Recombination Paper: Quantitative Results

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Part I: Parameterization

Introduction

- To find the parameters I will present, I basically did a grid search.
- Because the number of parameters is big, having fine grids and searching over every possible combination is not feasible.
- Having this in mind, I first defined very coarse grids that spanned a large interval for each parameter. Having found the points that minimize the distance between the model and the data, I redefine finer grids around those points and search again. I did this 3 times.
- Having said that, I found 2 parameterizations that yield vey similar results.

Table: Model Parameters

Parameter	Interpretation
η^H	New technology quality increase.
η^M	New combination quality increase.
η^L	Reuse/refinement quality increase.
τ	Scale parameter of the new ideas distribution.
λ	Scale parameter of the distribution of costs.
κ	Shape parameter of the distribution of costs.
ξ	Determines the fraction of viable combinations in a pool, $1/\xi$.
γ	Determines the scale of the final goods production function.
ϵ	Determines the elasticity of intertemporal substitution of consumption.
β	Intertemporal discount factor.
I	Number of inventors.
J	Number of firms.

Table: Parameters that do not affect patent type distribution.

variable	value	Moment
η^L	0	Normalized.
γ	0.6	Fits the labor share of GDP
ϵ	2	Taken from Acemoglu, Akcigit, Bloom and Kerr (2013).
β	0.954	$= \frac{1}{1+r}$, with $r = 5\%$.
J	depends on parameterization	chosen to fit average growth rate.

Moments of the Patent Type Distribution

- I used 10 moments to find the rest of the parameters:
  - New technology and new combination fractions in 1850, 1900, 1950 and 2000 (8 moments);
  - Reuse fraction peak value and year that it reaches the peak.

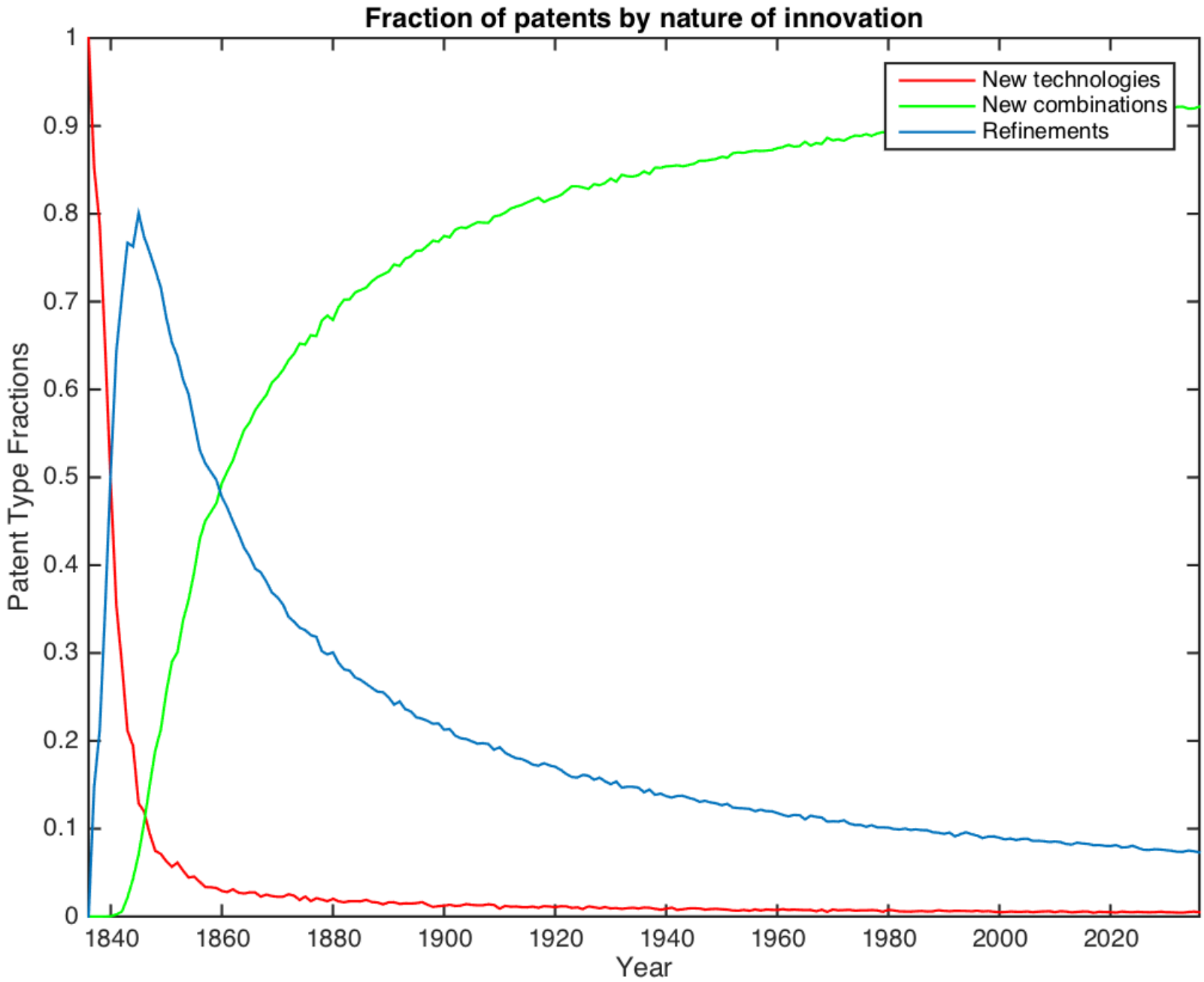
Parameterization 1: does not include I as a parameter

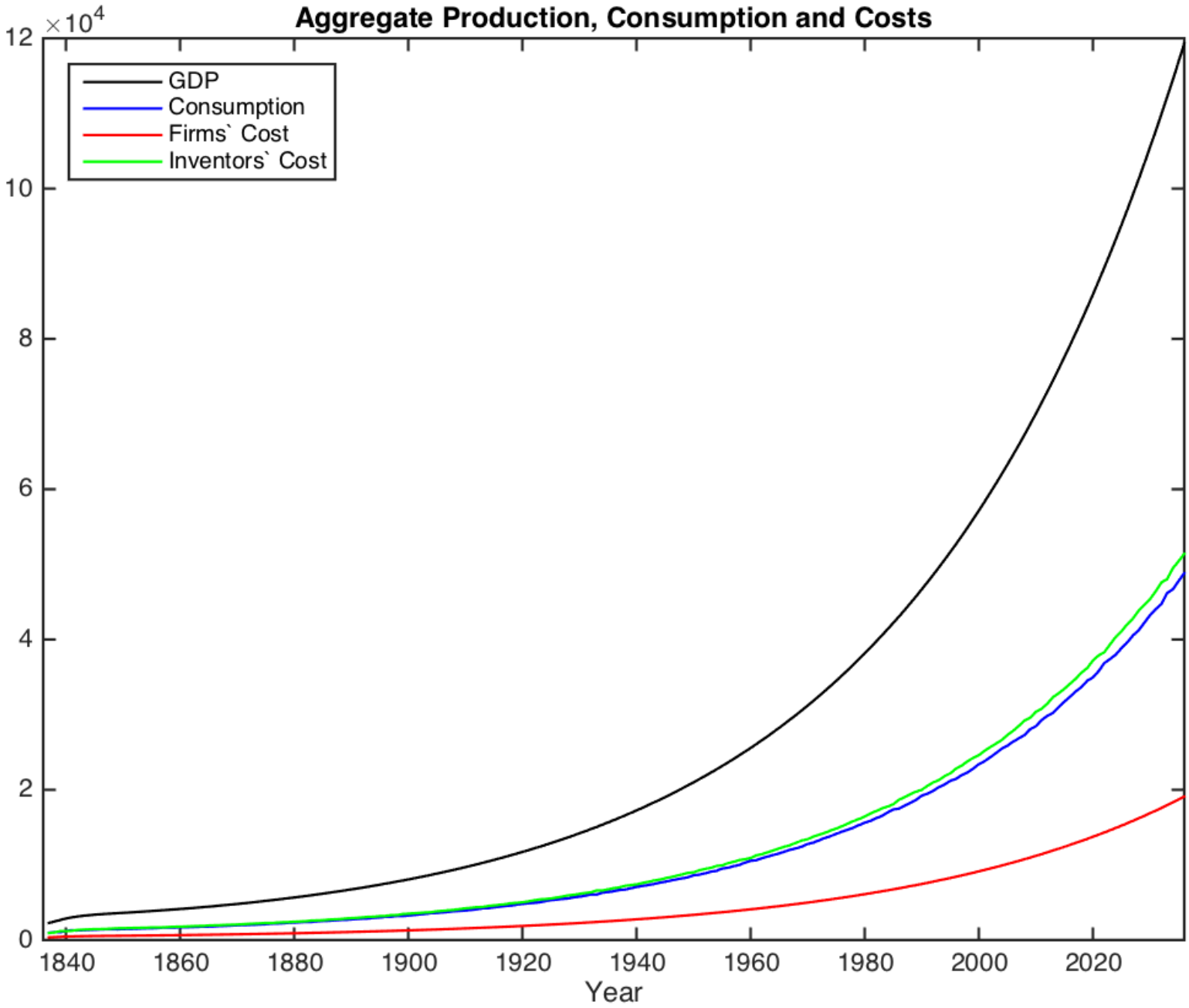
Table: Parameters related to the patent type distribution.

Parameter	Value
η^H	0.2
η^M	0.04
τ	400
λ	2.1
κ	7
ξ	75

and

$$I = 500; \qquad J = 910$$


Fraction of patents by nature of innovation
New technologies
New combinations
Refinements
Patent Type Fractions
Year
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020


Aggregate Production, Consumption and Costs
×10^4
12
10
8
6
4
2
0
GDP
Consumption
Firms` Cost
Inventors` Cost
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020
Year

Parameterization 2: includes I as a parameter

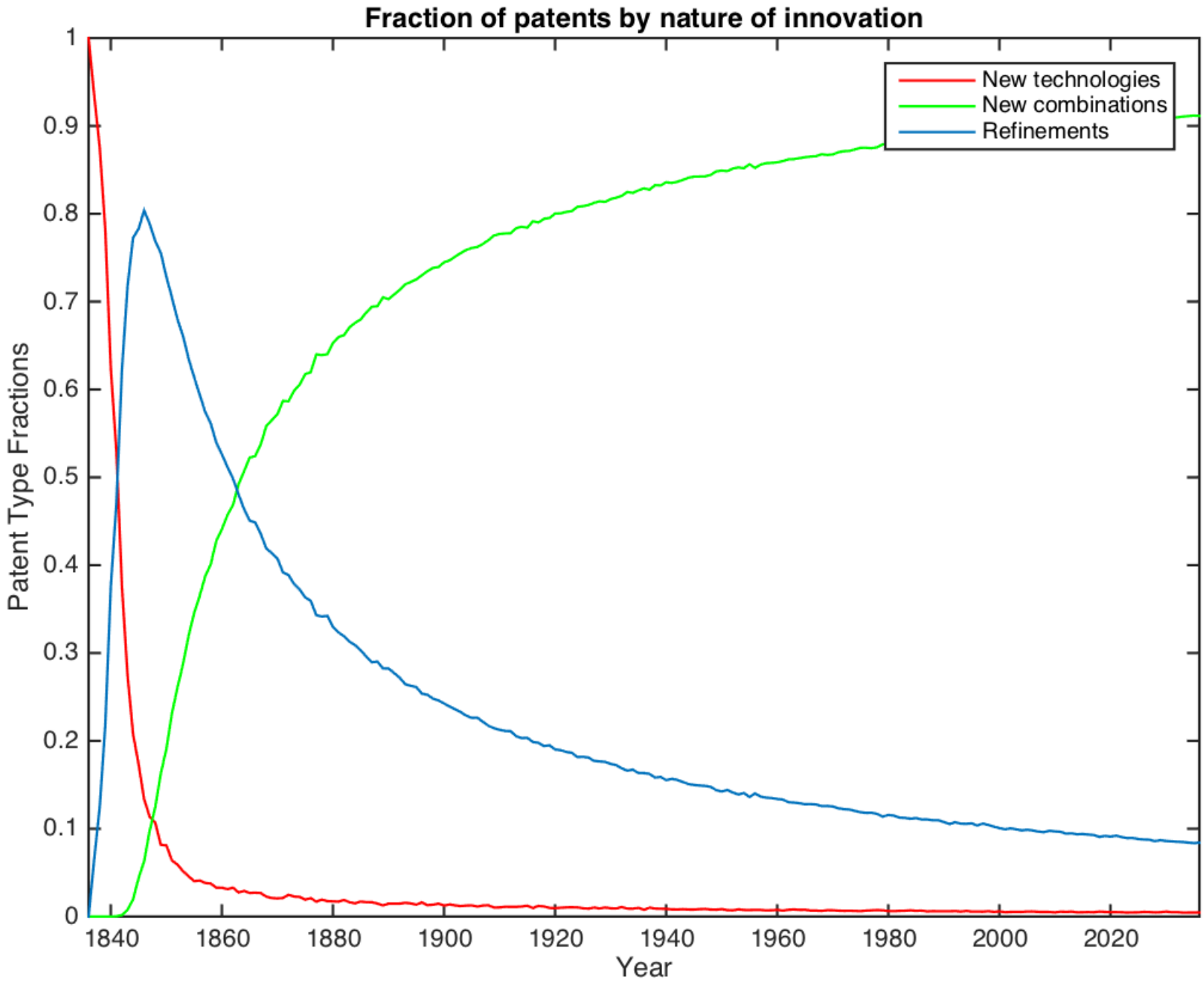
Table: Parameters related to the patent type distribution.

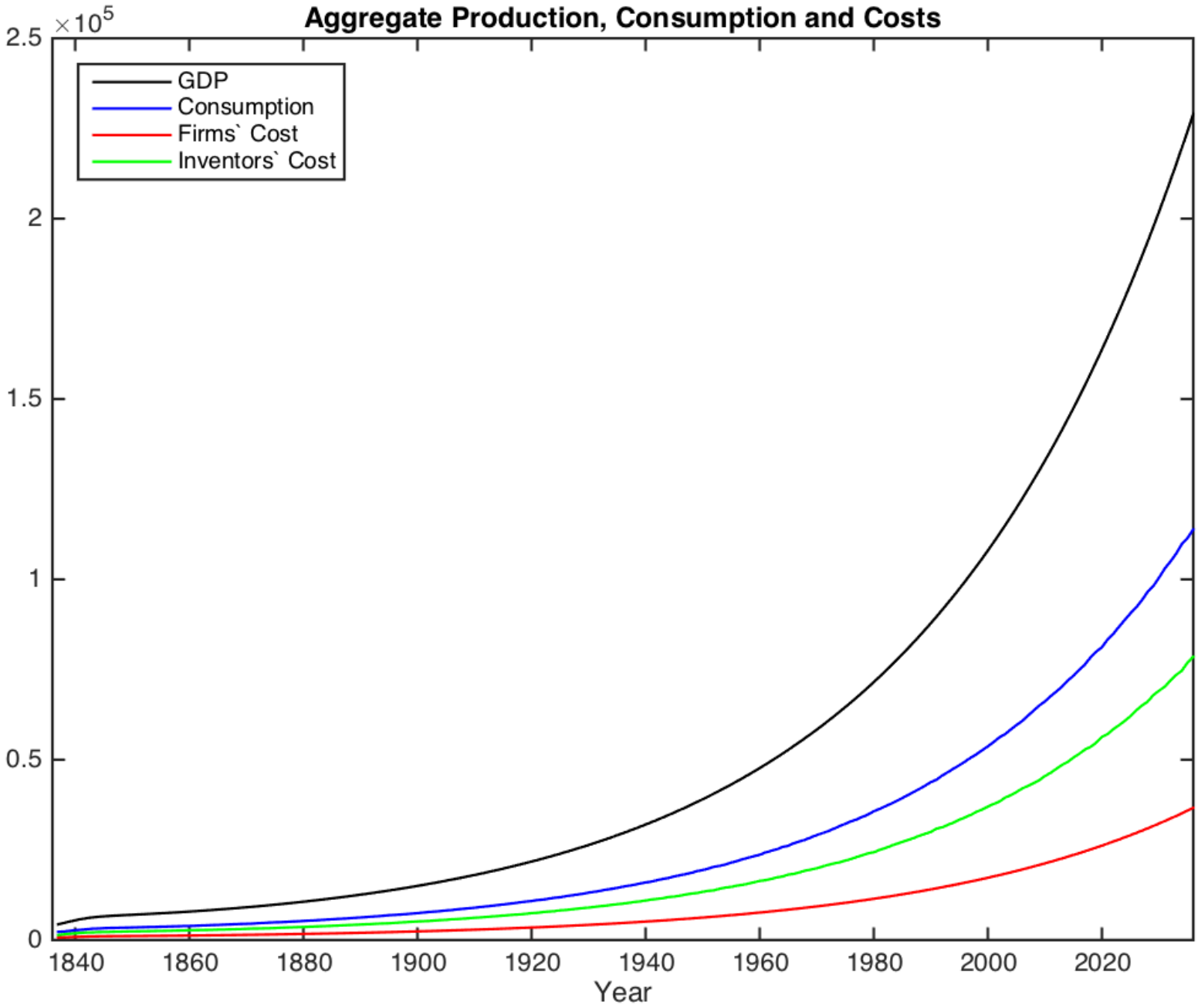
Parameter	Value
η^H	0.2
η^M	0.05
τ	800
λ	2
κ	7
ξ	150
I	800

and

$$J = 1750$$

- I will use this version to compute the counterfactuals.

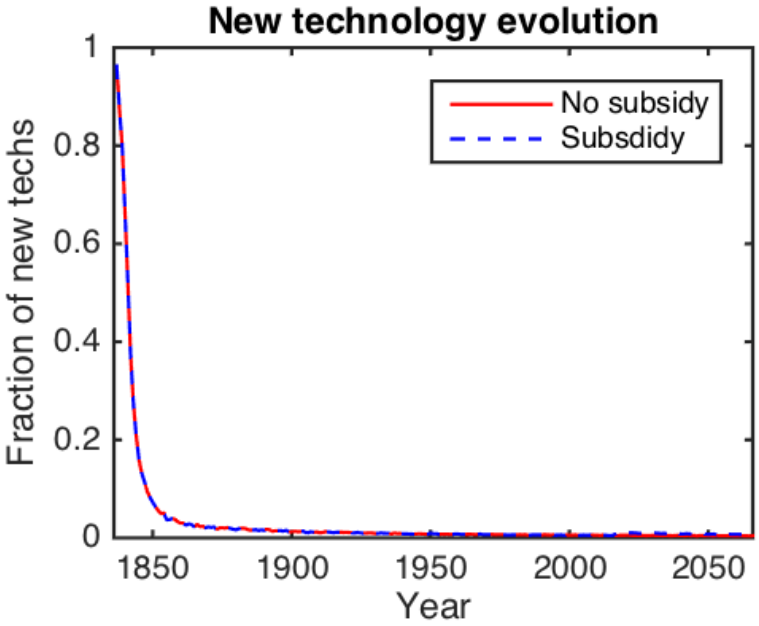

Fraction of patents by nature of innovation
New technologies
New combinations
Refinements
Patent Type Fractions
Year
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020

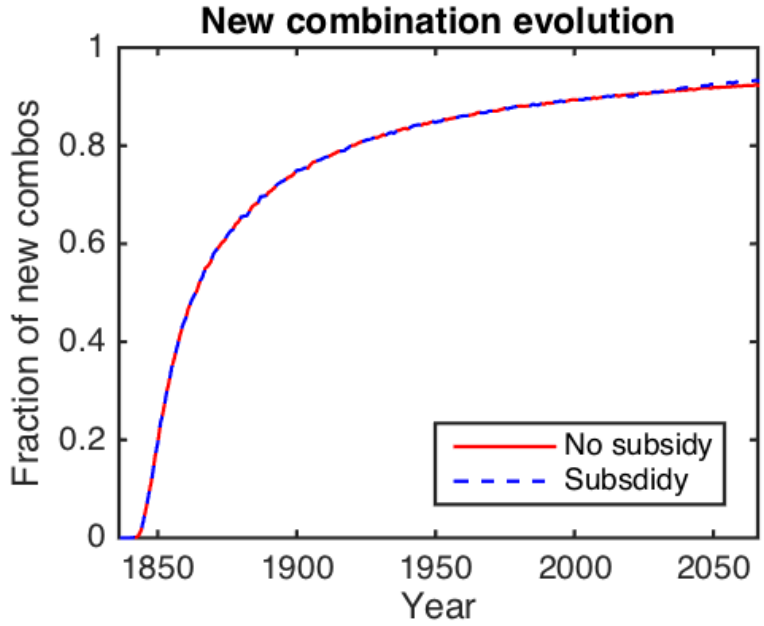

Aggregate Production, Consumption and Costs
×10^5
2.5
2
1.5
1
0.5
0
GDP
Consumption
Firms` Cost
Inventors` Cost
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020
Year

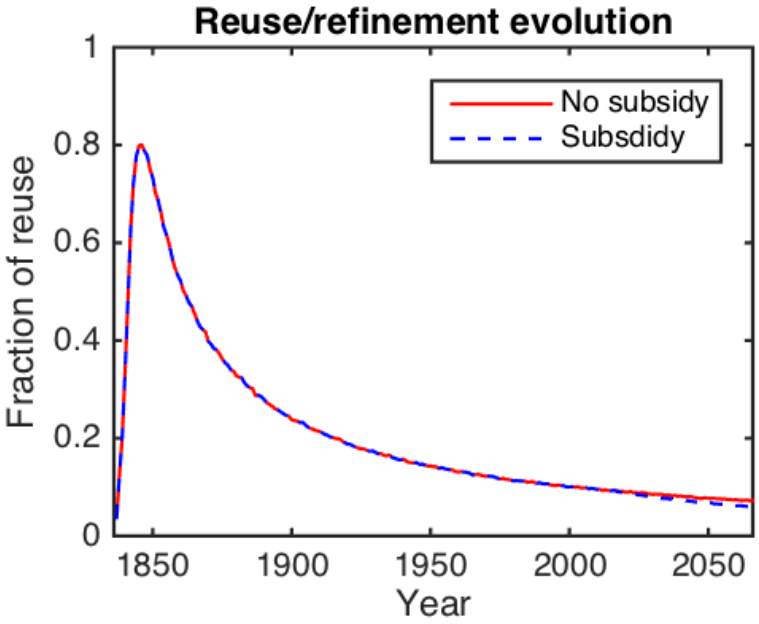
Part II: Counterfactuals

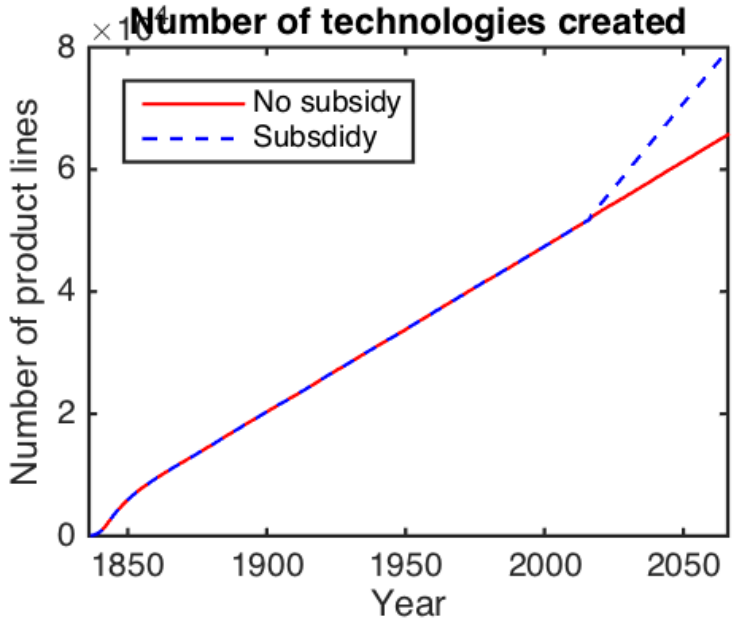
Introduction

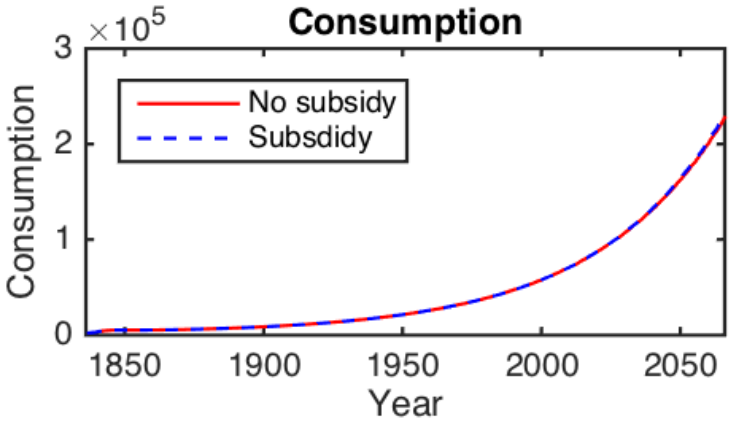
- The counterfactual here is a subsidy on patent creation.
- I will consider a subsidy for new technology patents only, new combination patents only and both.
- I will also alter the duration of the subsidy, lasting for 50 or 100 years.

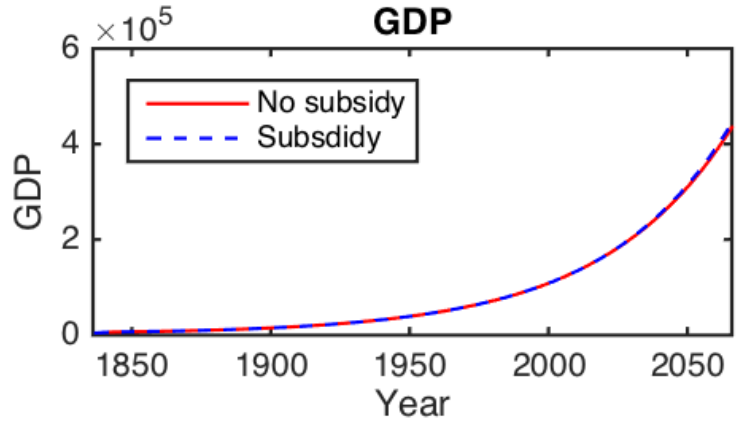

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

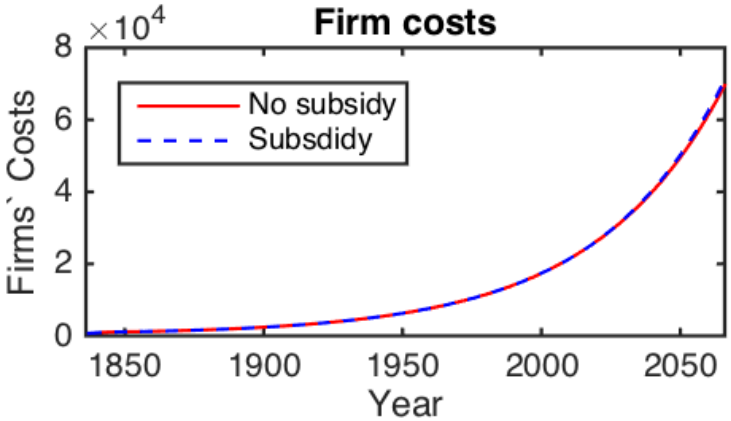

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

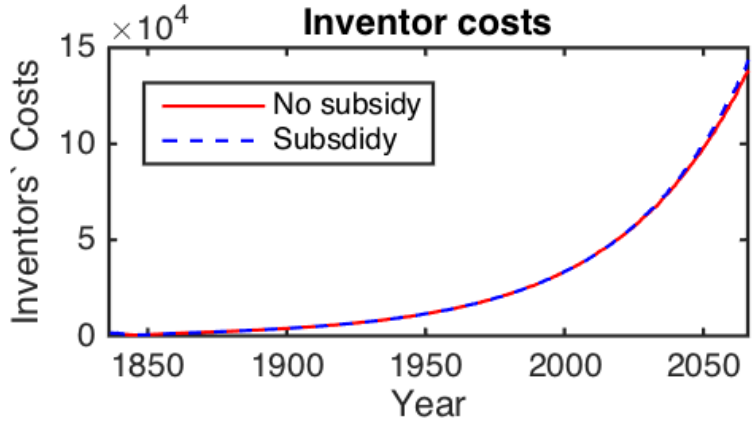

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

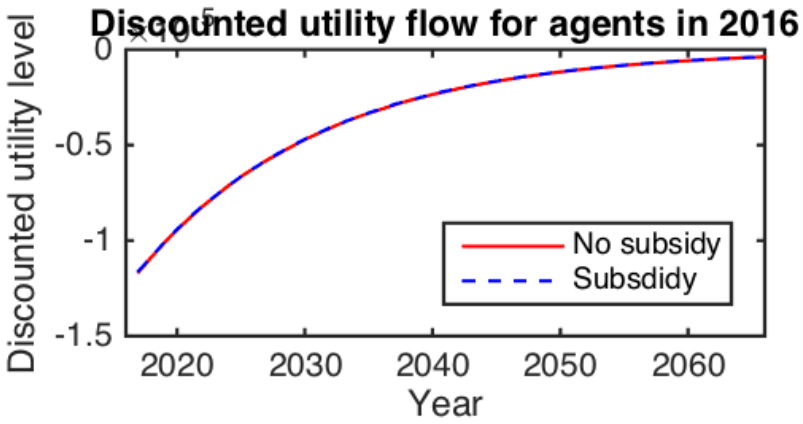

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
2
4
6
8
1850
1900
1950
2000
2050

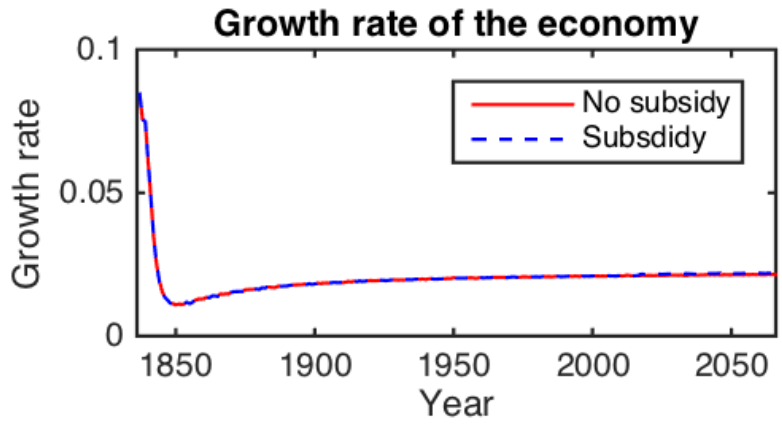

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy
0
1
2
3
1850
1900
1950
2000
2050


GDP
×10^5
GDP
Year
No subsidy
Subsdidy
0
2
4
6
1850
1900
1950
2000
2050

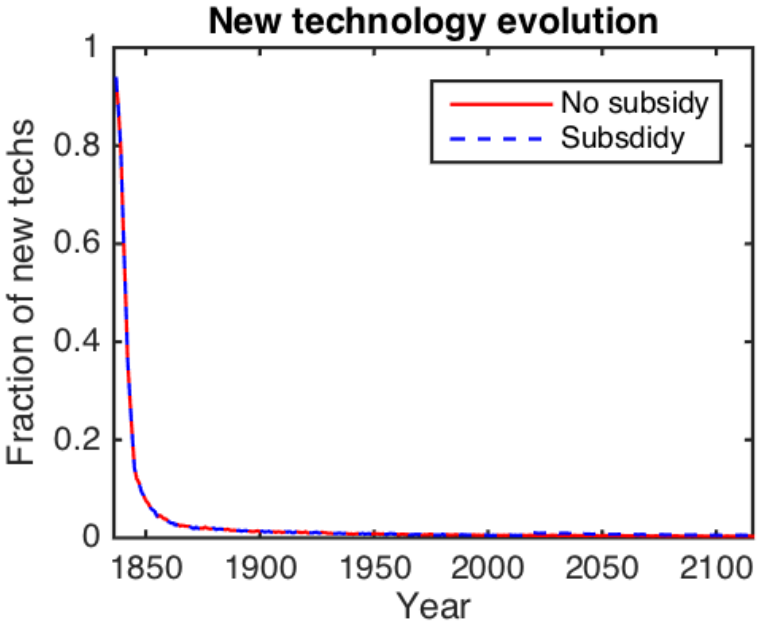

Firm costs
×10^4
Firms` Costs
Year
No subsidy
Subsdidy
0
2
4
6
8
1850
1900
1950
2000
2050

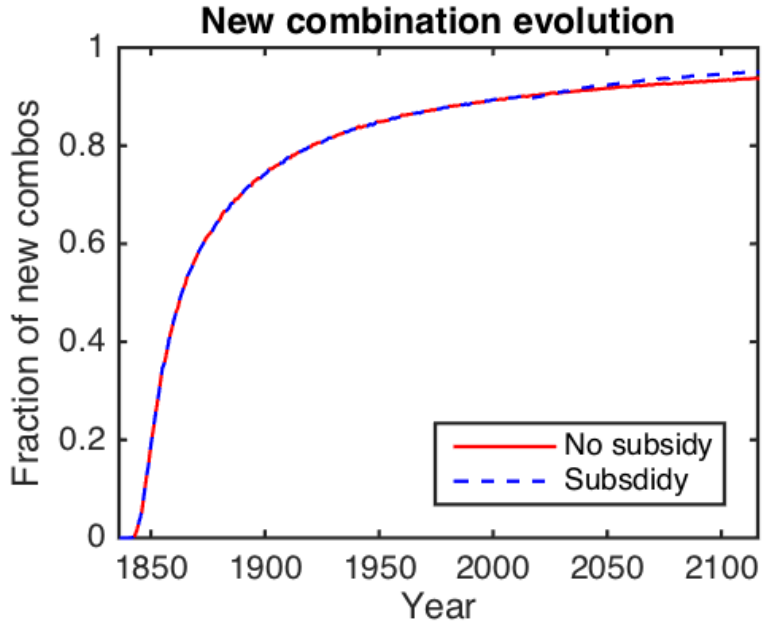

Inventor costs
×10^4
Inventors` Costs
Year
No subsidy
Subsdidy
0
5
10
15
1850
1900
1950
2000
2050

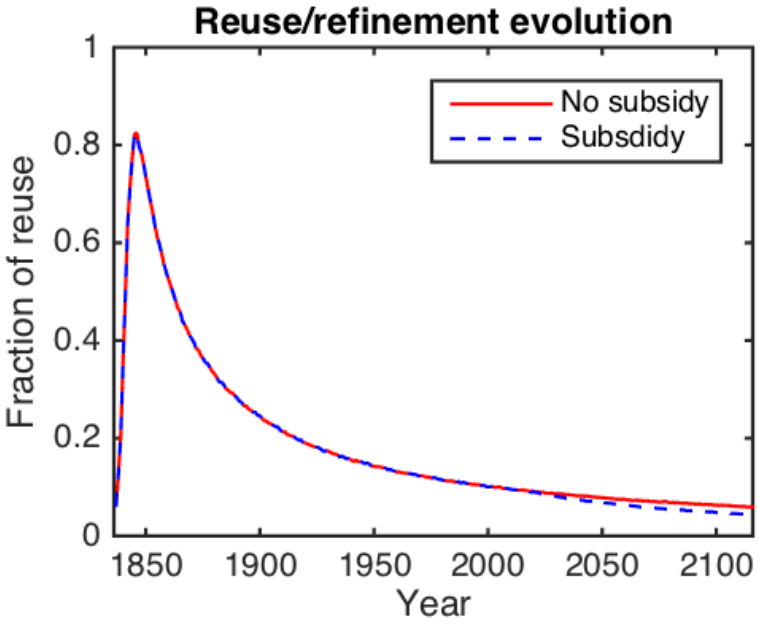

Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy
-1.5
-1
-0.5
0
2020
2030
2040
2050
2060

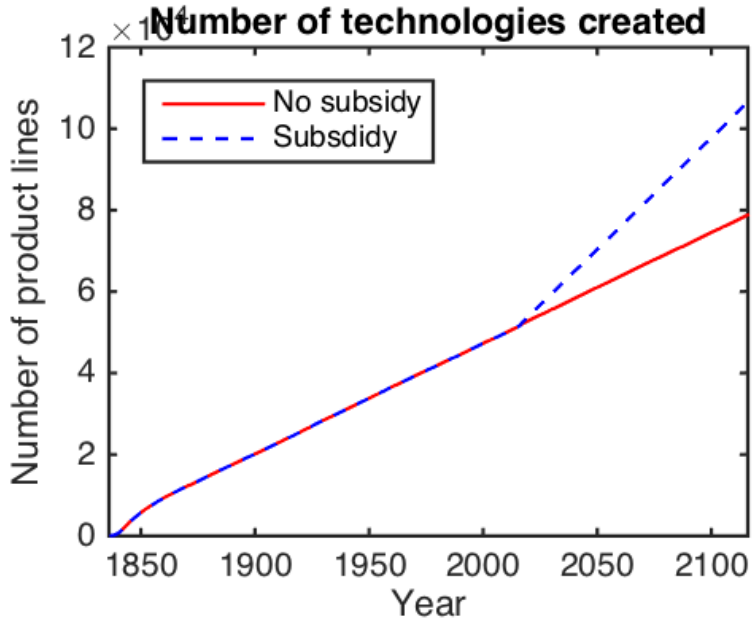

Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy
0
0.05
0.1
1850
1900
1950
2000
2050

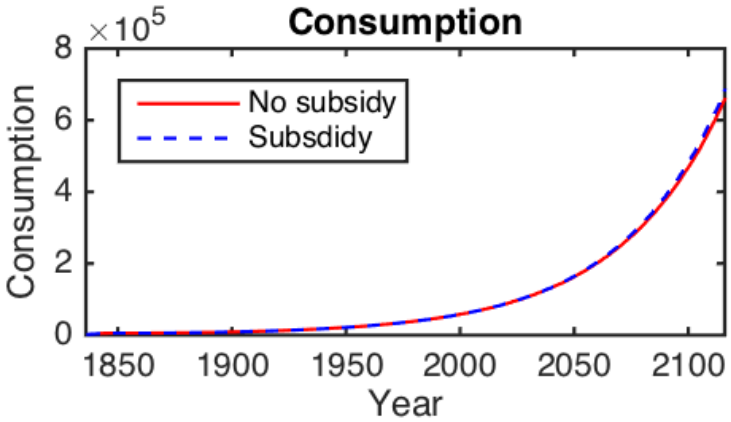
	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00016789	-0.00016727	0.0036889
# technologies	65679	79604	0.21202
Average GDP growth	0.021321	0.021753	0.020279

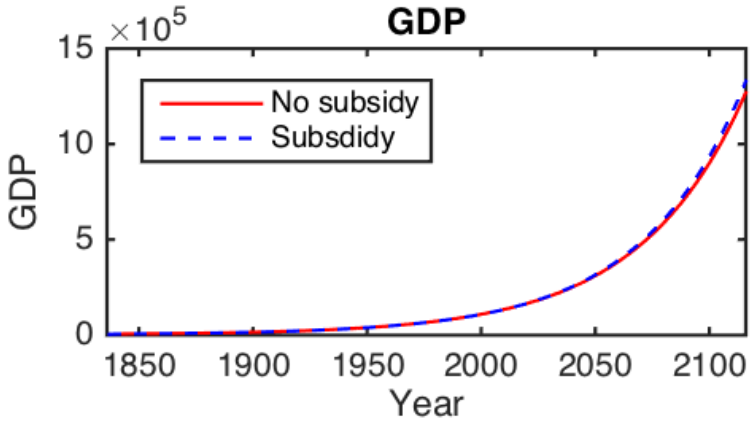

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

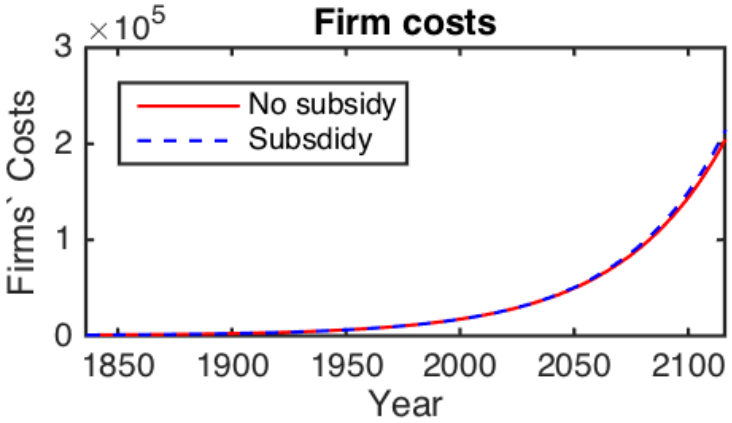

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

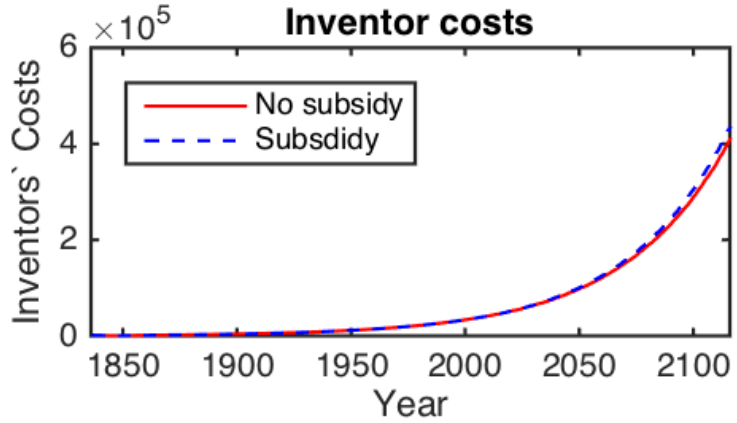

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

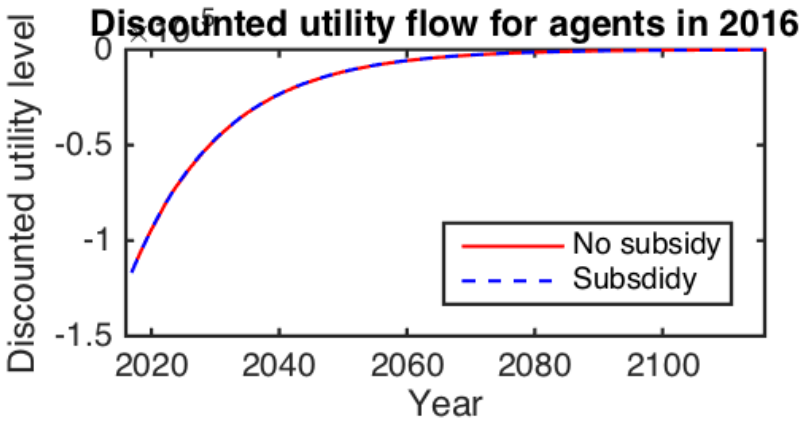

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
2
4
6
8
10
12
1850
1900
1950
2000
2050
2100

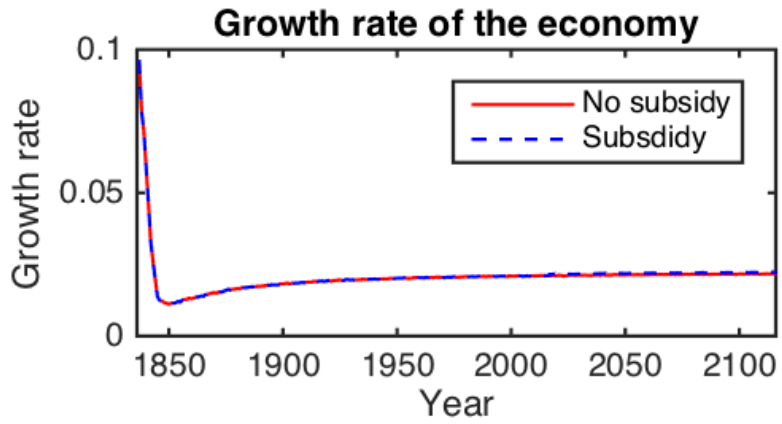

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy
0
2
4
6
8
1850
1900
1950
2000
2050
2100


GDP
×10^5
GDP
Year
No subsidy
Subsdidy
0
5
10
15
1850
1900
1950
2000
2050
2100

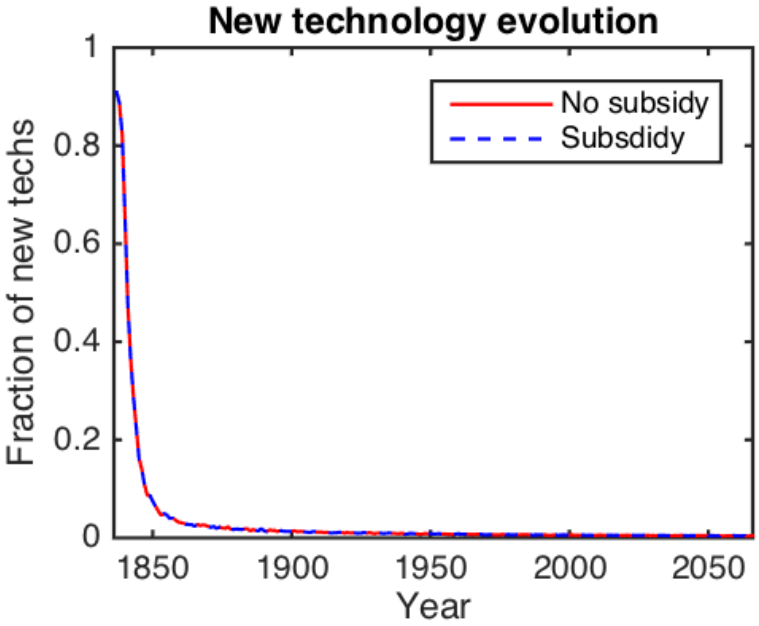

Firm costs
×10^5
Firms` Costs
Year
No subsidy
Subsdidy
0
1
2
3
1850
1900
1950
2000
2050
2100

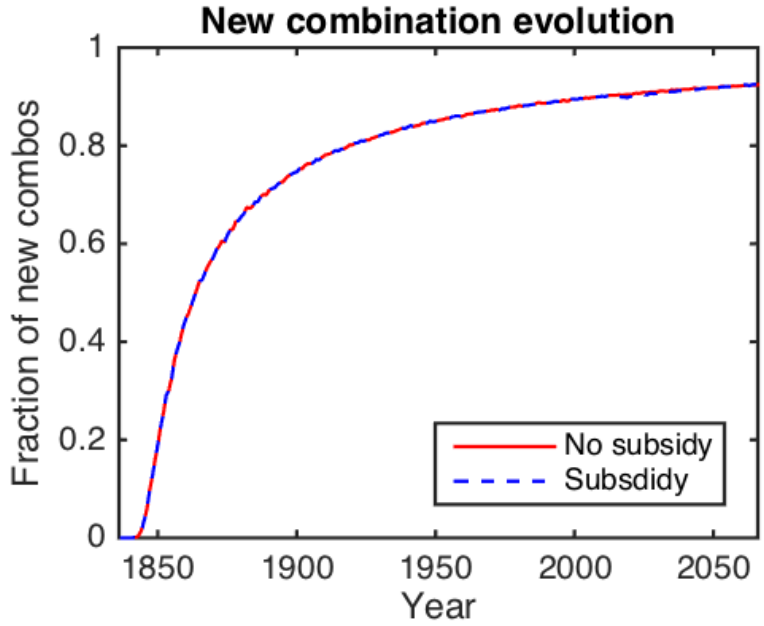

Inventor costs
×10^5
Inventors` Costs
Year
No subsidy
Subsdidy
0
2
4
6
1850
1900
1950
2000
2050
2100

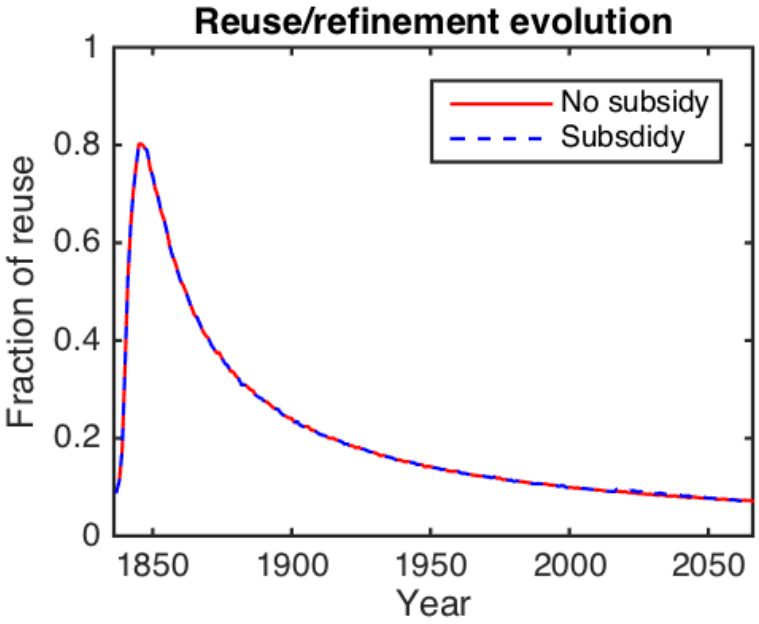

Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy
-1.5
-1
-0.5
0
2020
2040
2060
2080
2100

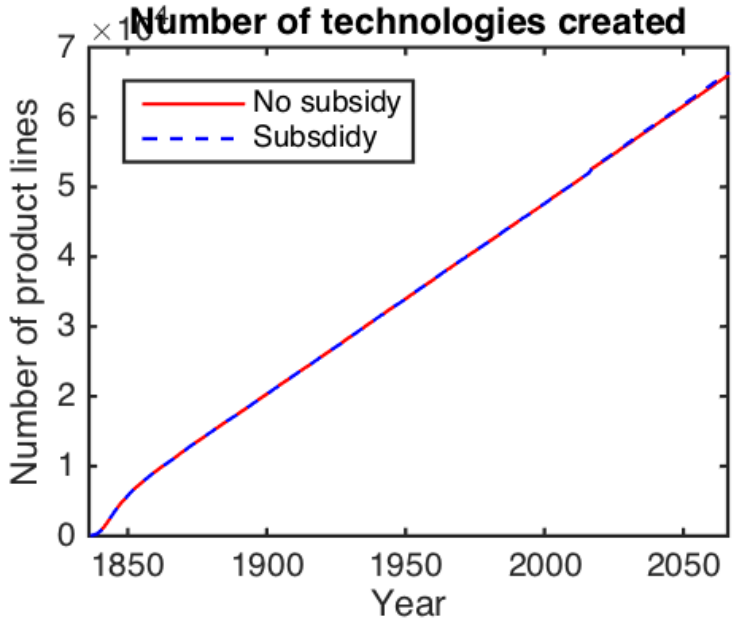

Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy
0
0.05
0.1
1850
1900
1950
2000
2050
2100

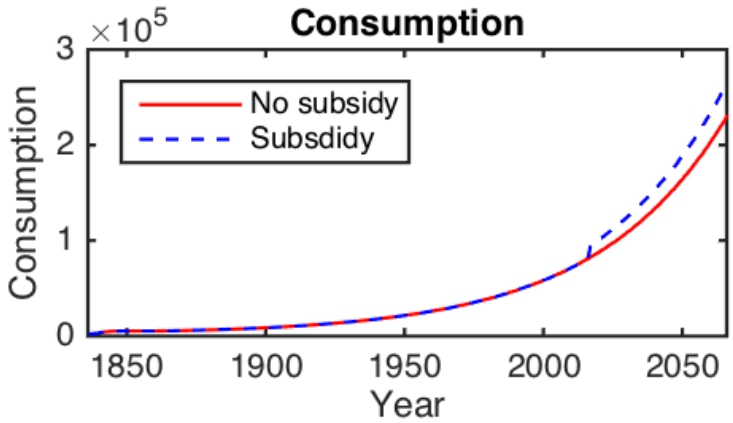
	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00017249	-0.00017185	0.0036683
# technologies	78806	106595	0.35263
Average GDP growth	0.021463	0.021933	0.021896

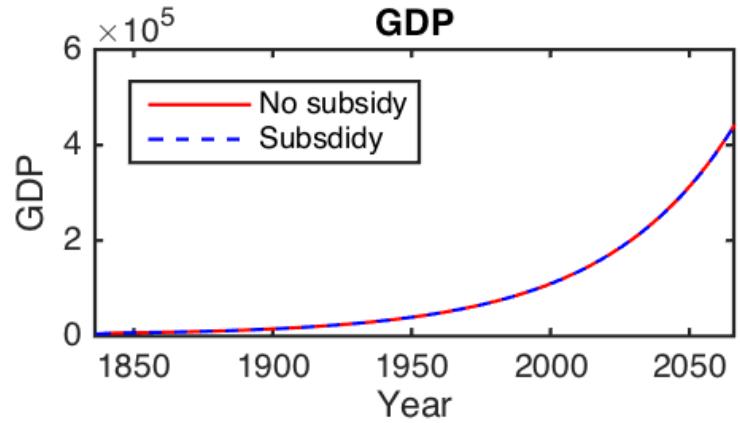

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

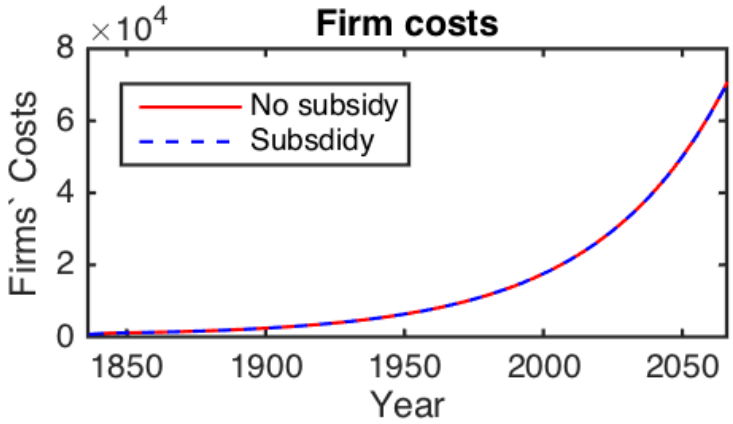

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

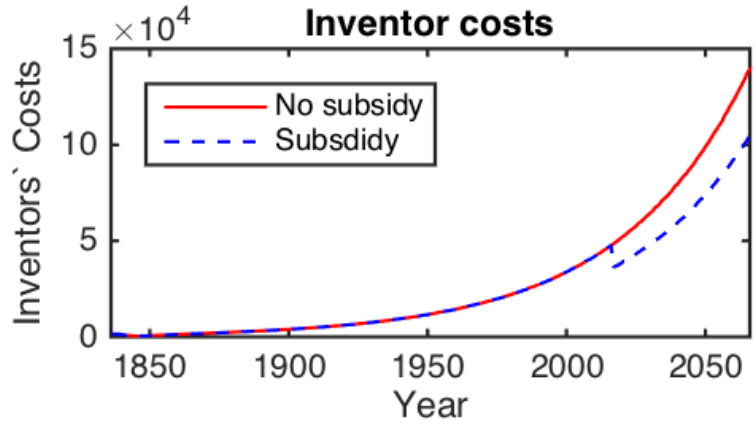

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

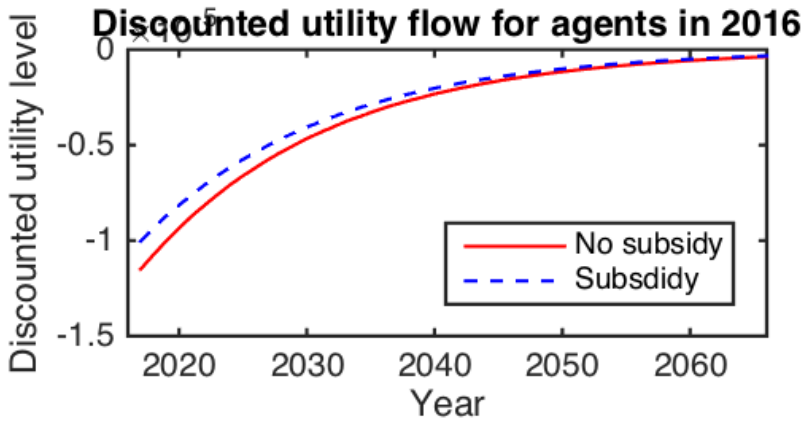

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
1
2
3
4
5
6
7
1850
1900
1950
2000
2050

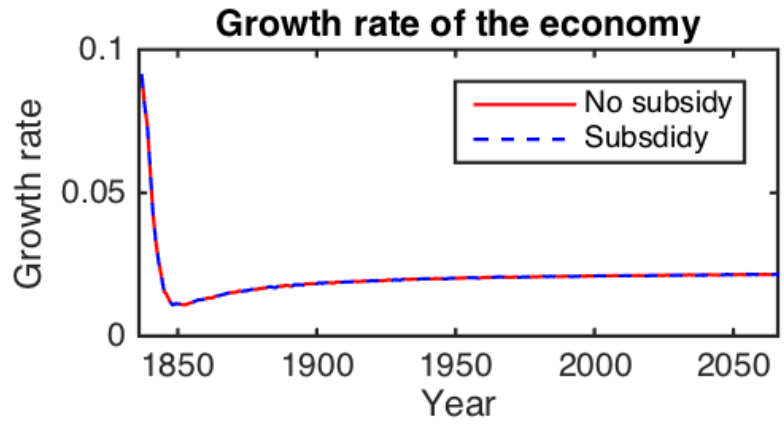

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy


GDP
×10^5
GDP
Year
No subsidy
Subsdidy

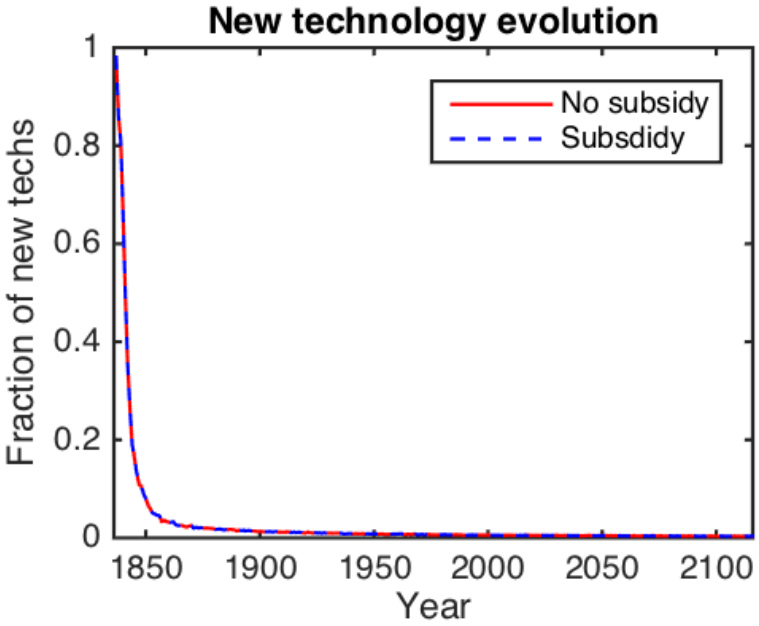

Firm costs
×10^4
Firms` Costs
Year
No subsidy
Subsdidy

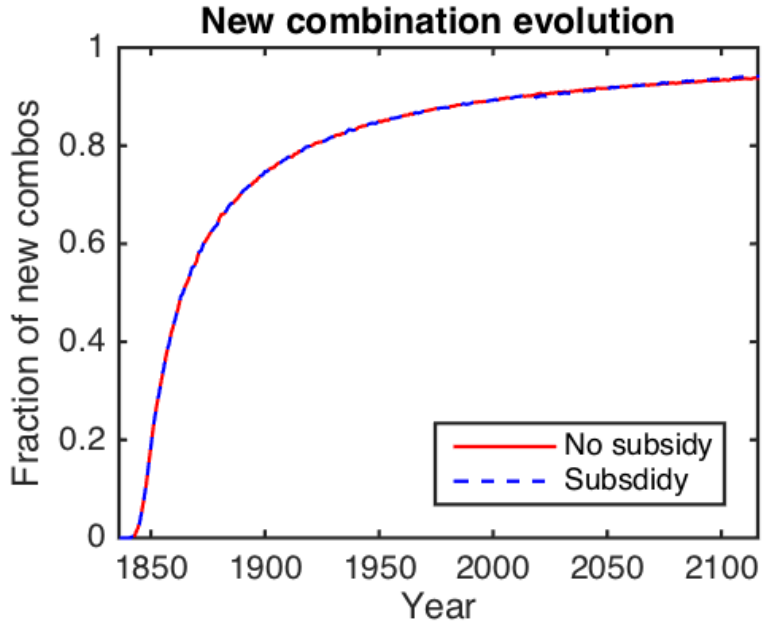

Inventor costs
×10^4
Inventors` Costs
Year
No subsidy
Subsdidy

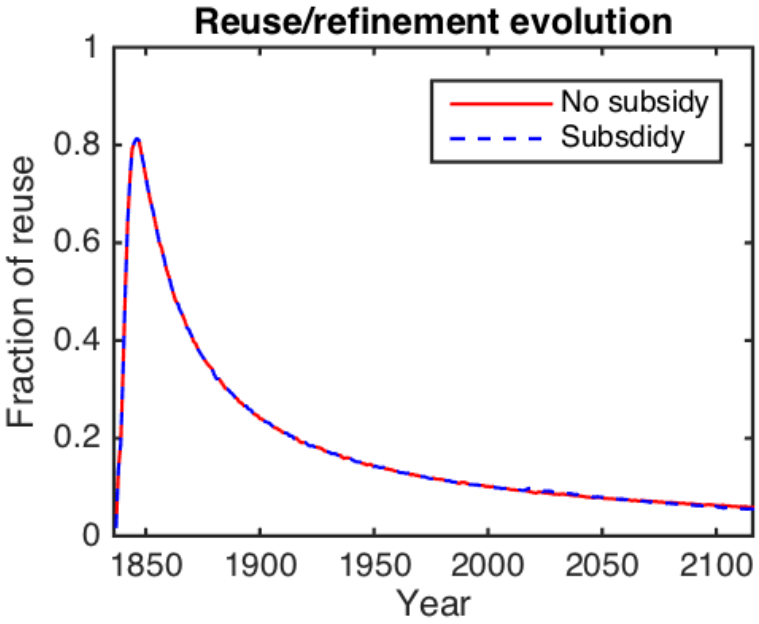

Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy

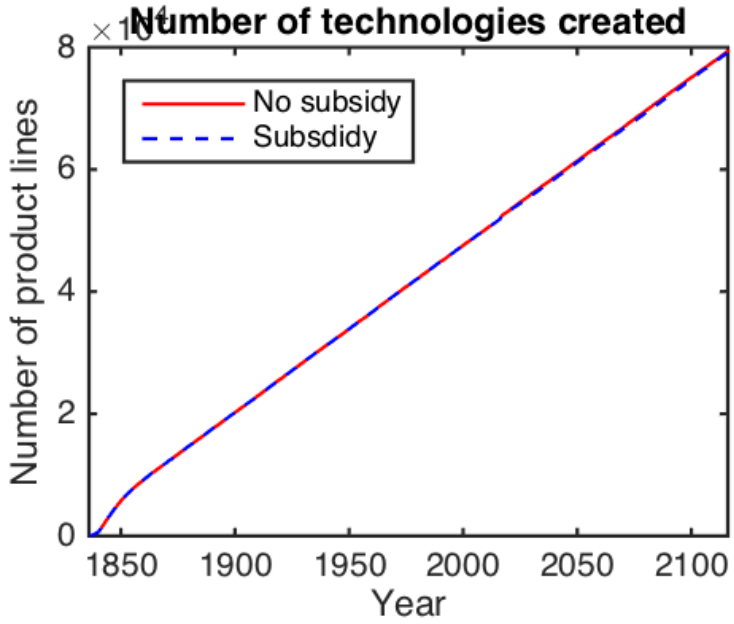

Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy

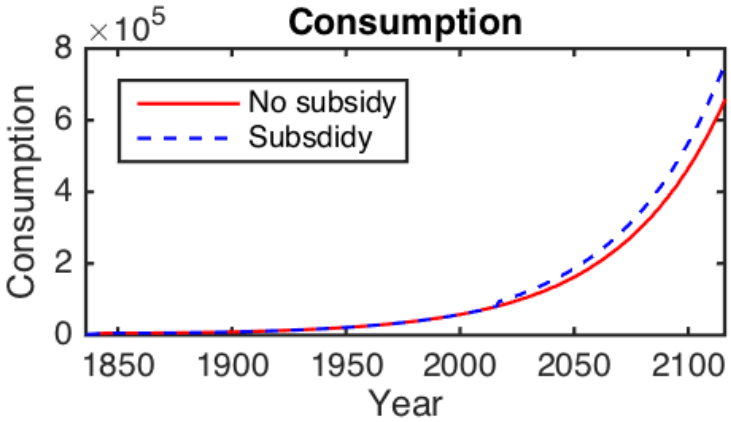
	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00016624	-0.0001447	0.12958
# technologies	65968	66259	0.0044112
Average GDP growth	0.021339	0.021305	-0.0015829

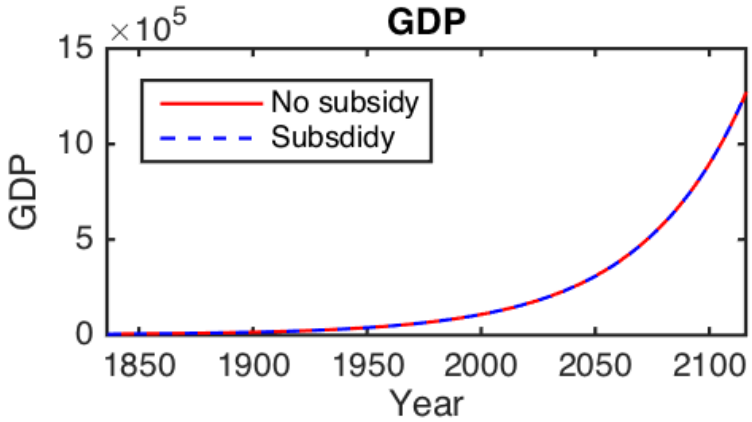

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

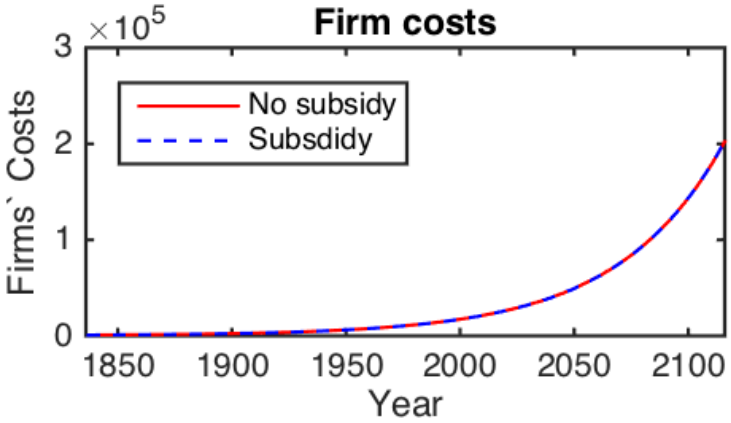

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

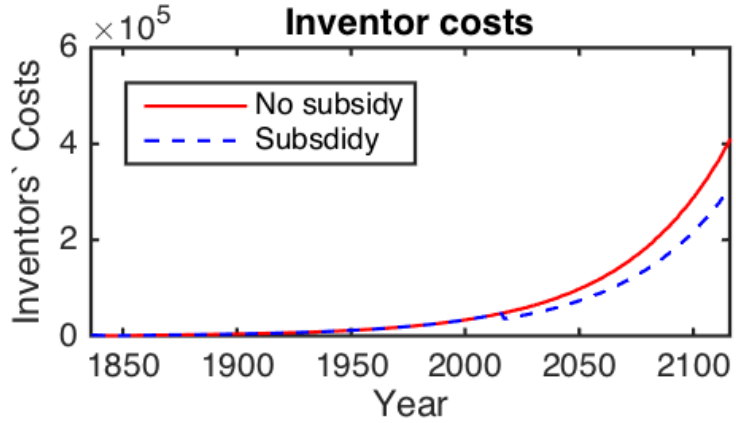

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

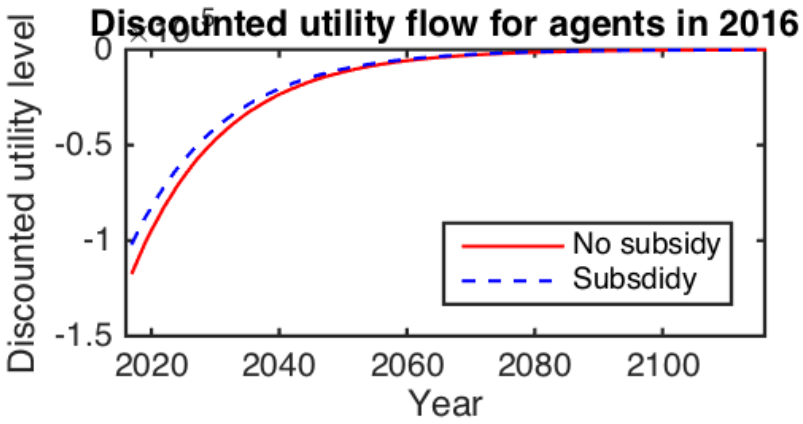

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
2
4
6
8
1850
1900
1950
2000
2050
2100

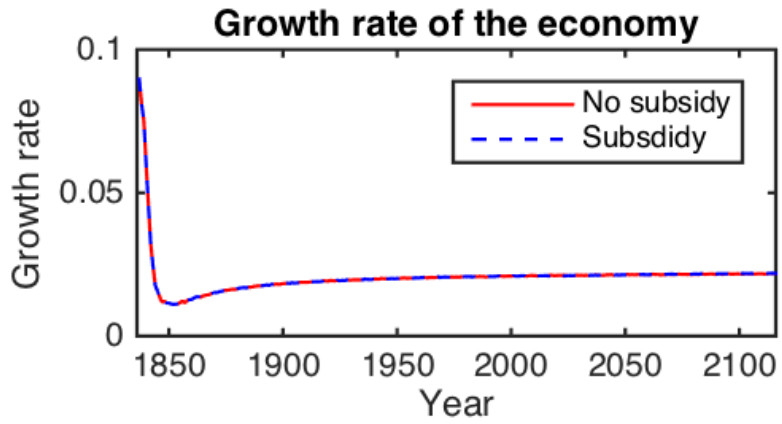

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy
0
2
4
6
8
1850
1900
1950
2000
2050
2100


GDP
×10^5
GDP
Year
No subsidy
Subsdidy
0
5
10
15
1850
1900
1950
2000
2050
2100

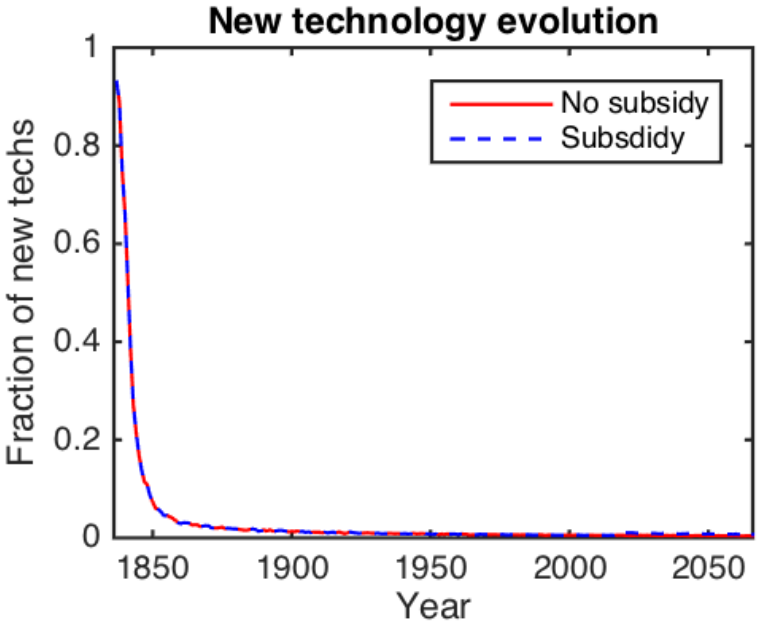

Firm costs
×10^5
Firms` Costs
Year
No subsidy
Subsdidy
0
1
2
3
1850
1900
1950
2000
2050
2100

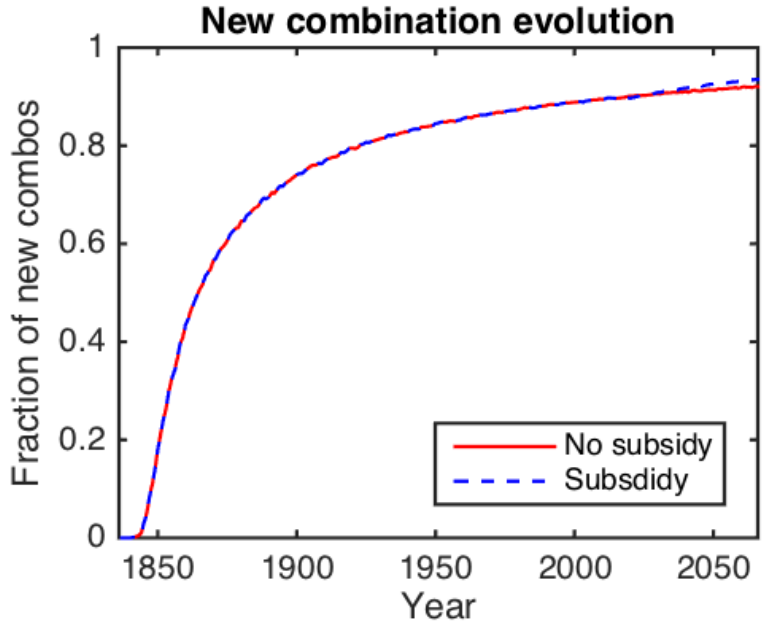

Inventor costs
×10^5
Inventors` Costs
Year
No subsidy
Subsdidy
0
2
4
6
1850
1900
1950
2000
2050
2100

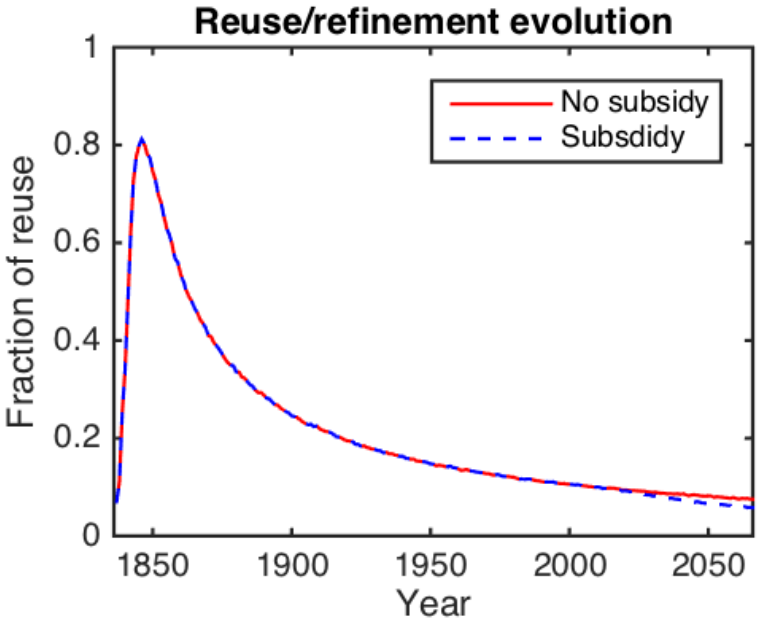

Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy
-1.5
-1
-0.5
0
2020
2040
2060
2080
2100

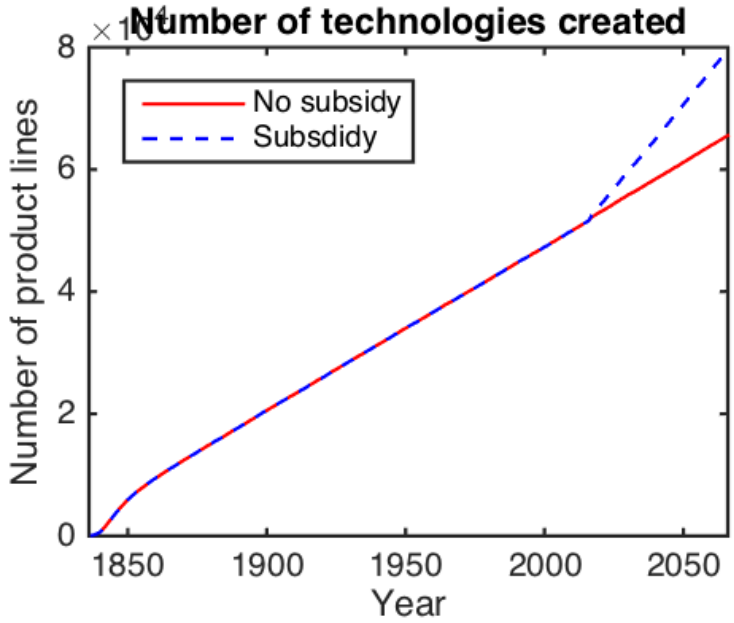

Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy
0
0.05
0.1
1850
1900
1950
2000
2050
2100

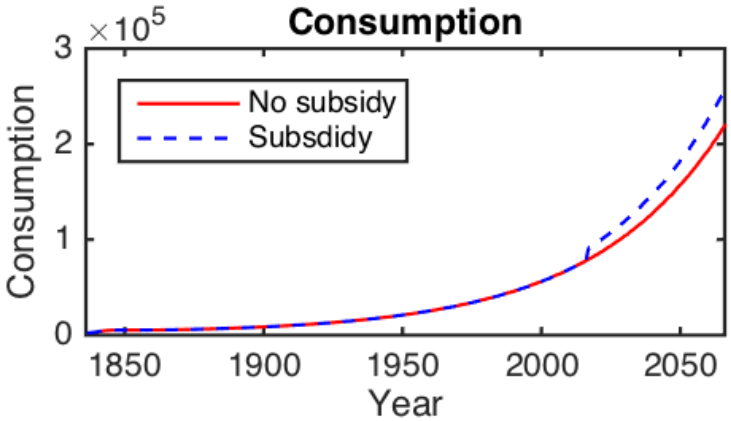
	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00017332	-0.00015093	0.12921
# technologies	79361	79179	-0.0022933
Average GDP growth	0.021469	0.02149	0.00099304

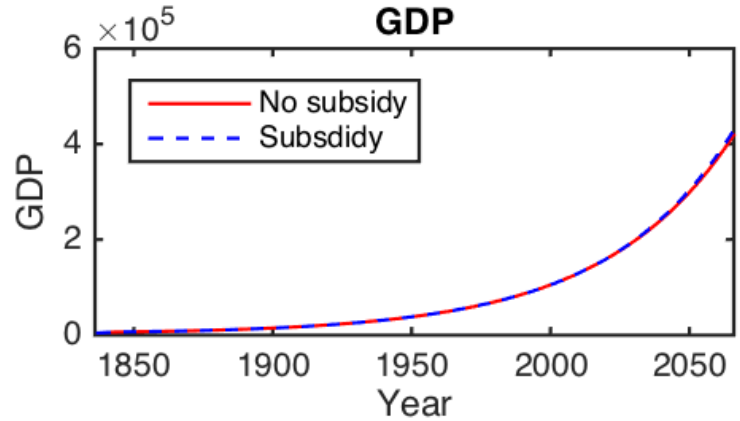

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

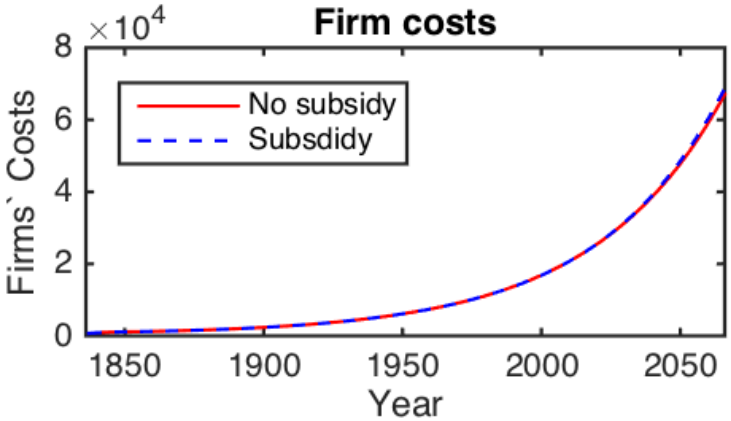

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

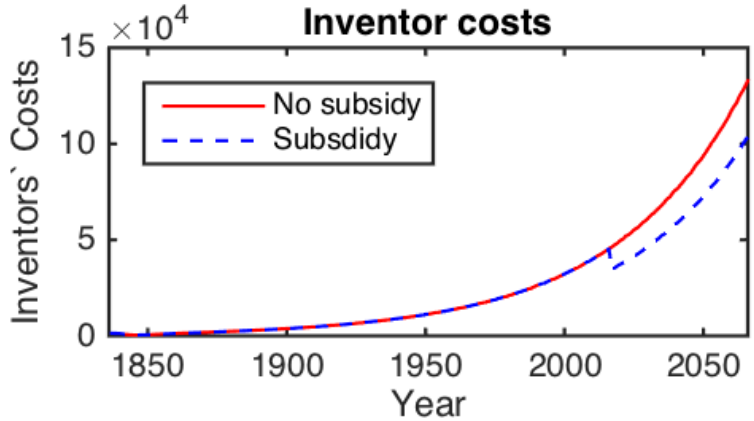

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050

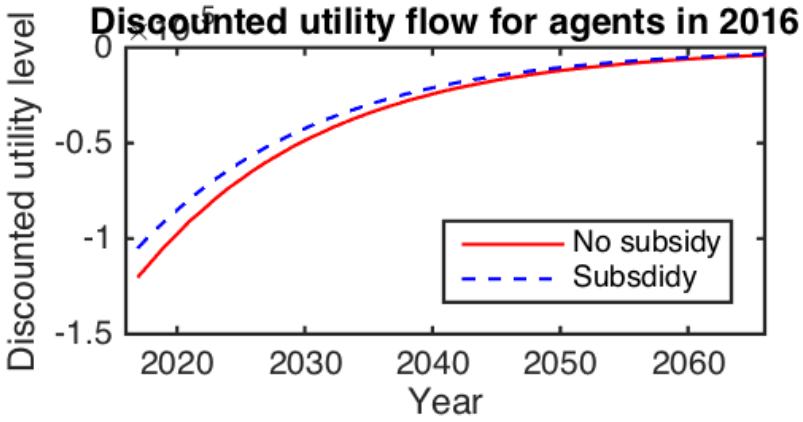

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
2
4
6
8
1850
1900
1950
2000
2050

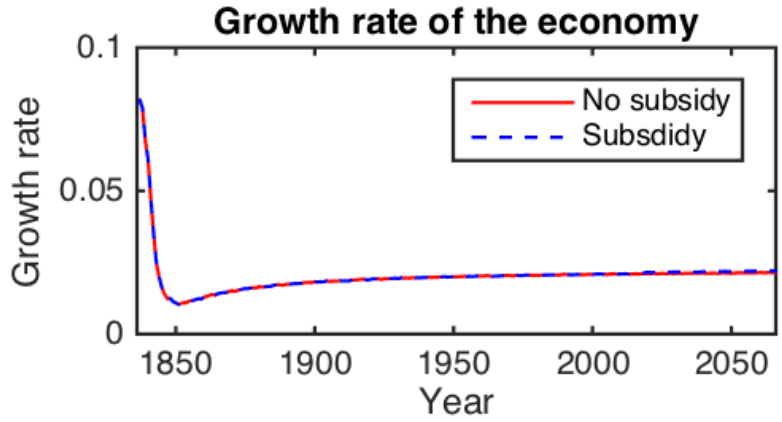

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy


GDP
×10^5
GDP
Year
No subsidy
Subsdidy

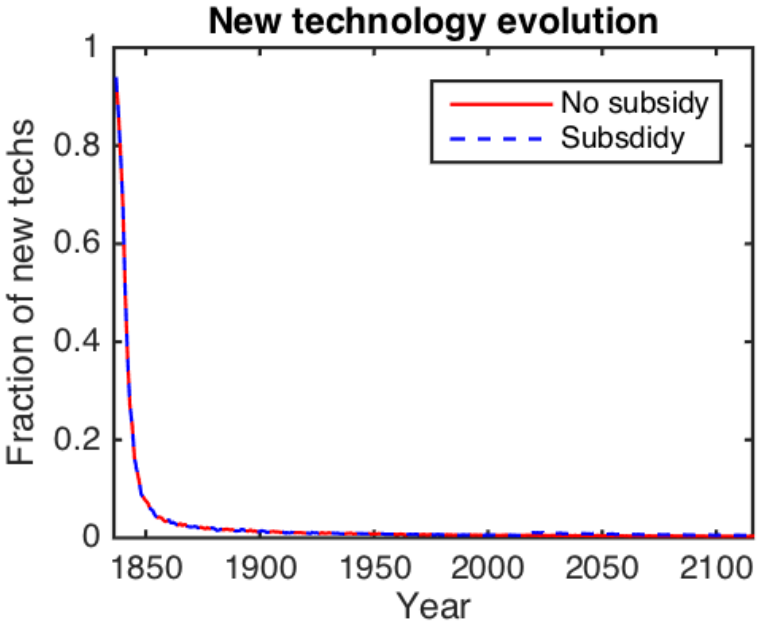

Firm costs
×10^4
Firms` Costs
Year
No subsidy
Subsdidy

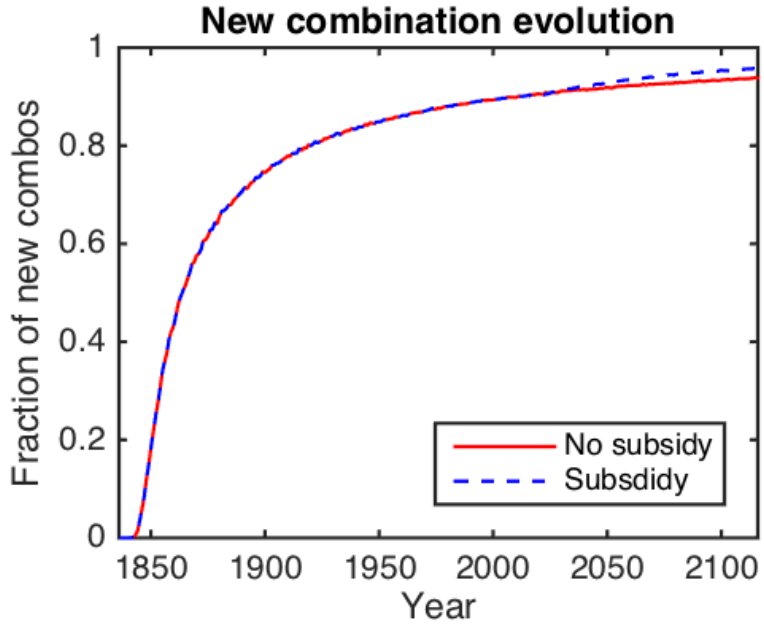

Inventor costs
×10^4
Inventors` Costs
Year
No subsidy
Subsdidy

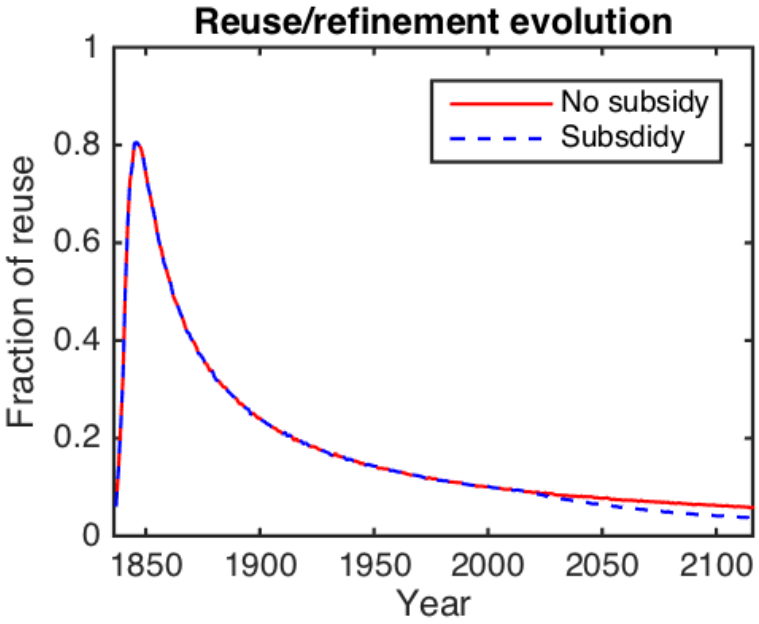

Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy

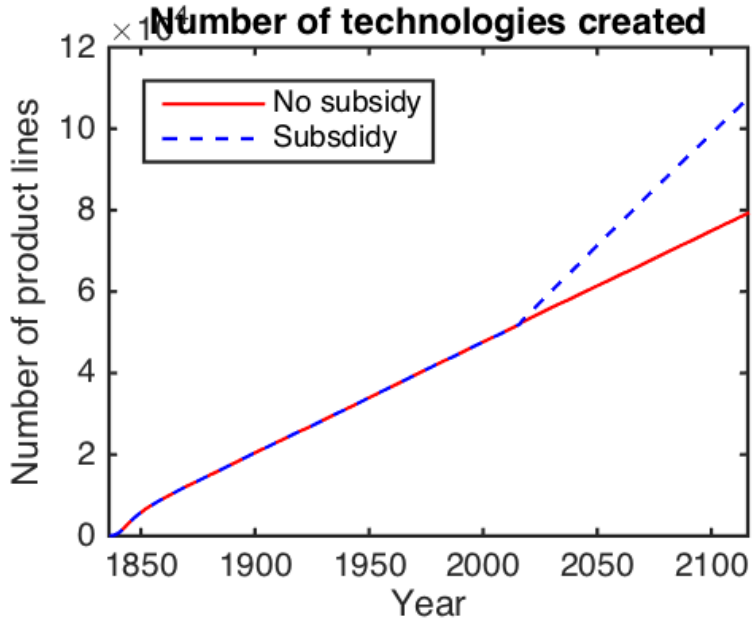

Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy

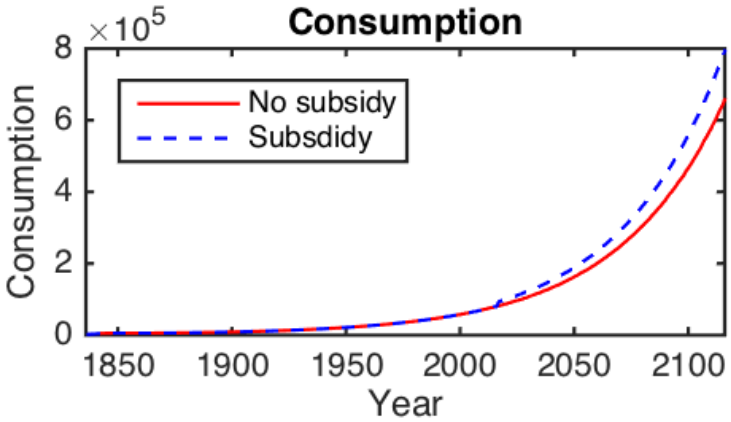
	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00017333	-0.00015062	0.13101
# technologies	65551	79535	0.21333
Average GDP growth	0.021245	0.02175	0.02379

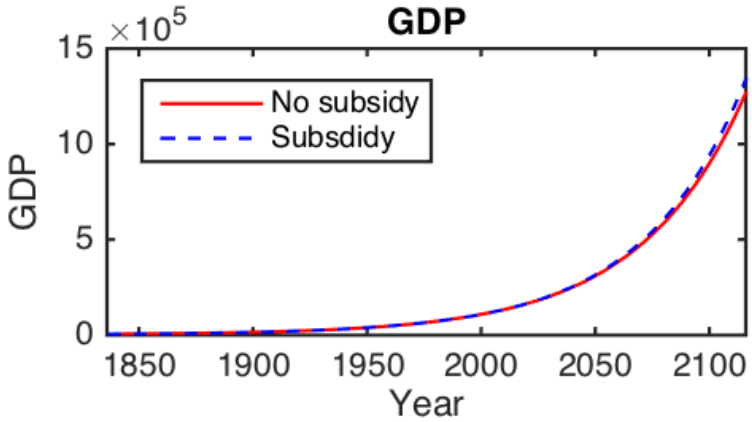

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

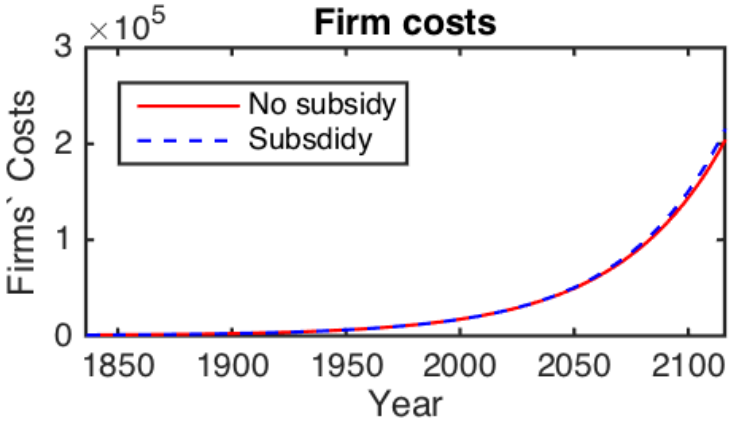

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

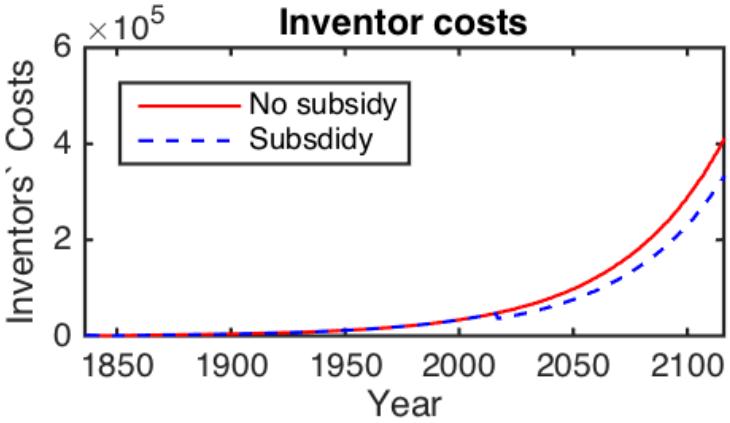

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

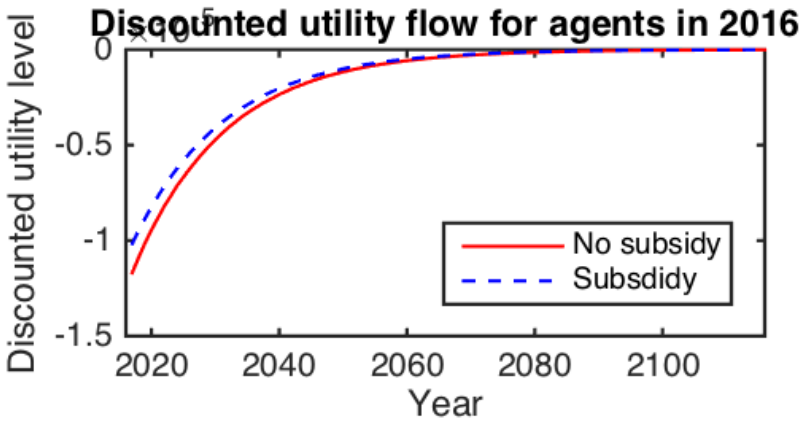

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
2
4
6
8
10
12
1850
1900
1950
2000
2050
2100

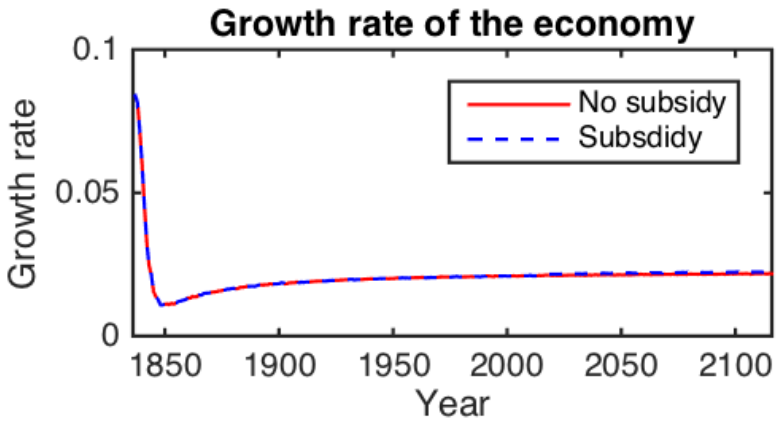

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy


GDP
×10^5
GDP
Year
No subsidy
Subsdidy


Firm costs
×10^5
Firms` Costs
Year
No subsidy
Subsdidy


Inventor costs
×10^5
Inventors` Costs
Year
No subsidy
Subsdidy

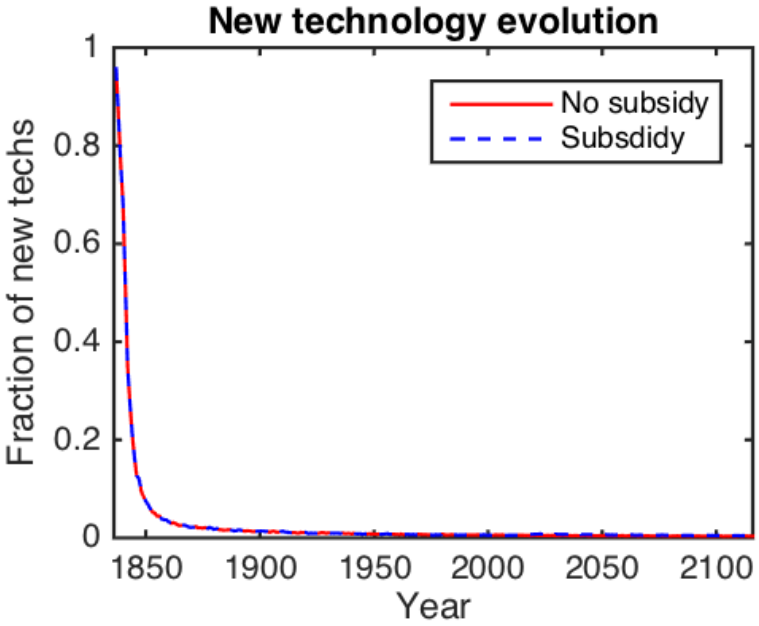

Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy

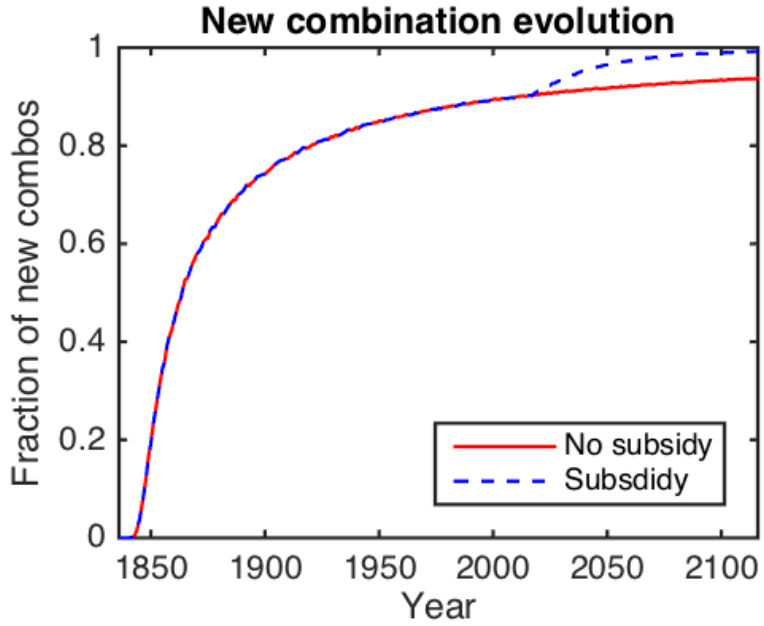

Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy

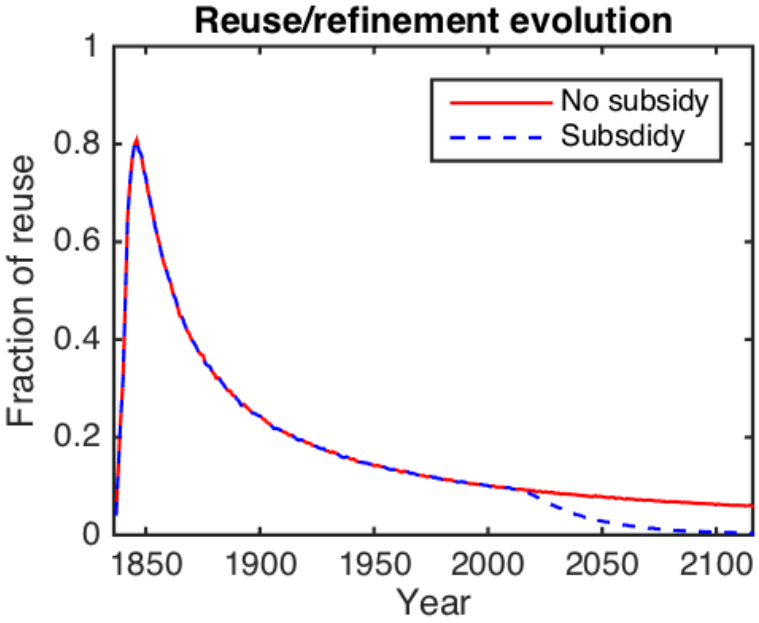
	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00017313	-0.00015022	0.13232
# technologies	79265	107507	0.3563
Average GDP growth	0.021484	0.022047	0.0262

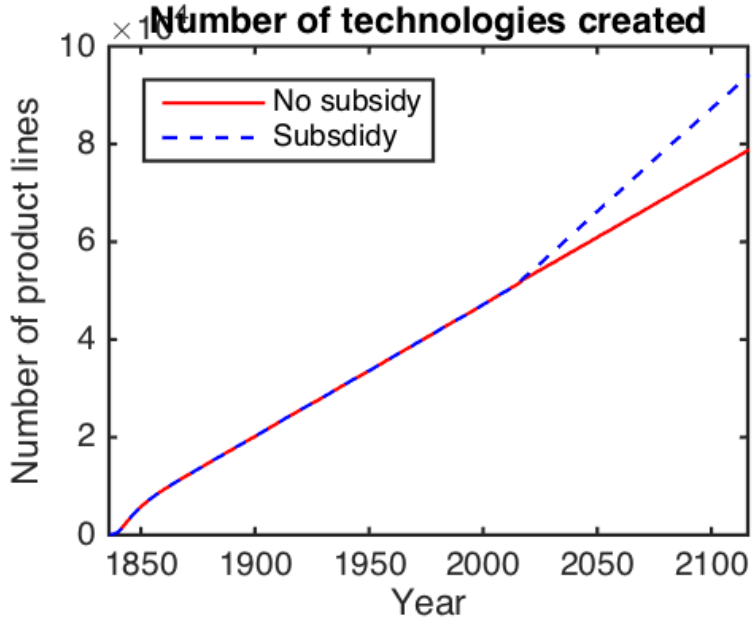
Patterns

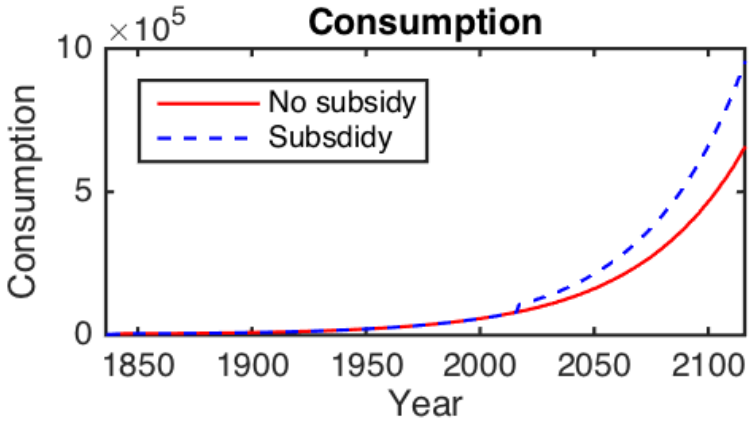
- The pattern is clear: subsidizing new combinations will have no effect no patent shares or in the number of technologies, but it will have the highest effect on welfare.
- In fact, growth is even smaller when subsidizing new combinations, since inventors might revert from producing new technologies to produce new combinations. But the number of combination possibilities is so great that new combinations more than make up for the difference.
- Finally, subsidizing new combinations and new technologies at the same time has a bigger effect than the sum of the two subsidies alone. There is a complementarity between the two as new technologies always create more hot product lines.
- Finally, we can experiment with different subsidies. For fun, the following has 10% subsidy for new technologies and 50% subsidy for new combinations. This subsidy runs for 100 years.

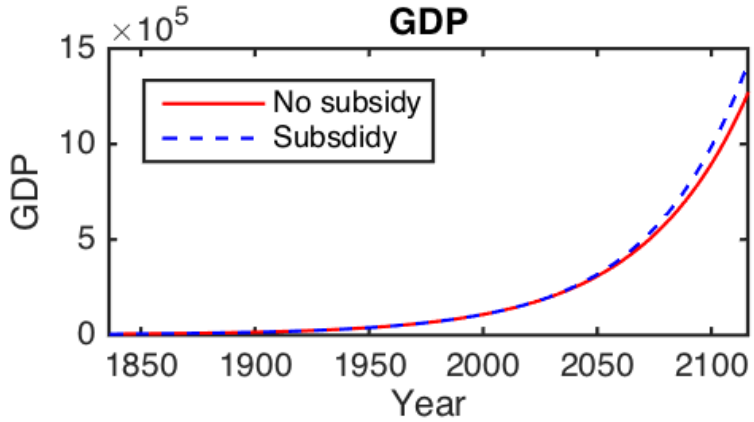

New technology evolution
Fraction of new techs
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

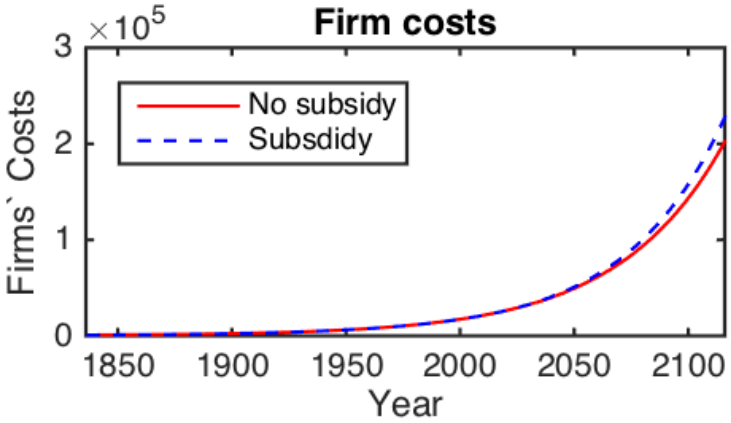

New combination evolution
Fraction of new combos
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

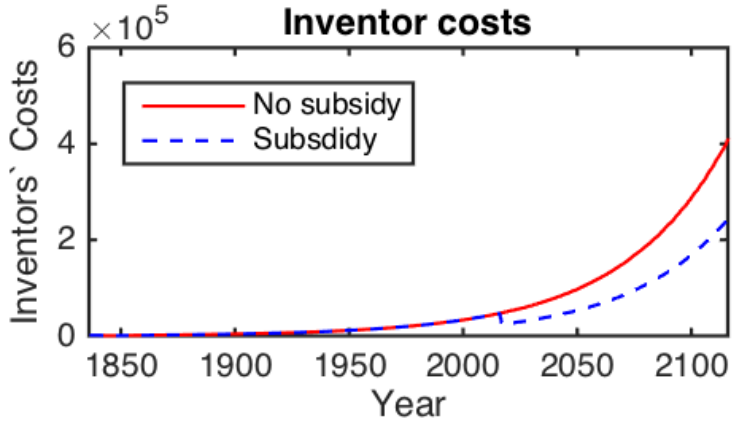

Reuse/refinement evolution
Fraction of reuse
Year
No subsidy
Subsdidy
0
0.2
0.4
0.6
0.8
1
1850
1900
1950
2000
2050
2100

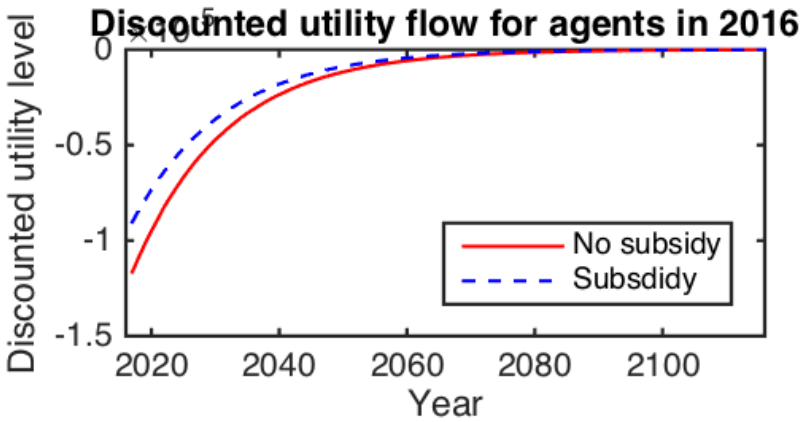

Number of technologies created
Number of product lines
Year
No subsidy
Subsdidy
0
2
4
6
8
10
1850
1900
1950
2000
2050
2100

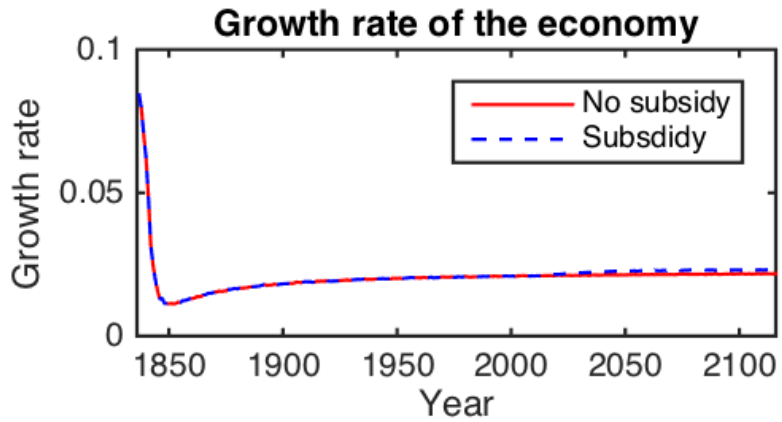

Consumption
×10^5
Consumption
Year
No subsidy
Subsdidy
0
5
10
1850
1900
1950
2000
2050
2100


GDP
×10^5
GDP
Year
No subsidy
Subsdidy
0
5
10
15
1850
1900
1950
2000
2050
2100


Firm costs
×10^5
Firms` Costs
Year
No subsidy
Subsdidy
0
1
2
3
1850
1900
1950
2000
2050
2100


Inventor costs
×10^5
Inventors` Costs
Year
No subsidy
Subsdidy
0
2
4
6
1850
1900
1950
2000
2050
2100


Discounted utility flow for agents in 2016
Discounted utility level
Year
No subsidy
Subsdidy
-1.5
-1
-0.5
0
2020
2040
2060
2080
2100


Growth rate of the economy
Growth rate
Year
No subsidy
Subsdidy
0
0.05
0.1
1850
1900
1950
2000
2050
2100

	Subsidy	**No subsidy**	**% Change**
Welfare	-0.00017347	-0.00013343	0.23086
# technologies	78682	93980	0.19443
Average GDP growth	0.021469	0.022677	0.056245