Knowledge Exchange and Productivity Spill-overs in Bangladeshi Garment Factories

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December 6, 2018

Introduction

Learning within organizations long been viewed as key driver of firm productivity growth (Arrow 1962, Lucas 1993)

$\Rightarrow$ But: Inherently difficult to observe.

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$\Rightarrow$ But: Inherently difficult to observe.

Standard approach by empirical literature: Studying productivity spill-over within firms

$\Rightarrow$ Are workers more productive when producing a good that others in firm have already produced? (Darr et al. 2013, Levitt et al., 2013)

Approach used to study whether productivity spill-over differ between products

- ⋆ that are technologically differentiated to different degrees (Thompson and Thornton 2001, Egelman et al. 2016)
- ⋆ that differ in how long ago other production units the product (Benkart 2000, Thompson 2007, David and Brachet 2011)

Introduction

Two main contributions, less explored in literature:

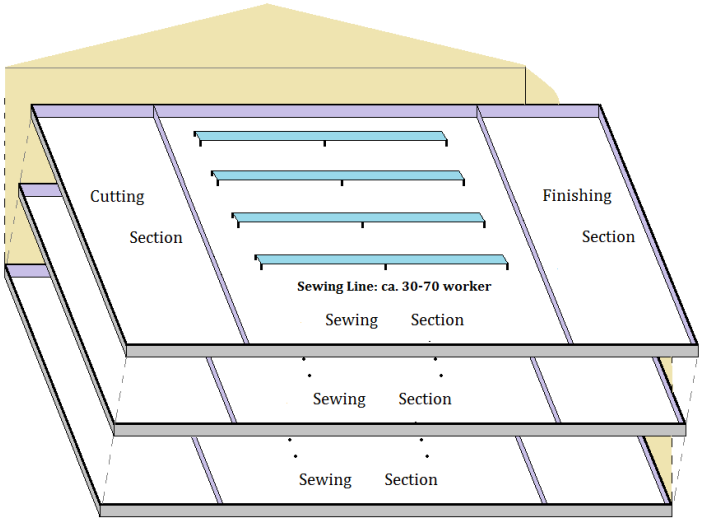
- How do productivity spill-over vary with establishment size?
  - Do they shrink as physical distance in plants increases?
  - Relevant to firms in developing countries.

  $\Rightarrow$ 2 years of daily production data from three B.deshi garment factories;
  - Large: 250+ production lines, producing 2,000+ different garments orders.
  - Basic and homogeneous technology and organisational set-up across factories.
  - Accurate productivity and garment complexity measures available.

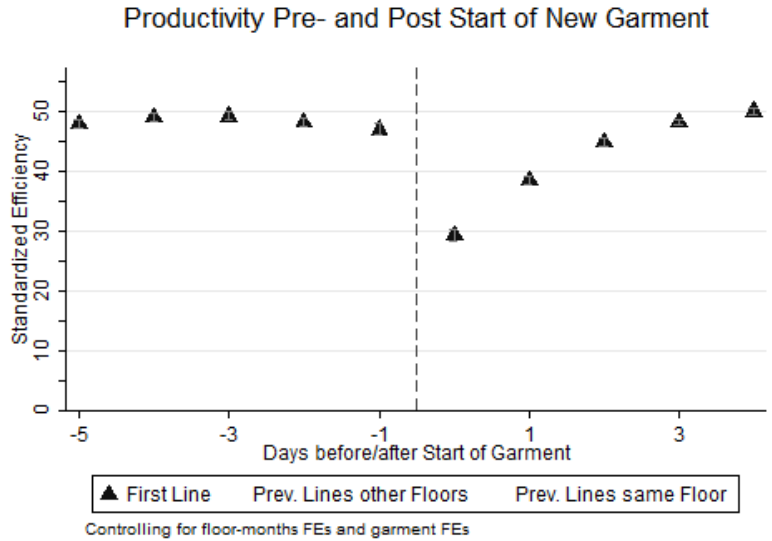
  Methodologically:
- Are spill-over driven by knowledge exchange, or other forms of peer effects?
  - Competition
  - Benchmark setting

  $\Rightarrow$ Exploit random variation in worker communication.

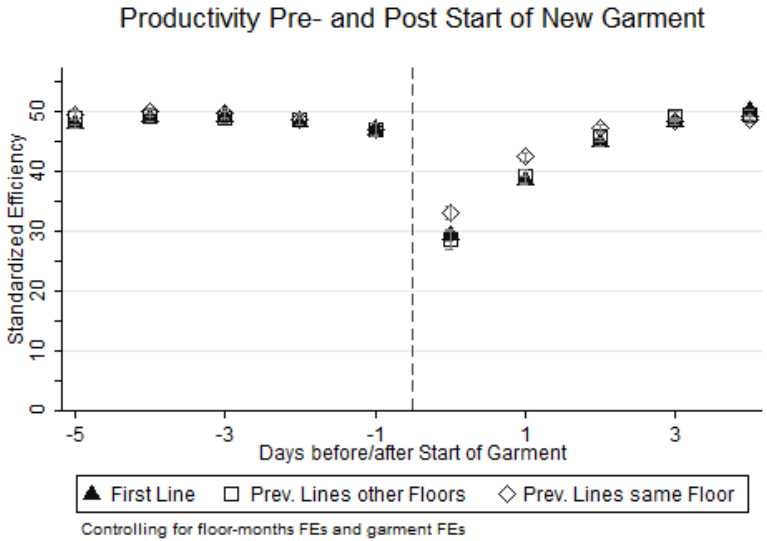
Introduction



Introduction



Lines switch to new garments on average every 12 production days



Lines switch to new garments on average every 12 production days

Daily Line Productivity Measure

$$Y = \frac{Piecew.\ Daily\ Output\ x\ SMV}{Nbr.Workers\ x\ Daily\ Hours\ x\ 60^{min}}$$

Results from Observational Data: Specification

Keep daily productivity data from first n Days a line produces new garment.

Empirical Model:

$$y_{fisnt} = \sum_n \beta_n^A ln(A_{isn}) + \sum_n \beta_n^F ln(F_{isn}) + \alpha_{fin} + \gamma_{ftn} + X_{fisnt} + \epsilon_{fisnt}$$

Results from Observational Data: Specification

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Identifying Assumption:

"Start-Rank" of order on a given line not correlated with garment type - line productivity interaction effects

$\Rightarrow$ Lines do not systematically specialise into garment types or "start-ranks"

Supporting Evidence

Basic Results: Same Floor vs Other Floors

	(1) Log Outp.		(2) Log Outp.		(3) Outp. >0	
Cumul. Previous Output x ...						
Day 1	0.296**	(0.12)	0.138	(0.14)	0.975	(1.15)
Day 2	0.292***	(0.09)	0.173	(0.11)	1.284	(0.90)
Day 3	0.204**	(0.09)	0.138	(0.09)	0.838	(0.73)
Day 4	0.327***	(0.09)	0.218**	(0.10)	1.673**	(0.77)
Day 5	0.229***	(0.07)	-0.041	(0.10)	-0.904	(0.84)
Day 6	0.215**	(0.09)	0.070	(0.11)	0.738	(0.96)
Day 7	0.161*	(0.10)	0.074	(0.13)	0.439	(0.92)
Cumul. Previous Output Same Floor x ...						
Day 1	0.516***	(0.13)	0.392***	(0.12)	3.259***	(1.03)
Day 2	0.291***	(0.10)	0.185*	(0.10)	1.714**	(0.82)
Day 3	0.258***	(0.09)	0.198**	(0.09)	2.004***	(0.72)
Day 4	0.161*	(0.09)	0.091	(0.09)	0.755	(0.81)
Day 5	0.214**	(0.08)	0.220**	(0.10)	2.001**	(0.86)
Day 6	0.218**	(0.11)	0.172	(0.12)	0.915	(0.95)
Day 7	0.193*	(0.10)	0.079	(0.12)	0.658	(0.96)
N	30,392		30,392		30,431	
Controls	YES		YES		YES	
Line Chief FE	YES		YES		YES	
Month FE	YES		YES		YES	
Style FE			YES		YES	

No further effect from Neighboring Lines on Same Floor

Interaction with Product Complexity - No Effect

Contolling for Production Pressure

Exploit Randomized Intervention

Whenever...

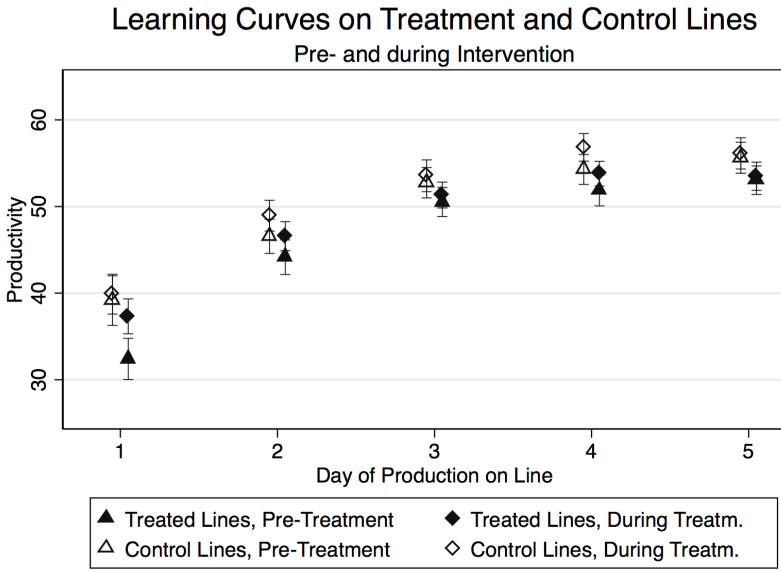
- a line on randomly selected treatment floor started a new garment style,...
- which had already been produced on some other line in the factory before,...
- the most senior "line chief" who already produced the style on his or her line,...
- was sent by his superiors to brief line chief starting to produce the style,...
- for 15-30 minutes on the most important production problems that had to be overcome on the earlier line.

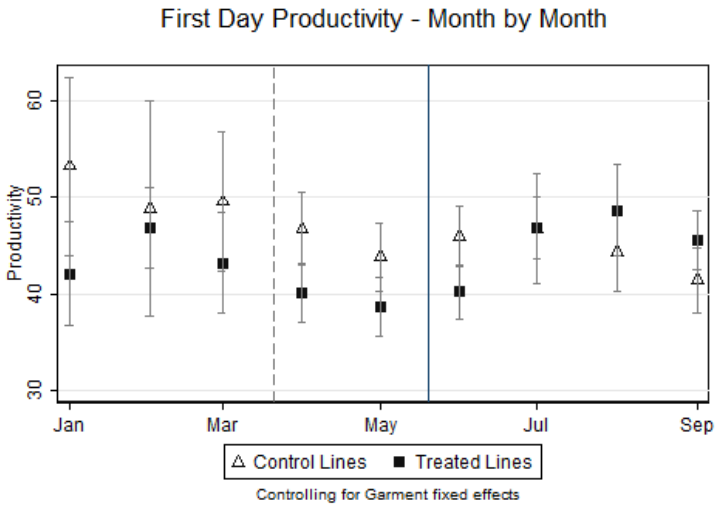
$\Rightarrow$ Does intervention increase the observed productivity spillover from earlier to later lines producing the same style?

Randomized Communication Intervention

- 17 floors in three factories, 9 randomly selected for treatment (stratified across factories)
  - 75 sewing lines on treated floors, 59 on control floors
- Intervention implemented for four month on treatment floors (Jun-Sep. 2014)
- 377 instances in which lines on treatment floors started producing new garment styles they had not produced before, but which another line had already.

Balance Tests


Learning Curves on Treatment and Control Lines
Pre- and during Intervention
Productivity
30
40
50
60
1
2
3
4
5
Day of Production on Line
Treated Lines, Pre-Treatment
Treated Lines, During Treatm.
Control Lines, Pre-Treatment
Control Lines, During Treatm.



By Factory & Longer Trends

Implementation Intensity across months

Randomized Communication Interv.: Basic Results

					Reweighted: DiNardo et al. (1996)	
Treatment x						
Day 1	5.537***††	(0.010/0.03)	5.386*†	(.070/0.05)	6.061**††	(.020/0.01)
Day 2	3.816*	(0.065/0.12)	3.204*†	(.050/0.06)	3.800***††	(.010/0.01)
Day 3	2.976	(0.330/0.35)	3.352	(.325/0.25)	2.522	(.470/0.33)
Day 4	1.955	(0.465/0.40)	4.061	(.215/0.25)	2.124	(.595/0.57)
Day 5	1.782	(0.670/0.75)	4.517	(.285/0.27)	5.719	(.255/0.32)
N	4,946		4,946		4,682	
Controls	YES		YES		YES	
Line Chief & Month FE	YES		YES		YES	
Style FE	NO		YES		YES	

*: Wild-cluster bootstrap SE. † Permutation based SE

No Effect on Gament Order Allocation

Randomized Comm. Interv.: Same vs. Other Floors

					Reweighted: DiNardo et al. (1996)	
Treatment x						
Day 1	7.911**††	(0.010/0.010)	10.210**††	(0.020/0.03)	12.765***††	(0.000/0.04)
Day 2	7.040**††	(0.010/0.04)	6.375**†	(0.025/0.08)	8.558**††	(0.025/0.03)
Day 3	6.890**†	(0.030/0.09)	8.501**†	(0.010/0.05)	8.639**†	(0.025/0.09)
Day 4	3.427	(0.245/0.32)	6.017	(0.100/0.31)	4.149	(0.405/0.25)
Day 5	1.831	(0.695/0.66)	3.558	(0.375/0.42)	4.246	(0.305/0.50)
Treatment x Other Floors x						
Day 1	-4.599*†	(0.055/0.075)	-9.088**	(0.025/0.17)	-12.102***	(0.005/0.20)
Day 2	-6.426*	(0.055/0.11)	-6.217	(0.175/0.31)	-9.189**	(0.030/0.13)
Day 3	-8.095**†	(0.025/0.08)	-11.189**††	(0.010/0.02)	-12.677**††	(0.025/0.01)
Day 4	-3.328	(0.110/0.28)	-5.000*	(0.060/0.33)	-5.134*	(0.080/0.25)
Day 5	-0.143	(1.000/0.70)	1.926†	(0.235/0.06)	2.844††	(0.200/0.01)
Other Floors x						
Day 1	1.206	(0.475)	3.987	(0.195)	5.020	(0.120)
Day 2	0.741	(0.690)	3.177	(0.470)	4.448	(0.315)
Day 3	1.520	(0.405)	4.274	(0.105)	5.277*	(0.080)
Day 4	1.618	(0.200)	3.497**	(0.010)	3.815**	(0.010)
Day 5	0.428	(0.925)	1.381	(0.485)	1.836	(0.370)
N	4946		4946		4682	
Controls	YES		YES		YES	
Line Chief FE	YES		YES		YES	
Month FE	YES		YES		YES	
Style FE	NO		YES		YES	

*: Wild-cluster bootstrap SE. † Permutation based SE

Garments produced on multiple floors not different

Sum Up

- Productivity Spill-over strength seem to strongly depend on distance
  - Spatial or Organizational Distance?

    Conditional on the same floor, spatial distance seems to have less effect
- Randomized increase in knowledge exchange further strengthens spill-over within floors
  - Reported implementation compliance lower for briefings across floors.

    Show
- Why not done earlier?
  - One of three firms discontinued after involved supervisors voiced resistance
  - Receiving help undermines status (Lee 1997, Bunderson and Reagans 2011) - especially for older supervisors?

    Lower reported compliance when older supervisors should have been briefed.

    Show

Placebo: Starting Production on Same Day

	Outp. >0		Outp. >0	
Output Lines Starting Same Day x ...				
Day 1	4.819	(3.26)	2.323	(1.73)
Day 2	3.438	(2.71)	0.786	(1.24)
Day 3	3.570	(2.71)	1.398	(1.29)
Day 4	4.972*	(2.95)	1.245	(1.30)
Day 5	2.318	(2.39)	0.686	(1.35)
Output Lines Starting Same Day, Same Floor x ...				
Day 1	7.049**	(3.39)	3.920**	(1.66)
Day 2	7.150**	(2.87)	3.484**	(1.53)
Day 3	4.129	(2.91)	1.563	(1.28)
Day 4	0.996	(3.10)	-0.553	(1.14)
Day 5	0.127	(2.67)	-0.063	(1.42)
Cumul. Previous Output x ...				
Day 1			0.724	(1.14)
Day 2			1.163	(0.91)
Day 3			0.667	(0.72)
Day 4			1.518*	(0.77)
Day 5			-0.939	(0.84)
Cumul. Previous Output Same Floor x ...				
Day 1			3.665***	(1.00)
Day 2			2.136**	(0.82)
Day 3			2.321***	(0.70)
Day 4			0.835	(0.81)
Day 5			2.038**	(0.89)
Day 6			0.902	(0.95)
N	11,776		30,159	
Controls, Line Chief & Month FE	YES		YES	
Style FE			YES	
Type FE	YES			

Controlling for Production Pressure Proxy

	(1) Log Outp.		(2) Log Outp.		(3) Outp. >0	
Cumul. Previous Output x ...						
Day 1	0.317***	(0.12)	0.037	(0.15)	0.064	(1.30)
Day 2	0.288***	(0.10)	0.244**	(0.12)	1.671*	(1.00)
Day 3	0.171*	(0.09)	0.197*	(0.10)	1.111	(0.83)
Day 4	0.29***	(0.09)	0.197*	(0.12)	1.374	(0.90)
Day 5	0.112	(0.08)	-0.088	(0.13)	-1.454	(1.05)
Day 6	0.13	(0.09)	0.065	(0.12)	0.605	(1.05)
Day 7	0.128	(0.10)	0.092	(0.15)	0.636	(1.06)
Cumul. Previous Output Same Floor x ...						
Day 1	0.396***	(0.13)	0.349***	(0.13)	2.790**	(1.13)
Day 2	0.248**	0(.10)	0.136	(0.10)	1.296	(0.87)
Day 3	0.25**	(0.10)	0.18*	(0.10)	1.945**	(0.81)
Day 4	0.151	(0.10)	0.137	(0.09)	1.117	(0.80)
Day 5	0.235***	(0.08)	0.221**	(0.11)	2.038**	(0.94)
Day 6	0.217*	(0.11)	0.214*	(0.12)	1.244	(1.01)
Day 7	0.177	(0.10)	0.07	(0.12)	0.542	(0.94)
N	27,661		27,661		27,700	
Controls	YES		YES		YES	
Line Chief FE	YES		YES		YES	
Month FE	YES		YES		YES	
Style FE			YES		YES	

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Including Neighboring Lines

	(1) Log		(2) Log		(3) Log	
Cumul. Previous Output x ...						
Day 1	0.295**	(0.12)				
Day 2	0.292***	(0.09)				
Day 3	0.204**	(0.09)				
Day 4	0.327***	(0.09)				
Day 5	0.228***	(0.07)				
Day 6	0.216**	(0.09)				
Cumul. Previous Output, Same Floor x ...						
Day 1	0.383**	(0.15)	0.844***	(0.20)	0.838***	(0.18)
Day 2	0.210*	(0.12)	0.482***	(0.16)	0.391***	(0.13)
Day 3	0.162	(0.10)	0.435***	(0.15)	0.265	(0.21)
Day 4	0.107	(0.10)	0.436***	(0.15)	0.280	(0.20)
Day 5	0.127	(0.10)	0.234	(0.16)	-0.029	(0.19)
Day 6	0.075	(0.12)	0.370**	(0.17)	0.178	(0.18)
Cumul. Previous Output, Neighbouring Lines x ...						
Day 1	0.257*	(0.14)	0.296	(0.24)	0.121	(0.23)
Day 2	0.155	(0.11)	0.141	(0.17)	0.144	(0.16)
Day 3	0.178**	(0.09)	0.190	(0.16)	0.341	(0.22)
Day 4	0.100	(0.09)	0.109	(0.18)	0.090	(0.19)
Day 5	0.168*	(0.09)	0.034	(0.18)	-0.049	(0.26)
Day 6	0.281**	(0.11)	0.138	(0.20)	-0.078	(0.21)
N	30,392		11,302		11,302	
Month & Line Ch. FE	YES		YES		YES	
Controls	YES		YES		YES	
Garment FE					YES	

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Interacting with Product Complexity

	(1) SMV		(2) SMV		(3) SMV > med. SMV	
Cumul. Previous Output ...						
Day 1	0.924***	(0.159)	0.685***	(0.200)	0.402**	(0.161)
Day 2	0.403***	(0.124)	0.215	(0.144)	0.200*	(0.112)
Day 3	0.219*	(0.112)	0.069	(0.128)	0.179*	(0.095)
Day 4	0.316***	(0.101)	0.371***	(0.141)	0.234**	(0.111)
Day 5	0.354***	(0.114)	0.317*	(0.167)	0.173	(0.127)
Day 6	0.281**	(0.124)	0.244	(0.187)	0.196	(0.127)
Day 7	0.271**	(0.108)	0.154	(0.188)	0.087	(0.147)
Cumul. Previous Output x SMV ...						
Day 1	-0.027**	(0.012)	-0.026	(0.016)	0.000	(0.208)
Day 2	0.007	(0.010)	0.008	(0.010)	0.192	(0.147)
Day 3	0.013	(0.009)	0.018**	(0.009)	0.176	(0.147)
Day 4	0.010	(0.008)	-0.008	(0.009)	0.081	(0.141)
Day 5	0.001	(0.009)	-0.019*	(0.011)	-0.123	(0.160)
Day 6	0.007	(0.009)	-0.006	(0.014)	-0.020	(0.154)
Day 7	0.001	(0.008)	-0.003	(0.012)	0.079	(0.147)
N	30,392		30,392		30,392	
Controls	YES		YES		YES	
Month FE	YES		YES		YES	
Line Chief FE	YES		YES		YES	
Style FE	NO		YES		YES	

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Communication Intervention: Balance

Average line and line chief observables on treatment and control floors, before start of randomization (Apr-May 2014)

Variable	Control	Diff.	N
Line Characteristics:			
Nbr. worker	30.20	-1.39	137
Daily Runtime	9.156	0.43*	137
Efficiency	50.83	-1.42	137
Efficiency First Day	36.77	-6.24**	121
SMV	10.81	-0.99	137
Start Rank	3.859	0.45	137
Supervisor Characteristics:			
Age	29.53	0.45	79
Seniority Factory	65.67	-3.21	72
Seniority as Supervisor	35.92	-1.94	79
Sen. as SV on curr. line	26.02	-2.60	69
External Arrival as SV	0.333	0.05	72
Nbr. Social Ties	2.806	0.47	79
Education	15.33	-0.41	72

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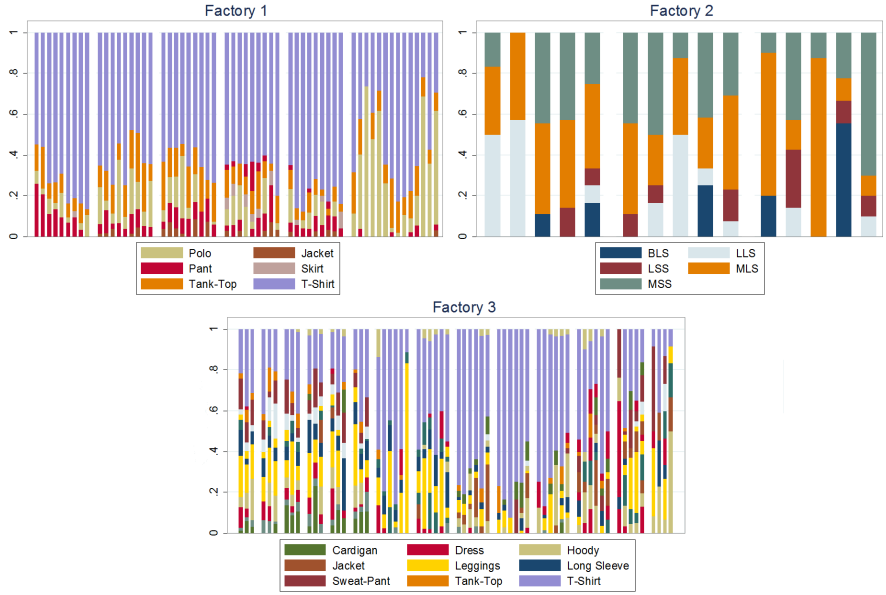
Allocation of Garments to Lines



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Allocation of Garments to Lines

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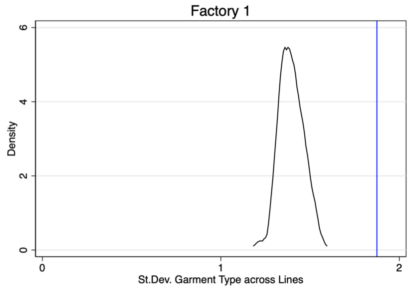
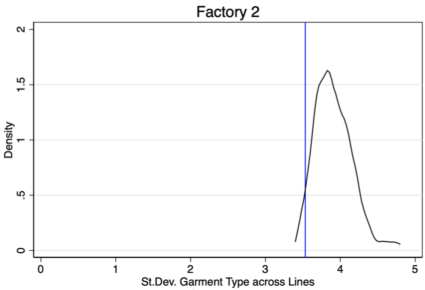
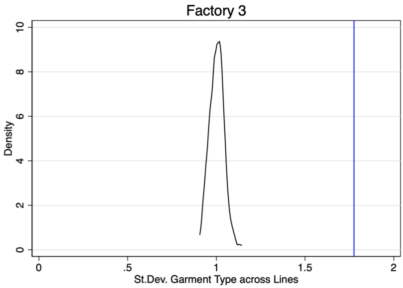
Allocation of Garments - Benchmark ag. Random Alloc.







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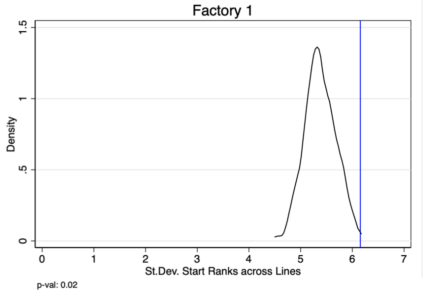
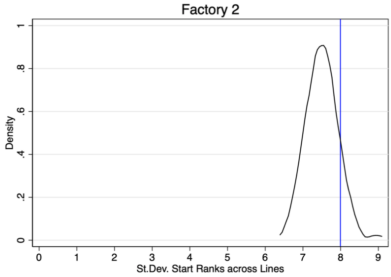
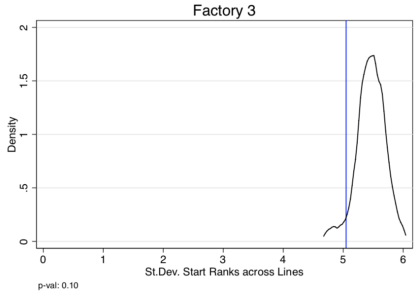
Allocation of Garments - Benchmark ag. Random Alloc.







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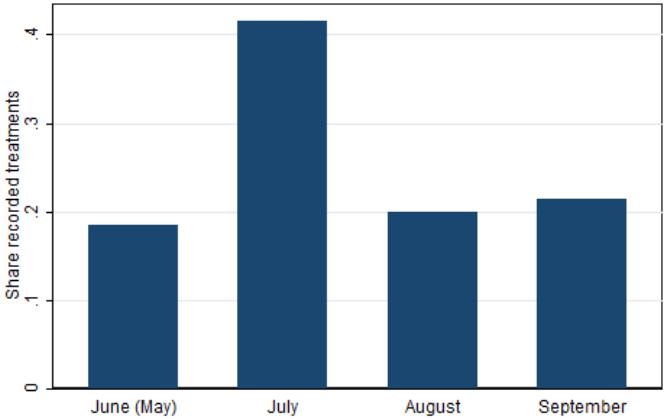
Implementation Intensity



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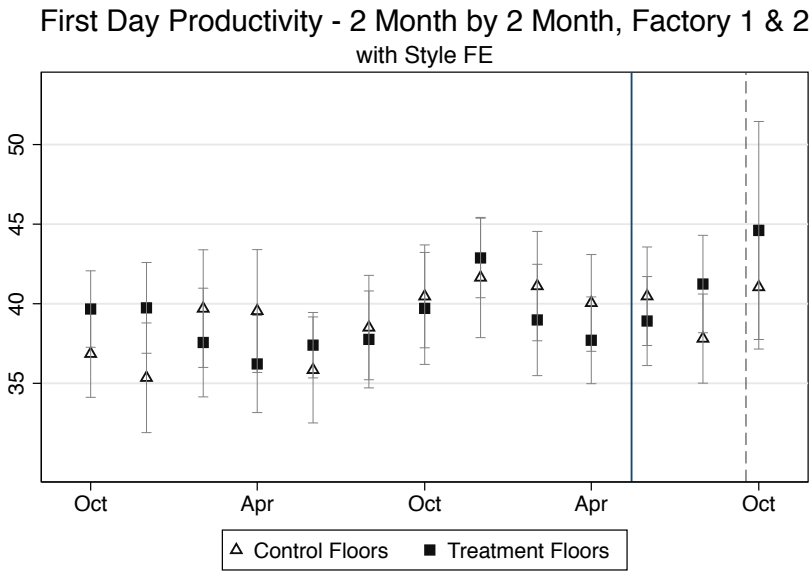
Diff-in-Diff. Graph: Factory 1 & 2



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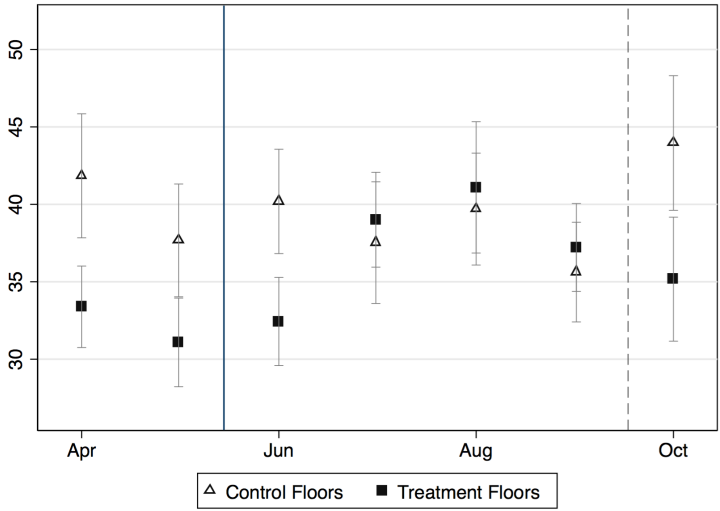
Diff-in-Diff. Graph: Factory 3



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Garment Order Allocation - Affected by Experiment?

VARIABLES	(1) Complexity	(2) Buyer Share	(3) Garment Type Share	(4) Buyer-Garment Type Share
Treatment	-0.0977	0.0032	-0.0102	-0.0021
	(0.793)	(0.014)	(0.021)	(0.009)
Observations	1,194	1,186	1,186	1,194
R-squared	0.419	0.939	0.764	0.420
Line Chief & Month FE	YES	YES	YES	YES

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

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Garments produced within vs across Floors

VARIABLES	(1) Complexity	(2) Buyer Share	(3) Garment Type Share	(4) Buyer-Garment Type Share
Produced on multipl. floors	-0.273 (0.358)	-0.004 (0.009)	0.002 (0.018)	0.0002 (0.005)
Observations	873	860	866	869
R-squared	0.606	0.878	0.394	0.153
Factory & Year FE	YES	YES	YES	YES

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Sum Up

	(1)	(2)	(3)
	Intervention Reported		
Other Floors Only	-0.166***	-0.163***	-0.176***
	(0.042)	(0.042)	(0.048)
Mean Reported Rate	0.211		
Observations	384	384	343
Factory FE	YES	NO	NO
Floor FE	NO	YES	YES
Controls	NO	NO	YES

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VARIABLES	(1) Treatm.	(2) Treatm.	(3) Treatm.
Age	-0.005*	-0.006*	-0.010*
	(0.003)	(0.004)	(0.006)
Seniority as Line Chief			0.002
			(0.002)
Female			-0.033
			(0.165)
Education			0.029*
			(0.016)
Nbr. Social Ties			0.014
			(0.013)
SMV			-0.002
			(0.003)
Productiv., Day			0.000
			(0.002)
Avg. Productiv., Year			-0.007
			(0.013)
Avg. Productiv., Year, First Style-Day			-0.007
			(0.009)
Observations	365	365	311
Factory FE	YES	NO	NO
Floor FE	NO	YES	YES

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