What determines firm's growth? The role of demand and TFP shocks

Andrea Pozzi[1] Fabiano Schivardi[2]

[1] EIEF

[2] EIEF and Università di Cagliari

CAED meeting Nuremberg, April 27, 2012

Motivation

- Modern theories of industry dynamics collapse individual heterogeneity to a single parameter (Jovanovic 1982, Hopenhayn 1992, Ericsonn and Pakes 1995)

$$x_i \cdot F(K, L)$$

- What is x_i? If all firms face the same demand, only difference can be in physical productivity
- This is the approach of a large empirical literature in IO (Bartelsmann and Doms, 2000) and, more recently, international trade (Melitz 2003)

Motivation II

- In reality, most firms sell differentiated goods (Berry 1994; BLP 1995)
- Distinct source of shifts in the revenue function ξ.
- Klette and Griliches (1995): without firm level prices, estimated productivity mixture of demand and true productivity effects
- Conceptually different from productivity: having both we can learn more
- Neglected so far due to data limitations

Our Contribution

1. We exploit rich data with unique information on firm level prices and a standard model of monopolistic competition + Cobb-Douglas production
2. We disentangle idiosyncratic supply and demand components
3. We investigate their effects on firms' inputs and output growth

Preview of the results

- Idiosyncratic demand shocks are as important, if not more, as TFP shocks
- Effects smaller than those predicted by simple, frictionless model
    1. Evidence of frictions causing misallocation
    2. Deviation from model larger for TFP shocks
- Importance of frictions that depend on the nature of the shock: organizational inertia, i.e., more difficult to take advantage of a TFP than a demand shock

Literature

- Industry dymamics (Dunne at al., 1998). We add an additional source of heterogeneity
- Foster, Haltiwanger, and Syverson (2008)
  - First to look at demand and productivity, linking them to survival
  - Nearly homogeneous goods with meaningful quantity data. We use information on firm prices
  - We consider firm growth
- Literature on misallocation (Hopenhayn and Rogerson (1993), Hsieh and Klenow (2009), Collard-Wexler, De Loecker, and Asker (2011))
  - we point out that typical frictions assumed have effects independent from the nature of the shock – there is more

Model: Monopolistic competition with Cobb-Douglas production

- Firms face CES demand

$$Q_{it} = P_{it}^{-\sigma} \Xi_{it} \tag{1}$$

- Production technology: Cobb-Douglas

$$Q_{it} = \Omega_{it} K_{it}^{\alpha} L_{it}^{\beta} M_{it}^{\gamma} \tag{2}$$

- Two forcing variables: Ξ_{it} demand shock and Ω_{it} productivity shock
- The firms' problem

$$\text{Max}_{K,L,M}\{P_{it} * Q_{it} - wL_{it} - rK_{it} - p_m M\} \tag{3}$$

s.t. (1) and (2)

Static variables equilibrium

- Solution (logs):

$$
\begin{aligned}
q_{it}^{*} &= c_q + \frac{\sigma}{\theta}\omega_{it} + \frac{(\alpha+\beta+\gamma)}{\theta}\xi_{it} && (4)\\
p_{it}^{*} &= c_P - \frac{1}{\theta}\omega_{it} + \frac{(1-\alpha-\beta-\gamma)}{\theta}\xi_{it} && (5)\\
x_{it}^{*} &= c_x + \frac{(\sigma-1)}{\theta}\omega_{it} + \frac{1}{\theta}\xi_{it} && (6)
\end{aligned}
$$

- where $\theta = \alpha+\beta+\gamma+\sigma(1-\alpha-\beta-\gamma)$,
- $x = k, l, m$; c_q, c_p, c_x are constants
- Role of RTS

Biases from ignoring firm prices

1. Klette and Griliches: if revenues deflated with sectoral prices, demand effects get mixed with true productivity:

$$\begin{aligned} \ln TFPR_{it} &= \omega_{it} - \bar{p}_t + p_{it} \\ &= (1 - \frac{1}{\theta})\omega_{it} + \frac{(1-\alpha-\beta-\gamma)}{\theta}\xi_{it} - \bar{p}_t \end{aligned} \tag{7}$$

2. Coefficients of the production function estimated on revenues are downward biased: $p = -\frac{1}{\sigma}q + \frac{1}{\sigma}\xi$, so

$$q_{it} + p_{it} = \frac{\sigma - 1}{\sigma}(\alpha k_{it} + \beta l_{it} + \gamma\omega_{it}) + \frac{1}{\sigma}\xi_{it} \tag{8}$$

Dynamics

- Important for control function in TFP estimation
- Capital stock *in place* evolves according to

$$\bar{K}_{it} = (1-\delta)\bar{K}_{it-1} + I_{it-1} \tag{9}$$

- Capital used for production is

$$K_{it} = u_{it}\bar{K}_{it}, \quad u_{it} \leq 1 \tag{10}$$

- Standard DP formulation, with state variables $\bar{K}$, ω and ξ, the latter assumed to be AR(1).

Invertibility

- We can show that, if $I_t > 0$, the policy function for investment - $g(\bar{K}_{it}, \Xi_{it}, \Omega_{it})$ - is increasing in Ξ_{it}, Ω_{it} for every level of $\bar{K}_{it}$
- Therefore, we can invert it and express productivity shocks like

$$\Omega_{it} = \Omega(I_{it}, \Xi_{it}, \bar{K}_{it}) \tag{11}$$

- If we explicitly consider demand shocks, we need to include the Ξ_{it}'s in the control function
- Log-linearize and take first differences

Data: INVIND survey + balance sheets

- Collected yearly (from 1984) by the Bank of Italy
- Representative of 50+ manufacturing firms
- We group firms into 7 sectors, based on ATECO categorization
- Descriptive Tables: Levels, Growth rates
- Main variables:
  - Δp: Distribution; mean 2.1%, s.d. 0.6%
  - Capital stock: self reported change in technical capacity
  - Capital utilization: average 81%, s.d. 13%

Estimation: Demand

- Availability of prices as changes forces us to translate everything to first differences
- Taking logs and differences, demand is

$$\Delta q_{it} = \sigma \Delta p_{it} + \Delta \xi_{it} \tag{12}$$

- With a consistent estimate of σ: $\widehat{\Delta\xi_{it}} = \Delta q_{it} - \hat{\sigma}\Delta p_{it}$
- A question in INVIND offers the chance to recover σ:
Consider now a thought experiment: if your firm raised today sale prices by 10%, what do you think would be the percentage variation of nominal sales, under the assumption that competitors do not change their prices and everything else holds equal?"
- Distribution average values
- We use the sectoral average of the self-reported σ

Demand elasticity estimates

Sector	INVIND	OLS	IV	INVIND Single product	INVIND Non exporters
Textile and leather	4.5	.27	6.1	4.7	8
Paper	5.1	.39	4.6	4.7	5.6
Chemicals	4.7	.40	5.2	5.7	5.6
Minerals	5.4	-.04	5.5	3.5	6.1
Metals	5.5	.28	4.9	6.4	7
Machinery	5	.39	5.7	5.1	7.4
Vehicles	6	.63	7.1	8.4	8.2

Estimation: Production function

- Estimate in first differences, with firm level deflators
- Endogeneity in inputs: control function (Olley and Pakes, 1996)
  - Policy function for investment also depends on demand shocks
  - Used capital K is not predetermined since firms can choose capacity utilization u after observing the shocks
- Estimating equation:

$$\Delta q_t = \alpha \Delta k_t + \beta \Delta l_t + \gamma \Delta m_{it} + h(\Delta \xi_t, \Delta i_t, \Delta \bar{K}_t) + \epsilon_t \tag{13}$$

- Then

$$\widehat{\Delta TFP}_t = \Delta q_t - \hat{\alpha} \Delta k_t - \hat{\beta} \Delta l_t - \hat{\gamma} \Delta l_t \tag{14}$$

Production function estimates: OP, own prices

	Txt+leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
Δk	0.14***	0.09**	0.11***	0.12***	0.09***	0.11***	0.17**
	(0.027)	(0.042)	(0.023)	(0.033)	(0.028)	(0.023)	(0.066)
Δl	0.17***	0.31***	0.23***	0.24***	0.24***	0.17***	0.33***
	(0.025)	(0.055)	(0.030)	(0.045)	(0.031)	(0.029)	(0.070)
Δm	0.49***	0.37***	0.58***	0.38***	0.52***	0.52***	0.38***
	(0.023)	(0.045)	(0.027)	(0.032)	(0.023)	(0.019)	(0.053)
$\alpha + \beta + \gamma$	0.8	0.77	0.92	0.74	0.85	0.8	0.88
Obs.	1,805	443	1,083	815	1,354	2,072	419
R^2	0.67	0.55	0.71	0.59	0.65	0.72	0.63

Production function estimates: OP, Sectoral deflator

	Txt+leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
Δk	0.11***	0.06	0.08***	0.10***	0.07***	0.08***	0.13**
	(0.023)	(0.038)	(0.020)	(0.030)	(0.024)	(0.018)	(0.062)
Δl	0.13***	0.20***	0.17***	0.23***	0.17***	0.15***	0.31***
	(0.022)	(0.050)	(0.025)	(0.039)	(0.027)	(0.023)	(0.064)
Δm	0.43***	0.36***	0.55***	0.34***	0.47***	0.50***	0.36***
	(0.020)	(0.041)	(0.025)	(0.029)	(0.021)	(0.017)	(0.050)
$\frac{\sigma(\tilde{\alpha}+\tilde{\beta}+\tilde{\gamma})}{\sigma-1}$	0.86	0.77	1.01	.82	.86	.91	.96
Obs.	1,806	446	1,083	816	1,356	2,076	419
R^2	0.77	0.72	0.82	0.70	0.76	0.79	0.67

Descriptive statistics: ΔTFP and $\Delta\xi$

						Percentiles		
	N	*Mean*	*Std.dev.*	*5th*	*25th*	*50th*	*75th*	*95th*
Panel A: ΔTFP								
ΔTFP-OP	12,110	.008	.14	-.16	-.04	.008	.06	.16
ΔTFP-factor	12,110	.001	.14	-.18	-.05	.00	.05	.17
Panel B: $\Delta\xi$								
$\Delta\xi$ sector	12,110	.014	.32	-.46	-.12	.02	.16	.47
$\Delta\xi$ class	10,315	.010	.34	-.48	-.12	.02	.15	.31
$\Delta\xi$ non exporters	12,110	.010	.41	-.58	-.15	.02	.19	.57

The impact of TFP and ξ on firm growth

- As TFP and ξ are exogenous, can just run:

$$\Delta y_{it} = \lambda_1 \Delta\omega_{it} + \lambda_2 \Delta\xi_{it} + \eta_{it}$$

- Pool obs. across sectors. Include year*sector dummies and area dummies. Bootstrapped s.e.
- Exclude the (few) observations at full capacity ($u_{it} = 1$)
- Experiment with many modifications (F.E., TFP estimates, sectoral regressions...)

Results: Sales and Output

	Sales			Output	
	Nominal	Quantity	Price	Nominal	Quantity
ΔTFP	0.597***	0.735***	-.154***	0.806***	0.982***
	(0.017)	(0.021)	(0.004)	(0.019)	(0.022)
$\Delta\xi$	0.408***	0.265***	.132***	0.356***	0.222***
	(0.006)	(0.008)	(0.002)	(0.006)	(0.007)
Observations	10,617	10,613	10,720	10,655	10,656
R^2	0.67	0.46	0.76	0.59	0.51

Direct and indirect effect

- Total differentiation of the DGP of output delivers

$$\frac{d\Delta q_{it}}{d\Delta \omega_{it}} = \underbrace{1}_{\text{direct effect}} + \underbrace{\alpha \frac{\partial \Delta k_{it}}{\partial \Delta \omega_{it}} + \beta \frac{\partial \Delta l_{it}}{\partial \Delta \omega_{it}} + \gamma \frac{\partial \Delta m_{it}}{\partial \Delta \omega_{it}}}_{\text{indirect effect}}$$

$$\frac{d\Delta q_{it}}{d\Delta \xi_{it}} = \alpha \frac{\partial \Delta k_{it}}{\partial \Delta \xi_{it}} + \beta \frac{\partial \Delta l_{it}}{\partial \Delta \xi_{it}} + \gamma \frac{\partial \Delta m_{it}}{\partial \Delta \xi_{it}}$$

Results: Variable inputs

	Hours worked	Intermediate inputs	Utilized capital
ΔTFP	0.013	0.240***	0.007
	(0.013)	(0.037)	(0.020)
$\Delta\xi$	0.103***	0.373***	0.110***
	(0.005)	(0.010)	(0.007)
Observations	10,576	10,652	10,580
R-squared	0.12	0.28	0.09

Results: Quasi-fixed inputs

	Employment	Hires	Separations	Investment rate
ΔTFP	0.061***	0.065***	-0.006	0.077***
	(0.010)	(0.012)	(0.012)	(0.014)
$\Delta\xi$	0.074***	0.068***	-0.015***	0.033***
	(0.004)	(0.004)	(0.004)	(0.005)
Observations	10,559	10,658	10,657	8,463
R-squared	0.11	0.10	0.04	0.05

Main findings

- Idiosyncratic demand is at least as important as TFP
- The indirect effect of improvement in productivity is small

Introducing a benchmark

- Given estimates of $\sigma, \alpha, \beta, \gamma$ we can compute the elasticities implied by the model- example:

$$\Delta q_{it}^{*} = \frac{\sigma}{\theta} \Delta \omega_{it} + \frac{(\alpha + \beta + \gamma)}{\theta} \Delta \xi_{it}$$

- We can compare them with those we get from the data

	$\Delta(p+q)$	Δq	Δp	Δx
$\Delta\omega$	2.2	2.8	-0.56	2.2
$\Delta\xi$	0.56	0.44	0.11	0.56

Insights from comparing model predictions with estimated elasticities

- Measured elasticities are much smaller $\Rightarrow$ Evidence of frictions? In fact, lagged shocks matter.
- Deviations from the frictionless models more substantial for TFP $\Rightarrow$ Asymmetric adjustment costs?

Organizational inertia

- TFP shocks impact output directly. To take full advantage, they might require reorganization (Bloom and Van Reenen)
- Less relevant for demand: just modify the scale of operation
- Firms that did not meet their investment plans are asked why. “Reasons related to internal organization of the firm" most often quoted (60%).
- Use it to construct an “inertia" dummy

Results: organizational inertia

	Output	Price	Employment	Investment rate
ΔTFP	1.039***	-0.167***	0.097***	0.097***
	(0.035)	(0.007)	(0.018)	(0.024)
$\Delta TFP \times$Organizational hurdles	-0.112**	0.020**	-0.045**	-0.035
	(0.047)	(0.009)	(0.023)	(0.036)
$\Delta\xi$	0.226***	0.131***	0.076***	0.034***
	(0.010)	(0.003)	(0.006)	(0.010)
$\Delta\xi\times$ Organizational hurdles	-0.005	0.001	0.002	0.001
	(0.011)	(0.003)	(0.007)	(0.012)
Organizational hurdles	0.006**	-0.001	0.002	-0.003
	(0.002)	(0.001)	(0.002)	(0.003)
Observations	8,038	8,075	7,964	6,426
R-squared	0.51	0.77	0.13	0.05

Family firms

- Bloom and Van Reenen (2007): family firms that select management via primogeniture are badly managed
- We have info on ownership type
- Lippi Schivardi (2012): family controlled firms tend to select executives based on personal ties rather than managerial abilities
- Check if family controlled firms are less responsive to shocks
- Other ownership modes: financial institutions, conglomerates, foreign.

Results: Family firms

	Output	Price	Employment	Investment rate
ΔTFP	1.051***	-0.164***	0.078***	0.085***
	(0.024)	(0.005)	(0.013)	(0.020)
$\Delta TFP \times$Family	-0.145***	0.022***	-0.036*	-0.013
	(0.036)	(0.008)	(0.019)	(0.030)
$\Delta\xi$	0.221***	0.133***	0.075***	0.031***
	(0.007)	(0.002)	(0.004)	(0.006)
$\Delta\xi\times$Family	0.004	-0.002	-0.001	0.006
	(0.011)	(0.003)	(0.006)	(0.010)
Family	-0.004*	0.001**	0.005***	-0.002
	(0.002)	(0.000)	(0.001)	(0.002)
	10,619	10,683	10,522	8,428
	0.52	0.76	0.12	0.05

Implications for misallocation

- Growing literature on the effects of misallocation on aggregate productivity (Hsieh and Klenow, 2009)
- Typically focused on external obstacles: labor market regulation, corruption ...
- They should have symmetric effects on the two shocks
- This is not what we find: obstacles within the firm

Conclusions

- We exploit knowledge of firm level prices to identify separately idiosyncratic demand and supply factors
- We assess quantitatively the importance of those factors in driving firm growth
- Demand factors, so far neglected, as important as TFP
- Firms under-react to TFP shocks and have a longer dynamic response
- Evidence consistent with frictions linked to firm behavior, and not only to institutional environment

Descriptive stats: Levels

Back

	All	Textile and leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
Sales	126,619	54,055	114,224	169,000	71,758	116,618	107,045	483,668
	(595,802)	(109,611)	(254,860)	(312,986)	(119,067)	(341,266)	(245,620)	(2,117,926)
Output	126,562	54,370	110,263	173,603	73,187	119,816	108,749	461,125
	(572,481)	(110,007)	(234,334)	(319,110)	(121,902)	(342,676)	(247,169)	(2,018,199)
Workers	525	314	445	510	331	335	565	1,950
	(2,454)	(559)	(823)	(972)	(479)	(903)	(1,271)	(8,852)
Obs.	12,110	2,718	705	1,666	1,192	1,887	3,159	783

Descriptive stats: Growth rates

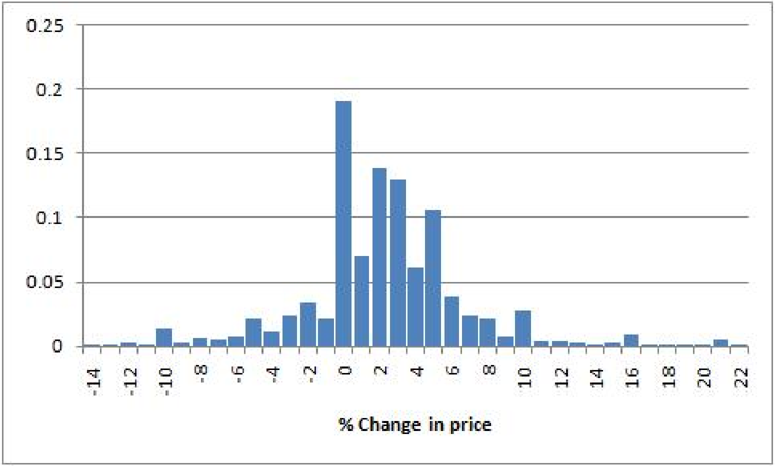
Back

	All	Textile and leather	Paper	Chemicals	Minerals	Metals	Machinery	Vehicles
ΔSales	.020	-.005	.027	.020	.016	.021	.036	.035
	(.19)	(.17)	(.13)	(.14)	(.18)	(.17)	(.19)	(.38)
ΔOutput	.023	-.007	.035	.029	.023	.034	.030	.043
	(.22)	(.20)	(.16)	(.20)	(.19)	(.20)	(.23)	(.30)
ΔInterm. inputs	.003	-.012	.039	.026	.027	.031	.038	.058
	(.30)	(.31)	(.25)	(.31)	(.25)	(.32)	(.34)	(.44)
Δhours worked	-.004	-.017	-.005	.001	-.008	.004	.001	-.003
	(.13)	(.14)	(.09)	(.11)	(.12)	(.14)	(.14)	(.15)
Δutilized capital	.038	.015	.052	.041	.040	.053	.043	.044
	(.20)	(.20)	(.19)	(.21)	(.20)	(.18)	(.19)	(.25)
Δprices	.021	.023	.016	.021	.026	.027	.017	.016
	(.06)	(.05)	(.08)	(.06)	(.05)	(.08)	(.06)	(.04)
Obs.	12,110	2,718	705	1,666	1,192	1,887	3,159	783

Distribution of price changes

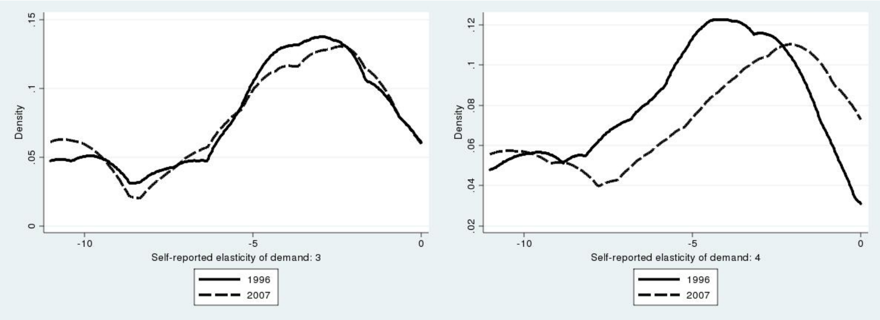
Back

"Average yearly percentage variation of prices of goods and services sold"



Distribution of self-reported elasticity

Back



Sample sectors: Chemicals (left) and Minerals (right)

Dynamic programming formulation

Back

- The DP is

$$
\begin{aligned}
V(\bar{K}_{it}, \Omega_{it}, \Xi_{it}) &= \max_{I_{it}} \{\Pi_{it} - pI_{it} + \\
&\quad \psi E(V(\bar{K}_{it+1}, \Omega_{it+1}, \Xi_{it+1}) | \Omega_{it}, \Xi_{it})\} \qquad (15) \\
\text{subject to} & \\
\bar{K}_{it+1} &= I_{it} + (1-\delta)\bar{K}_{it} \qquad (16) \\
\omega_{it+1} &= \rho^{\omega}\omega_{it} + \epsilon^{\omega}_{it+1} \qquad (17) \\
\xi_{it+1} &= \rho^{\xi}\xi_{it} + \epsilon^{\xi}_{it+1} \qquad (18)
\end{aligned}
$$

Demand elasticity estimates

Back

Sector	INVIND	OLS	IV	INVIND Single product	INVIND Non exporters
Textile and leather	4.5	.27	6.1	4.7	8
Paper	5.1	.39	4.6	4.7	5.6
Chemicals	4.7	.40	5.2	5.7	5.6
Minerals	5.4	-.04	-5.5	3.5	6.1
Metals	5.5	.28	4.9	6.4	7
Machinery	5	.39	5.7	5.1	7.4
Vehicles	6	.63	7.1	8.4	8.2

Sticky prices

- Evidence on lagged effects consistent with sluggish prices
- If prices not fully flexible, demand effects are magnified and productivity effects dampened:

$$\frac{dq}{d\xi} = \frac{\partial q}{\partial \xi} - \sigma \frac{\partial p}{\partial \xi}$$

- In 1996 and 2003, frequency of price adjustments. Define “sticky" those that adjust every six months or more

Results: Price sluggishness

	Price	Output	Employment	Investment rate
ΔTFP	-0.181***	1.146***	0.094***	0.124***
	(0.010)	(0.037)	(0.016)	(0.025)
$\Delta TFP\times$ Sluggish	0.030***	-0.194***	-0.019	-0.051
	(0.012)	(0.052)	(0.023)	(0.035)
$\Delta\xi$	0.146***	0.192***	0.063***	0.027***
	(0.003)	(0.010)	(0.005)	(0.008)
$\Delta\xi\times$ Sluggish	-0.021***	0.069***	0.022***	0.009
	(0.004)	(0.015)	(0.008)	(0.011)
Sluggish	0.002***	-0.006**	-0.001	0.002
	(0.001)	(0.003)	(0.002)	(0.004)
Observations	7,404	7,381	7,337	5,786
R-squared	0.80	0.55	0.13	0.07

Are the adjustment costs? Lagged effects ◂ Back

	Output	Price	Employment	Investment rate
ΔTFP_t	0.987***	-0.160***	0.076***	0.088***
	(0.031)	(0.006)	(0.014)	(0.020)
ΔTFP_{t-1}	0.155***	-0.041***	0.110***	0.071***
	(0.020)	(0.004)	(0.014)	(0.021)
ΔTFP_{t-2}	0.036*	-0.020***	0.062***	0.069***
	(0.022)	(0.004)	(0.013)	(0.021)
$\Delta\xi_t$	0.240***	0.133***	0.075***	0.035***
	(0.010)	(0.003)	(0.005)	(0.006)
$\Delta\xi_{t-1}$	-0.027***	0.010***	0.024***	0.015**
	(0.008)	(0.002)	(0.004)	(0.007)
$\Delta\xi_{t-2}$	0.001	-0.001	0.023***	0.028***
	(0.007)	(0.001)	(0.004)	(0.007)
Observations	5,425	5,436	5,378	4,390
R-squared	0.52	0.79	0.16	0.07