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Address:
The ROCKWOOL Foundation Research Unit
Ny Kongensgade 6
1472 Copenhagen, Denmark

Telephone +45 33 34 48 00
E-mail: kontakt@rff.dk
en.rockwoolfonden.dk/research/

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# Knowledge Spillovers from Cross Border Commuters: Evidence from a Natural Experiment *

Björn Thor Arnarson† Jakob R. Munch‡ Morten Olsen§ Emil A. L. Simonsen¶

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**Abstract**

How is knowledge transmitted across borders? We exploit the construction of the Øresund bridge which joined the capital region of Denmark with Malmö in Sweden, creating an integrated labor market. The bridge led to a steep increase in cross-border commuting, predominantly one-way from Sweden to Denmark. We examine the consequences of Swedish cross-border workers on the productivity of Danish firms and the wages of their close coworkers. We find substantial positive effects in Danish firms that (exogenously) increase the share of Swedish commuters, as cross-border commuters carry a productivity premium that likely reflects knowledge spillovers. To examine the extent of knowledge spillovers further, we estimate the impact of cross border commuters on wages of incumbent coworkers in occupations of the commuters and find a positive effect. We also find that high-skilled commuters and commuters with experience in high-tech occupations in the Swedish labor market have the strongest spillover effects on the wages of Danish coworkers.

**JEL Classification**: J24, J31, J61
**Keywords**: Knowledge Spillovers, Cross-Border Commuters, Coworker Wages, Firm Productivity

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†University of Copenhagen and The Centre for Oresund Region Studies at Lund University
‡University of Copenhagen and IZA
§University of Copenhagen
¶University of Copenhagen and The ROCKWOOL Foundation Research Unit

# 1 Introduction

How does knowledge and productivity spill over across borders? And how much of this knowledge transmission is embedded in individual workers? This is an inherently difficult question to answer, as it requires both detailed information on knowledge in both the origin and receiver country, but ideally also exogenous variation that allows for causal estimation of spillovers.

In this paper, we exploit the construction of the Øresund bridge between Denmark and Sweden as a natural experiment to examine knowledge flows embodied in workers. The bridge opened in mid-2000 allowing for cross-country daily commuting between the capital region of Denmark with the greater Malmö area. Cross-country daily commuting increased substantially in the following years, predominantly one-way from Sweden to Denmark. For this reason, we focus on how Swedish commuters bring knowledge and affect productivity and wages in the local labor market in the Danish capital region.

We use uniquely detailed merged and linked administrative data on firms and workers for both Sweden and Denmark. The data allows us, unlike previous researchers, to analyze the characteristics of cross-border workers at much higher granularity. We find evidence consistent with productivity spillovers: Hiring Swedish commuters leads to higher productivity for Danish firms and higher wages for Danish employees of those firms; these effects are concentrated for high-skilled Swedish commuters and those with experience in knowledge occupations (e.g. Tech occupations).

A distinct feature of our analysis is detailed information on cross-border commuters from Sweden, as we observe both their work employment in Denmark as well as in Sweden, before commuting. This is essential for our analysis, which has a particular focus on knowledge and productivity spillovers. In previous work, such as Dustmann et al. (2017), the inflow of commuters is conceptualized as a positive labor supply shock which negatively affects workers most closely substitutable to the commuters. In contrast, we find positive spillover effects for similar workers in receiving firms, a finding we interpret as positive spillovers. In

particular, we find that on average a ten percentage point increase in the share of colleagues who are commuters increases pay by $0.1 - 0.2$ per cent, whereas high-skill workers increase pay by 0.6 percent.

Our paper is related to several strands of the literature. First, recent studies consider how cross-border commuters affect labor market outcomes in receiving and sending countries. Dustmann et al. (2017) examine aggregate labor market effects of the sudden increase in the inflow of Czech cross-border workers in Germany in 1991. They find a strong negative effect on employment and a small negative effect on wages of natives in the short run. Beerli et al. (2021) study the effects of a reform that gave cross-border workers access to the Swiss labor market on labor market outcomes in Switzerland. They find that the reform increased wages of high-skilled native workers and weakly reduced wages of low-skilled natives. Consistent with this, they also find evidence that firms in local labor markets close to the border increased innovation and productivity if they were affected by a shortage of specialized personnel before the reform. Compared to these papers, we zoom in on knowledge spillovers and exploit that we observe the cross-border workers' Swedish labor market history (e.g., skills, occupations, and employer characteristics) to measure the extent and type of knowledge they are likely to carry. Further, we also analyze how cross-border workers affect wages and productivity of coworkers in the same occupation within the firms that employ cross-border workers. This allows us to distinguish local coworkers by their ability to absorb knowledge transferred by cross-border workers.

Bütikofer et al. (2022) also study the implications of the opening of the Øresund Bridge, but they consider the implications for the labor market and wages of commuting workers in the sending country, Sweden. They find that income inequality and the gender wage gap increases, and that these effects are driven by gender differences in the propensity to commute and by educational specialization. Based on regional data for Denmark, they also find that the opening of the bridge did not have negative effects on Danish residents. By contrast, we examine how the Swedish commuters affect firms and workers in the Danish labor market with a focus on knowledge spillovers.

Second, we relate to a body of work on spillovers through labor mobility across domestic firms. For example, Balsvik (2011) uses Norwegian matched worker-firm data to examine if domestic firms benefit from hiring workers from multinational companies. She finds evidence that workers with MNE experience contribute to higher productivity in domestic plants. Parrotta and Pozzoli (2012) study the implications of cross firm labor mobility for knowledge transfer and firm-level productivity. They use Danish worker-firm data, and estimate production functions to document that technicians and highly educated workers contribute to enhancing productivity of hiring firms. Poole (2013) uses Brazilian worker-firm data to show that workers in domestic plants obtain higher wages when hiring workers with experience from multinationals. These effects are most pronounced when hiring high-skilled workers with multinational experience, and for high-skilled incumbent domestic workers. Cornelissen et al. (2017) use detailed German worker-workplace data with information about the occupations of newly hired coworkers. They measure the productivity of coworkers as the average wage fixed effect of coworkers in the same occupation and workplace and find that an increase in average coworker productivity increases wages modestly. By contrast, we study the transmission of knowledge across countries, and we use the opening of the Øresund Bridge as a natural experiment to provide exogenous variation in labor mobility.

Third, there is broader literature on the flow of ideas across borders and regions. Halpern et al. (2015) highlight the role of imported intermediate goods in facilitating technology diffusion and enhancing productivity. Bottazzi and Peri (2003) examine the geographic dimensions of research spillovers within Europe, finding that proximity plays a critical role in the diffusion of non-codified, embodied knowledge, which tends to generate significant but localized externalities. Keller (2004) and Keller (2022) are reviews of the literature emphasizing the importance of geographic distance in moderating the effects of foreign research on domestic productivity. Crucially for our work, little is known about the embedded knowledge in commuters.

The rest of the paper is structured as follows. In the next section, we describe the background and history of the Øresund Bridge. In Section 3 we describe the Danish and

Swedish administrative matched worker-firm data. Section 4 explains the empirical strategy, and Section 5 presents the results. Section 6 concludes.

## 2 Historical background

On July 1st 2000, the Øresund Bridge[1] opened, creating a fixed land link between Copenhagen, the capital city of Denmark, and Malmö in Sweden. The cities of Copenhagen and Malmö are two of the largest cities in Scandinavia and they are only separated by a 15 kilometre wide strait. The 'birds eye' distance from the centre of Malmö to the centre of Copenhagen is around 28 kilometres. Despite the geographic closeness of the cities, only a ferry connected them prior to the introduction of the Øresund Bridge. As a daily ferry ride is not a flexible and convenient means of transport, not many people commuted between the cities before 2000. After the inception, the city centres' are connected by a 35-minute long train (or car) trip, well within reasonable commuting distance. Even if the geographic distance is unaltered between Malmö and Copenhagen, the Øresund Bridge provides a fixed connection that substantially reduced travel time, improved flexibility and transportation efficiency, altering the perception of distance. Figure 1 shows the geography of the Øresund Region.

The agreement to build the bridge was signed in 1991, final permissions granted in 1994 and construction started in late 1995.[2] Before the bridge opened, a ferry connected Malmö with Copenhagen. However, the most common way to cross the strait were the Helsingborg-Elsinore ferries, located 65 km north of Malmö's city centre.[3] In 1999, a year before the bridge opened, the Elsinore-Helsingborg ferries carried over 73% of the 1.95 million yearly passengers across the strait. After the introduction of the bridge, the yearly passenger traffic increased to 2.69 million by 2003.[4] Cross border commuting was further

[1]Technically this is a 16 km long fixed link, half of which is the Øresund bridge, while the remaining part is an immersed tunnel and an artificial island called Peberholm. For simplicity, we will refer to this link as the Øresund Bridge.

[2]Previous ideas and proposals of physically connecting Denmark and Sweden date back to late 19th century. In 1973 a formal agreement was signed between the two nations about a fixed link between Malmö and Copenhagen. However, in 1978, the Danish authorities rejected those plans.

[3]The shortest distance between Denmark and Sweden was between the cities of Helsingborg and Elsinore, 4 km. Multiple plans of placing a link there have been discussed and are still in 2024 under consideration.

[4]The market share in passenger traffic of the Øresund bridge was at the time around 57% and the


Figure 1: The Øresund Region. The Øresund bridge (fixed link) connects Malmö and Copenhagen. The Elsinore-Helsingborg ferry was the most used crossing prior to 2000.. Source: OpenStreetMap

facilitated by a tax reform in late 2003 which made it easier for commuters to file taxes in one country and live in the other (called "Øresundsaftalen").

Figure 2 shows the number of individuals who have income in one country but reside in the other. Prior to the opening of the bridge, commuting between Denmark and Sweden was limited. Only between 2,000 and 3,000 individuals commuted from Sweden to Denmark, mostly through the ferry connection between Elsinore and Helsingborg or a Malmö-Copenhagen ferry. The number of commuters rose steadily after the introduction of the bridge, and peaked just before the 2007-2008 financial crisis. Other factors inducing cross-border commuting is the variation in unemployment rates and standard of living. The unemployment rate was substantially higher in Sweden (see Appendix Figure A.1) and regional data from Eurostat (2024) shows that in 2000 GDP per capita in Skåne was €29,300 compared to €40,500 in the Copenhagen capital area. This differences in pay implies that

Elsinore-Helsingborg ferry accounting for the remainder. All other smaller ferry lines were discontinued by 2003 (Knowles 2006).

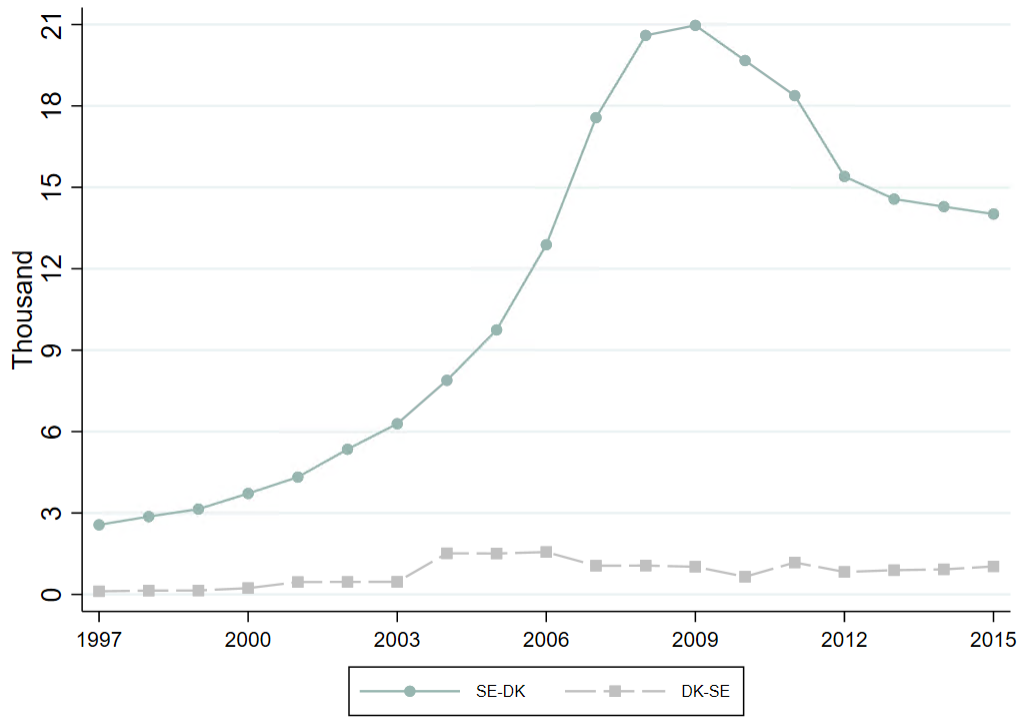


Figure 2: Cross-border commuters from Sweden to Denmark and from Denmark to Sweden. Commuters are required to earn at least 100,000 DKK in 2010 prices.

the observed commuter flows are mostly from Sweden to Denmark.

Figure 3 shows the geographic distribution of where Swedish cross border commuters live and work. It is evident that commuting depends on distance to the bridge. Most commuters from Sweden live in or close to Malmö, and the propensity to commute declines for Swedish municipalities further away from the bridge. It is also clear that most commuters from Sweden work in or around Copenhagen, but there is also a relatively high share of commuters in employment north of Copenhagen and in Elsinore. The share of commuters in employment is close to zero west of the Copenhagen metropolitan area. In the subsequent analysis, we will exploit this feature of the commuting patterns to define how exposed Danish firms and workers are to cross border commuters from Sweden.

The international border between Denmark and Sweden, and the separation of the countries by the Øresund Strait, meant that the local economies of Zealand and Skåne

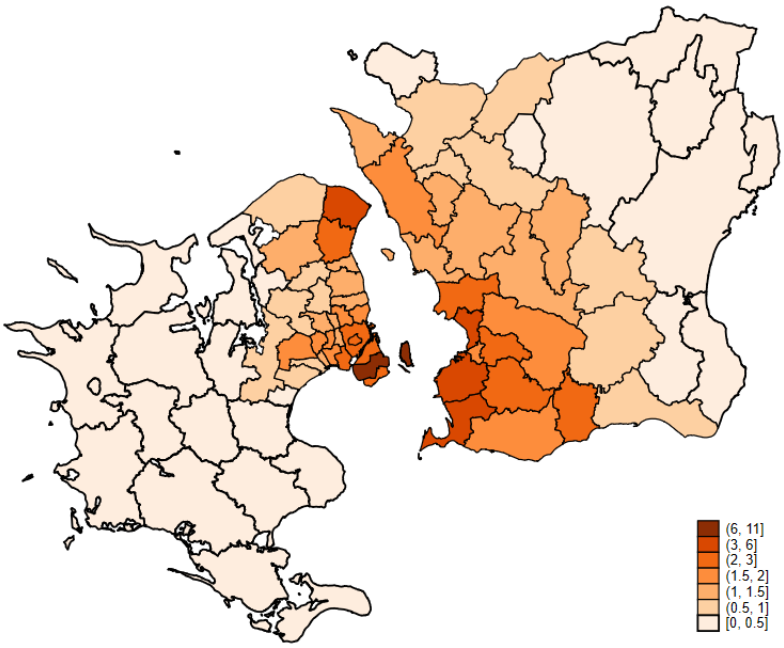


Figure 3: Swedish commuters relative to employment by municipality. The map shows the number of Swedish commuters per 1,000 employed workers for the workplace municipality in Denmark and the municipality of residence in Sweden (average year for 2000-2015).

were disconnected prior to the opening of the bridge. This is reflected in distinct industrial compositions of the two regions. Table 1 shows that on average in 1997-1999, almost 40% of the workers in Skåne were employed in manufacturing and related industries, compared to 22% in Zealand. Similarly, the Danish side of the region had a higher share of employment in trade, transport, information, communications as well as financial services.

## 3 Data

In this section, we provide information on the main data sources and the sample construction. We use administrative registers from both Denmark and Sweden that have been merged and linked between the two countries. That is, we have matched worker-firm data both within Denmark and Sweden as well as across the border for cross-border commuters. In the following sections, we describe the main sources from both Denmark and Sweden.

Table 1: Industrial composition in Sweden and Denmark

| | Mean | Mean |
|---|---|---|
| *Workers* | *Skåne (SWE)* | *Zealand (DK)* |
| Manufacturing, mining, quarrying | 39.6 | 22.4 |
| Construction | 9.0 | 8.6 |
| Trade and transport etc. | 29.1 | 38.4 |
| Information and communication | 3.2 | 9.4 |
| Financial and insurance | 3.1 | 7.9 |
| Real estate | 2.0 | 1.9 |
| Other business services | 14.0 | 11.5 |

Note: This table uses firms with 10+ employees on average in 1997-1999 in Zealand/Skåne. Workers of those firms are restricted to earn at least 100,000 DKK in a year (2010 prices).

### 3.1 Cross-border commuters

A core dataset we use is the Örestat database. This database was formed through cross-border cooperation between the statistical authorities in Denmark and Sweden where information on cross-border commuters is shared for the years 1997-2015. This database enables us to link a person living in one country to an employer in the other.[5] As the Örestat data is jointly collected both in Denmark and Sweden, we are able to link persons between the countries through a shared anonymized personal identification number. This link allows us to construct a worker-firm match for workers residing in Sweden and working in Denmark. The population includes persons who have employment or income in Denmark or Sweden while living in the other country.[6]

### 3.2 Other data sources

The main datasets we use on the Danish side are the following: 1) We observe information on cross-border commuters from Sweden to Denmark and their Danish work history in RAS (Registerbaserede arbejdsstyrkestatistik). This includes information on income, workplace ID, and occupation code. 2) We obtain information on workplace ID, hourly wage and occupation from LON/LONN (Lønstatistikken) and IDAN (IDA ansættelser). We link

[5]Bütikofer et al. (2022) use Swedish register data only combined with the Örestat register to investigate gender equality in the sender country (Sweden). Our main focus is on the receiving country.

[6]The definition of main employment follows the International Classification of Status in Employment (ICSE).

RAS and LON/LONN/IDAN through workplace and firm identifiers. 3) We use the UDDA (Uddannelser) for education of Danish residents, 4) Firm-level information is collected from FIRM (Generel firmastatistik) and FIRE (Regnskabsstatistikken). For Sweden, the main dataset is LISA, which provides employment history, general background characteristics, education and occupation codes.[7]

### 3.3 Sample construction

As previously noted, most cross border workers commute from Sweden to Denmark (Figure 2). We therefore restrict the sample of commuters to those who reside in Sweden and work in Denmark. In addition to the Swedes who started commuting, lower costs of living (in particular house prices) in Sweden meant that some Danish residents moved to Sweden while continuing to work in Denmark. Since we are interested in the inflow of new workers on firm and employee outcomes in Denmark, we exclude these individuals from our analysis. The regression sample in Denmark is restricted to cross border commuters that earn at least DKK 100,000 in annual wages.[8] This restriction ensures that the cross-border commuters we investigate have considerable attachment to the Danish labor market.

As most cross-border workers are employed by firms in Denmark located relatively close to the bridge (Figure 3), we limit the sample to establishments located on the island Zealand that had more than 10 employees on average in 1997-1999 (i.e., prior to the opening of the bridge). We include all sectors except the public sector and agriculture. Table 2 shows how each sample restriction impacts our sample of firms. The final sample of firms includes around 8,200 firms and 85,000 firm-years, and it captures more than half of private sector employment on Zealand in 2000.

Only about 9 percent of the firms in the final sample employ cross border commuters, but these firms are much larger in terms of employees, value added and capital than firms without commuters, see Table 3. The corresponding worker sample has around 47,000 cross-border commuter-year observations and over 2.2 million worker-year observations in

[7]We complement this with information from other registers (Yrkesregistret and Lönestrukturstatistiken).
[8]The amount is in 2010 prices. This amounts to around 13.500 USD.

Table 2: Sample restrictions and sample size

| | Firms | Firm-Years | Employment (2000) |
|---|---|---|---|
| All firms | 1,384,310 | 9,737,733 | |
| Firms on Zealand | 664,522 | 4,358,830 | |
| Selected industries | 471,338 | 2,929,946 | 812,367 |
| Observed in 1997-1999 | 70,699 | 587,102 | 745,847 |
| Avg. 10+ empl. 1997-1999 | 9,484 | 95,395 | 607,904 |
| Final est. sample | 8,281 | 85,725 | 428,262 |

The final estimation sample conditions on firms having positive value added, capital stock and employment.

Denmark, see the bottom panel of Table 3. The commuters are slightly younger than the average non-commuter and they are much more likely to be high-skilled than natives (35 percent of commuters are high-skilled while only 25 percent of natives are high-skilled).[9]

To examine the extent to which the commuters are different from native Danish workers, we calculate a commuter wage premium as the difference in wages conditional on observable characteristics. We find that commuters from Sweden earn 0.15 log points lower annual wage conditional on location. By further restricting on occupation fixed effects, firm fixed effects and tenure fixed effects (and their interaction), the difference is reduced to 0.03 log points. Hence, after controlling for observable characteristics, the wage of commuters is only marginally lower than local workers. For comparison, Dustmann et al. (2017) finds a negative commuter premium of 14 percent for Czech cross-border workers in Germany, after accounting for a similar set of controls.

We can also compare the Swedish commuters to non-commuters in the Swedish labor market. Table 4 shows that the commuters are younger, more likely to be males and high-skilled. They are also more likely to be enrolled in education the year before their first year as a commuter into the Danish labor market. On average their annual labor income is 235,000 DKK which is much lower than the 375.000 DKK income of non-commuters. However, once controlling for observable characteristics this difference is narrowed down to 3 percent, see the bottom panel of Table 4.

[9]We define a worker as high-skilled if their highest completed level of education is a bachelor's degree or more.

Table 3: Descriptive statistics for estimation sample of firms and workers in Denmark.

| | N | Mean | SD | N | Mean | SD |
|---|---|---|---|---|---|---|
| *Firms* | *With Commuters* | | | *Without Commuters* | | |
| Value added (1.000) | 7,225 | 264.1 | 1,201.4 | 78,500 | 21.1 | 65.7 |
| Capital (1.000) | 7,225 | 275.4 | 2,054.8 | 78,500 | 19.0 | 190.1 |
| Employees | 7,225 | 339.0 | 902.7 | 78,500 | 38.7 | 109.0 |
| Share of commuters | 7,225 | 4.8 | 7.1 | 78,500 | 0.0 | 0.0 |
| *Workers* | *Commuters* | | | *Natives* | | |
| Age | 46,661 | 38.3 | 10.4 | 2,287,381 | 41.9 | 11.5 |
| Female | 46,661 | 37.9 | 48.5 | 2,287,877 | 36.4 | 48.1 |
| High-skill | 46,661 | 34.6 | 47.6 | 2,287,877 | 25.0 | 43.3 |
| Managers | 42,739 | 4.9 | 21.7 | 2,332,185 | 6.6 | 24.9 |
| Tech workers | 42,739 | 21.4 | 41.0 | 2,332,185 | 23.0 | 42.1 |
| Support workers | 42,739 | 35.7 | 47.9 | 2,332,185 | 26.1 | 43.9 |
| Sales workers | 42,739 | 16.9 | 37.5 | 2,332,185 | 14.8 | 35.5 |
| Line workers | 42,739 | 18.3 | 38.7 | 2,332,185 | 28.6 | 45.2 |
| Hourly earnings | | - | | 2,287,877 | 303.1 | 157.1 |
| *Commuter Wage Premia (2008)* | | *Coeff.* | | | *S.E.* | |
| (i) Municipality fixed effects | | -0.15 | | | 0.01 | |
| (ii) Occupation × firm fixed effects | | -0.11 | | | 0.01 | |
| (iii) Occupation × firm × tenure fixed effects | | -0.03 | | | 0.01 | |
| No. workers | | | 97,060 | | | |

Note: This table compares Swedish cross border commuters to native workers in Denmark (individual-year observations). Commuters are restricted to those earning DKK 100,000 in the Danish labor market. The bottom panel uses data on annual wages from 2008 to compare cross-border commuters to non-commuters in Denmark in that year. In these regressions, we control for age, age-squared, gender, and a high-skill dummy.

### 3.4 Occupational composition and transitions of cross-border workers

An important component of our data is that we observe background characteristics and labor market history of the cross border commuters before and after commuting. This is unusual in the literature on immigration, and it allows us to account for occupational experience before commuting, and to examine if cross-border commuters move up or down in the occupational hierarchy after commuting.

We adopt the occupational classification from Bernard et al. (2020) and group occupations into Managers, Tech workers, Sales workers, Support workers and Line workers.[10] We are

[10]Tech workers include R&D workers, engineers, programmers, and technicians; Support workers include office jobs, data entry, legal work, accounting, customer service; Sales workers include sales, financing, and

Table 4: Descriptive statistics for Swedish commuters and non-commuters

| | N | Mean | SD | N | Mean | SD |
|---|---|---|---|---|---|---|
| *Workers* | *Commuters* | | | *Non-Commuters* | | |
| Age | 42,658 | 37.4 | 10.0 | 6,965,156 | 42.8 | 12.1 |
| Female | 42,658 | 39.2 | 48.8 | 6,965,156 | 48.7 | 50.0 |
| High-skill | 42,658 | 36.2 | 48.1 | 6,965,156 | 23.8 | 42.6 |
| Managers | 30,096 | 5.9 | 23.6 | 6,701,000 | 6.2 | 24.2 |
| Tech workers | 30,096 | 19.7 | 39.8 | 6,701,000 | 10.4 | 30.5 |
| Support workers | 30,096 | 44.8 | 49.7 | 6,701,000 | 52.3 | 49.9 |
| Sales workers | 30,096 | 13.5 | 34.1 | 6,701,000 | 10.0 | 30.0 |
| Line workers | 30,096 | 16.1 | 36.8 | 6,701,000 | 21.1 | 40.8 |
| R&D intensive firm | 42,658 | 16.6 | 37.2 | 6,965,156 | 14.4 | 35.1 |
| Annual wage (1.000) | 42,658 | 283.0 | 422.0 | 6,965,156 | 375.0 | 221.3 |
| Not employed | 42,658 | 20.2 | 40.2 | 10,990,022 | 21.5 | 41.1 |
| Enrolled in education | 42,658 | 20.1 | 40.1 | 10,990,022 | 13.4 | 34.1 |
| *Commuter Wage Premia (2006)* | | *Coeff.* | | | *S.E.* | |
| (i) Municipality fixed effects | | -0.12 | | | 0.01 | |
| (ii) Occupation × firm fixed effects | | -0.04 | | | 0.01 | |
| (iii) Occupation × firm × tenure fixed effects | | -0.03 | | | 0.01 | |
| No. workers | | | | 318,573 | | |

Note: This table compares Swedish cross border commuters to non-commuters in 2000-2015 (individual-year observations). The labor market characteristics for commuters are measured the year prior to commuting. Observations are restricted to those earning more than DKK 100,000 in the Swedish labor market. The bottom panel uses data on annual wages from 2006 only to compare cross-border commuters to non-commuters in Sweden. In these regressions, we control for age, age-squared, gender, and a high-skill dummy.

particularly interested in tech workers as they consist of both R&D workers and technicians, and are arguably the best available proxy for high-skilled knowledge workers (see Bernard et al. (2017)). Table 4 shows that half of the Swedish commuters worked as support workers, while 6 and 14 percent were employed in the more knowledge-intensive occupations of managers and tech workers before commuting. It is noteworthy that the proportion of tech workers in the Swedish labor market is lower at 10 percent.

Figure 4 shows the absolute numbers of Swedish cross border commuters over time and by the five occupational groups for their jobs held in Sweden prior to commuting. Interestingly, we see that both the number and share of tech workers and managers have been growing over time, while support workers, sales workers, and line workers have shown a more pronounced

procurement; Line workers include a wide range of production activities across sectors as well as transportation and warehousing jobs. See `https://faculty.tuck.dartmouth.edu/images/uploads/faculty/teresa-fort/occupation_list.pdf` for details.

decline after the financial crisis. Ultimately, we use the variation in firm-level commuter shares over time for identification, and the substantial changes in the inflow of cross border commuters depicted in Figure 4 provide ample variation at the firm-level too.[11]

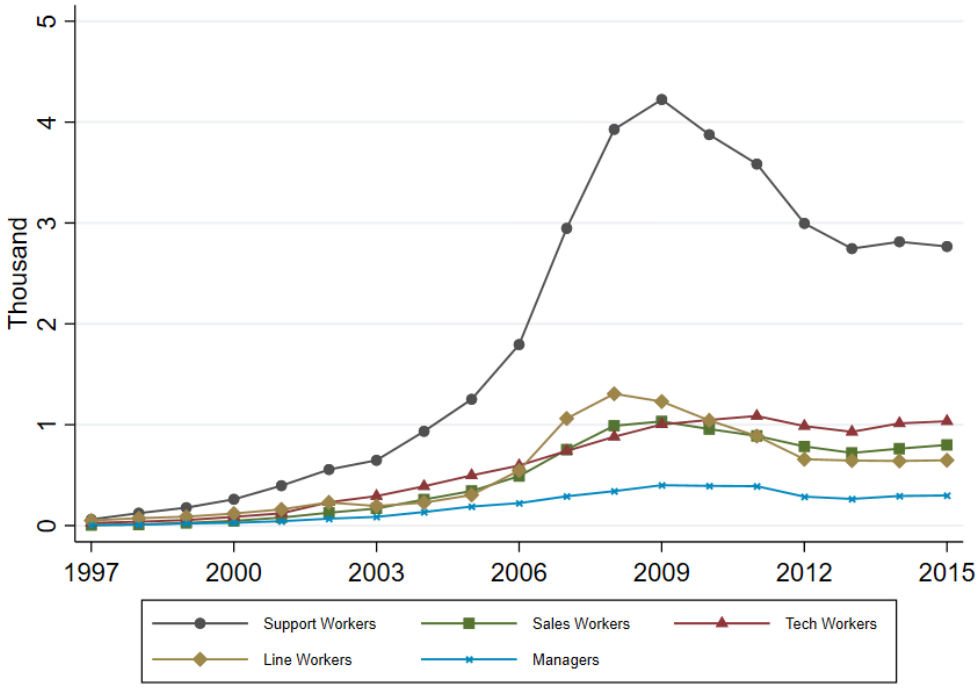


Figure 4: Job types for cross border commuters. The classification of occupation types follows Bernard et al. (2020), and the occupations refer to jobs held in Sweden prior to commuting.

Next, we compare the occupational group of the cross border commuters from the Swedish labor market before commuting to the occupational group in Denmark after commuting. As expected, commuters tend to find employment in Denmark in the same occupational group as the latest job in Sweden. For example, 55 percent of all cross border workers with experience as tech workers in Sweden find employment as tech workers in Denmark, see Panel A of Table 5. On the other hand, only 34 percent of commuters with sales worker experience find employment as sales workers in Denmark, while 49 percent work as support workers. More broadly, it is clear that occupational mobility is common for cross border

[11]Appendix Figure A.2 shows a histogram of demeaned shares of commuters in firm-level employment.

workers and more common than for native workers. For natives in the Danish labor market, we find more persistence in occupations in job-to-job transitions, see Panel B of Table 5. For example, 75 percent of tech workers in Denmark move to another tech worker occupation when changing employers.

Table 5: Transition matrix for Swedish cross border commuters and native Danes.

| | **Panel A: Cross Border Commuters** | | | | |
|---|---|---|---|---|---|
| | *SE (old)* | | | | |
| *DK (new)* | Managers | Tech Workers | Support Workers | Sales Workers | Line Workers |
| Managers | 37.2 | 4.6 | 2.9 | 4.4 | 1.0 |
| Tech Workers | 13.3 | 55.0 | 4.9 | 6.1 | 2.7 |
| Support Workers | 29.3 | 29.3 | 72.4 | 49.1 | 25.3 |
| Sales Workers | 17.3 | 6.5 | 11.9 | 34.0 | 5.6 |
| Line Workers | 2.9 | 4.5 | 7.9 | 6.4 | 65.4 |
| N | 549 | 2,495 | 6,951 | 2,783 | 1,861 |

| | **Panel B: Natives** | | | | |
|---|---|---|---|---|---|
| | *Old* | | | | |
| *New* | Managers | Tech Workers | Support Workers | Sales Workers | Line Workers |
| Managers | 57.9 | 2.0 | 1.0 | 2.1 | 0.5 |
| Tech Workers | 7.8 | 75.4 | 1.9 | 2.0 | 1.3 |
| Support Workers | 20.6 | 14.9 | 86.2 | 23.3 | 9.8 |
| Sales Workers | 10.6 | 3.9 | 7.2 | 66.2 | 3.9 |
| Line Workers | 3.1 | 3.7 | 3.7 | 6.4 | 84.6 |
| N | 82,596 | 258,604 | 1,429,615 | 368,368 | 439,335 |

Note: This transition matrix compares the last observed job to the new job in Denmark. In panel A, for cross border commuters, the last observed job is in Sweden, while in panel B, we only investigate domestic Danish transitions. The definition of occupational groups follows Bernard et al. (2020).

## 4 Empirical Strategy

In this section, we describe our empirical strategy. The goal of our analysis is to examine knowledge and productivity spillovers of Swedish commuters. Our main focus is on how Swedish commuters affect the productivity of close coworkers in Danish firms. This is because, at the worker level, we can better examine the mechanisms through which the knowledge carried by Swedish commuters affects local coworkers depending on their skills

and occupational characteristics. However, we first ask if Swedish commuters have a broader effect on productivity at the firm level.

### 4.1 Firm-level analysis

Consider a firm $i$ whose value added, $Y_i$ is given by:

$$Y_i = A_i K_i^{\beta_K} \left(L_i^*\right)^{\beta_L}, \tag{1}$$

where $\beta_K, \beta_L > 0$, $A_i$ is a TFP parameter, $K_i$ is capital and $L_i^*$ is effective units of labor given by:

$$L_i^* = \eta(s) L_D + \gamma L_C,$$

where $L_D$ is the number of native workers, $L_C$ is the number of commuters, $L = L_D + L_C$ is the total workforce, $s = \frac{L_C}{L}$ is the commuter share and $\eta, \gamma > 0$ as well as $\eta(0) = 1$ (a normalization). This specification allows commuters to affect output differently than native workers in two ways: if $\eta' > 0$ there are productivity spillovers: commuters make native workers more productive, and they do so in proportion to their share of the total work force. Further, if $\gamma > 1$ commuters are themselves more productive.

Taking a first order approximation of $\log(L_i^*)$ around $s = 0$ gives

$$\log(L^*) \approx \log(L) + \left(\eta'(0) + \gamma\right) \frac{L_C}{L} = \log(L) + \delta \times s, \tag{2}$$

where $\delta$ is the combined effect of spillovers and higher productivity of the share of total workers that are commuters, $s$. We use this in combination with (1) to write our estimating equation as:

$$\log Y_{i,t} = \kappa_i + \beta_K \log(K_{i,t}) + \beta_L \log(L_{i,t}) + \beta_L \delta s_{i,t} + \theta X_{i,t} + \lambda_{k,t} + \epsilon_{i,t}, \tag{3}$$

where $Y_{i,t}$ is value added, $\kappa_i$ is a firm fixed effect, $K_{i,t}$ is the capital stock, $L_{i,t}$ is total employment, $s_{i,t}$ is the share of workers that are commuters (potentially of a given type),

$X_{i,t}$ is a vector of controls, $\lambda_{k,t}$ is two-digit NACE industry-year fixed effects.

This specification is similar to that of Balsvik (2011), who considers the productivity spillover of hiring workers from multinational corporations. There are two important differences, though: First, we think of Swedish commuters both as being (potentially) more productive ($\gamma > 0$) *and* as (possibly) inducing spillovers on local workers ($\eta'(0) > 0$). The sum of these two effects is captured in $\beta_L \delta$, such that the direct effect $\delta$ can be recovered by diving the coefficient on $s_{i,t}$ with that of $\log(L_{i,t})$. This specification is not able to directly disentangle spillover effects from higher productivity of commuters. Nevertheless, it offers a useful first step to check if cross border commuters have a distinct effect on firm-level productivity, i.e., $\delta$ may be interpreted as a productivity premium of cross border commuters over incumbent workers. Second, as discussed above, we are able to exploit plausibly exogenous variation in the employment of commuters.

Naturally, running an OLS regression of equation (3) would lead to endogeneity problems: Firms with high demand shocks might both increase prices (thus increasing value added), and hire more commuters to meet demand, creating a spurious correlation between $Y$ and $s$. To address this concern we need an instrument. The following section describes how we combine two sources of exogenous variation into our instrument.

### 4.2 Identification strategy and instrument

Our instrument combines two types of exogenous variation into one. In the following we describe each in turn and how we combine them.

*Inflow and occupational composition of the commuters.* The Øresund bridge triggered a large inflow of Swedish commuters in the Copenhagen labor market as was documented in Section 2. Further, this increase evolved differently across occupational groups (Figure 4). To utilize these inflows, we construct an occupational shift-share variable, where we use firms' occupational distribution between 1997 and 1999 combined with the nation-wide inflow of commuters in a particular occupation. That is, firms that initially relied on occupations that saw a relatively large inflow of Swedish cross border commuters would stand to benefit more

from the opening of the Øresund bridge compared to firms that relied on occupations that did not see a similar increase in the inflow of Swedish cross border commuters. We interpret our results through the lens of Borusyak et al. (2022). In our context, identification can be obtained from conditionally randomly assigned commuter flows across occupations between the two countries.

*Distance to the border.* The other component of our instrument exploits the geographic commuting pattern revealed in Figure (3). Firms in Denmark are exposed to Swedish cross border commuting unevenly, as commuters tend to find employment close to the Øresund bridge. We therefore use municipality-specific distance to the beginning of the bridge on the Swedish side, to adjust the instrument to reflect declining exposure with distance. This is similar to Dustmann et al. (2017) and Beerli et al. (2021), who both use distance to the border to identify municipalities that are "treated" and not treated with an inflow of cross border workers. We rely on a similar intuition.

We combine these two sources of variation in our preferred specification of the instrument:

$$Z_{i,t} = \frac{\sum_o \bar{\omega}_{i,o} \times M_{o,-i,t}}{D_i}, \tag{4}$$

where $\bar{\omega}_{i,o}$ is the share of workers of three-digit occupation $o$ out of total employment in firm $i$ in the pre-sample years, 1997-1999. $M_{o,-i,t}$ is the total inflow of cross border workers that in Sweden most recently worked in occupation $o$, into all Danish firms other than firm $i$ at time $t$. That is, the numerator is a firm specific and time varying shift-share measure of exposure to cross border commuters for a given initial occupational composition of the work force. $D_i$ is the distance from firm $i$ to the Swedish border using the bridge (i.e., distance to the bridge, plus the length of the bridge). That is, distance to the bridge is used to give exposure of cross border commuters lower weight to firms.

Hence, our instrument combines two sources of variation which we argue strengthens the case for our instrument being exogenous. Consider first an instrument with only the shift-share element in the numerator of (4). In the language of Borusyak et al. (2022), the

validity of the instrument would require that the shocks to occupation-specific commuter flows are conditionally uncorrelated with other shocks to value added. Without the industry-year fixed effects, $\lambda_{k,t}$, this might not be plausible: industry-specific demand shocks are likely to affect value added as well as the employment of commuters, thereby violating the exclusion restriction. The inclusion of industry-year fixed effects controls for industry-wide demand shocks. Demand shocks that pose a threat to identification would therefore have to be within-industry firm-specific shocks with a particular correlation with the occupational structure of the firm. Finally, we add the correction for distance, which implies that such firm-specific shocks would have to only affect firms close to the border.

We employ this instrument both for our firm-level analysis and for the analysis of main interest, at the worker level. We now proceed to specify these estimating equations.

### 4.3 Worker-level analysis

The main focus of our analysis is on knowledge spillovers. As discussed above, a firm-level regression cannot disentangle whether newly hired workers are more productive or they make the existing workers more productive. We therefore proceed to worker-level regressions where we use hourly wages as a measure of productivity. Further, we zoom in on the workers within the firms that are most likely to learn from incoming cross border commuters, namely those workers that are employed in the same occupation.

Consequently, we run a regression of (log) wages, $w$, of worker $j$ in occupation $o$ at time $t$ who works for firm $i$ in industry $k$:

$$\log w_{j,i,t} = \gamma s_{i,t,o} + \beta_1 V_{j,t} + \beta_2 X_{i_{(j,t)},t} + \alpha_{j,i,o} + \lambda_{k,t} + u_{j,i,t}, \tag{5}$$

where $s_{i,t,o}$ is the share of commuters in firm $i$ in occupation $o$ at time $t$, and $\gamma$ is the coefficient of interest. A priori, the sign of $\gamma$ is unknown: The inflow of new workers might crowd out existing workers, and put downward pressure on wages. Alternatively, if there are knowledge spillovers, the inflow of new workers might increase the productivity of the

existing workers, and therefore increase their wages. $V_{j,t}$ are worker level controls and $X_{i,j,t}$ are firm-level controls such as capital and total employment. We also include job spell-occupation fixed effects, $\alpha_{j,i,o}$, such that only time variation within occupation specific job spells, i.e., observations for the same worker, firm and occupation, is used to identify the parameter of interest, $\gamma$. For most of our specifications, we include industry-year fixed effects, $\lambda_{k,t}$, at the two-digit industry level. These are included to account for supply and demand shocks at the industry level.

Estimating equation (5) using OLS would pose the same endogeneity problems as discussed above for the firm-level regression. We therefore employ the same instrument as for the firm-level regressions.

# 5 Results

In the following we present our results. We start out with estimating the firm-level equation (3) before proceeding to the worker-level regressions of equation (5).

## 5.1 Firm-level results

Table 6 shows the results of the firm-level regressions. In column (1) we run an OLS regression where we control for log employment and capital and include firm and industry-year fixed effects.[12] The coefficient of interest is on "Share of commuters". As discussed above, the parameter $\delta$ can be recovered by dividing the coefficient on the share of commuters by the coefficient on log(employment), i.e., $\delta = 0.0047/0.71 = 0.007$. This means that cross-border commuters increase production by 0.7 percent more than incumbent workers, possibly reflecting both a higher own-productivity and a spillover effect on incumbent workers' productivity. The coefficient is small in magnitude, but statistically significant.

The first stage results are reported in column (3), which demonstrates that the instrument is highly predictive of the endogenous variable, Share of commuters. Column (2) then shows

[12]Following Balsvik (2011), we also include the share of new domestic hires as a control variable to account for the fact that newly hired workers more broadly may be more productive than stayers.

Table 6: Cross border commuters and firm-level productivity

| Dependent Variable: | log(Value Added) | log(Value Added) | Share of Commuters |
|---|---|---|---|
| | (1) OLS | (2) 2SLS | (3) First Stage |
| Share of Commuters | 0.0047*** | 0.0821*** | |
| | (0.0015) | (0.0182) | |
| log(Employment) | 0.7107*** | 0.7106*** | 0.0003 |
| | (0.0068) | (0.0070) | (0.0298) |
| log(Capital) | 0.0958*** | 0.0947*** | 0.0143 |
| | (0.0025) | (0.0026) | (0.0095) |
| $Z_{imt}$ | | | 0.0659*** |
| | | | (0.0057) |
| Firm FE | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes |
| Additional Controls | Yes | Yes | Yes |
| $N$ | 85,725 | 85,725 | 85,725 |
| F-Stat on $Z_{imt}$ | | 133.5 | |

Robust standard errors in parentheses, clustered at the firm-year level. Additional controls are: Share of new hires.

*** p<0.01, ** p<0.05, * p<0.10.

the 2SLS results. The coefficient on employment and capital remains almost unchanged, but the coefficient on "Share of commuters" increases substantially to 0.0821. Again, we can use the coefficient on employment to back out $\delta$, which now becomes 0.116. In other words, once possible endogeneity bias is accounted for, the cross border worker productivity premium is 11.6 percent relative to incumbent workers. Thus, these results show a strong positive effect of hiring cross border commuters, though the results do not show whether commuters are more productive themselves, or whether productivity and knowledge spillovers from commuters make native workers more productive.

Having established that there is a plausible causal effect of hiring commuters on value added of firms, we proceed with our main analysis using worker-level regressions.

### 5.2 Worker-level results

We now turn to the question of whether cross-border commuters have a positive impact on the productivity of their closest coworkers within the firms they are hired by. If so, this is likely to reflect learning and knowledge spillovers. Following, e.g., Cornelissen et al. (2017), we use wages as a measure of productivity, and we interpret the wage effect of cross-border commuters on native workers within the same occupation as a peer effect on coworker productivity.

Results from estimating equation (5), where the dependent variable is log hourly wage, are shown in Table 7. Columns (1)-(2) show the OLS results. The coefficient on "Share of commuters", though significant, is economically very low: An increase of 10 percentage points in the share of commuters within the occupational group increases the hourly wage by the native workers by around 1/100 of a percent. When we instrument for the share of commuters using the same instrument as for Table 6, we get a coefficient of interest of 0.020 (column 4). The interpretation of this is that an exogenous 10 percentage point increase in the share of commuters increases the average pay of natives in the same occupational group by 0.2 percent.

#### 5.2.1 Spillover effects by type of commuter

If the findings in Table 7 is the result of knowledge spillovers from the commuters, one would expect the spillovers to vary across different types of commuters depending on skills and occupational experience. In the following, we split commuters by skill type (high and low skilled) and whether they have experience as tech workers in Sweden. That is, we define the share of commuters, $s_{j,t,o}$ in equation (5) as the share of either high-skilled commuters, low-skilled commuters or commuting tech workers out of total workers (regardless of worker type) in firm $i$ in occupation $o$ at time $t$. For each commuter share variable we construct our instrumental variable in equation (4) correspondingly such that, e.g., the instrument for the high-skilled commuter share only uses the aggregate inflow of high-skilled cross border

Table 7: Spillover effects of cross border commuters on native coworkers

| Dependent Variable: log(Hourly Wage) | (1) OLS | (2) OLS | (3) 2SLS | (4) 2SLS |
|---|---|---|---|---|
| Share of Commuters | 0.0007** | 0.0007*** | 0.0208*** | 0.0197** |
| | (0.0003) | (0.0003) | (0.0085) | (0.0085) |
| log(Employment) | | 0.0236*** | | 0.0254*** |
| | | (0.0027) | | (0.0030) |
| log(Capital) | | 0.0007 | | 0.0007 |
| | | (0.0007) | | (0.0007) |
| Individual-Firm-Occ. FE | Yes | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes | Yes |
| Additional Controls | Yes | Yes | Yes | Yes |
| $N$ | 2,282,779 | 2,282,779 | 2,282,779 | 2,282,779 |
| Firm-Years | 60,184 | 60,184 | 60,184 | 60,184 |
| F-Stat on $Z_{imt}$ | | | 107.1 | 109.5 |
| Avg. Commuter Share (%) | 0.7047 | 0.7047 | 0.7047 | 0.7047 |

Robust standard errors in parentheses, clustered at the firm-year level.

Additional controls are: Share of new hires, age, age-squared, tenure (years) and a high-skill dummy.

*** p<0.01, ** p<0.05, * p<0.10.

Table 8: Spillover effects by commuter type

| Dependent Variable: log(Hourly Wage) | (1) High-Skilled | (2) Low-Skilled | (3) Tech Workers |
|---|---|---|---|
| Share of Commuters | 0.0950*** | 0.0065 | 0.1051*** |
| | (0.0219) | (0.0131) | (0.0384) |
| log(Employment) | 0.0257*** | 0.0240*** | 0.0247*** |
| | (0.0032) | (0.0029) | (0.0030) |
| log(Capital) | 0.0014 | 0.0006 | 0.0018* |
| | (0.0010) | (0.0007) | (0.0009) |
| Individual-Firm-Occ. FE | Yes | Yes | Yes |
| Industry-Year FE | Yes | Yes | Yes |
| Additional Controls | Yes | Yes | Yes |
| $N$ | 2,282,779 | 2,282,779 | 2,282,779 |
| Firm-Years | 60,184 | 60,184 | 60,184 |
| F-Stat on $Z_{imt}$ | 36.77 | 71.42 | 14.46 |
| Avg. Commuter Share (%) | 0.297 | 0.408 | 0.137 |

Robust standard errors in parentheses, clustered at the firm-year level.

Additional controls are: Share of new hires, age, age-squared, tenure (years) and a high-skill dummy.

*** p<0.01, ** p<0.05, * p<0.10.

workers in the numerator.[13]

Table 8 shows the results. Column (1) only considers the share of high-skilled cross border workers and shows a sizeable positive spillover: A 10 percentage point increase in the share of high-skilled cross border workers increases wages by 0.95 percent. Low-skill workers, by contrast, do not show a significant wage effect on incumbent coworkers (column (2)). In other words, high-skilled cross border workers from Sweden are likely to carry knowledge that make their coworkers in Denmark more productive, while this is not the case for low-skilled cross border workers.

Cross border workers may also differ in terms of how much knowledge they carry depending on the occupation they worked in in Sweden before commuting. In Section 3.4 it

[13]To be precise, the instrument for the share of commuter type $T$ is defined as $Z^T_{i,t} = \frac{\sum_o \bar{\omega}_{i,o} \times M^T_{o,-i,t}}{D_i}$, where $M^T_{o,-i,t}$ is the total inflow of cross border workers of type $T$ that in Sweden most recently worked in occupation $o$ in all firms other than firm $i$ at time $t$.

was argued that tech workers are good proxy for high-skilled knowledge workers since this group of workers includes R&D workers, engineers, programmers, and technicians. In column (3) we examine the impact from commuting tech workers on incumbent coworkers and find a slightly stronger spillover effect than for high-skilled cross border workers. We take this as evidence that tech workers also carry valuable knowledge and that local coworkers learn from commuting tech workers and become more productive.

# 6 Conclusion

The transmission of knowledge across countries has long been regarded as an important driver of productivity growth, but causal micro-level evidence in support of this view has been lacking. This is mainly due to data limitations. It is inherently difficult to measure knowledge, and it is even more challenging to track how it transfers across borders and is absorbed by local firms and workers.

In this paper we use new and unique matched worker-firm data from Denmark and Sweden that allow us to track cross border commuters from Sweden to Denmark after the opening of the Øresund bridge. We observe the Swedish labor market history of the commuters including the firms and occupations where they worked before commuting as well as the firms and occupations they find employment in after commuting. This allows us to distinguish commuters by how likely they are to carry knowledge and affect their new coworkers after commuting.

We find evidence of substantial spillovers from commuters. In particular, in our firm-level analysis we show that commuters have a productivity premium compared to incumbent workers. This may reflect that cross border commuters are more productive than incumbent workers, or that they improve productivity of incumbent workers through a knowledge spillover effect (or both).

To establish that at least part of this productivity premium of cross border commuters is due to knowledge spillovers, we examine how coworkers of cross border commuters

within occupations of Danish firms are affected. We show that a higher share of cross border commuters in natives' firm-occupations increases wages. This effect is stronger for commuting tech workers, that are likely to carry and transmit more knowledge than other cross border commuters. We also find that commuting high-skilled workers have stronger peer effects on wages than low-skilled commuters. We take these results as evidence for knowledge spillovers through international labor mobility.

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# A Appendix Tables and Figures

Table A1: First stage results for columns 3-4 of Table 7

| Dependent Variable: Share of Commuters | (1) | (2) |
|---|---|---|
| $Z_{imt}$ | 0.0615*** | 0.0618*** |
| | (0.0059) | (0.0059) |
| log(Employment) | | -0.0971** |
| | | (0.0488) |
| log(Capital) | | -0.0065 |
| | | (0.0092) |
| Individual-Firm-Occ. FE | Yes | Yes |
| Industry-Year FE | Yes | Yes |
| Additional Controls | Yes | Yes |
| $N$ | 2,282,779 | 2,282,779 |
| Firm-Years | 60,184 | 60,184 |
| F-Stat on $Z_{imt}$ | 107.1 | 109.5 |
| Avg. Commuter Share (%) | 0.7047 | 0.7047 |

Robust standard errors in parentheses, clustered at the firm-year level.

Additional controls are: Share of new hires, age, age-squared, tenure (years) and a high-skill dummy.

*** p<0.01, ** p<0.05, * p<0.10.

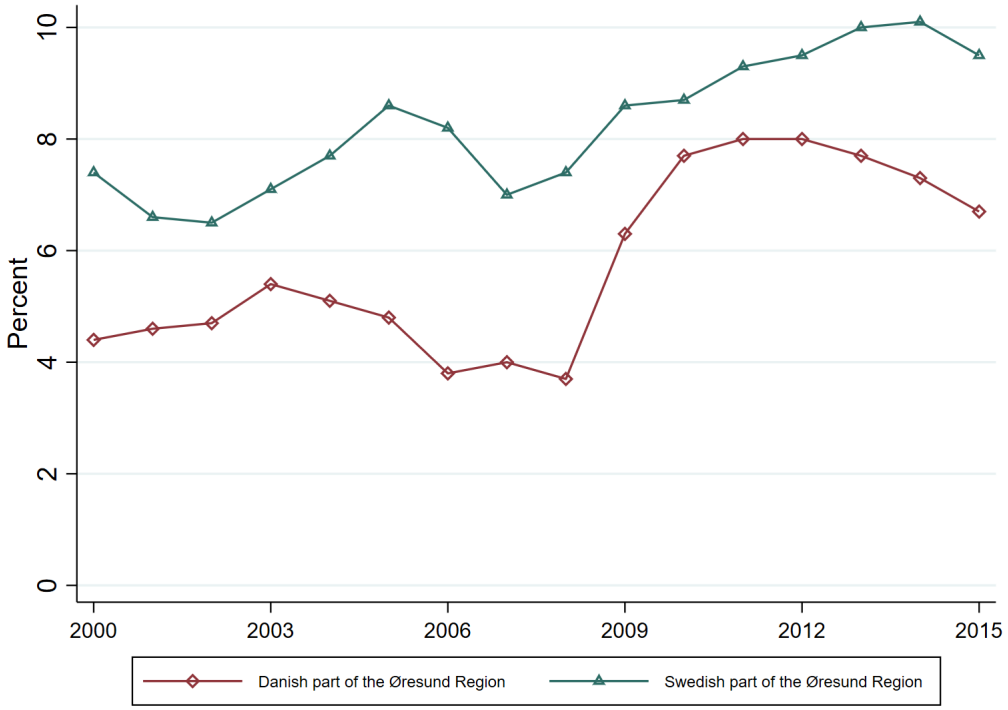


Figure A.1: Unemployment rate in Danish and Swedish part of Øresund region

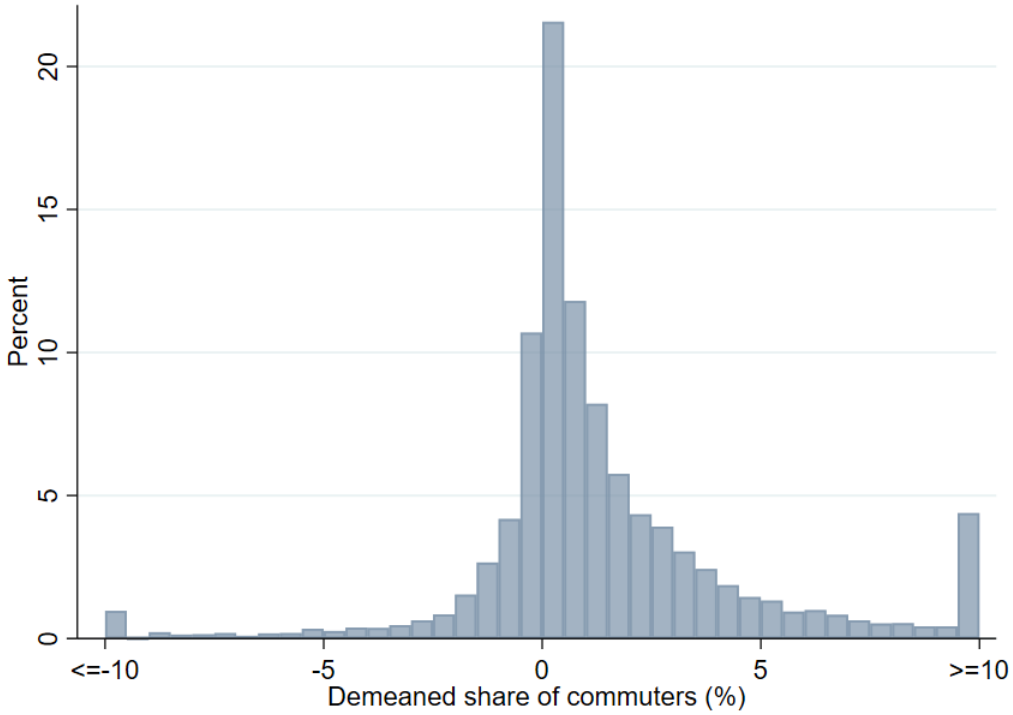


Figure A.2: The graph shows the share of commuters within firms demeaned with their average share in the years 2000-2015.