Firm-Level Input Price Changes and Their Effects: A Deep Learning Approach

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ABFER
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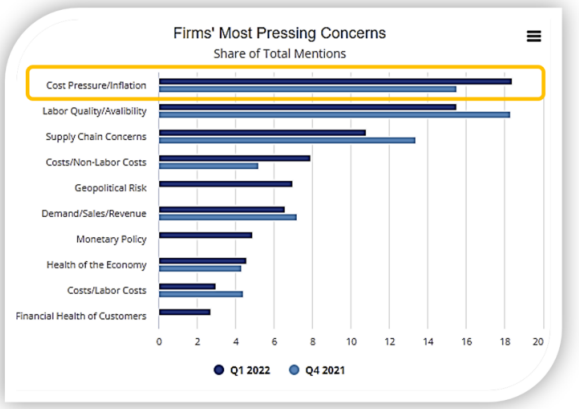

Source: Duke University, FRB Richmond, and FRB Atlanta, The CFO Survey - Q1 2022

Motivation

- Little is known about properties of input price changes and its effects.
  - Frequency?
  - Dynamics (e.g., persistence)?
  - Heterogeneity across industries and firms?
  - Effect on firm value and firm policies?
- Lack of input price data of U.S. firms

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  Virtues:
  - Publicly available
  - Wide coverage
  - Firm-level information (as opposed to national averages of product prices)
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- Contributions:
  1. Use NLP to develop firm-level measures of input and output price changes
  2. Establish facts about input price dynamics
  3. Effects on firm policies (e.g., product price setting and COGS)
  4. Effect on stock price

Challenges

Sanderson Farms operated very well during the second quarter of fiscal 2021 in all areas of our business. Improved poultry markets more than offset **feed grain costs that were significantly higher** compared to last year's record fiscal quarter, resulting in increased operating margins... In addition to improved domestic demand for chicken, export demand also improved during the quarter as a result of **higher crude oil prices**... **Prices paid for corn and soybean meal increased significantly** during the quarter compared to last year... **We have priced all of our soy meal basis** through October and **most of our corn basis** through September.

Constructing price change measures

- Step 1: Construct training sample
  - Use subperiod Jan – Jun 2021.
  - Define target words.
  - Count frequency of target words in each transcript.
  - Select top 5 transcripts in each FF 12 Industries (no Fin. and Util.)

- Step 2: Human labeling
  - Sentence level analysis of each transcript (no contextual info)
  - Two humans apply 4 labels to each sentence:
    - L_1 : price change related?
    - L_2 : price increase or not?
    - L_3 : input price or not?
    - L_4 : output price or not?

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Table: Number of Sentences in Labeled Training Sample

	Target Words	**No Target Words**	Sum
Price Change	*1,280 (95.88%)*	55 (4.12%)	1,335 (100%)
No Price Change	3,430 (12.43%)	24,167 (87.57%)	27,597 (100%)
Total			28,932

- Target words are useful but not sufficient

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Step 5: Sentence-level classification of entire sample

- Use RoBERTa to label all sentences with target words in full sample
  - Period: 2007-2021
  - 81,473 calls, 3,837 firms

Price change measures

- For each firm i at time t, we have four numbers:
  $\#InputUp_{i,t}$, $\#InputDown_{i,t}$, $\#OutputUp_{i,t}$, $\#OutputDown_{i,t}$
- Input price change measure:

$$InPrChg_{i,t} = \frac{\#InputUp_{i,t} - \#InputDown_{i,t}}{\#Sentences\ in\ Transcript_{i,t}}$$

- Output price change measure:

$$OutPrChg_{i,t} = \frac{\#OutputUp_{i,t} - \#OutputDown_{i,t}}{\#Sentences\ in\ Transcript_{i,t}}$$

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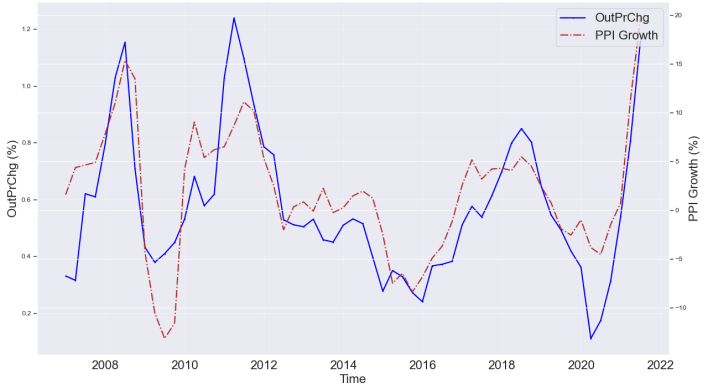
- Input (output) price change measures capture inflation plus relative price changes

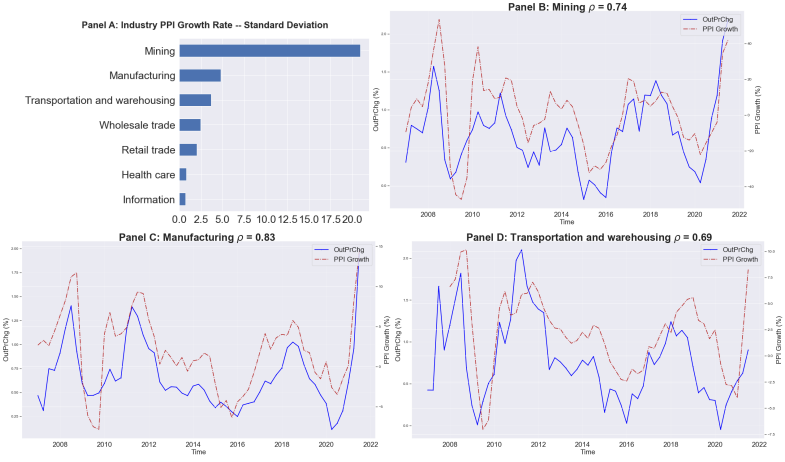
Validation: Aggregate

Cross-sectional mean of $OutPrChg_{i,t}$ vs. BLS PPI Growth Rate



Correlation: 0.8

Validation: Industry-level



Validation: Firm-level

Moments of output price changes:

1. Median frequency of increase:
   Our: 6 months Literature: 4.3 – 11 months
2. Median of ratio of likelihood of price decrease/increase:
   Our: 0.39 Literature: 0.33

Fact #1: Distribution of likelihood of input price changes

Estimate average freq. of price increase (decrease) per quarter for each firm

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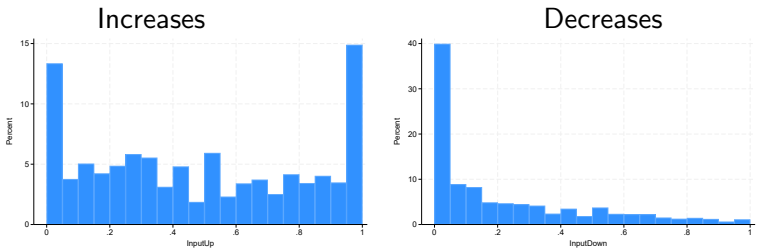

Median increase likelihood $= 0.44$ per quarter $\Rightarrow$ Once every 7 months
Median decrease likelihood $= 0.1$ per quarter $\Rightarrow$ Once every 30 months

Substantial heterogeneity across industries

Industry	$\chi_J^{InputUp}$ (1)	$\chi_J^{InputDown}$ (2)	$InPrChg_J$ (%) (3)
Chems	0.89	0.62	1.31
NoDur	0.78	0.37	1.10
Manuf	0.77	0.45	0.92
Shops	0.74	0.34	0.90
Durbl	0.76	0.36	0.88
Enrgy	0.78	0.51	0.49
Other	0.48	0.19	0.39
Hlth	0.38	0.12	0.20
Telcm	0.45	0.11	0.20
BusEq	0.32	0.12	0.15

Fact #2: Aggregate versus firm-specific input price changes

Incremental R^2	FF12 (1)	2-digit SIC (2)	3-digit SIC (3)
YearQtr FE	7.15%	7.15%	7.15%
Industry FE	11.27%	17.38%	25.66%
Industry $\times$ YearQtr FE	5.53%	10.58%	21.72%
Firm-level	76.05%	64.89%	45.47%
Permanent differences across firms	29.71%	22.89%	14.25%
Idiosyncratic input price changes	46.34%	42.00%	31.22%

Fact #3: Stock price reaction

	CAR[−1,+1] (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
InPrChg (%)	-0.263***	-0.363***	-0.327***	-0.366***	-0.377***	
	(-4.35)	(-5.38)	(-4.84)	(-5.37)	(-6.20)	
$Frac^{InputUp}$ (%)						-0.405***
						(-5.70)
$Frac^{InputDown}$ (%)						0.063
						(0.38)
Observations	81,473	81,473	66,946	76,976	43,195	81,473
Adjusted R-squared	0.065	0.103	0.108	0.103	0.112	0.103
Controls	✓	✓	✓	✓	✓	✓
Firm FE		✓	✓	✓	✓	✓
$InPrChg_{i,t-1}$			✓			
Risk				✓		
Low price volatility periods					✓	

Stock price reaction to large input price changes

	CAR[−1,+1] (%)	
	(1)	(2)
Group 1	0.102	-0.131
	(0.63)	(-0.84)
Group 3	-0.110	-0.165
	(-0.88)	(-1.39)
Group 4	-0.484***	-0.683***
	(-4.07)	(-5.87)
Group 5	-0.729***	-1.154***
	(-4.38)	(-6.64)
Observations	81,473	81,473
Adjusted R-squared	0.066	0.103
Controls	✓	✓
Firm FE		✓

Fact #4: COGS

$\Delta COGS$	t	$t+1$	$t+2$	$t+3$	$t+4$
	(1)	(2)	(3)	(4)	(5)
InPrChg (%)	0.002***	0.004***	0.004***	0.003**	0.001
	(3.71)	(5.85)	(5.37)	(2.57)	(1.07)
Observations	81,256	80,795	80,026	79,095	78,104
Adjusted R-squared	0.112	0.050	0.097	0.180	0.166
Controls	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓

Fact #5: Cost pass through

OutPrChg (%)	t	$t+1$	$t+2$	$t+3$	$t+4$
	(1)	(2)	(3)	(4)	(5)
InPrChg (%)	0.689***	0.414***	0.268***	0.157***	0.080***
	(62.83)	(16.88)	(9.04)	(5.78)	(3.42)
Observations	81,473	66,946	63,554	60,044	58,217
Adjusted R-squared	0.677	0.512	0.455	0.426	0.415
Controls	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓

Conclusion

- Develop text-based firm-level measures of input and output price changes using earnings calls
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- Develop text-based firm-level measures of input and output price changes using earnings calls
- Five facts about input price changes and their effects
- Potential applications:
  - Analyze effect of input prices on real and financial decisions made by firms