4 The data

To study the effects of the opening of the bridge in 1998, the data used in the empirical analysis are derived from annual register data from Statistics Denmark for the years 1995–2002. We observe the full population of firms and their workers. First, Statistics Denmark maintains a register of businesses designed to capture the total population of establishments. The register contains extensive accounting and balance sheet information. It provides, at the company level, data on sales, investments, inputs, employment and capital stock. Moreover, information is provided on the industrial sector (using a very detailed disaggregation of industries), the ownership structure of the business (for example, plants under common ownership) and its geographical location at the municipality level. Second, we derived information on individual workers from Statistics Denmark as well. For each year 1995-2002, we have information on workers' residence and workplace (both at the municipal level), we have data on hourly wages, and we have a range of explanatory variables for each worker: educational level, age, gender, whether working full-time or part-time, and the sector of employment.

Consider the data needed to estimate productivity (the wage data will be discussed in Section 6, where we estimate the effect of the bridge on wages). Like many similar data sources from other countries, the Danish register of businesses includes accounts and balance sheet data at the company level and not at the plant level, so that outputs and inputs cannot be assigned to individual plants in multi-plant companies.[18] This implies that plant-level productivity cannot be estimated for multi-plant companies. We therefore restrict the sample to single-plant firms.[19]

Statistics Denmark has organized the total number of registered industries in Denmark (825) into a number of NACE-standard groupings.[20] We focus on industries belonging to three aggregate sectors at the one-digit level for which we observe balance sheets for the years 1995–2002, i.e., i) manufacturing, ii) construction, and iii) wholesale and retail trade, hotels and restaurants. Our empirical analyses are conducted at the NACE four-digit grouping, in total containing 53 industries. However, for various reasons a number of industries had to be excluded.[21] One implication is that from the sector 'wholesale and retail trade' only

[18]Each plant is assigned a unique identification number and a company identification number corresponding to the firm that owns them (so plants under common ownership share a common company identifier). Accounts and balance sheet information is only available at the company level.

[19]We delete about 22% of observations that correspond to multi-plant companies.

[20]NACE: Nomenclature générale des Activités économiques dans les Communautes Europeennes.

[21]Some industries had to be excluded because of the small number of firms (examples include 'sale of automotive fuel' and 'wholesale of perfume and cosmetics'. Others were deleted (for example, 'manufacturing

‘retail trade and repair work’ turned out to be useful. Note that the sample consists of an un-balanced panel of 200,177 observations covering the period 1995–2002.

Table 1: Number of firms by year (one-digit NACE sectors)

Year	Manufacturing	Construction	Wholesale and retail trade	Total
1995	9,364	10,037	4,453	23,854
1996	9,287	10,340	4,655	24,282
1997	9,142	10,773	4,691	24,606
1998	9,099	11,066	4,719	24,884
1999	9,223	11,434	4,865	25,522
2000	9,128	11,957	4,990	26,075
2001	8,828	11,842	4,942	25,612
2002	8,495	11,849	4,998	25,342
Total	72,566	89,298	38,313	200,177

In Table 1 we provide information on the distribution of firms at the one-digit level by year in the final sample used for estimation. The number of manufacturing firms decreased by approximately 10% during the period considered, while the number of construction and service firms increased by some 18% and 12%, respectively. Table 2 reports the number of observations per industry at the four-digit level. Firms in our sample are mainly concentrated in manufacturing and construction. In the manufacturing sector we find the largest number of firms in the industries ‘processing of basic metals’, ‘paper’ and ‘machinery and equipment’.

In online Appendix B we show summary statistics at the firm level. In Table B.1 we report the mean of the firms’ turnover, the number of full time equivalents and the capital stock over the sample period. The mean turnover is almost constant over time; the slight mean changes in employment and capital are consistent with very modest labor-capital substitution. The high standard deviations indicate that we have substantial variation across firms. Table B.2 contains similar information at the level of the four-digit NACE sectors. It suggests that both in terms of average turnover and employment levels the largest sectors considered are (i) the chemical industry, (ii) the production of transport equipment and (iii) food, beverages and tobacco.

As the bridge may have very different regional effects, it is useful to consider Denmark’s regional economic structure. Figure 2 shows the five major regions (Zealand/Bornholm,

of wood and wood products’ and ‘manufacturing of rubber and plastic products’) because for these industries we do not observe segments, as required for the econometric technique used to estimate productivity due to De Loecker (2011), see the discussion above. The number of observations was further reduced by deleting observations with missing values, or zero sales and zero employment. Also note that in Denmark, during the studied period smaller privately owned businesses where not required to report balance sheets.

Table 2: Number of firms by year (one-digit NACE sectors)

NACE one-digit sectors	NACE four-digit sectors	Number of observations
Manufacturing	Mfr. of food, beverages and tobacco	6,395
	Mfr. of textiles and leather	4,943
	Mfr. of paper prod.; printing and publish.	12,200
	Mfr. of chemicals	1,681
	Mfr. of other non-metallic mineral products	2,829
	Mfr. and processing of basic metals	16,026
	Mfr. of machinery and equipment	10,649
	Mfr. of electronic components	8,139
	Mfr. of transport equipment	2,542
	Mfr. of furniture; manufacturing n.e.c.	7,162
Construction	Construction	89,298
Wholesale and retail trade	Other retail sale, repair work	38,313
Total		200,177

Funen, South Jutland, East Jutland, and West/North Jutland). Table 3 reports total employment in manufacturing, construction and retail in these five regions. Zealand/Bornholm has by far the largest manufacturing and construction sectors in the country. Manufacturing employment in the region declined over the sample period, from about 58,000 to 49,000; the construction industry grew from 33,000 to some 38,000. The Funen economy is markedly smaller, employing some 20,000 people in manufacturing (with a slight decline after 1998), and a rising construction industry (from 6000 to 7800) over the sample period. Note that the three Jutland regions all faced declining employment in the manufacturing industry over the sample period, partly compensated by slightly increasing construction sector employment.[22]

[22] For completeness sake, in Table B.3 in online appendix B we report sectoral information by region.

Figure 2: The five main regions

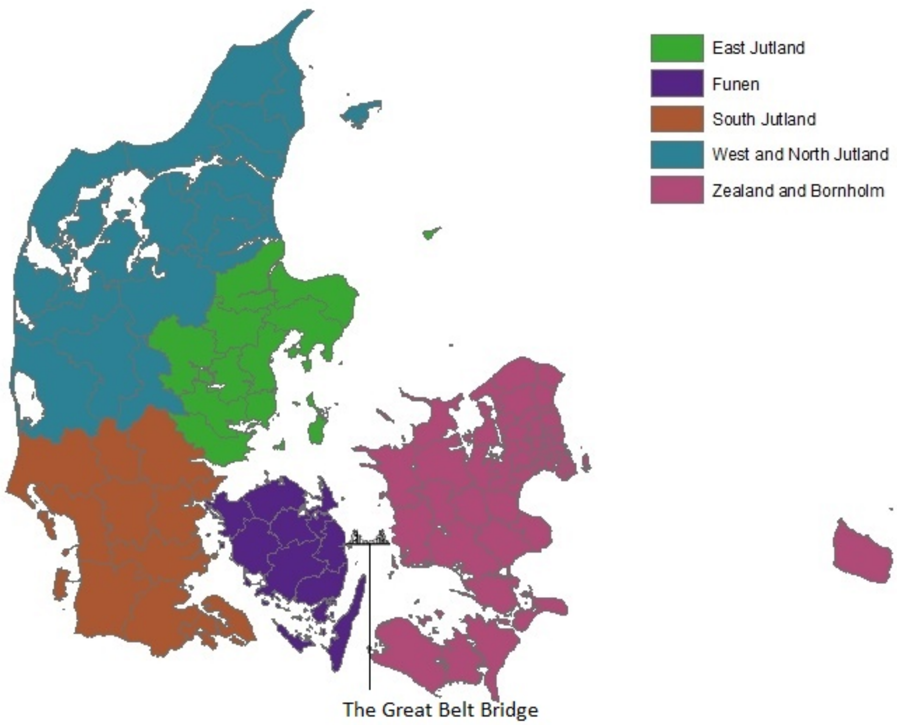


Table 3: Total number of full time job equivalents by sector and region

Year	Sector	1995	1996	1997	1998	1999	2000	2001	2002
Zealand	Manufacturing	58,147	54,133	53,181	51,846	53,160	52,049	50,145	48,844
and	Construction	33,147	34,107	36,407	36,285	37,284	38,705	38,539	37,558
Bornholm	Retail	7,319	7,853	7,852	7,985	8,189	8,550	8,139	8,296
Funen	Manufacturing	20,350	20,448	20,030	20,839	20,187	20,567	20,565	19,629
	Construction	6,121	6,518	7,320	7,406	7,934	8,538	7,897	7,786
	Retail	1,348	1,388	1,445	1,465	1,462	1,479	1,494	1,621
South	Manufacturing	33,688	33,793	30,650	31,761	31,383	29,520	29,485	25,689
Jutland	Construction	11,375	11,465	12,162	12,223	12,781	13,989	13,336	12,440
	Retail	2,933	2,866	2,744	2,798	2,833	2,767	2,707	2,574
East	Manufacturing	30,762	29,986	30,667	30,168	29,358	28,845	29,383	28,087
Jutland	Construction	9,226	9,753	10,876	11,127	11,852	12,099	12,437	12,208
	Retail	2,468	2,629	2,721	2,743	2,789	2,860	2,703	2,829
West and	Manufacturing	46,753	43,883	46,659	46,014	45,024	43,184	41,953	38,483
North	Construction	14,739	15,594	17,329	17,788	18,787	19,270	19,364	19,287
Jutland	Retail	3,550	3,878	3,877	4,024	4,083	4,015	3,952	3,974

5 Productivity, accessibility and the bridge: empirical results

In this section, we turn to the empirical results obtained when estimating the impact of the opening of the bridge on firms' productivity. In a first subsection, we summarize the results when estimating productivity, using the approaches of both Levinsohn-Petrin and De Loecker. As mentioned before, in both cases we employed Wooldridge's (2009) GMM methodology that avoids the issues highlighted in Ackerberg et al. (2015). Moreover, we provide preliminary evidence of the effect of the bridge by estimating a standard dif-in-dif model, where the opening of the bridge is captured by a simple dummy variable. A second subsection reports our findings of estimating the firm-level productivity effects of the bridge through its impact on accessibility. In a third subsection we zoom in on the effect of the bridge on firms in different sectors and regions, and we look at the impact on firms of different size.

5.1 Productivity

We estimate separate production functions for each of the four-digit industries listed in Table 2, using the two methods described in section 3.1. We limited the analysis to firms that did not relocate over the period 1995-2002; this reduces the total number of observations to 193,237 or about 96% of the total number of observations.[23]

To apply De Loecker's (2011) methodology we decomposed four-digit industries into a number of segments. To give an example, for the construction industry we observed seven subsectors: i) general contractors, ii) bricklaying, iii) installing of electrical wiring and fittings, iv) plumbing, v) joinery installation, vi) painting and glazing, and vii) other construction works. For the manufacturing industries we observed anywhere between three and six segments, with two exceptions: for transport equipment and furniture, we observed only two subsectors. Table B.4 in online appendix B provides more detailed information on the segments we distinguished.

We present detailed results of the estimated production functions in online appendix B, see Table B.6. The main findings can be summarized as follows. First, for the majority of sectors considered (including construction; food, beverages and tobacco; and chemicals), the hypothesis of constant returns to scale cannot be rejected. In cases where it is statistically

[23] Only 4% of firms in our sample relocate. These firms are not much different from the other firms in our sample, see Table B.5 in online appendix B.

rejected, scale economies (for example, for paper production) or diseconomies of scale (machinery and equipment; furniture) are very mild. Second, the coefficients of the inputs in production using De Loecker's methodology are almost systematically higher as compared to those that follow from Levinsohn-Petrin. As noted by (De Loecker, 2011, p. 1435-1436) there are two biases in the latter approach that may operate in opposite directions. First, omitted variable bias leads to downward bias in the coefficients of the inputs labor and capital. Second, however, simultaneity bias leads to a lower coefficient for labor and a higher coefficient for capital. The overall effect is therefore theoretically ambiguous; in our data set, the former bias seems to dominate the latter.

Based on the estimated production functions we then derive firm-level productivity estimates, as explained in section 3.1. In Table 4 we present summary statistics for the log of total factor productivity (denoted tfp) implied by our production function estimates. It is clear from these figures that there are important qualitative differences between the results of the two approaches. Compared to De Loecker's method which accounts for demand side adjustments, the implied mean productivity is overestimated if we use the Levinsohn-Petrin approach. The latter approach mixes productivity and demand effects, whereas the former attempts to remove the demand effects to get a 'pure' productivity measure.

Table 4: Summary statistics for the log of total factor productivity (tfp)

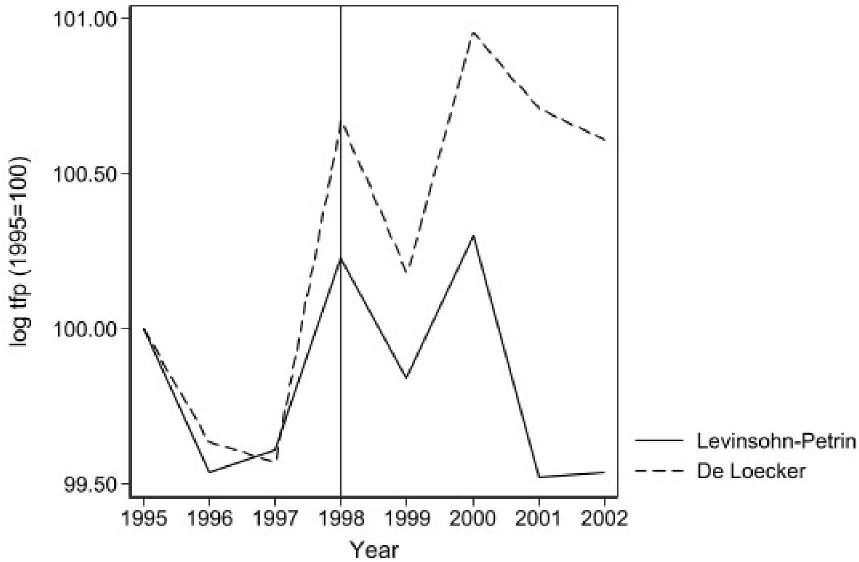
	Mean	Std. Dev.	Min.	Max.
tfp (Levinsohn-Petrin)	5.620	0.448	1.441	9.937
tfp (De-Loecker)	4.930	0.998	-0.212	13.971

Note: Number of observations: 193,277. Estimation of both models uses the GMM methodology proposed in Wooldridge (2009).

Figure 3 shows the development of productivity over the years, confirming that taking into account the impact of demand and price changes muted overall productivity estimates. However, the annual productivity changes produced by the two methods are clearly positively correlated. For example, both methods suggest a slight decline in productivity in the early sample years (1995-1997) and towards the end of the period considered (2000-2002), and they both indicate a relatively large positive change in 1998, the year the bridge opened, and in 2000. Do note that the correlation is far from perfect. Comparing 2002 with 1995, one approach suggests productivity growth, the other a decline.

In Figure 4 we decompose productivity by region. The positive productivity growth in 1998 and 2000 is observed in all regions. However, note that purely visual inspection does not allow to identify a clear positive impact of the opening of the bridge.

Figure 3: Index for means for the log of total factor productivity (1995=100), by year



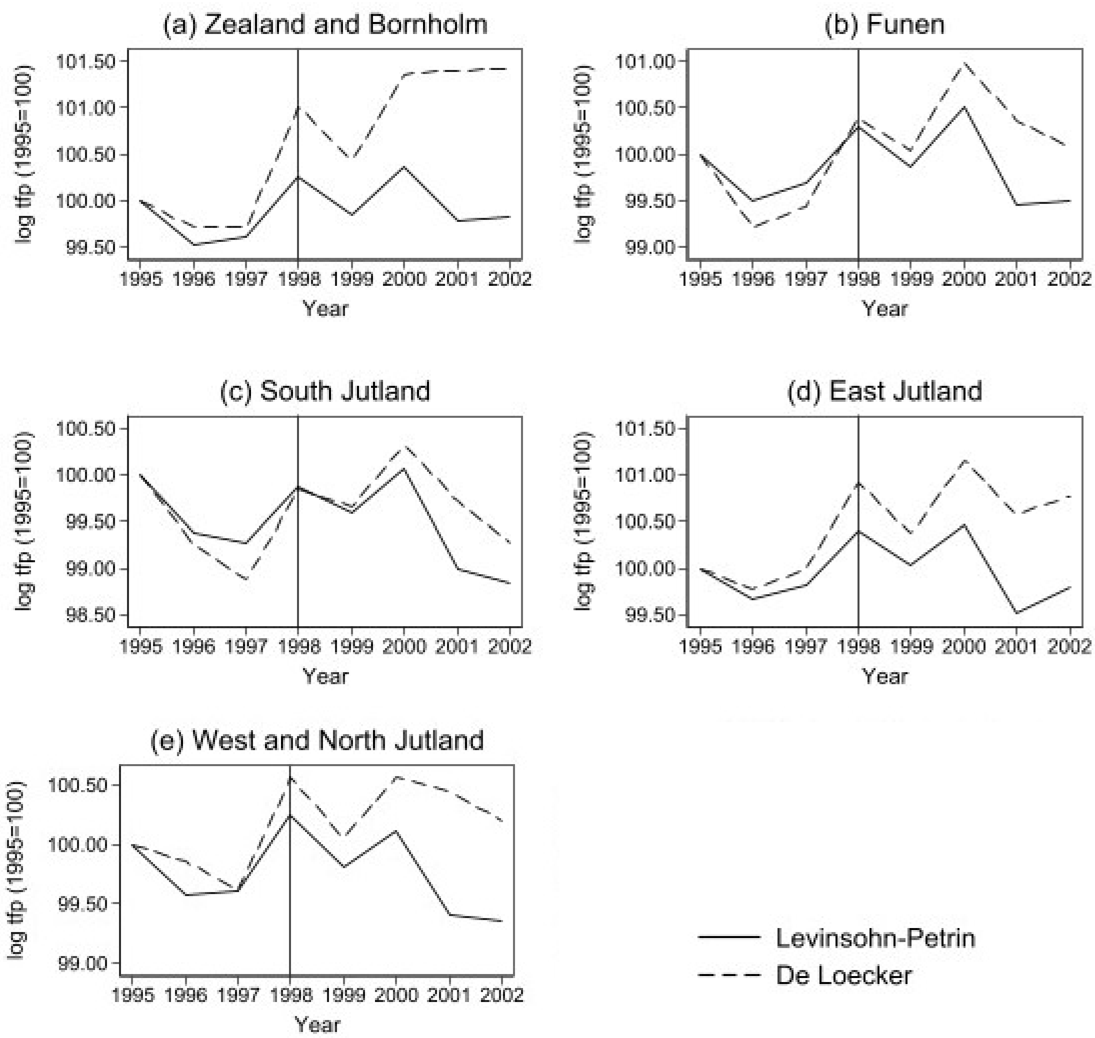
Note: See Table B.7 in online Appendix B for means and standard deviations.

Table 5 presents some first preliminary estimation results on the effect of the bridge on productivity. The first column refers to a very simple equation in which we have a dummy, taking on the value 0 prior to the opening of the bridge and 1 in the year the bridge opened and all following years, as the only explanatory variable apart from the firm fixed effects. The estimated coefficient suggests an increase of 0.6% in productivity (we use the estimates based on De Loecker's method) in the years the bridge was available. In column 2 a linear time trend has been added; the estimated coefficient indicates that the effect on productivity increases to 0.8%. In column 3 we report the result of a dif-in-dif specification in which we hypothesize that the treatment area of the bridge consists of the two regions it directly connects, Funen and Zealand/Bornholm. Formally, the specification is:

$$\hat{tfp}_{i,t} = \theta T_t + \vartheta t + \gamma_i + \varepsilon_{i,t}$$

where $\hat{tfp}_{i,t}$ is the log of total factor productivity of firm i in year t, T_t is a dichotomous variable that is 1 for for firms located in Funen and Zealand/Bornholm for the period after the bridge opening and 0 otherwise, t is a time trend, γ_i denotes firm-fixed effects, and $\varepsilon_{i,t}$ is a random error term. Estimation results suggest an increase in productivity of 1.2% relative to the control area (the regions not directly connected by the bridge). This is a sizable short-term effect. Recall that Zealand is the location of Copenhagen, the Danish capital

Figure 4: Index for means for the log of total factor productivity (1995=100), by year and region



Note: See Table B.8 in online Appendix B for means and standard deviations.

and economic center. In the next section we proceed to a more structural analysis that assumes that the impact of the bridge on productivity is realized via the implied change in accessibility.

Table 5: The short run impact of the Great Belt Bridge on total factor productivity (FE models for firms that did not relocate over the period 1995-2002)

	[1]	[2]	[3]
Dummy indicating bridge (T_t)	0.006***	0.008***	
	(0.001)	(0.003)	
Dummy indicating bridge (T_t) * Zealand and Bornholm and Funen			0.012***
			(0.002)
Firm fixed effects (γ_i)	Yes	Yes	Yes
Time trend (γ_t)	No	Yes	Yes
R-squared	0.0002	0.0001	0.0002
Number of obs.	193,277	193,277	193,277

Note: Dependent variable is logarithm of tfp. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors care in parentheses.

5.2 The bridge, accessibility and productivity

In this subsection, we present the results when estimating the effect of accessibility (which includes the effect of the bridge) on firms' productivity, following the methodology explained in Section 3.3. Specifically, we instrumented the accessibility measure with the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. Moreover, the nonlinear equation (6bis) was estimated using the control function approach due to Blundell and Powell (2003) and Wooldridge (2015).

Table 6 shows a first set of results. They report the effect of accessibility on productivity; all estimated equations included firm- and year-fixed effects. The estimated coefficient associated with the accessibility measure is positive and significant in both specifications. The elasticity of total factor productivity with respect to accessibility is estimated at 0.004 and 0.011, depending on whether demand effects are included in the estimation procedure for productivity. Since it seems preferable to remove the effect of price and demand adaptations when estimating productivity, we regard the estimates resulting from De Loecker's model as the preferred ones. They will be used in all further empirical work in the remainder of this paper (results based on Levinson and Petrin's method are available from the authors as well).

The decay parameter δ is positive and significant in both equations, and its value is within the range of estimates reported in the literature. Using the estimate of 0.017 (see the final column of Table 6) implies that employment 'around the corner' gets a weight equal to 1 in the definition of the accessibility index, employment half an hour away has a weight of

Table 6: Firm fixed effect models for accessibility impact on firm-level tfp

	Levinsohn-Petrin [1]	De Loecker [2]
log(A), instrumented	0.004***	0.011***
	(0.002)	(0.002)
e	0.012**	0.014***
	(0.005)	(0.006)
δ	0.012***	0.017***
	(0.005)	(0.005)
Firm-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes
Number of obs.	193,277	193,277

Note: Dependent variable is logarithm of tfp; the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table C.1 in online appendix C for first-step regression estimates. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors are in parentheses.

0.6, and employment one hour away still has a weight of 0.36. Note that the coefficient for the first stage residual, denoted as e in Table 6, is significant; this confirms the importance of distinguishing between the overall change in accessibility (including that resulting from changes in local employment) and that due to the opening of the bridge on travel times.[24]

To get a crude idea of the impact of the bridge on productivity at the level of the country as a whole, note that the effect of the bridge on productivity is the product of the coefficient for the log of the accessibility measure times the change in the accessibility measure. The latter is itself a function of the coefficient δ, which was jointly estimated with the accessibility effect. Table 7 reports the results of the estimated mean accessibility indices for 1995 and 2002 (well before and after the opening of the bridge in 1998), calculated using (5) in Section 3.2 for $\delta = 0.017$. Mean accessibility at the country level increased by 20.0%. Using this information suggests that the bridge raised productivity at the country level as a whole by approximately 0.22% (0.011 times 20%). Note that this properly estimated value is quite a bit lower than the 0.6% obtained using a simple dummy for the availability of the bridge (see Table 5).

The estimated changes in accessibility reported in Table 7 show substantial regional variability. By far the largest increase in accessibility is experienced by Funen (some 34%),

[24]Importantly, we found the instrument used to be strong. See Table C.1 in online appendix C for further information.

located across the bridge opposite the Copenhagen region: Funen's 'proximity' to the Copenhagen area is drastically increased by the opening of the bridge. The increase in accessibility for the other regions is more modest, especially for West/North Jutland, which is a low density region located at a much larger distance from the bridge. Interestingly, due to asymmetries in employment between the two regions, the accessibility improvement for the firms in the Copenhagen area (Zealand/Bornholm) is much smaller than for firms on the opposite side of the bridge (Funen).

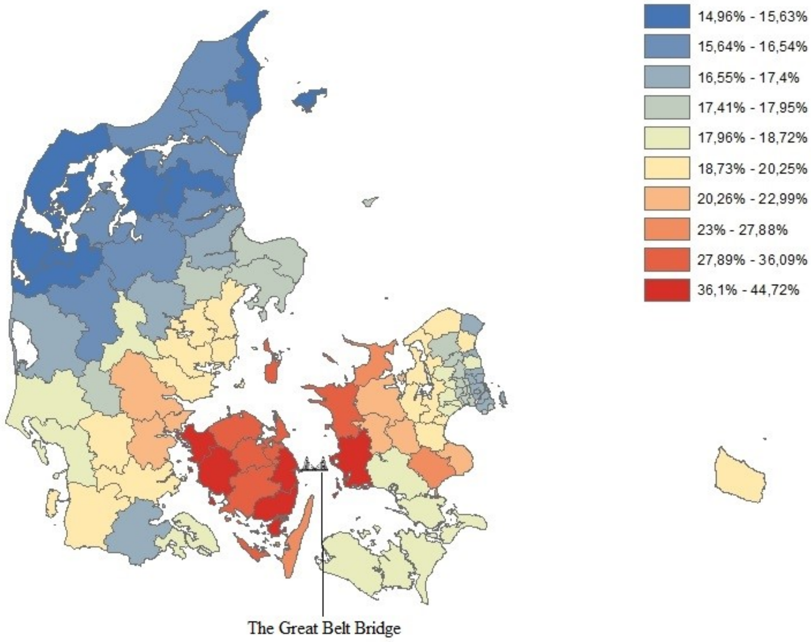
Table 7: Changes in mean of accessibility measure A between 1995 and 2002

Regions	A in 1995	A in 2002	Pct. change between 1995 and 2002
Zealand and Bornholm	494	578	18.82%
Funen	273	366	34.23%
South Jutland	286	342	19.69%
East Jutland	316	282	20.95%
West and North Jutland	220	255	15.98%
Total	371	445	20.01%

Note: The accessibility measure (A) has been computed as a weighted sum of FTEs in all municipalities, $A_{m,t} = \sum_{m'} FTE_{m',t} e^{-\delta d_{m,m',t}}$, where the summation runs over all municipalities m', FTE is full time job equivalents, d denotes distance measured in travel time minutes between municipalities. The accessibility measures are based on the decay parameter value estimated for Denmark as whole, $\delta = 0.017$ (see Table 6). Number of observations for each year equal the number of municipalities (98).

In Figure 5 we give a more detailed view of the increase in the calculated indices between 1995 and 2002 for individual municipalities. This clearly illustrates that accessibility increased most for the municipalities closest to the new bridge; these include several municipalities on Zealand and all those on Funen. Especially on the eastern part of Funen accessibility increases dramatically, for some municipalities by more than 40%. The large regional differences suggest sizeable differences in the estimated productivity effects of the bridge between regions, to which we now turn.

Figure 5: Percentage changes in accessibility measure A between 1995 and 2002



Note: The accessibility measure (A) has been computed as a weighted sum of FTEs in all municipalities, $A_{m,t} = \sum_{m'} FTE_{m',t} e^{-\delta d_{m,m',t}}$, where the summation runs over all municipalities m', FTE is full time job equivalents, d denotes distance measured in travel time minutes between municipalities. The accessibility measures are based on the decay parameter value estimated for Denmark as whole, $\delta = 0.017$ (see Table 6). Number of observations for each year equal the number of municipalities (98).

5.3 Decomposition by regions, sector, and firm size

The implications of accounting for regional variation are reported in Table 8. Despite the fairly similar percentage changes in accessibility in all regions except Funen (see Table 7), the picture that emerges is that of a highly localized impact of the new bridge. The opening of the bridge has affected productivity most for firms in Funen and, to a lesser extent, for firms in Zealand/Bornholm, the greater Copenhagen region. No significant effects are estimated for the other regions further from the bridge, so the impact of the bridge seems to be confined to the islands it directly connects. To elaborate, consider the implications for Funen. Accessibility increased on average by 34% between 1995 and 2002 (see Table 7). Using the estimated coefficient of accessibility changes on firm productivity in Funen then results in an estimated 0.68% average productivity increase for firms located there.[25] The

[25] To appreciate this result, note that Funen is a relatively small part of Denmark, and that the change in accessibility is substantial throughout the island, which makes it more difficult to distinguish the impact of the accessibility shock from year-fixed effects. To see why, note that the coefficient for accessibility is estimated on the statistical association between differences in accessibility and differences in productivity.

distance decay parameter for Zealand is much smaller than for Denmark as a whole, but still significant; this is probably related to the location of Copenhagen at the edge of the island. For Funen and East-Jutland we find much steeper distance decay effects. Note that the coefficient for the first stage residual (e) is never significant.

Table 8: Firm fixed effect models for accessibility impact on firm-level TFP for different regions

	Zealand and Bornholm	Funen	South Jutland	East Jutland	West and North Jutland
	[1]	[2]	[3]	[4]	[5]
log(A), instrumented	0.008***	0.020**	0.010	0.002	0.007
	(0.002)	(0.008)	(0.009)	(0.014)	(0.017)
e	0.015	0.026	-0.009	-0.039	-0.009
	(0.010)	(0.021)	(0.015)	(0.037)	(0.028)
δ	0.006***	0.071**	0.013	0.072*	0.030
	(0.001)	(0.036)	(0.031)	(0.041)	(0.026)
Firm-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
Number of obs.	76,632	17,261	28,044	29,452	41,888

Note: Dependent variable is logarithm of (De Loecker) tfp; the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table C.2 in online appendix C for first-step regression estimates. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors are in parentheses.

Table 9 reports estimates separately for the manufacturing industries, the construction industry, and the retail trade industry. Interestingly, the opening of the bridge is only statistically significant (and quite large) for the retail industries. These are typically located closer to the main population centers, and a relatively large share is based on Zealand and Funen. For many of these firms the bridge may have caused a substantial decrease in transport costs and a sizeable increase in their (potential) market area.

We find no significant effect on the productivity in the manufacturing industries. This contrasts with earlier findings in other countries. For example, Holl (2016) finds significant effects of the proximity to highways on firms' productivity in Spain's manufacturing sector as a whole. However, in a decomposition of the analysis, significant effects on productivity with the expected sign are only reported for 4 out of 20 manufacturing (sub)industries; for

The limited variation in the differences in accessibility in Funen then suggests that the productivity gain may have been partly absorbed in the year-fixed effect.

one sector the significant coefficient has the unexpected negative sign.[26] The sectors that do yield significant effects are 'mainly traditional manufacturing industries – which tend to have a higher weight-to-value ratio' (Holl, 2016, p. 132). Such industries are much less important in Denmark, a high wage country where the manufacturing sector emphasizes much more high value-added products.[27]

Table 9: Firm fixed effect models for accessibility impact on firm-level tfp for considered NACE one-digit sectors

	Manufacturing	Construction	Retail trade
	[1]	[2]	[3]
log(A), instrumented	0.006*	0.001	0.023***
	(0.004)	(0.003)	(0.005)
e	-0.020*	0.022***	0.031**
	(0.012)	(0.008)	(0.013)
δ	0.024	0.009***	0.021***
	(0.084)	(0.002)	(0.003)
Firm-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
Number of obs.	69,642	86,564	37,071

Note: Dependent variable is logarithm of (De Loecker) tfp; the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table C.3 in online appendix C for first-stage regression estimates. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors are in parentheses.

The estimated impact of the bridge on the productivity of the construction industry is also not significant, see Table 9. This may not be that surprising, as many construction firms are relatively small (see Table 3 above) and operating very locally. Of course, one could argue that many of these firms may have benefited directly or indirectly during the construction stage of the bridge. However, note that our estimates refer to effects realized *after* the opening of the bridge: our accessibility index only strongly increases when the bridge opened in 1998. If the construction itself would have caused a temporary increase in productivity of construction firms before the opening of the bridge, one might in fact expect a negative impact of the bridge becoming operational itself.

Note that the estimated coefficients for the first stage residuals are now significant (although borderline so in case of manufacturing), suggesting that concentrating on the acces-

[26] Table E1 in Holl (2016).

[27] Note also that Holl (2016) uses a different productivity index as well as a different explanatory variable (viz., proximity to highways) to capture the role of improved infrastructure. We use a similar variable as a robustness check, see below.

sibility effect of the bridge *per se* makes a difference.

Finally, Table 10 presents the results of decomposing the sample of firms on the basis of the number of employees. It shows that only the productivity of small firms (<50 FTE) are positively affected by the improved accessibility. The aggregate impact on medium-sized and larger firms is not significant.[28]

Table 10: Firm fixed effect models for accessibility impact on firm-level tfp for small, medium and large firms

	<50 FTEs	50-250 FTEs	>250 FTEs
	[1]	[2]	[3]
log(A), instrumented	0.014***	-0.001	0.006
	(0.002)	(0.007)	(0.023)
e	0.021***	-0.012	0.012
	(0.006)	(0.017)	(0.027)
δ	0.017***	0.040	0.032
	(0.006)	(0.086)	(0.091)
Firm-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
Number of obs.	144,603	41,764	6,910

Note: Dependent variable is logarithm of (De Loecker) tfp; the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table C.4 in online appendix C for first-stage regression estimates. Small firms have less than 50 FTEs, medium firms between 50 and 250 FTEs, and large firms more than 250 FTEs. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors are in parentheses.

Two remarks conclude this subsection. First, using the percentage increase in accessibility due to the bridge, estimated at 20% for the country as a whole (see above), we find that the country-wide effect of the bridge was to increase productivity by 0.22%. Looking at individual regions reveals huge differences in the effect of the bridge, however. For Zealand/Bornholm (including Copenhagen), the effect is much smaller; it amounts to 0.15%. However, for Funen, on the opposite side of the bridge, the total impact can be calculated at 0.68% of output. This is a sizeable effect for a single piece of infrastructure. Note that the effect on municipalities on Funen closest to the bridge is even much larger. For those communities the

[28]Note that we also considered estimating the effect of accessibility on productivity, jointly taking into account firm size as well as regional and sectoral variation. There are at least two approaches for doing this, but they turned out to be too demanding for our data. One approach only requires a single specification but has many coefficients; the other approach would be to have separate regressions for every cell of the 45 cells cross table (5 regions x 3 industries x 3 size classes). Unfortunately, since many of these cells have few observations neither approach produced interesting results on top of those reported in the paper.

increase in accessibility is more than 40%, and the contribution to productivity approximates 1%.

Second, we pointed out before that other studies have used proximity to the nearest highway ramp as an indicator for the changes in infrastructure. We use travel times as measured on the road network as included in our accessibility indicator with an estimated distance decay parameter, which is arguably a more appropriate indicator. However, we have these travel times only for the year 2002, which means that we may miss the impact of small changes in the network, such as new ramps on existing or extended highways, occurring in the period 1995-2002. For several regions, including Funen, there were no new highway ramps opened over the period 1995-2002 studied here. Nevertheless, as a robustness check, we did control for changes in the highway network at the country level. Doing so did not affect the estimated effect of the bridge on productivity at all, see online appendix D.[29]

6 Empirical results: wages

As described in the introduction of the paper, a large shock due to a drastic but localized improvement in transport infrastructure may have other effects than on firms' productivity. Of special interest is the potential effect on wages, which has often been interpreted as reflecting that on productivity. Intuitively, an increase in productivity will push up the value of the marginal productivity of labor; on a competitive labor market the resulting increase in demand leads to an increase in the wage level. However, there are at least two reasons why the spatial effects of an infrastructural improvement on wages may be different from that on productivity.

First, wages may be affected even in firms for which productivity has not increased due to the opening of the bridge. To the extent that these firms use the same types of labor, the increase in demand for workers with these particular skills will cause some reallocation and drive up wages for these workers in the whole local labor market (see e.g. Greenstone et al., 2010). Depending on the size of the local labor markets, the spatial impact of the opening of the bridge may therefore be different for wages and productivity.

Second, the opening of the bridge may have had a 'matching' effect (Helsley and Strange, 1990), because after its opening workers can more easily accept jobs in which they are more productive on the other side of the Great Belt Bridge. This not only increases firm productivity, it also raises the wages of the workers finding jobs that fit them better. This

[29] Admittedly, endogeneity is an obvious problem for this variable and, unlike the careful historical instrument used in Holl (2016), we have no appropriate instruments to deal with the endogeneity problem.

matching effect is again related to the size of the local labor market. For example, Dauth et al. (2018) find a strong positive relationship: high productivity workers are more likely to be employed by high productivity firms in larger cities. This phenomenon is probably related to the higher job mobility of younger workers in large local labor markets, as reported by Wheeler (2001) and Bleakley and Lin (2012). Of course, in our setting one expects this matching effect to be limited to the local labor market surrounding the location of the bridge, and to decline fast with greater distance from the bridge. This may also partly explain why we found a larger impact of a given change in accessibility on productivity when we restricted the analysis to the immediate surroundings of the bridge.

In this section, we consider the effect of the bridge on wages throughout the country. The wage data we use are derived from annual register data from Statistics Denmark for the years 1995–2002. We observe the full population of firms and their workers. For each year, we observe workers' residence and workplace (both at the municipal level), we have data on hourly wages, and we have a range of socio-economic characteristics for each worker: educational level, age, gender, full-time versus part-time, and the sector of employment. We select workers who have been employed for at least one year. Our wage regressions are then based on 1,990,619 workers. Table E.1 in online appendix E not only gives some descriptives for the full sample, but it also distinguishes subsamples for workers that did neither change job nor residence during the period considered, for workers changing jobs, for workers changing residence, and for workers changing residence as well as job.

We provide a similar first formal test of the impact of the bridge opening on wages as we did for productivity. The first two columns of Table 11 report the result of estimating a regression with a dummy that equals 1 for the years in which the bridge was available and 0 before. Without a time trend, we estimate a sizable coefficient 0.015, corresponding to an increase in wages of 1.5% (column 1). However, if we introduce the time trend, this decreases to 0.4%. The third column reports the results of estimating a dif-in-dif equation in which we suppose the treatment area consists of Funen and Zealand, the areas closest to the bridge:

$$w_{j,t} = \theta T_t + \vartheta t + \gamma_j + \varepsilon_{j,t}$$

where $w_{j,t}$ is the log of hourly wage of worker j in year t, T_t is a dichotomous variable that is 1 for workers in the treatment area for the period after the bridge opening and 0 otherwise, t is a time trend, γ_j denotes worker-fixed effects, and $\varepsilon_{j,t}$ is a random error term. The estimation results suggest an impact of the bridge on wages of 0.8%, somewhat smaller than we found in the analogous equation for productivity (see Table 5).

Table 11: The short run impact of the Great Belt Bridge on log hourly wages

	[1]	[2]	[3]
Dummy indicating bridge (T_t)	0.015***	0.004***	
	(0.0001)	(0.0001)	
Dummy indicating bridge (T_t) * Zealand and Bornholm and Funen			0.008***
			(0.0001)
Dummy variable indicating 1 child	0.010***	0.024***	0.024***
	(0.0002)	(0.0002)	(0.0002)
Dummy variable indicating 2 children	0.020***	0.039***	0.038***
	(0.0002)	(0.0002)	(0.0002)
Dummy variable indicating 3 children	0.030***	0.047***	0.047***
	(0.0004)	(0.0003)	(0.0003)
Dummy variable indicating more than 3 children	0.033***	0.051***	0.051***
	(0.001)	(0.001)	(0.001)
Dummy indicating registered partnership	0.003	-0.003	-0.004*
	(0.002)	(0.002)	(0.002)
Dummy indicating couple living in consensual union	-0.029***	-0.013***	-0.013***
	(0.0003)	(0.0003)	(0.0003)
Dummy indicating cohabiting couples	-0.038***	-0.009***	-0.009***
	(0.0003)	(0.0002)	(0.0002)
Dummy indicating singles	-0.035***	-0.008***	-0.008***
	(0.0002)	(0.0002)	(0.0002)
Worker fixed effects (γ_i)	Yes	Yes	Yes
Time trend	No	Yes	Yes
R-squared	0.045	0.053	0.055
Number of obs.	8,610,211	8,610,211	8,610,211

Note: Dependent variable is logarithm of hourly wage. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors are in parentheses.

To investigate the wage effects in more detail, we estimate Mincerian wage regressions in which the impact of the bridge is captured via its effect on accessibility. As our accessibility index is calculated using employment information, this might introduce correlation with the error term, because equilibrium wages and employment are jointly determined. As before, we therefore instrument the accessibility measure using the accessibility index that keeps employment fixed at its 1995 levels in all municipalities throughout Denmark. Moreover, we estimate the distance decay parameter δ in our accessibility measure simultaneously with the other parameters, just like we did for productivity.

In Table 12 we report results, ignoring regional differentiation. The model includes worker fixed effects and year fixed effects; we further introduce fixed effects for the industrial sector to which the firm where the worker is employed belongs, and for the municipality where the firm is located. Moreover, we included information on the number of children, cohabitation

Table 12: Minicerian wage regression, worker fixed effects

	[1] All workers	[2] All workers	[3] Job and residence stayers
log(A)	0.009***	0.017***	0.006***
	(0.001)	(0.002)	(0.001)
Dummy variable indicating 1 child		0.025***	0.018***
		(0.0009)	(0.001)
Dummy variable indicating 2 children		0.040***	0.028***
		(0.001)	(0.001)
Dummy variable indicating 3 children		0.049***	0.034***
		(0.002)	(0.002)
Dummy variable indicating more than 3 children		0.056***	0.040***
		(0.005)	(0.005)
Dummy indicating registered partnership		0.004	-0.001
		(0.012)	(0.012)
Dummy indicating couple living in consensual union		-0.016***	-0.013***
		(0.002)	(0.002)
Dummy indicating cohabiting couples		-0.012***	-0.006***
		(0.001)	(0.002)
Dummy indicating singles		-0.006***	-0.00002
		(0.001)	(0.002)
e	0.010***	0.0003	0.004***
	(0.002)	(0.002)	(0.002)
δ	0.163***	0.787***	0.145***
	(0.021)	(0.138)	(0.028)
Sector-fixed effect (53 sectors)	No	Yes	No
Municipality-fixed effect	No	Yes	No
Worker-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
Number of obs.	8,610,211	8,610,211	6,648,714

Note: Dependent variable is logarithm of hourly wage, the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. The deleted dummy for cohabitation status refers to married workers. See Table E.2 for first-stage regression estimates. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors are in parentheses.

status, etc. of the worker.[30] Note that many other household characteristics are implicitly captured by the worker fixed effects.

The first two columns in the table show that an increase in accessibility significantly raises

[30] Table E.1 in Appendix E reports descriptive statistics for workers. Note that the deleted dummy for cohabitation status refers to married workers.

wages, but that the effect is small. The estimated elasticity is 0.009 when no socio-economic attributes are included; it almost doubles when we control for worker characteristics (see column 2). Noting from above that overall accessibility increased by 20.01% for Denmark as a whole, the coefficient of 0.017 roughly means that accessibility raised wages by 0.33% over the period considered. Note that this effect concerns the whole Danish labor force, not just the workers in the industries we studied in the previous section on productivity. We further observe that de estimated decay parameters are much higher than the ones estimated in the analysis of the productivity effects of the bridge, suggesting that the impact on wages fades out faster when moving away from the bridge.

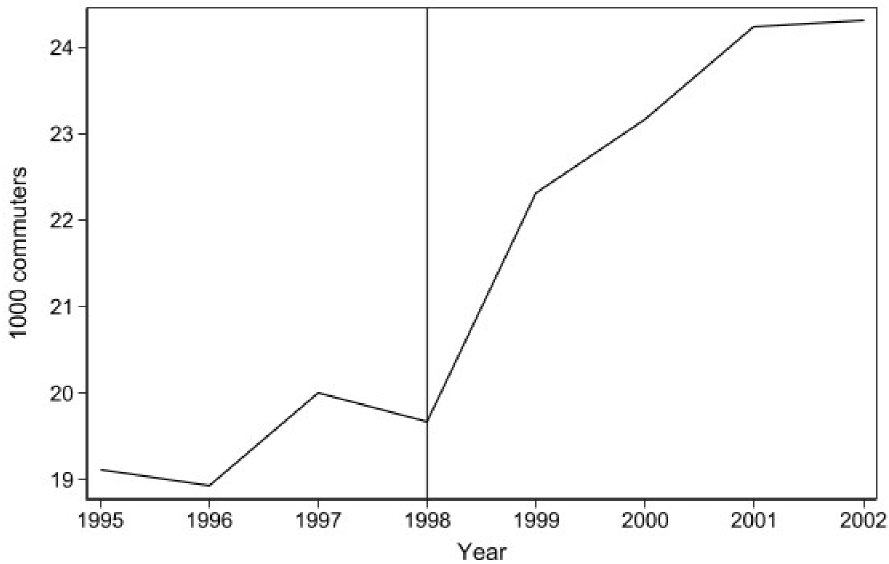
Column 3 shows the result of re-estimating the wage equation only for the subsample of workers for which residence and job locations did not change.[31] We thus exclude wage changes that resulted from changes in jobs or residence that were perhaps realized because of the opening of the bridge. This means that we also exclude the improved matching effect discussed above. The elasticity of wages with respect to accessibility drops to 0.006, suggesting that a large part of the wage effect that we measured in column (2) may be due to improved matching. In line with this interpretation, observe that the distance decay parameter in column (2) is much larger than the one estimated in column (3). Improved matching after opening of the bridge requires commuting across it, while most commutes are short. When matching is important (column 2), one therefore expects the decay effect to be large. Other (not requiring commuting) effects of improved accessibility on productivity may have smaller costs.

We further explore the regional and sectoral variation in the effect of accessibility on wages in online Appendix E. The results in Table E.3 suggest significant wage effects only for the regions closest to the bridge, but now also including East Jutland (where we didn't find a significant effect of productivity). We find larger distance decay parameters for Zealand and Funen, whereas for East Jutland the distance decay parameter is not significantly different from 0. These findings suggests that some wage effects, perhaps referring to improved matching (see below), are highly localized and restricted to the regions close to the bridge, while there also appears to be a wider ranging effect that is less sensitive to distance. One possible interpretation is that ripple effects may spread some of the impact of the bridge across a series of overlapping markets (Manning and Petrongolo, 2017).

In Table E.4 we explore the wage effects across industrial sectors. The results show that the opening of the bridge significantly raised wages in all sectors, but that the effect

[31] In our sample, 9.23% of workers move residence, 22.86% move job, 27.29% move job or residence, and 4.80% move both job and residence.

Figure 6: Number of commuters crossing the Great Belt, by year



Note: The vertical line shows the year of the Great Belt bridge opening.

for the manufacturing industry is only about half as large as for the construction and the retail trade industries. Recall here that we did not find a significant effect of the bridge on the productivity of the manufacturing and construction sectors, confirming that wages are affected even when productivity is not. A plausible explanation is that productivity increases in some sectors affect the demand for skills that are used in many firms in other sectors, including some whose productivity is not improved by the opening of the bridge. On a competitive labor market, this may result in higher wages for all workers having these skills.

We mentioned before that the estimated wage effects may to some extent be due to improved matching. To conclude this section, we further investigate the impact of the opening of the bridge on the local labor market and the potential role of improved matching. We present three pieces of evidence that support the hypothesis of improved matching due to the bridge opening. First, consider Figure 6. This shows that the number of commuters crossing the Great Belt grew from an average of 19.5 thousands workers in the period before the bridge opening to more than 24.0 thousands workers in 2002, an increase of more than 20%. The growth rate was particularly high in the year immediately after the bridge opening (about 13%). This suggests that a substantial number of workers found a better job on the other side after the bridge opened. Second, Table E.1 in online appendix E shows that

Table 13: Mincerian wage regression for different regions for job and residence stayers, worker fixed effect

	[1] log(w)	[2] log(w)	[3] log(w)
Dummy indicating job change cross the bridge	0.014***	0.010***	0.010
	(0.002)	(0.002)	(0.002)
Dummy variable indicating 1 child			0.019***
			(0.002)
Dummy variable indicating 2 children			0.035***
			(0.002)
Dummy variable indicating 3 children			0.045***
			(0.003)
Dummy variable indicating more than 3 children			0.048***
			(0.008)
Dummy indicating registered partnership			-0.022
			(0.022)
Dummy indicating couple living in consensual union			-0.014***
			(0.002)
Dummy indicating cohabiting couples			-0.008***
			(0.002)
Dummy indicating singles			-0.010***
			(0.002)
Sector-fixed effect (53 sectors)	No	Yes	Yes
Municipality fixed effect (workplace)	No	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
Number of obs.	358,920	358,920	358,920

Note: Dependent variable is logarithm of hourly wage, ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors are in parentheses. The results refer to workers who changed job after the opening of the bridge, did not use the ferry before the opening of the bridge, and did not change residence. All observations refer to the years 1999-2002.

workers who did not move residence but did move their jobs across the Great Belt after the bridge opened, experienced the highest wage growth. For these workers the hourly wage raised from 167 DKK in 1995 to 226 in 2002, so by 35%. For an average worker the hourly wage increased by 29%, from 151 DKK in 1995 to 194 DKK in 2002. The increase in commuting across the Great Belt and the higher wage increases for workers crossing the bridge are first indications that the bridge improved labor market matching.

Finally, a third piece of potential evidence on the matching effect can be obtained by focusing on the wage effects for the subsample of workers who changed jobs in the three years following the opening of the bridge and did not use the ferry to cross the Great Belt before the bridge opened. Some of these job changers took a job across the bridge, while others remained on the same side of the Great Belt. We then compare the wages of the workers crossing the bridge to arrive at their new job with those of the workers whose job and residence remained on the same side of the Great Belt. This gives us a reasonably clean estimate of the effect of the opening on the bridge on the quality of the job-worker match, as our control group also consist of job changers. Moreover, by introducing fixed effects for sectors and municipalities and a number of controls for worker characteristics we can deal with possible composition effects. The results are reported in Table 13. We find that workers who lived and worked on the same side of the Great Belt prior to the opening of the bridge and took a job on the other side after its opening, realize a wage that – depending on whether or not controls are included in the estimated relation – is 1.0%-1.4% higher than for job changers not crossing the bridge. Realizing that the average wage increase across Denmark due to the bridge was in the order of 0.8%-1.0%, this is a remarkably large effect, consistent with substantially improved labor matching.

7 Conclusion

In this paper, we studied the short-run effects of a large discrete shock in transport infrastructure, viz., the opening of the Great Belt Bridge connecting the Copenhagen region with the rest of the country. We captured the effect of the opening of the bridge throughout the country through its effect on accessibility, whereby the bridge drastically affected travel times between municipalities located on opposite sides of the bridge. We estimated the productivity and wage effects of the new bridge using data on the full population of firms and workers.

Productivity was estimated using the techniques developed by Levinsohn and Petrin (2003) and De Loecker (2011); in both cases we made use of the GMM methodology proposed by Wooldridge (2009) so as to avoid the identification problem highlighted in Ackerberg et al. (2015). We found rather modest productivity changes over the sample period. Moreover, we consistently found lower productivity changes using De Loecker's method, which makes an attempt to purify productivity effects from demand side effects.

In a next step we estimated the effect of the improvement in accessibility due to the opening of the bridge on firms' productivity. The effect of the distance decay parameter appearing in the accessibility indicator was estimated jointly with the effect of the bridge on productivity and wages, using a control function approach to deal with endogeneity problems. We found significant positive effects of the improved accessibility on the productivity of firms in the retail industry but, surprisingly in view of earlier results, not in the manufacturing sector. The opening of the bridge has affected productivity most for firms in the regions directly connected by the bridge (Funen and, to a lesser extent Zealand/Bornholm, which includes the greater Copenhagen region). Moreover, we find that the productivity improvements were limited to relatively small firms that are typically active on a local or regional scale.

The elasticities of improved accessibility due to the bridge on wages yielded systematically positive wage elasticities, mostly of the same order of magnitude than those estimated for productivity. However, the wage and productivity effects did differ in important ways. The wage effects showed much faster decay with distance from the bridge. Moreover, the wage effects manifest themselves also in industries where productivity was not affected by the opening of the bridge. For example, there was no significant effect of the bridge on productivity in the manufacturing industry, but improved accessibility due to the bridge did increase manufacturing wages.

The imperfect correspondence between the impact of the bridge on productivity and wages has several reasons. First, when productivity in some firms is positively affected by the opening of the bridge, demand for workers with the skills relevant to these firms will increase. To the extent that firms that did not benefit from a productivity increase use the same types of labor, the increase in demand for workers with these particular skills will cause some reallocation and drive up wages for these workers in the whole local labor market. Therefore, wages may be affected while productivity is not. Second, we found evidence that the opening of the bridge may have had a 'matching' effect: after its opening, workers could more easily accept jobs in which they were more productive on the other side of the Great Belt Bridge. The size of their local labor market increased which offered possibilities to switch to jobs offering higher wages. Of course, this matching effect was limited to the local labor market surrounding the location of the bridge, and it declined fast with greater distance from the bridge.

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References

Ackerberg, D. A., Caves, K., and Frazer, G. (2015). Identification properties of recent production function estimators. *Econometrica*, 83(6):2411–2451.

Ahlfeldt, G. M. and Feddersen, A. (2017). From periphery to core: measuring agglomeration effects using high-speed rail. *Journal of Economic Geography*, 18(2):355–390.

Baum-Snow, N. (2007). Did Highways Cause Suburbanization?*. *The Quarterly Journal of Economics*, 122(2):775–805.

Baum-Snow, N., Henderson, J. V., Turner, M. A., Zhang, Q., and Brandt, L. (2020). Does investment in national highways help or hurt hinterland city growth? *Journal of Urban Economics*, 115:103124. Cities in China.

Bleakley, H. and Lin, J. (2012). Thick-market effects and churning in the labor market: Evidence from us cities. *Journal of Urban Economics*, 72(2):87–103.

Blundell, R. and Powell, J. L. (2003). *Endogeneity in Nonparametric and Semiparametric Regression Models*, volume 2 of *Econometric Society Monographs*, page 312–357. Cambridge University Press.

Brooks, W. and Donovan, K. (2020). Eliminating uncertainty in market access: The impact of new bridges in rural nicaragua. *Econometrica*, 88(5):1965–1997.

Chandra, A. and Thompson, E. (2000). Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system. *Regional Science and Urban Economics*, 30(4):457–490.

Coughlin, C. and Segev, E. (2000). Location determinants of new foreign-owned manufacturing plants. *Journal of Regional Science*, 40:323–351.

Datta, S. (2012). The impact of improved highways on indian firms. *Journal of Development Economics*, 99(1):46–57.

Dauth, W., Findeisen, S., Moretti, E., and Suedekum, J. (2018). Matching in Cities. NBER Working Papers 25227, National Bureau of Economic Research, Inc.

De Loecker, J. (2011). Product differentiation, multiproduct firms, and estimating the impact of trade liberalization on productivity. *Econometrica*, 79(5):1407–1451.

Dekle, R. and Eaton, J. (1999). Agglomeration and land rents: Evidence from the prefectures. *Journal of Urban Economics*, 46(2):200–214.

Donaldson, D. (2018). Railroads of the raj: Estimating the impact of transportation infrastructure. *American Economic Review*, 108(4-5):899–934.

Donaldson, D. and Hornbeck, R. (2016). Railroads and American Economic Growth: A "Market Access" Approach *. *The Quarterly Journal of Economics*, 131(2):799–858.

Duranton, G. and Puga, D. (2004). Micro-foundations of urban agglomeration economies. In Henderson, J. V. and Thisse, J. F., editors, *Handbook of Regional and Urban Economics*, volume 4 of *Handbook of Regional and Urban Economics*, chapter 48, pages 2063–2117. Elsevier.

Faber, B. (2014). Trade Integration, Market Size, and Industrialization: Evidence from China's National Trunk Highway System. *The Review of Economic Studies*, 81(3):1046–1070.

Fretz, S., Parchet, R., and Robert-Nicoud, F. (2017). Highways, Market Access, and Spatial Sorting. Technical report.

Gaubert, C. (2018). Firm sorting and agglomeration. *American Economic Review*, 108(11):3117–53.

Ghani, E., Goswami, A. G., and Kerr, W. R. (2016). Highway to success: The impact of the golden quadrilateral project for the location and performance of indian manufacturing. *The Economic Journal*, 126(591):317–357.

Gibbons, S., Lyytikäinen, T., Overman, H. G., and Sanchis-Guarner, R. (2019). New road infrastructure: The effects on firms. *Journal of Urban Economics*, 110:35–50.

Graham, D. J. (2007a). Agglomeration, productivity and transport investment. *Journal of Transport Economics and Policy*, 41(3):317–343.

Graham, D. J. (2007b). Variable returns to agglomeration and the effect of road traffic congestion. *Journal of Urban Economics*, 62(1):103–120.

Greenstone, M., Hornbeck, R., and Moretti, E. (2010). Identifying agglomeration spillovers: Evidence from winners and losers of large plant openings. *Journal of Political Economy*, 118(3):536–598.

Hanson, G. H. (2005). Market potential, increasing returns and geographic concentration. *Journal of International Economics*, 67(1):1–24.

Harris, C. D. (1954). The market as a factor in the localization of industry in the united states. *Annals of the Association of American Geographers*, 44(4):315–348.

Helsley, R. W. and Strange, W. C. (1990). Matching and agglomeration economies in a system of cities. *Regional Science and Urban Economics*, 20(2):189–212.

Holl, A. (2004). Manufacturing location and impacts of road transport infrastructure: empirical evidence from spain. *Regional Science and Urban Economics*, 34(3):341–363.

Holl, A. (2012). Market potential and firm-level productivity in spain. *Journal of Economic Geography*, 12:1191–1215.

Holl, A. (2016). Highways and productivity in manufacturing firms. *Journal of Urban Economics*, 93:131–151.

Krugman, P. (1991). Increasing returns and economic geography. *Journal of Political Economy*, 99(3):483–499.

Krugman, P. and Venables, A. J. (1995). Globalization and the inequality of nations. *The Quarterly Journal of Economics*, 110(4):857–880.

Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, 70(2):317–341.

Li, H. and Li, Z. (2013). Road investments and inventory reduction: Firm level evidence from china. *Journal of Urban Economics*, 76:43–52.

Lucas, R. E. and Rossi-Hansberg, E. (2002). On the internal structure of cities. *Econometrica*, 70(4):1445–1476.

Manning, A. and Petrongolo, B. (2017). How local are labor markets? evidence from a spatial job search model. *American Economic Review*, 107(10):2877–2907.

Melo, P. C., Graham, D. J., and Noland, R. B. (2009). A meta-analysis of estimates of urban agglomeration economies. *Regional Science and Urban Economics*, 39(3):332–342.

Michaels, G. (2006). The Effect of Trade on the Demand for Skill - Evidence from the Interstate Highway System. CEP Discussion Papers dp0772, Centre for Economic Performance, LSE.

Olley, G. S. and Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, 64(6):1263–1297.

Puga, D. (2010). The magnitude and causes of agglomeration economies*. *Journal of Regional Science*, 50(1):203–219.

Redding, S. J. and Rossi-Hansberg, E. (2017). Quantitative spatial economics. *Annual Review of Economics*, 9(1):21–58.

Redding, S. J. and Turner, M. A. (2015). Chapter 20 - transportation costs and the spatial organization of economic activity. In Duranton, G., Henderson, J. V., and Strange, W. C., editors, *Handbook of Regional and Urban Economics*, volume 5 of *Handbook of Regional and Urban Economics*, pages 1339–1398. Elsevier.

Rich, J., Nielsen, O., Brems, C., and Hansen, C. (2010). Overall design of the Danish National transport model. Annual transport conference at aalborg university 2010.

Rosenthal, S. S. and Strange, W. C. (2001). The determinants of agglomeration. *Journal of Urban Economics*, 50(2):191–229.

Rosenthal, S. S. and Strange, W. C. (2004). Chapter 49 - evidence on the nature and sources of agglomeration economies. In Henderson, J. V. and Thisse, J.-F., editors, *Cities and Geography*, volume 4 of *Handbook of Regional and Urban Economics*, pages 2119–2171. Elsevier.

Shirley, C. and Winston, C. (2004). Firm inventory behavior and the returns from highway infrastructure investments. *Journal of Urban Economics*, 55(2):398–415.

Spiekermann, K., Wegener, M., Kveton, V., Marada, M., Schürmann, C., Biosca, O., Segui, U. U., Antikainen, H., Kotavaara, O., Rusanen, J., Bielanska, D., Fiorello, D., Komornicki, T., Rosik, P., and Stepniak, M. (2015). Transport Accessibility at Regional/Local Scale in Europe TRACC Scientific Report. working paper, Luxembourg: ESPON.

Tsivanidis, N. (2019). Evaluating the impact of urban transit infrastructure: evidence from Bogota's Transmilenio. working paper, University of California-Berkeley.

Wheeler, C. (2001). Search, sorting, and urban agglomeration. *Journal of Labor Economics*, 19(4):879–899.

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics Letters*, 104(3):112–114.

Wooldridge, J. M. (2015). Control Function Methods in Applied Econometrics. *Journal of Human Resources*, 50(2):420–445.

Online Appendix

Productivity and wage effects of an exogenous improvement in transport infrastructure: accessibility and the Great Belt Bridge

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Contents

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A Non-linear least squares estimation procedure

In our baseline empirical model, we assume that the firm- and year-specific estimates of total factor productivity $t\hat{f}p_{i,t}$ depend on the log of the accessibility index $a_{m(i),t}$, firm-fixed effects (γ_{i0}) and year-fixed effect (γ_t) (see section 3.3):

$$t\hat{f}p_{i,t} = \gamma_{i,0} + \gamma_1 a_{m(i),t} + \gamma_t + \varepsilon_{i,t} \tag{A.1}$$

where $m(i)$ denotes the municipality in which firm i is located. The accessibility index A is computed for each municipality as the weighted sum of full time equivalents (FTE's) in all municipalities:

$$A_m = \sum_{m'} FTE_{m',t} e^{-\delta d_{m,m',t}} \tag{A.2}$$

where d denotes distance measured in travel time minutes between municipalities; the 'distance decay' parameter is given by δ. This index takes the market potential form suggested by Harris (1954) and different versions of this index were used in Dekle and Eaton (1999), Ahlfeldt and Feddersen (2017) and in Lucas and Rossi-Hansberg (2002). Our estimation equation thus takes the following form:

$$t\hat{f}p_{i,t} = \gamma_{i,0} + \gamma_1 log\left(\sum_{m',t} FTE_{m',t} e^{-\delta d_{m,m',t}}\right) + \gamma_t + \varepsilon_{i,t}. \tag{A.3}$$

We follow Ciccone and Hall (1996) and Ahlfeldt and Feddersen (2017) and estimate the impact of the bridge on firm productivity, γ_1, the decay parameter, δ, and the other coefficients by Nonlinear Least Squares (NLS), see e.g. Amemiya (1974). Moreover, because we instrument the accessibility index with an alternative accessibility index that artificially eliminates all variability except that which is due to the opening of the bridge, and because this does not combine with the most popular way to use instrumental variables, we make use of the control function approach, in which the residual of the first-stage equation is added as an additional regressor to (A.3) (see Blundell and Powell, 2003; Wooldridge, 2015). Our instrument is the same accessibility specification, but now computed while keeping employment fixed at its 1995 value in all municipalities throughout Denmark. This ensures that the calculated change in accessibility between 1995 and 2002 only reflects the impact of the travel time changes due to the bridge.[1] The alternative accessibility index, which is strongly correlated with the initial one, 'purifies' the accessibility effect on productivity from changes that are potentially unrelated to the opening of the bridge. We apply a grid-search over different values of δ for the model (A.3). The objective is to identify the decay parameter δ that maximizes R^2. See section F for results of grid search over decay-parameter space. Standard errors have been computed using equation (12.52) in Wooldridge (2002).

[1] Recall that we only observe travel times referring to 2002 and take into account the impact of the opening of the bridge by decreasing the travel times of all trips crossing the bridge by the associated travel time savings.

B Supplementary tables and figures

B.1 Supplementary descriptives

Table B.1: Means and standard deviations for selected variables (1995-2002)

Year	Turnover (1000 DKK)	Full Time job Equivalents (FTE)	Capital (1000 DKK)
1995	11,763	11.82	2,953
	(55,292)	(46.29)	(20,543)
1996	11,607	11.46	2,834
	(57,283)	(43.99)	(18,448)
1997	11,821	11.54	2,971
	(50,330)	(39.44)	(26,081)
1998	11,881	11.43	2,872
	(51,171)	(40.27)	(18,398)
1999	11,958	11.25	2,981
	(55,238)	(38.19)	(21,762)
2000	11,812	10.99	3,037
	(49,108)	(34.65)	(36,155)
2001	11,940	11.01	3,237
	(53,096)	(35.28)	(37,571)
2002	11,829	10.63	3,261
	(52,177)	(32.79)	(28,934)

Note: Number of observations is 200,177. Standard deviations are in parentheses. Note that 1 Danish crown (denoted DKK) $\approx$ 0.13 EUR.

Table B.2: Means and standard deviations for selected variables (four-digit NACE sectors)

	Turnover (1000 DKK)	Full Time job Equivalents (FTE)	Capital (1000 DKK)
Mfr. of food, beverages and tobacco	35,187	20.49	9,412
	(99,341)	(56.46)	(69,227)
Mfr. of textiles and leather	17,589	14.57	5,635
	(64,374)	(32.68)	(30,458)
Mfr. of paper prod.; printing and publish.	14,980	12.38	3,757
	(43,298)	(26.30)	(16,304)
Mfr. of chemicals	60,120	35.06	23,770
	(173,219)	(98.24)	(95,865)
Mfr. of other non-metallic mineral prod.	18,897	17.46	6,827
	(50,782)	(45.27)	(26,371)
Mfr. and processing of basic metals	14,650	16.77	4,412
	(47,764)	(43.83)	(31,485)
Mfr. of machinery and equipment	24,646	26.29	7,084
	(70,843)	(70.35)	(41,525)
Mfr. of electronic components	23,871	22.78	8,028
	(85,149)	(58.39)	(60,014)
Mfr. of transport equipment	42,209	38.23	9,350
	(249,823)	(181.95)	(67,311)
Mfr. of furniture; manufacturing n.e.c.	15,975	17.54	4,281
	(82,990)	(60.85)	(20,886)
Construction	6,607	7.65	1,102
	(14,587)	(12.74)	(3,605)
Wholesale and retail trade	5,618	3.95	1,231
	(11,062)	(5.00)	(15,961)

Note: Number of observations is 200,177. Standard deviations are in parentheses. Note that 1 Danish crown (denoted DKK) $\approx$ 0.13 EUR.

Table B.3: Means and standard deviations for selected variables by region

Year		1995	1996	1997	1998	1999	2000	2001	2002
Zealand and	Turnover (1000 DKK)	10,389	9,88	10,035	10,097	10,175	10,079	10,012	9,903
Bornholm		(42,496)	(35,568)	(36,979)	(36,696)	(38,097)	(37,612)	(41,633)	(35,643)
	Full Time job Equivalents	10.40	9.85	9.91	9.62	9.55	9.35	9.22	9.04
		(34.39)	(28.15)	(28.61)	(26.43)	(26.76)	(23.42)	(23.81)	(24.96)
	Capital (1000 DKK)	2,638	2,431	2,420	2,467	2,580	2,955	3,038	2,750
		(21,039)	(15,845)	(14,423)	(15,350)	(17,480)	(47,200)	(47,081)	(22,691)
Funen	Turnover (1000 DKK)	11,665	12,528	12,516	13,074	13,289	13,653	14,322	14,901
		(67,793)	(96,166)	(82,557)	(82,733)	(96,384)	(82,024)	(97,880)	(111,328)
	Full Time job Equivalents	13.11	13.21	13.16	13.58	13.15	13.04	13.36	13.21
		(73.37)	(74.81)	(72.88)	(72.78)	(65.71)	(62.46)	(66.68)	(65.46)
	Capital (1000 DKK)	3,323	3,259	4,679	3,400	3,277	3,269	3,806	4,672
		(23,298)	(23,378)	(39,443)	(24,420)	(23,611)	(24,197)	(28,252)	(25,936)
South	Turnover (1000 DKK)	15,005	14,960	14,475	14,487	14,542	13,950	14,069	13,097
Jutland		(94,466)	(97,121)	(67,011)	(71,835)	(68,447)	(66,198)	(66,219)	(56,563)
	Full Time job Equivalents	13.62	13.56	12.88	13.14	13.08	12.49	12.50	11.49
		(69.68)	(68.64)	(43.24)	(53.02)	(47.80)	(42.83)	(42.40)	(31.06)
	Capital (1000 DKK)	3,511	3,645	3,473	3,327	3,560	3,075	3,242	3,200
		(23,065)	(24,941)	(21,007)	(19,454)	(23,074)	(18,577)	(20,052)	(17,653)
East	Turnover (1000 DKK)	11,551	11,554	11,729	11,616	11,604	11,528	12,146	12,671
Jutland		(42,388)	(41,476)	(41,980)	(38,677)	(36,943)	(35,115)	(39,219)	(43,622)
	Full Time job Equivalents	11.86	11.70	11.92	11.80	11.37	11.22	11.54	11.30
		(36.62)	(35.82)	(36.77)	(36.12)	(31.13)	(30.62)	(31.02)	(29.74)
	Capital (1000 DKK)	2,897	2,615	2,644	2,733	3,010	3,151	3,358	3,622
		(18,195)	(12,347)	(10,447)	(15,795)	(27,239)	(35,665)	(38,459)	(37,768)
West and	Turnover (1000 DKK)	12,264	12,207	13,134	13,161	13,325	13,134	13,122	12,904
North		(39,749)	(38,505)	(46,409)	(48,478)	(60,116)	(44,664)	(44,330)	(42,930)
Jutland	Full Time job Equivalents	12.64	12.17	12.73	12.52	12.38	12.09	12.15	11.62
		(35.67)	(33.50)	(36.08)	(35.59)	(38.45)	(32.54)	(32.40)	(28.99)
	Capital (1000 DKK)	3,038	3,014	3,181	3,205	3,214	2,990	3,298	3,464
		(17,948)	(18,991)	(20,166)	(21,418)	(22,964)	(22,577)	(27,043)	(29,537)

Notes: Number of observations is 200,177. Std. dev. is in parenthesis. 1 DKK $\approx$ 0.13 EUR.

Table B.4: Means for selected variables by four-digit NACE sectors and their segments

NACE four-digit sectors	Segments	Turnover (1000 DKK)	FTE
Mfr. of food, beverages and tobacco	Production etc. of meat and meat products	47.114	27,06
	Mfr. of dairy products	63.734	24,27
	Bakers shops	3.677	6,61
	Mfr. of other food products	69.234	36,27
	Mfr. of beverages	85.508	42,57
	Mfr. of tobacco products	63.095	57,86
Mfr. of textiles and leather	Mfr. of textiles	17.710	16,30
	Mfr. of wearing apparel	14.525	11,57
	Mfr. of leather and footwear	31.620	18,08
Mfr. of paper prod.; printingand publish.	Mfr. of pulp, paper and paper products	52.118	31,96
	Publishing of newspapers	42.565	43,86
	Publishing activities, excluding newspapers	13.350	9,66
	Printing activities	9.552	10,09
Mfr. of chemicals	Mfr. of chemical raw materials	98.537	48,40
	Mfr. of paints and soap	47.306	28,73
	Mfr. of pharmaceuticals	60.367	40,58
Mfr. of other non-metallic mineral prod.	Mfr. of glass and ceramic goods	21.459	19,85
	Mfr. of tiles, bricks, cement and concrete	17.646	16,29
Mfr. and processing of basic metals	Mfr. of basic metals	50.187	44,46
	Mfr. of building materials of metal	10.896	13,11
	Mfr. of various metal products	16.850	20,23
Mfr. of machinery and equipment	Mfr. of marine engines and compressors	36.565	40,01
	Mfr. of ovens and cold-storage plants	28.667	29,11
	Mfr. of agricultural machinery	16.359	17,36
	Mfr. of machinery for industries	18.167	20,01
	Mfr. of domestic appliances	65.877	72,93
Mfr. of electronic components	Mfr. of computers and electric motors	18.529	17,60
	Mfr. of radio and communication equipment	54.018	49,94
	Mfr. of medical and optical instruments	21.090	20,81
Mfr. of transport equipment	Building of ships and boats	45.488	40,95
	Mfr. of transport equipment, excl. ships	39.217	35,74
Mfr. of furniture; manufacturing n.e.c.	Mfr. of furniture	17.438	20,05
	Mfr. of toys and jewellery	12.647	11,81
Construction	General contractors	12.932	11,42
	Bricklaying	4.824	6,22
	Install. of electrical wiring and fittings	6.995	9,28
	Plumbing	5.922	7,28
	Joinery installation	5.729	6,59
	Painting and glazing	3.208	6,48
Wholesale and retail trade	Re. sale of furniture and household appliances	7.358	4,93
	Re. sale in other specialized stores	4.905	3,44
	Repair of household goods	3.197	3,52

Notes: 1 DKK $\approx$ 0.13 EUR.

Table B.5: Means and standard deviations for selected variables for stayers and movers

	Turnover (1000 DKK)	FTE	Capital (1000 DKK)	Number of obs.
All firms	11,905	11.12	2,935	200,177
	(51,008)	(38.19)	(25,791)	
Stayers	11,862	11.08	2,933	193,277
	(51,609)	(38.66)	(26,076)	
Movers	12,874	12.22	2,977	6,900
	(34,690)	(25.48)	(18,149)	

Notes: Std. dev. is in parenthesis. 1 DKK $\approx$ 0.13 EUR.

B.2 Estimation production functions

Table B.6: Production function estimation: empirical results

	Levinsohn-Petrin			De Loecker (βs)				De Loecker (αs)			Wald test of CRS De Loecker	No. of obs.
Sector	Labour	Capital	Energy and rent	Labour	Capital	Energy and rent	Output	Labour	Capital	Energy and rent	χ^2	
Mfr. of food, bever.	0.349***	0.187***	0.296***	0.330***	0.151***	0.283*	0.211***	0.418***	0.191***	0.359*	0.03	6,395
and tobacco	(0.013)	(0.015)	(0.050)	(0.018)	(0.020)	(0.159)	(0.011)	(0.024)	(0.025)	(0.202)	(p = 0.8655)	
Mfr. of textiles	0.505***	0.223***	0.143***	0.499***	0.161***	0.199***	0.112***	0.562***	0.182***	0.224***	0.98	4,943
and leather	(0.009)	(0.020)	(0.039)	(0.014)	(0.019)	(0.017)	(0.018)	(0.022)	(0.022)	(0.019)	(p = 0.3220)	
Mfr. of paper prod.;	0.489***	0.154***	0.232***	0.493***	0.140***	0.248***	0.226***	0.638***	0.181***	0.321***	4.27	12,200
printing and publish.	(0.008)	(0.008)	(0.025)	(0.012)	(0.009)	(0.004)	(0.041)	(0.042)	(0.012)	(0.031)	(p = 0.0388)	
Mfr. of chemicals	0.514***	0.108***	0.372***	0.527***	0.156***	0.399***	0.009	0.532***	0.158***	0.403***	0.61	1,681
	(0.018)	(0.015)	(0.051)	(0.035)	(0.053)	(0.019)	(0.010)	(0.035)	(0.054)	(0.120)	(p = 0.4342)	
Mfr. of other non-	0.608***	0.162***	0.114***	0.622***	0.179***	0.059**	0.089***	0.683***	0.196***	0.065**	2.70	2,829
metallic prod.	(0.013)	(0.019)	(0.022)	(0.024)	(0.030)	(0.024)	(0.016)	(0.031)	(0.032)	(0.027)	(p = 0.1003)	
Mfr. and processing	0.546***	0.121***	0.286***	0.539***	0.118***	0.226***	0.118***	0.545***	0.119***	0.228***	29.97	16,026
of basic metals	(0.006)	(0.007)	(0.023)	(0.010)	(0.004)	(0.017)	(0.004)	(0.010)	(0.009)	(0.017)	(p < 0.0001)	
Mfr. of machinery	0.512***	0.131***	0.226***	0.504***	0.118***	0.197***	0.058***	0.535***	0.125***	0.209***	33.16	10,649
and equipment	(0.007)	(0.010)	(0.023)	(0.012)	(0.011)	(0.021)	(0.005)	(0.013)	(0.012)	(0.022)	(p < 0.0001)	
Mfr. of electronic	0.482***	0.184***	0.287***	0.477***	0.112***	0.457***	0.046***	0.500***	0.118***	0.479***	2.06	8,139
components	(0.009)	(0.012)	(0.029)	(0.014)	(0.019)	(0.072)	(0.008)	(0.014)	(0.020)	(0.076)	(p = 0.1511)	
Mfr. of transport	0.516***	0.172***	0.124**	0.517***	0.151***	0.155***	0.105***	0.577***	0.168***	0.173***	1.78	2,542
equipment	(0.014)	(0.022)	(0.054)	(0.024)	(0.020)	(0.039)	(0.024)	(0.036)	(0.024)	(0.043)	(p = 0.1826)	
Mfr. of furniture	0.467***	0.138***	0.243***	0.459***	0.133***	0.247***	0.002	0.460***	0.133***	0.247***	42.06	7,162
	(0.008)	(0.011)	(0.030)	(0.013)	(0.014)	(0.026)	(0.002)	(0.012)	(0.014)	(0.025)	(p < 0.0001)	
Construction	0.524***	0.121***	0.295***	0.524***	0.110***	0.353***	0.024***	0.537***	0.113***	0.361***	0.04	89,298
	(0.003)	(0.003)	(0.009)	(0.005)	(0.007)	(0.062)	(0.002)	(0.005)	(0.007)	(0.063)	(p = 0.8387)	
Other retail sale,	0.406***	0.116***	0.249***	0.467***	0.102***	0.342***	0.029***	0.481***	0.105***	0.352***	4.07	38,313
repair work	(0.005)	(0.005)	(0.016)	(0.013)	(0.006)	(0.0.027)	(0.005)	(0.014)	(0.007)	(0.028)	(p = 0.0435)	

Notes: Number of observations is 193,277. Standard errors are in parentheses. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively.

Table B.7: Summary statistics for the log of total factor productivity (tfp), by year

	Levinsohn-Petrin		De Loecker	
Year	Mean	Std. Dev.	Mean	Std. Dev.
1995	5.630	0.465	4.916	1.018
1996	5.604	0.460	4.898	1.021
1997	5.608	0.436	4.895	0.994
1998	5.643	0.445	4.949	0.998
1999	5.621	0.431	4.925	0.992
2000	5.647	0.460	4.963	0.997
2001	5.603	0.441	4.951	0.988
2002	5.604	0.444	4.946	0.970

Notes: Notes: Number of observations: 193,277.

Table B.8: Summary statistics for the log of total factor productivity (tfp), by year and region

Year	Zealand and Bornholn	Funen	South Jutland	East Jutland	West and North Jutland
	Levinsohn-Petrin				
1995	5.599	5.622	5.669	5.618	5.674
	(0.471)	(0.451)	(0.461)	(0.458)	(0.460)
1996	5.572	5.594	5.634	5.599	5.650
	(0.458)	(0.447)	(0.462)	(0.465)	(0.460)
1997	5.577	5.605	5.627	5.608	5.652
	(0.433)	(0.427)	(0.434)	(0.440)	(0.437)
1998	5.614	5.639	5.662	5.640	5.688
	(0.446)	(0.440)	(0.445)	(0.443)	(0.444)
1999	5.591	5.615	5.646	5.620	5.663
	(0.430)	(0.426)	(0.438)	(0.426)	(0.428)
2000	5.619	5.651	5.673	5.644	5.680
	(0.466)	(0.451)	(0.444)	(0.459)	(0.460)
2001	5.587	5.591	5.612	5.591	5.640
	(0.444)	(0.445)	(0.423)	(0.437)	(0.445)
2002	5.589	5.594	5.603	5.606	5.637
	(0.443)	(0.454)	(0.436)	(0.459)	(0.435)
	De Loecker				
1995	4.842	4.969	4.994	4.906	4.982
	(1.068)	(0.933)	(0.988)	(1.052)	(0.943)
1996	4.828	4.930	4.957	4.895	4.975
	(1.063)	(0.947)	(0.991)	(1.069)	(0.946)
1997	4.828	4.941	4.938	4.905	4.963
	(1.040)	(0.917)	(0.961)	(1.040)	(0.917)
1998	4.891	4.988	4.986	4.951	5.010
	(1.037)	(0.934)	(0.964)	(1.043)	(0.935)
1999	4.863	4.971	4.977	4.924	4.985
	(1.033)	(0.919)	(0.966)	(1.037)	(0.922)
2000	4.908	5.018	5.010	4.963	5.010
	(1.041)	(0.918)	(0.970)	(1.044)	(0.922)
2001	4.910	4.987	4.980	4.934	5.004
	(1.028)	(0.925)	(0.950)	(1.038)	(0.922)
2002	4.911	4.973	4.958	4.944	4.992
	(1.000)	(0.920)	(0.940)	(1.028)	(0.907)

Notes: Notes: Number of observations: 193,277. Std. dev. are in parenthesis.

C First-stage results for the IV regressions

Table C.1: First stage – control function – estimation results for table 6 (firm fixed effect models for accessibility impact on firm-level tfp)

Dep. var.	log(A)	log(A)
δ	0.012	0.017
	[1]	[2]
log[A(FTE's fixed at 1995 level)], instrument	1.050***	1.058***
	(0.001)	(0.001)
Firm-fixed effect	Yes	Yes
Year-fixed effect	Yes	Yes
F test of excluded instruments	1.4e+06	1.4e+06
Anderson canon. corr. LM statistic (χ^2)	1.8e+05	1.8e+05
Cragg-Donald Wald F statistic	1.4e+06	1.4e+06
Number of obs.	193,277	193,277

Notes: Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

Table C.2: First stage – control function – estimation results for table 8 (Firm fixed effect models for accessibility impact on firm-level TFP for different regions)

	Zealand and Bornholm	Funen	South Jutland	East Jutland	West and North Jutland
Dep. var.	log(A)	log(A)	log(A)	log(A)	log(A)
δ	0.006	0.071	0.013	0.072	0.030
	[1]	[2]	[3]	[4]	[5]
log[A(FTE's fixed at 1995 level)], instrument	1.035***	1.075**	1.052***	1.075***	1.066***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
F test of excluded instruments	1.4e+06	1.1e+06	1.4e+06	1.1e+06	1.3e+06
Anderson canon. corr. LM stat. (χ^2)	1.8e+05	1.7e+05	1.8e+05	1.7e+05	1.8e+05
Cragg-Donald Wald F statistic	1.4e+06	1.1e+06	1.4e+06	1.1e+06	1.3e+06
Number of obs.	76,632	17,261	28,044	29,452	41,888

Notes: Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

Table C.3: First stage – control function – estimation results for table 9 (firm fixed effect models for accessibility impact on firm-level tfp for considered NACE one-digit sectors)

	Manufacturing	Construction	Retail
Dep. var.	log(A)	Log(A)	Log(A)
δ	0.024	0.009	0.026
	[1]	[2]	[3]
log[A(FTE's fixed at 1995 level)], instrument	1.064***	1.043***	1.062***
	(0.001)	(0.001)	(0.001)
Firm-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
F test of excluded instruments	1.3e+06	1.4e+06	1.4e+06
Anderson canon. corr. LM statistic (χ^2)	1.8e+05	1.8e+05	1.8e+05
Cragg-Donald Wald F statistic	1.3e+06	1.4e+06	1.4e+06
Number of obs.	69,642	86,564	37,071

Notes: Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

Table C.4: First step – control function – estimation results for table 10 (firm fixed effect models for accessibility impact on firm-level tfp for small, medium and large firms)

	<50 FTEs	50-250 FTEs	>250 FTEs
Dep. var.	log(A)	Log(A)	Log(A)
δ	0.017	0.040	0.032
	[1]	[2]	[3]
log[A(FTE's fixed at 1995 level)], instrument	1.058***	1.069***	1.067***
	(0.001)	(0.001)	(0.001)
Firm-fixed effect	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes
F test of excluded instruments	1.4e+06	1.2e+06	1.3e+06
Anderson canon. corr. LM statistic (χ^2)	1.8e+05	1.8e+05	1.8e+05
Cragg-Donald Wald F statistic	1.4e+06	1.2e+06	1.3e+06
Number of obs.	144,603	41,764	6,910

Notes: Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

D Control for highway access changes

Although we do have information on access to the nearest highway ramp over the sample period, we can only introduce this extra explanatory variable as a robustness check for our accessibility coefficients. There are two reasons for this. First, unlike previous authors, we do not have appropriate instruments to correct for the possible endogeneity of access to the nearest highway ramp. Second, for several regions, including Funen – a region of particular interest close to the bridge – we observe zero changes in this variable over the sample period.

When we introduced the change in highway access in the model for the country as a whole, doing so had no effect whatsoever on the coefficient of accessibility, see Table D.1.

Table D.1: Firm fixed effect models for accessibility impact on firm-level De Loecker tfp with control for highways

	[1]
log(A), instrumented	0.011***
	(0.002)
log (distance to nearest highway)	0.006
	(0.004)
e	0.014**
	(0.006)
δ	0.016***
	(0.005)
Firm-fixed effect	Yes
Year-fixed effect	Yes
Number of obs.	193,277

Notes: Notes: Dependent variable is logarithm of (De Loecker) tfp; the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table D.2 for first-stage regression estimates ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors are in parentheses.

Table D.2: First step – control function – estimation results for table D.1 (firm fixed effect models for accessibility impact on firm-level De Loecker tfp with control for highways)

Dep. var.	Log(A)
δ	0.016
	[1]
log[*A*(*FTE's fixed at 1995 level*)], *instrument*	1.056***
	(0.001)
Firm-fixed effect	Yes
Year-fixed effect	Yes
F test of excluded instruments	1.4e+06
Anderson canon. corr. LM statistic χ^2	1.8e+05
Cragg-Donald Wald F statistic	1.4e+06
Number of obs.	193,277

Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

E Wage regressions: supplementary tables

Table E.1: Descriptive statistics for workers, means and std. dev. in parenthesis

	All workers	Job and residence stayers	Residence movers	Job movers	Residence and job movers	Residence stayers and job movers cross the bridge
Hourly wage (DKK/hour)	167.081	161.291	186.941	191.792	198.495	192.259
	(55.300)	(52.019)	(61.640)	(62.535)	(65.173)	(64.579)
Hourly wage in 1995 (DKK/hour)	151.125	148.279	172.245	165.852	174.469	167.367
	(45.702)	(42.957)	(52.930)	(48.645)	(49.956)	(52.672)
Hourly wage in 2002 (DKK/hour)	194.417	188.352	213.302	215.415	229.469	226.326
	(58.7443)	(53.588)	(64.893)	(55.497)	(67.456)	(66.785)
Difference in hourly wage between 1995 and 2002	43.292	40.072	41.058	49.563	55.027	58.959
	(36.859)	(28.262)	(40.369)	(44.274)	(48.429)	(54.600)
t-test for the diff. in wages	912.995	809.453	195.947	133.268	46.586	61.076
Male (share)	0.547	0.544	0.580	0.613	0.611	0.726
	(0.498)	(0.498)	(0.494)	(0.487)	(0.488)	(0.446)
Age (year)	41.473	41.483	38.520	41.619	39.912	39.056
	(10.304)	(10.337)	(9.443)	(9.509)	(8.555)	(10.052)
One child (share)	0.210	0.210	0.212	0.212	0.216	0.205
	(0.407)	(0.407)	(0.409)	(0.408)	(0.412)	(0.404)
Two children (share)	0.233	0.232	0.253	0.183	0.202	0.237
	(0.423)	(0.422)	(0.435)	(0.387)	(0.401)	(0.425)
Three children (share)	0.053	0.054	0.056	0.036	0.040	0.054
	(0.225)	(0.225)	(0.230)	(0.187)	(0.197)	(0.225)
More than 3 children (share)	0.008	0.008	0.008	0.005	0.006	0.007
	(0.087)	(0.088)	(0.087)	(0.073)	(0.077)	(0.086)
Married couples (share)	0.584	0.584	0.436	0.603	0.545	0.561
	(0.493)	(0.493)	(0.496)	(0.489)	(0.496)	(0.496)
Registered partnership (share)	0.001	0.001	0.002	0.003	0.002	0.001
	(0.035)	(0.033)	(0.039)	(0.051)	(0.048)	(0.034)
Couple living in consensual union (share)	0.069	0.067	0.074	0.083	0.076	0.069
	(0.253)	(0.249)	(0.261)	(0.276)	(0.280)	(0.254)
Cohabiting couples (share)	0.113	0.106	0.118	0.211	0.210	0.145
	(0.316)	(0.308)	(0.323)	(0.408)	(0.407)	(0.352)
Singles (share)	0.234	0.234	0.221	0.274	0.258	0.223
	(0.423)	(0.424)	(0.415)	(0.446)	(0.437)	(0.416)
Number of obs.	8,610,211	6,648,714	624,083	1,639,533	302,119	46.454

Notes: Note that 1 Danish crown (denoted DKK) $\approx$ 0.13 EUR. The test hypothesis for t-test for the difference in hourly wages between 1995 and 2002 is $H_0 : mean(diff\ in\ hourly\ wages) = 0$.

Table E.2: First step – control function – estimation results for table 12 (Mincerian wage regression, worker fixed effects)

	All workers	All workers	Job and residence stayers
Dep. var.	log(A)	log(A)	log(A)
δ	0.163	0.787	0.145
	[1]	[2]	[3]
log[A(FTE's fixed at 1995 level)], instrument	1.127*** (0.001)	1.052*** (0.001)	1.221*** (0.001)
Worker fix effect	Yes	Yes	Yes
Year fix effect	Yes	Yes	Yes
F test of excluded instruments	1.6e+06	2.8e+06	6.7e+05
Anderson canon. corr. LM statistic (χ^2)	3.0e+05	3.1e+05	2.2e+05
Cragg-Donald Wald F statistic	1.6e+06	2.8e+06	6.7e+05
Number of obs.	8,610,211	8,610,211	6,648,714

Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

Table E.3: Mincerian wage regression for different regions for job and residence stayers, worker fixed effect

	[1] Zealand and Bornholm	[2] Funen	[3] South Jutland	[4] East Jutland	[5] West and North Jutland
log(A)	0.011***	0.015***	0.003	0.026***	0.003
	(0.001)	(0.006)	(0.051)	(0.007)	(0.008)
Dummy variable indicating 1 child	0.020***	0.018***	0.016***	0.015***	0.016***
	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
Dummy variable indicating 2 children	0.033***	0.026***	0.029***	0.023***	0.023***
	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
Dummy variable indicating 3 children	0.039***	0.027***	0.036***	0.025***	0.033***
	(0.004)	(0.008)	(0.006)	(0.006)	(0.005)
Dummy variable indicating more than 3 children	0.044***	0.061***	0.040***	0.050***	0.018*
	(0.008)	(0.023)	(0.010)	(0.014)	(0.011)
Dummy indicating registered partnership	0.019	-0.009	-0.053***	-0.031	-0.011
	(0.017)	(0.030)	(0.016)	(0.021)	(0.010)
Dummy indicating couple living in consensual un	-0.014***	-0.008	-0.014***	-0.019***	-0.009**
	(0.003)	(0.007)	(0.005)	(0.005)	(0.005)
Dummy indicating cohabiting couples	-0.005**	-0.001	-0.007*	-0.009*	-0.009**
	(0.002)	(0.006)	(0.004)	(0.004)	(0.004)
Dummy indicating singles	-0.001	0.007	-0.001	-0.002	-0.002***
	(0.002)	(0.006)	(0.004)	(0.004)	(0.003)
e	0.002	0.006	-0.002	-0.004	0.008
	(0.002)	(0.008)	(0.019)	(0.007)	(0.013)
δ	0.641**	0.204*	0.550**	0.237	0.249
	(0.281)	(0.121)	(0.288)	(0.279)	(0.218)
Time-variant controls	Yes	Yes	Yes	Yes	Yes
Worker-fixed effect	Yes	Yes	Yes	Yes	Yes
Year-fixed effect	Yes	Yes	Yes	Yes	Yes
Number of obs.	3,031,573	550,148	921,929	969,331	1,175,733

Note: Dependent variable is logarithm of hourly wage, the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table E.5 for first-stage regression estimates. ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors are in parentheses.

Table E.4: Mincerian wage regression for different sectors for job and residence stayers, worker fixed effect

	[1] Manufacturing	[2] Construction	[3] Retail
log(A), instrumented	0.006***	0.011**	0.011***
	(0.002)	(0.005)	(0.003)
Dummy variable indicating 1 child	0.017***	0.017***	0.026***
	(0.002)	(0.005)	(0.003)
Dummy variable indicating 2 children	0.026***	0.031***	0.037***
	(0.003)	(0.006)	(0.004)
Dummy variable indicating 3 children	0.038***	0.037***	0.036***
	(0.005)	(0.011)	(0.008)
Dummy variable indicating more than 3 children	0.042***	0.056***	0.053**
	(0.012)	(0.022)	(0.026)
Dummy indicating registered partnership	-0.004	-0.001	0.033
	(0.065)	(0.040)	(0.041)
Dummy indicating couple living in consensual union	-0.018***	-0.003	-0.016***
	(0.005)	(0.009)	(0.005)
Dummy indicating cohabiting couples	-0.017***	-0.0002	-0.007
	(0.004)	(0.009)	(0.005)
Dummy indicating singles	-0.001	-0.008	-0.0003
	(0.004)	(0.009)	(0.005)
e	0.005	0.001	-0.018***
	(0.006)	(0.011)	(0.007)
δ	0.384***	0.690***	0.969***
	(0.043)	(0.120)	(0.211)
Worker fix effect	Yes	Yes	Yes
Year fix effect	Yes	Yes	Yes
Numer of obs.	1,410,582	319,337	877,517

Notes: Dependent variable is logarithm of hourly wage, the accessibility measure (A) is instrumented using the accessibility index that artificially eliminates all variability except that which is due to the change in infrastructure (the opening of the bridge), keeping employment fixed in all municipalities throughout Denmark. See Table E.6 for first-stage regression estimates ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels respectively; standard errors are in parentheses.

Table E.5: First step – control function – estimation results for table 13 (Mincerian wage regression for different regions for job and residence stayers, worker fixed effect)

	Zealing and Bornholm	Funen	South Jutland	East Jutland	West and North Jutland
Dep. var.	log(A)	log(A)	log(A)	log(A)	log(A)
δ	0.826	0.201	0.550	0.196	0.249
	[1]	[2]	[3]	[4]	[5]
log[A (FTE92s fixed at 1995 level)], instrument	1.465***	1.113***	0.790***	1.631***	1.019***
	(0.004)	(0.005)	(0.030)	(0.012)	(0.007)
Worker fix effect	Yes	Yes	Yes	Yes	Yes
Year fix effect	Yes	Yes	Yes	Yes	Yes
F test of excluded instruments	1.2e+05	4.6e+04	6.8e+02	1.9e+04	1.9e+04
Anderson canon. corr. LM statistic (χ^2)	7.8e+04	1.7e+04	1.2e+03	1.8e+04	2.0e+04
Cragg-Donald Wald F statistic	1.2e+05	4.6e+04	6.8e+02	1.9e+04	2.0e+04
Number of obs.	3,031,573	550,148	921,929	969,331	1,175,733

Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

Table E.6: First step – control function – estimation results for table E.4 (Mincerian wage regression for different sectors for job and residence stayers, worker fixed effect)

	Manufacturing	Construction	Retail
log(A)	log(A)	log(A)	log(A)
δ	0.384	0.690	0.969
	[1]	[2]	[3]
log[A(FTE's fixed at 1995 level)], instrument	1.435***	1.549***	1.979***
	(0.007)	(0.024)	(0.016)
Worker fix effect	Yes	Yes	Yes
Year fix effect	Yes	Yes	Yes
F test of excluded instruments	3.6e+04	4.1e+03	1.5e+04
Anderson canon. corr. LM statistic (χ^2)	3.0e+04	4.5e+03	1.5e+04
Cragg-Donald Wald F statistic	3.7e+04	4.1e+03	1.5e+04
Number of obs.	1,410,582	319,337	877,517

Notes: ***, **, * indicate that estimates are significantly different from zero at the 0.01, 0.05 and 0.10 levels, respectively; standard errors clustered at the municipality level are in parentheses.

F Grid search over decay-parameter space

Figure F.1: Grid search over decay-parameter space for table 6 (firm fixed effect models for accessibility impact on firm-level tfp)

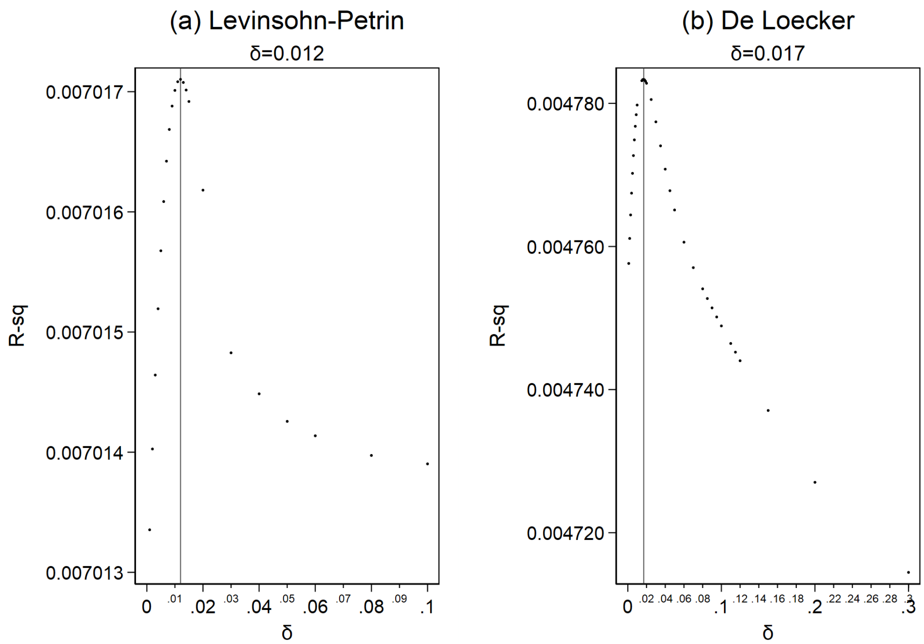
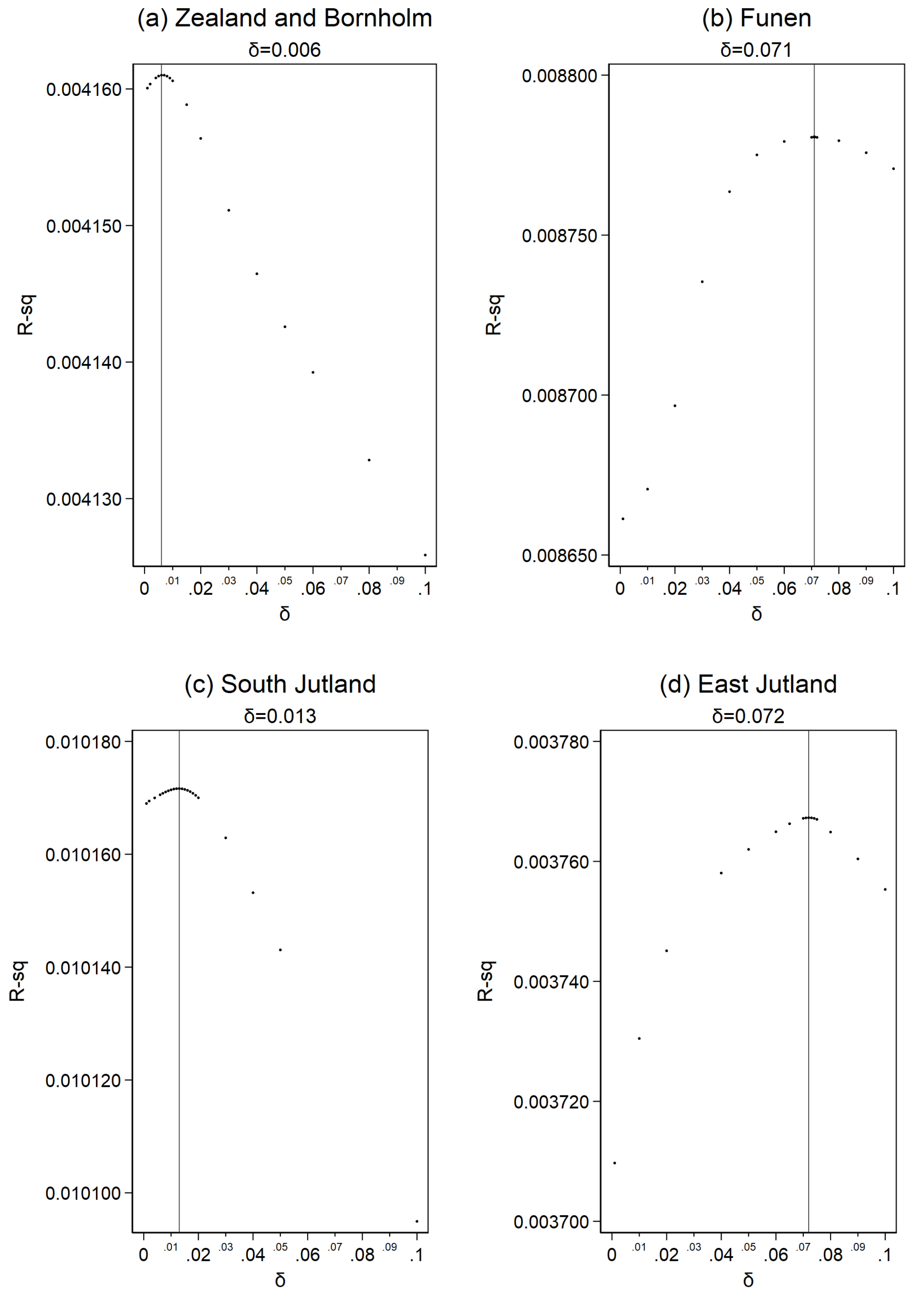


Figure F.2: Grid search over decay-parameter space for table 8 (firm fixed effect models for accessibility impact on firm-level TFP for different regions)



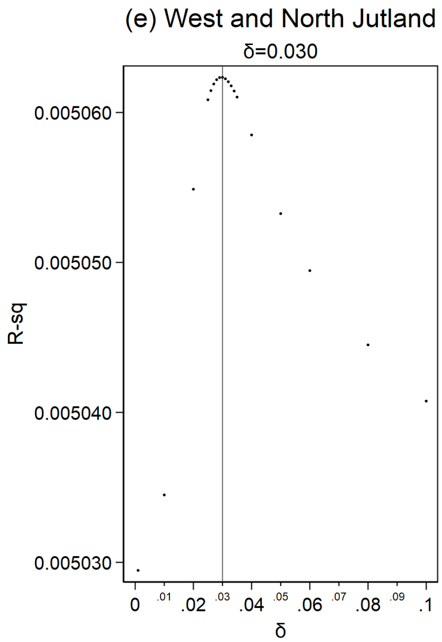

(e) West and North Jutland
δ=0.030
R-sq
0.005060
0.005050
0.005040
0.005030
0
.01
.02
.03
.04
.05
.06
.07
.08
.09
.1
δ

Figure F.3: Grid search over decay-parameter space for table 9 (firm fixed effect models for accessibility impact on firm-level tfp for considered NACE one-digit sectors)

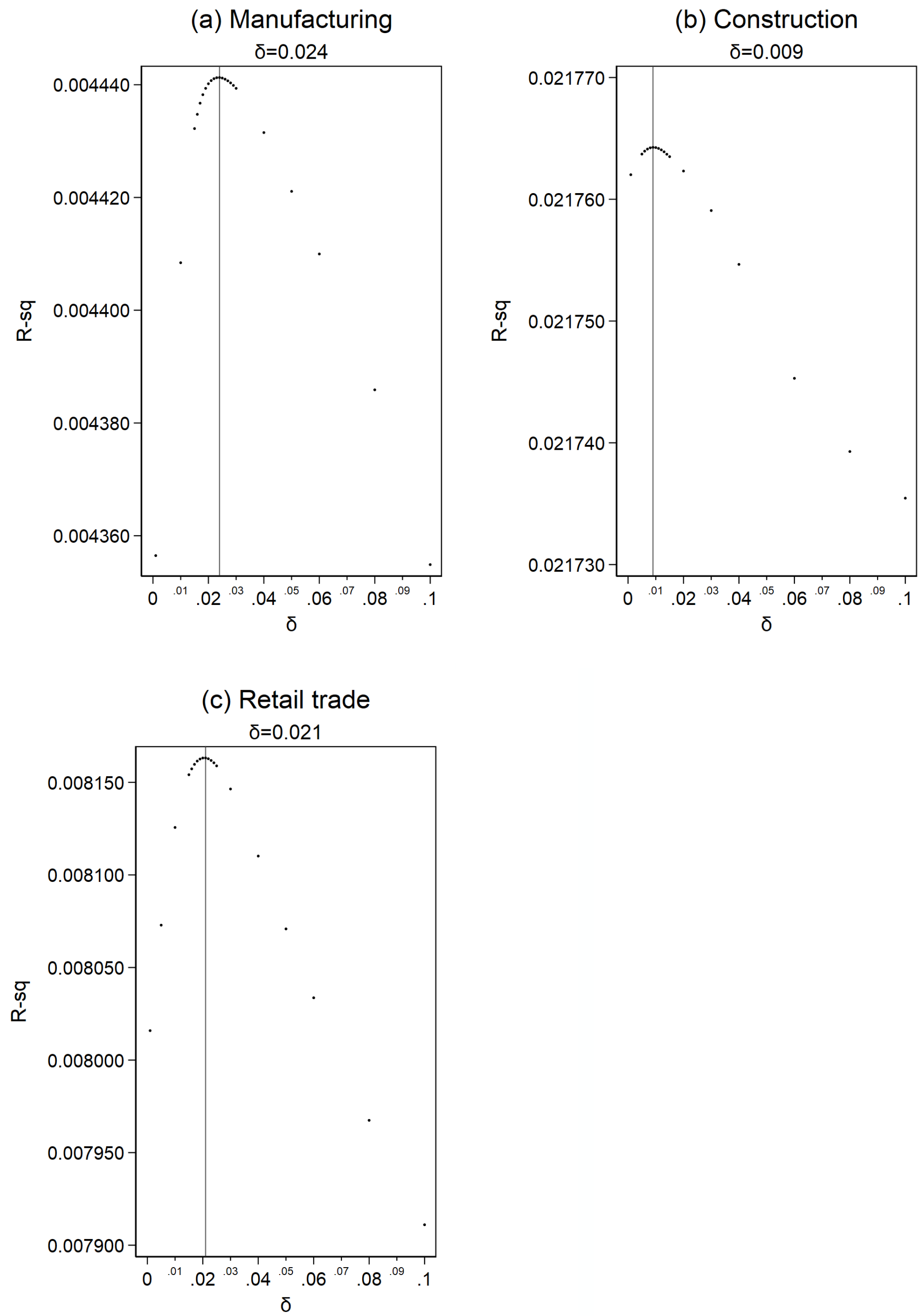
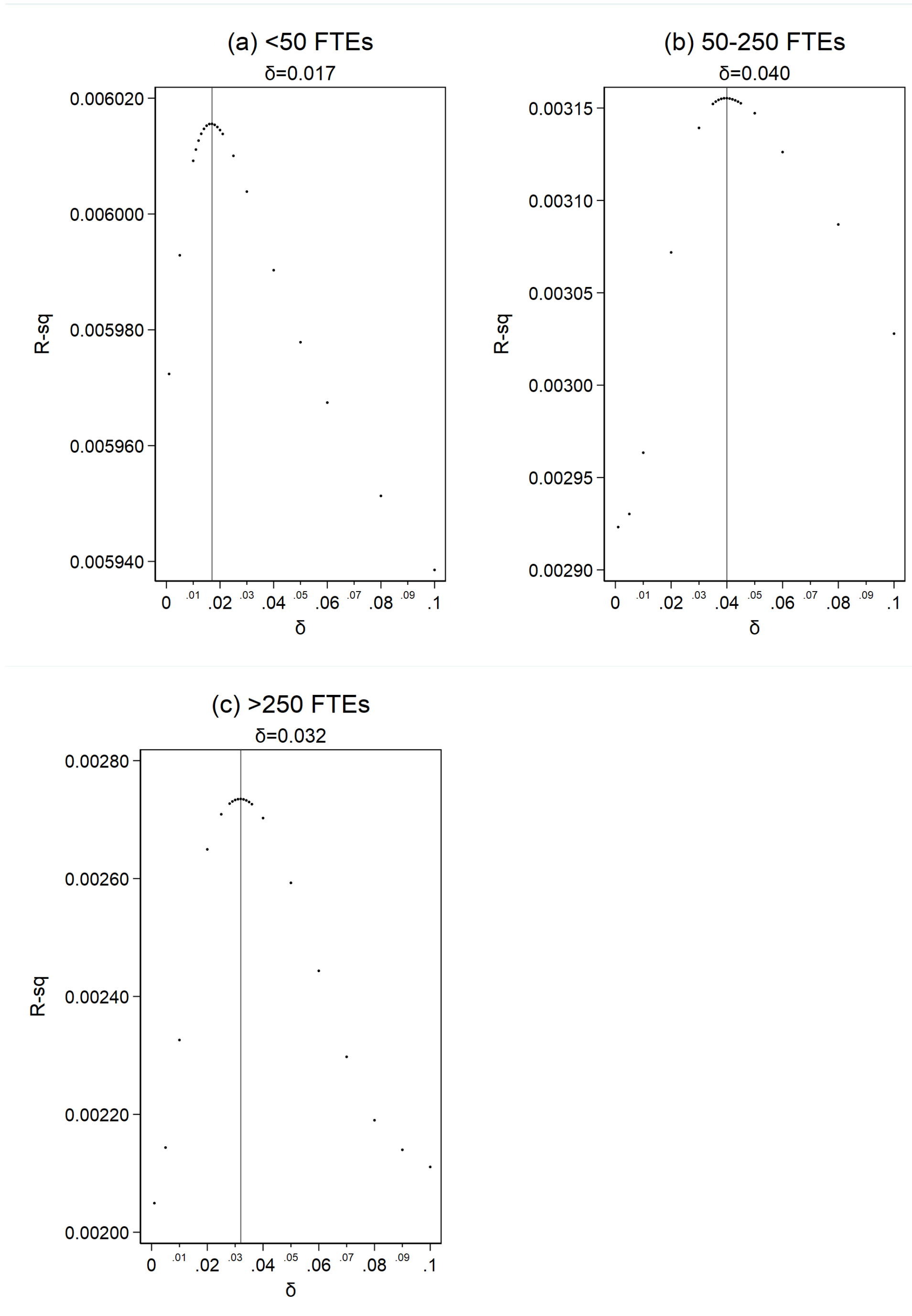


Figure F.4: Grid search over decay-parameter space for table 10 (firm fixed effect models for accessibility impact on firm-level tfp for small, medium and large firms)



F.1 Mincerian wage regression

Figure F.5: Grid search over decay-parameter space for table 12 (Mincerian wage regression, worker fixed effects)

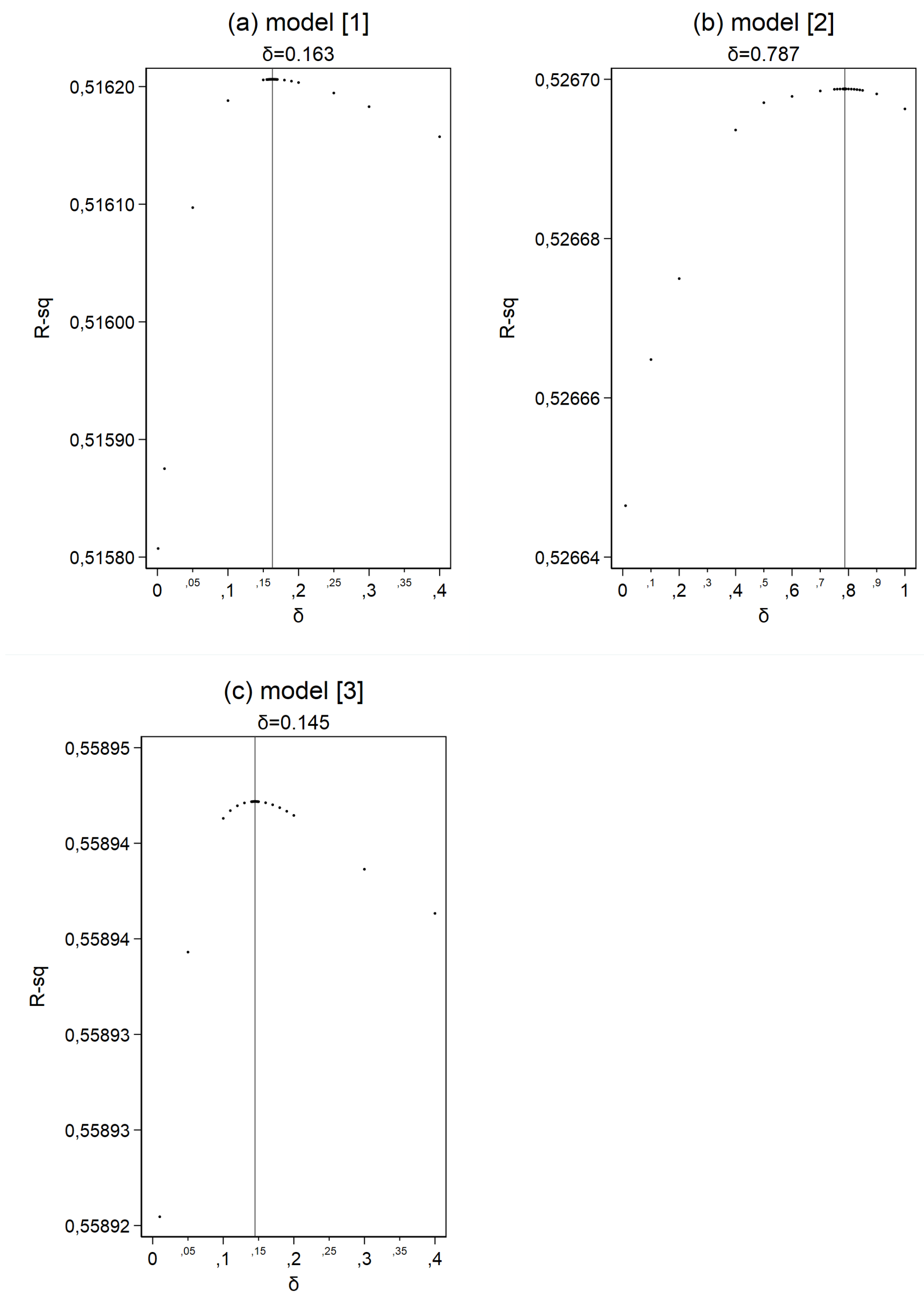
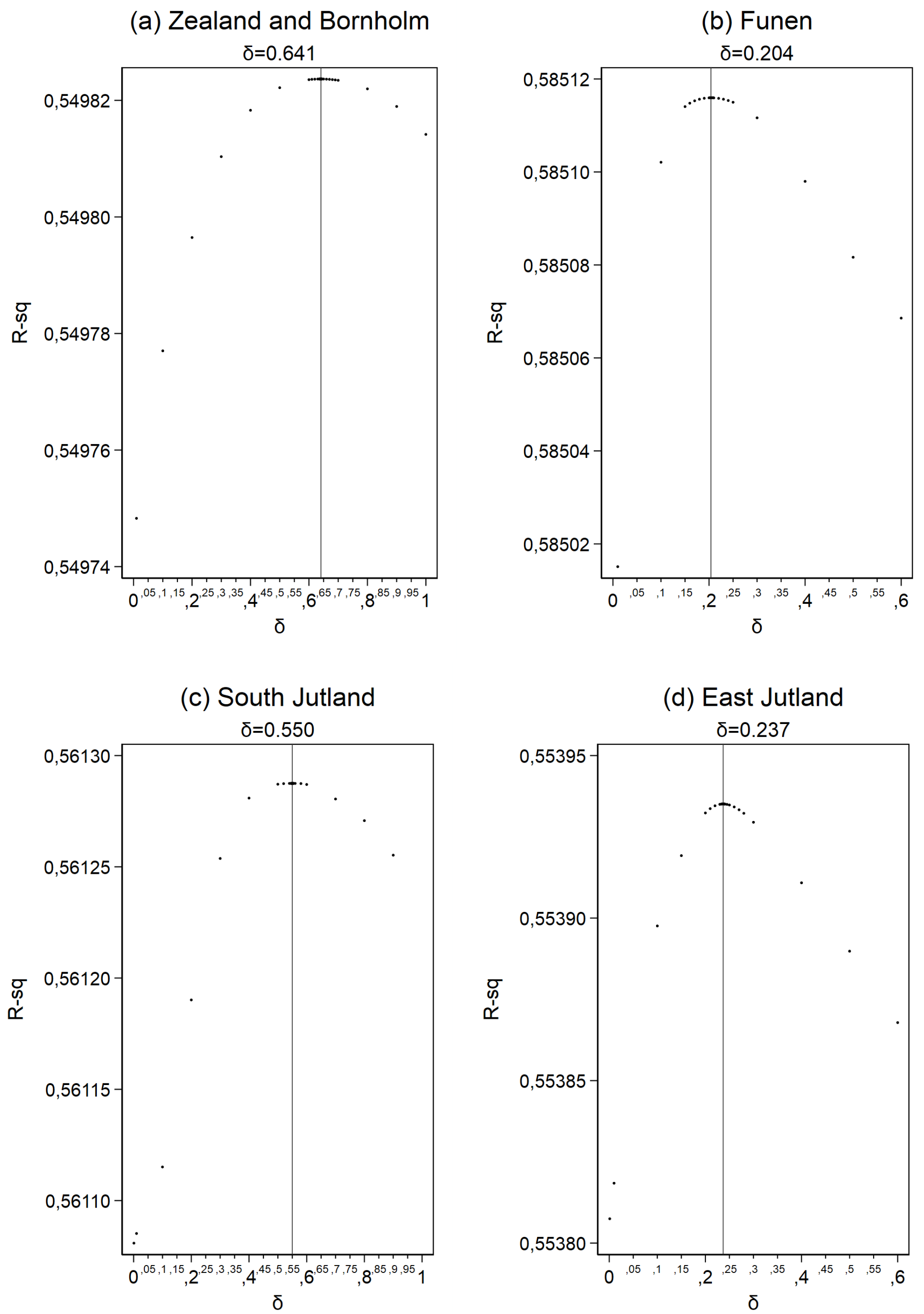


Figure F.6: Grid search over decay-parameter space for table E.3 (Mincerian wage regression for different regions for job and residence stayers, worker fixed effect)



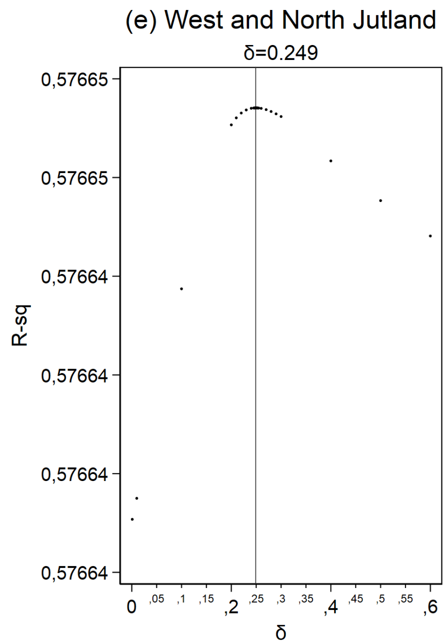
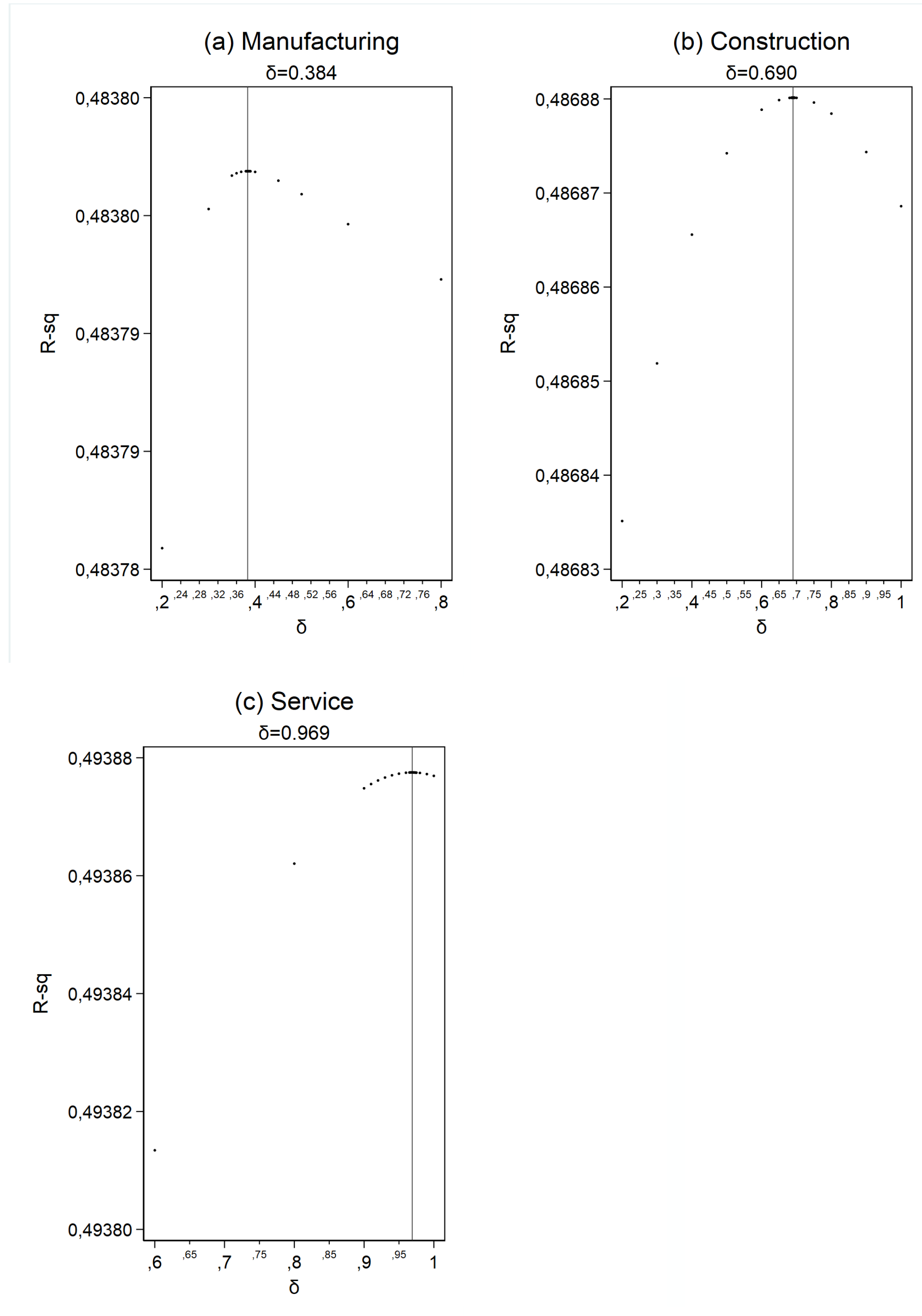
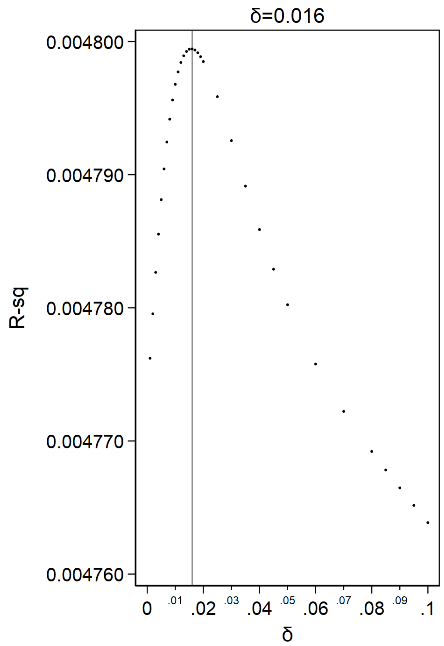

(e) West and North Jutland
δ=0.249
0,57665
0,57665
0,57664
0,57664
0,57664
0,57664
R-sq
0
,05
,1
,15
,2
,25
,3
,35
,4
,45
,5
,55
,6
δ

Figure F.7: Grid search over decay-parameter space for table E.4 (Mincerian wage regression for different sectors for job and residence stayers, worker fixed effect)



F.2 Control for highway changes

Figure F.8: Grid search over decay-parameter space for table D.1 (firm fixed effect models for accessibility impact on firm-level De Loecker tfp with control for highways)



References

Ahlfeldt, G. M. and Feddersen, A. (2017). From periphery to core: measuring agglomeration effects using high-speed rail. *Journal of Economic Geography*, 18(2):355–390.

Amemiya, T. (1974). The nonlinear two-stage least-squares estimator. *Journal of Econometrics*, 2(2):105–110.

Blundell, R. and Powell, J. L. (2003). *Endogeneity in Nonparametric and Semiparametric Regression Models*, volume 2 of *Econometric Society Monographs*, page 312–357. Cambridge University Press.

Ciccone, A. and Hall, R. E. (1996). Productivity and the density of economic activity. *The American Economic Review*, 86(1):54–70.

Dekle, R. and Eaton, J. (1999). Agglomeration and land rents: Evidence from the prefectures. *Journal of Urban Economics*, 46(2):200–214.

Harris, C. D. (1954). The market as a factor in the localization of industry in the united states. *Annals of the Association of American Geographers*, 44(4):315–348.

Lucas, R. E. and Rossi-Hansberg, E. (2002). On the internal structure of cities. *Econometrica*, 70(4):1445–1476.

Wooldridge, J. (2002). *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Cambridge, Massachusetts, London, England.

Wooldridge, J. M. (2015). Control Function Methods in Applied Econometrics. *Journal of Human Resources*, 50(2):420–445.