# History and Industry Location: Evidence from German Airports

Stephen J. Redding, Daniel M. Sturm, Nikolaus Wolf

# Introduction

This paper examines the impact of exogenous shocks on the location of the air hub.

The combination of the division of Germany in the wake of the Second World War and the reunification of East and West Germany is considered as a natural experiment to provide empirical evidence for multiple steady-states in industry location.

# Previous Empirical Research

(1) *Davis, Weinstein (2002, 2008)*: long-run city size and the location of industries is robust even to large temporary shocks (example of bombing the

*(2) Brakman et al. (2006):* the populations of West German cities recover rapidly from the devastation caused by the Second World War.

*(3) Miguel, Roland (2006):* bombing campaign in Vietnam does not seem to have had a permanent impact on the distribution of population and basic measures of economic development across the regions of Vietnam.

*(4) Bosker et al. (2007, 2008):* find some evidence of a permanent change in the distribution of population across West German cities after the Second World War.

# Theoretical Model: Assumptions

- ✓3 locations (cities)
- ✓A monopoly airline chooses whether to operate direct connections between all three cities or to create a hub.
- ✓There is a fixed cost of $F > 0$ units of labor of operating each direct connection.
- ✓There is a sunk cost of $H > 0$ units of labor of creating a hub.
- ✓The hub itself can be located in any one of the three cities.
- ✓It is assumed that direct connections are profitable on all three routes
- ✓Downward-sloping demand curve.
- ✓The airline chooses the price on a route to maximize profits.

# Theoretical model

$$\omega_i = F - \left(\pi^D_{kj} - \pi^I_{kj}\right) \qquad (1)$$

$\omega_i$ - the per-period difference in profits from locating the hub in city i and serving all three routes with direct connections

$\pi^D_{kj}$ , $\pi^I_{kj}$ - variable profits from a direct and indirect connection between cities k and j

$\pi^D_{kj} - \pi^I_{kj} \geq 0$

Choose i: $\Omega_1 \geq \Omega_2 \geq \Omega_3$

$\Omega_i$ - the present discounted value of the difference in profits

There are multiple steady-state locations of the hub if

$$\Omega_i > H \quad \text{and} \quad \Omega_j - \Omega_i < H \quad \text{for all } j \neq i \qquad (2)$$

City i is the unique steady-state location of the hub if

$$\Omega_i > H \quad \text{and} \quad \Omega_i - \Omega_j > H \quad \text{for all } j \neq i \qquad (3)$$

The exogenous shock of division will shift the location of the hub between multiple steady-states if

$$\Omega_2 - (\Omega_1 - S) > H \quad \text{and} \quad |\Omega_2 - (\Omega_1 - S')| < H \qquad (4)$$

# Data Description

*Total Departing Passengers at the ten main airports* (1927-1938 and 1950-2002) (The Statistical Yearbook of Germany).

*Bilateral Departures:* Data on bilateral departures between the 15 largest German airports in 2002 (The Statistical Yearbook of Germany).

*Transit Passengers and Local Departures* in 2002: Information on the number of air transit passengers, who are passengers changing planes at an airport on route to another destination, is reported for 2002 (The Statistical Yearbook of Germany).

*Departing Passengers in other European Countries*: Data on the concentration of departing passengers in other European countries in 2002 (Worldwide Airport Traffic Report 2002).

*Distances between Locations:* Data on the longitude and latitude of each airport (DAFIF Database), data on the longitude and latitude of the administrative capital of each German county (“Kreis”)(N250 GIS database).

*Population and GDP data:* Data on population and GDP in each German county in 2002 (Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder) and data on the population in all municipalities within 50 kilometers of each German city with more than 50,000 inhabitants (N250 GIS database).

*Foreign migration:* Data on bilateral migration between the German states (“Länder”) and foreign countries for 2002 (Federal Statistical Office).

*Foreign subsidiaries:* Data on the location of the foreign subsidiaries and headquarters of German companies (Bureau Van Dijk’s Orbis database).

# Model Specification

$$share_{at} = \sum_{a=1}^{A} \eta_{ap} + \sum_{a=1}^{A} \beta_{ap} time_t + u_{at}$$

where a – airport index, t – year, p – period

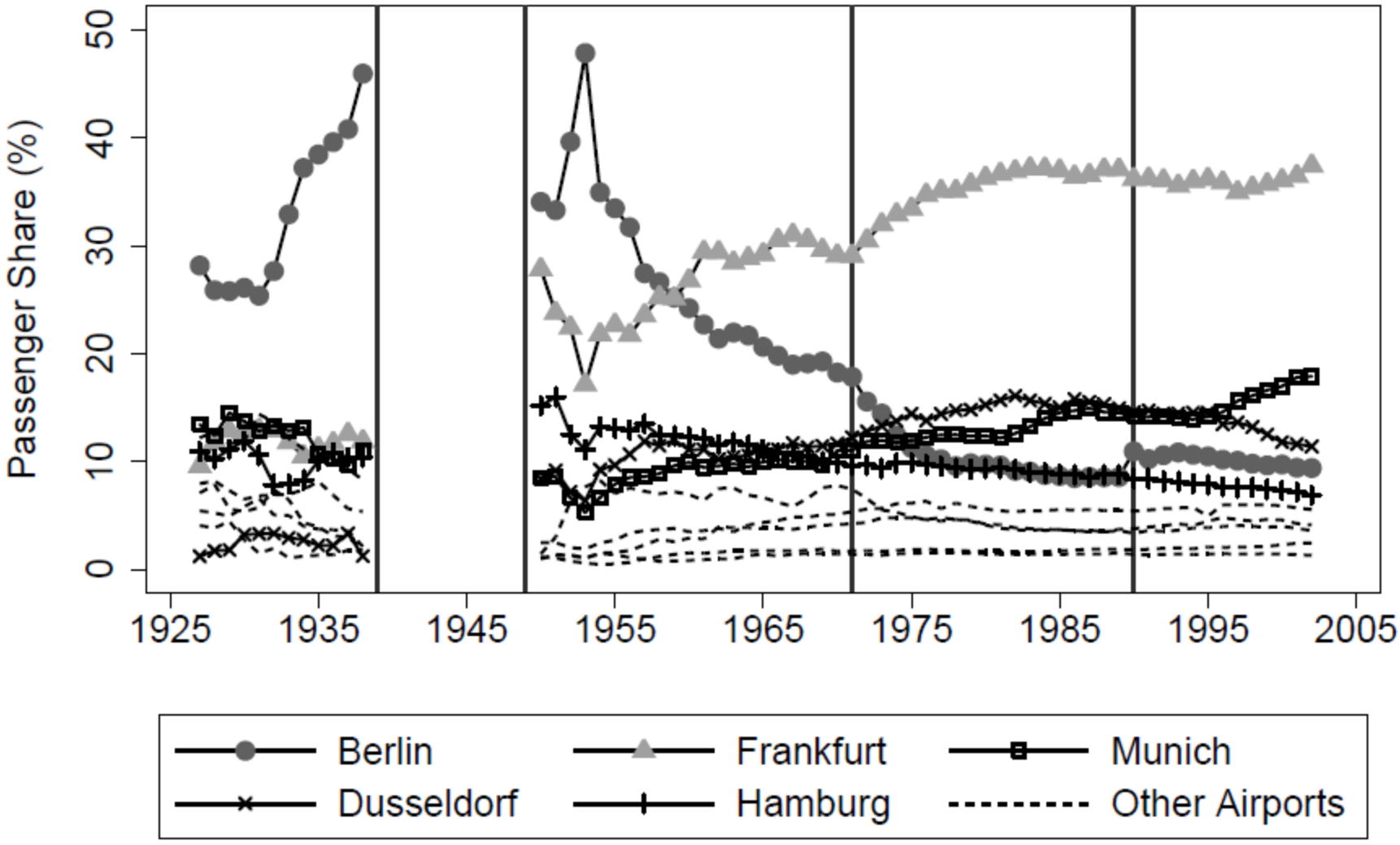
$share_{at}$ - the share of an airport in passenger traffic in year t

$\eta_{ap}$ - airport-period fixed effects, allow for changes in mean passenger shares for each airport between the pre-war, division and reunification periods

$\beta_{ap}$ allow trends in passenger shares for each airport to also vary between the pre-war, division and reunification periods

$u_{at}$ - stochastic error

# Airport Passenger Shares



# Estimation Results

TABLE 1

Estimated Time Trends for the Pre-war, Division and Reunification Periods

| Period | (1) 1927-1938 | (2) 1950-1989 | (3) 1990-2002 | (4) 1980-1989 |
|---|---|---|---|---|
| Berlin | 1.851*** | -0.814*** | -0.123*** | -0.139*** |
| | (0.267) | (0.067) | (0.018) | (0.024) |
| Bremen | -0.259*** | 0.022*** | -0.001 | 0.004 |
| | (0.062) | (0.003) | (0.004) | (0.005) |
| Cologne | -0.360*** | 0.064*** | 0.044** | -0.043** |
| | (0.086) | (0.013) | (0.021) | (0.020) |
| Dusseldorf | 0.036 | 0.203*** | -0.300*** | -0.050 |
| | (0.080) | (0.015) | (0.032) | (0.038) |
| Frankfurt | 0.029 | 0.436*** | 0.037 | 0.034 |
| | (0.098) | (0.036) | (0.048) | (0.031) |
| Hamburg | -0.078 | -0.145*** | -0.125*** | -0.084*** |
| | (0.068) | (0.014) | (0.006) | (0.017) |
| Hanover | -0.453*** | -0.082*** | 0.031* | -0.071*** |
| | (0.056) | (0.028) | (0.017) | (0.015) |
| Munich | -0.337*** | 0.195*** | 0.360*** | 0.320*** |
| | (0.081) | (0.013) | (0.043) | (0.053) |
| Nuremberg | -0.274*** | 0.017*** | 0.048*** | 0.028*** |
| | (0.058) | (0.002) | (0.005) | (0.005) |
| Stuttgart | -0.156*** | 0.096*** | 0.030** | 0.001 |
| | (0.056) | (0.009) | (0.014) | (0.010) |
| Airport-period intercepts | Yes | Yes | Yes | Yes |
| R-squared | 0.98 | 0.98 | 0.98 | 0.99 |

# Estimation Results

TABLE 2
Estimated Differences in Time Trends

| | (1) | (2) | (3) |
|---|---|---|---|
| **Panel A: Division** | | | |
| | Period 1927-1938 | Period 1950-1989 | Between-Period Difference |
| Berlin | 1.851*** | -0.814*** | 2.665*** |
| | (0.267) | (0.067) | (0.275) |
| Frankfurt | 0.029 | 0.436*** | -0.407*** |
| | (0.098) | (0.036) | (0.104) |
| Within-Period Difference | 1.823*** | -1.250*** | **3.072*** ** |
| | (0.284) | (0.075) | **(0.294)** |
| **Panel B: Reunification** | | | |
| | Period 1980 - 1989 | Period 1990-2002 | Between-Period Difference |
| Berlin | -0.139*** | -0.123*** | -0.016 |
| | (0.024) | (0.018) | (0.031) |
| Frankfurt | 0.034 | 0.037 | -0.003 |
| | (0.031) | (0.050) | (0.059) |
| Within-Period Difference | -0.172*** | -0.160*** | **-0.012** |
| | (0.039) | (0.053) | **(0.066)** |

# Is the Relocation of the Hub a Shift Between Multiple Steady-States?

- International Evidence
- The Selection of Frankfurt. The ability of policy interventions to influence location choices
- The role of the economic fundamentals:
  - ✓ Market Access
  - ✓ Local Economic Activity

# International Evidence

TABLE 3

The Largest Airports of European Countries in 1937 and 2002

| | (1) Largest Airport in 1937 | (2) Market share of largest airport in 1937 | (3) Market share of largest airport in 2002 | (4) Rank of largest airport 1937 in 2002 |
|---|---|---|---|---|
| Austria | Vienna | 94.1 | 76.5 | 1 |
| Belgium | Brussels | 65.6 | 89.9 | 1 |
| Denmark | Kopenhagen | 96.2 | 91.7 | 1 |
| Finland | Helsinki | 80.3 | 73.7 | 1 |
| France | Paris | 70.2 | 61.4 | 1 |
| Germany | Berlin | 30.8 | 35.0 | 4 |
| Greece | Athens | 43.9 | 34.7 | 1 |
| Ireland | Dublin | 100.0 | 78.1 | 1 |
| Italy | Rome | 35.7 | 34.5 | 1 |
| Netherlands | Amsterdam | 62.3 | 96.4 | 1 |
| Norway | Oslo | 75.6 | 45.8 | 1 |
| Portugal | Lisbon | 100.0 | 46.3 | 1 |
| Spain | Madrid | 43.5 | 26.8 | 1 |
| Sweden | Stockholm | 56.9 | 61.9 | 1 |
| Switzerland | Zurich | 55.7 | 62.0 | 1 |
| United Kingdom | London | 52.7 | 65.6 | 1 |

# The Selection of Frankfurt. The ability of policy interventions to influence location choices

Historical Background:

There is a remarkable similarity in pre-war shares of air traffic between Frankfurt, Cologne, Hamburg and Munich

Facts:

- ✓ In contrast to Cologne and Hamburg, Frankfurt was located in the U.S. occupation zone
- ✓ in 1948 was chosen as the European terminal for the U.S. Military Air Transport Service (MATS)

Conclusion: the observed pattern shows the ability of policy interventions to influence location choices.

# The Role of Market Access: The Model

$$\ln(A_{ij}) = m_i + s_j + \varphi \ln T_{ij} + u_{ij} \qquad (6)$$

$A_{ij}$ – bilateral departures from city j to i
$m_i$ – destination fixed effects
$s_j$ – source airport fixed effects
$T_{ij}$ – bilateral travel costs

$$\widehat{A}_j = \sum_i \widehat{A}_{ij} = \left[\sum_i T_{ij}^{\hat{\varphi}} \widehat{M}_i\right] \widehat{S}_j \equiv \widehat{MA}_j \widehat{S}_j \qquad (7)$$

$$M_i \equiv \exp(m_i) \qquad S_j \equiv \exp(s_i)$$

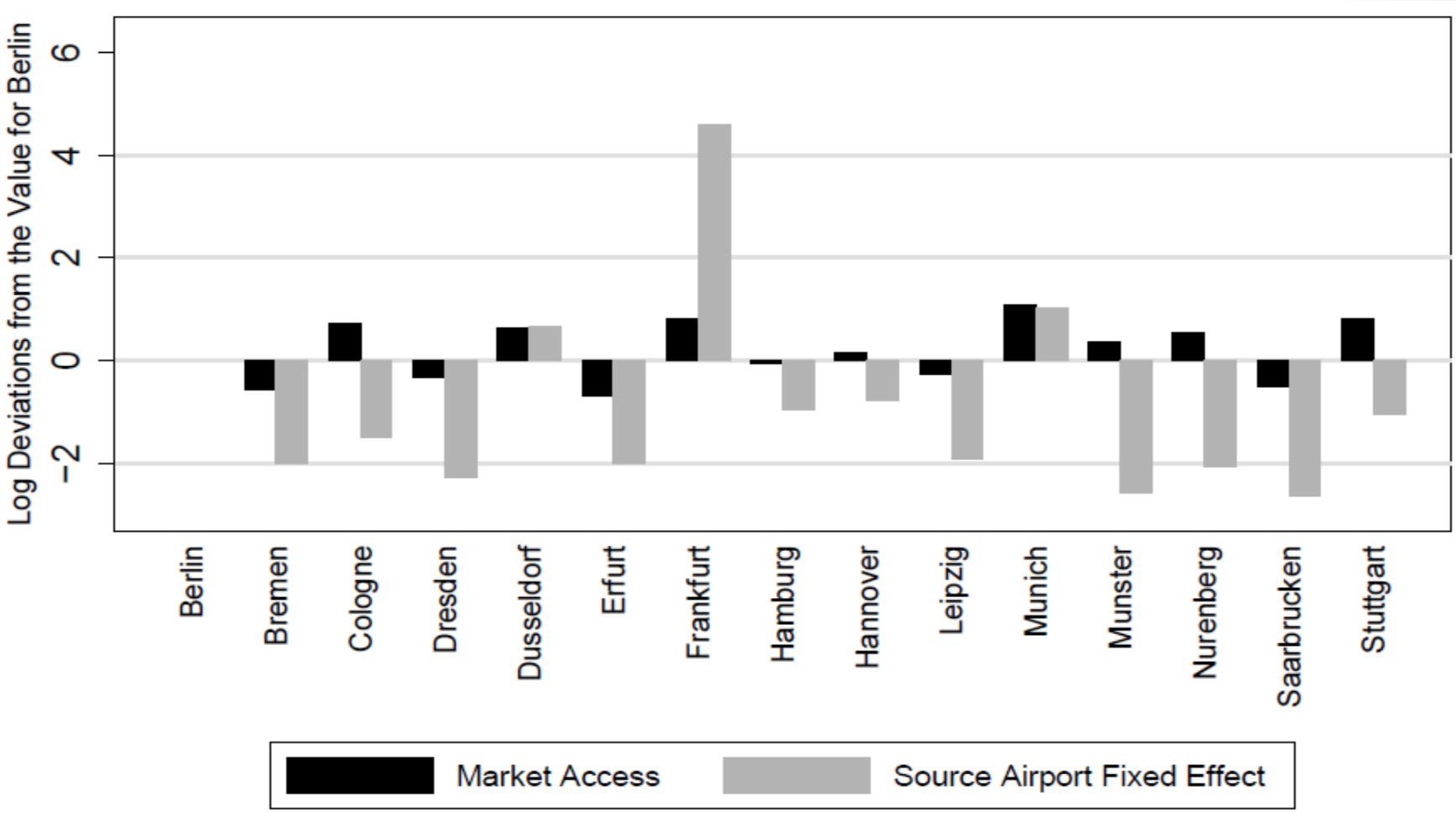
$$\ln\left(\frac{\widehat{A}_j}{\widehat{A}_b}\right) = \ln\left(\frac{\widehat{MA}_j}{\widehat{MA}_b}\right) + \ln\left(\frac{\widehat{S}_j}{\widehat{S}_b}\right) \qquad (8)$$

# The Role of Market Access: Estimation Results

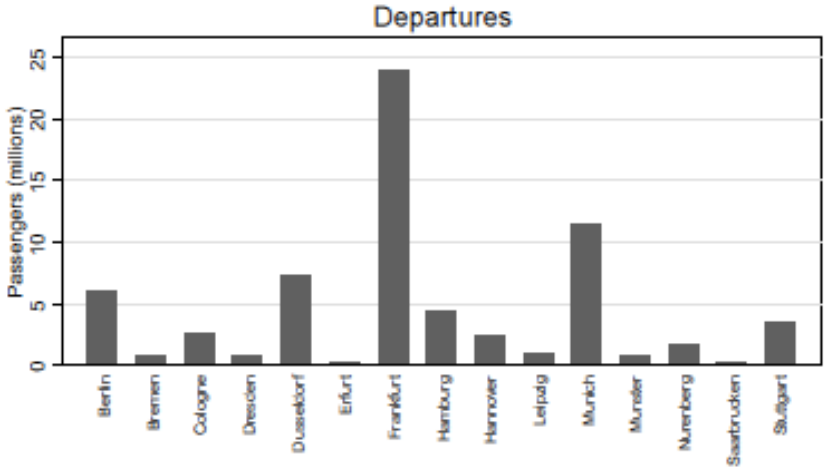
TABLE 4
Determinants of Bilateral Passenger Departures

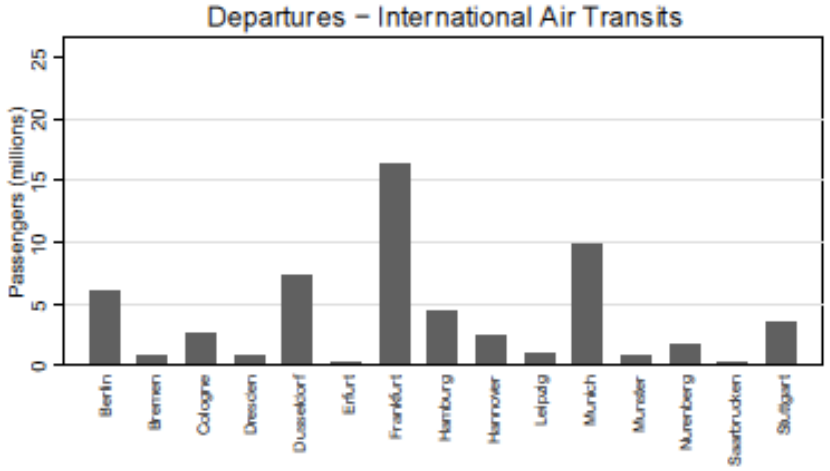
| | (1) Logarithm of Bilateral Passenger Departures | (2) Logarithm of Bilateral Passenger Departures | (3) Logarithm of Bilateral Passenger Departures | (4) Logarithm of Bilateral Passenger Departures |
|---|---|---|---|---|
| Logarithm of Distance | -1.652*** | -1.313*** | -1.556*** | -1.286*** |
| | (0.543) | (0.490) | (0.489) | (0.465) |
| Logarithm of Foreign Migration | | 0.370*** | | 0.325*** |
| | | (0.094) | | (0.105) |
| Logarithm of Subsidiaries | | | 0.206*** | 0.145* |
| | | | (0.067) | (0.076) |
| Source Airport Fixed Effects | Yes | Yes | Yes | Yes |
| Destination Airport Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 5130 | 5130 | 5130 | 5130 |
| R-squared | 0.680 | 0.683 | 0.682 | 0.684 |

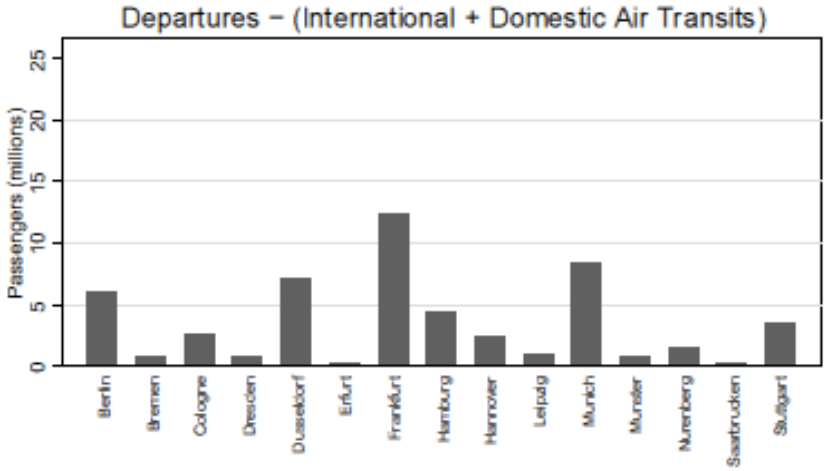
# The Role of Market Access: Estimation Results

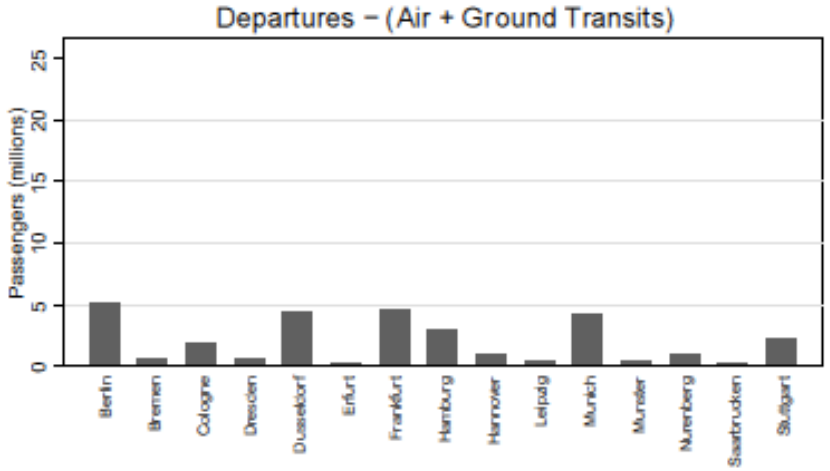


# Local Economic Activity and Local Departures

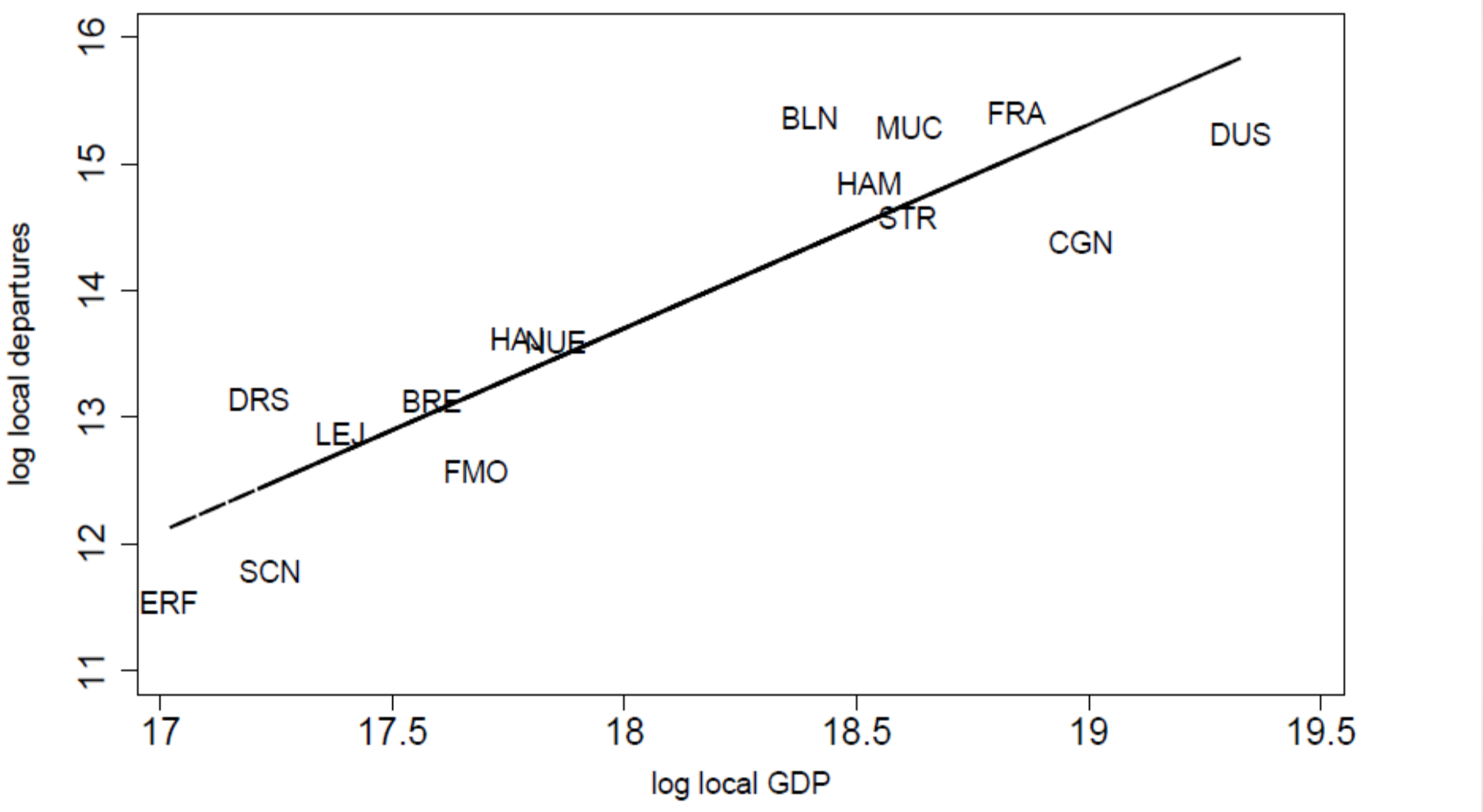


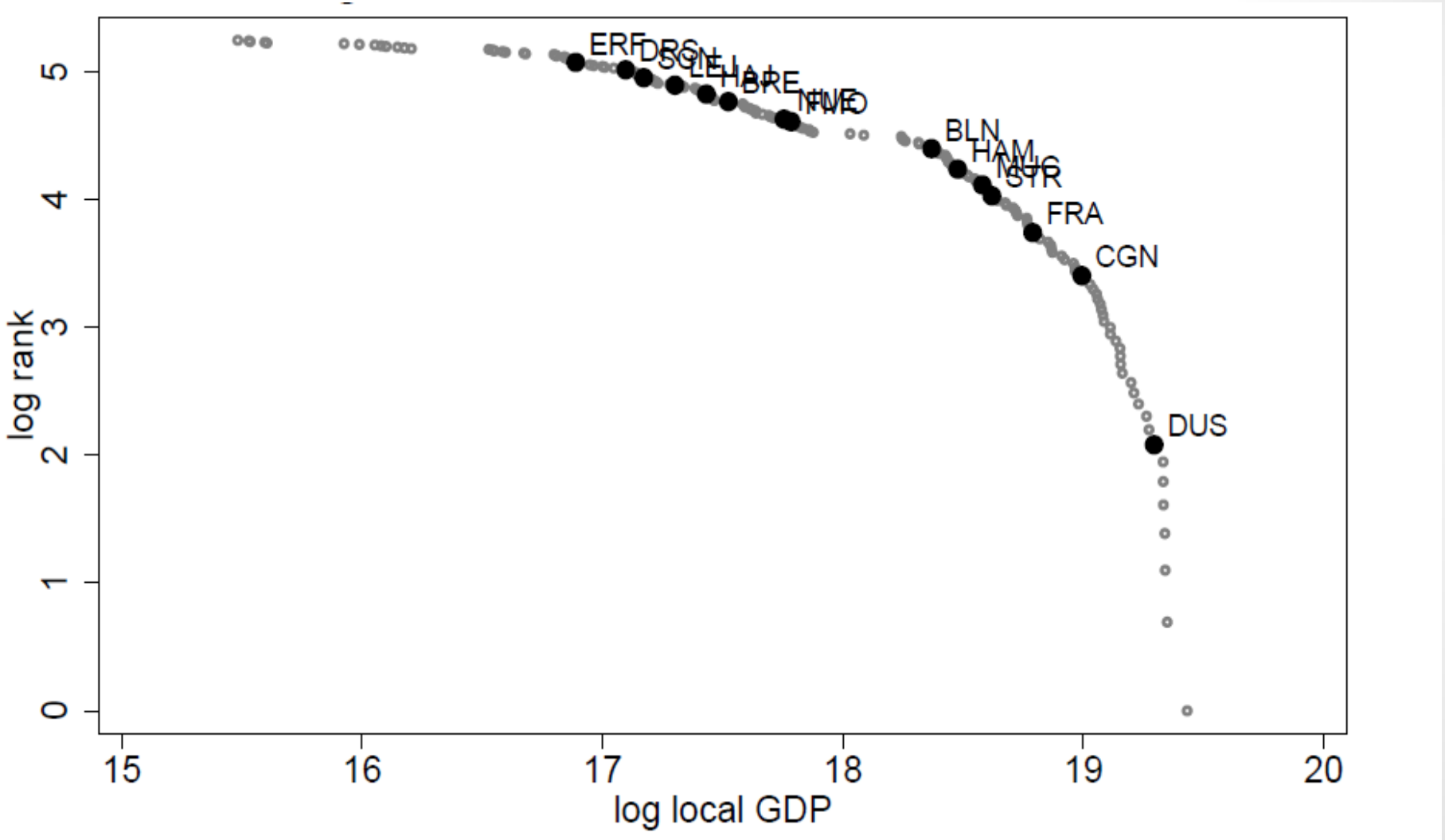



# Local Departures and Local GDP



# Local GDP for German Cities



# Quantifying Differences in Profitability Across Locations

TABLE 5

Estimated Impact of Relocating the Air Hub from Frankfurt on Total Passenger Departures Across the 15 German Airports

| Alternative Location of the Air Hub | (1) Estimated Change in Air Transit Passengers | (2) Estimated Change in Ground Transit Passengers | (3) Estimated Change in Total Passenger Departures | (4) Estimated Percentage Change in Total Passenger Departures |
|---|---|---|---|---|
| Berlin | -407,498 | -1,862,056 | -2,232,380 | -3.38% |
| Dusseldorf | 148,590 | -18,331 | 125,759 | 0.19% |
| Hamburg | -332,672 | -1,644,620 | -1,852,323 | -2.80% |
| Munich | 566,039 | -865,146 | -422,204 | -0.64% |

# Summary

- ✓ The exogenous shock of division results in a relocation of Germany's the leading airport from Berlin to Frankfurt, but there is no evidence of a return of the leading airport to Berlin in response to reunification.
- ✓ Industry location is not uniquely determined by fundamentals; there is instead a range of possible steady-state locations for the hub.
- ✓ This research also have broader implications for the ability of public policy to influence location choices.

# Literature


- Bosker, M., Brakman, S., Garretsen, H. and Schramm, M. (2007), Looking for Multiple Equilibria when Geography Matters: German City Growth and the WWII Shock, Journal of Urban Economics, 61, 152-169.
- Bosker, M., Brakman, S., Garretsen, H. and Schramm, M. (2008), A Century of Shocks: The Evolution of the German City Size Distribution 1925-1999, Regional Science and Urban Economics, 38, 330-347.
- Davis, D. and Weinstein, D. (2002), Bones, Bombs, and Break Points: The Geography of Economic Activity, American Economic Review, 92, 1269-1289.
- Davis, D. andWeinstein, D. (2008) A Search for Multiple Equilibria in Urban Industrial Structure, Journal of Regional Science, 48, 2965.
- Miguel, E. and Roland, G. (2006) The Long Run Impact of Bombing Vietnam, NBER Working Paper No. 11954.
- Redding, S. and Sturm, D. (2008) The Costs of Remoteness: Evidence from German Division and Reunification, American Economic Review, 98, 1766-1797.
- Redding S., Sturm D., Wolf N. (2011) History and Industrial Location: Evidence from German Airports, Review of Economics and Statistics, 93(3), 814-831.

# Thank you for your attention