Productivity growth, firm turnover and new varieties

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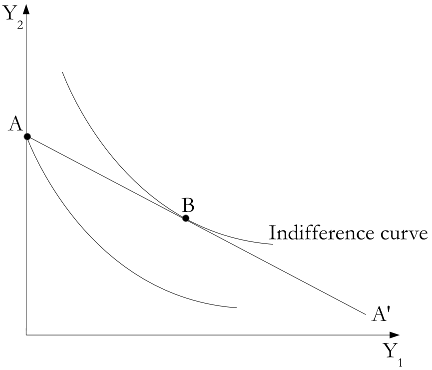
Many new goods have a significant effect on consumer welfare and this impact should be included in a cost-of-living based inflation rate (Groshen, 2017)

At least two conceptually different ways of doing this have been applied in the literature:

1. identify a virtual price for the new good before its appearance (Hausman,1999)
2. calculate the consumer gain from new varieties directly (typically a CES-framework is applied).

Even though the virtual price that drives demand to zero is infinite within a CES-framework, the consumer gain from a new variety is finite (Feenstra ,1994).



Firm turnover, new varieties and consumer welfare

New varieties and productivity growth

Despite a large literature on reallocation, firm turnover and productivity growth (Griliches, 1995; Baily, 1992; Foster, 2001; Foster et al, 2006; Acemoglu et al, 2017), the contribution from new varieties to overall productivity growth has not been analysed.

- These studies decompose productivity growth based on weighed average of productivity *levels*.
- When comparing productivity levels across firms it is implicitly assumed that the products are perfect substitutes.
- But new varieties yield extra welfare to consumers precisely because they hold some new characteristics

An index of productivity growth

An index of *aggregate productivity growth* may be written as

- Q_Y / Q_L

where Q_Y represents an index for overall output and Q_L represents an index for overall input usage. This definition of productivity is standard; see Diewert (2003).

Output index

To create the aggregate output index, we apply the results of Sato (1976), Vartia (1976) and Feenstra (1994) .

- Sato and Vartia showed how to calculate a price and a quantum index for a CES aggregator function when the number of goods is constant between different periods.
- Feenstra generalised the Sato-Vartia index to handle situations where the number of goods changes over time.

Varieties vs. firms

We assume that each firm in the same industry produces a different (single) variety of the same good. Hence, the set of varieties of a single good, can equivalently be interpreted as the set of firms in an industry, and the set of goods as the set of industries.

Formula

The derived analytical expression for the aggregate output index is as follows:

$$\ln Q_Y = \sum_{i \in I} w_{it} \left(\sum_{f \in C_{it}} w_{ift} \Delta \ln Y_{ift} + \left(\frac{\sigma_i}{1-\sigma_i} \right) \ln \left(1 - s_{it}^N \right) - \left(\frac{\sigma_i}{1-\sigma_i} \right) \ln \left(1 - s_{i,t-1}^X \right) \right)$$

where

- I is the set of industries
- C_{it} is the set of *continuing* firms in industry i: firms that exist in two consecutive time periods $t-1$ and t
- Y_{ift} is value added produced by firm f in industry i
- weights w_{ift} and w_{it} are based on logarithmic means of output shares
- s_{it}^N and $s_{i,t-1}^X$ are output shares of entering and exiting firms

Input index

We proceed with the standard approach using the sum of hours worked (L_{ift}) to derive the index for input usage growth, Q_L:

$$\ln Q_L = \sum_{i \in I} \theta_{it} \left(\sum_{f \in C_{it}} \theta_{ift} \Delta \ln L_{ift} - \ln \left(1 - h_{it}^N\right) + \ln \left(1 - h_{i,t-1}^X\right) \right).$$

where the weights θ_{ift} are based on the man-hour shares if firm f in industry i, and h_{it}^N and $\mathrm{h}_{i,t-1}^X$ are man-hours shares of entering and exiting firms.

Contribution from product innovation and firm turnover to overall productivity growth

$$\ln(Q_Y/Q_L) = \sum_{i\in I} w_{it}\left[\sum_{f\in C_{it}} w_{ift}\Delta\ln(Y_{ift}/L_{ift}) - \ln\left(\frac{1-s_{it}^N}{1-h_{it}^N}\right) + \ln\left(\frac{1-s_{i,t-1}^X}{1-h_{i,t-1}^X}\right) - \left(\frac{1}{\sigma_i-1}\right)\ln\left(\frac{1-s_{it}^N}{1-s_{i,t-1}^X}\right)\right] + RWI_t + RBI_t$$

- $-\left(\frac{1}{\sigma_i-1}\right)\ln\left(\frac{1-s_{it}^N}{1-s_{i,t-1}^X}\right) \doteq \left(\frac{1}{\sigma_i-1}\right)(s_{it}^N - s_{i,t-1}^X)$ is the contribution from new varieties.
- *RWI* and *RBI* are the contributions from reallocation of labour within and between industries.

The Feenstra-Soderbery estimator

To identify the impact of firm turnover on productivity growth requires an estimate of the elasticity of substitution

- In the literature, following (Fenstra, 1994), the key idea is to use panel data in combinations with identifying orthogonality restrictions on the error terms in the system of demand and supply equations.
- In this tradition, Soderbery (2015) created a hybrid estimator (the "Feenstra-Soderbery estimator") combining GMM with a nonlinear grid search routine.

Our estimator

Our estimation procedure builds on the Feenstra-Soderbery estimator, but we refine it along two dimensions:

1. We create a two-stage estimation framework that exploits cases where there are no simultaneity problems, i.e. when supply is elastic or inelastic.
2. We generalise the current practice of choosing a particular reference firm to eliminate time- and firm fixed effects.

System of supply and demand

For each industry: the demand share at t of the variety produced by firm f, s_{ft}, is assumed to be given by:

$$\ln s_{ft} = \beta \ln p_{ft} + |\beta|(\lambda_t^D + u_f^D + e_{ft}^D),\ \beta = 1 - \sigma < 0$$

The inverse supply equation is assumed to be given by:

$$\ln p_{ft} = \alpha \ln s_{ft} + \lambda_t^S + u_f^S + e_{ft}^S$$

where $\alpha = \omega/(1+\omega)$ and $\omega \geq 0$ is the inverse elasticity of supply.

Identification

Identifying assumption (Feenstra, 1994): the idiosyncratic error terms e_{ft}^{D} and e_{ks}^{S} are independent for *any* (f, t) and (k, s):

$$(\Delta^{(k)} \ln p_{ft})^2 = \theta_1 (\Delta^{(k)} \ln s_{ft})^2 + \theta_2 (\Delta^{(k)} \ln p_{ft} \Delta^{(k)} \ln s_{ft}) + U_{fkt}$$

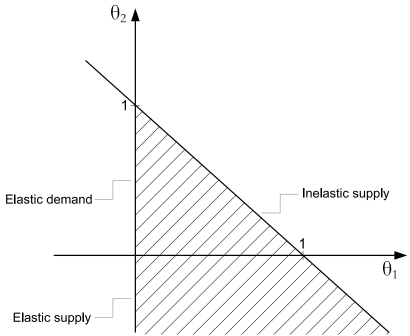
where

$$\theta_1 = -\frac{\alpha}{\beta}, \theta_2 = \frac{1}{\beta} + \alpha$$

and

$$E(U_{fkt}) \equiv E(\varepsilon_{fkt}^{D} \varepsilon_{fkt}^{S}) = 0.$$

Parameter space



The boundary $\{\theta : \theta_1 > 0 \cap \theta_1 + \theta_2 = 1\}$ corresponds to inelastic supply, $\{\theta : \theta_1 = 0 \cap \theta_2 < 0\}$ to elastic supply and $\{\theta : \theta_1 = 0 \cap 0 \leq \theta_2 \leq 1\}$ to elastic demand

Parametrization

Parameter space of θ	Elasticities (α, σ)	
$\Theta_{int} = \{\theta : \theta_1 > 0 \cap \theta_1 + \theta_2 < 1\}$	$\alpha = \left[\frac{-\theta_2+\sqrt{\theta_2^2+4\theta_1}}{2\theta_1}\right]^{-1}$	$\sigma = 1 + \frac{\theta_2+\sqrt{\theta_2^2+4\theta_1}}{2\theta_1}$
$\Theta_2 = \{\theta : \theta_1 > 0 \cap \theta_1 + \theta_2 = 1\}$	$\alpha = 1$	$\sigma = 1 + \frac{1}{\theta_1}$
$\Theta_3 = \{\theta : \theta_1 = 0 \cap \theta_2 < 0\}$	$\alpha = 0$	$\sigma = 1 - \frac{1}{\theta_2}$
$\Theta_4 = \{\theta : \theta_1 = 0 \cap 0 \leq \theta_2 \leq 1\}$	$\alpha = \theta_2$	$\sigma = \infty$

Two-stage estimator

We propose a two-stage estimator:

- 1. step: Apply the Feenstra-Soderbery estimator ($\widehat{\theta}$)
- 2. step: Apply (a more efficient) fixed effects regression estimator in the case $\widehat{\theta} \in \Theta_2$ (inelastic supply) or $\widehat{\theta} \in \Theta_3$ (elastic supply).

Of particular interest is inelastic supply ($\alpha = 1$), since this case corresponds to monopolistic competition. In the existing literature, this fact seems to have been overlooked.

Proposition (summary)

If θ^0 is at the boundary of the parameter space and σ is finite , our 2-stage estimator $\widehat{\sigma}$ will have a mixture distribution with a closed form formula of the asymptotic mean and variance.

Estimates of elasticities of substitution

	Two-stage estimator[a]							Feenstra-Soderbery est.		
Industry	First-stage		Second-stage					Unrestricted		Restricted
	$\widehat{\theta}_1^P$	$\widehat{\theta}_2^P$	$\widehat{\theta}_1$	$\widehat{\theta}_2$	$\widehat{\sigma}$	SE($\widehat{\sigma}$)	95% CI[b]	$\widehat{\theta}_1^{(u)}$	$\widehat{\theta}_2^{(u)}$	$\widehat{\sigma}$
10	0.19	0.90	0.14	0.86	7.93	1.54	[5.5, 11.8]	0.16	0.90	7.55
16	-0.17	1.08	0.22	0.78	5.56	0.69	[4.4, 7.2]	-0.25	1.42	1.66
23	-1.08	2.08	0.78	0.22	2.28	0.36	[1.6, 3.1]	0.28	0.76	4.69
25	0.35	0.42	0.35	0.42	3.39	0.24	[3.0, 3.8]	-0.32	-1.20	1.33
28	-0.49	1.50	0.17	0.87	8.92	4.12	[4.2, 12.4]	0.35	1.81	6.67
32	-0.46	1.70	0.27	0.73	4.67	0.91	[3.2, 7.0]	-0.64	1.72	1.74

[a] See Table 3 for definition of the two stages
[b] Transformed from symmetric confidence interval (CI) of $\widehat{u}$ where $\widehat{u} \equiv \ln(\widehat{\sigma}-1)$ and $SE(\widehat{u}) \simeq SE(\widehat{\sigma})/(\widehat{\sigma}-1)$

Productivity growth rates. By industry and aggregate for all industries, in per cent

NACE	σ[a]	Period (t)							
		96-98[b]	99-01	02-04	05-07	08-10	11-13	14-16	Mean
10	∞	2.1	-1.4	4.7	3.0	3.1	0.5	0.6	1.8
	$\hat{\sigma}$	3.2	-0.7	5.2	3.3	3.4	0.7	0.4	2.2
16	∞	1.0	0.7	0.5	0.3	0.2	0.2	-0.2	0.4
	$\hat{\sigma}$	-0.5	-0.6	6.2	-0.5	6.3	-0.8	3.5	1.9
23	∞	-1.7	-3.5	2.7	5.0	1.2	3.7	3.3	1.5
	$\hat{\sigma}$	-1.2	-2.1	3.7	5.5	1.4	4.1	2.9	2.0
25	∞	8.2	-1.6	2.4	4.6	2.0	2.8	-3.4	2.1
	$\hat{\sigma}$	10.8	-0.6	3.2	5.1	2.7	3.2	-3.7	3.0
28	∞	5.2	-4.3	6.3	4.8	3.7	-2.6	-4.2	1.3
	$\hat{\sigma}$	5.4	-4.2	6.7	5.1	3.8	-2.5	-4.2	1.4
32	∞	4.0	4.1	6.5	-3.0	9.9	1.1	5.4	4.0
	$\hat{\sigma}$	4.4	5.8	6.9	-2.7	10.0	1.3	5.1	4.4
All industries	∞	2.8	-1.2	4.2	3.1	3.5	1.1	0.1	1.9
	$\hat{\sigma}$	3.8	-0.5	4.7	3.4	3.7	1.2	-0.1	2.3

[a] $\hat{\sigma}$ refers to the estimated value of σ in Table 5
[b] Average annual rates during 3-year interval

Sources of aggregate productivity growth

Source	96-98	99-01	02-04	05-07	08-10	11-13	14-16	Mean
Continuing firms	2.7	-1.3	5.1	3.0	3.2	0.8	-0.8	1.8
Entering firms ($\sigma = \infty$)	-0.6	-0.2	-0.5	-0.2	-0.2	-0.4	-0.0	-0.3
Exiting firms ($\sigma = \infty$)	0.0	0.1	0.1	0.1	0.1	0.1	1.4	0.3
RWI	0.8	0.2	-0.5	-0.0	0.3	0.4	-0.4	0.1
RBI	-0.1	-0.0	0.0	0.2	0.1	0.1	-0.2	0.0
New varieties ($\sigma = \hat{\sigma}$)[b]	1.0	0.7	0.5	0.3	0.2	0.2	-0.2	0.4
	(0.08)	(0.08)	(0.06)	(0.04)	(0.03)	(0.03)	(0.03)	(0.05)
Total productivity growth	3.8	-0.5	4.7	3.4	3.7	1.2	-0.1	2.3

[a] Decomposed according to Equation (14)

[b] Standard error in the estimated contribution from new varieties (due to $\hat{\sigma}$) in parentheses

Sources of aggregate productivity growth

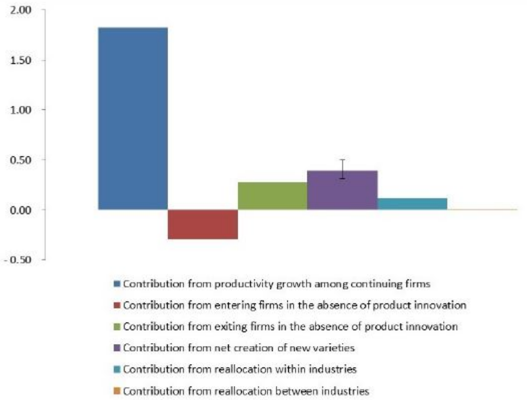
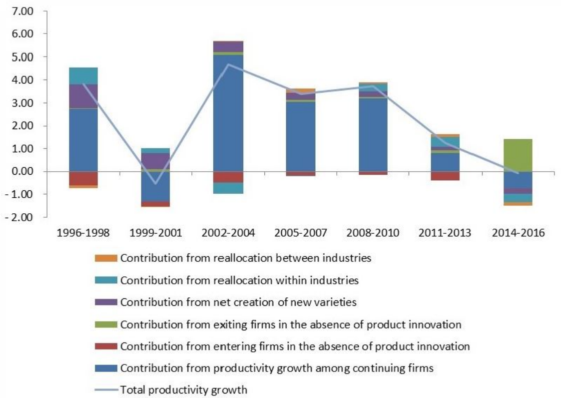


FIGURE 3: Contributions to aggregate productivity growth. Average annual growth rate in per cent across the sample 1996-2016

Contributions to aggregate productivity growth during 1996 – 2016. Average annual growth rate in per cent



Output shares of entering and exiting firms