Structural Transformation and the Role of Financial Friction

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Abstract

This paper examines the impact of financial frictions on the process of structural transformation. The financial constraints within the manufacturing sector impede both the paths of industrialization and de-industrialization by stimulating capital accumulation. Through numerical simulations, two key findings emerge: firstly, the presence of financial frictions slows down the pace of structural transformation, and secondly, it incentivizes capital accumulation, which is crucial for economic development. Building on these foundational insights, this paper conducts an examination of South Korea's developmental narrative during the 1970s. This case study serves as an illustration of how industrial policies interact with financial constraints to influence the trajectory of structural transformation. By dissecting South Korea's policies and their outcomes within the context of market imperfections, this paper finds that while the effect of the short term policy to hasten the industiralization is limited, the timing of the industrial policy was crucial in alleviating the financial frictions and encouraging structural transformation.

Keyword: Growth, Financial Frictions, Non-balanced Growth, Industrial Policy

JEL Classification: E2, O1, O2, O4, N6

1 Introduction

Developing nations striving to industrialize aim to achieve structural transformation by reallocating resources from low-productivity sectors, such as agriculture, to higher-productivity sectors like manufacturing.

Industrialization, in the process of structural transformation, is a policy goal for developing nations, because it is viewed as an essential for fostering overall economic growth and elevating living standards.

Nevertheless, these countries often confront substantial financial constraints that hinder this transformation. The industrial sector, being highly reliant on access to finance for investment in technology and capital, is particularly susceptible to such frictions. Consequently, there exists a pressing need for economic theory to develop models that integrate structural transformation while considering the financial impediments that obstruct this process.

Existing models of structural transformation, however, often lack the complexity to fully capture its nuances. Notably, these models, for example from Ngai and Pissarides (2007) to Herrendorf, Rogerson and Valentinyi (2020), typically assume efficient market. This omission hinders our ability to quantify the potential dynamic gains from industrial policy interventions or, conversely, the negative effects of financial frictions on structural transformation, capital accumulation, and long-term economic growth.In light of these observations, this paper aims to address a pivotal question: What is the role of financial friction in shaping the path of structural transformation, and what is the impact of the policy to alleviate them?

Building upon existing models, this paper addresses the role of financial frictions within a dynamic framework of structural transformation. Through simulations of the United States economy from 1700 to 2100, I demonstrate that financial friction acts as a drag on structural transformation. This friction impedes both industrialization and de-industrialization processes, while achieving higher growth at the expense of consumption.

To investigate the impact of financial friction, this paper builds upon existing structural transformation models similar to those presented in Buera et al. (2021), which assumes an efficient market, by introducing frictions. As a constraint, an acess to working capital needed to hire labor. This modified model successfully replicates the documented hump-shaped pattern of historical value-added transformation. My analysis demonstrates that under parameteric restrictions and binding financial constraints, the industrialization process experiences a delay, evident in both consumption and investment shares. Financial friction introduces two key distortions: (i) constrained labor demand choices negatively impacting total output, and (ii) distorted rental rates influencing investment decisions, leading to overinvestment This misallocation of labor and capital disrupts overall price dynamics, hindering relative price growth and relative value-added growth compared to the First Best benchmark. [1]

In light of the considerations outlined above, this paper proposes a novel algorithm specifically designed to compute the Stable Transformation Path (STraP) under financial friction. The Stable Transformation Path, first proposed Buera et al. (2021), is designed to capture the medium-run dynamics of an economy between two asymptotic balanced growth path (aBGP), regardless of its initial capital level. The approach employed in Buera et al. (2021) however, is not directly applicable due to the absence of closed-form aggregate production function in the economy.

In this paper, I exploited the fact that only the manufacturing sector is constrained – thus regardless of the existence of the financial frictrion, the two limit aBGP, namely agricultural economy and service economy, is identical to the First Best. The simulation path then is pinned down to ensure the "transitional dynamics" from agriculture to service economy. I have calibrated and simulate a quantitative STraP with the standard parameters from the United States economy with the additional financial tightness parameter. Jermann and Quadrini (2012)

Compared to a frictionless scenario ("First Best"), my model exhibits a delay in industrialization of approximately 25 years and a 5% overallocation of resources at the peak, measured by value-added share, to the manufacturing sector. Furthermore, the presence of financial friction incentivizes the economy to accumulate capitalmore aggresively, resulting in lower consumption during the industrialization and the early-stages of deindustrialization. For example, in the year 1700, representative households in the United States consumes 12% less if they are constrained, compared to the First Best. The model suggests that the economy attempts to compensate for the

[1] It is theoretically possible to demonstrate the model economy where the rate of overinvestment outweighs the negative impact of constrained labor supply, leading to a faster path of structural transformation. This scenario, however, would necessitate extreme parameter assumptions, thus unlikely.

inefficiencies in manufacturing by over-investing in capital relative to its output.

In addition, using this finding, this paper further extends the model by considering the impact of industrial policy to the financial constraints faced by industrial sector. Here, "industrial policy" is interpreted as government intervention designed to mitigate the working capital constraint, taking the form of a subsidy. By incorporating financial frictions into this dynamic framework, I demonstrate that these frictions significantly impede industrialization processes and capital accumulation. Through simulations of the South Korean economy, the model shows that well-designed industrial policies can counteract the negative effects of financial frictions and accelerate industrialization. The findings highlight the importance of considering financial frictions in economic models to better understand the dynamic impacts of industrial policies.

This paper complements the literature with three contributions. First, the literature on the structural transformation is built on the premise of efficient economy. For example, Ngai and Pissarides (2007) and the follow up models [2] have pioneered the model of multi-sector growth under the efficient market. Uy, Yi and Zhang (2013) studies the structural transformation under open but efficient economy. More recent contribution such as Herrendorf, Rogerson and Valentinyi (2020) and Buera et al. (2021) studied the accumulation of capital in the multi-sector growth model under the efficient market. I propose that the deviation from the efficient market in the dynamic multisector model is non-trivial, since efficiency of a economy and the following mathematical properties was a key method to pin down the relationship between relative price and technology.

Second, macroeconomic development literature on financial friction were mainly studied as a stationary analysis. Midrigan and Xu (2014) and Buera, Kaboski and Shin (2011) are examples that studied the effect of financial friction and development. They study the effect of financial friction on the TFP using the two-period overlapping generations model. More recent Choi and Levchenko (2021) studied the model of heterogenous firms featuring financial frictions and learning-by-doing, emphasizing the effectiveness of industrial policy in South Korea. This research enriches the literature by illustrating dynamic context of the effect of financial friction to the TFP.

Third, South Korean investment policy would augment the existing studies on case studies of industrial policy. Lane (2022), Kim, Lee and Shin (2021), Choi and Levchenko (2021) studied the

[2] See Herrendorf, Rogerson and Ákos Valentinyi (2014) for the survey of early contributions to the literature.

Heavy and Chemical Drive of 1970s South Korea and its effect on development. To the best of my knowledge, this research is unique in studying the explicit dynamics of industrial policy as well as path of industrialization and structural transformation.

The remainder of the paper is organized as follows. Section 2 introduces a model of structural transformation that incorporates these frictions. I then characterize the equilibrium dynamics and explore them theoretically, contrasting them with the First Best. Then I proposes a novel algorithm to compute the Stable Transformation Path (STraP) in the presence of financial frictions. The section then calibrates simulation of the model economy with financial friction and analyzes the results. Section 3 further extends the model with the introduction of government subsidy to the model. Then the section details the augmented model and calibration required for the analysis. Finally, Section 4 concludes the paper by summarizing the key findings and highlighting avenues for future research.

2 Baseline Model

I construct a 3-sector model of economic growth similar to Buera et al. (2021). The model has extended the previous literature with the borrowing constraint faced by the manufacturing sector, which leads to a deviation from the Pareto-optimal allocation. In the model, the distortion of the manufacturing sector will affect the economy first through its intratemporal choice of labor where the labor input expenditure is constrained. In addition, it will affect the intertemporal choice of capital, since the marginal "benefit" you get from the capital is not only limited to the marginal product but also the loosening the financial constraint.

(a) Household

Consider a intertemporal problem of a representative household, with CES preferences over a consumption aggregate C_t. The households provides labor exogenously at L with the wage rate w_t[3], and chooses bond B_t, which is priced in unit of consumption, and pays interest rate r_t. The household own capital, which depreciates at $\delta \in [0, 1]$ but is accumulated using X_t. The household's

[3]Exogenous labor was used for comparability with Buera et al. (2021) and Herrendorf, Rogerson and Valentinyi (2020). The broader result would quantitatively stay the same as long as households' disutility of labor is homogeneous across sectors.

problem is:

$$\max_{C_t, B_t} \int_0^{\infty} e^{-\rho t} \frac{C_t^{1-\theta}}{1-\theta} dt \tag{1}$$

subject to:

$$P_{ct}C_t + P_{xt}X_t + P_{ct}\dot{B}_t = w_t L + R_t K_t + r_t P_{ct} B_t, \tag{2}$$

$$\dot{k}_{jt} = I_{jt} - \delta k_{jt}, \tag{3}$$

where $\sum_j \omega_{cj} = 1$ and $\sigma_c < 1$. We further assume that the household faces intratemporal problem of aggregating C_t using the goods from agriculture C_{at}, manufacturing C_{mt}, and services C_{st}.

$$C_t = \left(\sum_{j \in \{a,m,s\}} \omega_{cj}^{1/\sigma_c} C_{jt}^{\sigma_c - 1/\sigma_c} \right)^{\frac{\sigma_c}{\sigma_c - 1}} \tag{4}$$

(b) Investment Goods Producer

There is an investment goods producing firm that bundles investment input from agriculture X_{at}, manufacturing X_{mt}, and services X_{st}. It sells investment good to the sectoral firms. Bundling technology is CES, given as follows:

$$X_t = A_{xt} \left(\sum_{j \in \{a,m,s\}} \omega_{xj}^{1/\sigma_x} X_{jt}^{\sigma_x - 1/\sigma_x} \right)^{\frac{\sigma_x}{\sigma_x - 1}} \tag{5}$$

, where:

$$\dot{A}_{xt} = \gamma_x A_{xt} \tag{6}$$

, $\sum_j \omega_{xj} = 1$, and $\sigma_x < 1$.

(c) Sectoral Producer

A competitive representative firm in each sector $j \in \{a, m, s\}$ produces y_{jt} from k_{jt} and l_{jt}. Unlike Buera et al. (2021), the producers in sector m must pay labor before its production using intraperiod loan. The producer's intertemporal problem is as follows:

$$\max_{l_{jt}, I_{jt}} \int_0^\infty e^{-m_t t} \left(p_{jt} y_{jt} - w_t l_{jt} - p_{xt} I_{jt} \right) dt \tag{7}$$

, subject to:

$$y_{jt} = F(k_{jt}, l_{jt}) = A_{jt} k_{jt}^{\alpha} l_{jt}^{1-\alpha} \tag{8}$$

$$\dot{A}_{jt} = \gamma_j A_{jt} \tag{9}$$

where $\gamma_a > \gamma_m > \gamma_s$, $m_t = r_t + \frac{\dot{P}_{ct}}{P_{ct}}$. In addition, firms in the manufacturing sector faces the working capital constraint:

$$w l_m \leq \xi k_m \qquad \text{if } j = m \tag{10}$$

(d) Equilibrium

The economy is characterized by the following sets of dynamic equations:

$$\theta \frac{\dot{C}_t}{C_t} = r_t - \rho \tag{11}$$

$$\dot{k}_{jt} = I_{jt} - \delta k_{jt} \tag{12}$$

$$F_{jk} + \mathbb{1}_{j=m} \left[\mu_t \xi \right] = P_{xt} \left(r_t + \delta + \left(\frac{\dot{P}_{ct}}{P_{ct}} - \frac{\dot{P}_{xt}}{P_{xt}} \right) \right), \tag{13}$$

where $F_{jz} = \partial F / \partial z$ and μ_t is a Lagrange multiplier in front of the working capital constraint. While (11) and (12) are standard results from the neoclassical growth model, (13) highlights the difference. First, in the right-hand side of the equation, the opportunity cost of utilizing a marginal unit of capital is i) market interest rate, ii) capital depreciation, and iii) the growth rate of relative price of consumption to investment. The endogenously varying relative price between investment and consumption will lead to the compositional change across sectors. (Buera et al., 2021) The left-hand side of the (13) illustrates the marginal benefit of investing in one marginal unit of capital. First, across all sectors, the direct consequence of investment is the marginal product gain, represented by F_{jk}. In addition, in the case of manufacturing sector, increase in a unit of capital will loosen the working capital constraint by ξ, and the loosening effect is measured with the Lagrange multiplier μ_t. Notice that since μ_t is time-varying, the additional cost induced by working capital constraint is also time-varying. This will add computational complexity when we solve the model.

Given the dynamic characterization of the model, we define the competitive equilibrium:

Definition 1. *Given the vector of initial states $\{K_0, \{A_{j0}\}_{j\in\{a,m,s,x\}}\}$, a competitive equilibrium for the model is:*

- *an allocation $\{C_t, B_t, K_t, X_t, \{C_{jt}, X_{jt}, y_{jt}, k_{jt}, n_{jt}\}_{j\in\{a,m,s\}}\}$ and*
- *prices $\{P_{ct}, P_{xt}, W_t, r_t, R_t, P_{at}, P_{mt}, P_{st}, \mu_t\}$*
- *technology $\{\{A_{jt}\}_{j\in\{a,m,s,x\}}\}$*

for $t \geq 0$ that solves:

1. *Given prices $\{P_{ct}, W_t, r_t, P_{at}, P_{mt}, P_{st}\}$, households maximize their lifetime utility by choosing $\{\{C_{jt}\}_{j\in\{a,m,s\}}, B_t, X_t\}$ subject to:*

   (a) budget constraint

$$P_{ct}C_t + P_{xt}X_t + P_{ct}\dot{B}_t = w_t L + R_t K_t + r_t P_{ct} B_t \tag{14}$$

   (b) consumption aggregation

$$C_t = \left(\sum_{j\in\{a,m,s\}} \omega_{cj}^{1/\sigma_c} C_{jt}^{\sigma_c - 1/\sigma_c} \right)^{\frac{\sigma_c}{\sigma_c - 1}} \tag{15}$$

   (c) law of motion for capital:

$$\dot{K}_t = X_t - \delta K_t \tag{16}$$

2. *Given prices $\{P_{xt}, P_{at}, P_{st}\}$ and the state vector $\{\{A_{jt}\}_{j\in\{a,m,s\}}, \{K_{jt}\}_{j\in\{a,m,s\}}\}$, investment goods producer minimizes their cost by choosing $\{\{X_{jt}\}_{j\in\{a,m,s\}}\}$ subject to:*

(a) investment goods production function:

$$X_t = A_{xt}\left(\sum_{j\in\{a,m,s\}} \omega_{xj}^{1/\sigma_x} X_{jt}^{\sigma_x-1/\sigma_x}\right)^{\frac{\sigma_x}{\sigma_x-1}} \tag{17}$$

(b) investment goods production technology:

$$\dot{A}_{xt} = \gamma_x A_{xt} \tag{18}$$

3. *Given prices* $\{P_{ct}, P_{xt}, W_t, P_{at}, P_{mt}, P_{st}\}$ *and the state vector* $\{\{A_{jt}\}_{j\in\{a,m,s\}}, \{K_t\}\}$*, sectoral producer in sector i maximizes their profit by choosing* $\{y_{it}, k_{it}, n_{it}\}$ *subject to:*

   (a) sectoral production function:

$$y_{jt} = F(k_{jt}, n_{jt}) = A_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha} \tag{19}$$

   (b) sectoral goods production technology:

$$\dot{A}_{jt} = \gamma_j A_{jt} \tag{20}$$

   (c) if $i = m$*, capital-in-advance constraint:*

$$w_t n_{mt} \le \xi P_{xt} k_{mt} \qquad \text{if } j = m \tag{21}$$

4. *bonds market clearing condition:*

$$B_t = 0 \tag{22}$$

5. *sectoral goods market clearing condition:*

$$C_{it} + X_{it} = y_{it} \tag{23}$$

   , where $i \in \{a, m, s\}$

6. *labor market clearing condition*

$$n_{at} + n_{mt} + n_{st} = L = 1 \tag{24}$$

7. *capital market clearing condition*

$$k_{at} + k_{mt} + k_{st} = K_t \tag{25}$$

(e) Price Dynamics

Notice that from the firm's intratemporal optimality, we can derive relative prices between each sectors:

$$\frac{P_{at}}{P_{st}} = \frac{A_{st}}{A_{at}} \tag{26}$$

$$\frac{P_{at}}{P_{mt}} = \frac{A_{mt}}{A_{at}} \left(\frac{R_t}{R_t - \mu_t \xi} \right)^{\alpha} \frac{1}{\left(1 + \mu_t\right)^{1-\alpha}} \tag{27}$$

$$\frac{P_{mt}}{P_{st}} = \frac{A_{st}}{A_{mt}} \left(\frac{R_t - \mu_t \xi}{R_t} \right)^{\alpha} \left(1 + \mu_t\right)^{1-\alpha}, \tag{28}$$

where $R_t = F_{jk} + \mathbb{1}_{j=m}\left[\mu_t \xi\right]$. Let us define $\tilde{A}_{mt} = A_{mt}\left(\frac{R_t}{R_t - \mu_t \xi}\right)^{\alpha} \frac{1}{\left(1+\mu_t\right)^{1-\alpha}}$. Then, the relative prices that includes manufacturing sector can be expressed as:

$$\frac{P_{at}}{P_{mt}} = \frac{\tilde{A}_{mt}}{A_{at}} \tag{29}$$

$$\frac{P_{mt}}{P_{st}} = \frac{A_{st}}{\tilde{A}_{mt}} \tag{30}$$

The relative price of investment can be expressed similar to the Buera et al. (2021):

$$\frac{P_{xt}}{P_{ct}} = \frac{1}{A_{xt}} \frac{\left(\omega_{xa} P_{at}^{1-\sigma_x} + \omega_{xm} P_{mt}^{1-\sigma_x} + \omega_{xs} P_{as}^{1-\sigma_x}\right)^{\frac{1}{1-\sigma_x}}}{\left(\omega_{ca} P_{at}^{1-\sigma_c} + \omega_{cm} P_{mt}^{1-\sigma_c} + \omega_{cs} P_{as}^{1-\sigma_c}\right)^{\frac{1}{1-\sigma_c}}} \tag{31}$$

(f) Structural Transformation in the Baseline Model

Notice that structural transformation in the Buera et al. (2021) and Herrendorf, Rogerson and Valentinyi (2020) is governed by the technological change differing in each sector, which can be traced by the relative prices. With some assumptions on the parameter, we can characterize the economy of the baseline model compared to the First Best scenario.

Proposition 1. *Given* $\gamma_a > \gamma_m > \gamma_s$, *if* $\frac{\alpha\xi}{R-\mu\xi} > \frac{1-\alpha}{1+\mu}$, $\left(\dot{\frac{P_{mt}X_{mt}}{P_{at}X_{at}}}\right) < (1-\sigma_x)(\gamma_a - \gamma_m)$.

Proposition 2. *Given* $\gamma_a > \gamma_m > \gamma_s$, *if*

$$\frac{\alpha\xi}{R-\mu\xi} > \frac{1-\alpha}{1+\mu}$$

, $\left(\dot{\frac{P_{mt}C_{mt}}{P_{at}C_{at}}}\right) < (1-\sigma_c)(\gamma_a - \gamma_m)$.

[4]

In other words, if the above constraint is satisfied, structural transformation of investment and consumption from agriculture to manufacturing sector is slower in working capital constrained case than the First Best.

Proposition 3. *Given* $\gamma_a > \gamma_m > \gamma_s$, *if* $\frac{\alpha\xi}{R-\mu\xi} < \frac{1-\alpha}{1+\mu}$, $\left(\dot{\frac{P_{st}X_{st}}{P_{mt}X_{mt}}}\right) < (1-\sigma_x)(\gamma_a - \gamma_m)$.

Proposition 4. *Given* $\gamma_a > \gamma_m > \gamma_s$, *if* $\frac{\alpha\xi}{R-\mu\xi} < \frac{1-\alpha}{1+\mu}$, $\left(\dot{\frac{P_{st}C_{st}}{P_{mt}C_{mt}}}\right) < (1-\sigma_c)(\gamma_m - \gamma_s)$.

[5]

In other words, if the above constraint is satisfied, structural transformation of investment and consumption from manufacturing to service sector is slower in working capital constrained case than the First Best.

$\frac{\alpha\xi}{R-\mu\xi}$ and $\frac{1-\alpha}{1+\mu}$ respectively implies the growth rate effect coming from i) investment wedge (distortion from the user cost of capital equation) and ii) labor wedge (distortion from labor demand equation), which are the two channels of the distortion in the baseline model. Notice that the financial constraint will negatively affect the reallocation in either cases.

[4]Proof for the Proposition 1 and 2 can be found in the appendix A.
[5]Proof for the Proposition 3 and 4 can be found in the appendix B.

(g) Computational Strategy

This research endeavors to bridge the gap between the theoretical framework established in Buera et al. (2021) and the practicalities of numerical solution. While rearranging terms from A_m to $\tilde{A}_m$ creates a conceptual alignment with Buera et al. (2021), a significant hurdle remains for numerically solving the model. Even with this theoretical alignment, determining the Lagrange multiplier, $\imath_t$, for each simulated period remains essential for numerical implementation.

The inclusion of financial friction within the manufacturing sector, as modeled in this study, does not inherently prevent the model from achieving an asymptotic balanced growth path (ABGP). This observation aligns with the concept of a stable structural transformation path (STraP) as proposed in Buera et al. (2021). Furthermore, successful convergence of the numerical model to a service-dominant economy, when initialized from an agricultural state, can be interpreted as achieving the ABGP. It is important to note, however, that the presence of friction in the manufacturing sector introduces inefficiencies during the transition period. Despite these temporary inefficiencies, the model ultimately converges to an efficient allocation where all resources are concentrated in the service sector.

In light of the considerations outlined above, this research proposes a novel algorithm specifically designed to compute the Stable Transformation Path (STraP) under conditions of financial friction. The approach employed in Buera et al. (2021) may not be directly applicable due to the presence of the financial friction. Therefore, a new approach is necessary to efficiently solve the model and determine the STraP within a numerical framework. The following section will detail the structure and functionality of this proposed algorithm.

The proposed algorithm directly addresses the challenge posed by the financial friction within the manufacturing sector. This friction introduces complexities that are not present in the model presented in Buera et al. (2021). The new algorithm specifically tackles these complexities and allows for the efficient computation of the STraP within the context of the current model with financial constraints.

The following section discusses the specifics of the proposed algorithm by exploring the structure and functionality of this new approach, explaining how it overcomes the challenges associated with financial friction and facilitates the determination of the STraP within the numerical framework.

1. Calculate initial capital stock at $t = -97$. This paper simulates the economy from $t = -97$ where the economy is close enough to the agricultural steady state. Notice that at $t = -\infty$, Buera et al. (2021) and this paper coincide at the agricultural steady-state. k_0 is determined from analytic steady-state, and the fundamental technological growth. Hence, I chose $t = -97$ such that after 97 years, k_0 determined at the fundamental productivity level where Buera et al. (2021) starts at k_0.
   - This is the value where backward shot value of Buera et al. (2021) achieves nearest point of $k_{-\infty}$. (stored at the variable `K_1_i`, index 403, 16) I chose k_{-97} as a the starting point of the economy, and adjusted the productivity accordingly.
2. Define and choose initial bounds for c_0.

   Notice that the expenditure c_0 at time t has a natural bounds from 0 to k_t^α. I chose the mid point of the two bounds.
3. Choose R_0.

   I chose the $R_{-\infty}$ as a initial points.
4. Given c_0, shoot forward toward k_∞. For each period:
   (a) Given R_t^i, solve the following. (Superscript i denotes the R_t at i-th loop.)
      - R_t being known implies: k_{it}/n_{it} for $i \in \{a, s\}$ and W_t is known from the FOC of the firms.
      - Further, μ_t is known, from the analytic expression for μ_t. Hence, k_{mt}/n_{mt} is also known.
      - Relative prices P_{it}/P_{jt} is also known.

   (b) Except for the first period, calculate c_{t+1} from the household's Euler equation.

(c) Cost minimization of the consumption and the investment aggregate implies that:

$$\frac{c_{it}}{c_{jt}} = \frac{\omega_{ic}}{\omega_{jc}}\left(\frac{P_{it}}{P_{jt}}\right)^{-\sigma_c}, \frac{x_{it}}{x_{jt}} = \frac{\omega_{ix}}{\omega_{jx}}\left(\frac{P_{it}}{P_{jt}}\right)^{-\sigma_x},$$

where $i, j \in \{a, m, s\}$.

(d) We can further denote aggregate consumption and investment as a functionm of sectoral consumption and sectoral investment input.

$$\begin{aligned}
c_t &= \left(\sum_{j\in\{a,m,s\}} \omega_{cj}^{1/\sigma_c} C_{jt}^{\sigma_c - 1/\sigma_c}\right)^{\frac{\sigma_c}{\sigma_c-1}} \\
&= \frac{1}{\omega_{mc}}\left(\omega_{ac}\left(\frac{P_{at}}{P_{mt}}\right)^{\sigma_c-1} + \omega_{mc} + \omega_{sc}\left(\frac{P_{st}}{P_{mt}}\right)^{\sigma_c-1}\right)^{\frac{\sigma_c}{\sigma_c-1}} c_{mt} \\
x_t &= \frac{1}{\omega_{mx}}\left(\omega_{ax}\left(\frac{P_{at}}{P_{mt}}\right)^{\sigma_x-1} + \omega_{mx} + \omega_{sx}\left(\frac{P_{st}}{P_{mt}}\right)^{\sigma_x-1}\right)^{\frac{\sigma_x}{\sigma_x-1}} x_{mt}
\end{aligned}$$

(e) Arbitrarily choose n_{at}. In the initial period, choose n_{at} a value sufficiently close to 1. In all other periods, starting value would be n_{at-1}.

i. Given n_{at}, from the first-order condition from R_t and definition of sectoral production function, y_{at} is known.

ii. Given c_t, c_{at}, c_{mt}, and c_{st} is known.

iii. Given y_{at} and c_{at}, x_{at} is known.

iv. Given x_{at}, x_{mt} and x_{st} known.

v. From c_{it} and x_{it}, y_{it} is known for $i \in \{a, s\}$.

vi. Since k_{it}/n_{it} is known, from the from y_{it}, first-order condition from R_t and definition of sectoral production function, n_{it} is known for $i \in \{a, s\}$.

vii. Check the labor market clearing condition $|\sum_i n_i - 1| < \epsilon_{\text{tolerance}}$ is satisfied. If $\sum_i n_i - 1 < 0$, increase n_{at}. If $\sum_i n_i - 1 > 0$, decrease n_{at}.

(f) Check the capital market clearing condition $|\sum_i k_{it} - K_t| < \epsilon_{\text{tolerance}}$ If $\sum_i k_{it} - K_t > 0$ set R_t^i as the new upper bound. choose the mid point as a new starting point R_t^{i+1}, and go back to a). If $\sum_i k_{it} - K_t > 0$ set R_t^i as the new lower bound. choose the mid point as a new starting point R_t^{i+1}, and go back to a).

5. If at any point, capital or consumption level is decreasing, and assign $\tilde{c}_0$ as the new upper bound, and return to 4). If capital series is exploding, assign $\tilde{c}_0$ as the new lower bound, and return to 4).

6. Since I have numerically approximated value of $k_{-\infty}$, and the corresponding fundamental productivity, I did not shoot backwards.

(h) Computation for μ and its Limiting Behavior

A central obstacle in computing the value of $\imath_t$ lies in its endogenous nature. Unlike exogenous variables, which are determined by external forces independent of the system being studied, μ_t is inherently generated within the system itself, making its calculation a complex and interconnected task. If we limit our parameter space, following proposition can be achieved.

Proposition 5. *Given $\gamma_a > \gamma_m > \gamma_s$, if the working capital constraint is binding, $\left(\frac{P_{mt}\dot{X}_{mt}}{P_{at}X_{at}}\right) < (1-\sigma_x)(\gamma_a - \gamma_m)$.*

[6]

Specifically, from the user cost of capital equation and labor demand equation, we get the following formula for μ_t. Let us define the cut-off value of k as $k^* = \left(\frac{1-\alpha}{\xi}\right)^{\frac{1}{1-\alpha}}$.[7] Then, the following holds:

$$\mu_t = \begin{cases} \frac{1-\alpha}{\xi}\alpha k_t^{\alpha-1} - \alpha & \text{if } k_t < k^* \\ 0 & \text{if } k_t \geq k^* \end{cases}$$

which implies in order to solve for μ_t, we need to calculate A_{jt} and k_{jt}/l_{jt}. Notice that, given $\tilde{A}_{mt}$,

$$\frac{k_{at}}{l_{at}} = \frac{k_{st}}{l_{st}} = \frac{\tilde{k}_{mt}}{\tilde{l}_{mt}} = \frac{\tilde{k}_t}{\tilde{l}_t},$$

[6]Proof for the proposition is given at the Appendix A.

[7]Since $\alpha - 1 < 0$, LHS and RHS is equated if $k = k^* = \left(\frac{1-\alpha}{\xi}\right)^{\frac{1}{1-\alpha}}$.

where $\frac{\tilde{k}_{mt}}{\tilde{l}_{mt}}$ and $\frac{\tilde{k}_t}{\tilde{l}_t}$ is the First Best scenario under $\tilde{A}_t$. Hence, by shooting algorithm, we can recursively recover μ_t and $\tilde{A}_t$ using the Stable Transformation Path proposed by Buera et al. (2021).

(i) Numerical Simulation Result

To exemplify the model's behavior, this paper utilizes a baseline simulation calibrated with parameters specific to the United States, as derived in Buera et al. (2021). Furthermore, the tightness parameter, denoted by ξ, is set at 0.8366, consistent with the findings of Jermann and Quadrini (2012). Jermann and Quadrini (2012) calibration targeted a steady-state debt-to-GDP ratio of 3.36, calculated on a quarterly basis from 1984Q1 to 2010Q2.

The simulation methodology employed a two-step approach. First, the model developed in Buera et al. (2021) was simulated both forward and backward in time. This process established a stable transformation path between the First-Best economic outcome and the allocation characterizing a purely agricultural society, utilizing the calibrated U.S. parameters. Following this initialization, the simulation proceeded forward in time, starting from the agricultural state. The results presented henceforth are derived from the final 400 simulated years.

Figure 1 depicts the simulated trajectories of value-added shares for the agricultural, manufacturing, and service sectors over a 400-year period. Both the baseline and simulated models exhibit the classic pattern of structural transformation documented in the literature. This pattern is characterized by a decline in the share of agriculture, a hump-shaped trajectory for manufacturing, and a late-stage acceleration in the service sector.

However, the baseline model exhibits a distinct intensity in the manufacturing sector compared to the simulated model. This disparity can be attributed to the high demand for investment goods within the baseline model, which in turn fosters a manufacturing-intensive economy. Further details regarding the sectoral composition of investment in the baseline model, compared to the findings of Buera et al. (2021), are provided in Appendix Figure 6. It is important to note that the investment input share exhibits minimal variation between the two models.

While our previous analysis focused on value-added shares, a closer look reveals a more nuanced picture when examining consumption and investment shares across sectors. Figure 2 and Figure 3 depict the simulated trajectories of these shares for the agricultural, manufacturing, and service

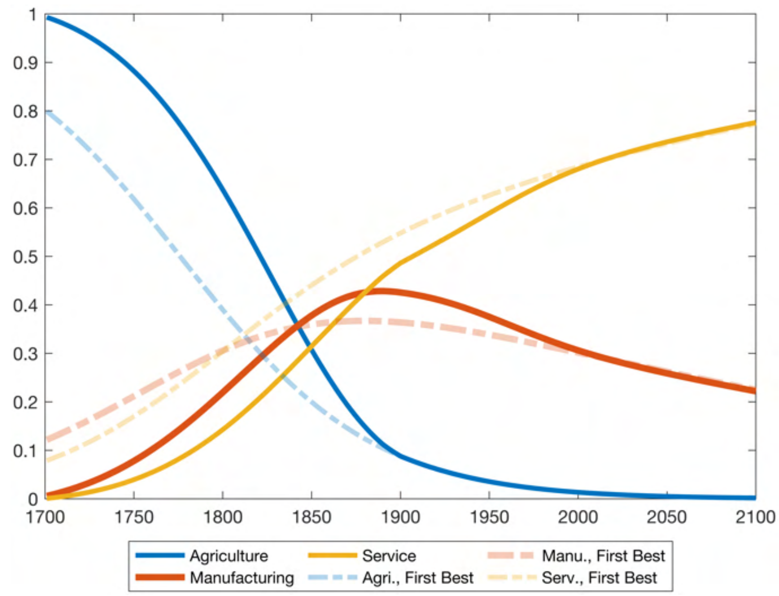


Figure 1: Structural transformation of value-added share, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

sectors over a 400-year period. While both shares exhibits a pattern broadly similar to the value-added share, compared to the First Best, the dynamics can be characterized by before and after around 1900, where the Lagrange multiplier in front of the working capital constraint μ_t becomes 0. [8]

While the financial constraint is binding, the economy suffers slowed-down structural transformation. Overinvestment and resulting misallocation of resources is hindering the structural transformation. Notice that the peak manufacturing share in the First Best is also not achieved in the constrained model. This further implies if the economy is suffering from the structural transformation, the immature deindustrialization of an economy in the case where economy is bounded by its financial condition.

However, once we have $\mu_t = 0$, the economy, the share of an economy converges to the First Best in terms of disaggregated sectoral share. Once the financial constraint is removed, the economy at the disaggregated level behaves essentially identical to the First Best, but with the off-

[8] Further discussion on μ_t can be found in Figure 6.

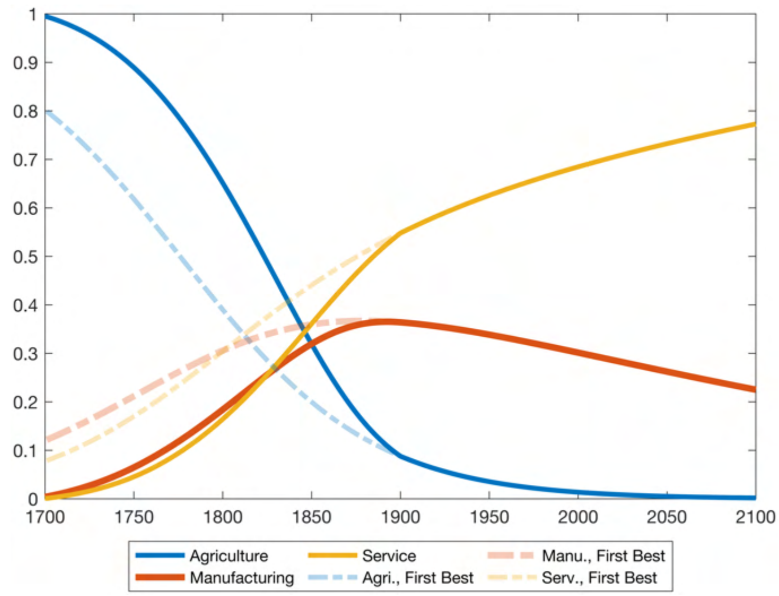


Figure 2: Structural transformation of consumption share, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

Transformation Path capital stock.

The investment share in Figure 3 displays a much more pronounced sectoral allocation from the consumption share, particularly in the manufacturing sector. This disparity highlights the significant influence of financial constraints on investment decisions within the model. The model exhibits a tendency towards overinvestment in the manufacturing sector, likely as a strategy to overcome the initial financial constraint. However, this prioritizes short-term gains in manufacturing at the expense of delayed industrialization and premature deindustrialization.

The elevated demand for investment goods in the baseline model, as discussed previously, finds further support in Figure 4 and Figure 5. Figure 4 depicts a higher absolute level of capital accumulation within the constrained model compared to the baseline model. In addition, the capital-to-output ratio in Figure 5, the constrained model displays a higher ratio.

At the aggregate level, the consequences of overinvestment are not limited to the period of financial constraint. Even after the simulated economy overcomes this initial hurdle, it continues to be affected from the initial overinvestment decisions. This is because the model exhibits a form of

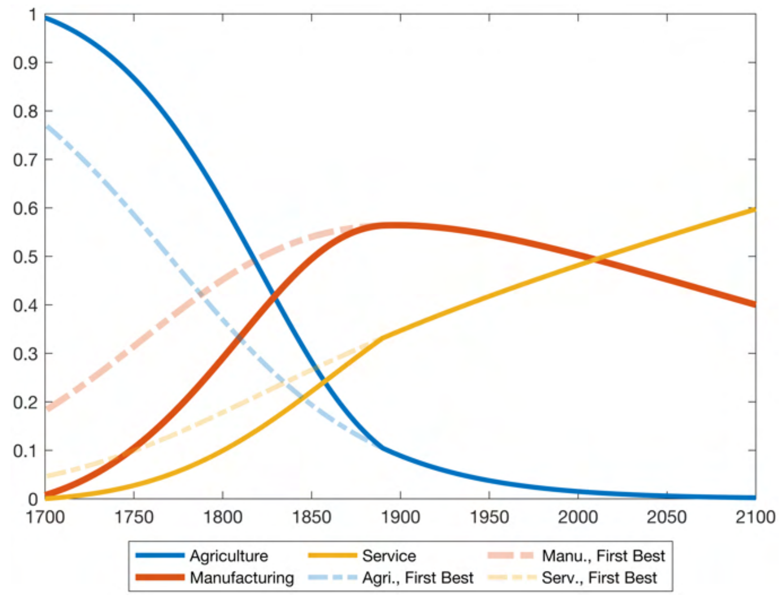


Figure 3: Structural transformation of investment share, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

path dependence. Even slight deviations from an optimal investment trajectory can lead the economy back into a state of financial constraint. Once trapped in this cycle, the economy becomes susceptible to a series of suboptimal investment choices. The model thus demonstrates how early decisions regarding investment can have lasting consequences for the economy's future trajectory.

Figure 6 depicts the trajectory of the Lagrange multiplier, μ_t , over time within the simulated U.S. economy (1700-2100). As predicted by the analytical framework, this multiplier, which represents the binding force of the working capital constraint, exhibits its most pronounced influence during the initial stages of the simulation. Over time, μ_t steadily decreases, ultimately reaching zero. This observation aligns with the theoretical expectation that the working capital constraint becomes progressively less restrictive as the economy matures.

However, despite the eventual relaxation of the working capital constraint, as evidenced by μ_t reaching zero, the simulated economy does not perfectly converge to the behavior predicted by the model presented in Buera et al. (2021) (Figures 1 and 1-2). This discrepancy arises because neglecting investment to achieve a faster decline in μ_t would ultimately lead to a renewed binding of

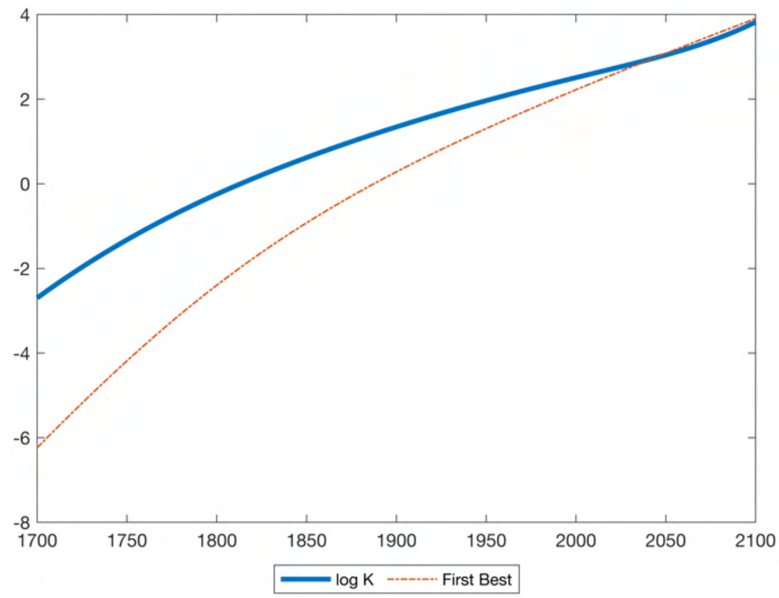


Figure 4: Capital accumulation, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

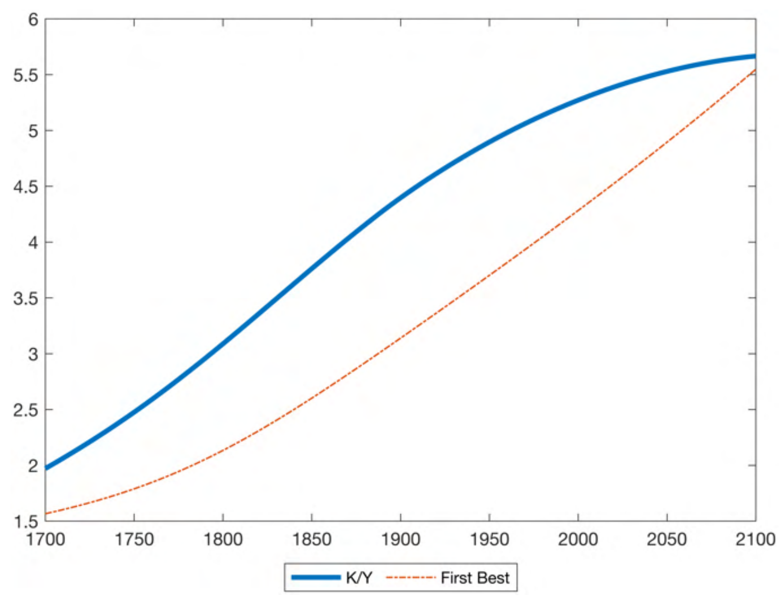


Figure 5: Capital to Output Ratio, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

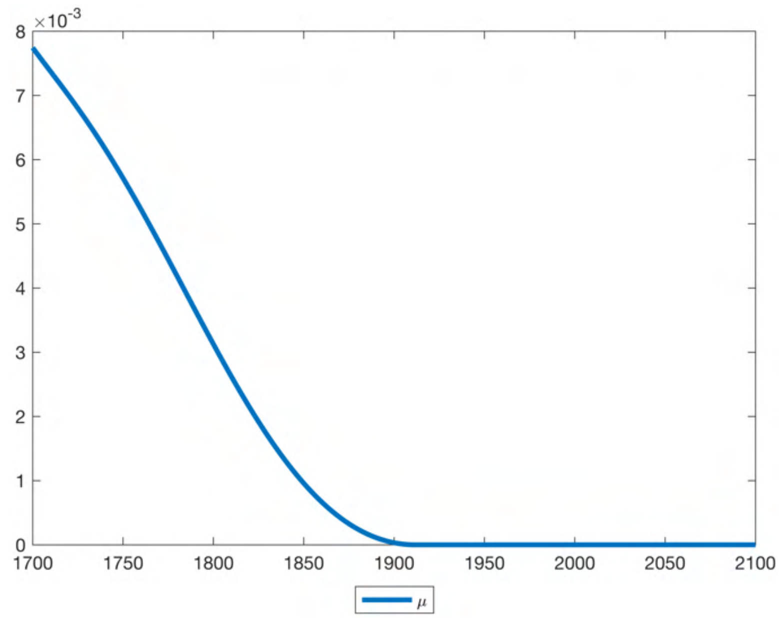


Figure 6: μ_t over time, simulation of the United States economy from 1700 to 2100.

the working capital constraint. In essence, there exists a trade-off between achieving a faster relaxation of the financial constraint and maintaining sufficient capital investment to sustain economic growth. This trade-off necessitates a more measured approach, resulting in a slower convergence towards the Buera et al. (2021) model. The sluggish convergence highlights the path dependence inherent within the model. Decisions regarding investment, even if motivated by a desire to alleviate the working capital constraint in the short-term, can have lasting consequences for the economy's long-term trajectory.

While Figure 7 illustrates that the working capital constraint seems to help economic growth, a more nuanced picture emerges when we consider investment patterns. As depicted in Figure 9, the constrained model exhibits a tendency towards overinvestment, particularly in terms of capital accumulation. This overinvestment creates a misallocation problem within the economy.

The presence of a working capital constraint incentivizes the model to prioritize investment strategies that may not be optimal in the long run. In an effort to alleviate the constraint, the model overinvests in capital. However, this excessive capital accumulation comes at the expense of re-

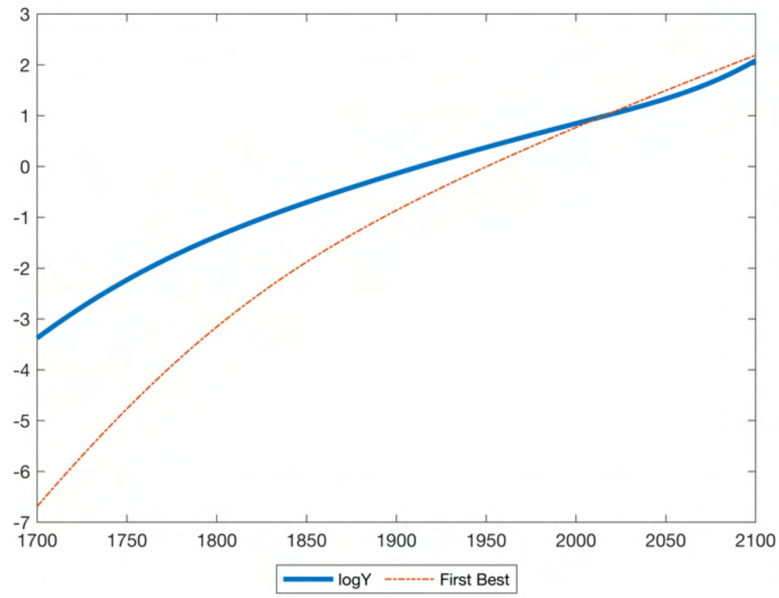


Figure 7: Output over time, simulation of the United States economy from 1700 to 2100.

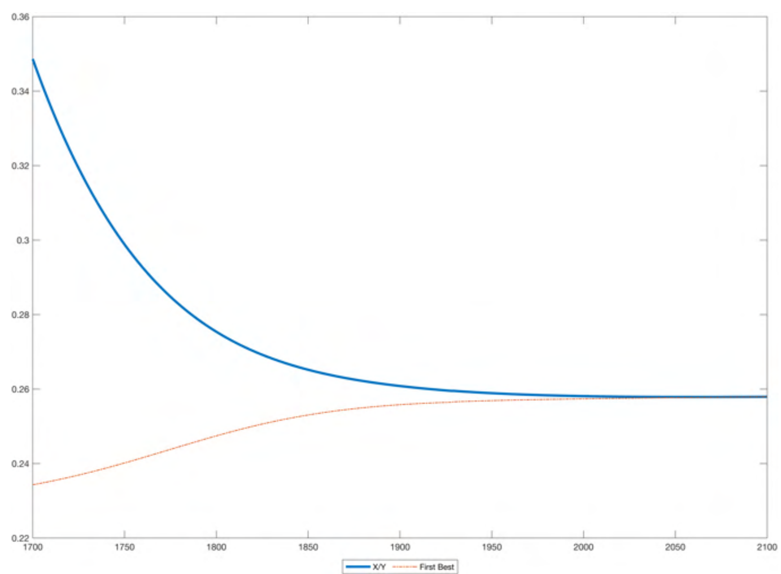


Figure 8: Investment to output ratio over time, simulation of the United States economy from 1700 to 2100.

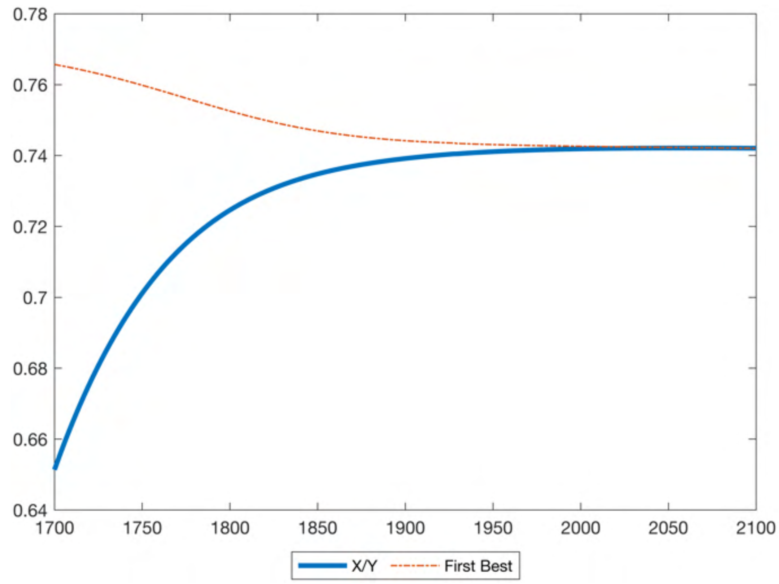


Figure 9: Consumption to output ratio over time, simulation of the United States economy from 1700 to 2100.

sources that could be directed towards consumption.

In essence, the working capital constraint creates a trade-off between investment and consumption. While alleviating the constraint may appear beneficial, the associated overinvestment leads to a suboptimal allocation of resources, ultimately resulting in suboptimal welfare.

3 Korean Industrial Policies of 1970s

The South Korean economy in 1972 faced a critical juncture, grappling with the destabilizing effects of unregulated private lending. Characterized by exorbitant interest rates, these private loans burdened firms, hindering economic growth and threatening financial instability. In response to this pressing challenge, the South Korean government enacted the Emergency Financial Act of August 3rd, 1972. This bold policy intervention aimed to mitigate the negative consequences of unregulated lending and stimulate economic recovery through a two-pronged approach: debt restructuring and financial intermediation.

The act implemented a two-pronged approach: debt restructuring and financial intermediation.

Firstly, it mandated the declaration of all private loans to the government. These declared loans were subsequently converted into long-term, government-backed loans with a significantly reduced interest rate of 16.2%. Additionally, a grace period of three years was included, followed by a five-year repayment schedule. This significant reduction in interest rates offered a crucial lifeline to struggling firms burdened by high-cost private debt.

Secondly, the act established a financial intermediation mechanism. Financial institutions, acting as intermediaries, were authorized to repay 30% of existing firm debts to lenders. These debts were then refinanced into long-term loans at an even lower interest rate of 8%, further alleviating the debt burden on Korean firms. The government assumed responsibility for repaying the initial 30% to the financial institutions, acting as a buffer against potential financial disruptions.

The immediate impact of the act was undeniable. Large manufacturing firms, particularly those in the crucial shipbuilding and chemical industries, were the most significant beneficiaries of the government's low-interest loan program. This, coupled with the debt restructuring, resulted in a dramatic decrease in private loan interest rates, falling from a staggering 40-50% to a more manageable 30%. This decline, in turn, significantly improved the average Korean firm's debt-to-capital ratio, offering them much-needed financial breathing room. Furthermore, the South Korean economy experienced a remarkable surge in GDP, jumping from 7.2% in 1972 to an impressive 14.8% in 1973.

However, the 1972 Emergency Financial Act was not without its critics. While it undoubtedly stabilized the financial system and stimulated economic growth in the short term, concerns regarding its long-term implications remain. The act, despite fostering increased transparency by channeling most private loans through regulated financial institutions, also facilitated indirect resource allocation. Government funds primarily flowed towards selected large manufacturing firms, raising concerns about potential favoritism and market distortions. This targeted approach, while seemingly beneficial in the immediate aftermath of the crisis, could have long-term consequences by hindering the development of other sectors and stifling competition.

Furthermore, the act's policy of enabling firms to aggressively invest in capital and fixed assets has been questioned in hindsight. While this strategy initially fueled economic growth, some scholars argue that it also contributed to an environment of excessive risk-taking within Korean firms.

This ultimately culminated in the devastating 1997 East Asian Financial Crisis, raising questions about the act's long-term sustainability and its unintended consequences.

In conclusion, the 1972 Emergency Financial Act served as a pivotal intervention in South Korea's economic history. While its immediate success in stabilizing the financial system and fostering economic growth is undeniable, a comprehensive evaluation requires careful consideration of its potential long-term drawbacks and unintended consequences. The act's legacy serves as a valuable case study for policymakers navigating similar economic challenges, highlighting the importance of crafting well-rounded and sustainable solutions that address immediate problems while considering potential long-term ramifications. Understanding the complexities of this intervention and its multifaceted impact offers valuable insights for navigating future financial turmoil and promoting sustainable economic development.

4 Policy Implication

In further developing the depth of analysis, I augment the baseline multisector model by introducing industrial policy which is modeled as a government subsidy κ on input expenditure. This particular modeling choice seeks to highlight the potential for industrial policy to influence structural transformation by alleviating financial constraints.

In the extended model, the government finances its expenditure through the capital investment tax. In particular, the tax is introduced at the point where a firm decides its capital stock for the next period. The capital investment tax is introduced to the model due to the existence of the exogenous labor supply[9], and for the government to self-finance in the firm side. The producer's intertemporal problem then is as follows:

$$\max_{l_{jt}, I_{jt}} \int_0^\infty e^{-M_t t} \left(p_{jt} y_{jt} - (1-\kappa) w_t l_{jt} - p_{xt} I_{jt} \right) dt \tag{32}$$

[9] Due to the exogenous nature of labor supply, labor income tax will generate trivially optimal result.

, subject to:

$$y_{jt} = F(k_{jt}, l_{jt}) = A_{jt} k_{jt}^{\alpha} l_{jt}^{1-\alpha} \tag{33}$$

$$\dot{A}_{jt} = \gamma_j A_{jt} \tag{34}$$

$$(1-\kappa) w l_m \leq \xi k_m \qquad \text{if } j = m, \tag{35}$$

where $\gamma_a > \gamma_m > \gamma_s$, $M_t = r_t + \frac{\dot{P}_{ct}}{P_{ct}}$, and κ denotes the government's subsidy on the firm's input expenditure.

Notice that the capital investment tax is distortionary. In order to illustrate, let us plug (**??**) to the household's Euler:

$$\theta \frac{\dot{C}_t}{C_t} = \frac{R_t}{(1+\tau_{lt}) P_{xt}} - \delta - \rho + \left(\frac{\dot{P}_{ct}}{P_{ct}} - \frac{\dot{P}_{xt}}{P_{xt}} - \frac{\dot{\tau}}{1+\tau} \right)$$

, where $R_t \equiv F_{jk} + \mathbb{I}_{j=m} \left[\mu_t \xi \right]$. Since $\frac{R_t}{(1+\tau_{lt})P_{xt}} - \delta - \frac{\dot{\tau}}{1+\tau} < \frac{R_t}{P_{xt}} - \delta$, capital investment tax is distortionary.

(a) Quantitative Analysis

I calibrated the economy that has historically adopted industrial policy similar to our setting, and evaluate the effectiveness of the industrial policy. In the extended model, the industrial policy is used to subsidize the input cost, which essentially alleviates the working capital constraint.

In the episode of Korean development of 1970s, large government intervention on the firm's borrowing ability helped the economy to achieve industrialization. One example would be Emergency financial act of August 3rd. In August 1972, South Korean government nullified the effect of the private loan unless the lender proves the financing source.

In addition, government funds has been instituted to lend a low interest rate loan to the qualified firms. 80% of the private loans have been publicly declared, and interest rate of the private loan decreased from 40~50% to 30%. South Korean GDP per capita increased from 7.2% in 1972 to 14.8% in 1973. Debt-to-capital ratio of the average Korean firm decreased from 394.2% in 1971 to 272.7% in 1973.

Borrowing from Choi and Levchenko (2021), I used a subsidy rate $\kappa = 0.13$. This subsidy rate was applied to a ten-year period of simulated data, ranging from 1970 to 1980. Following Herrendorf et al. (2013), data from the National Accounts of Statistics Korea (1970-2020) was used to determine the consumption and investment shares for each sector: agriculture, manufacturing, and services. These shares yields the value $\omega_{x,a} = 0.015$, $\omega_{x,m} = 0.502$, $\omega_{x,s} = 0.483$, $\omega_{c,a} = 0.013$, $\omega_{c,m} = 0.231$, and $\omega_{c,s} = 0.756$. I followed Buera et al.(2021) to recover sectoral productivity growth. $\gamma_a = 0.191$, $\gamma_m = 0.080$, $\gamma_s = 0.046$, and $\gamma_x = 0.001$.

The detailed process with which this paper constructed the parameters, which largely follows the Buera et al. (2021) is as follows.

First, this paper calibrated the consumption and investment weights $\omega_{c,i}$ and $\omega_{x,i}$ where $i \in \{a, m, s\}$ to capture the average consuption and investment share. I used Input-Output Table from the Statistics Korea, aggregating individual industries into 3 broad sectors, agriculture, manufacturing, and services. In particular, according to the specifications in Herrendorf et al. (2013), I estimated expenditure shares of consumption and investment:

$$s_{cit} = \frac{\omega_{c,i} p_{jt}^{1-\sigma}}{\sum_j \omega_{c,j} p_{jt}^{1-\sigma}} \tag{36}$$

$$s_{xit} = \frac{\omega_{x,i} p_{jt}^{1-\sigma}}{\sum_j \omega_{c,j} p_{jt}^{1-\sigma}} \tag{37}$$

The equations are estimated using quadratic approximation to the equations. [10] In order to impose non-negativity constriant, I transformed variables of interest as follows:

$$\omega_{c,i} = \frac{e^{\beta_i}}{\sum_j e^{\beta_j}} \tag{38}$$

. Notice that the specification ensures $\sum_j \omega_{c,i} = 1$.

In addition this paper calibrated the sectoral TFP parameters. I used real output, capital stock series, value-added series from the Statistics Korea from 1969-2019. Given the data on the quantity, value-added share, and capital stock, the total factor productivity of each sector can be described

[10] Herrendorf et al. (2013) uses iterated feasible generalized nonlinear least square estimation.

as follows:

$$A_{it} = \frac{\text{Quantity}_{it}}{\text{Value-added}_{it} K_t^{\alpha}} \tag{39}$$

Using the generated A_{it} series, I recover the average productivity growth.

Lastly, this paper calibrated the investment TFP parameters. I used price index for private fixed investment P_{xt} as well as the price indices of sectoral value-added. Then, the expression for the neutral total factor productivity can be described as follows:

$$A_{xt} = \left(\sum_j \omega_{xi} \frac{P_{it}}{P_{xt}}^{1-\sigma_x} \right)^{\frac{1}{1-\sigma_x}} \tag{40}$$

5 Numerical Simulation Results

The simulation methodology employed a two-step approach. First, under the calibrated parameters, the model developed in Buera et al. (2021) was simulated both forward and backward in time. This process established a stable transformation path between the First-Best economic outcome and the allocation characterizing a purely agricultural society, utilizing the calibrated South Korean parameters. Following this initialization, the simulation proceeded forward in time, starting from the agricultural state. The results presented henceforth are derived from the final 150 simulated years.

Figure 1 depicts the simulated trajectories of value-added shares for the agricultural, manufacturing, and service sectors over a 150-year period. Both the baseline and simulated models exhibit the pattern of structural transformation documented in the literature. This pattern is characterized by a decline in the share of agriculture, a hump-shaped trajectory for manufacturing, and a late-stage acceleration in the service sector.

In contrast to the First Best scenario, where optimal conditions prevail, the baseline model reveals a significant delay in achieving peak manufacturing sector intensity compared to the simulated model. This disparity amounts to approximately a century's difference between the peaks observed in the First Best scenario and those in economies constrained by working capital limitations. The enduring constraint on working capital in high-growth economies is identified as the primary driver

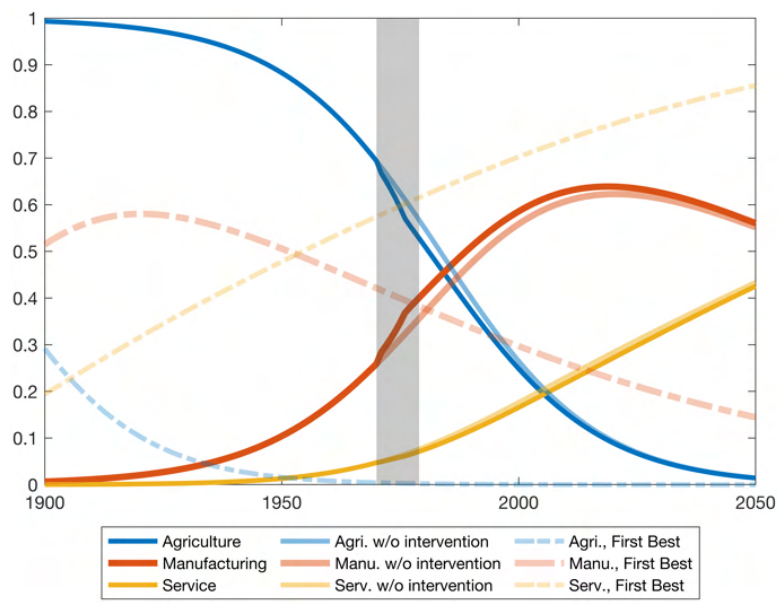


Figure 10: Structural transformation of value-added share, simulation of the South Korean economy from 1900 to 2100. The government subsidy was fed in to the economy from 1970 to 1979. Dotted line indicates the comparison with first best Buera et al. (2021) and faded line indicates the hypothetical state where government subsidy was absent.

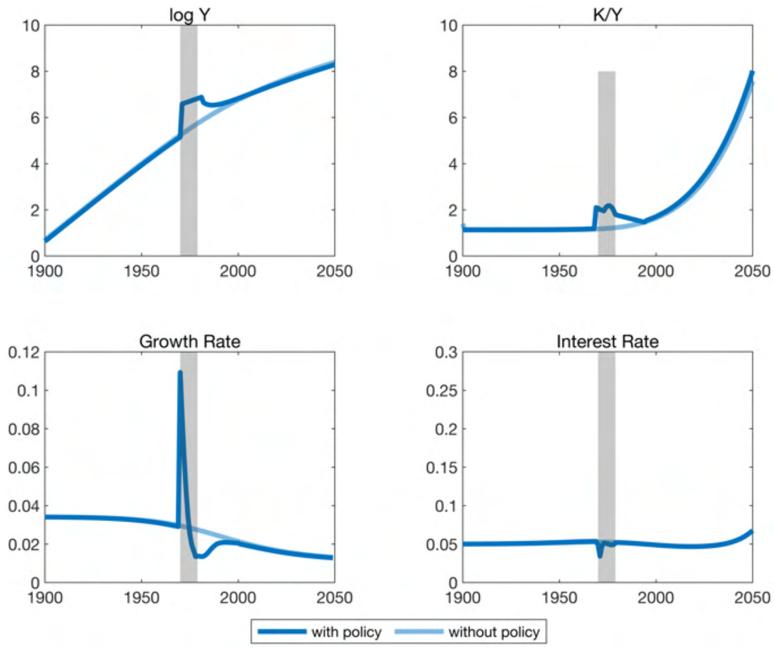


Figure 11: GDP, capital-to-output ratio, growth rate, and interest rate, simulation of the South Korean economy from 1900 to 2100. The government subsidy was fed in to the economy from 1970 to 1979. Faded line indicates the hypothetical state where government subsidy was absent.

of this discrepancy. According to the current parameterization, the analysis indicates that South Korea could have attained peak manufacturing intensity as early as the early 20th century if not for these financial constraints.

The government subsidy implemented in the 1970s notably facilitated the industrialization process. Over a decade, this subsidy accelerated industrial growth, leading to approximately an 8% increase in the manufacturing sector's value-added share. Despite being a temporary policy, its impact persists into the present day, influencing economic trajectories up to around 2020. While the economy is expected to converge to its Stable Transformation Path over time, the lingering effects of the 1970s policy underscore its enduring significance in shaping contemporary economic outcomes.

Figure 4 illustrates a detailed depiction of the dynamics governing aggregate variables within the economic framework under study. Central to these dynamics is the government subsidy, functioning as an exogenous input cost subsidy aimed at bolstering overall output without entailing internal trade-offs. This subsidy injects additional financial resources into the economy, effectively lowering production costs across sectors and fostering an environment conducive to heightened economic activity and output expansion.

Despite the observed increase in output facilitated by the subsidy, the capital-to-output ratio exhibits minimal fluctuation over time. This stability can be attributed to two distinct yet interrelated trade-offs within the economic system. Firstly, the reduction in capital demand arises from diminished concerns over excessive investment, leading to a corresponding decline in interest rates as financial resources are reallocated more efficiently across investment opportunities. Secondly, the subsidy itself augments the economy's spending capacity, driving up the demand for capital as businesses and industries capitalize on the newfound financial flexibility to expand operations and improve productivity.

These two opposing forces—reduced capital demand due to optimized investment allocation and increased capital demand stemming from enhanced spending capacity—operate in tandem to maintain a relatively steady capital-to-output ratio despite fluctuations in output levels.

(a) Timing of a Policy

An intriguing aspect of this economic model lies in its capacity to simulate various scenarios based on the timing of government policies.

For instance, while South Korea strategically implemented its transformative policies during the 1970s to bolster industrialization and economic growth, alternative socio-political contexts could have influenced the timing and efficacy of these interventions along the trajectory of structural transformation. If the socio-political environment differed significantly, the policies might have been implemented earlier or later in the economic evolution, potentially yielding divergent outcomes in terms of economic development and sectoral growth patterns.

Figure 12 and Figure 13 present distinct scenarios depicting varying timings of policy implementation within the economic model. In Figure 2-3, the subsidy is introduced from 1940 to 1949, a period when South Korea predominantly operated as an agricultural economy. Conversely, Figure 2-4 illustrates a later implementation of the subsidy, spanning from 2000 to 2010, a period charac-

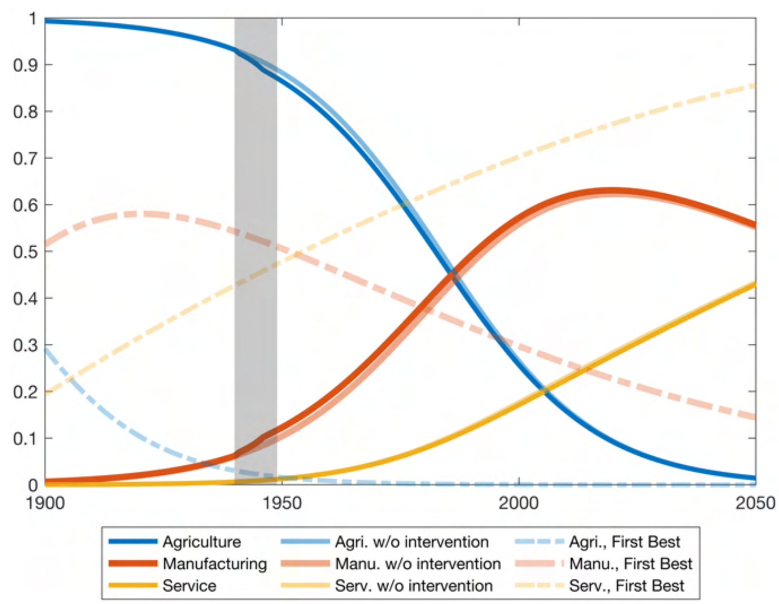


Figure 12: Structural transformation of value-added share, simulation of the South Korean economy from 1900 to 2100. The government subsidy was fed in to the economy from 1940 to 1949. Dotted line indicates the comparison with first best Buera et al. (2021) and faded line indicates the hypothetical state where government subsidy was absent.

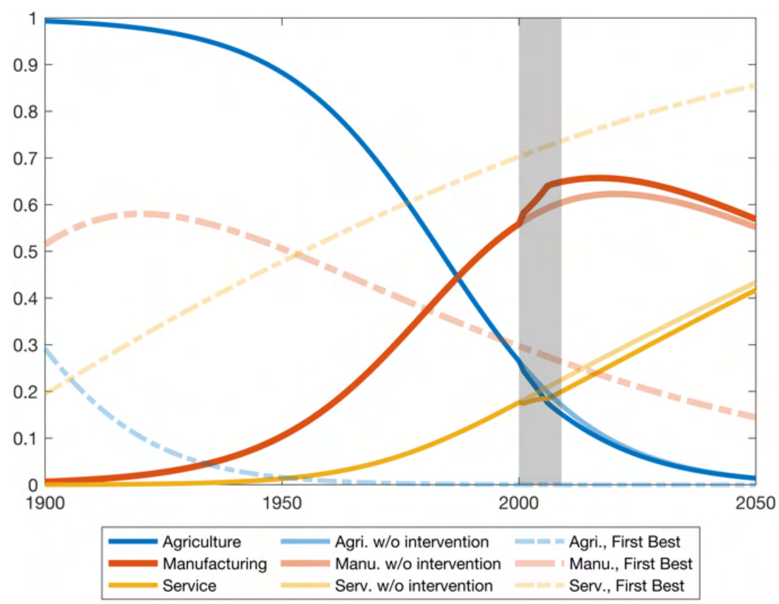


Figure 13: Structural transformation of value-added share, simulation of the South Korean economy from 1900 to 2100. The government subsidy was fed in to the economy from 2000 to 2010. Dotted line indicates the comparison with first best Buera et al. (2021) and faded line indicates the hypothetical state where government subsidy was absent.

terized by South Korea's advanced stage of de-industrialization and burgeoning service sector.

In Figure 12, the simulation reveals minimal economic impact following the introduction of the subsidy from 1940 to 1949. This outcome can be attributed to the predominantly agricultural nature of South Korea's economy during this period, where investment in the manufacturing sector was still nascent. As a result, the exogenous input cost subsidy aimed at bolstering manufacturing did not yield substantial improvements comparable to those observed in earlier periods of more developed industrialization.

The result indicates a modest industrialization gain of only 1-2 years attributable to this subsidy, contrasting sharply with the transformative effects witnessed under policies implemented during the 1970s. This disparity underscores the critical importance of economic context and readiness in determining the efficacy of policy interventions.

In Figure 2-4, which simulates the introduction of a subsidy from 2000 to 2010 when South Korea was in its later stage of industrialization and transitioning towards a service-oriented economy, a contrasting scenario unfolds. Here, the subsidy directed towards the manufacturing sector inadvertently impedes the ongoing structural transformation. With the economy already matured and poised for de-industrialization, increased resources allocated to manufacturing disrupt the natural progression towards a dominant service sector.

The subsidy's effect is observed as exacerbating the challenges of transitioning from industry to services. Instead of facilitating a smooth shift, it prolongs the industrial phase, delaying the anticipated gains from de-industrialization. Consequently, the Korean economy experiences a setback of approximately four years in its trajectory towards a service-driven economy, highlighting the unintended consequences of misaligned policy interventions in advanced economic stages.

The result emphasizes the critical importance of timing- and context-specific policy planning and timing in economic development. Policies should take the current structural transformation pattern into consideration to maximize their effectiveness and avoid counterproductive outcomes.

6 Conclusion

This paper has embarked on a comprehensive exploration of the intricate relationship between market inefficiency, industrial policy, and the trajectory of structural transformation. By meticulously constructing a multisector model that incorporates a working capital constraint, the analysis sheds light on the substantial impediments that financial friction poses to structural transformation. These impediments manifest as delays in both industrialization and de-industrialization processes, ultimately resulting in higher growth but lower welfare. The contrast between the model calibrated to the United States with financial friction and its frictionless counterpart underscores the magnitude of this effect.

Using South Korea's historical policy interventions as a case study, this paper has further examined the relationship between industrial policy, financial frictions, and structural transformation. It has shown how targeted industrial policies, such as subsidies to the manufacturing sector, can alleviate the impact of financial constraints and expedite industrialization. By incorporating financial frictions into a multisector economic growth model, the study underscores the importance of considering structural transformation in the design of policies aimed at promoting industrialization and guiding structural transformation.

This research contributes to the existing literature in the following ways. Firstly, it extends the existing models of structural transformation within the confines of an efficient market. This departure acknowledges the market imperfections in the economy and highlights the need for a more nuanced understanding of how these imperfections influence the path of economic development.

Secondly, the paper enriches the field of financial friction in macro development literature by introducing a dynamic context. Prior studies within this domain predominantly focused on stationary analyses. By incorporating a dynamic framework, this research offers a deeper understanding of how financial frictions impact total factor productivity (TFP) over time. This dynamic perspective informs long-term consequences of financial friction on a nation's ability to transform its economic structure and achieve sustained growth.

The findings presented in this paper hold implications for policymakers, particularly those in developing economies grappling with the challenges of structural transformation. The model serves as a powerful tool for policymakers to assess the potential benefits of crafting effective industrial policies. By strategically intervening to alleviate financial frictions, policymakers can create an economy conducive to a smoother and more rapid structural transformation. This, in turn, can pave the way for accelerated economic growth. Future research can delve deeper into the optimal design of industrial policies aimed at mitigating financial frictions. By exploring various policy instruments and their long-term effects, researchers can equip policymakers with the knowledge and tools necessary to navigate the complexities of structural transformation and foster robust and sustainable economic development.

Appendix

A Proof of Proposition 1 and 2

Notice that from the investment firm's cost minimization, we have:

$$\frac{P_{mt}X_{mt}}{P_{at}X_{at}} = \frac{\omega_{xm}}{\omega_{xa}}\left(\frac{P_{mt}}{P_{st}}\right)^{1-\sigma_x} = \frac{\omega_{xm}}{\omega_{xa}}\left(\frac{A_{at}}{\tilde{A}_{mt}}\right)^{1-\sigma_x} \tag{41}$$

Notice that the growth rate of $\tilde{A}$ is:

$$\begin{aligned}
&\tilde{A}_{mt} = A_{mt}\left(\frac{R_t}{R_t - \mu_t\xi}\right)^{\alpha}\frac{1}{\big((1-\kappa)(1+\mu_t)\big)^{1-\alpha}} \\
&\Rightarrow \log\tilde{A} = \log A_m + \alpha\log R - \alpha\log(R-\mu\xi) - (1-\alpha)\log(1+\mu) \\
&\Rightarrow \frac{\dot{\tilde{A}}}{\tilde{A}} = \gamma_m + \alpha\frac{\dot{R}}{R} - \alpha\frac{1}{R-\mu\xi}\left(\dot{R} - \xi\dot{\mu}\right) - (1-\alpha)\frac{\dot{\mu}}{1+\mu} \\
&\quad > \gamma_m + \dot{\mu}\left(\frac{\alpha\xi}{R-\mu\xi} - \frac{1-\alpha}{1+\mu}\right)
\end{aligned}$$

Notice that due to the nature of the model, $\dot{\mu}$ will be always positive until infinity. (Intuitively, as economy grows, manufacturing sector will grow, and thus cost of the financial constraint binding will be more severe.) Hence, if $\frac{\alpha\xi}{R-\mu\xi} - \frac{1-\alpha}{1+\mu}$ is positive, $\frac{\dot{\tilde{A}}}{\tilde{A}}$ will be greater than γ_m.

Hence, we conclude that $\left(\dot{\overline{\frac{P_{mt}X_{mt}}{P_{at}X_{at}}}}\right) < (1-\sigma_x)(\gamma_a - \gamma_m)$, and similarly $\left(\dot{\overline{\frac{P_{mt}C_{mt}}{P_{at}C_{at}}}}\right) < (1-\sigma_c)(\gamma_a - \gamma_m)$.

B Proof of Proposition 3 and 4

Notice that from the investment firm's cost minimization, we have:

$$\frac{P_{st}X_{st}}{P_{mt}X_{mt}} = \frac{\omega_{xs}}{\omega_{xm}}\left(\frac{P_{st}}{P_{mt}}\right)^{1-\sigma_x} = \frac{\omega_{xs}}{\omega_{xm}}\left(\frac{A_{mt}}{\tilde{A}_{st}}\right)^{1-\sigma_x} \tag{42}$$

Notice that from the Proposition 1 and 2, if $\frac{\alpha\xi}{R-\mu\xi} - \frac{1-\alpha}{1+\mu}$ is negative, $\frac{\dot{\tilde{A}}}{\tilde{A}}$ will be smaller than γ_m. Hence, we conclude that $\left(\dot{\overline{\frac{P_{st}X_{st}}{P_{mt}X_{mt}}}}\right) < (1-\sigma_x)(\gamma_m - \gamma_s)$, and similarly $\left(\dot{\overline{\frac{P_{st}C_{st}}{P_{mt}C_{mt}}}}\right) < (1-\sigma_c)(\gamma_m - \gamma_s)$.

C Equilibrium equations

1. budget constraint

$$P_{ct}C_t + P_{xt}X_t + P_{ct}\dot{B}_t = w_t L + R_t K_t + r_t P_{ct} B_t \tag{1}$$

2. consumption aggregation

$$C_t = \left(\sum_{j \in \{a,m,s\}} \omega_{cj}^{1/\sigma_c} C_{jt}^{\sigma_c - 1/\sigma_c} \right)^{\frac{\sigma_c}{\sigma_c - 1}} \tag{2}$$

3. law of motion for capital:

$$\dot{K}_t = X_t - \delta K_t \tag{3}$$

4. household's Euler equation from bonds market:

$$\sigma \frac{\dot{C}_t}{C_t} = r_t - \rho + \left(\frac{\dot{P}_{xt}}{P_{xt}} - \frac{\dot{P}_{ct}}{P_{ct}} \right) \tag{4}$$

5. household's Euler equation from capital market:

$$\sigma \frac{\dot{C}_t}{C_t} = \frac{R_t}{P_{xt}} - \delta - \rho \tag{5}$$

6. optimality condition induced by cost minimization:

$$\frac{C_{it}}{C_{jt}} = \frac{\omega_{ci}}{\omega_{cj}} \left(\frac{P_{it}}{P_{jt}} \right)^{-\sigma_c} \tag{6}$$

, where $i, j \in \{a, m, s\}$ [11]

[11] This implies

$$P_{ct} = \left(\omega_{ca} P_{at}^{1-\sigma_c} + \omega_{cm} P_{mt}^{1-\sigma_c} + \omega_{cs} P_{st}^{1-\sigma_c} \right)^{\frac{1}{1-\sigma_c}}$$

7. investment goods production function:

$$X_t = A_{xt} \left(\sum_{j \in \{a,m,s\}} \omega_{xj}^{1/\sigma_x} X_{jt}^{\sigma_x - 1/\sigma_x} \right)^{\frac{\sigma_x}{\sigma_x - 1}} \tag{7}$$

8. investment goods production technology:

$$\dot{A}_{xt} = \gamma_x A_{xt} \tag{8}$$

9. optimality condition induced by cost minimization

$$\frac{X_{it}}{X_{jt}} = \frac{\omega_{xi}}{\omega_{xj}} \left(\frac{P_{it}}{P_{jt}} \right)^{-\sigma_x} \tag{9}$$

, where $i, j \in \{a, m, s\}$

10. sectoral production function:

$$y_{jt} = F(k_{jt}, n_{jt}) = A_{jt} k_{jt}^{\alpha} n_{jt}^{1-\alpha} \tag{10}$$

11. sectoral goods production technology:

$$\dot{A}_{jt} = \gamma_j A_{jt} \tag{11}$$

12. if $i = m$, working capital constraint:

$$w_t n_{mt} \leq \xi P_{xt} k_{mt} \qquad \text{if } j = m \tag{12}$$

13. sectoral labor demand:

$$(1 + \mathbb{I}_{j=m} \mu_t) w_t = F_{jn} = (1 - \alpha) p_{jt} A_{jt} k_{jt}^{\alpha} n_{jt}^{-\alpha} \tag{13}$$

14. sectoral capital demand:

$$R_t = F_{jk} + \mathbb{1}_{j=m}\mu_t \xi P_{xt} \tag{14}$$

15. bonds market clearing condition:

$$B_t = 0 \tag{15}$$

16. sectoral goods market clearing condition:

$$C_{it} + X_{it} = y_{it} \tag{16}$$

, where $i \in \{a, m, s\}$

17. labor market clearing condition

$$n_{at} + n_{mt} + n_{st} = L = 1 \tag{17}$$

18. capital market clearing condition

$$k_{at} + k_{mt} + k_{st} = K_t \tag{18}$$

D Proof for Proposition 5

Given the analytic form of μ_t, assuming $\mu_t > 0$, we have $\dot{\mu}_t = \frac{1-\alpha}{\xi}\dot{R}_t$.

Notice that from the investment firm's cost minimization, we have:

$$\frac{P_{mt}X_{mt}}{P_{at}X_{at}} = \frac{\omega_{xm}}{\omega_{xa}}\left(\frac{P_{mt}}{P_{st}}\right)^{1-\sigma_x} = \frac{\omega_{xm}}{\omega_{xa}}\left(\frac{A_{at}}{\tilde{A}_{mt}}\right)^{1-\sigma_x} \tag{19}$$

Notice that the growth rate of $\tilde{A}$ is:

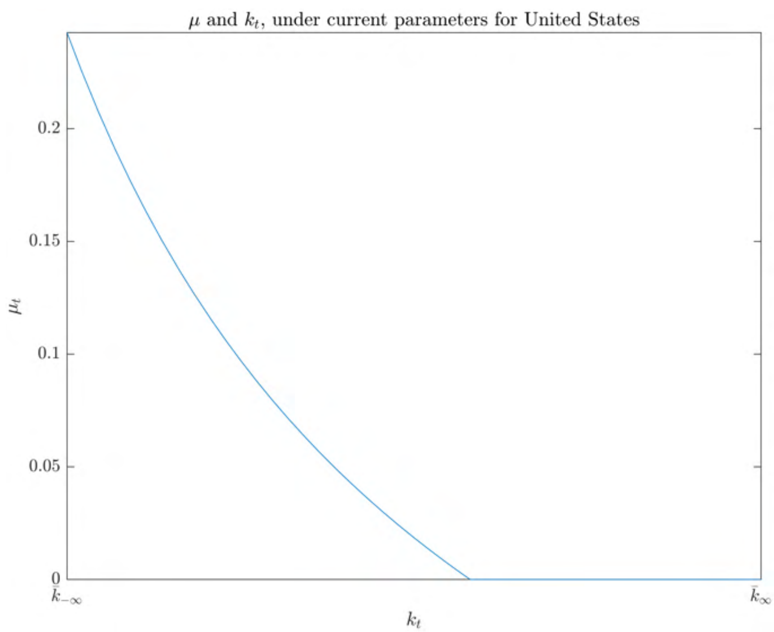
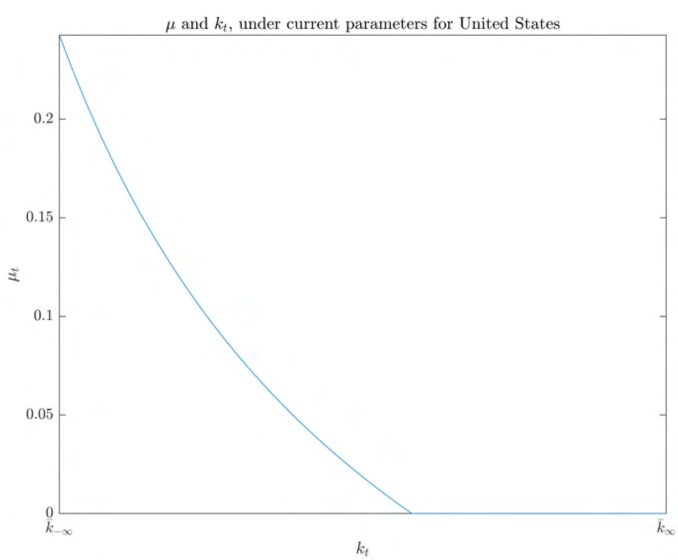


Figure 14: μ_t and k_t under the parameter values for the United States



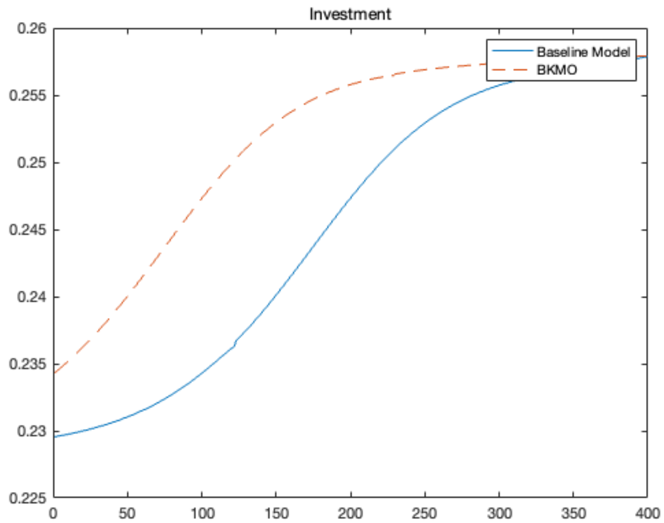


Figure 15: Total Investment Share

$$
\begin{aligned}
& \tilde{A}_{mt} = A_{mt} \left(\frac{R_t}{R_t - \mu_t \xi} \right)^{\alpha} \frac{1}{\left((1-\kappa)(1+\mu_t)\right)^{1-\alpha}} \\
\Rightarrow \quad & \log \tilde{A} = \log A_m + \alpha \log R - \alpha \log(R - \mu\xi) - (1-\alpha)\log(1+\mu) \\
\Rightarrow \quad & \frac{\dot{\tilde{A}}}{\tilde{A}} = \gamma_m + \alpha \frac{\dot{R}}{R} - \alpha \frac{1}{R - \mu\xi}\left(\dot{R} - \xi\dot{\mu}\right) - (1-\alpha)\frac{\dot{\mu}}{1+\mu} \\
& = \gamma_m + \left(\alpha - \frac{R}{R - \xi\mu} + \frac{\xi\mu}{R - \xi\mu} - (1-\alpha)\frac{\mu}{1+\mu} \right) \frac{\dot{R}_t}{R_t} \\
& = \gamma_m + (\alpha - 1)\left(1 + \frac{\mu}{1+\mu}\right)\frac{\dot{\mu}_t}{\mu_t}
\end{aligned}
$$

Since k_t is growing over time, μ_t is decreasing over time, hence $\dot{\mu}_t/\mu_t < 0$. Therefore, $(\alpha - 1)\left(1 + \frac{\mu}{1+\mu}\right)\frac{\dot{\mu}_t}{\mu_t} > 0$, which implies $\frac{\dot{\tilde{A}}}{\tilde{A}} > \gamma_m$.

Hence, we conclude that $\left(\frac{P_{mt}\dot{X}_{mt}}{P_{at}X_{at}}\right) < (1-\sigma_x)(\gamma_a - \gamma_m)$.

E Additional Graphs from the Simulation

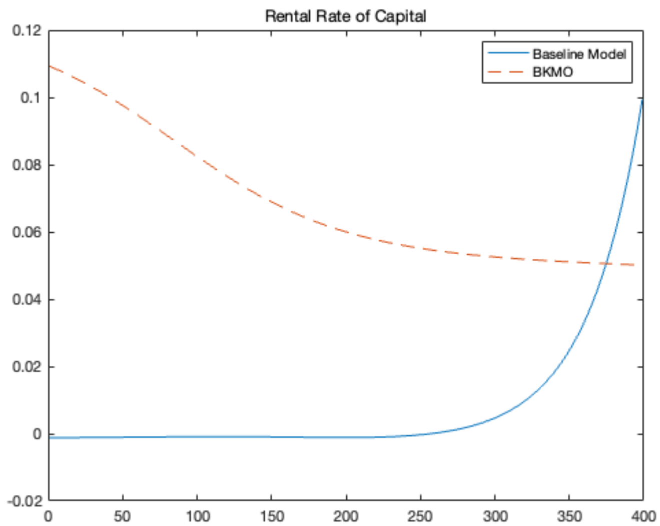


Figure 16: Rental Rate of Capital

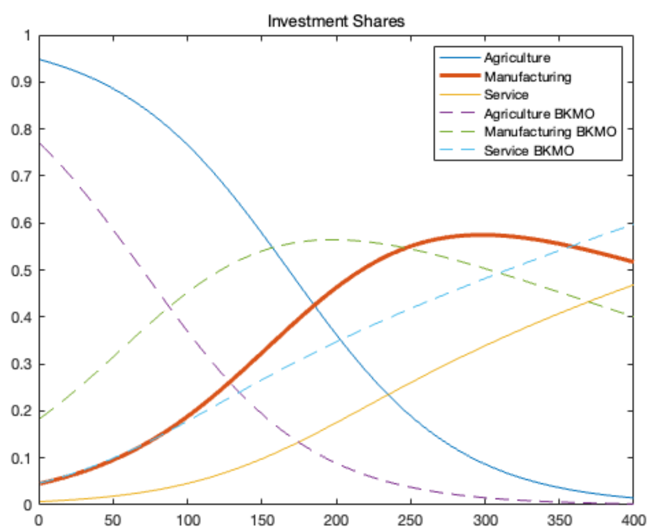


Figure 17: Structural transformation of investment share, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

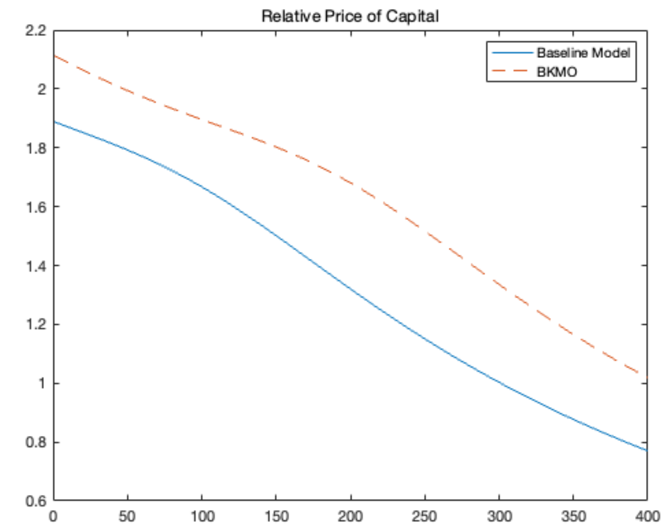


Figure 18: Relative Price of Capital, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

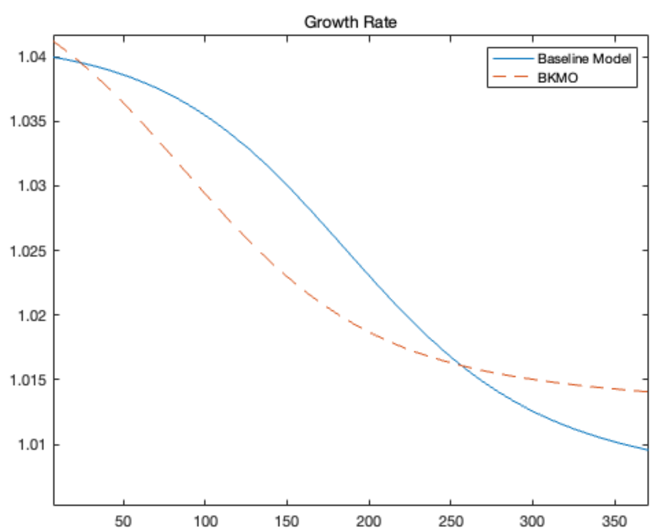


Figure 19: Growth rate, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

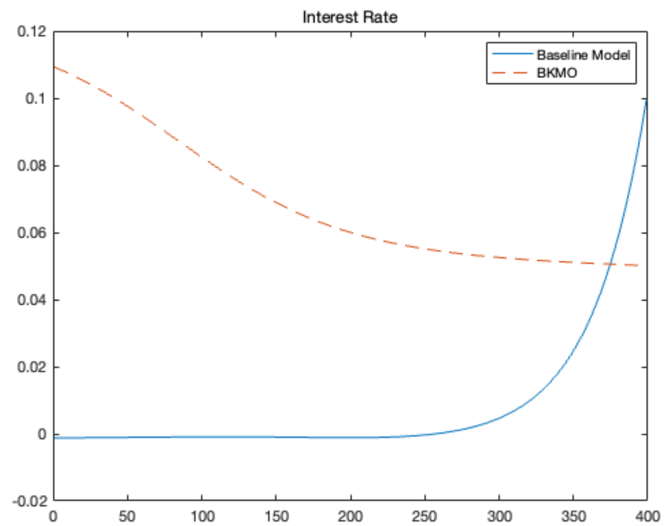


Figure 20: Interest rate, simulation of the United States economy from 1700 to 2100. Dotted line indicates the comparison with Buera et al. (2021).

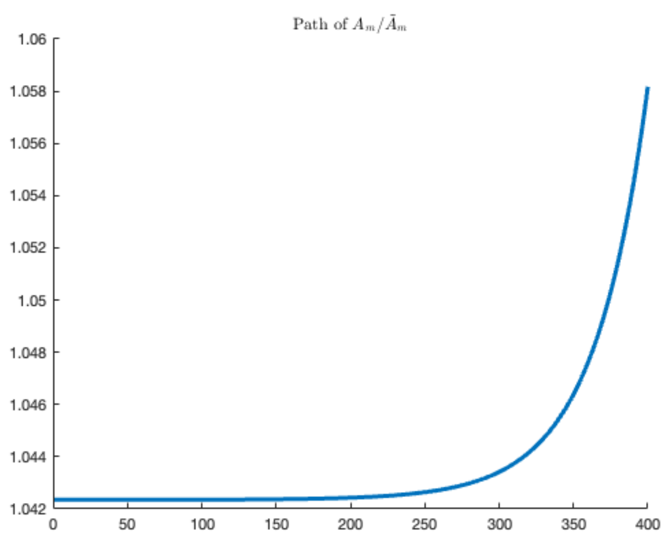


Figure 21: Path of $\tilde{A}$ compared to A_m

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