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Labor Productivity, Product Innovation and Firm-level Price Growth

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Productivity and Growth

- When labor productivity increases in the manufacturing industry, a nation can produce more value using less labor. Otherwise keeping labor effort constant it could produce a growing amount of value.
- This work estimates manufacturing labor productivity growth to evaluate how added welfare is growing and allowing further development to take place.

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Manufacturing Productivity

- In the study of the Chilean economy high importance is given to manufactured exports and the widening of the comparative advantage.

- This paper evaluates the effects of changing product variety over productivity at the firm level.

Motivation

- A relatively innovative feature of the present study is that we succeed in estimating productivity growth in real terms by using an individual firm-level price deflator.

- Additionally we introduce new measures of product innovation based on product-firm level panel data that describes the product mix changes inside firms over a period of eight years.

Productivity Shocks

- The literature has focused a rich discussion in two main sources of bias that appear from the original production function estimation.
- The first one is due to the correlation between observed input choices and unobserved productivity shocks.
- Marschak and Andrews (1944) proposed a two-equation model of producer while Griliches (1957) proposed a framework to analyze the bias.

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Absence of Prices

- A second source of bias that arises from the absence of the change of the prices at the firm level was analyzed in Klette and Griliches (1996).
- They showed that a common price deflator across firms is likely to bias the estimations of the production function.
- This problem is originated in the imperfectly competitive markets in which manufacturing firms operate.

Production Function

- A survey of empirical work with a review of the methods and criticisms of production function estimation was made by Griliches and Mairesse (1998).
- A complete review of the production function estimation literature may be found in Ackerberg, Benkard, Berry and Pakes (2005).

Firm-Level Price Control

- The first published paper that was capable to control for firm-level price changes in the context of production functions estimation was Abbott (1991)
- Mairesse and Jaumandreu (2005) developed a simple model to compare the estimates of production function using non-deflated output as well as industry-level and firm-level deflated output.

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Innovation and R&D

- Different approaches have been used to measure the role of innovation and R&D on productivity at the firm level.
- The works of Mairesse and Mohnen (1994) and Hall, Mairesse and Mohnen (2010) contain a complete review of previous works and empirical strategies that evaluated the impact of R&D investments on productivity.

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Estimation Strategy

- Following the idea of Mairesse and Jaumandreu (2005) we can write an expression in the form of the standard (log) linear regression as follows,

$$q_{it} = a_t + \alpha k_{it} + \beta l_{it} + \lambda inn_{it} + u_{it} \qquad \text{with } i = 1,\ldots,N \quad \text{and} \quad t = 1,\ldots,T$$

Unobserved Prices

- As previous studies lack firm information on the prices of output, the real value of output is approximated by the nominal output deflated by an industry average price growth index. Therefore instead of the equation above what we commonly estimate is:

$$(y_{it} - p_{St}) = q_{it} + (p_{it} - p_{St}) = a_t + \alpha k_{it} + \beta l_{it} + \lambda inn_{it} + v_{it}$$

New Variables

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- From product-firm level data we observe when and which products are introduced and dropped from firms' production.
- We computed a set of variables that describe firms' product-mix change behavior.
- From this information we have also obtained the value on the present year of the proportion of sales that corresponds to innovated products.

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Empirical Strategy

- The model on this paper was firstly used to test whether the behaviors of adding and dropping products over a period of two years have an impact over firms' labor productivity.

- Secondly the empirical strategy also tested the effects of the rate of innovative sales over firms' labor productivity.

Measuring the Bias

- Our strategy is based on production function estimation using firm-level price deflators instead of nominal output growth as a proxy for real output or industry-level price deflators as a second best solution.
- One of the main objectives of this research is to measure the biases on the parameters produced by the unobserved within-sectors price dispersion.

Manufacturing Data

- In this study we have combined data from manufacturing industry surveys, innovation surveys and manufacture products surveys.

- One of the advantages of merging different datasets is that we can combine the information at the firm level with specific details on quantities and prices of products within firms and across markets.

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Data Sources

- The data has been provided by the Chilean National Institute of Statistics (INE).
- Our main information source was the National Annual Industrial Survey (ENIA).
- An annex form was used that collected information on each product line inside of firms.

Product-Firm Information

- From product-firm level data we were able to construct a firm-level price growth variable and a set of product innovation indicator variables.

- This data was merged with the Annual Industrial Survey (ENIA) from which the rest of the production variables were obtained.

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Data Cleaning

- The observations with leaps and those that were observed less than 3 times over the 8-year period were deleted from the dataset.

- After merging the information from all datasets the result was an unbalanced panel of 8 periods from 1996 to 2003 that contains 2439 plants.

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Descriptive Statistics

Variable Name	Number of Observations	Mean value	Standard Deviation	Minimum Value	Maximum Value
Output per employee not deflated	15,839	26,030	40,358	1,298	894,349
Output per employee industry 3-digit deflated	15,839	23,037	35,822	1,120	834,017
Output per employee firm level deflated	15,839	24,474	37,712	1,181	757,116
Capital per employee not deflated	15,839	11,275	35,710	12	1,431,972
Capital per employee deflated	15,839	9,018	27,322	8	1,288,659
Intermediates per employee not deflated	15,839	13,023	22,284	189	392,016
Intermediates per employee deflated	15,839	12,291	20,682	74	355,978
Number of employees	15,839	66	125	5	2,325
Capacity utilization	15,839	0.780	0.131	0.003	1
Number of products added in 2 years	11,897	0.969	2.570	0	32
Number of products dropped in 2 years	12,284	0.621	1.764	0	30
Products added sales proportion	11,897	0.138	0.307	0	1
Products droped sales proportion (t-2)	12,284	0.068	0.232	0	1
Firm-level price growth	13,436	0.029	0.123	-0.583	0.596
4-digit sector level price growth	13,436	0.028	0.038	-0.353	0.341
Sales covered by product firm-level data before cleaning	15,839	0.717	0.193	0.001	1
Sales covered by product firm-level data after cleaning	15,839	0.549	0.317	0.000	1

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Correlation Matrix

	(obs=9876)	Mean	SD	Min	Max	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
[1]	Output per employee firm level deflated	0.02	0.29	-1.63	1.78	1.00										
[2]	Capital per employee deflated	-0.06	0.41	-1.77	1.74	0.20	1.00									
[3]	Intermediates per employee deflated	-0.02	0.38	-2.29	1.95	0.54	0.17	1.00								
[4]	Number of employees	-0.03	0.21	-1.34	1.46	-0.43	-0.40	-0.34	1.00							
[5]	Capacity utilization	0.00	0.12	-5.70	5.70	0.04	-0.05	0.02	0.03	1.00						
[6]	Number of products added	0.36	0.62	0.00	3.50	0.01	-0.03	0.01	0.04	0.01	1.00					
[7]	Number of products dropped	0.28	0.54	0.00	3.43	-0.02	0.01	-0.02	-0.04	-0.01	0.43	1.00				
[8]	Products added sales proportion	0.09	0.20	0.00	0.69	0.02	-0.01	0.01	0.04	0.02	0.64	0.17	1.00			
[9]	Products droped sales proportion (t-2)	0.05	0.17	0.00	0.69	-0.02	0.01	-0.03	-0.06	-0.03	0.08	0.57	0.05	1.00		
[10]	Firm-level price growth	0.03	0.12	-0.58	0.60	-0.31	0.01	0.05	0.02	-0.01	-0.02	-0.01	-0.02	-0.01	1.00	
[11]	4-digit sector level price growth	0.03	0.04	-0.35	0.34	-0.11	0.02	0.06	0.03	-0.02	-0.06	-0.04	-0.05	-0.01	0.31	1.00

Products Added and Products Dropped in Levels

Estimates in Levels					
	(1)	(2)	(3)	(4)	(5)
	Output per employee	Output per employee	Output per employee	Output per employee	Output per employee
VARIABLES	not deflated	industry 3-digit deflated	firm level deflated	not deflated	not deflated
Capital per employee	0.110***	0.107***	0.116***	0.111***	0.111***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Number of employees	0.093***	0.099***	0.090***	0.092***	0.091***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
Intermediates per employee	0.634***	0.622***	0.628***	0.635***	0.635***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Capacity utilization	0.147***	0.103***	0.132***	0.145***	0.147***
	(0.025)	(0.024)	(0.028)	(0.024)	(0.025)
Number of products added	0.019***	0.010	0.020***	0.019***	0.020***
	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)
Number of products dropped	-0.036***	-0.035***	-0.036***	-0.035***	-0.035***
	(0.007)	(0.008)	(0.008)	(0.007)	(0.007)
4-digit industry price growth				0.215***	
				(0.050)	
Firm-level price growth					0.074***
					(0.015)
Constant	2.016***	2.331***	2.105***	1.990***	1.996***
	(0.153)	(0.147)	(0.171)	(0.150)	(0.153)
Observations	10239	10239	10239	10239	10239
R-squared	0.811	0.796	0.760	0.811	0.811

Products Added and Products Dropped in First Diff.

Estimates in First Differences					
	(1)	(2)	(3)	(4)	(5)
	Output per employee	Output per employee	Output per employee	Output per employee	Output per employee
VARIABLES	not deflated	industry 3-digit deflated	firm level deflated	not deflated	not deflated
Capital per employee	0.030***	0.031***	0.029***	0.029***	0.029***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)
Number of employees	-0.364***	-0.371***	-0.383***	-0.366***	-0.370***
	(0.015)	(0.015)	(0.017)	(0.015)	(0.015)
Intermediates per employee	0.358***	0.348***	0.336***	0.357***	0.355***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Capacity utilization	0.075***	0.077***	0.092***	0.076***	0.077***
	(0.024)	(0.025)	(0.026)	(0.024)	(0.024)
Number of products added	0.007*	0.007*	0.008*	0.007*	0.006*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Number of products dropped	-0.014***	-0.013***	-0.016***	-0.013***	-0.014***
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)
4-digit industry price growth				0.115*	
				(0.059)	
Firm-level price growth					0.114***
					(0.018)
Constant	0.029***	0.019***	0.041***	0.027***	0.024***
	(0.005)	(0.006)	(0.006)	(0.005)	(0.006)
Observations	9876	9876	9876	9876	9876
R-squared	0.470	0.449	0.383	0.470	0.474

Products Added and Products Dropped Sales Proportion, Levels

Estimates in Levels					
	(1)	(2)	(3)	(4)	(5)
	Output per employee	Output per employee	Output per employee	Output per employee	Output per employee
VARIABLES	not deflated	industry 3-digit deflated	firm level deflated	not deflated	not deflated
Capital per employee	0.111***	0.111***	0.122***	0.111***	0.112***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Number of employees	0.094***	0.099***	0.090***	0.094***	0.094***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)
Intermediates per employee	0.630***	0.620***	0.624***	0.630***	0.630***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Capacity utilization	0.151***	0.112***	0.145***	0.151***	0.150***
	(0.025)	(0.024)	(0.029)	(0.025)	(0.025)
Products added sales proportion	0.006***	0.003	0.001	0.006***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Products dropped sales proportion	-0.012***	-0.012***	-0.011***	-0.012***	-0.012***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
4-digit industry price growth				0.002	
				(0.061)	
Firm-level price growth					0.051***
					(0.015)
Constant	2.044***	2.310***	2.085***	2.044***	2.035***
	(0.154)	(0.147)	(0.174)	(0.154)	(0.154)
Observations	10239	10239	10239	10239	10239
R-squared	0.813	0.800	0.769	0.813	0.813

Products Added and Products Dropped Sales Proportion, FD

Estimates in First Differences					
	(1)	(2)	(3)	(4)	(5)
	Output per employee	Output per employee	Output per employee	Output per employee	Output per employee
VARIABLES	not deflated	industry 3-digit deflated	firm level deflated	not deflated	not deflated
Capital per employee	0.029***	0.030***	0.028***	0.029***	0.029***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)
Number of employees	-0.367***	-0.375***	-0.384***	-0.368***	-0.370***
	(0.015)	(0.015)	(0.017)	(0.015)	(0.015)
Intermediates per employee	0.357***	0.347***	0.335***	0.356***	0.355***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Capacity utilization	0.074***	0.076***	0.091***	0.075***	0.076***
	(0.024)	(0.025)	(0.026)	(0.024)	(0.024)
Products added sales proportion	0.003**	0.004***	0.003**	0.003**	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Products dropped sales proportion	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
4-digit industry price growth				0.102*	
				(0.060)	
Firm-level price growth					0.115***
					(0.018)
Constant	0.012	0.019*	0.026**	0.009	0.010
	(0.010)	(0.011)	(0.012)	(0.010)	(0.010)
Observations	9876	9876	9876	9876	9876
R-squared	0.471	0.449	0.383	0.471	0.474

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Contribution

- One of the main contributions of this paper is proposing a measure for firm-level price inflation with which nominal output can be expressed in real terms in order to estimate the production function.

- We found that deflating output in different ways does not change significantly the results of production function estimates.

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Concluding Remarks

- Additionally this paper incorporates some new measures of product innovation into the traditional productivity estimates.

- We have found that the incorporation of new products to a firm is significantly associated with a positive increase on per worker average productivity.

- On the other hand, firms that stop producing part of their products or reduce the variety of production see themselves associated with a reduction of average labor productivity.