Peer Effects, Free-Riding and Team Diversity

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[1]This paper does not represent the views of Lufthansa Cargo AG.

Introduction

- Firms and **managers** underestimate or are **not** even **aware of** productivity **spillovers** among employees.
- Peer effects may increase a shift's overall performance without additional cost: **Allocate human resources optimally.**
- Setting: Warehouse **agents** who **consolidate** freight **items on** cargo **pallets.**
- **Transport and logistics** industrial sector is the 3**rd largest in Germany** (after automotive and retail) with around 3 **million employees.**
- **Many firms** in global economy **operate comparable team-productions** and may face similar effects (for instance, catering, retail industry, or automotive production).

Contribution: Team Size

- Existence of behavioral average peer effects is a **function of team size:**
  - No effect in teams of 3 to 9 agents.
  - Effects in teams with more than 9 agents (up to 20).

- **Sense of monitoring** and **spatial proximity:**
  - Agents in smaller teams behave independently because they fail to feel monitored.
  - Agents in larger teams behave dependently because they necessarily build pallets closer to each other.

Contribution: Whole Social Effect

- Assume that a **high** (permanent) **productivity** agent **temporarily** experiences irregularities, and, thus, **performs much lower** than expected for certain shifts.
- **Peers** perceive his current productivity is lower than the (expected) permanent performance (i.e., they **perceive a deviation**).
- Do peers react to his **current** productivity, to his **permanent** productivity, or **both?**
- If yes, **in what way?**
- In our data, in 55% of hourly shifts, the agent with the highest ability is not the one with the highest current productivity in the shift.

Contribution: Whole Social Effect

- In large teams, **current and permanent peer effects work in opposite directions:**
  - Agents affect each other's productivity **positively** through point-in-time performance (**current**).
  - Agents affect each other's productivity **negatively** through their fixed performance signal (**permanent**).

- As in Steinbach & Tatsi (2016), overall peer productivity effects are positive: **Short-term (current) more important than long-term (permanent) peer behavior**.

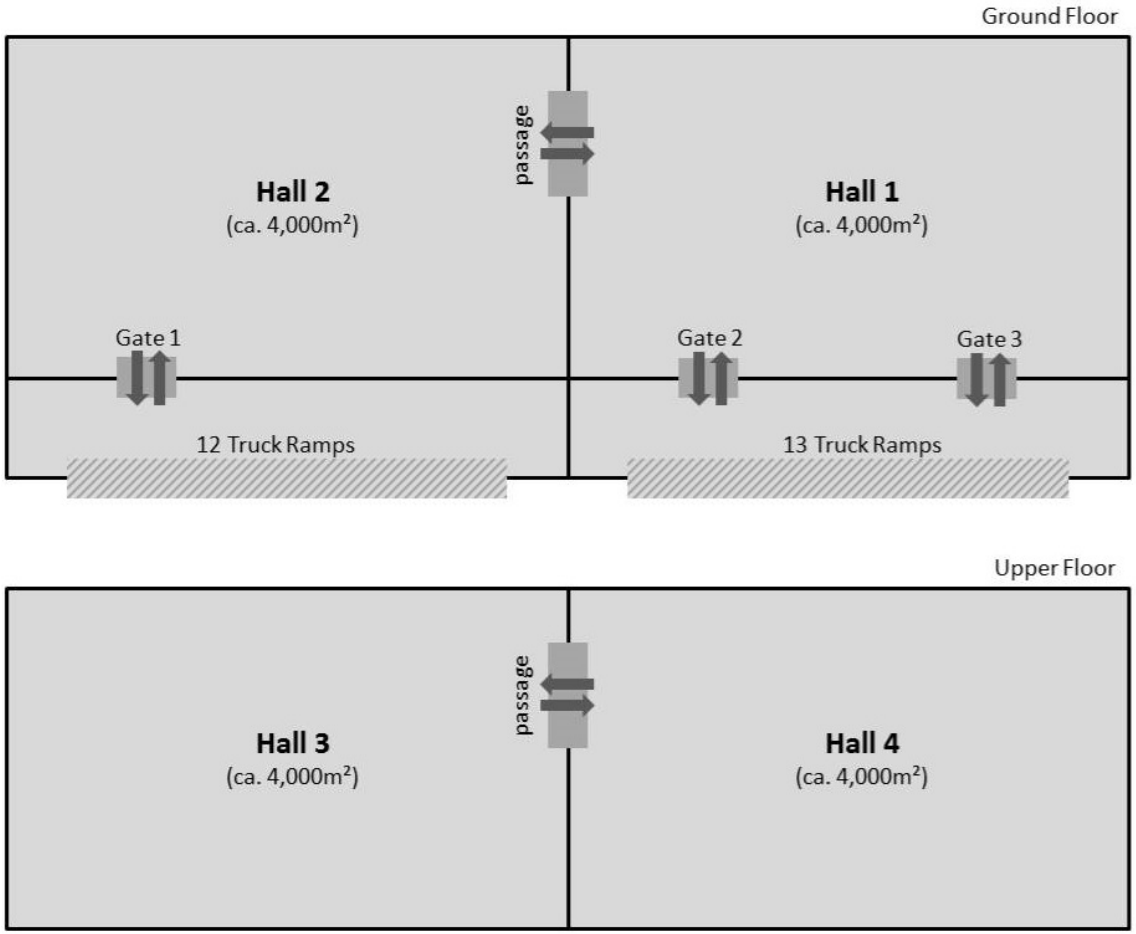
Contribution: Team Diversity

- **Free-riding is highest when all peers have the same foreign nationality:** Majority of agents with highest average permanent productivity.
- Role of **identity** and **culture** in economic outcomes (Akerlof & Kranton, 2000, 2005; Kreps, 1990): Agents with shared background have similar behavioral tendencies.
- Feel comfortable enough so that **free-riding becomes a socially acceptable behavior.**
- Empirical example of Kets & Sandroni (2016): **Team homogeneity** in terms of identity and culture **reduces strategic uncertainty** and agents get locked in an inefficient Nash equilibrium.
- Perhaps taking long breaks or working slowly every now and then is responsible for higher permanent productivity.

Literature

- **Working alone/presence of others:**
  - Falk & Ichino (2006).
  - Steinbach & Tatsi (2016).
- **Peer permanent productivity:**
  - Mas & Moretti (2009).
  - Steinbach (2016).
  - van Veldhuizen et al. (2014).
  - Kato & Shu (2008, 2009).
  - Cornelissen et al. (2017).
- Kaur et al. (2015), Bandiera et al. (2010), Guryan et al. (2009), Waldinger (2012).
- **Peer current productivity:**
  - Lindquist et al. (2015).
  - Horrace et al. (2016).

Warehouse Footprint

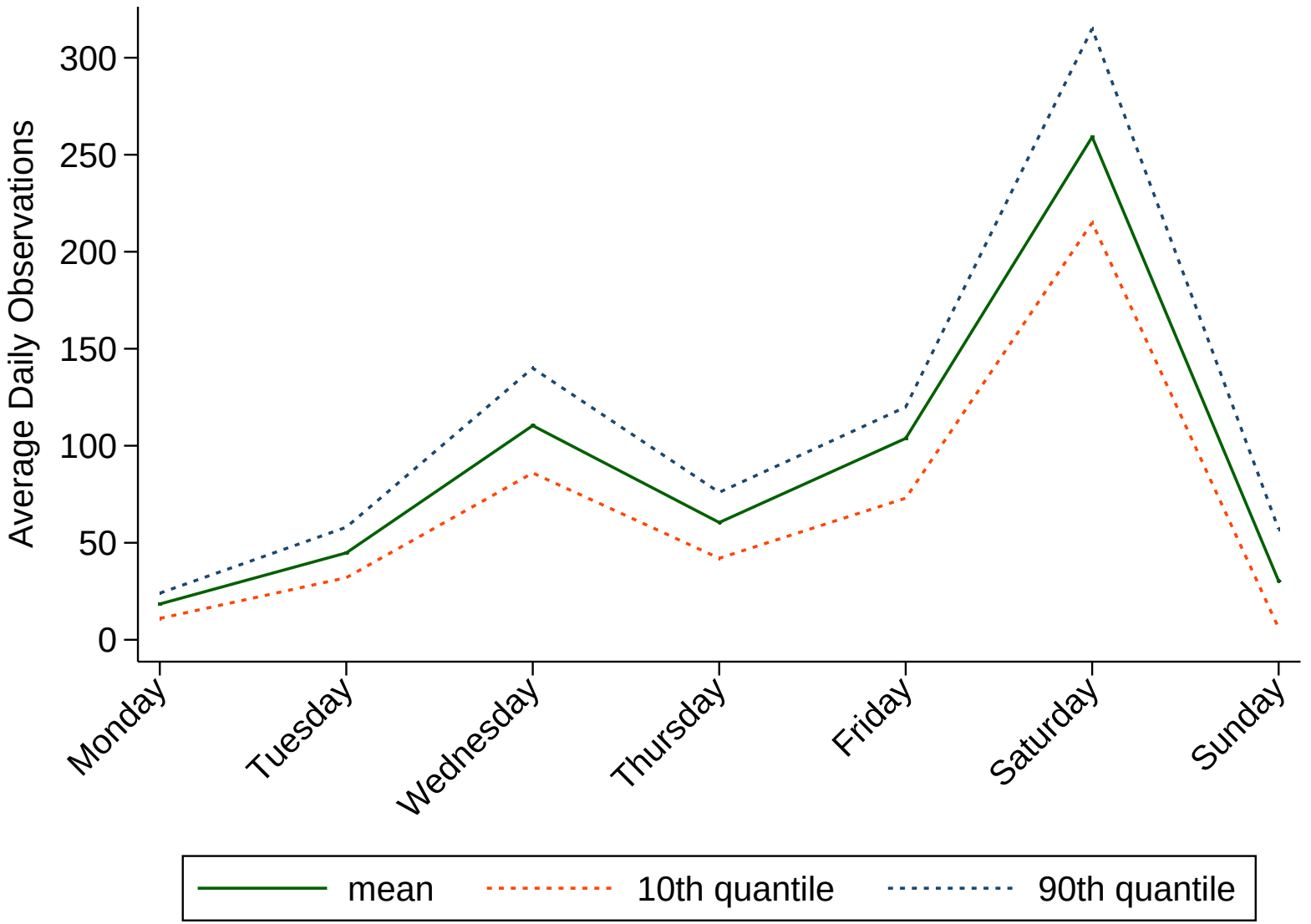


Pallets in Warehouse Hall

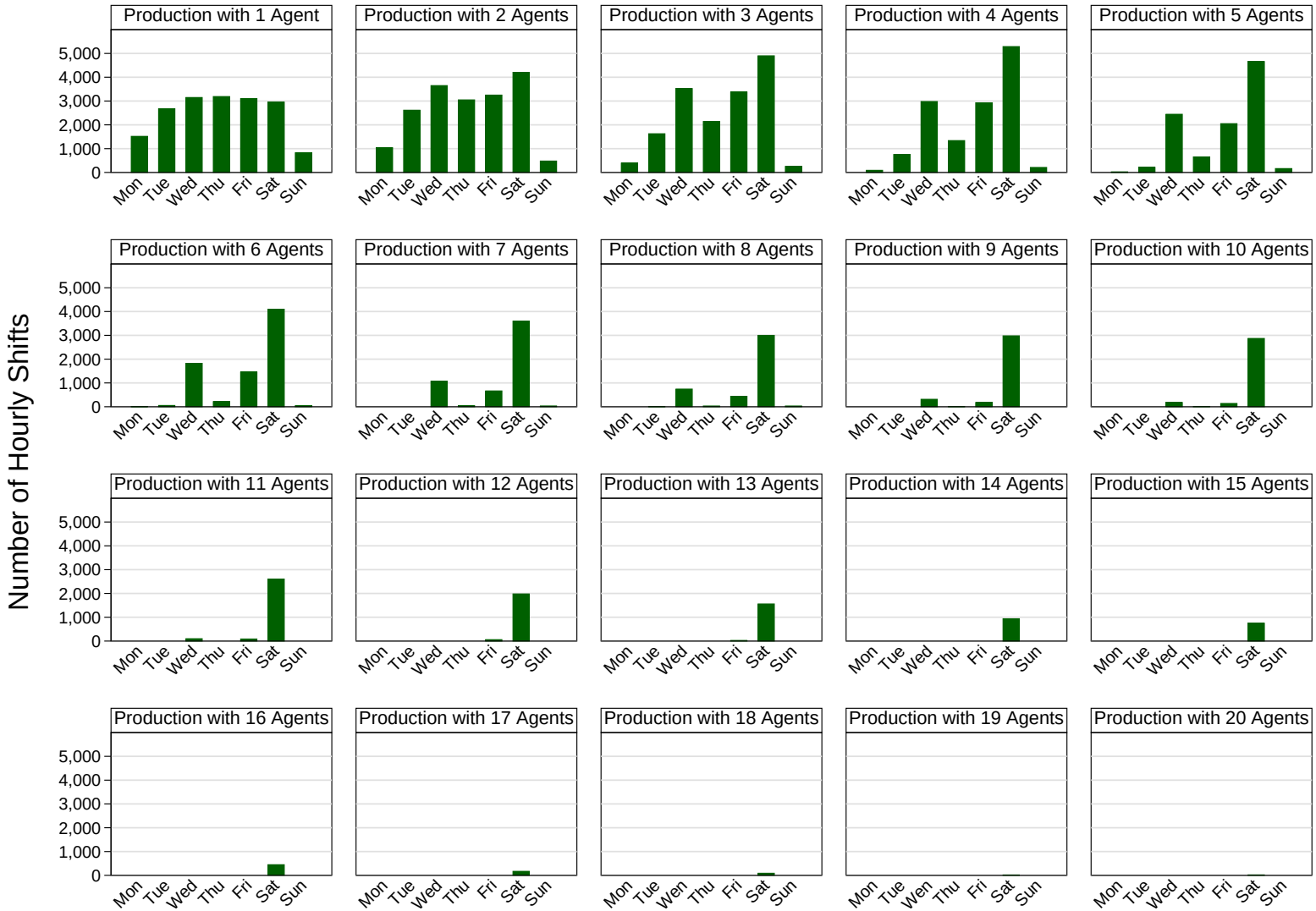
Forklift and Barcode Scanner

Finished Pallet

Weekly Demand Pattern



Hourly Shifts by Team Size and Day of Week



Work Shifts

- **Production is** performed **24/7** and operations are organized in **shift work.**

- Every day, 4 *work shifts* are planned
  - **Early** work shift from 6:00 until 14:30.
  - **Late** work shift from 14:00 until 10:30.
  - **Night** work shift from 22:00 until 6:30.
  - **Day** work shift from 09:30 until 18:00 (few agents).

- **Managers plan** work shifts several weeks **in advance** (usually 4 to 6).

Shift Scheduling & Composition I

- There exist **multiple managers** who schedule work shifts independently. In 80% of hourly shifts teams composed by agents from at least 2 different managers.
- **Managers** have **no information on individual worker productivity** (we do).
- **Managers** are **not present** in build-ups.
- **Working/hourly shift size is determined exogenously by demand.**
- **Laws protecting worker rights** prohibit employment of same high-productivity workers, for instance, every Saturday when demand meets its peak.

Shift Scheduling & Composition II

- **Agents operate in** 6 **different activities** exogenously depending on activity-related demand:
  - Truck loading/unloading.
  - Storing.
  - Relocating.
  - **Consolidating (build-up)**.
  - Deconsolidating (break downs).
- **Agents cannot choose their work/hourly shifts or tasks.** Agents log-in with personal ID to IT system (desktop, tablets and barcode scanners) to get information on next tasks. Consolidation is top priority in the warehouse after security and safety.
- **High rotation setting:** Frequent hires and quits.

Identical Shift Composition

- We observe $24,002$ **different** shift **compositions.**
- Within almost 4 years, the probability to observe one and the same shift composition
  - only once is 84.7%,
  - for more than 7 times is smaller than 2%,
  - for more than 17 times is smaller than 1%.

Conclusion

Assuming a haphazard shift composition is reasonable, and sorting can be ruled out.

Incentive Scheme

- Warehouse **agents** gain a **fixed wage** plus holiday premium and shift allowance.
- **No** effort-based or team-based **bonus.**
- Managers get effort-based premiums depending on meeting predefined targets.
- Build-up process seems to be **prone to free-riding.**

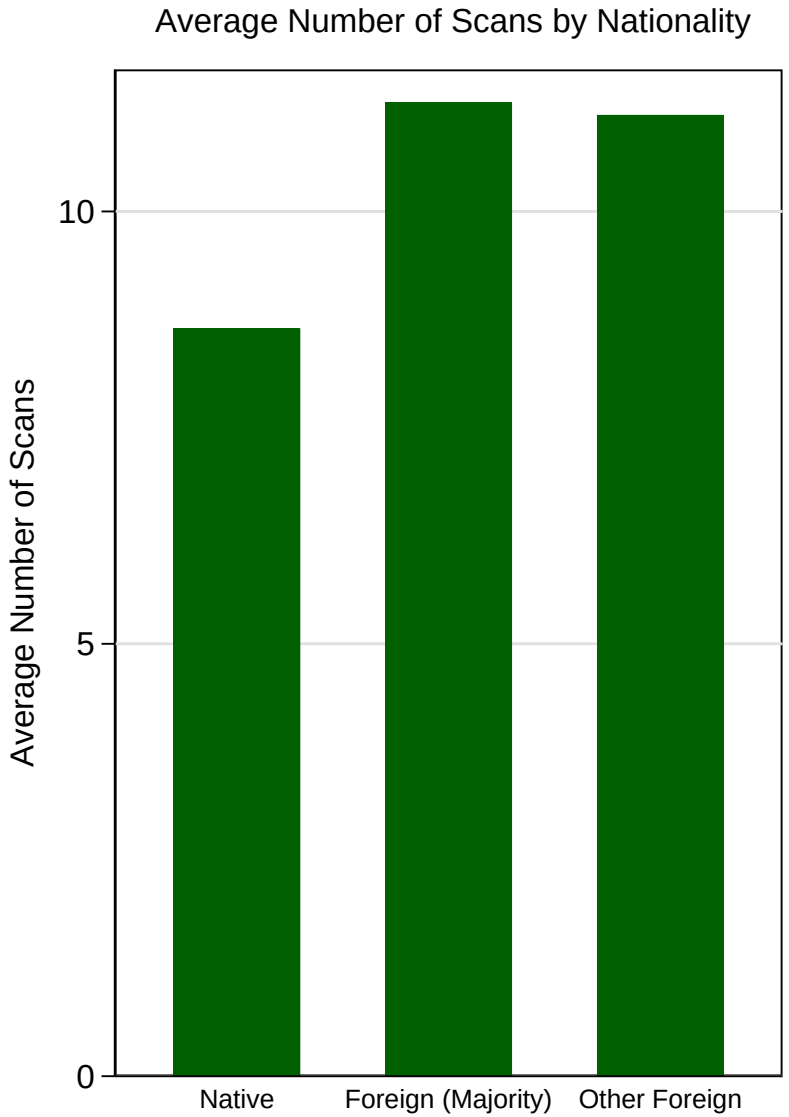
Estimation Sample

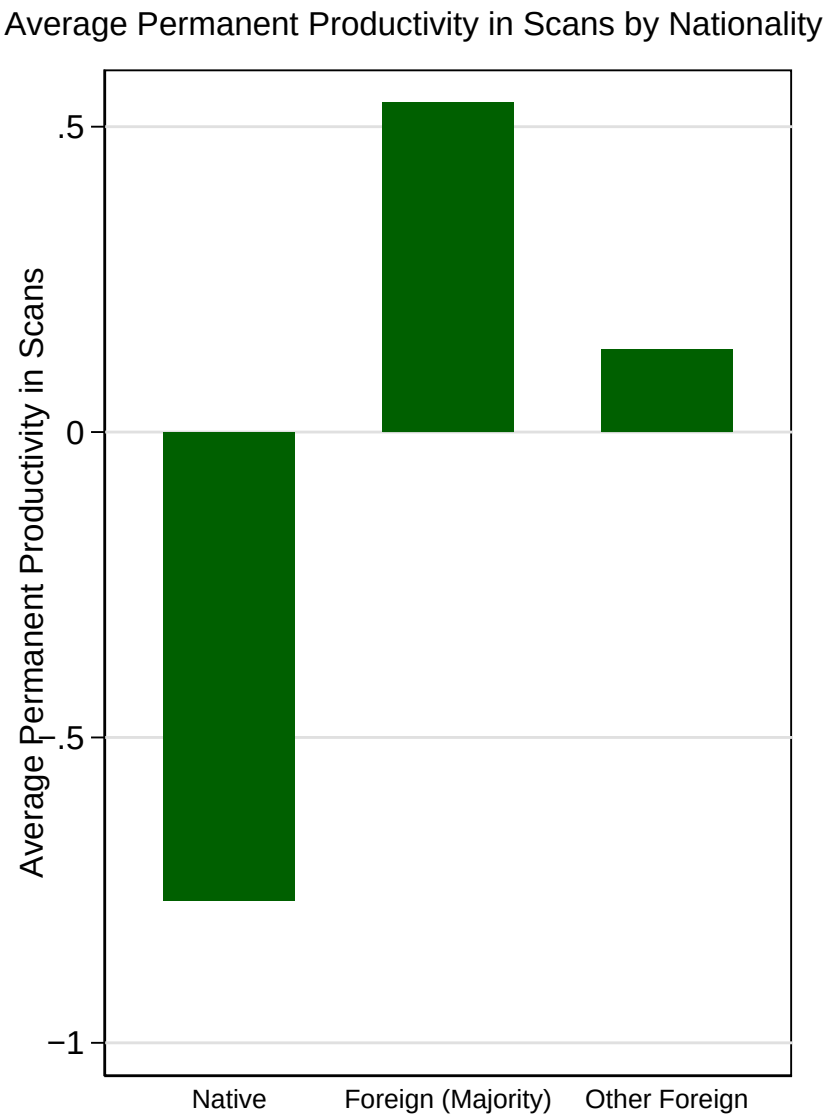
- January 2011 and September 2014 (45 months).
- 187 Saturdays, from 07:00 to 17:00.
- 4,830 hourly shifts in 2,000 hours of consolidation.
- From 335 agents, 320 observed consolidating pallets on Saturdays from 07:00 to 17:00.
- Permanent productivity, p_i, is estimated a la Mas & Moretti (2009) by Steinbach (2016) for the whole sample.

Summary Statistics

Continuous variables	Mean	Standard Deviation	10th Quantile	90th Quantile
Number of build-up scans per hour	10.625	9.31	2	24
Permanent productivity in scans	0.160	2.095	-2.303	2.927
Experience in hourly shifts	413.14	424.233	34	1,007
Indicator Variables	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Female	0.029	0.169	0	1
Natives	0.230	0.421	0	1
Foreign nationals (majority)	0.578	0.494	0	1
Other nationalities (omitted)	0.192	0.394	0	1
Manager 1	0.669	0.471	0	1
Manager 2	0.062	0.242	0	1
Manager 3	0.077	0.267	0	1
Manager 4	0.164	0.370	0	1
Other managers (omitted)	0.027	0.163	0	1
Number of Observations	30,659			

Scans Box Plots by Nationality





Saturdays between 7:00 and 17:00

Tests for Haphazard Shift Composition I

Question

Does an agent's average number of hours worked in the build-up procedure depend on permanent productivity?

	(1)	(2)	(3)	(4)	(5)
	All	Manager 1	Manager 2	Manager 3	Manager 4
Permanent	0.000	-0.002	-0.019	-0.023	0.113
productivity	(0.017)	(0.024)	(0.034)	(0.031)	(0.081)
Observations	335	198	52	33	38

Note: Dependent variable is the number of hours worked in the build-up procedure divided by the number of days the agent was employed in the cargo company. Estimation with OLS including a constant term. Specification (1) includes dummies for gender, nationality and manager. Specifications (2)-(5) include dummies for nationality. *, ** and *** denote significance at 10%, 5% and 1% level respectively; bootstrapped standard errors (1, 000 replications) in parentheses.

Tests for Haphazard Shift Composition II

Question

Does the probability that an agent works on Saturdays, 07:00-17:00, depend on permanent productivity?

	(1)	(2)	(3)	(4)
	Manager 1	Manager 2	Manager 3	Manager 4
Demand in (log) scans	0.259***	0.250***	0.365***	0.264***
	(0.009)	(0.028)	(0.020)	(0.018)
Permanent productivity	-0.009	-0.035	0.015	-0.017
	(0.007)	(0.021)	(0.010)	(0.028)
Demand in (log) scans ×	0.005	0.025***	-0.009*	-0.000
permanent productivity	(0.003)	(0.009)	(0.005)	(0.014)
Agents	198	52	33	38
Observations	72,854	8,464	6,589	18,116

Note: Dependent variable is the probability of working on a Saturday from 07:00 to 17:00. Estimation results from a Linear Probability Model (LPM) including random effects and dummies for nationality and production hall. *, ** and *** denote significance at 10%, 5% and 1% level respectively; bootstrapped standard errors (1, 000 replications) clustered at the agent level in parentheses.

Tests for Haphazard Shift Composition III

Question

Does the probability that an agent works in a team on Saturdays, 07:00-17:00, depend on permanent productivity?

	(1)	(2)	(3)	(4)
	Manager 1	Manager 2	Manager 3	Manager 4
Demand in (log) scans	0.063***	0.096***	0.031	-0.000
	(0.010)	(0.027)	(0.027)	(0.009)
Permanent productivity	0.004	0.034	-0.012	0.006
	(0.012)	(0.028)	(0.022)	(0.023)
Demand in (log) scans ×	-0.004	-0.014	0.006	-0.003
permanent productivity	(0.005)	(0.013)	(0.009)	(0.010)
Agents	192	49	32	35
Observations	22,808	2,241	3,074	5,303

Note: Dependent variable is the probability of working in a team during Saturdays from 07.00 to 17:00. Estimation results from a Linear Probability Model (LPM) including random effects and dummies for nationality and production hall. *, ** and *** denote significance at 10%, 5% and 1% level respectively; bootstrapped standard errors (1, 000 replications) clustered at the agent level in parentheses.

Econometric Model: Agent i, Hall h, Time t, Saturday s

$$y_{it} = \lambda \frac{1}{n_{ht}-1} \sum_{j=1, j\neq i}^{n_{ht}} y_{jt} + \gamma \frac{1}{n_{ht}-1} \sum_{j=1, j\neq i}^{n_{ht}} p_{jt} + x_{it}\beta_1 + \frac{1}{n_{ht}-1} \sum_{j=1, j\neq i}^{n_{ht}} x_{jt}\beta_2 + \alpha_i + \theta_s + \varepsilon_{it}$$

- y_{it}: (log of) number of build-up scans in an hour.
- $\frac{1}{n_{ht}-1} \sum_{j=1, j\neq i}^{n_{ht}} y_{jt}$: average peer current productivity.
- $\frac{1}{n_{ht}-1} \sum_{j=1, j\neq i}^{n_{ht}} p_{jt}$: average peer permanent productivity.
- x_{it} : individual characteristics.
- $\frac{1}{n_{ht}-1} \sum_{j=1, j\neq i}^{n_{ht}} x_{jt}$: peer average characteristics.
- ε_{nt}: i.i.d. across i and t with mean zero and variance σ^2_{ε}.
- α_i,θ_s : individual and Saturday fixed effects.

Econometric Model: Hall h, Time t, Saturday s

$$\boldsymbol{W}_{n_{ht}} = \frac{1}{n_{ht}-1}(\iota_{n_{ht}}\iota'_{n_{ht}} - \boldsymbol{I}_{n_{ht}}) = \begin{pmatrix} 0 & \frac{1}{n_{ht}-1} & \cdots & \frac{1}{n_{ht}-1} \\ \frac{1}{n_{ht}-1} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \frac{1}{n_{ht}-1} \\ \frac{1}{n_{ht}-1} & \cdots & \frac{1}{n_{nt}-1} & 0 \end{pmatrix},$$

$$Y_{n_{ht}t} = \lambda \boldsymbol{W}_{n_{ht}t} Y_{n_{ht}t} + \gamma \boldsymbol{W}_{n_{ht}t} P_{n_{ht}t} + \boldsymbol{X}_{n_{ht}t}\beta_1 + \boldsymbol{W}_{n_{ht}t}\boldsymbol{X}_{n_{ht}t}\beta_2 + \alpha_{n_{ht}} + \theta_s \iota_{n_{ht}} + \varepsilon_{n_{ht}t}.$$

Econometric Model: Time t, Saturday s

$$\boldsymbol{W}_{n_t t} = \begin{pmatrix} \boldsymbol{W}_{1t} & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \boldsymbol{W}_{2t} & \mathbf{0} & \vdots \\ \vdots & \mathbf{0} & \boldsymbol{W}_{3t} & \mathbf{0} \\ \mathbf{0} & \cdots & \mathbf{0} & \boldsymbol{W}_{4t} \end{pmatrix},$$

$$Y_{n_t t} = \lambda \boldsymbol{W}_{n_t t} Y_{n_t t} + \gamma \boldsymbol{W}_{n_t t} P_{n_t t} + \boldsymbol{X}_{n_t t} \beta_1 + \boldsymbol{W}_{n_t t} \boldsymbol{X}_{n_t t} \beta_2 + \alpha_{n_t} + \theta_s \iota_{n_t} + \varepsilon_{n_t t}.$$

Econometric Model: Saturday s

$$\boldsymbol{W}_{n_s s} = \begin{pmatrix} \boldsymbol{W}_1 & \mathbf{0} & \cdots & \mathbf{0} \\ \mathbf{0} & \boldsymbol{W}_2 & \mathbf{0} & \vdots \\ \vdots & \mathbf{0} & \ddots & \mathbf{0} \\ \mathbf{0} & \cdots & \mathbf{0} & \boldsymbol{W}_{10} \end{pmatrix},$$

$$Y_{n_s s} = \lambda \boldsymbol{W}_{n_s s} Y_{n_s s} + \gamma \boldsymbol{W}_{n_s s} P_{n_s s} + \boldsymbol{X}_{n_s s} \beta_1 + \boldsymbol{W}_{n_s s} \boldsymbol{X}_{n_s s} \beta_2 + \alpha_{n_s} + \theta_s \iota_{n_s} + \varepsilon_{n_s s}.$$

Estimation

$$E(\boldsymbol{W}_{n_s s} Y_{n_s s} \varepsilon'_{n_s s}) = \sigma_\varepsilon^2 \boldsymbol{W}_{n_s s} (I_{n_s} - \lambda \boldsymbol{W}_{n_s s})^{-1} \neq 0$$

$$E\left(\boldsymbol{W}_{n_s s} Y_{n_s s}\right) = \boldsymbol{W}_{n_s s} \left(I_{n_s} + \lambda \boldsymbol{W}_{n_s s} + \lambda^2 \boldsymbol{W}_{n_s s}^2 + \cdots\right) \left(\boldsymbol{X}_{n_s s} \beta_1 + \boldsymbol{W}_{n_s s} \boldsymbol{X}_{n_s s} \beta_2\right)$$

- $\boldsymbol{W}_{n_s s} Y_{n_s s}$ can be approximated with a power series expansion of the exogenous variables.
- Instrumental variables for $\boldsymbol{W}_{n_s s} Y_{n_s s}$ are the **linearly independent columns of** $\boldsymbol{W}_{n_s s}^2 Y_{n_s s}$ (Kelejian & Prucha, 1998, 2002, 2006; Lee, 2002, 2003, 2007; Bramoullé et al., 2009; Lee et al., 2012; Lee & Yu, 2014).
- Identification through **team size variation** and **variation in team composition**.

Results: All Team Sizes

	(1)	(2)	(3)	(4)	(5)	**(6)**
WY	-	-	-0.065	-0.020	-0.024	**0.101**
			(0.207)	(0.226)	(0.283)	**(0.278)**
WP	-0.009	-0.010*	-	-	-0.007	**-0.016**
	(0.006)	(0.006)			(0.023)	**(0.019)**
Own *X*	yes	yes	yes	yes	yes	**yes**
Peer *X*	no	yes	no	yes	no	**yes**
Method	OLS	OLS	2SLS	2SLS	2SLS	**2SLS**

Note: Dependent variable is (log) number of build-up scans in 1 hour. 30,654 observations for 315 agents and 187 Saturdays. All specifications include agent fixed effects, time fixed effects, dummies for production hall as well as indicator variables for team size (4 to 20 agents). Own and peer *X* include own and peer experience and their squares, peer gender, peer nationality and peer manager. *, ** and *** denote significance at 10%, 5% and 1% level respectively.

Results: Production with 3 to 9 Agents

	(1)	(2)	(3)	(4)	(5)	**(6)**
WY	-	-	-0.047	0.031	-0.271	**-0.117**
			(0.232)	(0.263)	(0.470)	**(0.491)**
WP	-0.002	-0.003	-	-	0.020	**0.005**
	(0.007)	(0.007)			(0.039)	**(0.033)**
Own *X*	yes	yes	yes	yes	yes	**yes**
Peer *X*	no	yes	no	yes	no	**yes**
Method	OLS	OLS	2SLS	2SLS	2SLS	**2SLS**

Note: Dependent variable is (log) number of build-up scans in 1 hour. 19,431 observations for 303 agents and 187 Saturdays. All specifications include agent fixed effects, time fixed effects and dummies for production hall. Own and peer *X* include own and peer experience and their squares, peer gender, peer nationality and peer manager. *, ** and *** denote significance at 10%, 5% and 1% level respectively.

Results: Production with 10 to 20 Agents

	(1)	(2)	(3)	(4)	(5)	**(6)**
WY	-	-	0.443*	0.604**	0.609**	**0.655****
			(0.237)	(0.290)	(0.258)	**(0.297)**
WP	-0.064***	-0.060***	-	-	-0.090***	**-0.078*****
	(0.017)	(0.020)			(0.022)	**(0.022)**
Own *X*	yes	yes	yes	yes	yes	**yes**
Peer *X*	no	yes	no	yes	no	**yes**
Method	OLS	OLS	2SLS	2SLS	2SLS	**2SLS**

Note: Dependent variable is (log) number of build-up scans in 1 hour. 11,116 observations for 273 agents and 177 Saturdays. All specifications include agent fixed effects, time fixed effects and dummies for production hall. Own and peer *X* include own and peer experience and their squares, peer gender, peer nationality and peer manager. *, ** and *** denote significance at 10%, 5% and 1% level respectively.

Who is the Free-Rider? Production with 10 to 20 Agents

	(1)	(2)	(3)	(4)
WY	-	0.652**	-	**0.646****
		(0.296)		**(0.297)**
WP	-0.114***	-0.118***	0.113*	**0.044**
	(0.030)	(0.032)	(0.058)	**(0.067)**
WP×Native peers	0.214**	0.162		
	(0.100)	(0.106)		
WP×Foreign peers (majority)			-0.319***	**-0.223****
			(0.094)	**(0.104)**

Note: Dependent variable is (log) number of build-up scans in 1 hour. 11,116 observations for 273 agents and 177 Saturdays. All specifications include agent and time fixed effects, own and peer experience and their squares, peer gender, peer nationality, peer manager and dummies for production hall. Columns (1) and (3) are estimated with OLS while (2) and (4) with 2SLS. *, ** and *** denote significance at 10%, 5% and 1% level respectively.

Conclusion

- We disentangle **endogenous** (current) effects and **exogenous** (permanent) **behavioral** effects.
- Emergence of both endogenous and exogenous effects is a **function of team size**: **Spatial circumstances** and the **sense of monitoring.**
- A 10% **increase** in peer **current** productivity **increases** own productivity by 6.5%.
- If all peers are majority-foreign (on average highest permanent productivity), then a 10% **increase** in peer **permanent** productivity **decreases** own productivity by 2.23%.
- Overall peer effect is positive: **Agents care more about their peers' short-term than long-term behavior.**