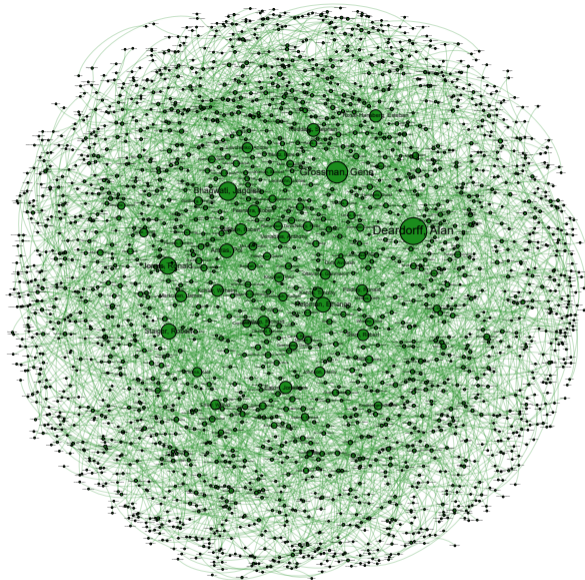


An 'Austrian' Model of Global Value Chains

Pol Antràs

Harvard University and NBER

October 7, 2022



(Size of ball is proportional to someone's number of PhD students with publications in International Trade)

Source: Alan Deardorff's family tree via Bohdan Kukharskyy



Ronald E. Findlay (1935-2021)



Ronald W. Jones (1931-2022)

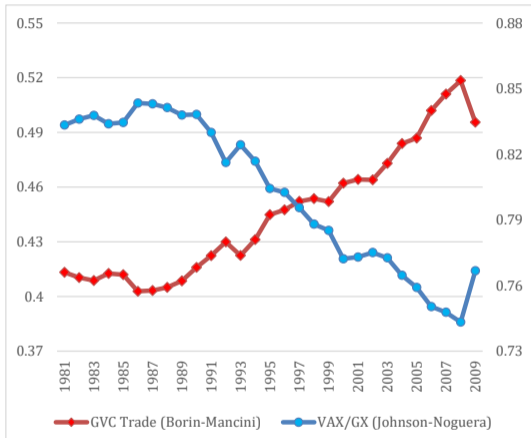
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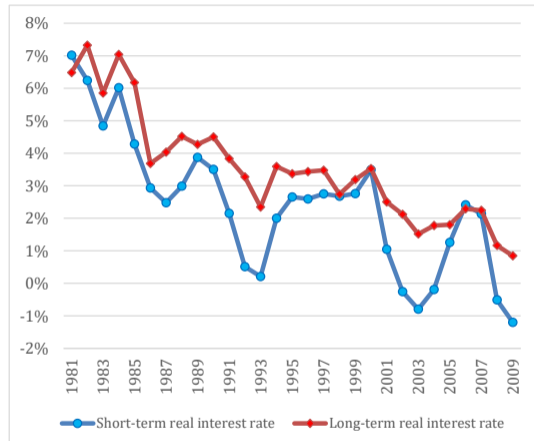
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Two Salient Trends in World Economy



Rising GVC Participation



Declining Real Interest Rates

A Link? Potential Mechanism

- Is the observed decline in real interest rates partly responsible for the growth in GVCs?
- **Potential mechanism:** a period of low interest rates can facilitate the sustainability of *longer* production processes and delivery times (which may better allocate worldwide resources to their more efficient use)
- Formalizing this hypothesis is not straightforward: it requires developing a framework with an explicit notion of production length and of delivery time (not standard in trade)
- I build an 'Austrian' model of GVCs à la Böhm-Bawerk (1889), Wicksell (1934), and Findlay (1978)

Goals of the Paper

- I develop a stylized model of sequential production with N stages in which the **time length** of each stage is **endogenously determined**
- Letting the production process *mature* increases labor productivity, but it comes at the cost of higher working capital needs for firms
- I study autarky, free trade and costly trade equilibria
- Some issues the model might be particularly suitable to shed light on:
 - ① Does it matter how **capital** is conceptualized? Clark (1888) vs. Böhm-Bawerk (1889)
 - ② What are the roles and effects of **trade credit** and **trade finance**?
 - ③ What are the implications of the **temporal dimension of trade costs**, and how are they shaped by interest rates?
- Let me defer the discussion of the main results (**Gene wants to see the model!**)

Literature Review (Gene **really** wants to see the model!)

- 'Austrian' concept of capital
 - ▶ Jevons (1871), Böhm-Bawerk (1889), Wicksell (1934), Metzler (1950), **Findlay (1978)**
- Sequential GVCs
 - ▶ Dixit and Grossman (1982), Sanyal and Jones (1982), Yi (2003, 2010), Harms et al. (2012), Antràs and Chor (2013), Costinot et al. (2013), Baldwin and Venables (2018), Kikuchi et al. (2018), Alfaro et al. (2019), Johnson and Moxnes (2019), Antràs and de Gortari (2020), Tyazhelnikov (2022)
- GVCs and Capital: Sposi et al. (2021), Ding (2022)
- Trade and Time: Deardorff (2003), Evans and Harrigan (2005), Hummels and Schaur (2013)
- Inventories, Just-in-Time: Alessandria et al. (2011), Ferrari (2022), Pisch (2022), Carreras-Valle (2022)

Closed-Economy Model: Environment

- Time evolves continuously
- Infinitesimal agents are born at a rate ρ per unit of time and die at the same rate; population mass is constant and equal to L
- All agents are endowed with one unit of labor services which they supply inelastically to the market
- Consumers value a single final good, which it is taken to be the numéraire
- The technologies to be described below are freely available to all agents in the economy, and perfect competition prevails in all markets

Closed-Economy Model: Multi-Stage Production

- Production of the final good needs to undergo N stages in a pre-determined order
- At each stage $n > 1$, production combines labor with the good finished up to $n - 1$
- Production in the initial stage $n = 1$ only uses labor
- Production technologies in all sectors are homogeneous of degree one
- I will restrict the analysis to Cobb-Douglas production technologies at all stages $n > 1$:

$$y_n = (z_n L_n)^{\alpha_n} (y_{n-1})^{1-\alpha_n}$$

- z_n denotes labor productivity at stage n , and $\alpha_n \in [0, 1]$ is value-added-intensity at n

Closed-Economy Model: Optimal Production Length

- Production *takes time*: the more time is spent on production, the more output is obtained
 - ▶ I formalize this in an 'Austrian' manner following the approach in Findlay (1978)
- Consider stage n : firms initially hire an amount L_n of labor, and could instantaneously produce an amount $y_n = (z_n(0) L_n)^{\alpha_n} (y_{n-1})^{1-\alpha_n}$ of stage- n output
- But by 'waiting' and letting the production process 'mature', labor efficiency increases as a function of time, though at a diminishing rate (Metzler's and Findlay's wood metaphor)
 - ▶ $z'_n(t) > 0$ and $z''_n(t) / z'_n(t) < z'_n(t) / z_n(t)$
- Lengthening production and delaying sales comes at cost of higher working capital needs
- Producers maximize their profits:

$$\pi_n = p_n (z_n(t_n) L_n)^{\alpha_n} (y_{n-1})^{1-\alpha_n} e^{-rt_n} - wL_n - p_{n-1}y_{n-1}$$

Closed-Economy Model: Optimal Production Length

- The optimal stopping (or 'chopping' off) time t_n^* satisfies:

$$\alpha_n \frac{z'_n(t_n^*)}{z_n(t_n^*)} = r$$

- The length and labor productivity of all production processes are decreasing in r
- **Log-linear case:** when $z_n(t_n) = (t_n)^{\zeta_n}$, we have $t_n^* = \alpha_n \zeta_n / r$
 - ▶ The optimal length t_n^* of a given stage is increasing in the value-added intensity α_n and time intensity ζ_n of stage n , and decreasing in the interest rate r
 - ▶ But rt_n^* is independent of the interest rate r (**very helpful!**)
- I obtain same results when solving the *lead-firm* problem (Antràs and de Gortari, 2020)

Closed-Economy Model: Equilibrium in the Labor Market

$$L_n = \frac{\alpha_n \beta_n e^{-r \sum_{m=n}^N t_m^*}}{\sum_{n'=1}^N \alpha_{n'} \beta_{n'} e^{-r \sum_{m=n'}^N t_m^*}} L$$

- More labor is allocated to relatively more important stages of production (high $\alpha_n \beta_n$) and also to relatively **downstream stages** (due to lower capital costs)

$$w = \kappa \prod_{n=1}^N \left(z_n(t_n^*) e^{-r \sum_{m=n}^N t_m^*} \right)^{\alpha_n \beta_n}$$

- Envelope theorem implies that the lower is the interest rate r , the higher is the wage

Closed-Economy Model: Demand for Capital

- **Cumulated** working capital needs associated with stage- n labor costs are given by

$$e^{r \sum_{m=n}^N t_m^*} wL_n$$

- In a stationary equilibrium with a time-invariant distribution of production processes of different ages, we have

$$K^d = \sum_{n=1}^N wL_n \int_0^{\sum_{m=n}^N t_m^*} e^{rt} dt = \sum_{n=1}^N wL_n \frac{e^{r \sum_{m=n}^N t_m^*} - 1}{r}$$

- Aggregate capital demand typically falls in interest rate r (certainly in log-linear case)
- Invoking the zero-profit condition at all stages, we obtain

$$y_N = \sum_{n=1}^N wL_n e^{r \left(\sum_{m=n}^N t_m \right)} = wL + rK^d$$

Closed-Economy Model: Supply of Capital and Capital-Market Equilibrium

- Borrow supply of capital from à la Antràs and Caballero (2009, 2010)
 - ▶ Final good is only store of value
 - ▶ Agents save their income and consume right before dying (ρ governs impatience)
- Supply of capital at any point in time is proportional to labor income

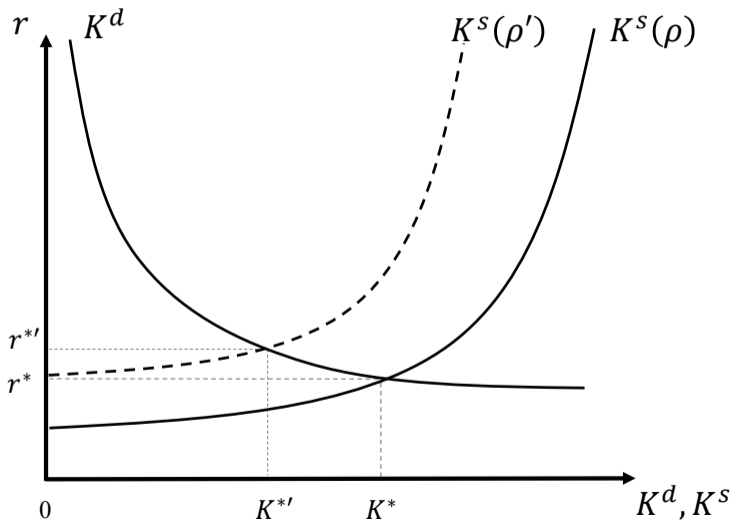
$$K^s = wL \times \sigma(r, \rho),$$

with σ being increasing in r and decreasing in ρ

- Equilibrium interest rate pinned down à la Metzler (1951)

$$\frac{K^d}{wL} = \sum_{n=1}^N \frac{L_n}{L} \frac{e^{r \left(\sum_{m=n}^N t_m^* \right) - 1}}{r} = \sigma(r, \rho) = \frac{K^s}{wL}$$

Equilibrium in the Capital Market



Open-Economy Model: Environment

- Consider a world economy in which two economies (Home and Foreign) engage in international trade
- I make a number of simplifying assumptions:
 - ▶ Countries are symmetric in all respects except for the ‘impatience’ of their agents (Home is more patient)
 - ▶ All production technologies and all functions $z_n(t_n)$ are common in both countries
 - ▶ I mostly focus attention on log-linear case with $z_n(t_n) = (t_n)^{\zeta_n}$
 - ▶ I abstract (for now) from trade costs, and rule out the possibility of international borrowing or lending, or of international trade credit/finance
- Under autarky, interest rate is lower ($r^H < r^F$) and wage is higher ($w^H > w^F$) at Home
- For now, I impose that factor price differences remains true under free trade

Comparative Advantage

- It may seem intuitive that the more patient Home would have a comparative advantage in relatively upstream stages of production
 - ▶ Cumulated interest until final consumption is higher for those stages
 - ▶ Indeed, a key result in Findlay (1978) is that the more patient country specializes upstream
- **WRONG!**
- No reason to wait to be paid until final good is completed and sold to consumers
- What if producers at n are paid right after producing by $n - 1$ producers?
- This is actually implied by **no international borrowing and lending** when n and $n + 1$ are produced in different countries

Comparative Advantage

- Ratio of Home to Foreign prices at stage n is given by

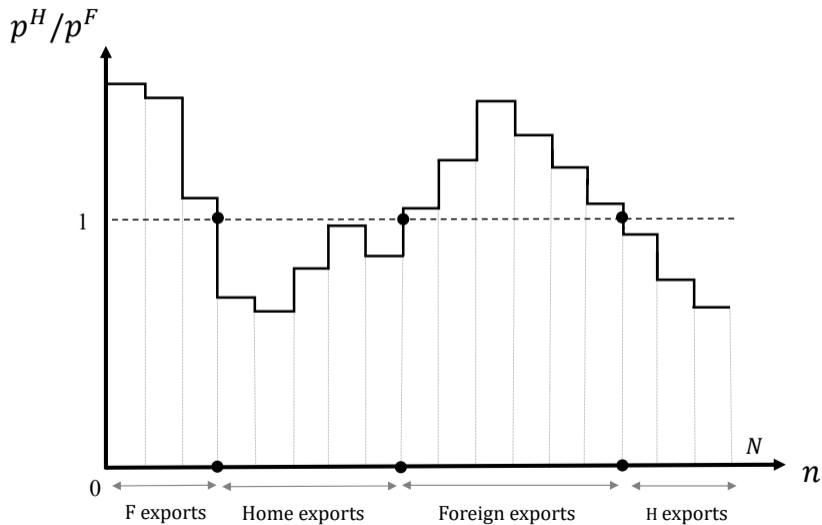
$$\frac{p_n^H}{p_n^F} = \left(\frac{w^H z_n(t_n^F) e^{r^H t_n^H}}{w^F z_n(t_n^H) e^{r^F t_n^F}} \right)^{\alpha_n} \left(\frac{p_{n-1} e^{r^H t_n^H}}{p_{n-1} e^{r^F t_n^F}} \right)^{1-\alpha_n}$$

- In the log-linear case ($z_n(t_n) = (t_n)^{\zeta_n}$) this reduces to

$$\frac{p_n^H}{p_n^F} = \left(\frac{w^H}{w^F} \left(\frac{r^H}{r^F} \right)^{\zeta_n} \right)^{\alpha_n}$$

- Comparative advantage is shaped by the relative size of the parameter ζ_n across stages
- So what matters is **relative time intensity**, not relative upstreamness

Comparative Advantage and Downstreamness



Trade Equilibrium with Factor Price Differences

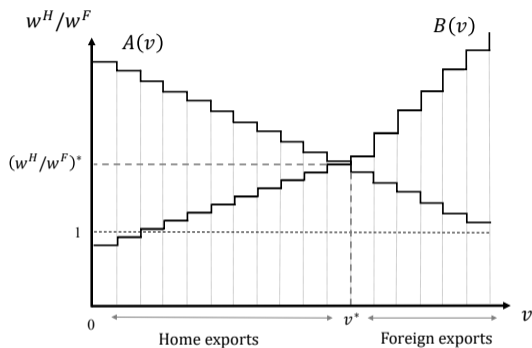
- Assume we can partition the set of stages into two disjoint sets \mathcal{N}^H and \mathcal{N}^F , with \mathcal{N}^j being the set of stages in which country $j = H, F$ has comparative advantage
- Let us next reorder stages in decreasing order of their time intensity ζ_n (using index ν)
- Define the relative labor efficiency schedule

$$A(\nu) \equiv \frac{z_n(t_n^H)}{z_n(t_n^F)} = \left(\frac{r^F}{r^H} \right)^{\zeta_\nu}$$

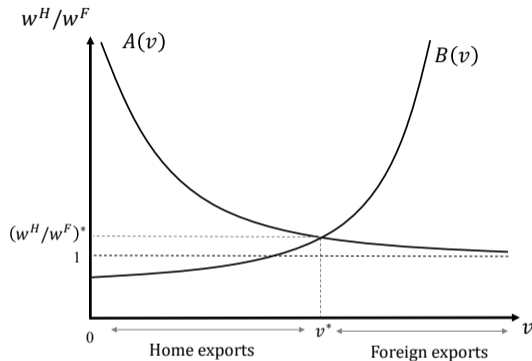
- Labor-market clearing imposes

$$\frac{w^H}{w^F} = \frac{\sum_{n \in \mathcal{N}^H} \alpha_n \beta_n e^{-\sum_{m=n}^N \alpha_m \zeta_m}}{\sum_{n \in \mathcal{N}^F} \alpha_n \beta_n e^{-\sum_{m=n}^N \alpha_m \zeta_m}} \equiv B(\nu^*)$$

Trade Equilibrium with Factor Price Differences



Discrete Number of Stages



Continuum of Stages

- Looks analogous to Dornbusch et al. (1977), but note that the $A(v)$ schedule is endogenous and shaped by differences in interest rates

Trade Equilibrium with Factor Price Differences

- Equilibrium r^H and r^F can be solved invoking capital-market clearing
- Capital intensity at stage n in country j can be expressed as

$$\frac{K_n^j}{L_n^j} = \frac{w^j}{r^j} \frac{1}{\alpha_n} e^{\alpha_n \zeta_n},$$

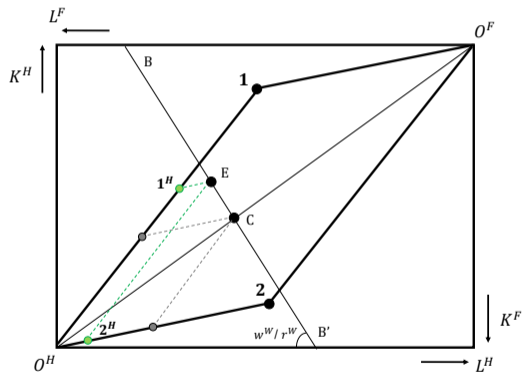
- Imposing capital-market clearing, we then get

$$\frac{w^H/r^H}{w^F/r^F} = \frac{(K^S)^H \sum_{n \in \mathcal{N}^F} L_n^F \frac{1}{\alpha_n} (e^{\alpha_n \zeta_n} - 1)}{(K^S)^F \sum_{n \in \mathcal{N}^H} L_n^H \frac{1}{\alpha_n} (e^{\alpha_n \zeta_n} - 1)} \quad (1)$$

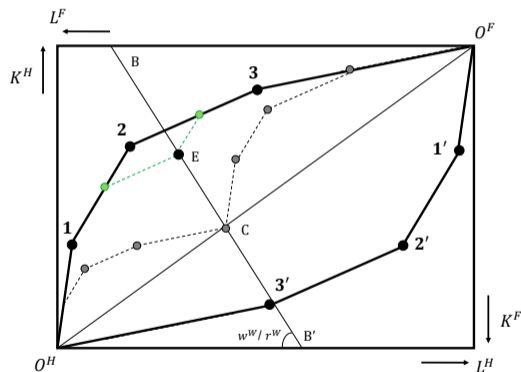
- As long as the right-hand side of equation (1) is higher than one, the equilibrium will indeed entail a lower interest rate at Home

Trade Equilibrium with Factor Price Equalization

- What if there is FPE? Then labor productivity differences across countries vanish, and we are back to Heckscher-Ohlin model. **Only capital intensity matters!**



Two-Stage ($N = 2$) Case



Four-Stage ($N = 4$) case

Trade Credit

- Without FPE, exporters sometimes face higher interest rates than importers
- Would importers not have an incentive to provide trade credit to exporters? Yes!
- **Insight #1:** International trade credit expands FPE set
- **Insight #2:** Relative to baseline model, Home is (typically) more likely to buy from Foreign (since it can do so using the Foreign wage and the Home interest rate)
- **Insight #3:** Relative to the baseline model without trade credit, Foreign is more likely to use Home inputs in production (because trade credit reduces their costs disproportionately)
- Insights #2 and #3 imply that the introduction of **trade credit deepens vertical specialization** and results in an increase in the extent to which intermediate goods cross borders along the production process

Costly Trade: Standard Iceberg Trade Costs

- This is not as simple as in the (seemingly) isomorphic Dornbusch et al. (1977) paper!
- Similar 'bunching' effects as in sequential models of Harms et al. (2012) and Baldwin and Venables (2013)
 - ▶ Though dynamic programming leads to neater characterization
 - ▶ For example, Foreign producers at stage $n + 1$ may choose Foreign as a source of inputs at stage n even when $w^F (r^F)^{\zeta_n} > w^H (r^H)^{\zeta_n}$, which indicates a **disproportionate desire to bunch contiguous stages** in the same location
- As in Antràs and de Gortari (2020), in choosing their optimal path of production, firms will be more concerned about reducing trade costs in relatively downstream stages than in relatively upstream stages

Costly Trade: Time as a Trade Barrier

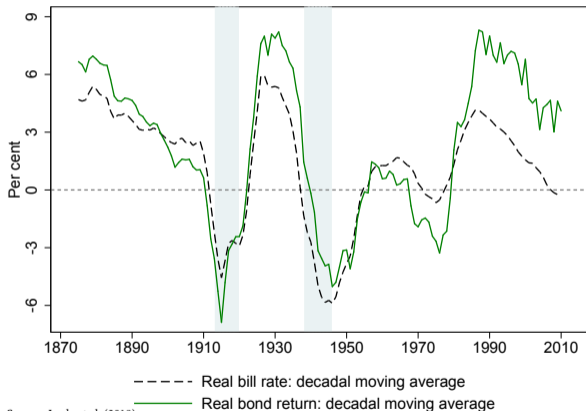
- By incorporating an explicit time value of money, framework can easily accommodate a temporal dimension of trade costs
 - ▶ Assume that shipping goods across borders involves an additional interval of time d
- **Insight #1:** Temporal trade costs have no bearing on the length of production processes
- **Insight #2:** Temporal trade costs generate same effects of standard trade costs
 - ▶ Bunching, compounding effect of trade costs
- **Insight #3:** As long as no FPE, $\tau^{HF} < \tau^{FH}$.
 - ▶ Asymmetric bilateral trade costs in the spirit of Waugh (2010)
- **Insight #4:** Reductions in interest rates worldwide tend to increase the extent to which goods cross borders, hence generating a higher amount of GVC participation

Conclusions

- I develop a stylized model of sequential production with N stages in which the time length of each stage is endogenously determined
- Letting the production process *mature* increases labor productivity, but it comes at the cost of higher working capital needs for firms
- ‘Austrian’ notion of capital has different implications for the pattern of specialization than the Clark-Samuelson notion of capital
- Incorporating an explicit notion of time and modeling interest rates has implications for:
 - ▶ The effects of **trade credit** and **trade finance**
 - ▶ The role of **temporal trade costs** in shaping specialization
- Many potential extensions come to mind: scale economies, imperfect competition, financial frictions, firm heterogeneity, etc.

Low Interest Rates in Historical Perspective

Figure 3: Trends in real returns on bonds and bills



Source: Jorda et al. (2019)