The Economics of Kenneth J. Arrow

E. Maskin
Harvard University

World Bank
Washington, DC
September, 2015

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

(1) *Social Choice Theory*

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

(1) *Social Choice Theory*

- how to choose from set of social alternatives on basis of individuals' (citizens', consumers') preferences over alternatives

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

(1) *Social Choice Theory*

- how to choose from set of social alternatives on basis of individuals' (citizens', consumers') preferences over alternatives
  - i.e., how to *aggregate preferences*

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

(1) *Social Choice Theory*

- how to choose from set of social alternatives on basis of individuals' (citizens', consumers') preferences over alternatives
  - i.e., how to *aggregate preferences*

(2) *General Equilibrium Theory*

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

(1) *Social Choice Theory*

- how to choose from set of social alternatives on basis of individuals' (citizens', consumers') preferences over alternatives
  - i.e., how to *aggregate preferences*

(2) *General Equilibrium Theory*

- study of markets for all goods *together*

Most of Ken Arrow's work in economics belongs to following (over-lapping) categories:

(1) *Social Choice Theory*

- how to choose from set of social alternatives on basis of individuals' (citizens', consumers') preferences over alternatives
  - i.e., how to *aggregate preferences*

(2) *General Equilibrium Theory*

- study of markets for all goods *together*
  - e.g., can all markets clear simultaneously?

(supply = demand in each market)

(3) *Public Economics*

(3) *Public Economics*

- provision and financing of *public goods*

(3) *Public Economics*

- provision and financing of *public goods*
  - goods that, once provided for anybody, are available to everybody

(3) *Public Economics*

- provision and financing of *public goods*
  - goods that, once provided for anybody, are available to everybody

(4) *Economics of Asymmetric Information*

(3) *Public Economics*

- provision and financing of *public goods*
  - goods that, once provided for anybody, are available to everybody

(4) *Economics of Asymmetric Information*

- implications for economic outcomes of

(3) *Public Economics*

- provision and financing of *public goods*
  - goods that, once provided for anybody, are available to everybody

(4) *Economics of Asymmetric Information*

- implications for economic outcomes of
  - *moral hazard* (hidden actions): agent's actions are unobservable to others

(3) *Public Economics*

- provision and financing of *public goods*
  - goods that, once provided for anybody, are available to everybody

(4) *Economics of Asymmetric Information*

- implications for economic outcomes of
  - *moral hazard* (hidden actions): agent's actions are unobservable to others
  - *adverse selection* (hidden knowledge): agent knows something that others don't

(5) *Economic Dynamics and Growth*

(5) *Economic Dynamics and Growth*

- study of economic decisions — e.g., investment — in *intemporal* settings

(5) *Economic Dynamics and Growth*

- study of economic decisions — e.g., investment — in *intemporal* settings

(6) *Economics of Risk*

(5) *Economic Dynamics and Growth*

- study of economic decisions — e.g., investment — in *intemporal* settings

(6) *Economics of Risk*

- how does *uncertainty* about outcome affect economic behavior

(1) *Social Choice Theory*

(1) *Social Choice Theory*

- Arrow's single most famous work:
  monograph *Social Choice and Individual Values*, 1951

(1) *Social Choice Theory*

- Arrow's single most famous work:

  monograph *Social Choice and Individual Values*, 1951
  - created modern field of social choice theory

(1) *Social Choice Theory*

- Arrow's single most famous work:

  monograph *Social Choice and Individual Values*, 1951
  - created modern field of social choice theory
- In 18th century, Condorcet studied *simple majority rule* as method for aggregating preferences over social alternatives (social welfare function)

(1) *Social Choice Theory*

- Arrow's single most famous work:

  monograph *Social Choice and Individual Values*, 1951
  - created modern field of social choice theory
- In 18th century, Condorcet studied *simple majority rule* as method for aggregating preferences over social alternatives (social welfare function)
  - alternative *x* chosen over *y* if more individuals prefer *x* to *y* than *y* to *x*

Majority rule has many attractive properties:

Majority rule has many attractive properties:

- if all people prefer *x* to *y*, then *x* chosen over *y*

Majority rule has many attractive properties:

- if all people prefer *x* to *y*, then *x* chosen over *y*

Pareto property

Majority rule has many attractive properties:

- if all people prefer *x* to *y*, then *x* chosen over *y*

Pareto property

- choice between *x* and *y* doesn't depend on how people evaluate third alternative *z*

Majority rule has many attractive properties:

- if all people prefer *x* to *y*, then *x* chosen over *y*

Pareto property

- choice between *x* and *y* doesn't depend on how people evaluate third alternative *z*

independence of irrelevant alternatives

But Condorcet identified important flaw in majority rule:

might not make *consistent (transitive) choices*:

But Condorcet identified important flaw in majority rule:

might not make *consistent (transitive) choices*:

1	2	3
x	*y*	*z*
y	*z*	*x*
z	*x*	*y*

But Condorcet identified important flaw in majority rule:

might not make *consistent (transitive) choices*:

1	2	3
x	*y*	*z*
y	*z*	*x*
z	*x*	*y*

- *x* chosen over *y*

But Condorcet identified important flaw in majority rule:

might not make *consistent (transitive) choices*:

1	2	3
x	*y*	*z*
y	*z*	*x*
z	*x*	*y*

- *x* chosen over *y*
- *y* chosen over *z*

But Condorcet identified important flaw in majority rule:

might not make *consistent (transitive) choices*:

1	2	3
x	*y*	*z*
y	*z*	*x*
z	*x*	*y*

- *x* chosen over *y*
- *y* chosen over *z*
- but *z* chosen over *x*!

But Condorcet identified important flaw in majority rule:

might not make *consistent (transitive) choices*:

1	2	3
x	*y*	*z*
y	*z*	*x*
z	*x*	*y*

- *x* chosen over *y*
- *y* chosen over *z*
- but *z* chosen over *x*!

Paradox of Voting

- Arrow (1951) identified much more general problem with aggregating preference

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that
  - satisfies Pareto property

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that
  - satisfies Pareto property
  - makes consistent choices

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that
  - satisfies Pareto property
  - makes consistent choices
  - satisfies independence of irrelevant alternatives

  must be *dictatorship*

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that
  - satisfies Pareto property
  - makes consistent choices
  - satisfies independence of irrelevant alternatives

    must be *dictatorship*
  - there is some individual who *always* gets her way: if she prefers *x* to *y*, then *x* chosen over *y*

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that
  - satisfies Pareto property
  - makes consistent choices
  - satisfies independence of irrelevant alternatives

    must be *dictatorship*
  - there is some individual who *always* gets her way: if she prefers *x* to *y*, then *x* chosen over *y*
- called *Impossibility Theorem*

- Arrow (1951) identified much more general problem with aggregating preference
- showed that any social welfare function that
  - satisfies Pareto property
  - makes consistent choices
  - satisfies independence of irrelevant alternatives

    must be *dictatorship*
  - there is some individual who *always* gets her way: if she prefers *x* to *y*, then *x* chosen over *y*
- called *Impossibility Theorem*
  - dictatorship not satisfactory

(2) *General Equilibrium*

(2) *General Equilibrium*

A. *Existence of Equilibrium*

(2) *General Equilibrium*

A. *Existence of Equilibrium*

- at least since Walras, recognized that studying single market by itself often inadequate

(2) *General Equilibrium*

A. *Existence of Equilibrium*

- at least since Walras, recognized that studying single market by itself often inadequate
  - can't understand market for gas without understanding market for oil

(2) *General Equilibrium*

A. *Existence of Equilibrium*

- at least since Walras, recognized that studying single market by itself often inadequate
  - can't understand market for gas without understanding market for oil
  - can't understand market for oil without understanding market for coal, etc.

(2) *General Equilibrium*

A. *Existence of Equilibrium*

- at least since Walras, recognized that studying single market by itself often inadequate
  - can't understand market for gas without understanding market for oil
  - can't understand market for oil without understanding market for coal, etc.
- fundamental question arises:

(2) *General Equilibrium*

A. *Existence of Equilibrium*

- at least since Walras, recognized that studying single market by itself often inadequate
  - can't understand market for gas without understanding market for oil
  - can't understand market for oil without understanding market for coal, etc.
- fundamental question arises:
  - can all markets clear simultaneously?

- Arrow and Debreu “Existence of Equilibrium for a Competitive Economy”, 1954

- Arrow and Debreu “Existence of Equilibrium for a Competitive Economy”, 1954
  - established existence of equilibrium in

- Arrow and Debreu “Existence of Equilibrium for a Competitive Economy”, 1954

  – established existence of equilibrium in very general model

- Arrow and Debreu “Existence of Equilibrium for a Competitive Economy”, 1954

  – established existence of equilibrium in

    very general model

    relatively simple argument

Arrow –Debreu model

Arrow –Debreu model

- finite number of firms, consumers, and goods

Arrow –Debreu model

- finite number of firms, consumers, and goods

  each agent takes prices as *given* (can't influence prices)

  competitive assumption

Arrow –Debreu model

- finite number of firms, consumers, and goods

  each agent takes prices as *given* (can't influence prices)

  competitive assumption

- each firm described by its *technology* (relationship of inputs to outputs)

Arrow –Debreu model

- finite number of firms, consumers, and goods

  each agent takes prices as *given* (can't influence prices)

  competitive assumption
- each firm described by its *technology* (relationship of inputs to outputs)
- each firm chooses *production plan*, choice of inputs and outputs (feasible for its technology) to maximize *profit* (revenue from selling outputs minus cost of inputs, given prices)

- each consumer described by his/her

- each consumer described by his/her

  (i) initial endowment of goods

- each consumer described by his/her

  (i) initial endowment of goods

  (ii) shares in different firms' profits

- each consumer described by his/her

  (i) initial endowment of goods

  (ii) shares in different firms' profits

  (iii) utility function for goods

- each consumer described by his/her

  (i) initial endowment of goods
  (ii) shares in different firms' profits
  (iii) utility function for goods

- each consumer chooses *consumption plan*, choice of goods to maximize utility subject to

- each consumer described by his/her

  (i) initial endowment of goods
  (ii) shares in different firms' profits
  (iii) utility function for goods

- each consumer chooses *consumption plan*, choice of goods to maximize utility subject to

  budget = income from endowment + shares of firms' profits

Theorem: There exists *competitive equilibrium:* prices, production plans by firms, and consumption plan by consumers such that

Theorem: There exists *competitive equilibrium:* prices, production plans by firms, and consumption plan by consumers such that

(i) each firm's production plan maximizes profit given prices

Theorem: There exists *competitive equilibrium:* prices, production plans by firms, and consumption plan by consumers such that

(i) each firm's production plan maximizes profit

given prices

(ii) each consumer's consumption plan maximizes utility

given budget and prices

Theorem: There exists *competitive equilibrium:* prices, production plans by firms, and consumption plan by consumers such that

(i) each firm's production plan maximizes profit given prices

(ii) each consumer's consumption plan maximizes utility given budget and prices

(iii) supply = demand, for each good

Theorem: There exists *competitive equilibrium:* prices, production plans by firms, and consumption plan by consumers such that

(i) each firm's production plan maximizes profit given prices

(ii) each consumer's consumption plan maximizes utility given budget and prices

(iii) supply = demand, for each good

- many models in applications are special cases of Arrow-Debreu

B. *Optimality of Equilibrium*

B. *Optimality of Equilibrium*

Arrow, “An Extension of The Basic Theorems of Classical Welfare Economics”, 1951

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)
- i.e., there exists redistribution of initial endowments, re-assignment of profit shares and corresponding competitive equilibrium such that

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)
- i.e., there exists redistribution of initial endowments, re-assignment of profit shares and corresponding competitive equilibrium such that
  - consumers' equilibrium plans = Pareto optimal consumptions plans

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)
- i.e., there exists redistribution of initial endowments, re-assignment of profit shares and corresponding competitive equilibrium such that
  - consumers' equilibrium plans = Pareto optimal consumptions plans
  - firms' equilibrium plans = Pareto optimal production plans

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)
- i.e., there exists redistribution of initial endowments, re-assignment of profit shares and corresponding competitive equilibrium such that
  - consumers' equilibrium plans = Pareto optimal consumptions plans
  - firms' equilibrium plans = Pareto optimal production plans
- results more general than preceding literature

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)
- i.e., there exists redistribution of initial endowments, re-assignment of profit shares and corresponding competitive equilibrium such that
  - consumers' equilibrium plans = Pareto optimal consumptions plans
  - firms' equilibrium plans = Pareto optimal production plans
- results more general than preceding literature
  - no differentiability

B. *Optimality of Equilibrium*

Arrow, "An Extension of The Basic Theorems of Classical Welfare Economics", 1951

- equilibrium of competitive model is *Pareto optimal* (First Welfare Theorem)
  - no other *feasible* consumption and production plans make any consumer better off without making someone else worse off
  - feasibility: amount consumed does not exceed amount available (initial endowment plus feasible production)
- any Pareto optimal plans can be decentralized as competitive equilibrium (Second Welfare Theorem)
- i.e., there exists redistribution of initial endowments, re-assignment of profit shares and corresponding competitive equilibrium such that
  - consumers' equilibrium plans = Pareto optimal consumptions plans
  - firms' equilibrium plans = Pareto optimal production plans
- results more general than preceding literature
  - no differentiability
  - no interiority

(3) *Public Economics*

(3) *Public Economics*

Arrow, “Economic Welfare and Allocation of Resources for Invention”, 1962

(3) *Public Economics*

Arrow, “Economic Welfare and Allocation of Resources for Invention”, 1962

- invention as public good

(3) *Public Economics*

Arrow, "Economic Welfare and Allocation of Resources for Invention", 1962

- invention as public good
  - once discovery made, optimal to disseminate to everyone for free

(3) *Public Economics*

Arrow, "Economic Welfare and Allocation of Resources for Invention", 1962

- invention as public good
  - once discovery made, optimal to disseminate to everyone for free
  - but then what is incentive to invent

(3) *Public Economics*

Arrow, "Economic Welfare and Allocation of Resources for Invention", 1962

- invention as public good
  - once discovery made, optimal to disseminate to everyone for free
  - but then what is incentive to invent
- patents

(3) *Public Economics*

Arrow, "Economic Welfare and Allocation of Resources for Invention", 1962

- invention as public good
  - once discovery made, optimal to disseminate to everyone for free
  - but then what is incentive to invent
- patents
  - allow inventors to obtain return on investment

(3) *Public Economics*

Arrow, "Economic Welfare and Allocation of Resources for Invention", 1962

- invention as public good
  - once discovery made, optimal to disseminate to everyone for free
  - but then what is incentive to invent
- patents
  - allow inventors to obtain return on investment
  - some dissemination (through licensing)

(3) *Public Economics*

Arrow, "Economic Welfare and Allocation of Resources for Invention", 1962

- invention as public good
  - once discovery made, optimal to disseminate to everyone for free
  - but then what is incentive to invent
- patents
  - allow inventors to obtain return on investment
  - some dissemination (through licensing)
  - but patent holder is monopolist, so dissemination suboptimal

(4) *Economics of Asymmetric Information*

(4) *Economics of Asymmetric Information*

Arrow, “Uncertainty and the Welfare Economics of Medical Care”, 1963

(4) *Economics of Asymmetric Information*

Arrow, “Uncertainty and the Welfare Economics of Medical Care”, 1963

- pioneering study of a market rife with asymmetric information

(4) *Economics of Asymmetric Information*

Arrow, "Uncertainty and the Welfare Economics of Medical Care", 1963

- pioneering study of a market rife with asymmetric information
  - moral hazard (patient does not know what physician has done)

(4) *Economics of Asymmetric Information*

Arrow, "Uncertainty and the Welfare Economics of Medical Care", 1963

- pioneering study of a market rife with asymmetric information
  - moral hazard (patient does not know what physician has done)
  - adverse selection (patient does not know what physician knows)

(4) *Economics of Asymmetric Information*

Arrow, "Uncertainty and the Welfare Economics of Medical Care", 1963

- pioneering study of a market rife with asymmetric information
  - moral hazard (patient does not know what physician has done)
  - adverse selection (patient does not know what physician knows)
- argues that "special features" of medical care follow from asymmetries

(4) *Economics of Asymmetric Information*

Arrow, "Uncertainty and the Welfare Economics of Medical Care", 1963

- pioneering study of a market rife with asymmetric information
  - moral hazard (patient does not know what physician has done)
  - adverse selection (patient does not know what physician knows)
- argues that "special features" of medical care follow from asymmetries
  - regulation

(4) *Economics of Asymmetric Information*

Arrow, "Uncertainty and the Welfare Economics of Medical Care", 1963

- pioneering study of a market rife with asymmetric information
  - moral hazard (patient does not know what physician has done)
  - adverse selection (patient does not know what physician knows)
- argues that "special features" of medical care follow from asymmetries
  - regulation
  - medical ethics

(5) *Economic Dynamics and Growth*

(5) *Economic Dynamics and Growth*

Arrow, “Economic Implications of Learning by Doing”, 1962

(5) *Economic Dynamics and Growth*

Arrow, “Economic Implications of Learning by Doing”, 1962

- producer improves technique as it produces

(5) *Economic Dynamics and Growth*

Arrow, “Economic Implications of Learning by Doing”, 1962

- producer improves technique as it produces
- improvement benefits society

(5) *Economic Dynamics and Growth*

Arrow, “Economic Implications of Learning by Doing”, 1962

- producer improves technique as it produces
- improvement benefits society
- but producer doesn’t fully capture benefit

(5) *Economic Dynamics and Growth*

Arrow, “Economic Implications of Learning by Doing”, 1962

- producer improves technique as it produces
- improvement benefits society
- but producer doesn’t fully capture benefit
- thus, public good problem - - may call for intervention

(5) *Economic Dynamics and Growth*

Arrow, “Economic Implications of Learning by Doing”, 1962

- producer improves technique as it produces
- improvement benefits society
- but producer doesn’t fully capture benefit
- thus, public good problem - - may call for intervention
- foundation of endogenous growth literature

(6) *Economics of Risk*

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, “Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques”, 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods
- can introduce *security* for each state θ (Arrow security)

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods
- can introduce *security* for each state θ (Arrow security)
  - pays off just in that state θ

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods
- can introduce *security* for each state θ (Arrow security)
  - pays off just in that state θ
  - S security markets today

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods
- can introduce *security* for each state θ (Arrow security)
  - pays off just in that state θ
  - S security markets today
  - G "spot" markets tomorrow

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods
- can introduce *security* for each state θ (Arrow security)
  - pays off just in that state θ
  - S security markets today
  - G "spot" markets tomorrow
  - $S + G$ markets

(6) *Economics of Risk*

A. *Securities in General Equilibrium*

Arrow, "Le Rôle des Valeurs Bousières pour la Répartition la Meilleure des Risques", 1953

- Arrow-Debreu model can take into account uncertainty about future
- state of world: complete description of all relevant eventualities
  - weather, natural disasters, new discoveries
- can index goods not only by physical qualities and by date of delivery, but by state of world
  - ensures that competitive equilibrium will be Pareto optimal even in world with uncertain states
  - but huge number of contingent goods

    G = number of goods tomorrow

    S = number of states

    $G \times S$ = number of contingent goods
- can introduce *security* for each state θ (Arrow security)
  - pays off just in that state θ
  - S security markets today
  - G "spot" markets tomorrow
  - $S + G$ markets
  - requires perfect foresight about spot prices

B. *Measures of Risk Aversion*

B. *Measures of Risk Aversion*

Arrow, “Aspects of the Theory of Risk-Bearing,” 1965

B. *Measures of Risk Aversion*

Arrow, “Aspects of the Theory of Risk-Bearing,” 1965

- risk aversion

B. *Measures of Risk Aversion*

Arrow, "Aspects of the Theory of Risk-Bearing," 1965

- risk aversion
  - preferring a monetary gamble's expectation to gamble itself

B. *Measures of Risk Aversion*

Arrow, "Aspects of the Theory of Risk-Bearing," 1965

- risk aversion
  - preferring a monetary gamble's expectation to gamble itself
- corresponds to curvature of utility function $u(m)$ for money m

B. *Measures of Risk Aversion*

Arrow, "Aspects of the Theory of Risk-Bearing," 1965

- risk aversion
  - preferring a monetary gamble's expectation to gamble itself
- corresponds to curvature of utility function $u(m)$ for money m
- Arrow-Pratt coefficient of absolute risk aversion = $-\dfrac{u''(m)}{u'(m)}$

B. *Measures of Risk Aversion*

Arrow, "Aspects of the Theory of Risk-Bearing," 1965

- risk aversion
  - preferring a monetary gamble's expectation to gamble itself
- corresponds to curvature of utility function $u(m)$ for money m
- Arrow-Pratt coefficient of absolute risk aversion = $-\dfrac{u''(m)}{u'(m)}$
- coefficient of relative risk aversion = $-\dfrac{mu''(m)}{u'(m)}$