R&D Subsidy and Import Substitution: Growing in the Shadow of Protection

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Question

- Most countries have large R&D subsidy programs
- Policymakers use R&D subsidies to stimulate firms to upgrade technology:
  - ⋆ Developing countries
  - ⋆ EU's Structural Funds
- **Question**:
  - ⋆ How an innovation subsidy in a developing country affects innovation and firm growth?

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Brazilian R&D Subsidy Program

Setting

- running for over 20 years
- 72 billion dollars

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Imitation

- biosimilar version of filgrastim, i.e., small patentable change in the compound
- previously imported from US and Europe

Main Result

Figure: It Made to the News!

Filgrastim biosimilar is first Latin copy biologic, says Brazil

By **Fiona BARRY**
24-Nov-2015 - Last updated on 12-Jul-2017 at 09:03 GMT

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Eurofarma is working under a PDP supply agreement with the Brazilian government

RELATED TAGS United States

Brazilian company Eurofarma claims it has developed Latin America's first home-grown biosimilar.

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Comparative Advantage

- 14% import tariff in imports of filgrastim

Methodology and Main Results

- **Identification Strategy**:
  - ⋆ Diff-in-diff comparing near-winners to near-losers of R&D subsidy application (Hirvonen et al. (2022), Choi and Levchenko (2021))

- **Results**:
  1. increase low-quality innovation
  2. large and persistent increases in growth
  3. expansion towards high-import tariff markets
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Data and Facts

Data

Firm's Labor Outcome:

⋆ employer-employee dataset RAIS

Exports and Imports:

⋆ panel customs record at the firm-destination-product level

Innovation:

⋆ Intellectual property applications to the Brazilian Patent Office

⋆ Citations from PATSTAT

Innovation Subsidy:

⋆ Applications for innovation subsidy

R&D Subsidy is 10 Times Yearly Wage Bill

Table: Statistics on R&D Subsidy

	(1) Subsidy Applicants			(2) All Brazilian Firms		
	Mean	Median	SD	Mean	Median	SD
Workers	536	70	1970	15	3	136
Avg. Wage	2076	1593	1675	712	579	617
Avg. Yrs. Educ.	10.51	10.41	2.36	9.03	9	2.76
N. Establishment	4.04	1	16.94	1.29	1	4.73
Stock N. Patents	.197	0	1.36	.001	0	.069
At Least One Patent	.072	0	.25	.0003	0	.019

R&D Subsidy Targets Manufacturing Sector

Figure: Subsidy Application by Sector

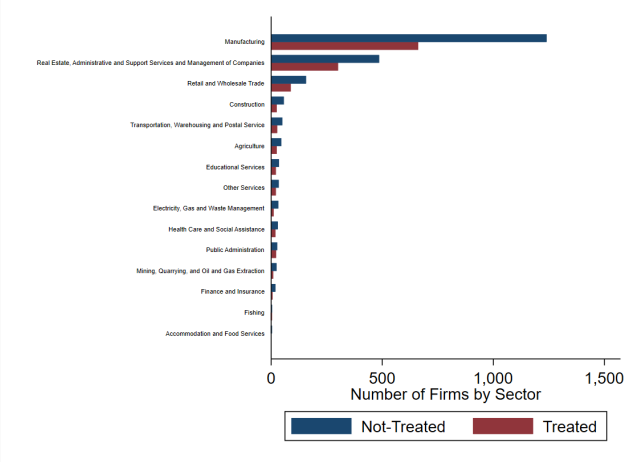

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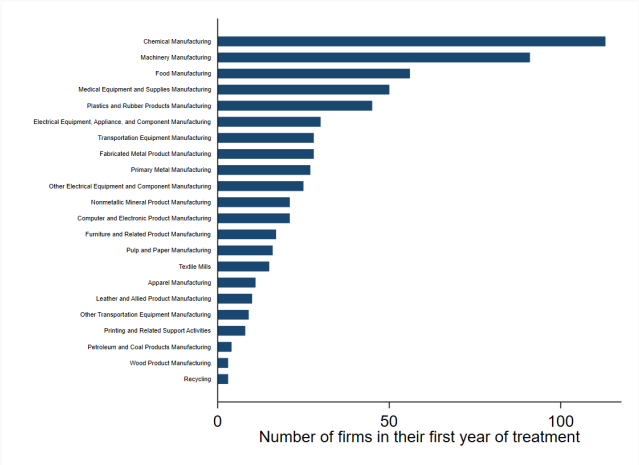
Figure: Subsidy Application in Manufacturing



Institutions

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- **Call for Projects**:
  - ⋆ The *Funding Authority for Studies and Projects* opens thematic call for projects
  - ⋆ Sectoral funds pre-determined by law, avoiding political interference
  - ⋆ Subsidy types: grants or subsidized lending
- **Selection Criteria**:
  - ⋆ Firms are scored by a board of anonymous technicians
  - ⋆ Criteria: degree of inventiveness, quality of the research team, and financial viability
- **Enforcement**:
  - ⋆ Tight enforcement: joint bank account, multiple installments, reports, and fines

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Empirics

Matching

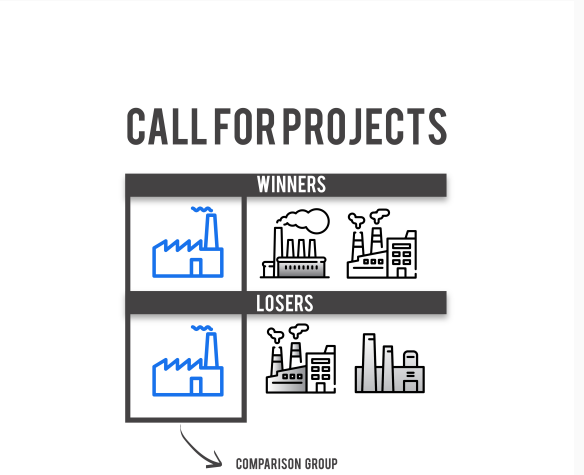
- **Matched Differences in Difference**:
  - ⋆ compare near losers to near winners in same call

- For each firm j that received the subsidy, find another firm i such that:
  1. j and i applied for the same call for project
  2. j received the subsidy but i didn't
  3. same number of employees & value requested (technical development)
  4. same number number of citations & number of patents (quality of the research)

- Robustness: text similarity, CEO wage, wage of scientists, text complexity of project

Matching: Intuition

Figure: Matching



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Empirical Model

- **Main empirical model**:

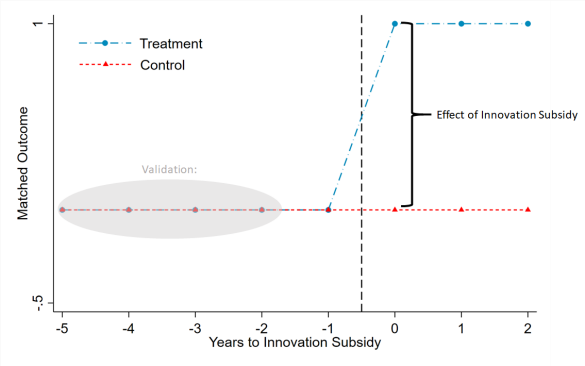
$$y_{i,t} = \theta \mathbb{I}_{i,t} \{Innovation\ Subsidy\} + \mu_i + \mu_{g(i),t} + \epsilon_{i,t} \tag{1}$$

where

  - ⋆ $y_{i,t}$: outcome of firm i in year t
  - ⋆ $\mathbb{I}_{i,t} \{Innovation\ Subsidy\}$: dummy after firm receive innovation
  - ⋆ μ_i: firm fixed effect
  - ⋆ $\mu_{g(i),t}$: time-year fixed effect

Identifying Variation: Intuition

Figure: Identifying Variation



Empirics: Validation

i. **Concern**: *treatment and control group are not comparable*

i. **Validation**:

   ⋆ parallel trends

   ⋆ treatment and control are similar even in non-matched variables

ii. **Concern**: *political intervention*

ii. **Validation**:

   ⋆ R&D subsidy does not correlate with campaign contribution or other subsidies

iii. **Concern**: *correlation with shocks*

iii. **Validation**:

   ⋆ placebo test

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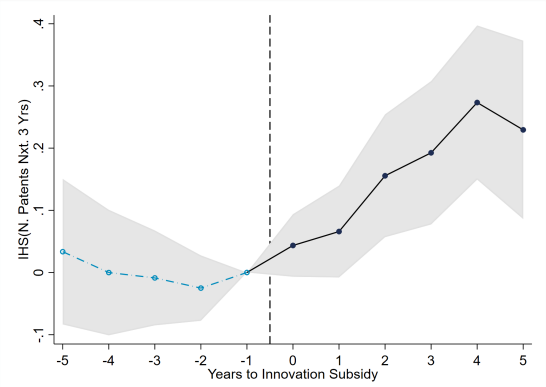
Results

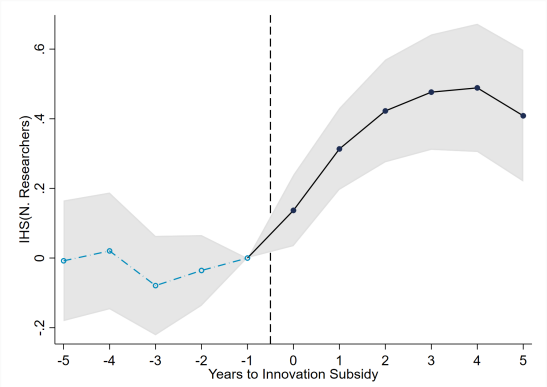
Effect on Innovation: Increase in Low-Quality Innovation

Figure: Effect of Innovation Subsidy on Innovation

(a) Number of Patents in the Next Three Years



(b) Number of Scientists



Effect on Innovation: Increase in Innovation Effort

Table: Innovation Subsidy and Innovation Effort

	(1) $\mathbb{IHS}(N.\ Patent)$	(2) $\mathbb{I}(Patent)$	(3) $\mathbb{IHS}(N.\ Scientists)$	(4) $\mathbb{I}(N.\ Scientists)$	(5) $\mathbb{IHS}(N.\ Ph.D.)$	(6) $\mathbb{IHS}(N.\ Trademarks)$
$\mathbb{I}\{Subsidy\}$	0.105**	0.0659**	0.364***	0.115***	0.109**	0.169*
	(0.0477)	(0.0256)	(0.0929)	(0.0357)	(0.0539)	(0.0877)
N	11403	11403	11403	11403	11403	11403
R^2	0.624	0.526	0.811	0.551	0.859	0.670

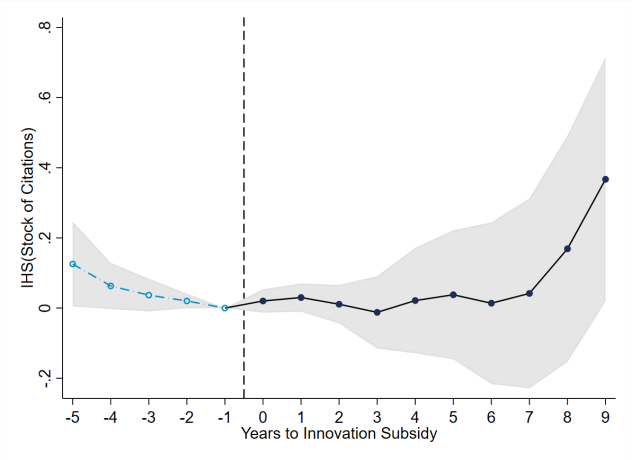
Effect on Innovation: Increase in Low-Quality Innovation

Table: Effect of Innovation Subsidy on Quality Weighted Patents

	(1)	(2)	(3)	(4)
	$\mathbb{IHS}$(*Citations*)	$\mathbb{IHS}$(*Citation Weighted Patents*)	$\mathbb{IHS}$(*Inventor Wage Weighted Patents*)	$\mathbb{IHS}$(*Inventor Educ. Weighted Patents*)
$\mathbb{I}\{Subsidy\}$	0.000374	0.00161	0.148	0.0895
	(0.0258)	(0.00158)	(0.149)	(0.0844)
N	11403	11403	11403	11403
R^2	0.131	0.120	0.449	0.459

Effect on Innovation: Weak Evidence for Leaning in the Long-Run

Figure: Effect of Innovation Subsidy on Stock of Citations

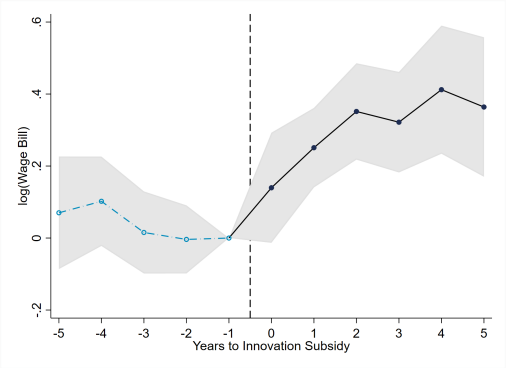


Results

1. **Effect on Innovation**: Increase in Low-Quality Innovation
2. **Effect on Firm Dynamics**: Large and Persistent Increases in Growth
3. **Effect on Product Lines**: Expansion Towards High-Import Tariff Markets
4. **Effect on Trade**: Selling to Developing Countries Ideas from Developed Countries
5. **No Spillover or Product Market Rivalry**

Effect on Firm Dynamics: Large Increases in Growth

Figure: Effect of Innovation Subsidy on Wage Bill



Effect on Firm Dynamics: Large Increases in Growth

Table: Effect of the Innovation Subsidy on Firm Size

	(1)	(2)	(3)	(4)	(5)	(6)
	log (*Workers*)	log (*Wage Bill*)	log (*Establishments*)	log (*N. Municipalities*)	$\mathbb{IHS}$ (*Exports*)	$\mathbb{IHS}$ (*Imports*)
$\mathbb{I}\{Subsidy\}$	0.274***	0.269***	0.119**	0.0602**	1.437***	1.141**
	(0.0924)	(0.0960)	(0.0557)	(0.0281)	(0.514)	(0.528)
N	9358	9358	9353	9358	7059	7059
R^2	0.837	0.861	0.834	0.832	0.814	0.740

Effect on Firm Dynamics: Persistent Increase in Growth

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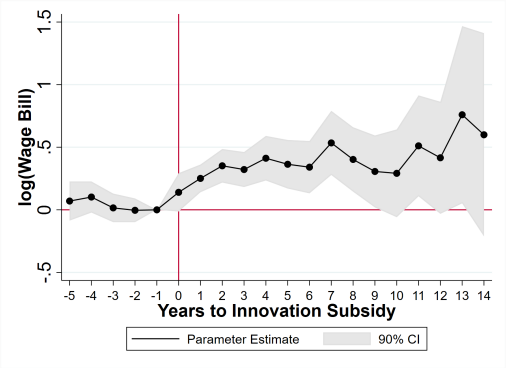
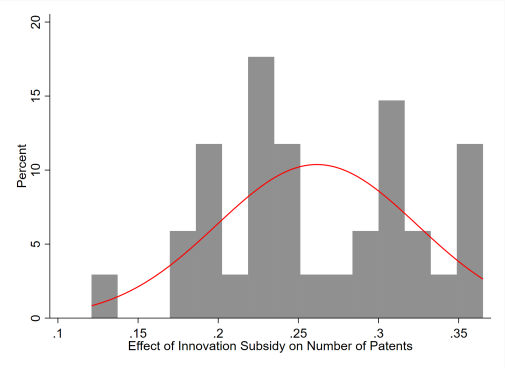


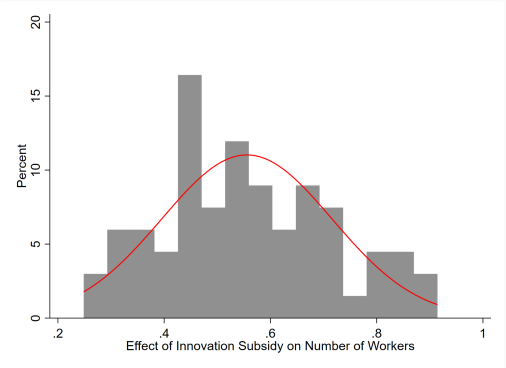
Heterogeneous Treatment Effect: All Firms Had Sizable Employment Gains

Figure: Distribution of Treatment Effects

(a) Number of Patents



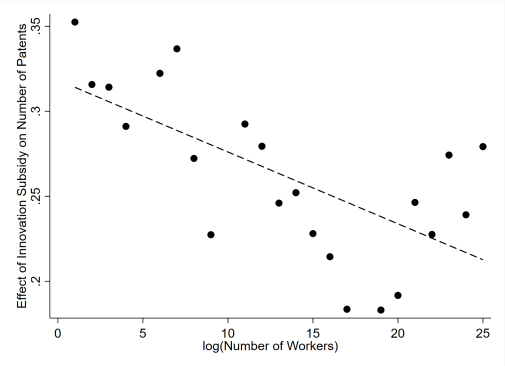
(b) Number of Workers



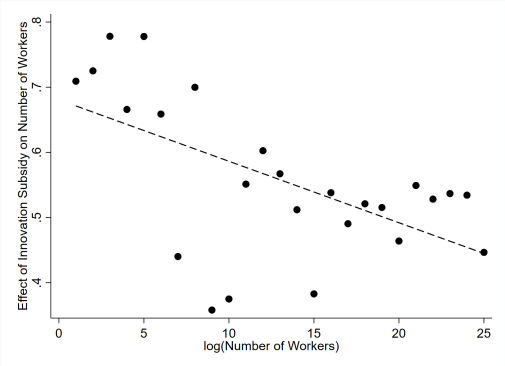
Heterogeneous Treatment Effect: Small Firms Increased by More

Figure: Correlation of Treatment Effect with Initial Employment

(a) Effect on Number of Patents



(b) Effect on Number of Workers



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Firms are Expanding their Product Lines

Table: Effect of Innovation Subsidy on Product Variety

	(1) $\mathbb{IHS}\{Product\ Patent\}$	(2) $\mathbb{IHS}\{Process\ Patent\}$	(3) $\mathbb{IHS}\{\#\ Pat.\ Class\}$	(4) $\mathbb{IHS}\{\#\ Trademark\ Class\}$	(5) $\mathbb{IHS}\{\#\ Export\ Products\}$	(6) $\mathbb{IHS}\{\#\ Import\ Products\}$
$\mathbb{I}\{Subsidy\}$	0.0852*	0.00826	0.148**	0.0737*	0.451***	0.470***
	(0.0453)	(0.0146)	(0.0742)	(0.0428)	(0.111)	(0.137)
N	11403	11403	11403	11403	7059	7059
R^2	0.636	0.383	0.846	0.839	0.853	0.766

Firms are Expanding Towards High-Import Tariff Markets

Table: Effect of Innovation Subsidy on the Direction of Innovation

	(1)	(2)	(3)	(4)	(5)	(6)
	IHS{*N. Patent High Tariff Prod.*}	IHS{*N. Patent Low Tariff Prod.*}	IHS{*Citation to High Tariff Pat.*}	IHS{*Citation to Low Tariff Pat.*}	IHS{*Exp. High Tariff Prod.*}	IHS{*Exp. Low Tariff Prod.*}
$\mathbb{1}\{Subsidy\}$	0.0635***	0.00284	0.0736***	0.0212	1.232**	0.335*
	(0.0239)	(0.0229)	(0.0271)	(0.0300)	(0.493)	(0.201)
N	11403	11403	11403	11403	7059	7059
R^2	0.574	0.711	0.430	0.487	0.822	0.745

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Effect on Trade: Importing Ideas & Inputs f/ Developed Countries

Table: Effect of Innovation Subsidy on Origin of Input Imports and Citation

	(1) $\mathbb{I}\{Imp.\ Mercosur\}$	(2) $\mathbb{I}\{Imp.\ South\ America\}$	(3) $\mathbb{I}\{Imp.\ Europe\}$	(4) $\mathbb{I}\{Imp.\ North\ America\}$	(5) $\mathbb{IHS}\{Citation\ to\ BR\}$	(6) $\mathbb{IHS}\{Citation\ to\ Foreign\}$
$\mathbb{I}\{Subsidy\}$	0.0435	0.0541	0.120***	0.0931**	0.0433*	0.118**
	(0.0366)	(0.0369)	(0.0374)	(0.0403)	(0.0233)	(0.0495)
N	7059	7059	7059	7059	11403	11403
R^2	0.586	0.597	0.670	0.633	0.372	0.440

Effect on Trade: Firms Export to Developing Countries

Table: Effect of Innovation Subsidy on Exports

	(1) $\mathbb{I}\{Exp.\ Mercosur\}$	(2) $\mathbb{I}\{Exp.\ South\ America\}$	(3) $\mathbb{I}\{Exp.\ Europe\}$	(4) $\mathbb{I}\{Exp.\ North\ America\}$
$\mathbb{I}\{Subsidy\}$	0.101***	0.0825**	0.0224	0.0271
	(0.0362)	(0.0365)	(0.0388)	(0.0378)
N	7059	7059	7059	7059
R^2	0.763	0.759	0.685	0.673

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Spillover and Market Rivalry Exposure

- Technological proximity (Bloom et al. (2013)):

$$tech_{i,j} = \frac{\left(T_i T_j'\right)}{(T_i T_i')^{1/2}(T_j T_j')^{1/2}}$$

- Technological exposure to treatment and control:

$$Spilltech_{i,t} = \sum_j spilltech_{i,j} \mathbb{I}_{j,t} \{Treatment\ Applied\ to\ Subsidy\}$$

$$SpilltechControl_{i,t} = \sum_j spilltech_{i,j} \mathbb{I}_{j,t} \{Control\ Applied\ to\ Subsidy\}$$

Spillover and Market Rivalry Exposure

- Product proximity (Bloom et al. (2013)):

$$SIC_{ij} = \frac{\left(S_i S_j'\right)}{\left(S_i S_i'\right)^{1/2}\left(S_j S_j'\right)^{1/2}}$$

- Product exposure to treatment and control:

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$$SpillSICControl_{i,t} = \sum_j SIC_{i,j}\mathbb{I}_{j,t}\left\{Control\ Applied\ to\ Subsidy\right\}$$

Spillover and Market Rivalry Exposure

- Main specification:

$$y_{i,t} = \lambda^{spill} \log(Spilltech_{i,t} + 1) + \lambda^{SIC} \log(SpillSIC_{ij} + 1) + X'_{i,t}\Lambda + \mu_i + \mu_t + \epsilon_{i,t}$$

  where

  - $y_{i,t}$: outcome of firm i in year t
  - $X_{i,t}$: exposure to control applications
  - μ_i: firm fixed effect
  - μ_t: time fixed effect

- Parameters of Interest: λ^{spill} and λ^{SIC}
  - identified from comparing firms more exposed to treatment to those more exposed to control

Spillover and Market Rivalry Exposure

Table: Spillover and Market Rivalry of Innovation Subsidy

	(1)	(2)	(3)	(4)	(5)
	$log(Workers)$	$log(Establishments)$	$log(Wage\ Bill)$	$\mathbb{IHS}(Wage\ Bill\ Scientists)$	$\mathbb{IHS}(Patents)$
$\log(Spilltech_{i,t}+1)$	-0.0157	-0.00485	-0.0149	-0.0408	-0.00389
	(0.0268)	(0.0134)	(0.0284)	(0.0674)	(0.0147)
$\log(SpillSIC_{ij}+1)$	-0.0407	-0.00105	-0.0687	-0.0501	-0.0468*
	(0.0451)	(0.0190)	(0.0482)	(0.120)	(0.0252)
N	85748	85745	85748	85748	85748
R^2	0.916	0.960	0.934	0.800	0.662

Results

1. **Effect on Innovation**: Increase in Low-Quality Innovation
2. **Effect on Firm Dynamics**: Large and Persistent Increases in Growth
3. **Effect on Product Lines**: Expansion Towards High-Import Tariff Markets
4. **Effect on Trade**: Selling to Developing Countries Ideas from Developed Countries
5. **No Spillover or Product Market Rivalry**

Contribution

- Now you know how an innovation subsidy affect laggard firms!
- Innovation subsidy:
  - ⋆ Increase in Low-Quality Innovation.
  - ⋆ Despite that: Large and Persistent Increases in Growth
  - ⋆ Due to: high import tariffs
  - ⋆ By: selling ideas from developed countries to developing countries
  - ⋆ Without affecting other firms

"can I copy your homework?"

"yeah just change it up a bit so it doesn't look obvious you copied"

"ok"