The Impact of Entrepreneurship on Endogenous Growth: Theory and Evidence

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ZEW 5TH SEEK Conference
"Overcoming the Crisis: How to Foster Innovation and Entrepreneurship in a Diverging European Economy"
October, 2015

Impact of Entrepreneurship on Growth? Evidence is mixed

- The Impact of Entrepreneurship on Growth
  - Positive: Audretsch & Keilbach,2004; Klapper et al., 2010
  - Negative: Blanchflower,2000
  - Non-linear: Carree et al, 2002; van Stel et al, 2005

- Overview of Measurement of Entrepreneurship
  - Self-Employment Rate (Business Ownership Rate)
  - New Business Start-up Rate
  - Measures Proposed by Global Entrepreneurship Monitor (GEM): Nascent Entrepreneurship rate, New Business Ownership rate, Total Early-Stage Entrepreneurial Activity (TEA), Established Business Ownership Rate, Overall Entrepreneurial Activity Rate
  - Measures Proposed by World Bank Group Entrepreneurship Survey (WBGES): Entry Rate, Entry per Capita, Business Density

- Patent
  - There is difference between persons who invent and who commercialize the inventions.
  - Braunerhjelm et al. (2010) show that
    - Only about half of the invention disclosures in US universities result in patent applications;
    - Half of the applications result in patents;
    - Only one-third of patents are licensed;
    - Only 10–20% of licenses yield significant income.
    - Put differently, only 1% or 2% of inventions are successful in reaching the market and yielding income.

Impact of Entrepreneurship on Growth? A tale of two theories

- Agent selects entrepreneurship vs. wage work if
  - Low risk aversion (Khilstrom and Laffont, 1979)
  - Jack of all trades (Lazear, 2005)
  - Wealthy and high ability (Evans and Jovanovic, 1989)

- Endogenous growth theory
  - Innovation is engine of growth (Aghion and Howitt, 1992; Grossman and Helpman, 1991; Jones, 1995; Romer, 1990)

Outline of Presentation

- Model
  - Embed entrepreneurial occupational choice into Romer (1990) endogenous growth model
  - Entrepreneurship and growth have inverted U relationship
- Evidence
  - 8 U.S. high tech manufacturing sectors, 1983-1999
  - Self-employment has positive first-order and negative second-order effects on contemporaneous and long-run output growth. Overall, positive effect dominates.
  - Spillover of entrepreneurship from high-tech to non high-tech manufacturing sectors.
- Conclusion

The Model:
Romer (1990) with occupational choice

- Sectors: final goods, intermediate goods, research
  - Research firm invents new intermediate goods, gets infinitely-lived patents, and sells rights to monopolists
  - Monopolists sell intermediate goods to competitive firm that manufactures final goods

- Continuum of agents indexed by entrepreneurial skill s drawn from F with two occupational choices:
  - *Production worker* hired by final goods firm, earning competitive wage w
  - *Entrepreneur* that launches research firm, earning $e(s)$

- Engine of growth: expansion in number of intermediate goods

Final & Intermediate Goods

- Final goods competitive firm: $\max_{L, X_i} AL^{\beta} \int_0^K X_i^{1-\beta} di - wL - \int_0^K P_i X_i di$
  - Wage paid production labor: $w = \beta A L^{\beta - 1} \int_0^K X_i^{1-\beta} di$
  - Demand for intermediate goods: $P_i = (1-\beta) A L^{\beta} X_i^{-\beta}$
- Intermediate goods monopolist: $\max_{X_i} (1-\beta) A L^{\beta} X_i^{1-\beta} - cX_i$
  - Output policy: $X_i = L[(1-\beta)^2 A / c]^{1/\beta}$
  - Payoff per innovation: $\pi = (1 + 1/r) \beta L [A(1-\beta)^{2-\beta} / c^{1-\beta}]^{1/\beta}$

Research Firm & Occupational Choice

- Research firm innovation production function: $n(I;s) = \eta(sK)^{1-\alpha} I^{\alpha}$
  - Externality: stock of knowledge *K* → engine of growth
  - Firm's problem: $\max_{I(s)} \pi\eta(sK)^{1-\alpha} I(s)^{\alpha} - I(s)$
  - Investment policy: $I(s) = (\alpha\pi\eta)^{1/(1-\alpha)} sK$
  - Entrepreneurial income: $e(s) = (1-\alpha)(\alpha^{\alpha}\pi\eta)^{1/(1-\alpha)} sK$
- Occupational choice: $e(\hat{s}) = (1-\alpha)(\alpha^{\alpha}\pi\eta)^{1/(1-\alpha)} \hat{s}K \equiv w$
  - Labor supply equals demand: $L = F(\hat{s})$
  - Extent of entrepreneurship: $p \equiv 1 - F(\hat{s})$

Equilibrium & BGP

- Equilibrium threshold skill level: (determines E)

$$\hat{s}^{1-\alpha} F(\hat{s}) = \{(1+1/r)\eta(1-\alpha)^{1-\alpha}(\alpha\beta A^{1/\beta}/c^{(1-\beta)/\beta})^{\alpha}(1-\beta)^{(2\alpha(1-\beta)+\beta)/\beta}\}^{-1}$$

- BGP growth rate:

$$g = \{(1+1/r)\alpha\beta\eta^{1/\alpha} F(\hat{s})[A(1-\beta)^{2-\beta}/c^{1-\beta}]^{1/\beta}\}^{\alpha/(1-\alpha)} \int_{\hat{s}}^{\infty} s dF(s)$$

- Extent of entrepreneurship $p \equiv 1 - F(\hat{s})$ determined by threshold skill level $\hat{s}$, which is independent of growth rate *g*
  - Thus G does not affect E

Impact of Entrepreneurship on Growth: Inverted U relationship

- To determine impact of E on G, take derivative of *g* with respect to threshold skill level $\hat{s}$

- **Proposition 3**: An increase in E is associated with an increase in G if and only if $p < \overline{p}$

  - Cutoff skill: $[\overline{s}F(\overline{s})]^{-1}\int_{\overline{s}}^{\infty} s\,dF(s) \equiv 1/\alpha - 1$

  - Peak impact of E on G: $\overline{p} \equiv 1 - F(\overline{s})$

Impact of Entrepreneurship on Growth: Inverted U relationship

- Two competing effects of E on G:
  - *Entrepreneurship effect* (positive): increase in E → more innovation
    - Occurs in any R&D-based growth model
  - *Production effect* (negative): increase in E → reduces no. of production workers → reduces final goods output → reduces demand for intermediate goods → lowers payoff per innovation
    - Due to occupational choice
- Entrepreneurship effect subject to diminishing returns, so get inverted U relationship

Empirical Evidence

- Empirical proxies
  - Entrepreneurship: self-employment rate *SER* in high-tech manufacturing sectors.
    - high-tech : there are at least 15 R&D workers and 190 technology-oriented workers per thousand workers, where technology-oriented workers include engineers, life and physical scientists, mathematical specialist, and engineering, scientific, and computer managers. (Kask and Sieber, 2002, Table 1)
  - Growth: output growth
- Datasets
  - U.S. Bureau of Labor Statistics (BLS): SER
  - NBER-CES manufacturing productivity database: employment, the capital stock, value of shipments, value added, payroll
  - Final merged dataset: 8 sectors, 1983-1999

TABLE 1: HIGH-TECH U.S. MANUFACTURING SECTORS

SIC	Industry Description
281	Industrial inorganic chemicals
283	Drugs
286	Industrial organic chemicals
357	Computer and office equipment
366	Communications equipment
367	Electronic components and accessories
372	Aircraft and parts
376	Guided missiles, space vehicles ,and parts
381	Search and navigation equipment
382	Measuring and controlling devices

Source: Kask and Sieber (2002).

Measures of Growth

- Output Growth:
  - Growth rate of real value of shipments per employee (GRSHP); Growth rate of real value added per employee (GVADD)

- Calculate contemporaneous growth rates and 5-year geometric average growth rates

TABLE 4: MEANS OF KEY VARIABLES BY SECTOR

BLS Sector	*SER*	*GRSHP*	*GVADD*
26	0.0043	0.0874	0.0888
27	0.0049	0.1791	0.1938
29	0.0020	0.0395	0.0306
32	0.0010	0.0339	0.0403
34	0.0065	0.0406	0.0378
61	0.0003	0.0199	0.0195
65	0.0016	0.0306	0.0456
22&23	0.0025	0.2472	0.2298
Average	0.0029	0.0848	0.0858

Empirical Strategy

- Regression Equation:

$$G_{it} = \gamma_0 + \gamma_1 SER_{it} + \gamma_2 SER_{it}^2 + \gamma_3 \log KL_{it} + D_t + \lambda_i + \varepsilon_{it}$$

  - OLS regressions
  - 2SLS regressions
    - Endogenous variables: SER, SER^2
    - Instrumental variables: L.SER, L. SER^2, lnPL
    - Tests: endogeneity test, Basmann over-identification test, Arelleno Bond test for autocorrelation

TABLE 8: OLS REGRESSIONS ASSESSING THE IMPACT OF ENTREPRENEURSHIP ON GROWTH

	(1)	(2)	(3)	(4)
	GRSHP	*GVADD*	*GRSHP5*	*GVADD5*
SER	19.3279***	24.6450***	0.0965**	0.0811*
	(3.4200)	(3.9898)	(2.3393)	(1.6877)
SER^2	-1155.9735***	-1391.7581***	-7.3838***	-6.6263**
	(-3.2646)	(-3.5961)	(-2.8577)	(-2.2003)
LnKL	-0.0055	0.0160	0.0000	-0.0000
	(-0.3509)	(0.9396)	(0.1062)	(-0.0619)
Year Dummies	Yes	Yes	Yes	Yes
Sector Dummies	No	No	No	No
Constant	0.0582	-0.0372	-0.0001	0.0000
	(0.8012)	(-0.4687)	(-0.1308)	(0.0155)
Observations	131	131	131	131

Notes: *t* statistics in parentheses; * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level.

TABLE 9: PEAK SELF-EMPLOYMENT RATES IN THE INVERTED U RELATIONSHIP BETWEEN ENTREPRENEURSHIP AND GROWTH USING THE OLS REGRESSIONS

Contemporaneous		Long-Run		Average
GRSHP	*GVADD*	*GRSHP5*	*GVADD5*	
0.0084	0.0089	0.0065	0.0061	0.0075

Notes: The peak in the case of *GRSHP* is the coefficient of *SER* divided by 2 times the coefficient of SER^2 reported in Regression (1) of Table 8, and the other peaks are similarly calculated.

TABLE 10: OLS REGRESSIONS WITH SECTOR DUMMIES ASSESSING THE IMPACT OF ENTREPRENEURSHIP ON GROWTH

	(1)	(2)	(3)	(4)
	GRSHP	*GVADD*	*GRSHP5*	*GVADD5*
SER	2.3539	7.9395	0.0304	-0.0265
	(0.4279)	(1.1665)	(0.6587)	(-0.4515)
SER^2	-167.9831	-458.7302	-3.7117	-1.0704
	(-0.5300)	(-1.1696)	(-1.3970)	(-0.3170)
LnKL	-0.0005	0.0807	0.0003	0.0002
	(-0.0118)	(1.4509)	(0.7378)	(0.5208)
Year Dummies	Yes	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes	Yes
Constant	0.0110	-0.4040	-0.0017	-0.0015
	(0.0459)	(-1.3654)	(-0.8277)	(-0.5787)
Observations	131	131	131	131

Notes: *t* statistics in parentheses; * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level.

TABLE 13: 2SLS REGRESSIONS ASSESSING THE IMPACT OF SELF-EMPLOYMENT ON GROWTH (THE SECOND STAGE)

	(1)	(2)	(3)	(4)
	GRSHP	*GVADD*	*GRSHP5*	*GVADD5*
SER	121.8934*	129.2906*	1.2923**	0.9240*
	(1.9101)	(1.9359)	(2.0197)	(1.7428)
SER^2	-7332.1835**	-7639.2297**	-75.8368**	-54.8115*
	(-2.0263)	(-2.0172)	(-2.0902)	(-1.8232)
LnKL	-0.1233	-0.0493	-0.0009	-0.0006
	(-0.9483)	(-0.3622)	(-0.6553)	(-0.5869)
Year Dummies	YES	YES	Yes	Yes
Sector Dummies	YES	YES	Yes	Yes
Constant	0.6105	0.2007	0.0033	0.0026
	(0.7883)	(0.2477)	(0.4227)	(0.4003)
Observations	121	121	121	121
Basmann over-identification test (p-value)	0.8819	0.9708	0.9150	0.7473
Arellano Bond test for autocorrelation (p-value)	0.9979	0.9220	0.9522	0.2922

Notes: *t* statistics in parentheses; * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level.

Endogenous variable: *SER*, SER^2; Instrumental variables: L.*SER*, L.SER^2, *LnPL*

TABLE 14: PEAK SELF-EMPLOYMENT RATES IN THE INVERTED U RELATIONSHIP BETWEEN ENTREPRENEURSHIP AND GROWTH USING THE 2SLS REGRESSIONS

Contemporaneous		Long-Run		Average
GRSHP	*GVADD*	*GRSHP5*	*GVADD5*	
0.0083	0.0085	0.0085	0.0084	0.0084

Notes: the peak in the case of *GRSHP* is the coefficient of *SER* divided by 2 times the coefficient of SER^2 reported in Regression (1) of Table 13 and the other peaks are similarly calculated.

- All sectors have average self-employment rates below the peak. We infer that on average an increase in entrepreneurship should be associated with an increase in growth.
- The self-employment rate in sector 34 “Scientific & controlling instruments” has self-employment rate at 1.91% in 1983, 1.41% in 1994, 1.89% in 1995, 1.66% in 1996.and 0.98% in 1999.
- E and G have inverted U relationship, but dominant effect is positive: *entrepreneurship effect* dominates *production effect*

FIGURE 2: SELF EMPLOYMENT RATE AND OUTPUT GROWTH IN HIGH-TECH MANUFACTURING AND NON HIGH-TECH MANUFACTURING, 1983-1999

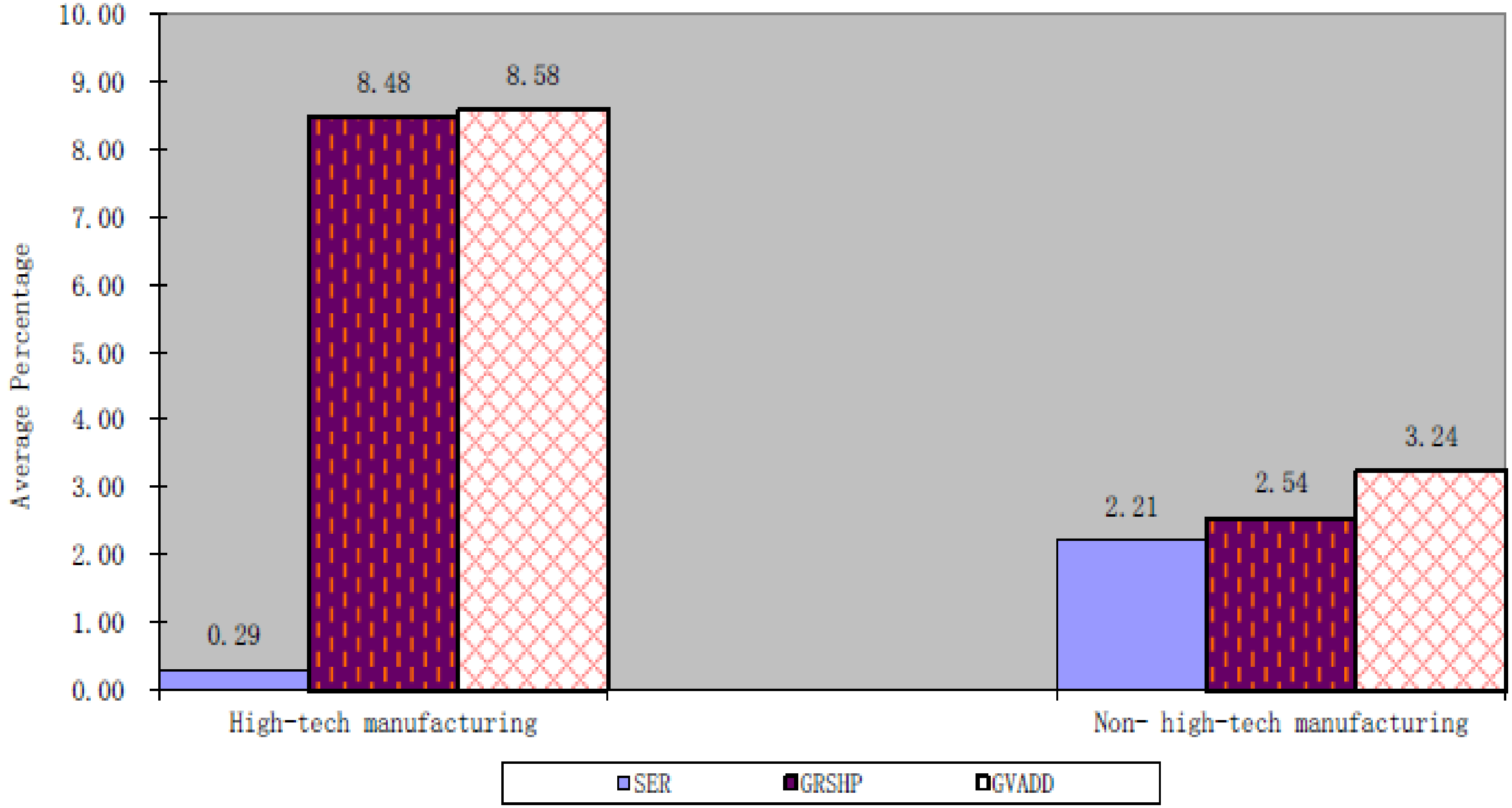
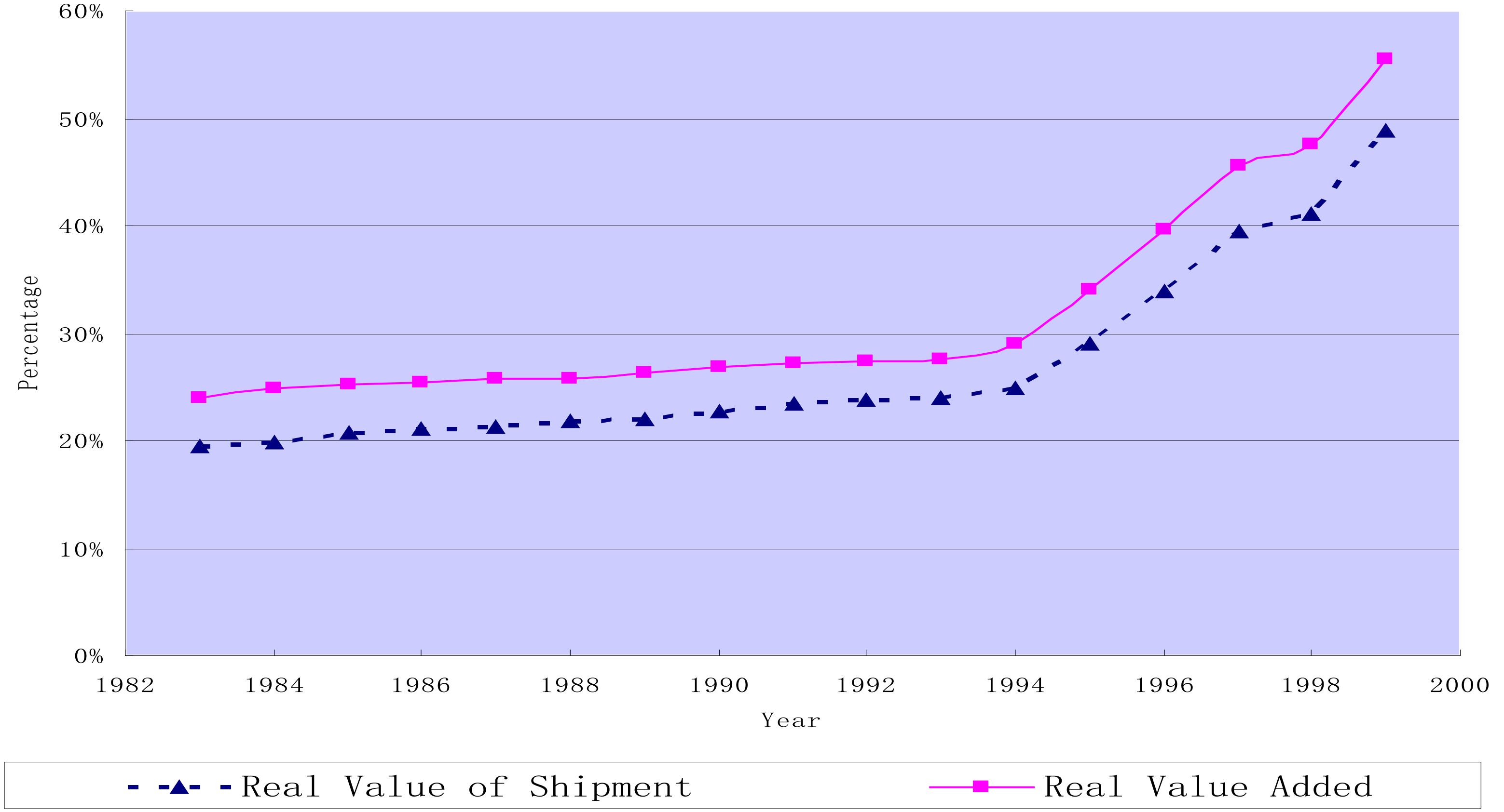


FIGURE 1: HIGH-TECH MANUFACTURING OUTPUT AS A PRECENTAGE OF ALL MANUFACTURING OUTPUT, 1983-1999



Empirical Strategy (Cont.)

- Testing Entrepreneurship Spillover Effects

$$G_{it} = \gamma_0 + \gamma_1 L.Hightech\_SER_t + \gamma_2 SER_{it} + + \gamma_3 \ln KL_{it} + \gamma_4 D_{95-99} + u_i + \varepsilon_{it}$$

  - $L.Hightech\_SER_t$: lagged self-employment rate in the high tech manufacturing sectors
  - D_{95-99} :Dummy variable for years after 1994 (Figure 1)
  - Estimation:
    - OLS
    - 2SLS (Endogenous var: SER; IV: L.SER and L.SER^2)
  - We find there is a spillover effect from high-tech to non high-tech sectors

TABLE 16: OLS& 2SLS REGRESSIONS ASSESSING THE SPILLOVER EFFECTS. DEPENDENT VARIABLE: OUTPUT GROWTH OF NON HIGH-TECH MANUFACTURING SECTORS

	(1)	(2)	(3)	(4)
	GVADD	***GRSHP***	***GVADD***	***GRSHP***
	OLS	**OLS**	**2SLS**	**2SLS**
L.Hightech _ SER	6.9339**	4.1338*	7.3996**	3.0369
	(2.1220)	(1.8866)	(1.9720)	(1.1774)
SER	-0.1424	-0.3583***	-0.7703	0.6455
	(-0.7093)	(-2.6620)	(-0.3937)	-0.4799
LnKL	0.0176	0.0126	0.0047	0.0138
	(0.8956)	(0.9561)	(0.2164)	(0.9218)
D_{95-99}	-0.0128**	-0.0075*	-0.0106	-0.0083*
	(-2.0148)	(-1.7736)	(-1.5358)	(-1.7537)
Sector Dummies	YES	YES	YES	YES
Constant	0.0675***	0.0300**	0.0690***	0.0321**
	(3.2306)	(2.1417)	(3.0800)	(2.0854)
Observations	961	961	943	943
Basmann test (p-value)			0.1823	0.1938

Notes: *t* statistics in parentheses; * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level.
In columns (3) and (4), endogenous variable: *SER;* Instrumental variables: L.*SER* and L.SER^2

Conclusion

- Identified inverted U relationship between E and G theoretically and empirically
- Proposed two competing mechanisms:
  - Entrepreneurship effect (positive)
  - Production effect (negative)
- Positive effect dominates empirically
- There are spillovers of entrepreneurship across industries.
- Future research
  - Theory: study impact of G on E, not just E on G
  - Empirics:
    - Better measures of E
    - Estimate inter-relationship between E and G

Thank you!

Appendix

- Following grow at rate *g* along BGP:
  - Number of innovations, R&D investment, research firm size, final goods output, wage paid worker, entrepreneurial income
- Following constant along BGP:
  - Payoff per innovation, threshold skill level (no. of E), intermediate goods output

TABLE 2: SIC INDUSTRY CODES FOR HIGH-TECH U.S. MANUFACTURING SECTORS, EXACT BUREAU OF LABOR STATISTICS (BLS) DESCRIPTIONS, AND BLS SECTOR NUMBERS

SIC Industry Codes	BLS Description	BLS Sector
281&286	Industrial & misc chemicals	65
283	Drugs	61
357	Computers & related equipment; Office & accounting machines	22&23
366	Radio, TV, & communication equipment	26
367	Elect mach, equip & suppl,n.e.c.,not spec	27
372	Aircraft & parts	29
376	Guided missiles, space vehicles, & parts	32
381&382	Scientific & controlling instruments	34

Source: unpublished reports from the U.S. Bureau of Labor Statistics (BLS).

TABLE 11: TESTS CONCERNING THE ENDOGENEITY OF *SER* AND SER^2 IN THE GROWTH REGRESSIONS, ESTIMATED BY OLS

	(1)	(2)	(3)	(4)
	GRSHP	*GVADD*	*GRSHP5*	*GVADD5*
SER	81.8046***	86.9886***	0.8272***	0.5457***
	(5.2881)	(4.2413)	(6.4344)	(2.8940)
SER^2	-5074.7369***	-5259.2381***	-49.6985***	-33.5782***
	(-5.6981)	(-4.4540)	(-6.7147)	(-3.0933)
LnKL	-0.1075**	-0.0316	-0.0006*	-0.0004
	(-2.4384)	(-0.5401)	(-1.7652)	(-0.8365)
SER_RES	-82.9648***	-82.3454***	-0.8398***	-0.6040***
	(-5.2779)	(-3.9511)	(-6.4286)	(-3.1524)
SER^2*_RES*	5228.3472***	5103.3480***	48.7368***	34.2904***
	(5.7476)	(4.2314)	(6.4468)	(3.0928)
Year Dummies	Yes	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes	Yes
Constant	0.6296**	0.2124	0.0033	0.0025
	(2.3397)	(0.5954)	(1.4772)	(0.7510)
Observations	121	121	121	121
F-test statistics (H_0: *SER*_res= SER^2_res=0)	16.62***	8.96***	21.31***	5.03***

Notes: *t* statistics in parentheses; * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level. *SER_RES* and SER^2*_RES* are the residuals obtained from the OLS regressions of the self-employment rate *SER* and SER^2 on all exogenous variables.

TABLE 12: REDUCED FORM REGRESSIONS OF *SER* AND SER^2 (THE FIRST STAGE)

	(1)	(2)
	SER	SER^2
L.SER	0.1631	0.0011
	(0.8030)	(0.2814)
$L.\ SER^2$	19.6068*	0.4267*
	(1.6855)	(1.9600)
LnPL	0.0010	-0.0000
	(1.1691)	(-0.3952)
LnKL	0.0004	-0.0000
	(0.2313)	(-0.0762)
Year Dummies	YES	YES
Sector Dummies	YES	YES
Constant	-0.0051	0.0000
	(-0.4910)	(0.2232)
Observations	121	121
Adj. R^2	0.518	0.401
F-test (H_0: *L.SER*=L. SER^2=LnPL=0)	10.66***	10.04***

Notes: *t* statistics in parentheses; * = significant at the 10% level; ** = significant at the 5% level; *** = significant at the 1% level.

- Testing for Coefficient Heterogeneity
  - Interact SER and SER^2 with sector dummies
  - Instruments for interaction terms: interact *L.SER*, *L.SER^2* and *lnPL* with sector dummies.
  - No evidence suggesting the growth-maximizing SER varies across sectors

TABLE 3: SUMMARY STATISTICS OF KEY VARIABLES

Variable	Mean	Std Dev	Min	Max	Obs
SER	0.0029	0.0034	0	0.0191	136
GRSHP	0.0848	0.1110	-0.0543	0.5637	136
GVADD	0.0858	0.1225	-0.1344	0.5792	136

Notes: *SER* is the self-employment rate, obtained from the U.S. Bureau of Labor Statistics (BLS); *GRSHP* is the growth rate in the real value of shipments per employee; *GVADD* is the growth rate in the real value of value added per employee, both obtained from the NBER-CES database.

TABLE 5: MEANS OF KEY VARIABLES BY YEAR

Year	*SER*	*GRSHP*	*GVADD*
1983	0.0015	0.0583	0.0550
1984	0.0020	0.0685	0.0888
1985	0.0030	0.0592	0.0248
1986	0.0022	0.0540	0.0619
1987	0.0011	0.0859	0.1238
1988	0.0012	0.0558	0.0402
1989	0.0021	0.0249	0.0319
1990	0.0026	0.0710	0.0470
1991	0.0026	0.0618	0.0319
1992	0.0023	0.0918	0.0972
1993	0.0060	0.0626	0.0819
1994	0.0036	0.1038	0.1287
1995	0.0045	0.1511	0.1307
1996	0.0043	0.1235	0.1030
1997	0.0026	0.1558	0.1630
1998	0.0041	0.0413	0.0820
1999	0.0036	0.1717	0.1667
Average	0.0029	0.0848	0.0858

TABLE 6: MEANS OF KEY VARIABLES BY YEAR FOR THE ENTIRE U.S. MANUFACTURING SECTOR

Year	*SER*	*GRSHP*	*GVADD*
1983	0.0184	0.0477	0.0673
1984	0.0179	0.0555	0.0573
1985	0.0177	0.0311	0.0239
1986	0.0172	0.0317	0.0545
1987	0.0184	0.0418	0.0743
1988	0.0198	0.0184	0.0163
1989	0.0183	0.0170	0.0094
1990	0.0208	0.0094	-0.0035
1991	0.0195	0.0087	0.0074
1992	0.0203	0.0374	0.0620
1993	0.0207	0.0343	0.0369
1994	0.0270	0.0408	0.0524
1995	0.0244	0.0192	0.0069
1996	0.0230	0.0368	0.0342
1997	0.0198	0.0662	0.0854
1998	0.0257	0.0242	0.0316
1999	0.0242	0.0357	0.0410
Average	0.0208	0.0327	0.0387

TABLE 7: HIGH-TECH MANUFACTURING OUTPUT AS A PRECENTAGE OF ALL MANUFACTURING OUTPUT, 1983-1999

Year	Real Value Added	Real Value of Shipment
1983	24.0%	19.5%
1984	24.8%	19.9%
1985	25.3%	20.7%
1986	25.4%	21.2%
1987	25.7%	21.3%
1988	25.9%	21.8%
1989	26.3%	22.0%
1990	26.9%	22.8%
1991	27.2%	23.5%
1992	27.3%	23.9%
1993	27.5%	23.9%
1994	29.0%	24.9%
1995	34.1%	29.0%
1996	39.6%	34.0%
1997	45.7%	39.4%
1998	47.6%	41.0%
1999	55.5%	48.8%
Average	**31.6%**	**26.9%**