Отклик экономики на шок в предпочтениях потребителей: прогноз, основанный на модели общего равновесия
Response of an Economy to the Shock in Preferences of Consumers: Scenarios Inferred from General Equilibrium Modeling

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HSE University

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Laboratory

- Lab of modeling and control of complex systems
- Application of modern mathematical, computational, machine learning, and statistical tools to analyze data, construct predictions, detect anomalies, and assess the probabilities of extreme events.
- Collaboration with such centers of excellence as the Paris Institute of the Earth Physics, Paris-Sud University, New Economics School (Russia), the Gran Sasso Science Institute, Toulouse School of Economics, and the University of St. Gallen.
- General equilibrium modeling of economy: theoretical predictions and computations

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Motivation

Income inequality

- Rise of income dispersion in the US and UK since 1960s and 1970s (review by Machin, 2008)
- "Race" between the relative demand for labor and the relative supply of it, Katz & Murphy 1992
- Skill-biased technological changes, Acemoglu 2002
- Labor market institutions, Lee 1999

Between-industry inequalities

- up to 40% of income redistribution in favor of high-skilled workers, Berman et al 1998
- Integral development of industries matters, Gittleman & Wolf 1993
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Research question

The aim of the talk

Using General Equilibrium Model (GEM) with monopolistically competing firms to describe the response of an economy to a shift in markets' size driven by consumers' tastes for skill-intensive products, namely, changes in:
(1) in inter-industry wage inequality,
(2) prices,
(3) output,
(4) number of firms,
(5) sector output,
(6) number of employed and unemployed workers

Source of ambiguity: elasticity of substitution between high-tech goods

Recent development underlying our model

- GEM with a single high-tech sector, monopolistically competing firms, and additive unspecified consumers' preferences, Zhelobodko et al 2012
- Applications of intra-firm bargaining game within organizations where employees and the firm engage in wage negotiations, Stole & Zwiebel 1996
- Monopolistic competition settings are combined with labour market frictions, Helpman et al 2008
- GEM with a shift in consumers' tastes and consequent changes in the demand for labor, Leonardi 2003

History

- At the time of the Agricultural Revolution the demand for plants and wheat changed the lifestyle of Homo Sapiens and increased the inequality, as the surplus of food was taken by the regime.
- Covid restrictions affect the demand of Homo Sapiens. What are consequences for inequality?

History

- At the time of the Agricultural Revolution the demand for plants and wheat changed the lifestyle of Homo Sapiens and increased the inequality, as the surplus of food was taken by the regime.
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The structure of economy

- An economy consists of a traditional sector (henceforth sector 0) with perfect competition and of n high-tech sectors with N_i monopolistically competing single-product firms in each sector, $i = 1, \ldots, n$.
- In a traditional sector, firms price their products at the marginal cost because of the perfect competition. Productivity is supposed to be 1, prices are equal to wages: $p_0 = w_0$.
- $L_0, L_1, \ldots, L_n$ denote the number of employed workers in sectors $0, 1, \ldots, n$.
- L_i^u is a number of unemployed workers at the i-th sectors where $i = 1, \ldots n$. General number of unemployed $L_{n+1} = L_1^u + \ldots + L_n^u$ forms the 'virtual' $(n+1)$-th sector.
- $\mathcal{L}$ is the number of workers in the economy: $\mathcal{L} = L_0 + \sum_{k=1}^{n} (L_i + L_i^u)$

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Supply: high-tech sectors, following the Krugman model

- Firms maximize their profits
- Free entry condition

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Demand

Upper tier: a common Cobb–Douglas utility

- The income of consumers depends on the sector.
- There are $n+2$ types of the incomes y_0, y_1, …, y_{n+1} in the economy, denoted after the sectors.
- A representative consumer with an income y_j decides upon her demand in two steps:
  Step 1: she differentiates between high-tech varieties represented by consumption indices H_i, $i = 1, \ldots, n$, and a traditional good H_0:

$$U = H_0^{\beta_0} H_1^{\beta_1} \ldots H_n^{\beta_n} \longrightarrow \max, \qquad (1)$$

  where the exponents β_i, $i = 0, 1, \ldots, n$, are summed up to 1, and allocates her income proportionally to the exponents β_i for products of the i-th sectors.

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Lower tier: sector-specific additive utilities

Step 2: each consumer "reminds" the details of the ith consumption index and chooses specific varieties of the composites based on a low-tier utilities $u_i(\varkappa)$ (identical among consumers). which reflects preferences for sector i's variety, subject to budget constraint

- Elasticity of substitution

$$\sigma_i(\varkappa) = -\frac{u_i'(\varkappa)}{u_i''(\varkappa)\varkappa}$$

- Two types of $\sigma_i(\cdot)$: increasing and decreasing
- Examples:

$$\sigma(\varkappa) = A\left(1 + \frac{1}{\varkappa+1}\right) \quad \text{and} \quad \sigma(\varkappa) = A\left(2 - \frac{1}{\varkappa+1}\right), \quad A \geqslant 1,$$

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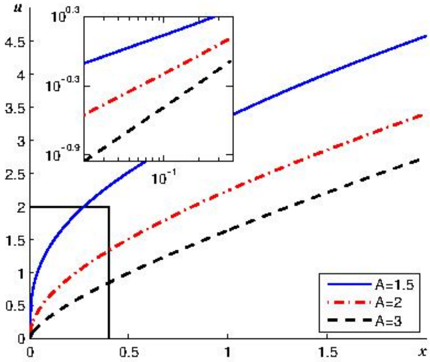
Elasticity of substitution. Example



Labor market

- Workers and firms are homogeneous within each sector. This equalizes intra-sector wages.
- Labor market exhibits frictions: rejected candidates cannot find another job immediately. The balance on the labor market is achieved when the *average* incomes in different sectors coincide
- Taxes are transferred to unemployed agents

Equilibrium

The problem is well posed

Sector-symmetrical equilibrium exists under general assumptions

By construction

- Workers are attracted by higher wages but face the risk to be unemployed
- The choice of jobs is balanced by *average* wages; therefore unemployment remains in the equilibrium
- Workers accept wages proposed by firms under pressure of unemployment agents
- A fixed part of employment workers' income is transfered to unemployment agents

Comparative statics: $\beta_i \nearrow$, sector i expands, $\beta_0 \searrow$

Exponents β_i appear in the Cobb–Douglas utility

	$\beta_i \nearrow$			
	$\sigma' > 0$		$\sigma' < 0$	
Response	competitive		monopolistic	
	expanding sector i	another sector j	expanding sector i	another sector j
# {firms}	$N_i \nearrow$	$N_j \searrow$	$N_i \nearrow$	$N_j \nearrow$
RD (relative diversity)	$\frac{N_i}{\beta_i \mathcal{L}} \searrow$	$\frac{N_k}{\beta_k \mathcal{L}} \searrow$	$\frac{N_i}{\beta_i \mathcal{L}} \nearrow$	$\frac{N_k}{\beta_k \mathcal{L}} \nearrow$
Outputs	$Q_i \nearrow$	$Q_j \nearrow$	$Q_i \searrow$	$Q_j \searrow$
Sector output	$N_i Q_i \nearrow$	$N_j Q_j \nearrow$	$N_i Q_i \nearrow$	$N_j Q_j \searrow$
# {employed}	$L_i \nearrow$	$L_j \nearrow$	$L_i \nearrow$	$L_j \searrow$
Prices	$p_i \searrow$	$p_j \searrow$	$p_i \nearrow$	$p_j \nearrow$
Income inequality	$y_i/y_0 \searrow$	$y_j/y_0 \searrow$	$y_i/y_0 \nearrow$	$y_j/y_0 \nearrow$
#{unemployed}	$L_{n+1} \nearrow$		$L_{n+1} \nearrow$	

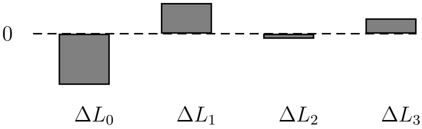
Unemployment

A growth of unemployment as the response to demand shocks

Although in most cases the number of employed workers in all high-tech sectors goes up, we can expect that
(1) initially employed workers are still employed in the expanding sector,
whereas
(2) other individuals attracted by sector expansion enter its labour market to find a job,
(3) the number of accepted candidates is regulated by firms' equilibrium output so that only a part of them is accepted.

Changes in unemployment and welfare

- Example
  - decreasing elasticity of substitution ($\sigma' < 0$);
  - 3-sector economy;
  - shock in demand: from sector 0 to sector 1
- The differences ΔL_i, $i = 0, 1, 2, 3$, between new and old numbers of individuals associated with sector i; index 3 corresponds to the unemployed agents, the horizontal dashed line indicates 0.



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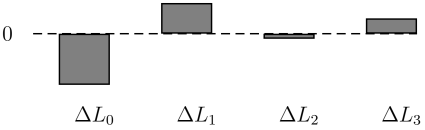

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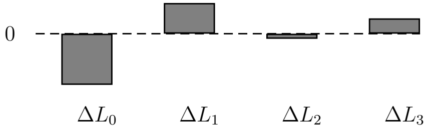

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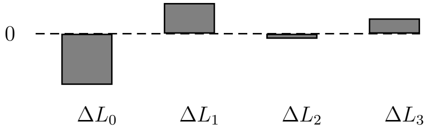

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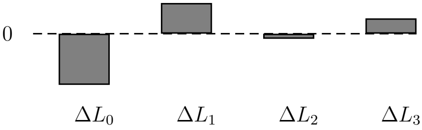


Prices and outputs

If the elasticity of substitution $\sigma_i(\cdot)$ is an increasing function

High-tech sectors response pro-competitively to inflow of workers, increasing output Q_i and decreasing prices p_i

If the elasticity of substitution $\sigma_i(\cdot)$ is an decreasing function

We have the opposite effect: output Q_i of a firm goes down while prices p_i go up

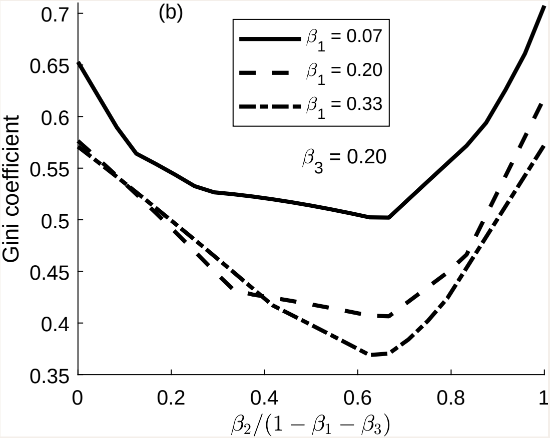
In any case the sector output increases

The last effect is interesting as it takes place in parallel to a drop in the output in the second case. The effect is provided by a faster growth in the number of firms N_i. So, the number and output of firms "compete" in the monopolistic case resulting in the growth in the expected output.

Quantitative response

- We are the first who find the significant quantitative effect in the model from the variable elasticity of substitution

Gini coefficient



Changes in the Gini coefficient, as β_2 varies. The utility is characterized by the decreasing elasticity of substitution.

THANK YOU

THANK YOU

СПАСИБО

THANK YOU

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high-tech sectors, following the Krugman model

Maximization of profit

A firm producing a good ξ_i in the i-th high-tech sector faces sector specific variable c_i^v and fixed c_i^φ costs. It tunes its price $p(\xi_i)$ to maximizes the profit:

$$\pi(\xi_i) = p(\xi_i)Q(\xi_i) - c_i^v Q(\xi_i) - c_i^\varphi \longrightarrow \max,$$

where $Q(\xi_i)$ is the aggregate demand for the good ξ_i in the i-th sector that depends on the price $p(\xi_i)$. Free entry condition $\pi(\xi_i) = 0$ regulates the number (mass) N_i of goods in the i-th sector.

Negligibility of each firm

Accepting standard monopolistic competition settings, we expect each particular firm to be so small that tuning its prices it fails to affect a price index in the i-th sector.

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Lower tier: sector-specific additive utilities

Step 2: each consumer "reminds" the definition of the consumption index as an additive utility from the consumption of each particular product $\xi_i \in [0, N_i]$, $i = 1, \ldots, n$. Consumers choose the demands $q_j(\xi_i)$, where $j = 0, \ldots, n$ indicates the income y_j of the consumer, for each $i = 1, \ldots, n$ maximizing the consumption index

$$H_i = \int\limits_{N_i} u_i\left(q_j(\xi_i)\right) d\xi_i \longrightarrow \max,$$

with a low-tier utility function $u_i(\varkappa)$, which reflects preferences for sector i's variety, subject to budget constraint

$$\int\limits_{N_i} p(\xi_i) q_j(\xi_i) d\xi_i \leqslant \beta_i y_j.$$

$$\text{Elasticity of substitution} \quad \sigma_i(\varkappa) = -\frac{u_i'(\varkappa)}{u_i''(\varkappa)\varkappa},$$

between high-tech goods, underlies the optimal individual demands $q_j(\xi_i)$:

$$\text{elasticity} \quad \mathcal{E}_{p(\xi_i)} q_j(\xi_i) = -\sigma_i(q_j(\xi_i)) \quad \text{(FOC)}$$

Equilibrium in the model with a single high-tech sector is described with $\sigma_i(q_j(\xi_i))$, $j = i$. Multi-sector case requires an aggregate elasticity of substitution

$$\mathfrak{S}(\xi_i) = \sum_{j=0}^{n} \frac{q_j(\xi_i) L_j}{Q(\xi_i)} \sigma_i(q_j(\xi_i)), \text{where} \quad Q(\xi_i) = \sum_{j=0}^{n} L_j q_j(\xi_i),$$

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- Labor market exhibits frictions: rejected candidates cannot find another job immediately. The balance on the labor market is achieved when the *average* incomes in different sectors coincide

$$\frac{y_i L_i}{L_i + L_i^u} + \frac{y_{n+1} L_i^u}{L_i + L_i^u} = y_0$$

- Tax and unemployment payment

$$y_i = (1-\alpha) w_i,\ i = 0 \ldots, n, \quad y_{n+1} = \frac{\alpha(L_0 w_0 + L_1 w_1 + \ldots + L_n w_n)}{L_{n+1}}$$

Assumptions

Assumption 1

Sectors are large in the equilibrium, $\sigma_i(\varkappa) > 1$

$$|\sigma_i'(\varkappa)| < \frac{c_i^{\varphi} L_j}{2c_i^v} \quad \text{for all } i = 1, \ldots, n,\ j = 0, \ldots, n+1, \text{ and } \varkappa \geqslant 0.$$

Assumption 2

Limited diversity of equilibrium individual demands q_{ij}:

$$\frac{\sigma_i(q_{ij})}{\sigma_i(q_{ij'})} < 2 \quad \text{for all } j = 0, 1, \ldots, n+1,\ j' = 0, 1, \ldots, n+1.$$

Assumptions

Assumption 1

Sectors are large in the equilibrium, $\sigma_i(\varkappa) > 1$

$$|\sigma_i'(\varkappa)| < \frac{c_i^{\varphi} L_j}{2c_i^v} \quad \text{for all } i = 1, \dots, n,\ j = 0, \dots, n+1, \text{ and } \varkappa \geqslant 0.$$

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Equilibrium

The problem is well posed

Under the above assumptions an equilibrium exists. It is unique and sector-symmetrical, $p_i = p(\xi_i)$, $q_{ij} = q_j(\xi_i)$.

By construction

- Workers are attracted by higher wages but face the risk to be unemployed
- The choice of jobs is balanced by *average* wages; therefore unemployment remains in the equilibrium
- Workers accept wages proposed by firms under pressure of unemployment agents
- A fixed part of employment workers' income is transfered to unemployment agents

Description of the equilibrium

When $\mathcal{L}$ is large enough (Assumption 1)

- Outputs $Q_i \sim C_i = c_i^{\varphi}/c_i^{v}$ (scaled by C_i)
- Individual outputs $q_{ij} \sim \theta_i c_i^{v} C_j/\mathcal{L}$ tend to 0
- Two previous conclusions agree with that in the model with CES preferences
- Restrictive Assumption 2: $\sigma_i(q_{ij})/\sigma_i(q_{ij'}) < 2$ turns to

$$\frac{\sigma_i(0) + |\sigma_i'(0)|K_i/\mathcal{L}}{\sigma_i(0)} < 2, \quad K_i > 0 \text{ is an appropriate constant,}$$

which only repeats (Assumption 1) that $\sigma_i'(0)$ is small with respect to $1/\mathcal{L}$ (not restrictive)

Equilibrium variables

Proposition 1

A general equilibrium exists, and it is unique. This equilibrium is symmetrical with respect to goods in the i-th variety: $p(\xi_i)$ *and* $q_j(\xi_i)$ *depends on* i *but not on specific goods. We denote*

$$p_i = p(\xi_i), \quad q_{ij} = q_j(\xi_i), \quad Q_i = Q(\xi_i), \quad \mathfrak{S}_i = \mathfrak{S}(\xi_i). \tag{2}$$

symmetrical equilibrium variables. Then they are

$$Q_i = c_i^{\varphi} \frac{\mathfrak{S}_i - 1}{c_i^{v}}, \tag{3}$$

$$L_i = \frac{\beta_i \mathcal{L}}{\mu_i} \cdot \frac{\mathfrak{S}_i - 1}{\mathfrak{S}_i}, \quad L_i^u = \beta_i \mathcal{L} - L_i, \quad L_0 = \beta_0 \mathcal{L}, \tag{4}$$

$$w_i = \frac{\mu_i w_0 \mathfrak{S}_i}{\mathfrak{S}_i - 1}, \quad N_i = \beta_i \frac{w_0 \mathcal{L}}{c_i^{\varphi} \mathfrak{S}_i}. \tag{5}$$

Concluding remarks

- We construct a general equilibrium assuming that firms select an optimal amount of workers within job market candidates. Our model separates effects from a technological progress and the evolution of tastes. A development of technologies reduces the number of (less skilled) workers but increases wages.
- The role of demand posited in this paper needs empirical evidence. On one hand, our research can reconcile somewhat controversial empirical conclusions obtained with various data describing different countries. On the other hand, it is difficult to discriminate between consequences of abrupt shocks linked to f.e., trade agreements and changes in spending that lead to the opposite predictions regarding the monopolistic competition.

Concluding remarks

- We construct a general equilibrium assuming that firms select an optimal amount of workers within job market candidates. Our model separates effects from a technological progress and the evolution of tastes. A development of technologies reduces the number of (less skilled) workers but increases wages.
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Concluding remarks

- Our framework suggests an empirical strategy that highlights the role of the elasticity of demand in development of high-tech sectors. First, the paper predicts that a percentage change in the relative income gap depends linearly on the ratio of fixed to variable costs. Second, effects of supply (measured with markup) and demand (measured with its elasticity) are separated when the number of employees is investigated.