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# Financial Intermediation and Structural Change: Theory and Evidence

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# Financial Intermediation and Structural Change: Theory and Evidence

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**Abstract**

Does financial intermediation affect structural change? We investigate both theoretically and empirically whether financial development accelerates structural change during the post-industrialization phase where employment, value-added and expenditure shares change towards services and away from manufacturing. We build a dynamic general equilibrium model where firms and households face different types of intermediation costs, and structural change can be driven by mutually independent technology differences – exogenous productivity gaps or asymmetric factor elasticities – as well as by learning-by-doing. Besides suggesting a stronger impact of financial development when productivity is endogenous and services are labor-intensive, all the model specifications robustly predict that exogenous reductions in intermediation costs – e.g., deregulation shocks – accelerate the pace and extent of structural change. We test this prediction empirically by examining the effects of state-by-state bank branching deregulation in the United States in the 1970-1990s period. Using a range of estimation techniques including synthetic control methods – pooled, augmented, and with staggered treatment – we show that bank branching deregulation accelerated the structural change that was already underway, i.e., services account for a greater share of output and employment than they would have in the absence of deregulation.

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# Contents

# 1 Introduction

Does financial intermediation affect structural change? There is a large literature linking finance and growth (Levine, 2005), and economic development is known to go hand-in-hand with the evolving structure of the economy – as economies get richer, manufacturing shrinks as a share of the economy, while services grow (Herrendorf et al., 2014) – but comparatively little attention has been paid to the direct relationship between finance and structural change. In this paper, we examine the relationship between financial intermediation and structural change both theoretically and empirically. We build a two-sector dynamic general equilibrium model where reductions in intermediation costs accelerate the pace and extent of structural change towards services and away from manufacturing. We investigate this prediction empirically by studying the effect of bank branching deregulation in the United States on the structure of individual states' economies. Using a range of synthetic controls methods, we find that bank branching deregulation accelerated the structural change that was already underway: states that deregulated ended up with a significantly higher share of services and lower share of manufacturing in the economy than they would have done in the absence of deregulation.

Over the past three decades, the finance-growth relationship and the origins of structural change have been central but separate topics in macroeconomics: each has attracted considerable interest, but remained a distinct area of research.[1] The existence of causal links between financial intermediation and structural change is empirically plausible, but is seldom incorporated in theoretical models. Still, robust theoretical predictions would be highly informative for empirics: most advanced economies faced radical changes in financial intermediation and in banking regulation while experiencing the decline of manufacturing and the rise of services. This consideration motivates our first aim in this paper, i.e., modelling the impact of financial intermediation on the shares of employment, capital use, value added, and expenditures respectively captured by manufacturing and service sectors.

The key objective of our theoretical analysis is to find robust predictions that hold true across models containing (a) alternative engines of structural change and (b) different types of intermediation costs affecting capital-using firms and/or capital-lending savers. By adopting flexible specifications of production technologies, we obtain three variants of the benchmark model that generate two mutually independent engines of structural change (Models I and II), and a third, hybrid mechanism that incorporates endogenous productivity (Model III). In Model I, structural change results from *exogenous gaps in productivity growth* given identical input elasticities. In Model II, productivity growth plays no role and structural change originates, instead, in *asymmetric factor elasticities.* In Model III, learning-by-doing in manufacturing makes sectoral productivity gaps *endogenous* and input elasticities *asymmetric ex post.* Each model variant includes different types of financial intermediation costs: capital rental rates and the returns to financial assets exhibit a 'double wedge' caused by *funnelling* – i.e., real resources being lost while intermediaries transform savings into physical capital – and by *wealth depletion* – i.e., real intermediation costs reducing the net value of the stock financial assets owned by households. These wedges are captured by parameters representing the inherent inefficiencies of financial intermediaries and/or real costs induced by regulation. All the variants of our model predict that relieving financial intermediation costs – especially, wealth-depleting costs – increases the pace and extent of structural change by increasing the transitional growth rates, and the long-run levels, of the employment and output shares of the service sector. Moreover, since structural change is accompanied by *sectoral capital diversion* – a progressive decline in the manufacturing

[1] Besides two exceptions that we discuss below (Buera et al. 2011; Heblich and Trew, 2019), the finance-structural change nexus has so far been substantially under-researched at both the theoretical and empirical levels.

share of capital use – reduced intermediation costs boost capital accumulation at the economy level but not in manufacturing, because (reinforced) structural change drives (additional) capital units towards the production of services. We show that endogenous productivity enhances both structural change and capital diversion. Reduced intermediation costs trigger a positive productivity response that further expands the value added share of services while curbing capital accumulation in manufacturing firms.

In our empirical analysis, we investigate whether bank branching deregulation in the United States did accelerate structural change towards services in terms of employment and value added shares. Prior to the 1970s, most states had unit banking restrictions that were relaxed state-by-state in a quasi-random order until the mid-1990s. Most banks in most states were limited to a single branch, until bank branching deregulation allowed for expansion, relieving intermediation costs for lenders and borrowers. This event can be interpreted as an exogenous shock to the financial sector that allows us to infer causality from banking regulation to sectoral shares dynamics.[2] Following the approach of pooled synthetic controls originally developed in policy evaluation studies (Abadie and Gardeazabal, 2003), we build a statistical test that assesses the contribution of the financial shock to the ongoing structural change by checking the overall pre-treatment goodness of fit.[3] Our results suggest that bank branching deregulation did in fact cause faster structural change towards services and away from manufacturing than would have occurred without deregulation, drawing a direct line from finance to structural change, consistent with our theory.

Our analysis contributes to different strands of theoretical and empirical research. Among the few papers to theorise an explicit link between finance and structural change, Buera et al. (2011) consider a two-sector economy where manufacturing firms are large in scale and have relatively large financing needs, so that financial frictions disproportionately disadvantage manufacturers relative to service producers.[4] Our model does not impose asymmetric financial needs and focuses, instead, on the equilibrium co-movements of input and output prices when sectors have asymmetric technological characteristics. This allows us to show that financial intermediation costs reinforce the pace and extent of structural change in a model that incorporates, and distinguishes between, multiple drivers of structural change: exogenous gaps in productivity

[2] Several papers have studied the effects of bank branching deregulation in the US. Jayaratne and Strahan (1996) find that deregulation leads to significantly higher output growth. Krozsner and Strahan (1999) show that deregulation is othorgonal to many outcome variables of interest. Beck et al. (2000) find that bank branching deregulation reduces income inequality. Jerzmanowski (2017) shows that bank branching deregulation affects economic growth through a mixture of physical capital accumulation and TFP growth, while finding no effect on human capital. In particular, the effect of deregulation on manufacturing works by increasing TFP growth rather than accelerating capital accumulation – a result that we are able replicate in our theoretical model with endogenous productivity.

[3] The synthetic control method (SCM) was introduced by Abadie and Gardeazabal (2003) to study the effect of terrorism on the Basque Country. They construct a synthetic Basque Country as the convex combination of other Spanish regions that minimises a measure of distance between actual and synthetic outcomes prior to the onset of terrorism, and see how the actual and synthetic Basque Countries diverge after the onset of terrorism. If the synthetic Basque Country is a good fit for the real Basque Country in all respects except the onset of terrorism, then any difference between the two after 'treatment' – in this case, the onset of terrorism – can be interpreted as the causal effect of that treatment. The same method has been used to assess the efficacy of a tobacco control policies in California (Abadie et al., 2010) and the economic effect of German reintegration in 1990 (Abadie et al., 2015). These instances of the SCM each consider a single case study. Dube and Zipperer (2015) extend this idea by using a mean percentile rank test to pool multiple synthetic control studies. This is the approach we take later in the paper, with particular attention paid to the validity of such pooling exercises.

[4] The existence of sectoral asymmetries in financing needs is empirically documented (Chakraborty and Mallick, 2012)) and can certainly play a role in feeding structural change. Without neglecting this real-world aspect, our analysis takes a different approach that emphasizes general equilibrium relationships and is thus complementary to the analysis of Buera et al. (2011).

growth, asymmetric factor elasticities, and learning-by-doing in manufacturing.[5] In particular, we show that the endogenous response of productivity in the manufacturing sector reinforces both structural change and sectoral capital diversion: this theoretical prediction is consistent with recent empirical evidence showing that bank branching deregulation increases productivity growth but does not necessarily increase fixed capital formation in the manufacturing sector Jerzmanowski (2017).

At the empirical level, our paper contributes to both the finance-and-growth literature and structural change studies. The hypothesis that finance causally affects economics growth is gaining increasing empirical support, but this literature on finance and growth has not yet engaged in the systematic analysis of structural change.[6] Symmetrically, most structural change studies tend to downplay the role of finance and focus, instead, on the fundamental origins of *industrialization* – the early phase of development during which manufacturing surpasses agriculture in terms of value added and employment – and *post-industrial growth* – the phase during which the service sector takes the lead and the relative importance of manufacturing declines.[7] To our knowledge, the only study establishing causal links between financial liberalisation and structural change is Heblich and Trew (2019), which shows that improved access to banks accelerated the Industrial Revolution in England and Wales over the period 1817-1881. While Heblich and Trew (2019) study the industrialization phase (i.e., manufacturing overtaking agriculture) in Britan, we study post-industrial growth (i.e., services overtaking manufacturing) in the United States. This is a useful point of comparison to our results: Heblich and Trew (2019) find that enhanced banking access pushed resources into manufacturing, whereas we find that bank branching deregulation helped the service sector, in line with our model of manufacturing decline. This is further evidence that the role finance has to play depends crucially on the state of economic development, as found by Rioja and Valev (2004). While more work is needed to establish this definitively, it appears that finance may 'grease the wheels' of structural change, and accelerate whatever shift predominates in any given economy at any given time – a result that can perhaps be reproduced in a unified model containing both phases of structural change.

Also, our empirical analysis contributes to the recent literature on Synthetic Control Methods (SCM). This novel approach is preferable to some more traditional policy evaluation methods in several respects. First, the SCM is specification-free. Second, the treatment need not be exogenous: we find in Section 5.2 that the timing of bank branching deregulation is likely to be related to the *ex ante* structural composition of the economy, which undermines the causal interpretation of the difference-in-differences regressions. However, so long as there is a 'good fit' when creating a synthetic counterpart for each treated unit, this is not a problem for the SCM. While not something that can be tested directly, we propose a simple statistical test for the overall 'goodness of fit' relative to placebo deregulations that provides some indication of the validity of pooling several studies. In order to alleviate concerns with the goodness of fit, we improve pre-treatment fit by employing the ridge augmented synthetic control method

[5] Acemoglu (2009), Chap.20, provides an in-depth discussion of existing theories of structural change, including preference-based explanations - e.g., Kongsamut et al. (2001). Exogenous gaps in productivity growth are discussed in detail in Ngai and Pissarides (2007). Asymmetric factor elasticities are analyzed in Mehlum et al. (2016). This literature does not consider financial intermediation costs, which is our main focus.

[6] See Levine (2005) and Giovannini et al. (2013) for comprehensive reviews. This literature includes the studies of bank branching deregulation cited above.

[7] Herrendorf et al. (2014) present an exhaustive list of stylised facts of structural change. Expressed as a share of the economy, whether in terms of employment or value-added, for both currently rich and currently poor countries, the following stylised facts appear to hold: the richer an economy in terms of GDP per capita, the smaller the share of agriculture; the richer an economy, the greater the share of services; and the richer an economy, the greater the share of manufacturing, up to a certain point – thereafter, manufacturing decreases as a country becomes richer, forming an inverted 'U' shape.

(Ben-Michael et al., 2019b), which can be thought of as a bias-correction model that allows limited extrapolation outside the convex hull of the 'donor states' used to create the synthetic counterfactual for each deregulation event. As a robustness check, we confirm our results using the staggered synthetic control method (Ben-Michael et al., 2019a), which balances finding a good fit for *individual* deregulated states with finding a good fit for the *average* deregulated state, thus reducing bias in estimates of the average treatment effect on the treated.

# 2 The Benchmark Model

This section describes the structure of our benchmark model. Households consume manufactured goods and services, and save in the form of financial assets representing ownership of physical capital. Firms in both sectors use labor and physical capital to produce their respective outputs. Banks operate as intermediaries between households and firms: they collect household savings into a 'capital fund' and give producers access to physical capital by setting up rental contracts. These intermediation activities entail real costs that create a structural wedge between capital rental rates and the rate of return to private wealth. In this section, we adopt a flexible specification of technologies that can generate different engines of structural change.

## 2.1 Households

Total population is denoted $N(t)$ at time $t$ and grows at the exogenous net rate $n$,

$$\dot{N}(t) = N(t) \cdot n \tag{1}$$

Households are dynasties of homogeneous individuals endowed with the same initial endowments at time zero and exhibiting identical preferences and fertility rates. Individuals purchase manufactured goods and services, with instantaneous utility given by

$$u(c(t), s(t)) = \ln \left[ \gamma \cdot (c(t))^{\frac{\sigma-1}{\sigma}} + (1-\gamma) \cdot (s(t))^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where $c$ is individual consumption of manufactured goods, $s$ is individual consumption of services, $\gamma \in (0,1)$ is a weighting parameter and $\sigma \in (0,1)$ is the elasticity of substitution between manufactured goods and services. As clarified by previous literature, the hypothesis of strict complementarity $\sigma < 1$ in this class of models is necessary to generate joint dynamics of expenditure shares and of sectoral output shares that are consistent with the empirically observed patterns of structural change.[8]

We take the manufactured good as the numeraire and set its price to unity. Each household supplies inelastically one unit of labor and receives the wage rate $w$. Households also earn asset income $r_q q$, where $q$ is the stock of financial assets per capita and $r_q$ is the associated rate of return. Individual savings are entirely used to accumulate financial assets, $\dot{q}$, and equal the difference between total current incomes $r_q q + w$ and expenditures on goods and services $c + p_s s$, where $p_s$ is the market price of services. The budget constraint reads

$$\dot{q}(t) = r_q(t) q(t) + w(t) - c(t) - p_s(t) s(t). \tag{3}$$

Consumption and saving choices obey the standard utilitarian criterion whereby each household maximizes the dynastic utility function

$$\int_0^{\infty} u(c(t), s(t)) \cdot e^{-(\rho-n)t} dt \tag{4}$$

[8] Assuming $\sigma < 1$ guarantees that rising (declining) shares of services (manufacturing) in production are accompanied by rising (declining) shares of services (manufacturing) in expenditures independently of what drives structural change in production shares: see Ngai and Pissarides (2007)) and Mehlum et al. (2016).

subject to (2) and (3). The key utility-maximizing relationships can be formulated more easily in terms of expenditure shares and consumption growth as follows. Denoting individual expenditure by $x \equiv c + p_s s$, the solution to the household problem (see Appendix) yields

$$\frac{c(t)}{p_s(t)\,s(t)} = \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}, \tag{5}$$

$$\frac{\dot{x}(t)}{x(t)} = r_q(t) - (\rho - n). \tag{6}$$

Condition (5) determines the allocation of individual expenditure between manufactured goods and services at each point in time: following an increase in the price of services, the expenditure share of manufactured goods increases under substitutability, $\sigma > 1$, and declines under complementarity, $\sigma < 1$. Condition (6) is a standard Euler equation establishing that expenditure per capita grows (declines) over time when the rate of return to financial assets exceeds (falls short of) the utility discount rate adjusted for population growth.

### 2.2 Financial intermediation

The productive asset ('real asset') of the economy is physical capital – a manufactured commodity used as an input by firms – denoted by $K$ in aggregate terms. The aggregate private wealth of households, $qN$, consists of 'financial assets' representing ownership of physical capital. Banks operate as intermediaries between households and firms. On the one hand, banks collect all household savings into a 'capital fund' that finances the provision of physical capital to firms, and remunerate each individual share $q$ at the rate of return $r_q$. On the other hand, banks give producers access to physical capital by setting up rental contracts whereby firms pay a rental rate $r_k$ for each unit of physical capital borrowed through the capital fund. In order to model the existence of frictions in a coherent way, we rule out direct lending between households and producers: the banking sector is strictly necessary to transform savings into productive investments. This hypothesis can be justified in many ways (e.g., informational gaps, lack of know-how, coordination failures), but the essential point is that financial intermediation is costly and private agents cannot circumvent such costs on their own. In this environment, the market equilibrium will exhibit a structural wedge between the rate of return to wealth received by households, $r_q$, and the capital rental rate paid by firms, $r_k$.

Since our analysis focuses on intermediation costs, we do not model physical capital production explicitly: the transformation of savings into physical capital is a process that we incorporate into the broad set of operations carried out by banks. This assumption is innocuous as long as physical capital is produced under competitive conditions and is *de facto* homogeneous with manufactured goods – e.g., produced by means of unconsumed commodities using a linear technology – so that its price can be normalized to unity, like in standard neoclassical growth models.[9]

The macroeconomics literature suggests two main channels through which financial intermediation creates gaps between the capital rental rate and the return to financial assets. The first

[9]This assumption allows us to define an equilibrium wedge $r_k$ and $r_q$ that is exclusively determined by financial intermediation costs. In reality, there are many potential sources of structural gaps between rental rates and returns to savings. A more complicated model would be one in which banks sell to households securities that represent ownership of a set of intermediate firms that produce physical capital and rent it to final producers (and then compensate their shareholders with the proceeds from capital rentals). In this environment, a distinct price of capital goods and the possibility of imperfect competition (e.g., market power for capital producers) would introduce further elements into the wedge between $r_k$ and $r_q$, namely, a mark-up wedge and further price effects. We purposefully exclude these aspects from our model in order to focus on the real costs induced by financial intermediation.

channel captures ex-ante transformation costs that affect the size of investment before production takes place. Assume that a fraction $(1-\psi)<1$ of the total savings collected by banks is actually transformed into new physical capital for production purposes,

$$\dot{K}(t)=(1-\psi)\cdot\left[\dot{q}(t)\,N(t)+n\cdot q(t)\,N(t)\right], \tag{7}$$

where the term in square brackets equals aggregate savings and incorporates the combined effects of increased financial assets per capita and of increased population. The constant parameter $\psi\in(0,1)$ measures the extent of the *funnelling effect* caused by financial intermediation, i.e., the real resources lost while transforming savings into productive capital (Pagano, 1993). To simplify the analysis, we assume that initial stocks at time zero are linked by the same transformation technology, $K(0)=(1-\psi)\,q(0)\,N(0)$, where $q(0)\,N(0)=q_0N_0$ is a predetermined stock of homogeneous commodity held by households at time zero. In this case, integration of (7) over time yields the general relationship linking physical capital to financial assets[10]

$$K(t)=(1-\psi)\,q(t)\,N(t)\ \text{ in each } t\in(0,\infty]\,. \tag{8}$$

The second channel through which intermediation absorbs real resources is through variable operating costs that ultimately reduce disposable private wealth. Assume that banks managing the capital fund are subject to real costs equal to a constant fraction $\theta\in(0,1)$ of each individual share $q$ owned by households. We can interpret $\theta$ as a composite parameter capturing, at the same time, real transaction costs, inherent inefficiencies of financial intermediaries as well as the effects of regulations like reserve requirements (Roubini and Sala-i Martin, 1992). In general, assuming $\theta>0$ implies that financial intermediation erodes the ex-post value of the stock of assets held by households. We will refer to this mechanism as to the *wealth depletion effect*.

In our analysis, we will think of both $\psi$ and $\theta$ as inefficiency parameters that may be subject to shocks induced by banking regulation – in particular, less stringent regulations can be represented by exogenous reductions in $\psi$ or $\theta$. The key property of the model is that both funnelling and wealth depletion generate gaps between the rents paid by capital users and the returns to financial assets received by households. The aggregate budget constraint of the banking sector includes capital rents $r_kK$ as an inflow, the returns paid to households $r_qqN$ as an outflow, and total operating costs $\theta qN$. Therefore, assuming a competitive banking sector, the zero-profit condition reads $r_kK=r_qqN+\theta qN$. Substituting (8) in the zero-profit condition, we obtain

$$r_k(t)\,(1-\psi)=r_q(t)+\theta. \tag{9}$$

Expression (9) shows that, for a given real return to physical capital $r_k$, intermediation costs reduce the overall return from financial wealth in different ways. The funnelling effect is similar to a capital-income tax rate: following an exogenous change $\mathrm{d}\psi$, the resulting increase in the interest rate differential is quantitatively small because it is proportional to the rental rate paid by firms, $\mathrm{d}(r_k-r_q)=r_k{\cdot}\mathrm{d}\psi$. The effect of $\theta$, instead, is similar to that of a wealth tax: for a given capital rental rate, an increase $\mathrm{d}\theta$ causes an equivalent reduction in the return to wealth, $\mathrm{d}r_q=-\mathrm{d}\theta$.

[10] The hypothesis $K(0)=(1-\psi)\,q_0N_0$ is innocuous for the applications that we will perform in this paper, including the comparative effects of different values of $\psi$ for the equilibrium path followed by an economy between time $t=0$ and $t\to\infty$ given that $\psi$ is constant throughout the reference time horizon $t\in(0,\infty]$. For more sophisticated applications – e.g., studying the transition from a first steady state characterized by $\psi=\psi_0$ to a second steady state characterized by $\psi=\psi_1$ – equation (8) needs to be modified to account for changes in the ratio $K(t)\,/q(t)\,N(t)$ implied by changes in the value of parameter $\psi$.

### 2.3 Production sectors

This section considers flexible specifications of the sectoral production functions that will allow us to discuss three different variants of the model as subcases. We denote by $\ell$ the fraction of workers employed in the manufacturing sector, and by $1-\ell$ the fraction employed in service production. Perfect labor mobility and competition in the labor market ensure wage equalization in equilibrium. In the manufacturing sector, production equals

$$M(t) \equiv a_M(t) \cdot (K_M(t))^{\alpha} \left(a_\ell(t)\,\ell(t)\,N(t)\right)^{1-\alpha} \tag{10}$$

where $M$ is the aggregate output of manufactured goods, $a_M$ is an index of Hicks-neutral productivity, $a_\ell$ is an index of labor productivity in manufacturing, and $K_M$ is physical capital employed in goods production with an elasticity parameter $\alpha \in (0,1)$. The productivity indices $a_M$ and $a_\ell$ are generally time-varying and we will make different hypotheses about the process of technological change so as to consider cases of exogenous as well as endogenous productivity growth. In the service sector, production equals

$$S(t) \equiv a_S \cdot (K_S(t))^{\beta} \left[(1-\ell(t))\,N(t)\right]^{1-\beta} \tag{11}$$

where $S$ is the aggregate output of services, $a_S > 0$ is a constant productivity parameter, $K_S$ is physical capital employed in service production with an elasticity parameter $\beta \in [0,1)$. As we show below, different specifications of productivity $a_M$ and of the elasticity parameters, $\alpha$ and $\beta$, yield variants of the benchmark model where structural change is driven by different, mutually independent engines.

# 3 Financial Intermediation and Structural Change

This section derives theoretical predictions about the impact of financial intermeditation costs on the pace and the extent of structural change when the latter is driven by different engines. In general, rising employment and output shares for the service sector may result from sectoral productivity gaps or from asymmetric factor elasticities, whereas rising shares of expenditures in services depend on endogenous responses of product prices to structural change in output shares. This section considers three cases of particular interest to our research question. In Model I, structural change is driven by exogenous gaps in productivity growth given identical input elasticities (subsection 3.1). In Model II, instead, structural change originates exclusively in a factor reallocation mechanism that hinges on asymmetric factor elasticities (subsection 3.2). In Model III, learning-by-doing in manufacturing makes sectoral productivity gaps endogenous and input elasticities asymmetric ex-post (subsection 3.3). The main results of our theoretical analysis are summarized in subsection 3.4. Detailed derivations and the proofs of all Propositions are reported in a separate Appendix.

### 3.1 Model I: Exogenous Gaps in Productivity Growth

This subsection assumes identical input elasticities in the two sectors, $\alpha = \beta$, and a persistent gap in total factor productivity growth: while $a_S$ remains constant over time, $a_M(t)$ grows at the positive exogenous rate

$$\frac{\dot{a}_M(t)}{a_M(t)} = g_M > 0. \tag{12}$$

For simplicity, labor productivity in the manufacturing sector is normalized to unity, $a_\ell(t) = 1$. In this setup, the engine of structural change is the exogenous gap in productivity growth studied in Ngai and Pissarides (2007). The key characteristic of Model I is that identical input elasticities imply the same capital-labor ratio in the two sectors, which we denote by $\kappa$. From the profit-maximizing conditions of both sectors, factor price equalization yields

$$\frac{K_M(t)}{\ell(t)N(t)} = \frac{K_S(t)}{N(t)(1-\ell(t))} = \kappa(t). \tag{13}$$

Identical input elasticities imply, in turn, that the price of services will grow at the same rate as total factor productivity growth in the manufacturing sector:

$$a_M(t) = p_s(t)\cdot a_S, \qquad \frac{\dot{p}_s(t)}{p_s(t)} = g_M. \tag{14}$$

The intuition for result (14) is that service firms need to compensate capital and labor at the respective market rates of reward while keeping the same input proportions as manufacturing firms: this is only possible if the price of services grows indefinitely so as to exactly compensate for the persistent gap in productivity growth. The joint dynamics of individual expenditures, $x$, and capital per worker, $\kappa$, determine a unique equilibrium path leading to the following long-run outcomes: individual expenditures and capital per worker grow asymptotically at the same rate

$$\lim_{t\to\infty}\frac{\dot{x}(t)}{x(t)} = \lim_{t\to\infty}\frac{\dot{\kappa}(t)}{\kappa(t)} = \frac{1}{1-\alpha}g_M \equiv g^*, \tag{15}$$

and the rental rate of capital converges to the steady state level

$$\lim_{t\to\infty} r_k(t) = \frac{g^*+\theta+(\rho-n)}{1-\psi} \equiv r_k^{ss}. \tag{16}$$

Result (16) confirms that both funnelling and wealth depletion effects modify the rental rate of capital in the long run. By (9), the long-run rate of return to financial wealth, instead, is pinned down by productivity growth and the utility discount rate, $\lim_{t\to\infty} r_q(t) = g^* + \rho - n$. The reason is that infinitely-lived households will keep on accumulating financial wealth until the associated rate of return matches their utility discount rate, regardless of the underlying level of the marginal product of capital. Considering sectoral variables, this model predicts that employment and output value shares converge to stationary levels,

$$\lim_{t\to\infty}\ell(t) = \alpha\frac{g^*+\theta}{g^*+\theta+\rho-n} \equiv \ell^{ss}, \tag{17}$$

$$\lim_{t\to\infty}\frac{M(t)}{p_s(t)S(t)} = \alpha\frac{g^*+\theta}{(1-\alpha)(g^*+\theta)+\rho-n} = \frac{\ell^{ss}}{1-\ell^{ss}}, \tag{18}$$

whereas consumption expenditure shares diverge permanently,

$$\lim_{t\to\infty}\frac{p(t)s(t)}{x(t)} = 1 \text{ and } \lim_{t\to\infty}\frac{c(t)}{x(t)} = 0. \tag{19}$$

The long-run divergence of expenditure shares is due to the indefinite increase in the relative price of services, which raises the share of consumption expenditures devoted to services. Despite divergence in expenditure shares, the ratio between sectoral output values approaches a stationary level in (18) because manufacturing goods are used for both consumption and investment purposes.[11] The equilibrium path of individual expenditures, capital per worker and interest

[11] As shown in the Appendix, the stationary ratio of output values is accompanied by ever-growing 'physical ratios' in consumed and produced units: as employment shares stabilize, output growth in the service sector is exclusively due to capital accumulation, whereas manufacturing output grows faster due to sectoral productivity growth.

rates is reminiscent of standard neoclassical models: as $x$ and $\kappa$ grow, the marginal product of capital declines, ensuring a constant expenditure-wealth ratio in the long run. Considering sectoral variables, expenditure shares exhibit monotonic convergence to their respective long-run values (19), whereas employment shares may follow either monotonic or hump-shaped paths depending on parameter values: the manufacturing share of employment is surely declining, if not always, from some finite instant onwards:

$$\dot{\ell}(t) < 0 \text{ in each } t \in \left[t', \infty\right) \text{ for some finite } t' \geqslant 0. \tag{20}$$

The share of labor employed in manufacturing will eventually decline as workers must move towards the service sector to support increased demand for services, at least in the medium to long run.[12]

The following Proposition describes the impact of financial intermediation costs on key long-run variables:

**Proposition 1** *(Long-run effects of intermediation costs in Model I) Assume $\alpha = \beta$, $a_\ell(t) = 1$ and $a_M(t)$ given by (12). In the long-run equilibrium characterized by (15)-(18), exogenous increases in $\theta$ and in $\psi$ yield the following effects:*

$$\frac{\partial r_k^{ss}}{\partial \theta} > 0, \quad \frac{\partial}{\partial \theta} \lim_{t\to\infty} \frac{x(t)}{\kappa(t)} > 0, \quad \frac{\partial}{\partial \theta} \lim_{t\to\infty} \frac{x(t)}{q(t)} > 0, \quad \frac{\partial \ell^{ss}}{\partial \theta} > 0,$$

$$\frac{\partial r_k^{ss}}{\partial \psi} > 0, \quad \frac{\partial}{\partial \psi} \lim_{t\to\infty} \frac{x(t)}{\kappa(t)} > 0, \quad \frac{\partial}{\partial \psi} \lim_{t\to\infty} \frac{x(t)}{q(t)} = 0, \quad \frac{\partial \ell^{ss}}{\partial \psi} = 0.$$

*Proof: see Appendix.*

Proposition 1 shows that different types of intermediation costs bear asymmetric effects on some variables. While both funnelling and wealth depletion effects reduce the expenditure to physical capital ratio, $x/\kappa$, their impact on the average propensity to spend out of wealth, $x/q$, differs. On the one hand, both $\theta$ and $\psi$ tend to increase $x/\kappa$ because a higher rental rate $r_k$ reduces the demand for physical capital of all firms. On the other hand, considering household behavior, changes in $\theta$ and in $\psi$ induce different responses in savings. An increase in $\theta$ raises $x/q$ in the long run because the wealth depletion effect increases the unconsumed fraction of manufacturing output, prompting households to permanently reduce net saving rates.[13] An increase in $\psi$, instead, affects the rate of wealth accumulation indirectly through the rate of return to assets, but this effect vanishes as $r_q \to r_q^{ss} = \rho - n$, leaving net saving rates and $x/q$ unchanged in the long run.

The different effects of $\theta$ and $\psi$ on net asset accumulation bear substantial implications for structural change. An increase in $\theta$ permanently increases the employment share of the manufacturing sector, whereas changes in the intensity of funnelling do not affect $\ell^{ss}$. The reason is that manufacturing output has two competing uses – i.e., consumption or investment good – and different types of intermediation costs affect the unconsumed fraction of $M$ in different

[12] The smooth path of structural change that we observe in expenditure shares is driven by the consumer response to the price of services – which grows exogenously in this variant of the model – does not map into a smooth path of structural change in output and employment shares because the manufactured good can be either consumed or transformed into physical capital. In the very short run, if the economy starts with very low initial capital, the initial demand for capital can be strong enough to attract more labor in manufacturing. Still, this will be the case only for a finite time interval since workers will eventually move to the service sector to support increased demand for services.

[13] The notion of net saving rate mentioned in the text is $\dot{q}/(r_q q + w)$, that is, the net accumulation of financial assets divided by current income. An increase in the net saving rate implies a complementary decline in the expenditure-assets ratio: from (3), we have $\dot{q}/(r_q q + w) = 1 - (x/q)$.

ways. In the long run, the share of expenditures devoted to manufacturing consumption vanishes, $c(t)/x(t) \to 0$, making unconsumed goods the dominant destination of manufacturing output. The relative value of manufacturing output in the long run is thus determined by the opportunity cost of saving, which includes the discounting effect created by wealth depletion: as shown in Appendix, an increase in $\theta$ increases the relative value of manufacturing production,

$$\frac{\mathrm{d}}{\mathrm{d}\theta}\lim_{t\to\infty}\frac{M(t)}{p_s(t)\,S(t)} = \frac{\mathrm{d}}{\mathrm{d}\theta}\lim_{t\to\infty}\frac{1}{x(t)/q(t)}\cdot[g^*+\theta] > 0, \tag{21}$$

and such increase implies, from (18), a higher employment share in manufacturing in the long run, $\mathrm{d}\ell^{ss}/\mathrm{d}\theta > 0$. The same reasoning implies that changes in the funnelling rate $\psi$ do not modify sectoral employment and value added shares in the long run.[14]

Figure 1 reports the full equilibrium paths of key macroeconomic variables and the impact of *relieving* financial intermediation costs – that is, shocks that reduce $\theta$ or $\psi$ – on the pace and extent of structural change, both in the transition and in the long run. All the graphs in the left column refer to Model I and compare three numerical simulations obtained with the same initial level of aggregate wealth $q(0)N(0) = q_0N_0$. The baseline parametrization assumes $\theta = 0.02$ and $\psi = 0.10$. The second parametrization assumes a lower wealth depletion effect, $\theta = 0.01$. The third parametrization assumes a lower funnelling effect, $\psi = 0.05$. Lower $\theta$ and lower $\psi$ bear the same qualitative effects on interest rates: reducing either type of intermediation costs boosts capital per worker and reduces the wedge between the rates of capital rental and the return to wealth by permanently reducing $r_k$ and by increasing $r_q$ in the short run. However, the nature of the shock matters for structural change. The graphs in the second and third rows show the sectors' shares in total value added, defined as $y^M \equiv M/(M+p_sS)$ and $y^S \equiv 1-y^M$, and in total employment. A reduction in $\theta$ reinforces structural change in value added and employment by pushing more labor out of maufacturing production, which permanently increases the GDP share of services; a reduction in $\psi$, instead, bears no long-run effects on employment and GDP shares in this model. The graphs in the fourth row show that the sectoral shares in consumption expenditures, defined as $x^M \equiv c/x$ and $x^S \equiv 1-x^M$, are totally independent of intermediation costs: this is due to the hypothesis of identical input elasticities between the two sectors' technologies, which implies that the entire path of the service price is determined by exogenous productivity gaps – see expression (14) above. This prediction will change in Models II and III, where intermediation costs do accelerate structural change in expenditure shares. The bottom graphs in Figure 1 show the impact of intermediation costs on net saving rates and unconsumed manufacturing output and confirm that a lower $\theta$ reinforces the pace and extent of structural change, whereas a reduction in $\psi$ bears limited effects especially in the long run.

Another important prediction of Model I is that structural change brings about *sectoral capital diversion*. As capital accumulation proceeds at the economy level, falling (rising) employment shares in manufacturing (services) imply falling (rising) shares of total capital used by manufacturing (services) firms since

$$\frac{K_M(t)}{K_S(t)} = \frac{\ell(t)}{1-\ell(t)}. \tag{22}$$

Given our previous results, expression (22) implies that a reduction in $\theta$ unambiguously reduces (increases) the manufacturing (services) share of capital use in the long run.[15] In other words, a

[14] From Proposition 1, an increase in $\psi$ does not modify the spending propensity, $\mathrm{d}(x/q)^{ss}/\mathrm{d}\psi = 0$. Therefore, a shock on $\psi$ does not affect the unconsumed fraction of manufacturing output in the long run, leaving sectoral employment and value added shares unchanged in the long run, as confirmed by (18).

[15] From (18), we have $\mathrm{d}\ell^{ss}(1-\ell^{ss})^{-1}/\mathrm{d}\theta > 0$ and therefore $\mathrm{d}(K_M/K_S)^{ss}/\mathrm{d}\theta > 0$.

drop in financial intermediation costs curbs capital use in the manufacturing sector by reinforcing structural change and its capital-diversion effects. This prediction is relevant for empirical research, as we discuss in detail later.

### 3.2 Model II: Asymmetric Factor Elasticities

This subsection relaxes the hypothesis of identical input elasticities by assuming, instead, that manufacturing production is capital intensive and service production is labor intensive. In this case, structural change is driven by the factor reallocation effects triggered by asymmetric factor intensities. Similarly to Mehlum et al. (2016), consider the polar case with $0 < \alpha < 1$ and $\beta = 0$, that is, labor is used in both sectors whereas all physical capital is employed in manufacturing. Interest and capital rental rates are thus pinned down by the demand schedule of the manufacturing sector, where $K_M = K$. In the labor market, wage equalization implies

$$w(t) = (1-\alpha)\, a_M(t)\, a_\ell(t)^{1-\alpha} (1-\psi)^\alpha \left(\frac{q(t)}{\ell(t)}\right)^\alpha = a_S p_s(t)\,. \tag{23}$$

where the last term emphasizes the linear relationship between the wage rate and the price of services at each point in time. Expression (23) incorporates the relationship between physical capital and financial assets (8): it shows that a higher ratio $q/\ell$ implies a higher marginal product of labor in manufacturing and thereby a higher real wage in the labor market, $w$, which then raises $p_s$, the price of the labor-intensive good in the economy. The price of services, in turn, determines housholds' relative demand for manufacturing consumption goods and services. In this respect, the key condition (5) yields the equilibrium level of individual expenditures

$$x(t) = \left[1 + \left(\frac{\gamma}{1-\gamma}\right)^\sigma \cdot p_s(t)^{\sigma-1}\right] \cdot p_s(t)\, a_S (1-\ell(t))\,, \tag{24}$$

where the last term in the right hand side equals per capita expenditure on services, $p_s a_S (1-\ell) = p_s s$. Hence, from (24), an increase in $p_s$ raises the service share of private consumption spending.

In this Model II, we deliberately exclude productivity growth of any kind by setting all indices equal to constant parameters, $a_M(t) = a_M$ and $a_\ell(t) = a_\ell$. The absence of sectoral productivity gaps allows us to generate a different form of structural change, namely, structural change induced by input reallocation – a mechanism that originates in the hypothesis of asymmetric factor intensities. As shown in the Appendix, the dynamics of employment shares are governed by

$$\frac{\dot{\ell}(t)}{\ell(t)} = -\Lambda(t) \cdot \left[\frac{\dot{x}(t)}{x(t)} - \alpha\Gamma(t)\frac{\dot{q}(t)}{q(t)}\right], \tag{25}$$

where we have defined

$$\Gamma(t) \equiv \frac{1 + \sigma\left(\frac{\gamma}{1-\gamma}\right)^\sigma \cdot p_s(t)^{\sigma-1}}{1 + \left(\frac{\gamma}{1-\gamma}\right)^\sigma \cdot p_s(t)^{\sigma-1}} < 1 \text{ and } \Lambda(t) \equiv \frac{1-\ell(t)}{\ell(t) + \alpha\Gamma(t)(1-\ell(t))} > 1. \tag{26}$$

Note that $\Gamma$ is a function of the ratio $q/\ell$ via the price of services $p_s$, as shown in (23) above. Therefore, the equation for employment shares (25) can be combined with the wealth constraint (3) and the expenditure equation (6) to obtain an autonomous 3×3 dynamic system which determines the equilibrium paths of the three variables $(x, q, \ell)$. Such dynamic system exhibits a unique steady state characterized by the stationary values

$$q^{ss} = \left[\frac{\alpha a_M a_\ell^{1-\alpha}(1-\psi)^\alpha}{\rho+\theta-n}\right]^{\frac{1}{1-\alpha}} \cdot \ell^{ss} \tag{27}$$

$$x^{ss} = a_M a_\ell^{1-\alpha}(1-\psi)^\alpha\left[1-\alpha\left(1-\ell^{ss}\right)\right]\cdot\left(q^{ss}/\ell^{ss}\right)^\alpha - \theta q^{ss} \tag{28}$$

$$1-\ell^{ss} = \frac{x^{ss}/a_S}{p_s^{ss}+\left[\gamma/\left(1-\gamma\right)\right]^\sigma\left(p_s^{ss}\right)^\sigma} \tag{29}$$

$$p_s^{ss} = (1-\alpha)\left(a_M/a_S\right)a_\ell{}^{1-\alpha}(1-\psi)^\alpha\cdot\left(q^{ss}/\ell^{ss}\right)^\alpha \tag{30}$$

The key characteristic of the long-run equilibrium is the stationarity of assets per capita, individual expenditures, and employment shares. The constant long-run ratio $q^{ss}/\ell^{ss}$ implies constant interest rates: from (27) and (9), we have

$$r_q^{ss} = \rho - n, \qquad r_k^{ss} = \frac{\rho-n+\theta}{1-\psi}. \tag{31}$$

Positive shocks on $\theta$ or $\psi$ increase the user cost of capital and, hence, capital per worker and individual private wealth. The resulting decline in wages and in the price of services trigger further effects that are relevant to structural change, as we establish in the next Proposition.

**Proposition 2** *(Long-run effects of intermediation costs in Model II). Assume $\beta = 0$ and constant productivity in manufacturing, $a_M(t) = a_M$ and $a_\ell(t) = a_\ell$. In the steady state equilibrium characterized by (28)-(30), an increase in $\theta$ implies*

$$\frac{dq^{ss}}{d\theta} < 0 \qquad \frac{dx^{ss}}{d\theta} < 0 \qquad \frac{d\ell^{ss}}{d\theta} > 0 \qquad \frac{dw^{ss}}{d\theta} < 0 \qquad \frac{dp_s^{ss}}{d\theta} < 0 \tag{32}$$

*Provided that $\rho - n > \theta(1-\alpha)\cdot\frac{\ell^{ss}-(1-\Gamma^{ss})}{\ell^{ss}+(1-\Gamma^{ss})(1-\alpha)}$ holds, an increase in $\psi$ implies*

$$\frac{dq^{ss}}{d\psi} < 0 \qquad \frac{dx^{ss}}{d\psi} < 0 \qquad \frac{d\ell^{ss}}{d\psi} > 0 \qquad \frac{dw^{ss}}{d\psi} < 0 \qquad \frac{dp_s^{ss}}{d\psi} < 0 \tag{33}$$

*Proof: see Appendix.*

Proposition 2 shows that both funnelling and banks operating costs reduce per capita incomes in the long run, reduce the price of services and increase the employment share of manufacturing.[16] The effect of funnelling on employment differs from Model I, where $\mathrm{d}\ell^{ss}/\mathrm{d}\psi = 0$ holds. In Model II, a change in the extent of funnelling does affect employment shares due to the input reallocation mechanism. More precisely, the intuition for results (32)-(33) is the following. Rising costs of financial intermediation depress the demand for physical capital and slow down accumulation, which results into lower financial assets per capita ($q^{ss}$) and expenditures ($x^{ss}$) in the long run. As manufacturing firms substitute capital with labor inputs, increased sectoral employment ($\ell^{ss}$) drives down the equilibrium wage ($w^{ss}$) and thereby the price of services ($p_s^{ss}$) from the cost side.

The transitional dynamics of Model II clarify that input reallocations caused by asymmetric factor intensities is an independent driver of structural change. Assuming that initial individual

[16] The restriction $\rho-n > \theta(1-\alpha)\cdot\frac{\ell^{ss}-(1-\Gamma^{ss})}{\ell^{ss}+(1-\Gamma^{ss})(1-\alpha)}$ is satisfied by any parametrization in which $\rho-n > \theta(1-\alpha)$ holds as well as by any parametrization in which $\ell^{ss} < 1-\Gamma^{ss}$. Moreover, we have obtained $\mathrm{d}\ell^{ss}/\mathrm{d}\psi > 0$ in all the numerical simulations that we have attempted even when setting parameters so as to have $\rho - n < \theta(1-\alpha)$. These results suggest that $\mathrm{d}\ell^{ss}/\mathrm{d}\psi > 0$ generally holds at least for the vast majority (if not all) parametrizations.

wealth satisfies $q(0) < q^{ss}$, we can characterize regular equilibrium paths along which interest rates decline while both individual wealth $q$ and expenditures $x$ grow at positive rates until they reach their respective steady states. In our Model II, a regular equilibrium path exhibits structural change induced by reallocation effects, as we establish in the next Proposition.[17]

**Proposition 3** *(Regular transitional dynamics in Model II) Consider a regular equilibrium path $\{q(t), x(t)\}_{t=0}^{\infty}$ along which individual assets and expenditures satisfy*

$$\dot{q}(t) > 0 \text{ and } \dot{x}(t) > 0 \text{ in each } t \in [0, \infty)$$

*while converging to the steady state values $(q^{ss}, x^{ss})$. Along such regular equilibrium path, the $q/\ell$ ratio and wage rate increase, the price of services and the expenditure share of services increase, and the expenditure share of manufactured goods declines in each instant:*

$$\begin{aligned} \frac{d}{dt}\left(\frac{q(t)}{\ell(t)}\right) &> 0, \quad \frac{d}{dt}w(t) > 0, \quad \frac{d}{dt}p_s(t) > 0, \\ \frac{d}{dt}\left(\frac{p_s(t)\,s(t)}{x(t)}\right) &> 0 \quad \text{and} \quad \frac{d}{dt}\left(\frac{c(t)}{x(t)}\right) < 0 \text{ in each } t \in [0, \infty). \end{aligned}$$

*Sectoral employment shares reflect structural change in favor of services and behave monotonically at least locally,*

$$\dot{\ell}(t) < 0 \text{ in each } t \in \left[t', \infty\right) \text{ for some finite } t' \geqslant 0.$$

Proposition 3 illustrates the chain of mechanisms activated by positive net savings. Growing financial assets drive down interest rates while increasing the wage rate over time. This in turn raises the price of services – the labor-intensive good – prompting substitution effects in expenditures whereby the share of services increases and that of manufactured goods declines. Similar substitution effects operate on the input markets, where growing wages re-direct labour towards the service sector.

By combining Propositions 2 and 3, we obtain a complete picture of the impact of intermediation costs on structural change. Figure 1 reports the full equilibrium paths of Model II (graphs in the right column) *vis-a-vis* those obtained in Model I. The paths of sectoral shares in value added and employment suggest a robust conclusion on the impact of financial imperfections: in both frameworks, reducing intermediation costs speeds up and reinforces structural change, predominantly through the wealth dilution channel. The key observation is that this result is not exclusive to models where structural change is driven by gaps in productivity growth: intermediation costs increase the path and extent of structural change even when the latter is driven by asymmetric factor intensities between the two sectors and there is no productivity growth in either sector, like in our Model II. The paths of expenditure shares deliver a more specific insight. In Model I, these variables are unaffected by intermediation costs since the price of services is exclusively determined by productivity growth. In Model II, instead, intermediation costs matter due to input reallocation: the price of services – the labor intensive good – is directly affected by intermediation costs since $\theta$ and $\psi$ modify the relative rewards of capital and labor. Hence, reduced intermediation costs reinforce structural change in expenditure shares in Model II, but not in Model I.

[17] Proposition 3 assumes a regular path because the stability properties of the 3x3 dynamic system of Model II need to be verified numerically (see Appendix on this point). In our numerical analysis, the equilibrium paths that we obtained in all attempted parametrizations are indeed regular, with monotonically declining interest rates as well as $\dot{\ell}(t) < 0$, that is, increasing (declining) employment shares in services (manufacturing) during the transition.

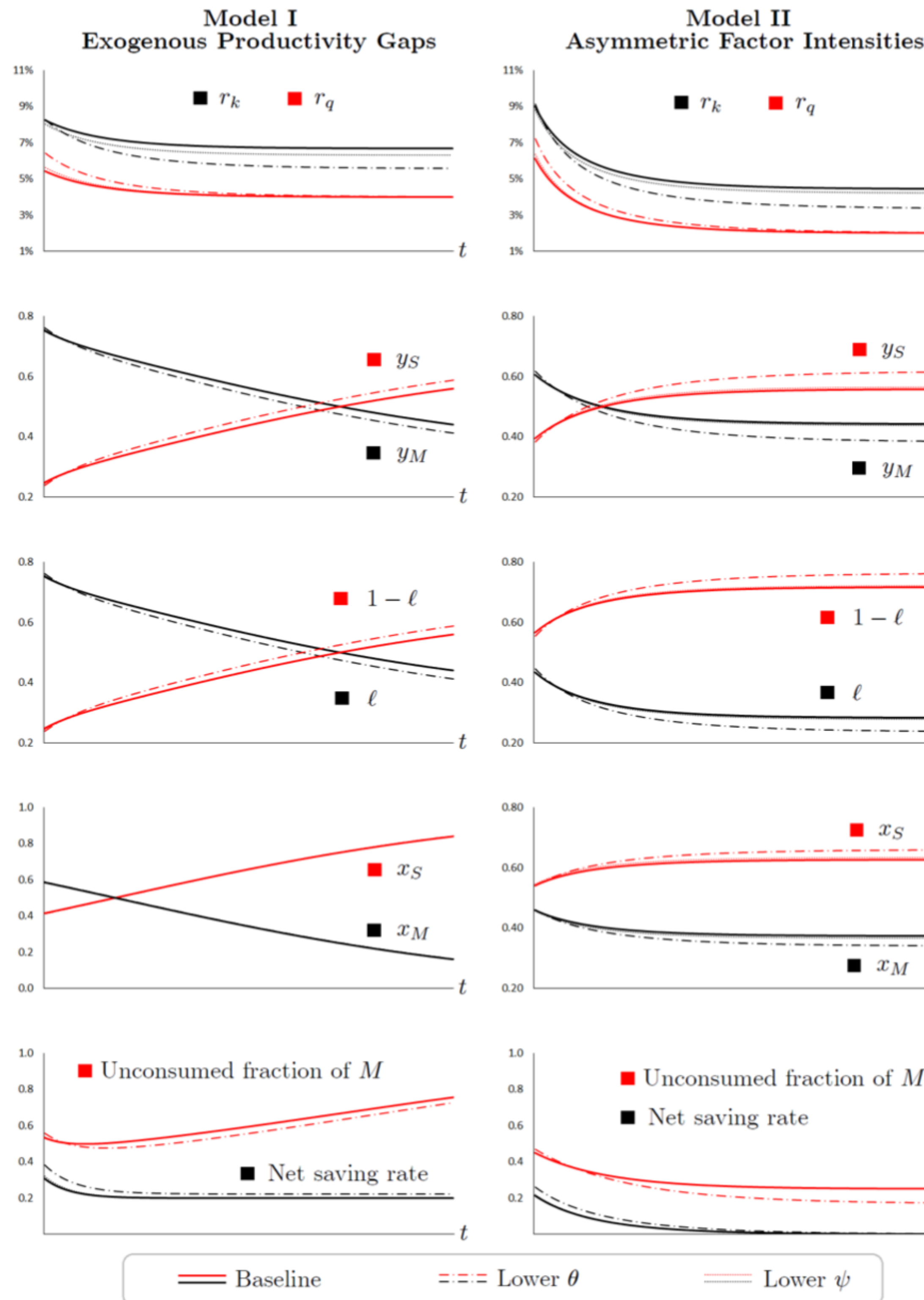


Figure 1: Equilibrium dynamics of Model I (left column graphs, assuming $\alpha = \beta = 0.5$) and Model II (right column graphs, assuming $\alpha = 0.5$ and $\beta = 0$). Within each model, we impose the same initial financial wealth $q_0 N_0$. 'Baseline' simulations assume $\theta = 0.02$ and $\psi = 0.10$. Simulations with 'low wealth depletion' assume $\theta = 0.01$. Simulations with 'low funnelling' assume $\psi = 0.05$. In the last-row graphs, the unconsumed fraction of $M$ is calculated as $1 - (cN/M)$, and the net saving rate is $\dot{q}/(r_q q + w)$.

### 3.3 Model III: Endogenous Productivity

This subsection extends the benchmark model to include endogenous productivity growth in the manufacturing sector. In particular, we assume that productivity responds endogenously to accumulation via learning-by-doing spillovers. This setup actually extends both Models I and II by combining their two main ingredients. Identical input elasticities at the firm level imply equal capital-to-labor ratios in the two sectors. But learning-by-doing makes the ex-post elasticity of production to capital higher in manufacturing and this directly affects the pace of structural change.

As in subsection 3.1, we set $\alpha = \beta \in (0,1)$ and we assume that $a_M$ grows at the exogenous rate $g_M > 0$ like in expression (12). Differently from Model I, the manufacturing technology has an endogenous element: at the sectoral level, labor efficiency $a_\ell$ is positively related to capital per worker $\kappa = K_M/(\ell N)$ according to the spillover function

$$a_\ell(t) = \kappa(t)^\nu, \qquad 0 < \nu < 1. \tag{34}$$

In view of Hicks-neutrality, hypothesis (34) is equivalent to assuming that total factor productivity in manufacturing is given by a comprehensive index $a \equiv a_M \cdot \kappa^{\nu(1-\alpha)}$, where the first component captures exogenous forces and the second component captures the endogenous response to capital accumulation: from (10), sectoral output and TFP growth can be rewritten as

$$M(t) = a(t) \cdot K_M(t)^\alpha \cdot (\ell(t) N(t))^{1-\alpha}, \qquad \frac{\dot{a}(t)}{a(t)} = g_M + \nu(1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)}. \tag{35}$$

Note that (35) implies an ex-post elasticity $\alpha + \nu(1-\alpha) > \alpha$ of manufacturing output per worker to capital per worker. The restriction $\nu < 1$ ensures diminishing marginal returns to capital at the sectoral level, a concavity assumption that preserves the existence of a steady state directly comparable to the long-run equilibrium of Model I.[18] As we show in the Appendix, individual expenditures and capital per worker grow asymptotically at the rate

$$\lim_{t\to\infty} \frac{\dot{x}(t)}{x(t)} = \lim_{t\to\infty} \frac{\dot{\kappa}(t)}{\kappa(t)} = \frac{g_M}{(1-\alpha)(1-\nu)} \equiv g^{**}, \tag{36}$$

and the rental rate of capital converges to the steady state level

$$\lim_{t\to\infty} r_k(t) = \frac{g^{**} + \theta + (\rho - n)}{1-\psi} \equiv r_k^{ss}. \tag{37}$$

The long-run equilibrium is isomorphic to that of Model I. The long run levels of sectoral variables are given by the same expressions – that is, (17)-(18) with $g^*$ replaced by $g^{**}$ – and the steady-state effects of exogenous changes in financial intermediation costs are, qualitatively, the same as those established in Proposition 1. The distinctive predictions of Model III refer to the transitional dynamics and provide important insights for quantitative analysis: the nature of economic growth, rather than its long-run rate, crucially determines the pace of structural change and its sensitivity to financial intermediation. We can address this point analytically by considering alternative parametrizations of $g_M$ and $v$ that produce a straightforward comparison of Model III with Model I.

[18] From (35), manufacturing output per sectoral worker reads $M/(\ell N) = a\kappa^{\alpha+\nu(1-\alpha)}$, and the restriction $\alpha + \nu(1-\alpha) < 1$ guarantees bounded dynamics for interest rates. Therefore, the dynamics of manufacturing output in Model III are reminiscent of one-sector semi-endogenous growth models (i.e., models where endogenous productivity growth reinforces, but does not substitute for, sustained exogenous growth forces in the long run). The knife-edge case $\nu = 1$ would, instead, imply constant returns to savings and sustained endogenous long-run growth in manufacturing: the consequences of this further variant of the model are relevant but beyond the scope of this paper, as we explain in subsection 3.4.

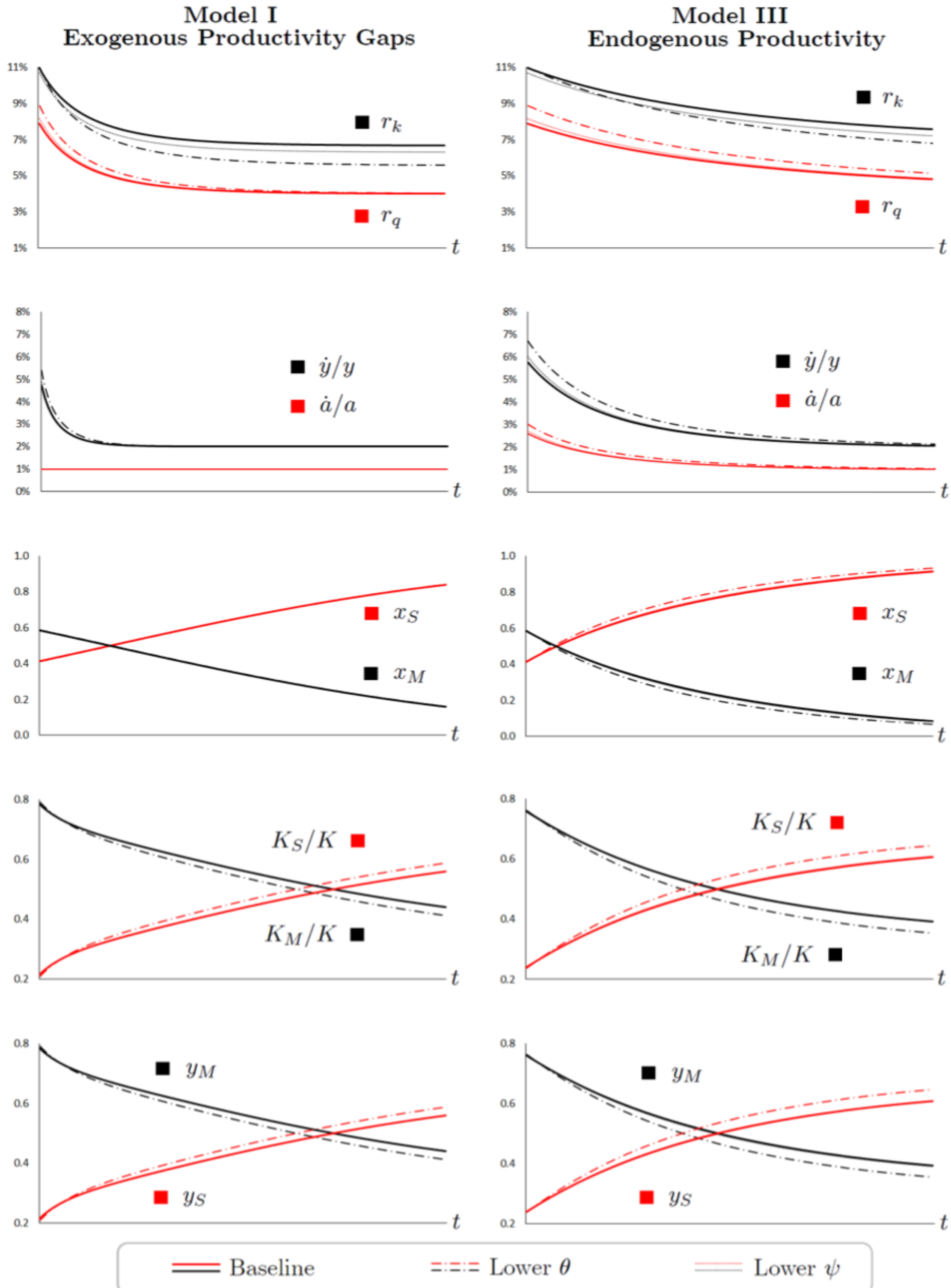


Figure 2: Equilibrium dynamics of Model I (left column graphs, assuming $\nu = 0$ and $g_M = 1\%$) and Model III (right column graphs, assuming $\nu = 0.75$ and $g_M = 0.25\%$). The same initial financial wealth $q_0 N_0$ is imposed in all simulations. 'Baseline' simulations assume $\theta = 0.02$ and $\psi = 0.10$. Simulations with 'low wealth depletion' assume $\theta = 0.01$. Simulations with 'low funnelling' assume $\psi = 0.05$.

Consider two different combinations of $g_M$ and $\nu$ yielding the same long-run growth rate $g^{**} = \bar{g}$. In these two scenarios, we keep $\alpha$ and all other parameters unchanged, and we assume identical *levels* of capital and TFP at time zero.[19] In the first scenario, we consider the polar case with $\nu = 0$ and $g_M = (1-\alpha)\,\bar{g}$, which eliminates endogenous productivity growth and thus coincides with Model I. In the second scenario, we assume $\nu > 0$ and $g_M = (1-\alpha)(1-\nu)\,\bar{g}$, so as to obtain Model III with endogenous productivity. Given the same initial conditions and identical asymptotic growth rates, these 'two economies' converge towards the same sectoral shares of employment and output in the long run, but at different speeds and in different ways due to the endogenous response of productivity growth (or the lack of it).[20] In this context, we can establish the following

**Proposition 4** *(Model III versus Model I with $g^* = g^{**} = \bar{g}$) Given identical initial conditions and parameters except for the combination $(\nu, g_M)$, Model III implies faster productivity growth, slower capital accumulation, higher interest rates and faster expenditure growth during the whole transition:*

$$(\dot{a}/a)^{III} > (\dot{a}/a)^{I}, \quad (\dot{\kappa}/\kappa)^{III} < (\dot{\kappa}/\kappa)^{I}, \quad r_k^{III} > r_k^{I}, \quad (\dot{x}/x)^{III} > (\dot{x}/x)^{I}.$$

The intuition behind Proposition 4 is that endogenous productivity growth flattens the (declining) time path of the rental rate of capital due the higher ex-post elasticity of capital in production, $\alpha + \nu(1-\alpha) > \alpha$. Therefore, Model III produces slower capital accumulation, $\dot{\kappa}/\kappa$, faster TFP growth, $\dot{a}/a$, and stronger growth in expenditures, $\dot{x}/x$, via higher interest rates. Figure 2 reports the detailed time paths of key macroeconomic variables: in these numerical simulations, we set $\alpha = 0.5$ and a target growth rate $\bar{g} = 2\%$, and we compare the cases $\nu = 0$ and $\nu = 0.75$ by adjusting $g_M$ accordingly. Endogenous productivity generates faster GDP growth during the whole transition[21] and, more interestingly, increases the pace of structural change. This conclusion hinges on two mechanisms, the *consumption share effect* and the *capital diversion effect*.

The consumption share effect is the stronger growth that we observe in the expenditure share of services in Model III. Endogenous productivity inflates the relative price of services, which grows at the same rate $\dot{p}_s/p_s = \dot{a}/a$ given by (35), and this accelerates the decline in the expenditure share of manufactured consumption goods,

$$\frac{\dot{x}^M(t)}{x^M(t)} = -(1-\sigma)\left[g_M + \nu(1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)}\right] = -(1-\sigma)\frac{\dot{a}(t)}{a(t)}. \tag{38}$$

Figure 2 confirms that the expenditure share of services grows faster, and becomes dominant earlier, in Model III than in Model I. The consumption share effect is the first reason why endogenous TFP accelerates structural change.

The second reason is capital diversion, i.e., the fact that relative capital use in the two sectors follows the same dynamics as employment shares: the ratio $K_M/K_S$ falls over time since the demand for capital of service producers grows faster than that of manufacturers. The intensity of capital diversion can be measured by the accumulation gap

$$\frac{\dot{K}_S(t)}{K_S(t)} - \frac{\dot{K}_M(t)}{K_M(t)} = (2-\ell(t))\left[\frac{\dot{x}(t)}{x(t)} - \frac{\dot{\kappa}(t)}{\kappa(t)} + (1-\Gamma(t))\frac{\dot{a}(t)}{a(t)} - \frac{\dot{r}_k(t)}{r_k(t)}\right], \tag{39}$$

[19] Expression (34) implicitly assumes $a_\ell(0) = 1$. In order to have identical initial TFP levels in the production function (35), we normalize $a_M(0) = \kappa(0)^{-\nu(1-\alpha)}$, which yields $a(0) = 1$ in both scenarios, $\nu = 0$ and $\nu > 0$. Due to symmetric sectoral elasticities, initial capital use in manufacturing $\kappa(0)$ coincides with capital per capita, $K(0)/L(0)$, and is therefore exogenously given at time zero.

[20] This exercise is conceptually equivalent to making competing predictions about a given economy by calibrating Model I and Model III on the same set of current observables, $\kappa(0)$ and $a(0)$, and long-term forecasts, $g^* = g^{**}$.

[21] In Figure 2, we denote GDP growth by $\dot{y}/y$ by defining aggregate value added as $y = M + p_s S$.

which approaches zero in the long run but drives structural change during the transition. Endogenous productivity growth tends to accelerate capital diversion via multiple channels that we assess in detail in Appendix D. On the one hand, the decline in $K_M/K_S$ is accelerated by the consumption share effect – i.e., faster growth in household demand for services relative to manufacturing products. On the other hand, capital diversion becomes quicker because endogenous productivity growth acts as a substitute for physical capital investment at both the aggregate and the sectoral levels. At the aggregate level, faster TFP growth slows down capital accumulation and speeds up expenditure growth, $\dot{x}/x$, via higher interest rates in Model III. At the sectoral level, productivity growth implies that manufacturing firms require less additional capital units to generate the same marginal product as service firms, which reduces the relative demand for capital of manufacturing firms at given interest rates. These mechanisms operate during the whole transition and tend to reinforce capital diversion in Model III. The baseline simulations reported in Figure 2 confirm this conclusion: the manufacturing share of total capital use, $K_M/K$, falls below 0.5 much earlier in Model III than in Model I. More generally, the combination of the consumption share effect and the capital diversion effect speeds up structural change in all types of sectoral variables, including the respective GDP shares, $y^M$ and $y^S$.

Since the endogenous component of TFP is directly linked to saving-investment decisions, Model III predicts an increased sensitivity of structural change to changes in financial intermediation costs. In particular, two qualitative differences with respect to Model I are that, in Model III, a lower $\theta$ accelerates structural change in expenditure shares via the consumption share effect,[22] and a lower $\psi$ reinforces transitional structural change via its impact on TFP. Even with respect to employment shares, the impact of reduced intermediation costs appears stronger in the earlier stages of the transition in Model III, because the growth rate of $(1-\ell)/\ell$ is positively related to both the consumption share effect and the growth rate of TFP.[23] These results are illustrated in Figure 2. In particular, the fact that a lower $\theta$ spurs TFP growth in the transition while reducing permanently the manufacturing share of capital use is relevant from an empirical perspective, as explained below.

### 3.4 Summary of theoretical predictions

The main results of our theoretical analysis are summarized in Table 1 below. The robust conclusion suggested by all variants of the benchmark model is that a decline in $\theta$ increases the pace and extent of structural change by increasing the transitional growth rates, and the long-run levels, of employment and output shares for the service sector. When structural change is driven by asymmetric factor intensities or endogenous productivity gaps, a decline in $\psi$ bears similar consequences to those of a drop in $\theta$, and relieving either type of intermediation costs boosts growth in the expenditure share of services.

Structural change brings about capital diversion – i.e., the manufacturing share of capital use declines over time – and lower intermediation costs reinforce capital diversion: even though capital per worker permanently increases at the economy level, an increasing fraction of the economy's capital stock moves to the service sector. Importantly, this mechanism is enhanced by endogenous productivity: in Model III, reduced costs of financial intermediation trigger an endogenous response of productivity that not only increases the value added share of services, but also curbs fixed capital formation in manufacturing. This result deserves attention because it

[22] See Figure 2. In Model I, the time path of expenditure shares is unaffected by a lower $\theta$ because the growth rate of the price of servcies $p_s$ is exogenously determined by $g_M$ and, hence, independent of accumulation and saving behavior. In Model III, the growth rate of $p_s$ is affected by accumulation via the endogenous component of TFP growth, and this effect becomes stronger the lower the cost of financial intermediation.

[23] In view of expression (22), which holds in both Models I and III, the growth rate of $(1-\ell)/\ell$ is given by the right hand side of (39).

Table 1: Summary of theoretical predictions

| | **Model I** | | **Model II** | | **Model III** | |
|---|---|---|---|---|---|---|
| Cause of structural change | Exogenous P.G. | | Asymmetric F.E. | | Endogenous P.G. ex-post Asy.F.E. | |
| Effect of intermediation costs... | lower $\theta$ | lower $\psi$ | lower $\theta$ | lower $\psi$ | lower $\theta$ | lower $\psi$ |
| on employment share of services: | *pos.* | - | *pos.* | *pos.* | *pos.* | *pos.* |
| on value added share of services: | *pos.* | - | *pos.* | *pos.* | *pos.* | *pos.* |
| on expenditure share of services: | - | - | *pos.* | *pos.* | *pos.* | *pos.* |
| on rate of return to wealth: | *pos.* | *pos.* | *pos.* | *pos.* | *pos.* | *pos.* |
| on capital rental rate: | *neg.* | *neg.* | *neg.* | *neg.* | *neg.* | *neg.* |
| on capital share of manufacturing: | *neg.* | - | - | - | *neg.* | *neg.* |
| on TFP growth of manufacturing: | - | - | - | - | *pos.* | *pos.* |

Summary of model predictions under different engines of structural change: exogenous productivity growth differentials (Model I), asymmetric factor elasticities (Model II), endogenous productivity growth in manufacturing with ex-post differences in factor elasticities (Model III).

is consistent with recent empirical evidence showing that bank branching deregulation increases productivity growth but does not necessarily accelerate capital accumulation in the manufacturing sector (Jerzmanowski, 2017). In this respect, our analysis bridges two growing bodies of literature – the current research on the macroeconomic effects of banking regulation and that on structural change – by delivering predictions about the impact of exogenous changes in intermediation costs on the speed at which the service sector expands relative to the manufacturing sector. We test these predictions empirically in the following sections.

Obviously, our benchmark model does not incorporate all the existing theories of structural change: this is a field characterized by a variety of hypotheses (e.g., non-neoclassical technologies, non-homotetic preferences) and outcomes (e.g., unbalanced growth).[24] Nonetheless, a simple extension of Model III immediately suggests that the impact of intermediation costs will be furthermore relevant when considering models of sustained endogenous growth. If we set $g_M = 0$ and modify the spillover function (34) by imposing linear returns, $\nu = 1$, the interest rate becomes constant and an interior equilibrium satisfying the Euler condition

$$\frac{\dot{x}(t)}{x(t)} = \alpha(1-\psi) - \theta - (\rho - n) \tag{40}$$

in the long run will exhibit sustained endogenous growth. If such asymptotic equilibrium exists, both $\theta$ and $\psi$ affect not only the pace and extent of structural change during the transition but also in the long run via the rate of economic growth, with fundamental consequences for welfare. This observation suggests that building tractable multi-sector models of endogenous growth is a task that, although technically challenging, is worth pursuing at the theoretical level since it is very likely to deliver further insights on the finance-structural change nexus.

# 4 Facts: United States 1970-2000

Despite the huge evidence linking financial development to higher GDP per capita, only a few empirical studies consider interactions between financial development and structural change.

[24]See Acemoglu (2009), Chapter 20, for an extensive discussion.

The general prediction of our theoretical model is that exogenous reductions in financial intermediation costs accelerate the pace and extent of structural change. In the remainder of this paper, we assess this prediction empirically by checking whether policy-induced changes in financial conditions accelerated the transition from manufacturing to services. To preserve internal consistency, our empirical analysis must consider an economy that already experienced industrialization – i.e., the transition from agriculture to manufacturing – and exhibits post-industrial growth – i.e., the phase during which employment, value-added and expenditure shares change towards services and away from manufacturing. The second necessary element is that the time period covered by the data sample include a shock that can be interpreted as an exogenous reduction in financial intermediation costs. These considerations lead us to consider data for the United States during the late 20th century, a period of post-industrial growth during which intermediation costs have been subject to a relevant shock induced by bank branching deregulation.

### 4.1 Structural change in the United States

The United States has been secularly shifting away from manufacturing and towards services for several decades. Figure 3 shows the gradual increase in services employment and output, and the gradual decrease in manufacturing employment and output, with the output trajectories more volatile than the employment trajectories[25]. The grey lines represent individual U.S. states and the District of Columbia (D.C.), while the red lines represent the (unweighted) average across all states. Figure 3 makes clear that the United States had, by 1970, become sufficiently rich that the manufacturing share of both employment and output were in decline. The U.S. economy thus satisfies the first pre-condition for the internal consistency of our analysis, namely, that the economy under study was developed and had already experienced the first phase of industrialization. Moreover, empirical research shows that the rise of services and the decline of manufacturing employment shares in the U.S. were accompanied by substantial gaps in sectoral productivity growth: Jorgenson and Stiroh (2000) find that TFP growth in services firms in the latter part of the 20th century may actually have been negative. This is strongly consistent with both the hypotheses and the drivers of structural change in our theoretical models.

### 4.2 Bank branching deregulation

At the beginning of the 1970s, most states in the U.S. had unit banking restrictions. The vast majority of banks were prohibited from expansion within states. Apart from a few historical exceptions, banks were further prohibited from crossing state lines by the Douglas Amendment to the Bank Holding Company Act of 1956. Therefore, banks were typically small enterprises, often consisting of a single branch. From the 1970s until the mid-1990s, individual states relaxed restrictions on bank branching. Most states allowed bank branching by merger and acquisition (M&A) in the first instance, then shortly afterwards allowed expansion by *de novo* branching. This process culminated in the passage of the federal Riegle-Neal Interstate Banking and Branching Efficiency Act in 1994, which effectively lifted any remaining bank branching restrictions across the United States. Following the literature, we take as the date of deregulation the year in which bank branching was first permitted by M&A[26].

Krozsner and Strahan (1999, pp. 1460-1461) identify three reasons for bank branching deregulation beginning in the 1970s in particular. First, ATMs became more prevalent and allowed

[25] For a description of the data used to construct these graphs, see Section 5.1.

[26] More precisely, we follow previous authors in taking the year of M&A deregulation as the year in which the process of deregulation was *completed*. See for instance Jayaratne and Strahan (1996, p. 646).

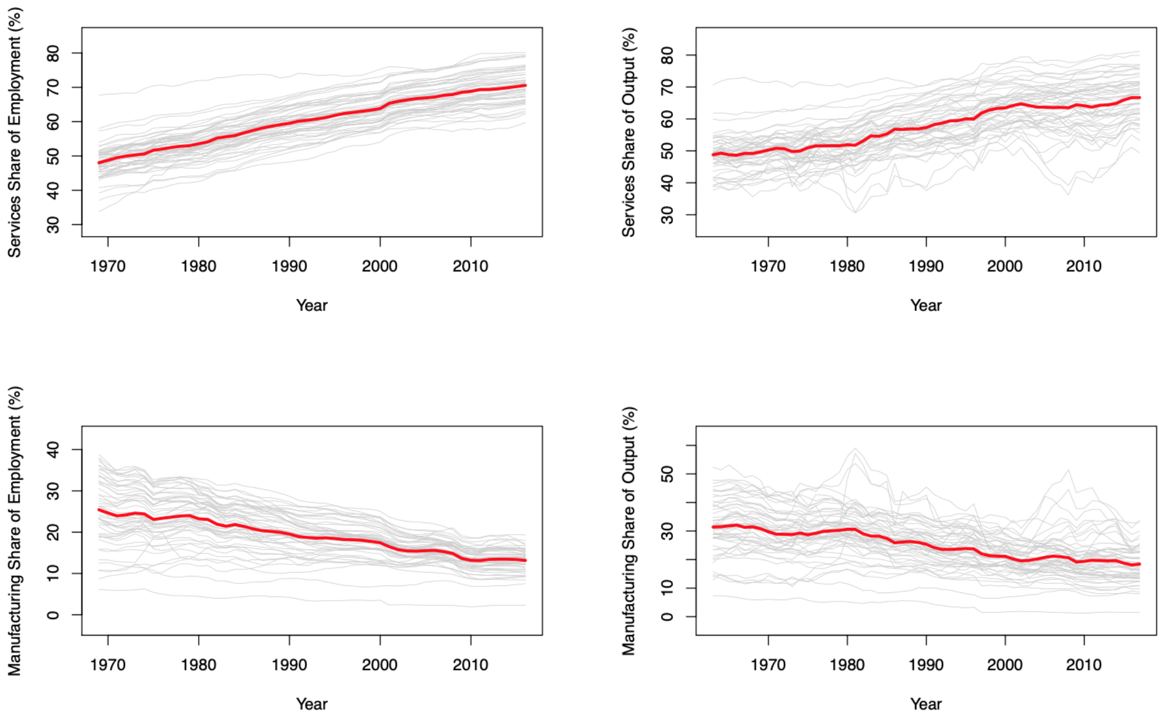


Figure 3: Long-term trends in the sectoral composition of U.S. states and D.C. The grey lines represent individual U.S. states and D.C., while the red lines represent the (unweighted) average across all states.

some banking services to be accessed remotely; second, banking by mail and telephone increased, with checkable money market funds and the Merrill Lynch Cash Management Account; and third, general technological progress reduced the costs of transport and communication. All of these advances served to weaken the geographical link between banks and their customers. The authors also find that the timing and order of states' deregulation can be explained by a private interest model: they show that "deregulation occurs earlier in states with fewer small banks, in states where small banks are financially weaker, and in states with more small, presumably bank-dependent, firms" (Krozsner and Strahan, 1999, p. 1438). Jayaratne and Strahan (1998) find that post-deregulation, banks' operating costs and loan losses decrease, and that these cost reductions are mostly passed on to borrowers in the form of reduced interest rates. Therefore bank branching deregulation can reasonably be taken as a positive shock to financial development, or equivalently, a reduction of financial intermediation costs to firms and households.

The effects of bank branching deregulation have been studied by several authors.[27] In particular, Jerzmanowski (2017) finds that deregulation accelerated both capital accumulation and TFP growth, while having no effect on human capital growth; moreover, increases in the rate of growth in the manufacturing sector are driven entirely by increased TFP growth, rather than increased capital accumulation. Using a more granular decomposition of the economy into smaller sectors, Acharya et al. (2011) find that shares of output in the economy converge more quickly to the optimal tangency portfolio post-deregulation than pre-deregulation. These contributions

[27] Jayaratne and Strahan (1996) find that deregulation increased growth in real GDP per capita – although comparing outcomes in contiguous pairs of counties across state lines, where one state deregulated and the other did not, Huang (2008) finds less support for this result. Beck et al. (2010) find that income inequality, as measured by the Gini coefficient, is reduced after bank branching deregulation, primarily by increasing the incomes of those at the bottom of the distribution.

suggest, implicitly or explicitly, that bank branching deregulation is related to the structural composition of the economy. Below, we provide a preliminary assessment of temporal links between bank branching deregulation and the relative shares of manufacturing and services in employment and output.

### 4.3 Suggestive evidence of a link

Figure 4 shows each state's year of bank branching deregulation against its share of services and manufacturing in employment and output in both 2016 and 1969, for states that had not undergone bank branching deregulation by 1969. On average, states that deregulated earlier have a higher services share and a lower manufacturing share of both employment and output in 2016. In naïve regressions, all four of these relationships are significant at the 5% level. Visual inspection suggests that initial sectoral shares – that is, output and employment shares in 1969, prior to deregulation – are not related to the year of deregulation, with the possible exception of the manufacturing employment share displaying a downward-sloping line of best fit. Nonetheless, in naïve regressions, none of these relationships – not even the relationship between the year of deregulation and the manufacturing share of employment in 1969 – are significant at the 5% level. These results, in combination with those of Krozsner and Strahan (1999), [28] suggests that deregulation is essentially orthogonal to *ex ante* structural composition[29]. Moreover, it appears that the timing of bank branching deregulation *is* related to *ex post* structural composition. While this falls a long way short of being evidence of any particular causality, it does suggest that there is a correlation between bank branching deregulation and structural composition. We model this relationship formally in the next section.

## 5 Empirical analysis: data and results

In this section, we assess the effect on structural change of state-by-state bank branching deregulation, initially using difference-in-differences regressions. These regressions suggest that deregulation increases services over time as a share of the economy, and decreases manufacturing. To alleviate concerns with endogeneity of treatment, we employ a more robust estimation strategy by exploiting the synthetic control method (SCM). We follow Dube and Zipperer (2015) in pooling the results across several synthetic control case studies in order to increase their statistical power, determining statistical significance with reference to the mean percentile rank, whose distribution is known exactly under the null hypothesis of uniform distribution of individual percentile ranks. We also propose a simple statistical test of the validity of pooling multiple synthetic controls studies. To improve the pre-treatment fit of the synthetic controls, we employ the ridge augmented synthetic control method (ridge ASCM) proposed by Ben-Michael et al. (2019a). We find that bank branching deregulation significantly increases the services share of employment and decreases the manufacturing share of both employment and output in the economy 10 years after deregulation. As a final robustness check we employ the staggered synthetic control method (staggered SCM) developed by Ben-Michael et al. (2019b), finding the same results as using ridge ASCM.

[28]Krozsner and Strahan (1999) plausibly show that the timing and order of bank branching deregulation are explained by national technological trends and the private interests of banks in any given state.

[29]We show in Section 5.2 that this is in fact may be untrue: the timing of bank branching deregulation does appear to be related to *ex ante* structural composition.

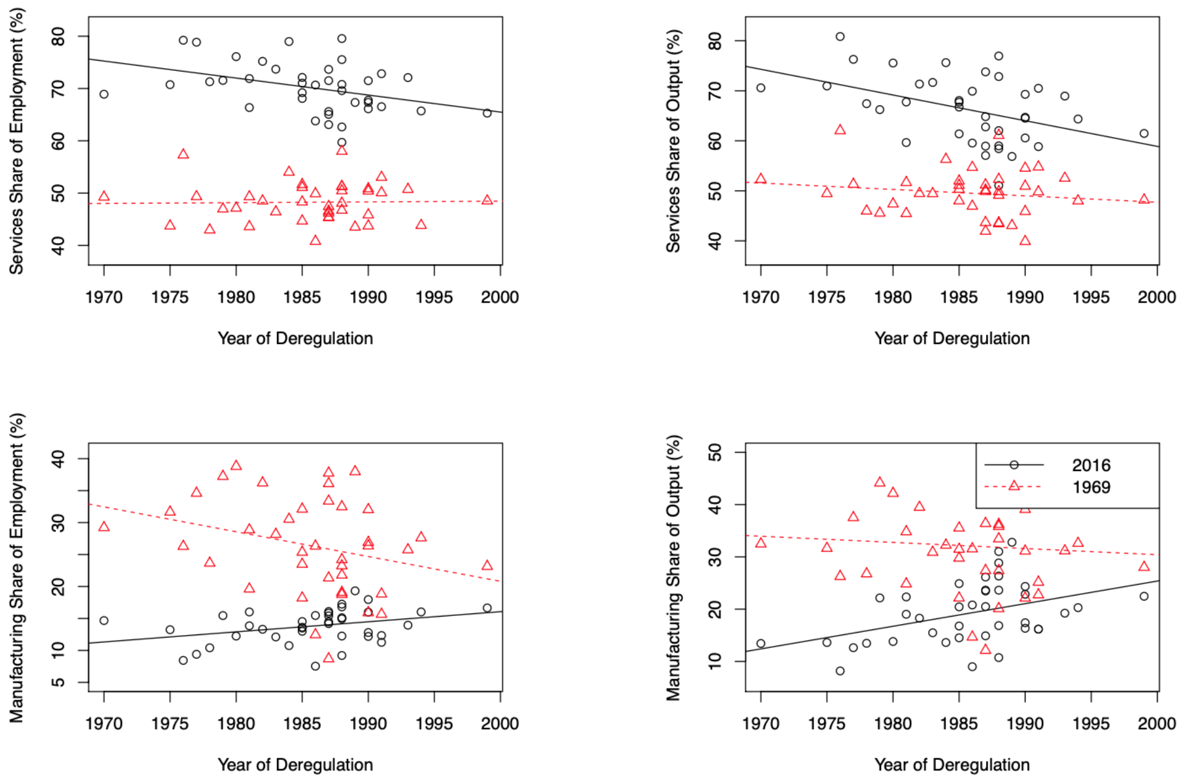


Figure 4: Scatter plots of the 2016 and 1969 services and manufacturing shares of employment and output against the year of bank branching deregulation for each U.S. state and D.C. that had not deregulated by 1969, with lines of best fit. On average, states that deregulated earlier have a higher services share and a lower manufacturing share of both employment and output in 2016; in naïve regressions, the year of deregulation is a significant predictor at the 5% level of all sectoral shares in 2016 (that is, all the solid black lines of best fit have a slope significantly different from zero at the 5% level). There does not seem to be a strong relationship between the year of deregulation and sectoral shares in 1969; in naïve regressions, no sectoral share in 1969 is a significant predictor at the 5% level of the year of deregulation (that is, none of the dotted red lines of best fit have a slope significantly different from zero at the 5% level), even the manufacturing share of employment.

## 5.1 Data

***BEA data***. Herrendorf et al. (2014) suggest three measures of structural change: changes over time in relative sectoral shares in each of employment, output (value added), and consumption. Data on sectoral shares of consumption by U.S. state and year do not appear to exist prior to the 1990s, which is too late to be of use in studying bank branching deregulation. However, the U.S. Bureau of Economic Analysis (BEA) provides industry-level employment data by U.S. state and year from 1969-2000 (aggregated using SIC code) and from 2001-2016 (aggregated using NAICS code). This allows the calculation of sectoral shares of employment. The BEA also provides industry-level output data by U.S. state and year from 1963-1996 (aggregated using SIC code) and from 1997-2017 (aggregated using NAICS code). According to the BEA's official methodology notes, "[n]o matter how a GDP by state component is estimated, it is always adjusted to be consistent with BEA's definition of value added" (U.S. Department of Commerce and Bureau of Economic Analysis, 2017, p. iii). This data therefore allows the calculation of sectoral shares of value added, as proposed by Herrendorf et al. (2014).[30] There is a discontinuity in the data when the aggregation method switches from aggregation by SIC code to NAICS code, and the BEA cautions against combining the two datasets to form a unified dataset spanning from the 1960s to the present. However, there are several reasons why this is not likely to be a major concern for this exercise. First, we are largely interested in shares of output or employment, so changes in absolute values are not important unless they are systematically different from one sector to another[31]. Second, since we are aggregating into four major sectors, unless there are large changes in sector assignment between the two methodologies, small-scale differences in methodology will not be significant. Third, while the difference-in-differences regressions span both datasets, the synthetic controls study does not in fact use any data from after 1996 (there were no deregulations late enough, with enough states left as members of the donor pool, for this situation to arise). For completeness, we also report the difference-in-differences results obtained using only the data aggregated using SIC code in Appendix E.3.

***IPUMS USA data***. Control data was taken from the University of Minnesota's IPUMS USA database (Ruggles et al., 2019). This database collates and harmonises U.S. census microdata. Three control variables were constructed at the state-year level: the average years of education of state residents, the average age of state residents, and the proportion of state residents who are black. Where a particular state-year combination doesn't appear in the data, the value is constructed by linearly interpolating between the latest observation for that state prior to the year of interest, and the earliest observation for that state subsequent to the year of interest. We have collected data from all three sources across a span of 55 years from 1963 to 2017, for 50 states and D.C., so that variables with an observation for every year have $55 \times 51 = 2,805$ observations. However, employment data in particular is only available from 1969 to 2016, so many of the results below are calculated using data that is from 1969 and more recent. Table 2 reports descriptive statistics for the state-year data taken from the BEA and IPUMS USA.

[30] Where a particular state-year-industry combination has not been provided – typically in order to avoid the disclosure of confidential information – we have interpolated linearly between the nearest available entries. However, the numbers involved are typically small. For example, employment in mining in D.C. is redacted in the years 1998-2000, so in calculating aggregate employment numbers for the manufacturing sector in D.C. in those years, interpolated figures are used for mining employment. The number of employees in mining in DC in 1997 is only 309, however, so it seems reasonable to assume that this will not skew the results significantly. Indeed, where data is redacted to avoid the disclosure of confidential information, almost by definition the numbers are likely to be small.

[31] The SIC output data is presented in chained 1997 U.S. dollars, while the NAICS output data is presented in chained 2012 U.S. dollars. Conversion from one to the other would therefore be necessary if we were to report absolute values spanning the two datasets. However, this issue does not arise in the results presented below.

Table 2: Descriptive statistics (BEA / IPUMS USA data)

| Statistic | N | Mean | St. Dev. | Min | Max |
|---|---|---|---|---|---|
| Services Share of Employment (%) | 2,448 | 60.3 | 8.4 | 33.7 | 80.1 |
| Services Share of Output (%) | 2,805 | 57.5 | 9.2 | 30.6 | 81.2 |
| Manufacturing Share of Employment (%) | 2,448 | 19.0 | 6.5 | 1.9 | 38.8 |
| Manufacturing Share of Output (%) | 2,805 | 25.1 | 9.3 | 1.2 | 59.0 |
| Output per Worker ($000) | 2,448 | 46.9 | 27.2 | 7.5 | 141.5 |
| Output per Services Worker ($000) | 2,448 | 44.8 | 25.4 | 8.2 | 131.6 |
| Output per Manufacturing Worker ($000) | 2,448 | 62.3 | 45.5 | 8.3 | 423.5 |
| Population | 2,499 | 5,138,421.0 | 5,754,892.0 | 296,000.0 | 39,250,017.0 |
| Total Employment | 2,448 | 2,774,139.0 | 3,120,785.0 | 143,816.0 | 23,265,312.0 |
| Total Output ($million) | 2,805 | 141,227.6 | 247,679.6 | 993 | 2,746,873 |
| Employment Rate (%) | 2,448 | 55.9 | 11.4 | 37.1 | 137.7 |
| GDP per Capita ($000) | 2,499 | 28.4 | 20.9 | 3.1 | 192.3 |
| GDP Growth (%) | 2,754 | 6.5 | 4.3 | −31.0 | 44.2 |
| Average Years of Education | 2,805 | 10.1 | 1.0 | 7.3 | 12.5 |
| Proportion of Black Residents (%) | 2,805 | 10.2 | 11.9 | 0.0 | 70.8 |
| Average Age of Residents | 2,805 | 34.5 | 2.9 | 24.8 | 42.4 |

Data from BEA and IPUMS USA. Services share of employment, services share of output, manufacturing share of employment, manufacturing share of output, output per worker, output per services worker, output per manufacturing worker, employment rate, GDP per capita and GDP growth are the authors' own calculations based on BEA data. Population, total employment and total output are from BEA data. Average years of education, proportion of black residents and average age of residents are the authors' own calculations based on IPUMS USA data. Note that the maximum employment rate in the data is above 100%, but this is for D.C., which has many workers commuting from nearby states; all other states' maximum employment rate is well under 100%.

***Date of deregulation***. The year of bank branching deregulation in each state is taken from Amel (1993), Jayaratne and Strahan (1996), Krozsner and Strahan (1999), and Beck et al. (2010). Following this literature, we take the year of deregulation to be the year that a state allowed bank branching by merger and acquisition (M&A). Appendix E.2 lists the year of deregulation for each state.

## 5.2 Difference-in-differences regressions

A standard method of assessing the effect of a staggered treatment is to fit difference-in-differences regressions. This type of regression has been used to assess the effects of bank branching deregulation on output growth (Jayaratne and Strahan, 1996) and inequality as measured by the Gini coefficient (Beck et al., 2010), among others. Our model predicts that the effect of financial deregulation on structural change includes a growth effect, so we need to allow the effect of deregulation on sectoral shares to grow or diminish over time. We therefore estimate the following specification,

$$Y_{st} = \beta_0 + \beta_1 D_{st} + \beta_2 T_{st} + \beta_3 D_{st} T_{st} + \boldsymbol{\gamma}_1' \mathbf{X}_s + \boldsymbol{\gamma}_2' \mathbf{X}_t + \varepsilon_{st}, \tag{41}$$

where $Y_{st}$ is the outcome variable of interest in state $s$ in year $t$, $D_{st}$ is a treatment dummy that is equal to 1 once a state has deregulated and equal to 0 otherwise, $T_{st}$ is equal to the number of years since deregulation (it takes a negative value prior to deregulation), $\mathbf{X}_s$ is a vector of state dummies accounting for state fixed effects, $\mathbf{X}_t$ is a vector of time dummies accounting for time fixed effects, and $\varepsilon_{st}$ is an error term. This specification allows us to account for unobserved, time-invariant state effects by including state dummies, and for unobserved nationwide shocks by including time dummies. The estimated value of $\beta_1$ indicates the level effect caused by deregulation, while the estimated value of $\beta_3$ indicates whether the effect of deregulation is changing over time.

We estimate the effect of deregulation on four outcome variables: services share of employment, services share of output, manufacturing share of employment, and manufacturing share of output. We do not estimate the effect of bank branching deregulation on agriculture, as it accounts for such a small share of most state economies over the period in question. We also do not estimate the effect of bank branching deregulation on the government share of the economy; while this may yield interesting results, almost by definition any effect cannot be argued to be a clean consequence of market forces at work in the financial sector.

Table 3 reports the results of the regressions[32]. As in Beck et al. (2010), standard errors are clustered at the state level (that is, at the level of the treatment unit), accounting for the fact that the error term may exhibit serial correlation within states. Consistent with Jayaratne and Strahan (1996) and Beck et al. (2010), the year of deregulation is excluded, as are Delaware and South Dakota, which have long been major centres for the credit card industry. Not all of the coefficients on the deregulation dummy are significant, suggesting that the effect of deregulation on structural composition does not operate solely – or even primarily – by having an instantaneous, permanent level effect on the outcome variables. Conversely, all the coefficients on 'Dereg.*Time' are highly significant, suggesting that deregulation causes the share of services to increase over time, in both employment and output, while having the opposite effect on manufacturing.

[32]These regressions use the full span of BEA data available. However, as noted in Section 5.1, there is a change in methodology when the BEA switches from aggregation using SIC code to aggregation using NAICS code. For completeness, the results in Table 3 are replicated in Table 10 in Appendix E.3 using only SIC-based data. None of the results are contradictory.

Table 3: Difference-in-differences regressions

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Services Share of Employment (%) | Services Share of Output (%) | Man. Share of Employment (%) | Man. Share of Output (%) |
| Deregulation | $-0.234^{*}$ | 0.076 | 0.065 | $-0.811^{***}$ |
| | (0.129) | (0.201) | (0.185) | (0.245) |
| Time | $-0.110^{*}$ | $1.294^{***}$ | $0.769^{***}$ | $-1.518^{***}$ |
| | (0.065) | (0.113) | (0.077) | (0.141) |
| Dereg.*Time | $0.249^{***}$ | $0.284^{***}$ | $-0.360^{***}$ | $-0.407^{***}$ |
| | (0.017) | (0.020) | (0.023) | (0.024) |
| Constant | $40.399^{***}$ | $66.346^{***}$ | $40.627^{***}$ | $8.841^{***}$ |
| | (0.935) | (2.196) | (1.217) | (2.725) |
| Observations | 1,833 | 2,106 | 1,833 | 2,106 |
| $R^2$ | 0.972 | 0.925 | 0.874 | 0.856 |
| Adjusted $R^2$ | 0.971 | 0.922 | 0.868 | 0.849 |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Difference-in-differences OLS estimates of the effect of bank branching deregulation on structural composition, accounting for year and state fixed effects. Standard errors clustered at the state level in parentheses. 'Deregulation' is a dummy that is equal to 1 when a state has deregulated, and equal to 0 otherwise. 'Time' is the time in years since deregulation (this variable takes a negative value prior to deregulation). The year of deregulation is excluded for each state. States that deregulated prior to 1963 are excluded (Alaska, Arizona, California, Delaware, the District of Columbia, Idaho, Maryland, Nevada, North Carolina, Rhode Island, South Carolina and South Dakota).

These results are apparently very strong, and certainly suggest that structural change accelerates post-deregulation. However, the fact that the coefficients on 'Time' are significant in Table 3 raises concerns about the validity of a causal interpretation of the effect of bank branching deregulation. Difference-in-difference regressions rely on a number of assumptions, notably the assumption of exogenous treatment: assignment to treatment should not be correlated with the outcome variable, conditional on observables. Significant coefficients on 'Time' suggest that pre-deregulation structural composition is correlated with the number of years until deregulation, raising concerns about the exogeneity of treatment. In order to alleviate these concerns, we turn to the synthetic control method, which allows us to relieve the exogeneity requirement.

## 5.3 Pooled synthetic controls

### 5.3.1 Synthetic controls

The synthetic control method (SCM) is a recent development in case study analysis. When a treatment takes place in only one or a small number of units, it is not generally possible to use traditional techniques to estimate the treatment effect. Without being able to identify a plausible counterfactual had the unit not been treated – which becomes much easier when there are large numbers of treated and untreated units that are similar in characteristics – it is impossible to identify the treatment effect. Even when only one unit is treated, however, the SCM provides a rigorous, quantitative framework for constructing a counterfactual. For a treated unit, the SCM constructs a 'synthetic' treated unit as a convex combination of untreated control units, in order to minimise the distance between the real unit and the synthetic unit prior to treatment. Subject to some assumptions, divergence between the real unit and the treated unit post-treatment can be interpreted as the causal effect of treatment.

The SCM was introduced by Abadie and Gardeazabal (2003) in order to study the economic effects of terrorism in the Basque Country. Since it is impossible to observe the Basque Country in the absence of terrorism over the period of interest, a synthetic Basque Country is constructed as a convex combination of other Spanish regions. 'Treatment' in this case is the onset of violence. When constructing the synthetic Basque Country, weights are given to each of the other Spanish regions – known collectively as the donor pool – in order to minimise the gap between the real and synthetic Basque Countries in the period prior to treatment for the outcome variable of interest, in this case GDP per capita. Formally, following the notation and exposition in Abadie and Gardeazabal (2003), let $\mathbf{W} = (w_2, ..., w_{J+1})'$ be a $(J \times 1)$ vector of weights on the $J$ regions in the donor pool – where we reserve the index 1 for the treated region, the Basque Country – such that the weights are non-negative and sum to unity. Let $\mathbf{X}_1$ be a $(K \times 1)$ vector of predictor variables for GDP per capita in the Basque Country, and $\mathbf{X}_0$ be a $(K \times J)$ matrix containing the same $K$ variables for each of the $J$ regions in the donor pool. Let $\mathbf{V}$ be a diagonal $(K \times K)$ matrix with non-negative entries. Given $\mathbf{V}$, the optimal weight vector $\mathbf{W}^* (\mathbf{V})$ is chosen to minimise

$$(\mathbf{X}_1 - \mathbf{X}_0\mathbf{W})' \mathbf{V} (\mathbf{X}_1 - \mathbf{X}_0\mathbf{W}) .$$

The optimal matrix $\mathbf{V}^*$ is chosen to minimise the mean squared prediction error (MSPE) in GDP per capita between the real and synthetic Basque Countries in the pretreatment period. $\mathbf{V}^*$ can be thought of as a weighting of the importance of the $K$ different predictor variables.

The SCM has a number of desirable properties relative to the traditional difference-in-differences estimator[33]. While the fixed effects model can control for time-invariant unobserved

[33] There are some other estimators that we might have employed, such as propensity score weighting matching. While we do not discuss these alternatives in detail here, it is worth noting that synthetic control models can be related closely to propensity score models (Ben-Michael et al., 2019a,b).

unit-specific characteristics, the synthetic controls estimator "allows the effects of confounding unobserved characteristics to vary with time" (Abadie et al., 2010, p. 495). Moreover, "treatment and control states need not follow parallel trends, conditional on observables" (Dube and Zipperer, 2015, p. 8). Importantly, the SCM does not impose a functional form on the effect of deregulation, and so avoids many of the pitfalls associated with misspecified difference-in-difference regressions. Unlike with traditional regressions, an analyst using the SCM can be completely agnostic about both the direction and the character of any treatment effect under study. This ensures that we will not infer an incorrect effect because of functional misspecification: the data speak for themselves – although this does mean that it will be harder to distinguish between level and growth effects over time. Finally, we can relax the necessity for treatment exogeneity: given a good synthetic control, the difference between the treated unit and the synthetic control is treatment alone, and the counterfactual is valid even when treatment is endogenous. Thus while the difference-in-differences estimates derived above may not be valid, in principle, estimates derived using the SCM can be.

The validity of the SCM is subject to two key assumptions. First, the treated unit is assumed to be in the convex hull of the donor pool, so that a good fit for the treated unit is assumed to exist. If this assumption holds, then even when assignment to treatment is non-random and correlated with unobservable confounders, causal inference is valid. While it's not possible to test directly the existence of a good synthetic control, we go some way towards addressing this concern with a statistical validity test that is described below. Second, validity requires "that outcomes of the untreated units are not affected by the intervention implemented in the treated unit" (Abadie et al., 2010, pp. 494-495). Since we are focussed on intra-state bank branching deregulation, it seems plausible to assume that there is very little effect of deregulation in one state on outcomes in any other. Indeed, Huang (2008) studies the effects of intra-state branching deregulation by examining pairs of contiguous counties across state lines, one of which belonged to a state that deregulated and the other of which belonged to a state that did not deregulate for at least three years subsequently. In order to test indirectly for cross-border spillover effects, deregulated counties are also compared to 'hinterland' counties that are not contiguous with any deregulated county, and no major difference is found to the contiguous case (Huang, 2008, pp. 701-702). This suggests that spillover effects are not a major concern.

We use synthetic controls to study the effect of bank branching deregulation on the same four outcome variables as we studied with difference-in-differences regressions: services share of employment, services share of output, manufacturing share of employment, and manufacturing share of output[34]. The predictors we use to construct our $\mathbf{X}_0$ vector and $\mathbf{X}_1$ matrix are the state's population, total employment, total output, GDP per capita, GDP growth, employment rate, average years of education, proportion of residents who are black, and average age. We use these predictors because there is reason to believe that socio-demographic and economic variables such as these are good predictors of long-term growth potential (Sala-i-Martin et al., 2004), and we know that growth goes hand-in-hand with structural change. Each of these predictors is used for the full pretreatment span of time, from 1969 to the year prior to deregulation. As is common practice, we also use two observations, in 1969 and the year prior to deregulation, of each of the four outcome variables. These predictors are all calculated from BEA data, except for the average years of education, proportion of residents who are black, and average age, which are calculated from IPUMS USA data.

[34]In order to address concerns that we are only detecting an increase in the size of the financial sector after deregulation, in Appendix E.4 we also assess the effect of bank branching deregulation on the relative shares of different sectors when finance is excluded. These results are consistent with the effects found in the main body of the paper.

### 5.3.2 Statistical inference and pooling

Statistical inference when using the SCM is typically done by running placebo tests – either across time, by assigning the treatment date to some time when treatment did not actually occur, or across units, by assigning as the treated unit a member of the donor pool (Abadie et al., 2010). If the treatment does indeed have an effect, one would expect to see a greater deviation between the real and synthetic treated units after treatment in the genuine, non-placebo case than when running placebo tests. If some measure of deviation, say the gap between the treated unit and its synthetic counterfactual some specified time after treatment, is at the tail of the placebo distribution then we can have some confidence that the effect is statistically significant.

This method relies on having a reasonably large number of units in the donor pool, or a reasonably large time span across which to run placebo tests. In the case of bank branching deregulation, this presents a challenge. For example, there are only 9 deregulation events for which there are at least 3 other states in the donor pool, if we impose the requirements that there be at least 5 years of pre-treatment data to generate the synthetic treatment unit, and at least 10 years of post-treatment data in order to allow the treatment some time to take effect. If a deregulated state has only 3 other states in the donor pool, then even in principle a placebo test across units could only achieve a 40% significance level[35].

In order to enhance the statistical power of such placebo tests, we will pool different deregulation events and consider their joint statistical significance. Following an idea used by Dube and Zipperer (2015) to estimate the effect of minimum wage increases, we will calculate the mean percentile rank of the estimated treatment effect relative to the placebo tests. Under the null hypothesis of uniform distribution, this statistic has a distribution that can be calculated exactly even for small samples. Section 5.3.3 describes in detail the method used for constructing this distribution and calculating $p$-values.

### 5.3.3 Model selection and $p$-value calculation

When choosing the specification for constructing synthetic control units, there are competing imperatives. Clearly the longer the pre-treatment span of time, the better[36], as this improves the fit of the synthetic control unit. The longer the post-treatment span of time, the better, as this gives more time for the treatment to take effect and be discernible: the difference-in-differences regressions are suggestive of the fact that treatment may have an increasingly large effect over time. Finally, for each deregulation event, the more states in the donor pool, the better, as this increases the chance that a good synthetic control unit can be constructed. However, tightening these restrictions has the effect of reducing the number of deregulation events that can be used, which reduces their joint statistical power.

In order to get a good balance of all these requirements, our specification is to require that each treated state has at least 5 years of pre-treatment data, and a donor pool of at least 3 states that do not deregulate for at least 10 years after the treated state deregulates. We judge that this should balance the need for enough deregulation events to pool with the likelihood of a reasonably good fit and enough time to see gradual effects take hold. This specification gives us 9 deregulation events to study[37]. Tightening any of these requirements results in fewer deregulation events available for study, which reduces the statistical power of the pooled study.

[35] See Section 5.3.3 for a detailed description of the calculation of $p$-values.

[36] Data for all the variables of interest are only available from 1969, as described in Section 5.1, so for example a state that deregulated in 1975 would only have 6 years of pre-treatment data available.

[37] The bank branching deregulation events captured in this specification are those in Alabama, Connecticut, Maine, New Jersey, New York, Ohio, Pennsylvania, Utah and Virginia.

In order to get some estimate of the size of the effect of deregulation, we will focus on the value of the outcome variable at the end of the specified post-treatment period. For instance, in our baseline specification, when assessing the effect of deregulation on the share of services employment in the economy, we will focus on the gap between the share of services employment in the treated state and the share of services employment in the synthetic state, 10 years after deregulation occurs. We calculate two key values: first, the mean gap across all of the deregulation events; and second, a $p$-value associated with the mean percentile rank across all of the deregulation events.

The $p$-value is calculated as follows. Suppose there are $N$ deregulation events under study and a specified post-treatment span of $T$ years. For each $i \in [1, N]$, suppose there are $N_i - 1$ states in the donor pool. Including the treated state and the placebo studies, therefore, there are $N_i$ values for the gap in the outcome variable (real value minus synthetic value) $T$ years after deregulation. Any placebo deregulations with MSPE prior to deregulation greater than 5 times that of the treated state are removed from consideration, to exclude comparisons with states that do not have a well-fitting synthetic counterpart. Suppose this leaves $n_i - 1$ 'valid' placebo tests, so that for each treated state there are now $n_i$ values for the gap in the outcome variable $T$ years after deregulation. Suppose the treated state is at rank $j_i$ out of those $n_i$ values, so there are $j_i - 1$ placebo states that have a smaller gap and $n_i - j_i$ placebo states that have a larger gap. Then the percentile rank for state $i$ is calculated as

$$\pi_i = \frac{j_i}{n_i + 1}.$$

This has the property of being symmetrical – that is, a treated state that has exactly as many placebo values above it as below it would generate a percentile rank of 0.5.

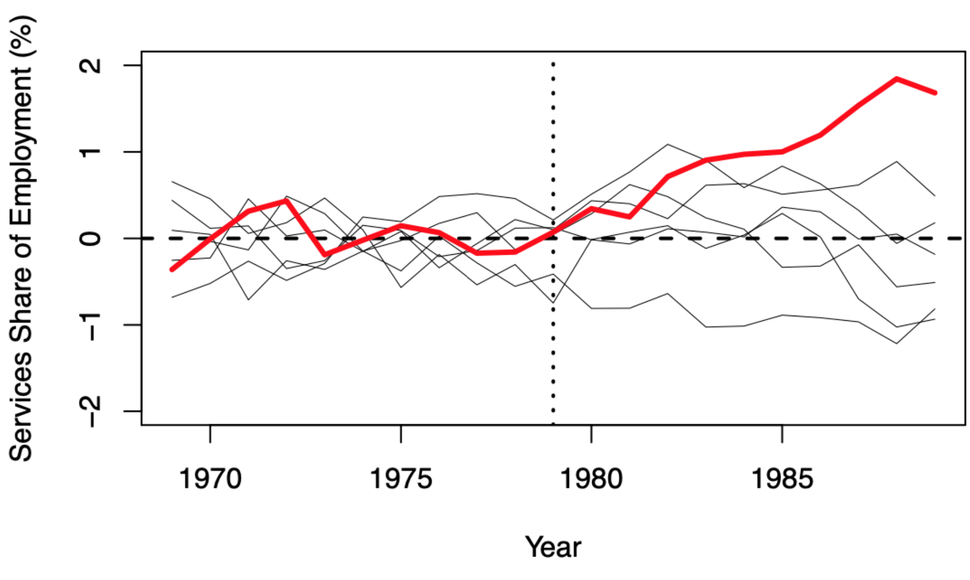


Figure 5: 'Gap plot' for placebo test of the effect of bank branching deregulation on the services share of output in Ohio. The synthetic Ohio in this case is optimally calculated as 9% Kentucky, 34% Missouri and 57% Wisconsin. Deregulation took place in 1979 in Ohio. The red line represents the gap between the real Ohio and the synthetic Ohio, while the black lines represent the gaps between real but untreated states in Ohio's donor pool and their synthetic counterparts.

As an example, Figure 5 shows a placebo test of the effect of deregulation on the services share of employment in Ohio. The synthetic Ohio in this case is optimally calculated as 9%

Kentucky, 34% Missouri and 57% Wisconsin. Since the effect on Ohio (the red line) is greater 10 years after deregulation than it is for any of the placebo states, and since there are 6 states in the donor pool, the percentile rank in this case would be

$$\pi_{\text{Ohio}} = \frac{j_{\text{Ohio}}}{n_{\text{Ohio}} + 1} = \frac{7}{8} = 0.875.$$

Once percentile ranks have been calculated for each individual deregulation event, the mean percentile rank across all deregulation events under study is calculated as

$$\bar{\pi} = \frac{1}{N} \sum_{i=1}^{N} \frac{j_i}{n_i + 1}. \tag{42}$$

Under the null hypothesis that each $\pi_i$ is uniformly distributed – that is, under the null hypothesis that there is in fact no treatment effect – the exact distribution of $\bar{\pi}$ can be derived using Monte Carlo methods[38]. For each $i \in [1, N]$, we take a random draw of $\hat{j}_i \in [1, n_i]$, then calculate

$$\hat{\pi} = \frac{1}{N} \sum_{i=1}^{N} \frac{\hat{j}_i}{n_i + 1}.$$

We repeat this five million times to construct an exact distribution for $\hat{\pi}$. The distribution of $\hat{\pi}$ allows us to assign $p$-values to the true value $\bar{\pi}$. If, for example, $\bar{\pi}$ is at either the 2.5th or the 97.5th percentile of the distribution of $\hat{\pi}$, we assign to $\bar{\pi}$ a $p$-value of 5%.

Note that the $p$-value does not directly relate to the estimated size of the effect. Instead, it is derived from the extremity of the genuine results in relation to placebo results. Thus we cannot construct a confidence interval around the point estimates reported in Section 5.3.5. Instead, we report a point estimate and report the $p$-value associated with there being *some* non-zero effect. In that sense, the point estimates are best thought of as giving some indication of the size and direction of the effect, rather than any precise value.

#### 5.3.4 Validity test

There is a danger in pooling multiple synthetic control studies that the pooling is invalid; that is, we must guard against the possibility that the apparent effect of deregulation 10 years after the event is statistically different from zero only because the SCM studies we pooled were systematically bad fits. For example, if we find that deregulation has a significantly positive effect on the services share of employment, we want to ensure this is not because there was a significant gap between the real states and their synthetic counterparts even prior to deregulation.

We propose therefore a simple statistical test of the validity of the pooling. We repeat the percentile rank test described above, but instead of using the percentile ranks from estimate of the gap 10 years after deregulation, we use percentile ranks based on the MSPE between the

[38] The distribution we have calculated also assumes that, under the null hypothesis, the individual percentile ranks $\pi_i$ are independent. Since the states in the donor pool have some overlap – the states that deregulate latest appear in the donor pool for multiple deregulation events – this assumption may not be correct. Dube and Zipperer (2015) address this concern by randomly permuting the state assignment in the whole dataset and conducting the entire exercise again as a placebo. They iterate this one million times and derive a distribution which allows statistical inference. However, as they note, this is computationally expensive – given that the computation for Section 5.3.5 of this paper takes several hours, it would not be feasible to replicate this methodology – and they find little difference from the assumption of independence, concluding that "accounting for donor overlap has little impact on the estimated critical values, justifying our use of the mean of independent uniform distributions" (Dube and Zipperer, 2015, p. 15).

Table 4: Pooled synthetic controls results

| Outcome Variable | Mean Gap | Mean Percentile Rank | $p$-Value | Validity $p$-Value |
|---|---|---|---|---|
| Services share of employment (%) | 1.958 | 0.698 | 0.009*** | 0.333 |
| Services share of output (%) | 1.798 | 0.674 | 0.030** | 0.785 |
| Manufacturing share of employment (%) | −1.299 | 0.342 | 0.054* | 0.003*** |
| Manufacturing share of output (%) | −2.484 | 0.300 | 0.015** | 0.017** |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Results from a pooled synthetic controls study requiring a minimum of 3 states in the donor pool, a minimum of 5 years of pre-treatment data, and 10 years of post-treatment data. 'Mean Gap' is the mean gap between the treated state and the synthetic state 10 years after deregulation across the 9 deregulation events fitting the specification. 'Mean Percentile Rank' is calculated as in equation (42), 10 years after deregulation. '$p$-Value' indicates how statistically different 'Mean Percentile Rank' is from 0.5. The null hypothesis is that 'Mean Percentile Rank' is equal to 0.5, and thus that deregulation has no effect. 'Validity $p$-Value' indicates how statistically different the mean percentile rank of the MSPE prior to deregulation is from 0.5. The null hypothesis is that the mean percentile rank of the MSPE is equal to 0.5, and thus that the treated states have synthetic counterparts that are just as good as those of the placebo states, in which case the pooling is valid.

real state and its synthetic counterpart prior to treatment. The null hypothesis of this test is that the mean percentile rank generated from the MSPE is equal to 0.5. The test will therefore detect a situation in which the treated states are systematically harder to fit with synthetic counterparts than the placebo states, and will indicate that we should not rely on the results generated from pooling those studies[39]. Note that this test does not guarantee that any given synthetic control study generates a good fit; it does however give us some confidence that if the treated and placebo states end up behaving differently after deregulation, it's not because they were already behaving differently prior to deregulation.

### 5.3.5 Pooled synthetic controls results

Table 4 shows the results of the pooled synthetic controls study. 10 years after deregulation, states have a significantly higher services share of both employment and output than they would have done if they did not deregulate. This accords with the suggestive evidence from the difference-in-differences regressions in Section 5.2, and more particularly, matches the predictions of the theory. Deregulation appears to have a statistically significant negative effect on the manufacturing share of output, also as predicted, and we find a negative point estimate for the effect of deregulation on the manufacturing share of employment, which is significant just below the 5% level. However, neither of the results pertaining to manufacturing pass the validity test. Our results suggest that bank branching deregulation causes a statistically significant increase in the share of output and employment accounted for by services, but that we are not able to fit the treated states' manufacturing shares using states that have not yet deregulated, so we cannot confidently say anything about the effect of bank branching deregulation on manufacturing.

In order to deal with the poor pre-treatment fit for manufacturing shares, we turn to augmented synthetic controls.

[39] The two-sided test will *also* detect a situation in which the treated states are systematically *easier* to fit with synthetic counterparts than the placebo states. While an argument could be made for considering only the one-sided version of this test, the placebo results are also invalid if the placebo fits are poor. We therefore use the two-sided version of the test.

### 5.3.6 Ridge augmented synthetic controls

Ben-Michael et al. (2019a) propose the augmented synthetic control method as an extension of the SCM to settings where a good pre-treatment fit is not feasible. The traditional SCM requires the treated unit to lie within the convex hull of the donor pool; that is, it restricts the weight vector $\mathbf{W}$ to non-negative entries. The augmented SCM allows extrapolation outside this convex hull by permitting negative weights on donor units.

The following exposition closely mirrors the basic outline presented in Ben-Michael et al. (2019a). Formally, as before, let $\mathbf{W} = (w_2, ..., w_{J+1})'$ be a $(J \times 1)$ vector of weights on the $J$ units in the donor pool, such that the weights are still non-negative and sum to unity. We will index by 1 the treated unit, while the units in the donor pool are indexed from 2 to $J+1$. Let $\mathbf{X}_1$ be a $(T_0 \times 1)$ vector of observations of the outcome variable for the treated unit in the $T_0$ periods prior to treatment[40], and $\mathbf{X}_0$ be the $(T_0 \times J)$ matrix containing the outcome variable for the $J$ donor units in the same $T_0$ periods. Then the optimal SCM weight vector $\mathbf{W}^{\text{SCM}}$ is chosen to minimise

$$(\mathbf{X}_1 - \mathbf{X}_0\mathbf{W})' (\mathbf{X}_1 - \mathbf{X}_0\mathbf{W}) + \sum_{i=2}^{J+1} \xi (w_i),$$

where $\xi$ is a function that penalises the dispersion of the weights $w_i$. However, when the weights are constrained to be non-negative, as they are here, "the particular choice of dispersion penalty does not play a central role" (Ben-Michael et al., 2019a, p. 5), so we do not dwell on the choice of $\xi$.

The weights $\mathbf{W}^{\text{SCM}}$ are the baseline SCM weights, essentially chosen by optimising pre-treatment fit and restricting weights to be non-negative, that we will augment by fitting an outcome model. Suppose for simplicity of exposition that there is only one post-treatment period, and let $Y_i$ be the outcome in unit $i$ in the period after unit 1 is treated, in the absence of treatment (this is the observed outcome for all units in the donor pool, and the untreated counterfactual we wish to estimate for unit 1). Let $Y_i = m(\mathbf{X}_i) + \varepsilon_i$ be a working outcome model, where $m$ is some function, $\mathbf{X}_i$ is the $(T_0 \times 1)$ vector of pre-treatment outcomes in unit $i$, and $\varepsilon_i$ is an independent error term with zero expectation. Then we can write down the bias of the SCM estimator based on the weights $\mathbf{W}^{\text{SCM}}$,

$$\text{bias} = Y_1 - \sum_{i=2}^{J+1} w_i^{\text{SCM}} Y_i = m(\mathbf{X}_1) - \sum_{i=2}^{J+1} w_i^{\text{SCM}} m(\mathbf{X}_i) + \mathbb{E}\left[\varepsilon_1 - \sum_{i=2}^{J+1} w_i^{\text{SCM}} \varepsilon_i\right].$$

Given an estimator $\hat{m}$ for $m$, we therefore have an estimator for the bias of the SCM estimator,

$$\widehat{\text{bias}} = \hat{m}(\mathbf{X}_1) - \sum_{i=2}^{J+1} w_i^{\text{SCM}} \hat{m}(\mathbf{X}_i),$$

which yields a bias-corrected SCM estimator for $Y_1$,

$$\begin{aligned}
\hat{Y}_1^{\text{aug}} &= \sum_{i=2}^{J+1} w_i^{\text{SCM}} Y_i + \left(\hat{m}(\mathbf{X}_1) - \sum_{i=2}^{J+1} w_i^{\text{SCM}} \hat{m}(\mathbf{X}_i)\right) \\
&= \hat{m}(\mathbf{X}_1) + \sum_{i=2}^{J+1} w_i^{\text{SCM}} (Y_i - \hat{m}(\mathbf{X}_i)).
\end{aligned}$$

[40]Note that, in the traditional SCM, the fit is based on $K$ predictor variables (which may or may not include pre-treatment observations of the outcome variable). Here, the fit is solely based on minimising the distance between the real and synthetic treated units prior to treatment.

All that remains to fit such an estimator therefore is to choose a function to employ as the estimator $\hat{m}$. Ben-Michael et al. (2019a) focus primarily on a ridge-regularised linear model, $\hat{m}(\mathbf{X}_i) = \hat{v}_0^r + \mathbf{X}_i'\hat{\mathbf{v}}^r$, where

$$\{\hat{v}_0^r, \hat{\mathbf{v}}^r\} = \arg\min_{v_0,\mathbf{v}} \frac{1}{2} \sum_{i=2}^{J+1} \left(Y_i - \left(v_0 + \mathbf{X}_i'\mathbf{v}\right)\right)^2 + \chi^r \mathbf{v}'\mathbf{v},$$

given a penalty hyperparameter $\chi^r$ that determines how sensitive we are to deviations from the initial SCM estimates. This leads to the ridge augmented synthetic control estimator

$$\hat{Y}_1^{\text{aug}} = \sum_{i=2}^{J+1} w_i^{\text{SCM}} Y_i + \left(\mathbf{X}_1 - \sum_{i=2}^{J+1} w_i^{\text{SCM}} \mathbf{X}_i\right)' \hat{\mathbf{v}}^r.$$

The choice of $\chi^r$ is important: as $\chi^r \to \infty$, the ridge-augmented estimator converges to the original SCM estimator; as $\chi^r \to 0$, by contrast, pre-treatment fit becomes perfect but only at the expense of potentially significant extrapolation outside the convex hull of the donor pool, which could exacerbate errors in the post-treatment estimate. In practice, a 'leave one out' cross-validation approach to the selection of $\chi^r$ is proposed, in which $\chi^r$ is chosen to minimise the mean squared error between the true pre-treatment outcomes in the treated unit and estimates of those outcomes based on the ridge augmented synthetic control estimator (Ben-Michael et al., 2019a, p. 13).

The ridge-augmented synthetic control estimator has a number of interesting properties, elucidated in the original paper. First, it is a weighting estimator which allows for potentially negative weights on donor units, but which penalises deviation from the baseline SCM estimator, so limits extrapolation bias and over-fitting to noise. Second, ridge augmented SCM (ridge ASCM) improves the pre-treatment fit of a synthetic control relative to traditional SCM, suggesting we may have more luck in finding good fits for pre-treatment manufacturing shares than we did in the results reported in Table 4. Finally, the authors show using simulation studies that there are estimation gains from using ridge ASCM relative to SCM alone. These properties make it a useful method to adopt, given the poor pre-treatment fits for the manufacturing shares of the economy found in Section 5.3.5, since we will get a better fit, with potentially more accurate results, while minimising unnecessary extrapolation outside the convex hull of the donor states.

Figure 6 illustrates the improvement in fit that ridge ASCM can achieve compared to standard SCM. The pre-treatment fit for the manufacturing share of employment in Connecticut is rather poor using standard SCM, but ridge ASCM is able to construct a much better synthetic Connecticut. We turn now to implementing pooled ridge ASCM to study the effects of bank branching deregulation on structural composition.

#### 5.3.7 Pooled ridge ASCM results

Given the ridge ASCM, we can conduct a pooled study based on individual synthetic controls, estimated exactly as in Section 5.3.5. The results of this pooled study are presented in Table 5. We find that bank branching deregulation caused a significantly increased services share of employment, and a significantly reduced manufacturing share of both employment and output, 10 years after deregulation. While we find a positive point estimate for the effect of deregulation on the services share of output, the mean percentile rank is not quite significant, with a $p$-value of around 13%. Ridge ASCM has substantially improved the pre-treatment fit relative to SCM alone: all of the validity $p$-values have increased, and we do not come close to rejecting the null hypothesis – that the treated states are fit as well as the placebo studies – for any of the

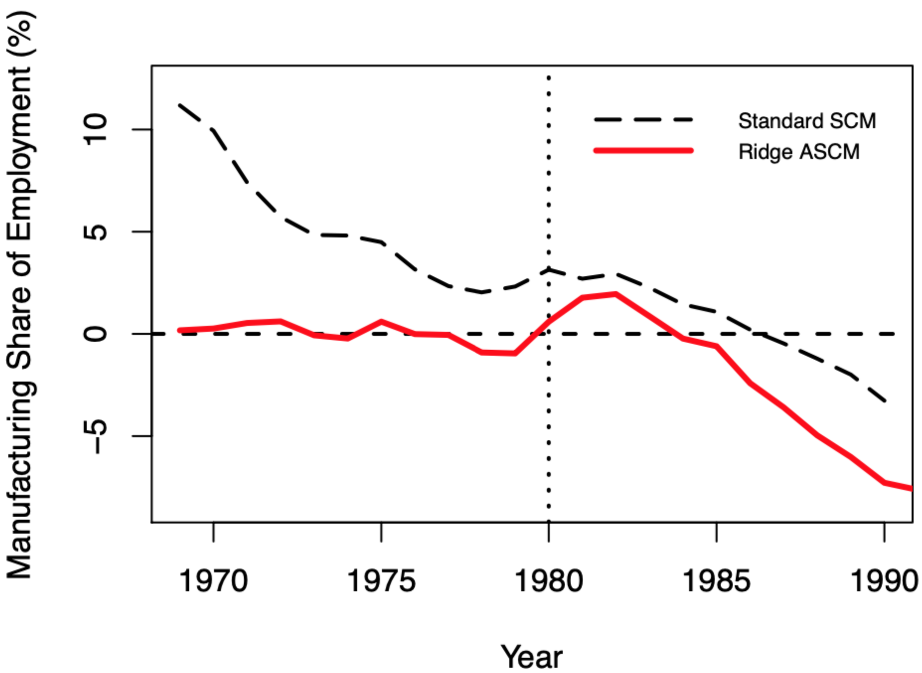


Figure 6: 'Gap plot' for the effect of bank branching deregulation on the manufacturing share of employment in Connecticut. The dashed black line shows the optimal fit using standard SCM. In this case Connecticut is optimally calculated as 100% Arkansas – that is, the proxy for the counterfactual untreated Connecticut is simply the outcome in Arkansas – but it is clear that the fit prior to deregulation in 1980 is rather poor. The solid red line shows the optimal fit using ridge ASCM. In this case Connecticut is optimally calculated as 1.56×Minnesota, 0.44×Iowa, 0.39×Arkansas, −0.25×Colarado and −1.14×New Mexico. The pre-deregulation fit is substantially improved.

Table 5: Pooled ridge ASCM results

| Outcome Variable | Mean Gap | Mean Percentile Rank | $p$-Value | Validity $p$-Value |
|---|---|---|---|---|
| Services share of employment (%) | 2.081 | 0.738 | 0.003*** | 0.865 |
| Services share of output (%) | 1.807 | 0.628 | 0.130 | 0.821 |
| Manufacturing share of employment (%) | −2.297 | 0.304 | 0.018** | 0.635 |
| Manufacturing share of output (%) | −3.566 | 0.231 | 0.001*** | 0.737 |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Results from a pooled ridge ASCM study requiring a minimum of 3 states in the donor pool, a minimum of 5 years of pre-treatment data, and 10 years of post-treatment data. 'Mean Gap' is the mean gap between the treated state and the synthetic state 10 years after deregulation across the 9 deregulation events fitting the specification. 'Mean Percentile Rank' is calculated as in equation (42), 10 years after deregulation. '$p$-Value' indicates how statistically different 'Mean Percentile Rank' is from 0.5. The null hypothesis is that 'Mean Percentile Rank' is equal to 0.5, and thus that deregulation has no effect. 'Validity $p$-Value' indicates how statistically different the mean percentile rank of the MSPE prior to deregulation is from 0.5. The null hypothesis is that the mean percentile rank of the MSPE is equal to 0.5, and thus that the treated states have synthetic counterparts that are just as good as those of the placebo states, in which case the pooling is valid.

outcome variables. The point estimates found for the effect on services are very similar to those found with traditional SCM, but the magnitude of the effects on the manufacturing shares are substantially increased with ridge ASCM. This suggests that, while we could not find good fits for the manufacturing shares using traditional synthetic controls, the bad fits were actually working to *decrease* rather than increase the apparent effect of deregulation.

As a final robustness check, we estimate the effects of bank branching deregulation on structural change using the staggered synthetic control method.

#### 5.3.8 Staggered synthetic controls

Our study presents a very natural setting in which to use the extension of the SCM proposed by Ben-Michael et al. (2019b) in order to account for staggered adoption of a treatment, which we will refer to as the staggered synthetic control method (staggered SCM). Our approach so far has been to fit *fully separate* synthetic counterfactuals for each deregulation event, and derive our point estimate of the average treatment effect on the treated (ATT) by taking a simple mean of individual effects; an alternative approach would be to fit *fully pooled*[41] synthetic counterfactuals, where we aim to minimise the pre-treatment imbalance between the average treated state and the average synthetic counterfactual. In rough terms, when fitting *fully separate* synthetic controls, we fit then average, and when fitting *fully pooled* synthetic controls, we average then fit[42].

Ben-Michael et al. (2019b) show that using fully separate synthetic controls and averaging across deregulation events is a potentially biased estimator of the ATT, where the bias arises if there is no good fit for a particular treated state, so the point estimates we find in Table

[41] In order to avoid conflict with the original paper, we use 'fully pooled' in the sense employed by Ben-Michael et al. (2019b). However, note that throughout the rest of the paper we use 'pooled synthetic controls' to refer to joint statsitical analysis of more than one deregulation event using the SCM and its extensions. Thus even the 'fully separate' approach in the parlance of Ben-Michael et al. (2019b) is a 'pooled synthetic controls study' in our terminology.

[42] For the sake of concision, a formal treatment of staggered synthetic controls has been omitted. See Ben-Michael et al. (2019b) for technical details.

Table 6: Staggered SCM results

| Outcome Variable | Effect | Standard Error | $p$-Value |
|---|---|---|---|
| Services share of employment (%) | 2.237 | 0.730 | 0.002*** |
| Services share of output (%) | 1.452 | 1.833 | 0.428 |
| Manufacturing share of employment (%) | −3.643 | 1.117 | 0.001*** |
| Manufacturing share of output (%) | −4.612 | 0.972 | 0.000*** |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Results from a staggered synthetic controls study requiring a minimum of 3 states in the donor pool, a minimum of 5 years of pre-treatment data, and 10 years of post-treatment data. 'Effect' is the estimated effect of deregulation on the outcome variable – relative to the counterfactual of no deregulation – 10 years after deregulation across the 9 deregulation events fitting the specification. 'Standard Error' is the jackknifed standard error of this estimated effect, and '$p$-Value' indicates how statistically different 'Effect' is from 0 based on the standard error. The null hypothesis is that bank branching deregulation has no effect.

4 are likely to be unreliable[43]. The fully pooled synthetic control improves on the separate synthetic controls in minimising the average pre-treatment imbalance, but performs more poorly in controlling the imbalance for individual states, which introduces potential interpolation bias in the estimation of the ATT. Neither of these approaches is therefore a 'silver bullet', but the authors show theoretically and by simulations that taking a weighted average of the separate and the pooled estimators can minimise overall bias and improve performance over either the separate or the pooled approaches alone.

The key hyperparameter associated with this method is the weight $\tilde{\nu} \in [0, 1]$ placed on the pooled synthetic controls, with $1 - \tilde{\nu}$ being the weight placed on the separate synthetic controls. In practice, the authors propose a heuristic for choosing $\tilde{\nu}$ by considering how bad the average pre-treatment balance is when using separate synthetic controls, and thus deciding how great the need for adjustment (see Ben-Michael et al., 2019b, pp. 13-14). In our results below, in all cases $\tilde{\nu}$ falls between 0.45 and 0.6, so the estimates are somewhere close to being 'half and half'. Similarly to the ridge ASCM, we further improve the fit when using the staggered SCM by combining the estimates with a simple outcome model, in this case unit fixed effects. Standard errors and the resultant $p$-values are calculated using a leave-one-out jackknife approach.

#### 5.3.9 Staggered synthetic controls results

The staggered SCM estimates of the effects of bank branching deregulation are presented graphically in Figure 7 and numerically in Table 6. As with the ridge ASCM, we find that 10 years after deregulation, the services share of employment is significantly higher and the manufacturing shares of both employment and output are significantly lower than they would have been in the absence of deregulation. Again, as we found using the ridge ASCM, bank branching deregulation does not appear to have a significant effect on the services share of output over the time horizon studied. All the significant effects are of the same order of magnitude as those found using ridge ASCM, but slightly larger still.

Other than finding insufficient evidence for a change in the services share of output, we therefore find that bank branching deregulation did have a significant effect on structural change, accelerating the secular shift that was already underway towards services and away from manufacturing, as predicted by our theory. The United States from the 1970s to the 1990s was

[43] While we have already addressed this source of bias using augmented synthetic controls, we present the results in Section 5.3.9 for robustness.

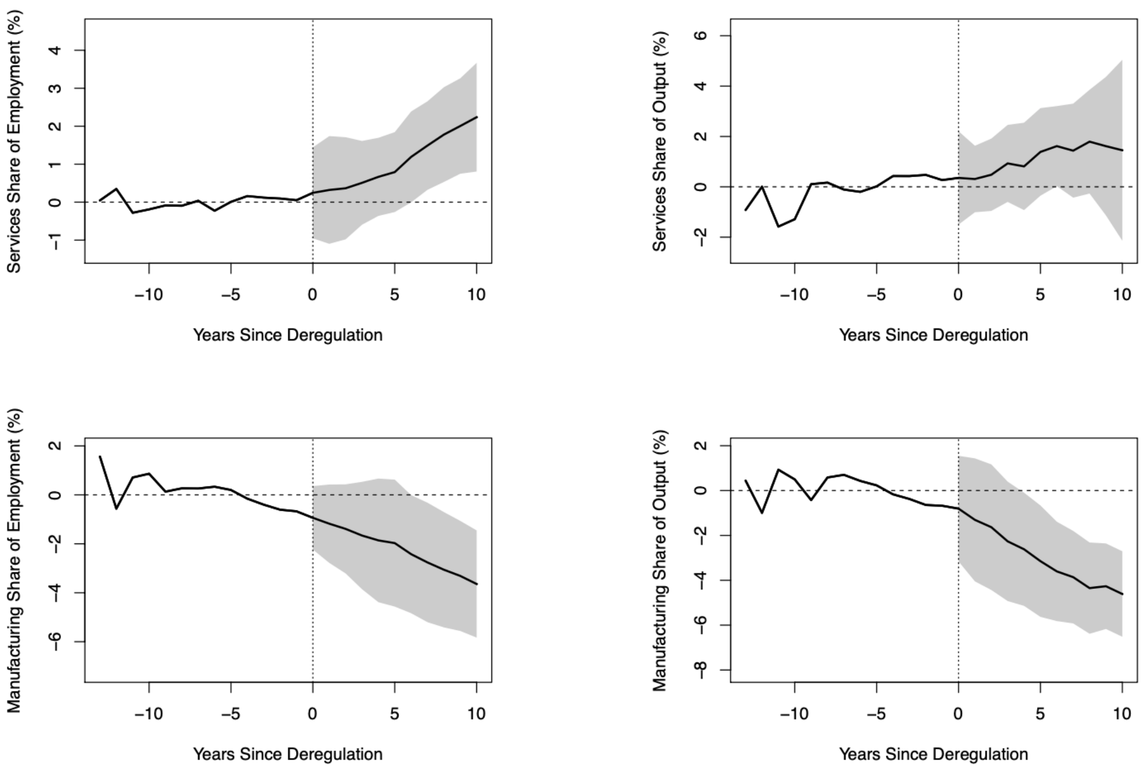


Figure 7: 'Gap plots' of the results of a staggered synthetic controls study estimating the effect of bank branching deregulation on structural change, partially pooled across multiple U.S. states. Plots show the share of the economy accounted for by each sector, relative to the synthetic counterfactual of no deregulation. 95% confidence intervals are shaded in grey.

relatively economically developed, so it is unclear whether these results would hold in the context of a less developed economy; indeed, Heblich and Trew (2019) find that finance increases manufacturing employment in an industrialising economy. Looking at the same bank branching deregulation episode as we consider in this paper, other work has shown that manufacturing firms achieve faster TFP growth post-deregulation (Jerzmanowski, 2017), consistently with our theoretical model. This mechanism may only work in relatively industrialised economies, when manufacturing firms have accumulated sufficient capital but would like to invest more in R&D, for example. Nonetheless, our results show a significant effect of bank branching deregulation on the structure of state economies.

## 6 Conclusions

The central research question of our paper is whether financial development accelerates structural change in the post-industrialization phase. At the theoretical level, we have shown that sectoral differences in production technologies can generate alternative engines of structural change: the comparison of three possible specifications of the model – exogenous productivity gaps, asymmetric factor elasticities, and learning-by-doing in manufacturing – suggests that exogenous reductions in intermediation costs exert stronger effects on expenditure shares and capital diversion when productivity is endogenous and services are labour-intensive. Besides this, all the model variants robustly predict that exogenous reductions in intermediation costs – e.g., deregulation shocks – accelerate the pace and extent of structural change towards services and away from manufacturing.

Our empirical results support the theoretical predictions. Considering data for the United States in the late 20th century, we examine the effect on structural change of the bank branching deregulation which occurred state-by-state from the 1970s to the 1990s. For robustness, we employ a range of estimation methods centred on recent advances in the synthetic control method – pooled synthetic controls, augmented synthetic controls, and synthetic controls in the presence of staggered treatment. The estimations show that bank branching deregulation accelerated the structural change that was already underway: services account for a greater share of output and employment than they would have in the absence of deregulation.

Our analysis unveils several open questions, and three in particular, deserving further research. First, endogenous productivity growth seems to be a key ingredient in the interactions between financial intermediation and structural change: in the present paper, we have incorporated this aspect in the most parsimonious way – learning-by-doing externalities – in order to compare alternative specifications of the benchmark model, but it is clear that a richer theory where firms undertake investment in physical capital and R&D would yield novel and hopefully testable predictions. Tackling this topic would shed further light not only on the origins of structural change, but also on the impact of financial development on growth and welfare. Second, our analysis focused on advanced economies experiencing the second, post-industrial phase of structural change where services overtake manufacturing sectors, with no role played by agriculture. Given the existing evidence on the industrialization phase – where financial development appears to drive the rise of manufacturing overtaking agriculture (Heblich and Trew, 2019) – a central question is to characterize the dynamic role played by financial intermediation across stages of development by building a comprehensive framework where both phases of structural change can be rationalized. Third, a particularly useful extension to the work presented here would be to conduct a similar exercise by explicitly including international trade: in open economies, the path of structural change is necessarily affected by specialization patterns and the tradeability of manufactured goods versus services. These elements can directly affect the finance-structural change nexus provide further insights on the effects of financial development. More generally, the interaction between financial intermediation and structural change remains a relatively under-researched topic: further contributions, in the form of alternative theories or new evidence, would bring substantial value added not only to current knowledge but also to concrete policymaking.

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# Appendices

## A The Benchmark Model

**Households**. In its general specification, the household problem is

$$\begin{aligned}
&\max_{\{c(t),s(t)\}_{t=0}^{\infty}} \int_0^{\infty} u\left(c\left(t\right), s\left(t\right)\right) \cdot e^{-(\rho-n)t} dt \\
&\text{subject to} \\
u\left(c\left(t\right), s\left(t\right)\right) &= \ln\left[\gamma \cdot \left(c\left(t\right)\right)^{\frac{\sigma-1}{\sigma}} + (1-\gamma) \cdot \left(s\left(t\right)\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \\
\dot{q}\left(t\right) &= r_q\left(t\right) q\left(t\right) + w\left(t\right) - c\left(t\right) - p_s\left(t\right) s\left(t\right)
\end{aligned}$$

where $c\left(t\right), s\left(t\right)$ are the control variables and $q\left(t\right)$ is the state variable, with $q\left(0\right) = q_0$ given at time zero. We can decompose this problem into a static sub-problem, which determines the allocation of total expenditure between manufactured goods and services at each point in time, and an intertemporal solution determining the optimal time path of overall expenditures and financial wealth. The static sub-problem is to maximize instantaneous utility $u\left(c, s\right)$ subject to the income constraint

$$r_q q\left(t\right) + w = \dot{q} + c + p_s s$$

in each instant $t$. The first order conditions imply that consumers will allocate expenditures between manufactured goods and services so as to satisfy

$$p_s = \frac{u_s}{u_c} = \frac{1-\gamma}{\gamma}\left(\frac{c}{s}\right)^{\frac{1}{\sigma}}. \tag{A.1}$$

Condition (A.2) implies that the ratio between manufaturing and service expenditures is

$$\frac{c\left(t\right)}{p_s\left(t\right) s\left(t\right)} = \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s\left(t\right)^{\sigma-1}. \tag{A.2}$$

Hence, if $\sigma > 1$, an increase in the price of services increases the expenditure share of manufactured goods. If $\sigma < 1$, instead, an increase in $p_s$ reduces the expenditure share of manufactured goods. Defining individual expenditure as

$$x\left(t\right) \equiv c\left(t\right) + p_s\left(t\right) s\left(t\right),$$

the expenditure function can be written as

$$x\left(t\right) = p_s\left(t\right) s\left(t\right) \cdot \left[1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s\left(t\right)^{\sigma-1}\right] = c\left(t\right) \cdot \frac{1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s\left(t\right)^{\sigma-1}}{\left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s\left(t\right)^{\sigma-1}} \tag{A.3}$$

Also, the physical ratio between the two types of consumption can be written as

$$\frac{c\left(t\right)}{s\left(t\right)} = \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s\left(t\right)^{\sigma} \tag{A.4}$$

which can be substituted back into the utility function to obtain a separable form of the type

$$u\left(c, s\right) = \ln\left[\gamma \cdot c^{\frac{\sigma-1}{\sigma}} + (1-\gamma) \cdot s^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} = \bar{u}\left(p_s\right) + \ln x \tag{A.5}$$

where we have defined

$$\bar{u}(p_s) \equiv \ln \frac{\left[\gamma\left(\frac{\gamma}{1-\gamma}\right)^{\sigma-1} p_s(t)^{\sigma-1} + (1-\gamma)\right]^{\frac{\sigma}{\sigma-1}}}{p_s(t) + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma}}.$$

By exploiting result (A.5), we can write the residual intertemporal optimization problem as

$$\begin{aligned} & \max_{\{x(t)\}_{t=0}^{\infty}} \int_0^{\infty} \left[\bar{u}(p_s(t)) + \ln x(t)\right] \cdot e^{-(\rho-n)t} dt \\ & \text{subject to} \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \text{(A.6)} \\ \dot{q}(t) &= r_q(t)\, q(t) + w(t) - x(t) \end{aligned}$$

where the only control variable is expenditure $x(t)$. Denoting by $\lambda(t)$ the dynamic multiplier associated with the state variable $q(t)$, the necessary conditions for utility maximization read

$$1/x(t) = \lambda(t), \tag{A.7}$$

$$(\rho - n)\lambda(t) - \dot{\lambda}(t) = r_q(t)\lambda(t), \tag{A.8}$$

$$\lim_{t\to\infty} \lambda(t)\, q(t)\, e^{-(\rho-n)t} = 0, \tag{A.9}$$

where (A.7) is the first order condition on $x$, (A.8) is the costate equation and (A.9) is the relevant transversality condition on financial wealth. From (A.7) and (A.8), the growth rate of expenditures along the utility maximizing path is

$$\frac{\dot{x}(t)}{x(t)} = r_q(t) + n - \rho. \tag{A.10}$$

For future reference, note that the expenditure-share equation (A.10) implies

$$\begin{aligned} \frac{c(t)}{p(t)\, s(t)} &= \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}, \\ \frac{x(t) - p(t)\, s(t)}{p(t)\, s(t)} &= \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}, \end{aligned}$$

that is

$$x(t) = \left[1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}\right] \cdot p(t)\, s(t). \tag{A.11}$$

**Profit maximizing conditions under the general technologies (10)-(11).** In the manufacturing sector, the price of output is normalized to unity, profits read $M - r_k K_M - w\ell N$ and the profit maximizing conditions are

$$r_k(t) = \alpha a_M(t)\, a_\ell(t)^{1-\alpha} \cdot \left(\frac{K_M(t)}{\ell(t)\, N(t)}\right)^{\alpha-1} = \alpha \frac{M(t)}{K_M(t)}, \tag{A.12}$$

$$w(t) = (1-\alpha)\, a_M(t)\, a_\ell(t)^{1-\alpha} \left(\frac{K_M(t)}{\ell(t)\, N(t)}\right)^{\alpha} = (1-\alpha) \frac{M(t)}{\ell(t)\, N(t)}. \tag{A.13}$$

In the service sector, profits equal $p_s S - r_k K_S - w(1-\ell) N$ and the maximizing conditions are

$$r_k(t) = p_s(t) \cdot \beta a_S \left(\frac{K_S(t)/N(t)}{1-\ell(t)}\right)^{\beta-1} = \beta \frac{p_s(t)\, S(t)}{K_S(t)}, \tag{A.14}$$

$$w(t) = p_s(t) \cdot (1-\beta)\, a_S \left(\frac{K_S(t)/N(t)}{1-\ell(t)}\right)^{\beta} = (1-\beta) \frac{p_s(t)\, S(t)}{(1-\ell(t))\, N(t)} \tag{A.15}$$

**Factor-price equalization and market clearing under the general technologies (10)-(11)**. By combining the respective demands for capital and labor, the key conditions for the allocation of inputs between the two sectors are given by

$$r_k(t) = \beta \frac{p_s(t) S(t)}{K_S(t)} = \alpha \frac{M(t)}{K_M(t)} \quad \text{with} \quad K_M(t) + K_S(t) = K(t) \tag{A.16}$$

and

$$w(t) = \frac{(1-\alpha) M(t)}{\ell(t) N(t)} = \frac{(1-\beta) p_s(t) S(t)}{(1-\ell(t)) N(t)}. \tag{A.17}$$

For future reference, note that the condition for wage equalization (A.17) can be used to the define the price of services that is consistent with the equilibrium in the labor market as

$$p_s(t) = \frac{(1-\alpha)(1-\ell(t))}{(1-\beta)\ell(t)} \cdot \frac{M(t)}{S(t)} = \frac{(1-\alpha)(1-\ell(t))}{(1-\beta)\ell(t)} \cdot \frac{a_M(t) a_\ell(t)^{1-\alpha}}{a_S} \cdot \frac{K_M(t)^\alpha}{K_S(t)^\beta} \cdot \frac{(\ell(t) N(t))^{1-\alpha}}{[(1-\ell(t)) N(t)]^{1-\beta}}. \tag{A.18}$$

# B Exogenous Productivity Gaps (Model I)

**Derivation of results (13)-(14)**. The profit-maximizing conditions with respect to capital and labor respectively yield

$$\begin{aligned} r_k(t) &= \alpha a_M(t) \left( \frac{K_M(t)}{\ell(t) N(t)} \right)^{\alpha-1} = p_s(t) \cdot \alpha a_S \left( \frac{K_S(t)/N(t)}{1-\ell(t)} \right)^{\alpha-1} && \text{(B.1)} \\ w(t) &= (1-\alpha) a_M(t) \left( \frac{K_M(t)}{\ell(t) N(t)} \right)^{\alpha} = p_s(t) \cdot (1-\alpha) a_S \left( \frac{K_S(t)/N(t)}{1-\ell(t)} \right)^{\alpha} && \text{(B.2)} \end{aligned}$$

Solving (B.1) and (B.2) for $\frac{a_M}{p_s \cdot a_S}$ yields

$$\begin{aligned} \frac{a_M(t)}{p_s(t) \cdot a_S} &= \left( \frac{K_M(t)}{\ell(t) N(t)} \right)^{1-\alpha} \left( \frac{K_S(t)/N(t)}{1-\ell(t)} \right)^{\alpha-1}, && \text{(B.3)} \\ \frac{a_M(t)}{p_s(t) \cdot a_S} &= \left( \frac{K_M(t)}{\ell(t) N(t)} \right)^{-\alpha} \left( \frac{K_S(t)/N(t)}{1-\ell(t)} \right)^{\alpha}. && \text{(B.4)} \end{aligned}$$

Combining (B.3)-(B.4) to eliminate $\frac{a_M}{p_s \cdot a_S}$ yields $\frac{K_M}{\ell N} = \frac{K_S}{N(1-\ell)}$ and therefore (13). Plugging (13) back into (B.3) yields (14). Also note, for future reference, that the ratio between the capital rental rate and the wage rate is

$$\frac{r_k(t)}{w(t)} = \frac{\alpha}{1-\alpha} \cdot \frac{1}{\kappa(t)} \tag{B.5}$$

and that the rental rate of capital can be equivalently written as

$$r_k(t) = \alpha a_M(t) \kappa(t)^{\alpha-1} = \alpha \left[ a_M(t)^{\frac{1}{1-\alpha}} \right]^{1-\alpha} \kappa(t)^{\alpha-1} = \alpha \left( \frac{\kappa(t)}{a_M(t)^{\frac{1}{1-\alpha}}} \right)^{\alpha-1} \tag{B.6}$$

For future reference, note that equal capital-labor intensities imply the following levels of output in the two sectors:

$$\begin{aligned} M(t) &\equiv a_M(t) a_\ell(t)^{1-\alpha} \cdot \kappa(t)^\alpha \cdot \ell(t) N(t), && \text{(B.7)} \\ S(t) &\equiv a_S \cdot \kappa(t)^\alpha (1-\ell(t)) N(t). && \text{(B.8)} \end{aligned}$$

**Dynamic system of Model I**. The equilibrium path of the economy is determined by the joint dynamics of individual expenditures, $x$, and capital per worker, $\kappa$, given by

$$\frac{\dot{x}(t)}{x(t)} = r_k(t)(1-\psi) - \theta - (\rho - n), \tag{B.9}$$

$$\frac{\dot{\kappa}(t)}{\kappa(t)} = r_k(t)\frac{1-\psi}{\alpha} - \theta - (1-\psi)\frac{x(t)}{\kappa(t)}. \tag{B.10}$$

Equation (B.9) is the Euler equation (6) in which we have substituted $r_q$ by means of (9). Equation (B.10) is derived as follows. The household wealth constraint (3) may be written as

$$\frac{\dot{q}(t)}{q(t)} = r_q(t) + \frac{w(t)}{q(t)} - \frac{x(t)}{q(t)}. \tag{B.11}$$

From (8) and (9), we have

$$q(t) = \frac{\kappa(t)}{1-\psi}, \quad \frac{\dot{q}(t)}{q(t)} = \frac{\dot{\kappa}(t)}{\kappa(t)} \text{ and } r_q(t) = r_k(t)(1-\psi) - \theta. \tag{B.12}$$

Moreover, from (B.5) we have

$$\frac{w(t)}{\kappa(t)} = \frac{1-\alpha}{\alpha} r_k(t). \tag{B.13}$$

Plugging (B.12) and (B.13) into (B.11) yields

$$\frac{\dot{q}(t)}{q(t)} = r_k(t)(1-\psi) - \theta + (1-\psi)\frac{1-\alpha}{\alpha} r_k(t) - (1-\psi)\frac{x(t)}{\kappa(t)}$$

and therefore equation (B.10). As we show below, (B.9) and (B.10) determine a unique equilibrium path leading to the long-run outcomes (15)-(16) reported in the main text.

**Proof of results (15) and (16)**. The analysis of system (B.9)-(B.10) becomes straightforward if we normalize both $x$ and $\kappa$ relative to $a_M^{\frac{1}{1-\alpha}}$, the implicit labor-efficiency gain that the manufacturing sector enjoys from the assumed form of Hicks-neutral technological progress (12).[44] Defining the convenient variables

$$x_A(t) \equiv \frac{x(t)}{a_M(t)^{\frac{1}{1-\alpha}}} \text{ and } \kappa_A(t) \equiv \frac{\kappa(t)}{a_M(t)^{\frac{1}{1-\alpha}}} \tag{B.14}$$

we can write the rental rate of capital from (B.6) in intensive form as

$$r_k(t) = \alpha \kappa_A(t)^{\alpha-1}. \tag{B.15}$$

Defining the growth rate of $a_M(t)^{\frac{1}{1-\alpha}}$ as

$$g^* \equiv \frac{1}{a_M(t)^{\frac{1}{1-\alpha}}} \frac{\mathrm{d}a_M(t)^{\frac{1}{1-\alpha}}}{\mathrm{dt}} = \frac{1}{1-\alpha} g_M, \tag{B.16}$$

we can rewrite system (B.9)-(B.10) in terms of normalized variables as

$$\frac{\dot{x}_A(t)}{x_A(t)} = \alpha \kappa_A(t)^{\alpha-1}(1-\psi) - \theta - (\rho - n) - g^*, \tag{B.17}$$

$$\frac{\dot{\kappa}_A(t)}{\kappa_A(t)} = \kappa_A(t)^{\alpha-1}(1-\psi) - \theta - (1-\psi)\frac{x_A(t)}{\kappa_A(t)} - g^*. \tag{B.18}$$

[44]The production function of the manufacturing sector can be written as $M = a_M K_M^{\alpha}(\ell N)^{1-\alpha} = (K_M)^{\alpha}(a_M^{\frac{1}{1-\alpha}} \ell N)^{1-\alpha}$ so that the growth rate of $a_M^{\frac{1}{1-\alpha}}$ is the implicit rate of labour-augmenting progress.

System (B.17)-(B.18) is perfectly isomorphic to the standard one-sector neoclassical model (also known as the Ramsey-Cass-Koopmans model). On the one hand, the steady state locus $\dot{x}_A = 0$ in (B.17) defines a unique non-trivial stationary rental rate of capital as well as a stationary level of "normalized" capital per worker,

$$\dot{x}_A = 0 \to r_k^{ss} \equiv \alpha \left(\kappa_A^{ss}\right)^{\alpha-1} = \frac{g^* + \theta + (\rho - n)}{1 - \psi}, \tag{B.19}$$

$$\dot{x}_A = 0 \to \kappa_A^{ss} \equiv \left[\frac{\alpha (1-\psi)}{g^* + \theta + (\rho - n)}\right]^{\frac{1}{1-\alpha}}. \tag{B.20}$$

The steady state $\dot{\kappa}_A = 0$ in (B.18), on the other hand, defines a stationary locus for "normalized" expenditure per capita that is a hump-shaped function in the $\kappa_A$–$x_A$ plane,

$$\dot{\kappa}_A = 0 \to x_A^{ss} = \kappa_A^{\alpha} - \frac{\theta + g^*}{1 - \psi}\kappa_A. \tag{B.21}$$

The simultaneous steady state is thus characterized by a constant ratio between (non-normalized) individual expenditures and capital per worker

$$\dot{x}_A = \dot{\kappa}_A = 0 \to \frac{x_A^{ss}}{\kappa_A^{ss}} = \left(\kappa_A^{ss}\right)^{\alpha-1} - \frac{g^* + \theta}{1 - \psi} = \frac{\rho - n + (1-\alpha)(g^* + \theta)}{\alpha (1-\psi)} \equiv \frac{x^{ss}}{\kappa^{ss}}. \tag{B.22}$$

The stability of the simultaneous steady state $\dot{x}_A = \dot{\kappa}_A = 0$ is proved just like in the Ramsey model. The linearized system reads

$$\dot{x}_A \simeq 0 \cdot \left(x_A - x_A^{ss}\right) + (\alpha - 1)(1-\psi)\,\alpha \left(\kappa_A^{ss}\right)^{\alpha-2} \cdot \left(\kappa_A - \kappa_A^{ss}\right), \tag{B.23}$$

$$\dot{\kappa}_A \simeq -(1-\psi) \cdot \left(x_A - x_A^{ss}\right) + (\rho - n) \cdot \left(\kappa_A - \kappa_A^{ss}\right), \tag{B.24}$$

and its eigenvalues are given by the solution to

$$\lambda_A^2 - \lambda_A (\rho - n) + (\alpha - 1)(1-\psi)^2 \alpha \left(\kappa_A^{ss}\right)^{\alpha-2} = 0,$$

that is, two real eigenvalues of opposite sign:

$$\lambda_A = \frac{\rho - n \pm \sqrt{(\rho - n)^2 + (1-\alpha)(1-\psi)^2 \alpha \left(\kappa_A^{ss}\right)^{\alpha-2}}}{2}. \tag{B.25}$$

Therefore, the simultaneous steady state $\dot{x}_A = \dot{\kappa}_A = 0$ is saddle-point stable and admits a unique equilibrium path converging to the steady state point $(x_A^{ss}, \kappa_A^{ss})$ where $x_A^{ss}$ is given by (B.21) and $\kappa_A^{ss}$ is given by (B.20). The stationarity of $x_A^{ss}$ and $\kappa_A^{ss}$ implies that the non-normalized variables, $x$ and $\kappa$ grow at the same rate given by the growth rate of $a_M(t)^{\frac{1}{1-\alpha}}$ defined in (B.16), which proves result (15). The convergence of $\kappa_A$ to $\kappa_A^{ss}$ implies, by (B.19), result (16).

**Employment shares: proof of result (17)**. From (A.3), we can write individual expenditures divided by capital per worker as

$$\frac{x(t)}{\kappa(t)} = \left[1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}\right] \cdot \frac{p_s(t)}{\kappa(t)} \cdot s(t), \tag{B.26}$$

where we can substitute the production function $s(t) = a_S \kappa(t)^{\alpha} (1 - \ell(t))$, as well as $a_M(t) = p_s(t) \cdot a_S$ from (14), to obtain

$$\frac{x(t)}{\kappa(t)} = \left[1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}\right] \cdot a_M(t)\,\kappa(t)^{\alpha-1} \cdot (1 - \ell(t)), \tag{B.27}$$

Recalling that $r_k(t) = \alpha a_M(t)\,\kappa(t)^{\alpha-1}$, expression (B.27) yields

$$1 - \ell(t) = \frac{1}{1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}} \cdot \alpha \cdot \frac{x(t)}{\kappa(t)} \cdot \frac{1}{r_k(t)}. \tag{B.28}$$

Since $p_s(t) = a_M(t)/a_S$ grows indefinitely at constant rate $g_M > 0$, the limit of the above expression as $t \to \infty$ is given by

$$\lim_{t\to\infty}(1 - \ell(t)) = \frac{1}{1+0} \cdot \alpha \cdot \lim_{t\to\infty}\left(\frac{x(t)}{\kappa(t)}\right) \cdot \frac{1}{r_k^{ss}}, \tag{B.29}$$

where the asymptotic expenditure-capital ratio is, from (B.22), equal to

$$\lim_{t\to\infty}\left(\frac{x(t)}{\kappa(t)}\right) = \frac{x_A^{ss}}{\kappa_A^{ss}} = \frac{\rho - n + (1-\alpha)(g^* + \theta)}{\alpha(1-\psi)} \tag{B.30}$$

Subtituting (B.30) in (B.29) as well as $r_k^{ss}$ from (16), we obtain

$$\lim_{t\to\infty}(1 - \ell(t)) = \frac{(1-\alpha)(g^* + \theta) + (\rho - n)}{g^* + \theta + (\rho - n)} \equiv 1 - \ell^{ss}, \tag{B.31}$$

which implies result (17) in the main text.

**Value added shares: proof of result (18)**. From the production functions (10)-(11) and the efficiency conditions (13)-(14), the ratio between $M$ and $p_s S$ with $\alpha = \beta$ reads

$$\frac{M(t)}{p_s(t)\,S(t)} = \frac{a_M(t)}{p(t)\,a_S} \cdot \frac{\kappa(t)^{\alpha}}{\kappa(t)^{\alpha}} \cdot \frac{\ell(t)}{1-\ell(t)} = \frac{\ell(t)}{1-\ell(t)} \tag{B.32}$$

so that, from (17), the limit as $t \to \infty$ reads

$$\lim_{t\to\infty}\frac{M(t)}{p_s(t)\,S(t)} = \frac{\ell^{ss}}{1-\ell^{ss}} = \frac{\alpha(g^* + \theta)}{\rho - n + (1-\alpha)(g^* + \theta)}. \tag{B.33}$$

**Consumption expenditure shares: proof of result (19)**. From (A.3), the expenditure share of services equals

$$\frac{p_s(t)\,s(t)}{x(t)} = \frac{1}{1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}}. \tag{B.34}$$

Since $p_s(t) = a_M(t)/a_S$ grows indefinitely at constant rate $g_M > 0$, the expenditure share of services $p_s s/x$ grows monotonically over time and eventually reaches unity,

$$\lim_{t\to\infty}\frac{p(t)\,s(t)}{x(t)} = \frac{1}{1+0} = 1.$$

The behavior of the share of manufacturing consumption of total individual consumption expenditures is, by definition, symmetrical: $c/x$ declines monotonically over time

$$\frac{c(t)}{x(t)} = 1 - \frac{p(t)\,s(t)}{x(t)}, \quad \lim_{t\to\infty}\frac{c(t)}{x(t)} = 0.$$

**Consumption and production shares in physical terms.** From (A.2), the ratio between consumed units of manufacturing goods and services is

$$\frac{c(t)}{s(t)} = \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma}. \tag{B.35}$$

From the production functions (10)-(11) and the efficiency conditions (13)-(14), the ratio between $M$ and $p_s S$ with $\alpha = \beta$ reads

$$\frac{M(t)}{S(t)} = \frac{a_M(t)}{a_S} \cdot \frac{\ell(t)}{1-\ell(t)} = p_s(t) \cdot \frac{\ell(t)}{1-\ell(t)}. \tag{B.36}$$

Since $p_s(t) = a_M(t)/a_S$ grows indefinitely at constant rate $g_M > 0$, expressions (B.35) and (B.36) imply that $c/s$ and $M/S$ grow monotonically over time and indefinitely in the long run: in physical terms, both produced and consumed units of the manufactured good grow faster than services

$$\lim_{t\to\infty} \frac{c(t)}{s(t)} = \infty \text{ and } \lim_{t\to\infty} \frac{M(t)}{S(t)} = \infty. \tag{B.37}$$

**Proof of result (20).** Defining the convenient variable

$$\wp(t) \equiv p_s(t) + [\gamma/(1-\gamma)]^\sigma \cdot p_s(t)^\sigma$$

we can rewrite individual expenditures (A.3) as

$$x(t) = \left[p_s(t) + \left(\frac{\gamma}{1-\gamma}\right)^\sigma \cdot p_s(t)^\sigma\right] \cdot s(t) = \wp(t)\,\kappa(t)^\alpha (1-\ell(t)) \tag{B.38}$$

Time-differentiation of (B.38) gives

$$\frac{\dot{x}(t)}{x(t)} = \frac{\dot{\wp}(t)}{\wp(t)} + \alpha\frac{\dot{\kappa}(t)}{\kappa(t)} - \frac{\dot{\ell}(t)}{1-\ell(t)}. \tag{B.39}$$

The growth rate of $\wp(t)$ can be written as

$$\frac{\dot{\wp}(t)}{\wp(t)} = \Gamma(t)\frac{\dot{p}_s(t)}{p_s(t)} \text{ where } \Gamma(t) \equiv \frac{1+\sigma\left(\frac{\gamma}{1-\gamma}\right)^\sigma \cdot p_s(t)^{\sigma-1}}{1+\left(\frac{\gamma}{1-\gamma}\right)^\sigma \cdot p_s(t)^{\sigma-1}} < 1,$$

so that (B.39) becomes

$$\frac{\dot{x}(t)}{x(t)} = \Gamma(t)\frac{\dot{p}_s(t)}{p_s(t)} + \alpha\frac{\dot{\kappa}(t)}{\kappa(t)} - \frac{\dot{\ell}(t)}{1-\ell(t)}. \tag{B.40}$$

Substituting $\dot{p}_s/p_s = g_M$ from (14) and rearranging terms, we obtain

$$\frac{\dot{\ell}(t)}{\ell(t)} = -\frac{1-\ell(t)}{\ell(t)}\left[\frac{\dot{x}(t)}{x(t)} - \alpha\frac{\dot{\kappa}(t)}{\kappa(t)} - g_M\Gamma(t)\right]$$

which, recalling that $g^* = \frac{g_M}{1-\alpha}$, can be further manipulated as

$$\frac{\dot{\ell}(t)}{\ell(t)} = -\frac{1-\ell(t)}{\ell(t)}\left\{(1-\alpha)\left[\frac{\dot{\kappa}(t)}{\kappa(t)} - g^*\Gamma(t)\right] - \left(\frac{\dot{\kappa}(t)}{\kappa(t)} - \frac{\dot{x}(t)}{x(t)}\right)\right\}. \tag{B.41}$$

In the long run, we have

$$\lim_{t\to\infty}\frac{\dot{\kappa}(t)}{\kappa(t)} = \lim_{t\to\infty}\frac{\dot{x}(t)}{x(t)} = g^* \text{ and } \lim_{t\to\infty}\Gamma(t) = 1, \tag{B.42}$$

where the last limit follows from the fact that $\lim_{t\to\infty} p_s(t) = \infty$. Results (B.42) imply that the right hand side of (B.41) converges to zero as $t \to \infty$. What happens during the transition can be inferred as follows. Consider an initial condition whereby the initial augmented capital-labour ratio $\kappa_A(0)$ is strictly below the steady state level, $\kappa_A^{ss}$. In this case, system (B.17)-(B.18) determines the typical equilibrium path of neoclassical models with monotonically declining interest rates during the whole transition. Since the augmented capital-labour ratio $\kappa_A(t)$ grows during the whole transition, the non-augmented capital-labor ratio $\kappa(t)$ grows faster than its asymptotic rate $g^*$ during the whole transition. This implies that the term in square brackets in (B.41) is strictly positive during the whole transition, not least because $\Gamma(t) < 1$. Hence, if $\frac{\dot{\kappa}(t)}{\kappa(t)} - \frac{\dot{x}(t)}{x(t)}$ is negative or is positive but not too large during the whole transition, equation (B.41) predicts $\dot{\ell}(t) < 0$ during the whole transition. If, instead, $\frac{\dot{\kappa}(t)}{\kappa(t)} - \frac{\dot{x}(t)}{x(t)}$ is positive and large in the short run, we may observe $\dot{\ell}(t) > 0$ in the short run, but this sign reversal will disappear as both $\frac{\dot{\kappa}(t)}{\kappa(t)}$ and $\frac{\dot{x}(t)}{x(t)}$ converge to $g^*$. This implies that, along the typical path with growing capital and expenditures (i.e,. monotonically declining interest rates), we will observe $\dot{\ell}(t) < 0$ in each $t \in [t', \infty)$ for some finite $t' \geqslant 0$.

**Proof of Proposition 1**. Result (16) implies $\frac{\partial r_k^{ss}}{\partial \theta} > 0$ and $\frac{\partial r_k^{ss}}{\partial \psi} > 0$. Result (B.22) implies $\frac{\partial}{\partial \theta} \lim_{t\to\infty} \frac{x(t)}{\kappa(t)} > 0$ and $\frac{\partial}{\partial \psi} \lim_{t\to\infty} \frac{x(t)}{\kappa(t)} > 0$. From (8), we can substitute

$$\kappa(t) = (1-\psi)\, q(t)$$

into (B.22) to obtain

$$\lim_{t\to\infty} \left(\frac{x(t)}{q(t)}\right) = \frac{\rho - n + (1-\alpha)(g^* + \theta)}{\alpha} \tag{B.43}$$

which implies $\frac{\partial}{\partial \theta} \lim_{t\to\infty} \frac{x(t)}{q(t)} > 0$ and $\frac{\partial}{\partial \psi} \lim_{t\to\infty} \frac{x(t)}{q(t)} = 0$. From (18), we have

$$\frac{\partial}{\partial \theta}\left(\frac{\ell_{ss}}{1-\ell_{ss}}\right) = \frac{\alpha(\rho - n)}{[\rho - n + (1-\alpha)(g^*+\theta)]^2} > 0, \tag{B.44}$$

$$\frac{\partial}{\partial \psi}\left(\frac{\ell_{ss}}{1-\ell_{ss}}\right) = 0, \tag{B.45}$$

which proves $\frac{\partial \ell^{ss}}{\partial \theta} > 0$ and $\frac{\partial \ell^{ss}}{\partial \psi} = 0$.

**Proof of result (21)**. Manufacturing output has two competing uses – i.e., consumption or investment good – and different types of intermediation costs affect the unconsumed fraction of $M$ in different ways. To see this formally, consider the ratio between manufacturing output and aggregate expenditure,

$$\frac{M(t)}{x(t)\,N(t)} = \frac{c(t)}{x(t)} + \frac{1}{x(t)/q(t)} \cdot \left[\frac{\dot{q}(t)}{q(t)} + \theta\right], \tag{B.46}$$

where the right hand side distinguishes between directly consumed manufactured goods (first term) and unconsumed manufactured goods for saving purposes (second term). In the long run, the share of expenditures devoted to manufacturing consumption vanishes, $c(t)/x(t) \to 0$, making unconsumed goods the dominant destination of manufacturing output. Hence, in the long run, $M/(xN)$ coincides with the *sectoral value added ratio*, $M/(pS)$, and expression (B.46) yields

$$\lim_{t\to\infty} \frac{M(t)}{p_s(t)\,S(t)} = \lim_{t\to\infty} \frac{M(t)}{x(t)\,N(t)} = \lim_{t\to\infty} \frac{1}{x(t)/q(t)} \cdot [g^* + \theta]. \tag{B.47}$$

Expression (B.47) shows that an increase in $\theta$ exherts two effects on relative value added. The first (direct) effect is through the term in square brackets, which captures the wealth depletion effect: all else equal, a higher $\theta$ increases the unconsumed fraction of manufacturing output. The second (indirect) effect of $\theta$ is through the spending propensity: as explained above,

$\mathrm{d}(x/q)^{ss}/\mathrm{d}\theta > 0$. It is easy to show that the direct effect of wealth depletion always dominates: from (18), an increase in $\theta$ increases the relative value added of manufacturing production,

$$\frac{\mathrm{d}}{\mathrm{d}\theta}\lim_{t\to\infty}\frac{M(t)}{p_s(t)\,S(t)}=\frac{\mathrm{d}}{\mathrm{d}\theta}\lim_{t\to\infty}\frac{1}{x(t)/q(t)}\cdot[g^*+\theta]>0,$$

and such increase implies a higher employment share in manufacturing in the long run, $\mathrm{d}\ell^{ss}/\mathrm{d}\theta > 0$. By the same reasoning, expression (B.47) implies that funnelling does not modify sectoral employment shares. An increase in $\psi$ does not modify the spending propensity, $\mathrm{d}(x/q)^{ss}/\mathrm{d}\psi = 0$, and does not affect the unconsumed fraction of manufacturing output in the long run. Therefore, following a shock on $\psi$, the sectoral value added ratio and the associated employment shares do not change.

# C Asymmetric Factor Intensities (Model II)

**Interest rates in Model II.** Setting $K_M = K$ in (A.12), the profit-maximizing condition $\partial M/\partial K_M = 0$ becomes

$$r_k(t)=\alpha a_M(t)\,a_\ell(t)^{1-\alpha}\cdot\left(\frac{K(t)}{\ell(t)\,N(t)}\right)^{\alpha-1}=\alpha a_M(t)\,a_\ell(t)^{1-\alpha}(1-\psi)^{\alpha-1}\cdot(q(t)/\ell(t))^{\alpha-1} \tag{C.1}$$

where the last term is obtained by exploiting the saving-investment relationship (8). Therefore, we can write the rate of return to private wealth as a function of the ratio $q/\ell$ at given productivity:

$$r_q(t)=r_k(t)(1-\psi)-\theta=\alpha a_M(t)\,a_\ell(t)^{1-\alpha}(1-\psi)^{\alpha}\cdot(q(t)/\ell(t))^{\alpha-1}-\theta. \tag{C.2}$$

**Derivation of (23).** Setting $K_M = K$ in (A.13), the profit-maximizing condition $\partial M/\partial(\ell N) = 0$ becomes

$$w(t)=(1-\alpha)\,a_M(t)\,a_\ell(t)^{1-\alpha}\left(\frac{K(t)}{\ell(t)\,N(t)}\right)^{\alpha}=(1-\alpha)\,a_M(t)\,a_\ell(t)^{1-\alpha}(1-\psi)^{\alpha}\left(\frac{q(t)}{\ell(t)}\right)^{\alpha} \tag{C.3}$$

where the last term is obtained by exploiting the saving-investment relationship (8). Setting $\beta = 0$ in (A.15), we obtain

$$w(t)=a_S p_s(t) \tag{C.4}$$

Imposing wage equalization between the two sectors, (C.3) and (C.4) yield (23) in the main text.

**Derivation of the expenditure levels (24).** Starting from condition (5), we have

$$\frac{c(t)}{p_s(t)\,s(t)}=\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}.$$

From the expenditure constraint $x = c + p_s s$, we can substitute $c = x - p_s s$ in the above expression to get

$$c(t)=\frac{\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}}{1+\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}}x(t). \tag{C.5}$$

Next, we can re-substitute $c$ with (5) to obtain

$$x(t)=\left[p_s(t)+\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma}\right]\cdot s(t), \tag{C.6}$$

where we can substitute the technology of the service sector (11) in per capita terms and with $\beta = 0$ to obtain

$$x(t) = \left[p_s(t) + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma}\right] \cdot a_S \cdot (1-\ell(t)) \tag{C.7}$$

which is expression (24) in the main text. Note that this implies a sectoral share of labor in services equal to

$$1-\ell(t) = \frac{1}{p_s(t) + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma}} \cdot x(t) \cdot \frac{1}{a_S},$$

so that positive production in services strictly requires

$$0 < \frac{1}{p_s(t) + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma}} \cdot x(t) \cdot \frac{1}{a_S} < 1. \tag{C.8}$$

**Dynamic equations in Model II**. In Model II, the equilibrium path is characterized by the following dynamic system:

$$\dot{q}(t) = a_M a_\ell^{1-\alpha} (1-\psi)^{\alpha} (1-\alpha+\alpha\ell(t)) \cdot \left(\frac{q(t)}{\ell(t)}\right)^{\alpha} - x(t) - \theta q(t) \tag{C.9}$$

$$\frac{\dot{x}(t)}{x(t)} = \alpha a_M a_\ell{}^{1-\alpha} (1-\psi)^{\alpha} \cdot \left(\frac{q(t)}{\ell(t)}\right)^{\alpha-1} - (\rho+\theta-n) \tag{C.10}$$

$$\frac{\dot{\ell}(t)}{\ell(t)} = -\Lambda(t) \cdot \left[\frac{\dot{x}(t)}{x(t)} - \alpha\Gamma(t)\frac{\dot{q}(t)}{q(t)}\right] \tag{C.11}$$

where $\Gamma$ and $\Lambda$ are defined in expression (26). This dynamic system is derived below.

**Derivation of system (C.10)-(C.11)**. From (C.2) and (23), it follows that total factor incomes per capita may be written as

$$r_q(t)q(t) + w(t) = a_M(t)a_\ell(t)^{1-\alpha}(1-\psi)^{\alpha}(1-\alpha+\alpha\ell(t)) \cdot \left(\frac{q(t)}{\ell(t)}\right)^{\alpha} - \theta q(t)$$

so that the household budget constraint (3) becomes

$$\dot{q}(t) = a_M(t)a_\ell(t)^{1-\alpha}(1-\psi)^{\alpha}(1-\alpha+\alpha\ell(t)) \cdot \left(\frac{q(t)}{\ell(t)}\right)^{\alpha} - x(t) - \theta q(t). \tag{C.12}$$

Equation (C.9) directly follows from (C.12) with constant productivity indices, $a_M(t) = a_M$ and $a_\ell(t) = a_\ell$. Next, from the Euler condition (6) and the definition of gross interest rate in (C.2), the growth rate of individual expenditures is

$$\dot{x}(t) = x(t) \cdot \left[\alpha a_M(t)a_\ell(t)^{1-\alpha}(1-\psi)^{\alpha} \cdot \left(\frac{q(t)}{\ell(t)}\right)^{\alpha-1} - (\rho+\theta-n)\right]. \tag{C.13}$$

Equation (C.10) directly follows from (C.13) after setting $a_M(t) = a_M$ and $a_\ell(t) = a_\ell$. Similarly, setting constant productivity indices in (23), we have

$$p_s(t) = (1-\alpha) \cdot \frac{a_M(t)a_\ell(t)^{1-\alpha}}{a_S} \cdot (1-\psi)^{\alpha}\left(\frac{q(t)}{\ell(t)}\right)^{\alpha}. \tag{C.14}$$

In order to derive (C.11), define the convenient variable

$$\wp(t) \equiv p_s(t) + [\gamma/(1-\gamma)]^{\sigma} \cdot p_s(t)^{\sigma} \tag{C.15}$$

and rewrite equation (24) as

$$x(t) = \wp(t) \cdot a_S \cdot (1 - \ell(t)). \tag{C.16}$$

Time-differentiation of (C.16) yields

$$\frac{\dot{\ell}(t)}{1-\ell(t)} = \frac{\dot{\wp}(t)}{\wp(t)} - \frac{\dot{x}(t)}{x(t)} \tag{C.17}$$

where the growth rate of $\wp$ from (C.15) is

$$\frac{\dot{\wp}(t)}{\wp(t)} = \frac{\dot{p}_s(t)}{p_s(t)} \cdot \frac{p_s(t) + \sigma [\gamma/(1-\gamma)]^{\sigma} \cdot p_s(t)^{\sigma}}{p_s(t) + [\gamma/(1-\gamma)]^{\sigma} \cdot p_s(t)^{\sigma}} \tag{C.18}$$

and the growth rate of $p_s$ from (C.14) with $a_M(t) = a_M$ and $a_\ell(t) = a_\ell$ is

$$\frac{\dot{p}_s(t)}{p_s(t)} = \alpha \cdot \left( \frac{\dot{q}(t)}{q(t)} - \frac{\dot{\ell}(t)}{\ell(t)} \right). \tag{C.19}$$

Plugging (C.19) in (C.18), and the resulting expression back into (C.17), we obtain

$$\frac{\dot{\ell}(t)}{1-\ell(t)} = \alpha \cdot \left( \frac{\dot{q}(t)}{q(t)} - \frac{\dot{\ell}(t)}{\ell(t)} \right) \cdot \frac{p_s(t) + \sigma [\gamma/(1-\gamma)]^{\sigma} \cdot p_s(t)^{\sigma}}{p_s(t) + [\gamma/(1-\gamma)]^{\sigma} \cdot p_s(t)^{\sigma}} - \frac{\dot{x}(t)}{x(t)}. \tag{C.20}$$

Defining the convenient variable

$$\Gamma(t) \equiv \frac{1 + \sigma \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}}{1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}} < 1 \tag{C.21}$$

we can rearrange terms in (C.20) to isolate $\dot{\ell}(t)$, obtaining

$$\frac{\dot{\ell}(t)}{\ell(t)} = \frac{1-\ell(t)}{\ell(t) + \alpha(1-\ell(t))\Gamma(t)} \left[ \alpha \cdot \Gamma(t) \cdot \frac{\dot{q}(t)}{q(t)} - \frac{\dot{x}(t)}{x(t)} \right]. \tag{C.22}$$

Defining the convenient variable

$$\Lambda(t) \equiv \frac{1-\ell(t)}{\ell(t) + \alpha\Gamma(t)(1-\ell(t))} > 1$$

we obtain equation (C.11). For future reference, we define the *expenditure to assets ratio* as

$$\tau(t) \equiv \frac{x(t)}{q(t)} \tag{C.23}$$

and derive its growth rate from (C.10)-(C.9) as

$$\frac{\dot{\tau}(t)}{\tau(t)} = \tau(t) - a_S \frac{p_s(t)}{q(t)} - (\rho - n). \tag{C.24}$$

**Steady State: existence, uniqueness and derivation of (27)-(30)**. The limiting conditions applying to the gross rate of return

$$\begin{aligned}\lim_{(q/\ell)\to 0} \alpha a_M {a_\ell}^{1-\alpha} (1-\psi)^\alpha \cdot (q/\ell)^{\alpha-1} &= +\infty,\\ \lim_{(q/\ell)\to +\infty} \alpha a_M {a_\ell}^{1-\alpha} (1-\psi)^\alpha \cdot (q/\ell)^{\alpha-1} &= 0,\end{aligned}$$

imply that, setting $\dot{x}=0$ in equation (C.10), there exists a unique steady-state locus $x=x^{ss}$ characterized by the condition

$$\dot{x}(t)=0 \to q(t)/\ell(t) = \left[\frac{\alpha a_M a_\ell^{1-\alpha}(1-\psi)^\alpha}{\rho+\theta-n}\right]^{\frac{1}{1-\alpha}} \tag{C.25}$$

which in turn implies a stationary price of services from (C.14), that is,

$$\dot{x}(t)=0 \to p_s(t) = (1-\alpha)(a_M/a_S)\, {a_\ell}^{1-\alpha}(1-\psi)^\alpha \cdot (q(t)/\ell(t))^\alpha = p_s^{ss}. \tag{C.26}$$

The constant $q(t)/\ell(t)$ ratio in (C.25) combined with $\dot{x}(t)=0$ imply $\dot{\ell}(t)=\dot{q}(t)=0$ to satisfy (C.11), so that the condition $\dot{x}(t)=0$ triggers a simultaneous steady state where $(x(t), q(t), \ell(t))$ are all constant and equal to stationary values $(x^{ss}, q^{ss}, \ell^{ss})$. The stationary value for the $q^{ss}/\ell^{ss}$ ratio shown in (27) follows from (C.25). The stationary value for $x=x^{ss}$ shown in (28) follows directly from setting $\dot{q}=0$ in (C.9). The stationary value for $\ell=\ell^{ss}$ follows from equation (24).

**Proof of Proposition 2 (preliminaries)**. For future reference, let us define the ratio $q/\ell$ as

$$\Phi(t) \equiv \frac{q(t)}{\ell(t)}, \tag{C.27}$$

the composite parameter for productivity indices

$$\bar{a} \equiv a_M {a_\ell}^{1-\alpha}(1-\psi)^\alpha, \tag{C.28}$$

and the price-share function

$$\wp(t) \equiv \left[p_s(t) + \left(\frac{\gamma}{1-\gamma}\right)^\sigma (p_s(t))^\sigma\right]. \tag{C.29}$$

From (23), the price of services is a strictly increasing, concave function of the ratio $q/\ell$. Therefore, in each instant $t$, the following equilibrium relationships hold:

$$\begin{aligned} p_s &= p_s(\Phi) \equiv \frac{1-\alpha}{a_S}\cdot \bar{a}\cdot \Phi^\alpha, && \text{(C.30)}\\ \frac{\partial p_s(\Phi)}{\partial \Phi} &= \alpha\frac{1-\alpha}{a_S}\cdot\bar{a}\cdot\Phi^{\alpha-1} = \frac{\alpha}{\Phi}p_s(\Phi) > 0. && \text{(C.31)}\end{aligned}$$

From (C.27)-(C.29), we can rewrite the steady-state system (27)-(30) as

$$\begin{aligned} \frac{q^{ss}}{\ell^{ss}} &= \left[\frac{\alpha\bar{a}}{\rho+\theta-n}\right]^{\frac{1}{1-\alpha}} \equiv \Phi^{ss} && \text{(C.32)}\\ p_s^{ss} &= \frac{1-\alpha}{a_S}\bar{a}\cdot(\Phi^{ss})^\alpha && \text{(C.33)}\\ x^{ss} &= \wp^{ss}\cdot a_S\cdot(1-\ell^{ss}) && \text{(C.34)}\\ x^{ss} &= a_S\frac{1-\alpha(1-\ell^{ss})}{1-\alpha}\cdot p_s^{ss} - \theta q^{ss} && \text{(C.35)}\end{aligned}$$

The remainder of the proof considers the effects of $\theta$ and $\psi$ separately.

**Proof of Proposition 2 (effects of $\theta$).** This part of the proof of Proposition 2 derives the expressions appearing in (32). From (C.32), an *increase in $\theta$ reduces the ratio $q/\ell$ in the steady state.*

$$\frac{\mathrm{d}}{\mathrm{d}\theta}\left(\frac{q^{ss}}{\ell^{ss}}\right)=\frac{\mathrm{d}\Phi^{ss}}{\mathrm{d}\theta}\equiv\Phi_\theta^{ss}=-\frac{1}{1-\alpha}\frac{1}{\rho+\theta-n}\Phi^{ss}<0, \tag{C.36}$$

where the elasticity of $\Phi^{ss}$ with respect to $\theta$ is given by

$$\frac{\Phi_\theta^{ss}}{\Phi^{ss}}=-\frac{1}{1-\alpha}\frac{1}{\rho+\theta-n}<-1. \tag{C.37}$$

Total differentiation of (C.32) with respect to $\theta$ yields

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}=\Phi_\theta^{ss}\cdot\ell^{ss}+\Phi^{ss}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}=\frac{\Phi_\theta^{ss}}{\Phi^{ss}}\cdot q^{ss}+\Phi^{ss}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} \tag{C.38}$$

Next, total differentiation of (C.33) with respect to $\theta$ yields

$$\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}=\frac{1-\alpha}{a_S}\bar{a}\cdot\alpha\cdot(\Phi^{ss})^{\alpha-1}\cdot\Phi_\theta^{ss}<0, \tag{C.39}$$

that is, using result (C.37),

$$\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}=p_s^{ss}\cdot\alpha\cdot\frac{\Phi_\theta^{ss}}{\Phi^{ss}}=-\frac{\alpha\theta}{1-\alpha}\cdot\frac{1}{\rho+\theta-n}\cdot\frac{p_s^{ss}}{\theta}<0. \tag{C.40}$$

Expressions (C.39)-(C.40) prove that an *increase in $\theta$ reduces the price of services $p_s^{ss}$ in the steady state.* Next, total differentiation of (C.34) and (C.35) with respect to $\theta$ yields, respectively,

$$\frac{\mathrm{d}x^{ss}}{\mathrm{d}\theta}=\frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\theta}\cdot a_S\cdot(1-\ell^{ss})-\wp^{ss}\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} \tag{C.41}$$

and

$$\frac{\mathrm{d}x^{ss}}{\mathrm{d}\theta}=a_S\frac{1-\alpha(1-\ell^{ss})}{1-\alpha}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}+a_S\frac{\alpha}{1-\alpha}p_s^{ss}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}-q^{ss}-\theta\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta} \tag{C.42}$$

Combining (C.41)-(C.42) to eliminate $x_{ss}$ yields,

$$\left(\frac{\alpha}{1-\alpha}p_s^{ss}+\wp^{ss}\right)\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}=\frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\theta}\cdot a_S\cdot(1-\ell^{ss})-a_S\frac{1-\alpha(1-\ell^{ss})}{1-\alpha}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}+q^{ss}+\theta\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}. \tag{C.43}$$

In order to simplify the right hand side of (C.43), note that (C.29) implies

$$\frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\theta}=\frac{\partial\wp^{ss}}{\partial p_s^{ss}}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}=\left[1+\sigma\left(\frac{\gamma}{1-\gamma}\right)^\sigma(p_s^{ss})^{\sigma-1}\right]\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}. \tag{C.44}$$

Substituting (C.44) as well as $x_{ss}$ from (C.34) into (C.43), we have

$$\left(\frac{\alpha}{1-\alpha}p_s^{ss}+\wp^{ss}\right)\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}=\frac{x^{ss}}{p_s^{ss}}\cdot\underbrace{\frac{1+\sigma\left(\frac{\gamma}{1-\gamma}\right)^\sigma(p_s^{ss})^{\sigma-1}}{1+\left(\frac{\gamma}{1-\gamma}\right)^\sigma(p_s^{ss})^{\sigma-1}}}_{\Gamma^{ss}}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}-a_S\frac{1-\alpha(1-\ell^{ss})}{1-\alpha}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}+q^{ss}+\theta\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}. \tag{C.45}$$

Further substituting $x_{ss}$ from (C.35), and rearranging terms, yields

$$\left(\frac{\alpha}{1-\alpha}p_s^{ss}+\wp^{ss}\right)\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}=-\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}\cdot(1-\Gamma^{ss})\cdot\frac{x^{ss}}{p_s^{ss}}+q^{ss}\left\{1+\theta\left[\frac{1}{q^{ss}}\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}-\frac{1}{p_s^{ss}}\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}\right]\right\}. \tag{C.46}$$

From (C.38), (C.40) and (C.37), we know that

$$\frac{1}{q^{ss}}\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta} = -\frac{1}{1-\alpha}\frac{1}{\rho+\theta-n}+\frac{1}{\ell^{ss}}\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} \tag{C.47}$$

$$\frac{1}{p_s^{ss}}\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta} = -\frac{\alpha}{1-\alpha}\cdot\frac{1}{\rho+\theta-n} \tag{C.48}$$

so that

$$\frac{1}{q^{ss}}\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}-\frac{1}{p_s^{ss}}\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}=\frac{1}{\ell^{ss}}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}-\frac{1}{\rho+\theta-n} \tag{C.49}$$

From (C.49), the last term in curly brackets in (C.46) equals

$$\left\{1+\theta\left[\frac{1}{q^{ss}}\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}-\frac{1}{p_s^{ss}}\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}\right]\right\}=\frac{\rho-n}{\rho-n+\theta}+\theta\frac{1}{\ell^{ss}}\frac{\mathrm{d}\ell_{ss}^{ss}}{\mathrm{d}\theta}. \tag{C.50}$$

Plugging (C.50) into (C.46), and rearranging terms to isolate $\mathrm{d}\ell^{ss}$, we obtain

$$\left\{\left(\frac{\alpha}{1-\alpha}p_s^{ss}+\wp^{ss}\right)\cdot a_S-\theta\frac{q^{ss}}{\ell_{ss}}\right\}\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}=\underbrace{-\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}\cdot(1-\Gamma^{ss})\cdot\frac{x^{ss}}{p_s^{ss}}+q^{ss}\frac{\rho-n}{\rho-n+\theta}}_{>0} \tag{C.51}$$

where the right hand side is strictly positive due to $\Gamma^{ss}<1$ and to $\mathrm{d}p_s^{ss}/\mathrm{d}\theta<0$ as established in (C.40). Next, from (C.34) and (C.35), we have

$$\frac{\alpha}{1-\alpha}p_s^{ss}\cdot a_S = \frac{\alpha\left(x^{ss}+\theta q^{ss}\right)}{1-\alpha\left(1-\ell^{ss}\right)}, \tag{C.52}$$

$$\wp^{ss}\cdot a_S = \frac{x^{ss}}{1-\ell^{ss}}, \tag{C.53}$$

which implies

$$\begin{aligned}\left\{\left(\frac{\alpha}{1-\alpha}p_s^{ss}+\wp^{ss}\right)\cdot a_S-\theta\frac{q^{ss}}{\ell_{ss}}\right\} &= \frac{\alpha\left(x^{ss}+\theta q^{ss}\right)}{1-\alpha\left(1-\ell^{ss}\right)}+\frac{x^{ss}}{1-\ell^{ss}}-\theta\frac{q^{ss}}{\ell^{ss}}= \\ &= \frac{\ell^{ss}x^{ss}-\theta q^{ss}\left(1-\alpha\right)\left(1-\ell^{ss}\right)}{\left(1-\ell^{ss}\right)\left[1-\alpha\left(1-\ell^{ss}\right)\right]\ell^{ss}}.\end{aligned} \tag{C.54}$$

We can thus substitute (C.54) in the left hand side of (C.51), to obtain

$$\frac{\ell^{ss}x^{ss}-\theta q^{ss}\left(1-\alpha\right)\left(1-\ell^{ss}\right)}{\left(1-\ell^{ss}\right)\left[1-\alpha\left(1-\ell^{ss}\right)\right]\ell^{ss}}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}=\underbrace{-\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}\cdot\left[1-\Gamma^{ss}\right]\cdot\frac{x^{ss}}{p_s^{ss}}+q^{ss}\frac{\rho-n}{\rho-n+\theta}}_{>0} \tag{C.55}$$

From (C.55), the sign of $\frac{\mathrm{d}\ell_{ss}}{\mathrm{d}\theta}$ is determined by the sign of $\ell^{ss}x^{ss}-\theta q^{ss}\left(1-\alpha\right)\left(1-\ell^{ss}\right)$. We now prove that the crucial term is always positive, that is:

**Lemma 5** *In the steady state of Model II, the following strict inequality holds*

$$\ell^{ss}x^{ss}-q^{ss}\theta\left(1-\alpha\right)\left(1-\ell^{ss}\right)>0. \tag{C.56}$$

*Proof: From the stationarity condition on interest rates (31), we have*

$$\alpha\bar{a}\cdot\left(\Phi^{ss}\right)^{\alpha-1}=\rho-n+\theta, \tag{C.57}$$

*and, from (C.33) and (C.35), long-run expenditure equals*

$$x^{ss} = \left[1 - \alpha\left(1 - \ell^{ss}\right)\right] \cdot \bar{a} \cdot \left(\Phi^{ss}\right)^{\alpha} - \theta q^{ss}. \tag{C.58}$$

*Combining (C.57) and (C.58), we have*

$$x^{ss} = \left[1 - \alpha\left(1 - \ell^{ss}\right)\right] \cdot \frac{\rho - n + \theta}{\alpha} \Phi^{ss} - \theta q^{ss} \tag{C.59}$$

*so that inequality (C.56) reduces to*

$$\theta + \rho - n > \alpha\theta,$$

*which is always true since* $\alpha < 1$ *and* $\rho - n > 0$. *Q.E.D.*

Going back to expression (C.55), result (C.56) implies that an *increase in* $\theta$ *increases the employment share of the manufacturing sector in the steady state*:

$$\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} = \frac{-\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta} \cdot \left(1 - \Gamma^{ss}\right) \cdot \frac{x^{ss}}{p_s^{ss}} + q^{ss} \frac{\rho - n}{\rho - n + \theta}}{\frac{\ell^{ss} x^{ss} - \theta q^{ss}(1-\alpha)(1-\ell^{ss})}{(1-\ell^{ss})[1-\alpha(1-\ell^{ss})]\ell^{ss}}} > 0. \tag{C.60}$$

Using result (C.60), expression (C.41) yields

$$\frac{\mathrm{d}x^{ss}}{\mathrm{d}\theta} = \frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\theta} \cdot a_S \cdot \left(1 - \ell^{ss}\right) - \wp^{ss} \cdot a_S \cdot \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} < 0, \tag{C.61}$$

where $\mathrm{d}\wp^{ss}/\mathrm{d}\theta < 0$ due to the fact that $\wp^{ss}$ is strictly increasing in $p_s^{ss}$, and we have already established that $\mathrm{d}p_s^{ss}/\mathrm{d}\theta < 0$. Therefore, an *increase in* $\theta$ *increases individual expenditure in the steady state*. The last step of this part of Proposition 2 determines the effect of $\theta$ on $q^{ss}$. Consider the expenditure-wealth ratio, $\tau \equiv x/q$, in the steady state. Imposing the condition $\dot{\tau}(t) = 0$ in (C.24) gives

$$\frac{x^{ss}}{q^{ss}} = \tau^{ss} = a_S \frac{p_s^{ss}}{q^{ss}} + \rho - n, \tag{C.62}$$

which implies

$$q^{ss} = \frac{x^{ss} - a_S p_s^{ss}}{\rho - n}. \tag{C.63}$$

Using (C.34) to substitute $x^{ss}$ in (C.63), we obtain

$$q^{ss} = a_S \frac{\left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \left(p_s^{ss}\right)^{\sigma} \left(1 - \ell^{ss}\right) - \ell^{ss} p_s^{ss}}{\rho - n}. \tag{C.64}$$

Totally differentiating (C.64) yields

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta} = \frac{a_S}{\rho - n} \left[\left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \frac{\mathrm{d}\left(p_s^{ss}\right)^{\sigma}\left(1 - \ell^{ss}\right)}{\mathrm{d}\theta} - \frac{\mathrm{d}\ell^{ss} p_s^{ss}}{\mathrm{d}\theta}\right]. \tag{C.65}$$

From our previous results (C.38) and (C.40), we have

$$\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta} \frac{\theta}{p_s^{ss}} = \alpha\theta \frac{\Phi_\theta^{ss}}{\Phi^{ss}} \text{ and } \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} \frac{\theta}{\ell^{ss}} = \frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta} \frac{\theta}{q^{ss}} - \theta \frac{\Phi_\theta^{ss}}{\Phi^{ss}}. \tag{C.66}$$

Therefore,

$$\frac{\mathrm{d}\ell^{ss} p_s^{ss}}{\mathrm{d}\theta} \frac{\theta}{\ell^{ss} p_s^{ss}} = \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta} \frac{\theta}{\ell^{ss}} + \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta} \frac{\theta}{p_s^{ss}} = \frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta} \frac{\theta}{q^{ss}} - \theta\left(1 - \alpha\right) \frac{\Phi_\theta^{ss}}{\Phi^{ss}}. \tag{C.67}$$

Substituting (C.67) into the last term in (C.65), and rearraning the resulting expression to isolate $\mathrm{d}q^{ss}/\mathrm{d}\theta$, we have

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}=\frac{a_S q^{ss}}{(\rho-n)\,q^{ss}+\theta a_S}\left[\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\frac{\mathrm{d}\,(p_s^{ss})^{\sigma}\,(1-\ell^{ss})}{\mathrm{d}\theta}+\theta\,(1-\alpha)\,\frac{\Phi_{\theta}^{ss}}{\Phi^{ss}}\right]. \tag{C.68}$$

Our previous results $\mathrm{d}p_s^{ss}/\mathrm{d}\theta<0$, $\mathrm{d}\ell^{ss}/\mathrm{d}\theta>0$ and $\Phi_{\theta}^{ss}=\mathrm{d}\Phi^{ss}/\mathrm{d}\theta<0$ imply that the term in square brackets in (C.68) is strictly negative. Therefore, an *increase in $\theta$ reduces financial assets per capita in the steady state,* $\mathrm{d}q^{ss}/\mathrm{d}\theta<0$. This completes the proof of all the expressions appearing in (32), i.e.,

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta}<0\qquad\frac{\mathrm{d}x^{ss}}{\mathrm{d}\theta}<0\qquad\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\theta}>0\qquad\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta}<0\qquad\frac{\mathrm{d}w^{ss}}{\mathrm{d}\theta}<0$$

where the last expression follows from the linear relationship (23) between $p_s^{ss}$ and $w^{ss}$.

**Proof of Proposition 2 (effects of $\psi$).** This part of the proof of Proposition 2 derives the expressions appearing in (33). From (C.32) and (C.28), we have

$$\Phi^{ss}=\left[\frac{\alpha\bar{a}}{\rho+\theta-n}\right]^{\frac{1}{1-\alpha}},\quad\bar{a}\equiv a_M a_{\ell}{}^{1-\alpha}\,(1-\psi)^{\alpha}. \tag{C.69}$$

Therefore, an *increase in $\psi$ reduces the ratio $q/\ell$ in the steady state,*

$$\frac{\mathrm{d}}{\mathrm{d}\psi}\left(\frac{q^{ss}}{\ell^{ss}}\right)=\frac{\mathrm{d}\Phi^{ss}}{\mathrm{d}\psi}\equiv\Phi_{\psi}^{ss}=-\frac{\alpha}{(1-\alpha)\,(1-\psi)}\Phi^{ss}<0. \tag{C.70}$$

Total differentiation of (C.32) with respect to $\psi$ yields

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi}=\Phi_{\psi}^{ss}\cdot\ell^{ss}+\Phi^{ss}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi}=\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}}\cdot q^{ss}+\Phi^{ss}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} \tag{C.71}$$

Next, total differentiation of (C.33) with respect to $\psi$ yields

$$\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}=\frac{1-\alpha}{a_S}\bar{a}\frac{\mathrm{d}\Phi^{\alpha}}{\mathrm{d}\psi}=\alpha p_s^{ss}\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}}<0$$

that is,

$$\frac{1}{p_s^{ss}}\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}=\alpha\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}}=-\frac{\alpha^2}{(1-\alpha)\,(1-\psi)}<0. \tag{C.72}$$

Expression (C.72) prove that an *increase in $\psi$ reduces the price of services $p_s^{ss}$ in the steady state.* Next, total differentiation of (C.34) and (C.35) with respect to $\psi$ yields, respectively,

$$\frac{\mathrm{d}x^{ss}}{\mathrm{d}\psi}=\frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\psi}\cdot a_S\cdot(1-\ell^{ss})-\wp^{ss}\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} \tag{C.73}$$

and

$$\frac{\mathrm{d}x^{ss}}{\mathrm{d}\psi}=a_S\frac{1-\alpha\,(1-\ell^{ss})}{1-\alpha}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}+a_S\frac{\alpha}{1-\alpha}p_s^{ss}\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi}-\theta\frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi} \tag{C.74}$$

Combining (C.73)-(C.74) to eliminate $x_{ss}$ yields,

$$\left(\frac{\alpha}{1-\alpha}p_s^{ss}+\wp^{ss}\right)\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi}=\frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\psi}\cdot a_S\cdot(1-\ell^{ss})-a_S\frac{1-\alpha\,(1-\ell^{ss})}{1-\alpha}\cdot\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}+\theta\frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi}. \tag{C.75}$$

In order to simplify the right hand side of (C.75), note that (C.29) implies

$$\frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\psi} = \frac{\partial \wp^{ss}}{\partial p_s^{ss}} \cdot \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} = \left[1 + \sigma \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} (p_s^{ss})^{\sigma-1}\right] \cdot \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}. \tag{C.76}$$

Substituting (C.76) as well as $x_{ss}$ from (C.34) into (C.75), we have

$$\left(\frac{\alpha}{1-\alpha} p_s^{ss} + \wp^{ss}\right) \cdot a_S \cdot \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} = \frac{x^{ss}}{p_s^{ss}} \Gamma^{ss} \cdot \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} - a_S \frac{1-\alpha\,(1-\ell^{ss})}{1-\alpha} \cdot \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} + \theta \frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi}. \tag{C.77}$$

Further substituting $x_{ss}$ from (C.35), and rearranging terms, yields

$$\left(\frac{\alpha}{1-\alpha} p_s^{ss} + \wp^{ss}\right) \cdot a_S \cdot \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} = -\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} \cdot (1-\Gamma^{ss}) \cdot \frac{x^{ss}}{p_s^{ss}} + \theta q^{ss} \left[\frac{1}{q^{ss}} \frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi} - \frac{1}{p_s^{ss}} \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}\right]. \tag{C.78}$$

From (C.71) and (C.72), we have

$$\frac{1}{q^{ss}} \frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi} = -\frac{\alpha}{(1-\alpha)(1-\psi)} + \frac{1}{\ell^{ss}} \cdot \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} \tag{C.79}$$

$$\frac{1}{p_s^{ss}} \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} = -\frac{\alpha^2}{(1-\alpha)(1-\psi)} \tag{C.80}$$

so that

$$\frac{1}{q^{ss}} \frac{\mathrm{d}q^{ss}}{\mathrm{d}\theta} - \frac{1}{p_s^{ss}} \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\theta} = \frac{1}{\ell^{ss}} \cdot \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} - \frac{\alpha}{1-\psi} \tag{C.81}$$

Plugging (C.81) into (C.78), and rearranging terms to isolate $\mathrm{d}\ell^{ss}$, we obtain

$$\left\{\left(\frac{\alpha}{1-\alpha} p_s^{ss} + \wp^{ss}\right) \cdot a_S - \theta \frac{q^{ss}}{\ell_{ss}}\right\} \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} = -\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} \frac{1}{p_s^{ss}} (1-\Gamma^{ss})\, x^{ss} - \frac{\alpha}{1-\psi} \theta q^{ss},$$

where we can substitute $\mathrm{d}p_s^{ss}/\mathrm{d}\psi$ by means of (C.80) to obtain

$$\underbrace{\left\{\left(\frac{\alpha}{1-\alpha} p_s^{ss} + \wp^{ss}\right) \cdot a_S - \theta \frac{q^{ss}}{\ell_{ss}}\right\}}_{>0} \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} = \frac{\alpha\left[\alpha\,(1-\Gamma^{ss})\, x^{ss} - \theta\,(1-\alpha)\, q^{ss}\right]}{(1-\psi)(1-\alpha)}. \tag{C.82}$$

In (C.82), the term in curly brackets in the left hand side is strictly positive as proved in Lemma 5. Therefore, if the right hand side of (C.82) is strictly positive, we have $\mathrm{d}\ell^{ss}/\mathrm{d}\psi > 0$. The necessary and sufficient condition for $\mathrm{d}\ell^{ss}/\mathrm{d}\psi > 0$ is derived in the following:

**Lemma 6** *In (C.82), $d\ell^{ss}/d\psi > 0$ holds if and only if*

$$\rho - n > \theta\,(1-\alpha) \cdot \frac{\ell^{ss} - (1-\Gamma^{ss})}{\ell^{ss} + (1-\Gamma^{ss})(1-\alpha)} \tag{C.83}$$

*Proof: From (C.82), $d\ell^{ss}/d\psi > 0$ holds if and only if the term in square brackets in the right hand side is strictly positive, that is, iff*

$$\frac{x^{ss}}{q^{ss}} > \frac{\theta\,(1-\alpha)}{\alpha\,(1-\Gamma^{ss})}. \tag{C.84}$$

*Substituting $x^{ss} = a_S p_s^{ss} + q^{ss}(\rho - n)$ from (C.62) and rearranging terms, (C.84) becomes*

$$\frac{a_S p_s^{ss}}{q^{ss}} > \frac{\theta\,(1-\alpha) - (\rho - n)}{\alpha\,(1-\Gamma^{ss})} \tag{C.85}$$

*where we can substitute $a_S p_s^{ss} = (1-\alpha)\,\bar{a} \cdot (\Phi^{ss})^{\alpha}$ from (C.33) and $\bar{a} \cdot (\Phi^{ss})^{\alpha-1} = \frac{\rho-n+\theta}{\alpha}$ from (31) to obtain*

$$\frac{(1-\alpha)(\rho - n + \theta)}{\alpha \ell^{ss}} > \frac{\theta\,(1-\alpha) - (\rho - n)}{\alpha\,(1-\Gamma^{ss})},$$

*which can be rearranged as (C.83). Q.E.D.*

Condition (C.83) is satisfied by any parametrization in which $\rho - n > \theta(1-\alpha)$ holds as well as by any parametrization in which $\ell^{ss} < 1 - \Gamma^{ss}$. Moreover, we have obtained $\mathrm{d}\ell^{ss}/\mathrm{d}\psi > 0$ in all the numerical simulations that we have attempted, including those where $\rho - n < \theta(1-\alpha)$. These results suggests that (C.83) generally holds at least for the vast majority (if not all) parametrizations. We will thus proceed under the hypothesis that (C.83) is satisfied, so that from (C.82), an *increase in* $\psi$ *increases the employment share of the manufacturing sector in the steady state*:

$$\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} = \frac{\alpha\left[\alpha\left(1-\Gamma^{ss}\right)x^{ss} - \theta\left(1-\alpha\right)q^{ss}\right]}{\left(1-\psi\right)\left(1-\alpha\right)\left[\left(\frac{\alpha}{1-\alpha}p_s^{ss} + \wp^{ss}\right)\cdot a_S - \theta\frac{q^{ss}}{\ell_{ss}}\right]} > 0. \tag{C.86}$$

Using (C.86), expression (C.73) yields

$$\frac{\mathrm{d}x^{ss}}{\mathrm{d}\psi} = \frac{\mathrm{d}\wp^{ss}}{\mathrm{d}\psi}\cdot a_S\cdot\left(1-\ell^{ss}\right) - \wp^{ss}\cdot a_S\cdot\frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} < 0, \tag{C.87}$$

where $\mathrm{d}\wp^{ss}/\mathrm{d}\psi < 0$ due to the fact that $\wp^{ss}$ is strictly increasing in $p_s^{ss}$, and we have already established that $\mathrm{d}p_s^{ss}/\mathrm{d}\psi < 0$. Therefore, an *increase in* $\psi$ *increases individual expenditure in the steady state*. The last step of this part of Proposition 2 determines the effect of $\psi$ on $q^{ss}$. Consider the expenditure-wealth ratio, $\tau \equiv x/q$, in the steady state. Totally differentiating (C.64) with respect to $\psi$ yields

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi} = \frac{a_S}{\rho - n}\left[\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\frac{\mathrm{d}\left(p_s^{ss}\right)^{\sigma}\left(1-\ell^{ss}\right)}{\mathrm{d}\psi} - \frac{\mathrm{d}\ell^{ss}p_s^{ss}}{\mathrm{d}\psi}\right]. \tag{C.88}$$

From our previous results (C.71) and (C.72), we have

$$\frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}\frac{\psi}{p_s^{ss}} = \alpha\psi\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}} \text{ and } \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi}\frac{\psi}{\ell^{ss}} = \frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi}\frac{\psi}{q^{ss}} - \psi\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}},$$

so that

$$\frac{\mathrm{d}\ell^{ss}p_s^{ss}}{\mathrm{d}\psi}\frac{\psi}{\ell^{ss}p_s^{ss}} = \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi}\frac{\psi}{\ell^{ss}} + \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi}\frac{\psi}{p_s^{ss}} = \frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi}\frac{\psi}{q^{ss}} - \psi\left(1-\alpha\right)\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}}. \tag{C.89}$$

Substituting (C.89) into the last term in (C.88), and rearraning the resulting expression to isolate $\mathrm{d}q^{ss}/\mathrm{d}\psi$, we have

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi} = \frac{a_S q^{ss}}{\left(\rho-n\right)q^{ss} + \psi a_S}\left[\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\frac{\mathrm{d}\left(p_s^{ss}\right)^{\sigma}\left(1-\ell^{ss}\right)}{\mathrm{d}\psi} + \psi\left(1-\alpha\right)\frac{\Phi_{\psi}^{ss}}{\Phi^{ss}}\right]. \tag{C.90}$$

Our previous results $\mathrm{d}p_s^{ss}/\mathrm{d}\psi < 0$, $\mathrm{d}\ell^{ss}/\mathrm{d}\psi > 0$ and $\Phi_{\psi}^{ss} = \mathrm{d}\Phi^{ss}/\mathrm{d}\psi < 0$ imply that the term in square brackets in (C.90) is strictly negative. Therefore, an *increase in* $\psi$ *reduces financial assets per capita in the steady state,* $\mathrm{d}q^{ss}/\mathrm{d}\psi < 0$. This completes the proof of all the expressions appearing in (33), i.e.,

$$\frac{\mathrm{d}q^{ss}}{\mathrm{d}\psi} < 0 \qquad \frac{\mathrm{d}x^{ss}}{\mathrm{d}\psi} < 0 \qquad \frac{\mathrm{d}\ell^{ss}}{\mathrm{d}\psi} > 0 \qquad \frac{\mathrm{d}p_s^{ss}}{\mathrm{d}\psi} < 0,$$

under condition (C.83).

**Proof of Proposition 3**. Assume that $\dot{q}(t) > 0$ and $\dot{x}(t) > 0$ in each $t \in [0,\infty)$. From (C.11), the growth rate of the ratio $q/\ell = \Phi$ is given by

$$\frac{\dot{\Phi}(t)}{\Phi(t)} = \frac{\dot{q}(t)}{q(t)} - \frac{\dot{\ell}(t)}{\ell(t)} = \Lambda(t)\frac{\dot{x}(t)}{x(t)} + \left(1 - \alpha\Gamma(t)\Lambda(t)\right)\frac{\dot{q}(t)}{q(t)}. \tag{C.91}$$

From definitions (26), we have

$$1-\alpha\Gamma(t)\Lambda(t)=1-\frac{\alpha\Gamma(t)(1-\ell(t))}{\ell(t)+\alpha\Gamma(t)(1-\ell(t))}>0. \tag{C.92}$$

From (C.91) and (C.92), it follows that $\dot{q}(t)>0$ and $\dot{x}(t)>0$ in each $t\in[0,\infty)$ imply

$$\dot{\Phi}(t)>0 \text{ in each } t\in[0,\infty). \tag{C.93}$$

From (23), both $w(t)$ and $p_s(t)$ are strictly increasing functions of $q(t)/\ell(t)=\Phi(t)$. Therefore, result (C.93) implies

$$\dot{w}(t)>0 \text{ and } \dot{p}_s(t)>0 \text{ in each } t\in[0,\infty). \tag{C.94}$$

From (A.3), the expenditure shares of services

$$\frac{p_s(t)s(t)}{x(t)}=\frac{1}{1+\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}} \tag{C.95}$$

is strictly increasing in $p_s(t)$: from (C.95), this implies

$$\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{p_s(t)s(t)}{x(t)}\right)>0 \text{ and } \frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{c(t)}{x(t)}\right)<0 \text{ in each } t\in[0,\infty), \tag{C.96}$$

where the decline in the share of manufactured consumption goods follows by definition of $c/x=1-(p_s s/x)$. The result for employment shares follows from (): since $\Lambda(t)>0$, $\alpha<1$ and $\Gamma(t)<1$ in each $t\in[0,\infty)$, the growth rate of the employment share of manufacturing

$$\frac{\dot{\ell}(t)}{\ell(t)}=-\Lambda(t)\cdot\left[\frac{\dot{x}(t)}{x(t)}-\alpha\Gamma(t)\frac{\dot{q}(t)}{q(t)}\right] \tag{C.97}$$

can be negative if and only if $\dot{q}/q$ strictly exceeds $\dot{x}/x$ by a factor greater than one,

$$\frac{\dot{q}(t)}{q(t)}>\frac{1}{\alpha\Gamma(t)}\cdot\frac{\dot{x}(t)}{x(t)}. \tag{C.98}$$

Since $x(t)/q(t)$ converges to a constant, $\dot{q}/q$ must approach $\dot{x}/x$ either from above or from below over time. This convergence process is monotonic because result (C.93) implies that the interest rate declines monotonically too, and this progressively reduces the growth rates of both $\dot{x}/x$ and $\dot{q}/q$. Therefore, inequality (C.98) is necessarily violated from some finite instant $t'\geqslant 0$ onwards. From (C.97), this means that during the transition, the employment share of the manufacturing sector either declines through the whole time horizon or is declining in each $t\in[t',\infty)$ for some finite $t'\geqslant 0$.

**Linearization of system (C.10)-(C.11)**. For convenience, rewrite system (C.10)-(C.11) as

$$\begin{aligned}
\dot{q} &= \bar{a}\cdot(1-\alpha+\alpha\ell)\cdot\Phi^{\alpha}-x-\theta q && \text{(C.99)}\\
\dot{x} &= x\cdot\left[\alpha\bar{a}\Phi^{\alpha-1}-(\rho+\theta-n)\right] && \text{(C.100)}\\
\dot{\ell} &= \Theta\cdot\left[\alpha\Gamma(\Phi)\cdot\frac{\dot{q}}{q}-\frac{\dot{x}}{x}\right] && \text{(C.101)}
\end{aligned}$$

where we have defined $\Theta=\ell\frac{1-\ell}{\alpha(1-\ell)\cdot\Gamma(\Phi)+\ell}$: this term depends on $\ell$ and $\Phi$ but does not qualitatively affect the local dynamics around the steady state because linearization will delete all the associated derivatives, $\partial\Theta/\partial\ell$ and $\partial\Theta/\partial\Phi$, from the resulting linearized time-derivative $\dot{\ell}$. Note that the steady state conditions (27)-(30) can be rewritten as

$$\begin{aligned} \frac{q^{ss}}{\ell^{ss}} &= \Phi_{ss} = \left[\frac{\alpha\bar{a}}{\rho+\theta-n}\right]^{\frac{1}{1-\alpha}} && \text{(C.102)} \\ x^{ss} &= \bar{a}\left[1-\alpha\left(1-\ell^{ss}\right)\right]\cdot\Phi_{ss}^{\alpha}-\theta q^{ss} && \text{(C.103)} \\ x^{ss} &= a_S\wp_{ss}\left(1-\ell^{ss}\right) && \text{(C.104)} \\ p_s^{ss} &= \left(\frac{1-\alpha}{a_S}\right)\bar{a}\cdot\Phi_{ss}^{\alpha} && \text{(C.105)} \end{aligned}$$

We can linearize (C.99)-(C.101) around the steady state as follows. First, from (C.99), we have

$$\begin{aligned} \frac{\partial}{\partial q}\dot{q} &= \left(\frac{1-\alpha+\alpha\ell}{\ell}\right)\cdot\alpha\bar{a}\Phi^{\alpha-1}-\theta, \\ J_{11} &\equiv \left.\frac{\partial}{\partial q}\dot{q}\right|_{ss} = \frac{1-\alpha+\alpha\ell}{\ell}\left(\rho-n\right)+\frac{\left(1-\alpha\right)\left(1-\ell\right)}{\ell}\theta>0, && \text{(C.106)} \end{aligned}$$

and

$$J_{12} \equiv \left.\frac{\partial}{\partial x}\dot{q}\right|_{ss} = \frac{\partial}{\partial x}\dot{q} = -1<0, \qquad \text{(C.107)}$$

and

$$J_{13} \equiv \left.\frac{\partial}{\partial \ell}\dot{q}\right|_{ss} = \frac{\partial}{\partial \ell}\dot{q} = -\frac{\left(1-\alpha\right)\left(1-\ell\right)}{\ell}\alpha\bar{a}\Phi^{\alpha}<0. \qquad \text{(C.108)}$$

Next, from (C.100), we have

$$\begin{aligned} J_{21} &\equiv \left.\frac{\partial}{\partial q}\dot{x}\right|_{ss} = -\frac{x}{q}\cdot\left(1-\alpha\right)\alpha\bar{a}\Phi^{\alpha-1} = -\frac{x_{ss}}{q_{ss}}\cdot\left(1-\alpha\right)\left(\rho+\theta-n\right)<0, && \text{(C.109)} \\ J_{22} &\equiv \left.\frac{\partial}{\partial x}\dot{x}\right|_{ss} = 0, && \text{(C.110)} \\ J_{23} &\equiv \left.\frac{\partial}{\partial \ell}\dot{x}\right|_{ss} = \frac{x}{\ell}\left(1-\alpha\right)\cdot\alpha\bar{a}\Phi^{\alpha-1} = \frac{x_{ss}}{\ell_{ss}}\left(1-\alpha\right)\cdot\left(\rho+\theta-n\right)>0. && \text{(C.111)} \end{aligned}$$

Before proceeding with (C.101), notice that

$$\begin{aligned} \left.\frac{\partial}{\partial\cdot}\left(\frac{\dot{q}}{q}\right)\right|_{ss} &= \left.\frac{1}{q}\left(\frac{\partial\dot{q}}{\partial\cdot}-\frac{\dot{q}}{q}\right)\right|_{ss} = \frac{1}{q}\frac{\partial\dot{q}}{\partial\cdot} \\ \left.\frac{\partial}{\partial\cdot}\left(\frac{\dot{x}}{x}\right)\right|_{ss} &= \left.\frac{1}{x}\left(\frac{\partial\dot{x}}{\partial\cdot}-\frac{\dot{x}}{x}\right)\right|_{ss} = \frac{1}{x}\frac{\partial\dot{x}}{\partial\cdot} \end{aligned}$$

Therefore,

$$\begin{aligned} J_{31} &\equiv \left.\frac{\partial}{\partial q}\dot{\ell}\right|_{ss} = \Theta\frac{1}{q}\left[\alpha\Gamma_{ss}\cdot\frac{\partial\dot{q}}{\partial q}-\frac{\partial\dot{x}}{\partial q}\right] = \Theta\frac{1}{q^{ss}}\left[\alpha\Gamma_{ss}\cdot J_{11}-J_{21}\right]>0, && \text{(C.112)} \\ J_{32} &\equiv \left.\frac{\partial}{\partial x}\dot{\ell}\right|_{ss} = \Theta\frac{1}{x}\left[\alpha\Gamma_{ss}\cdot\frac{\partial\dot{q}}{\partial x}-\frac{\partial\dot{x}}{\partial x}\right] = \Theta\frac{1}{x^{ss}}\left[\alpha\Gamma_{ss}\cdot J_{12}-J_{22}\right] = -\Theta\frac{1}{x}\left[\alpha\Gamma_{ss}\right]<0, && \text{(C.113)} \\ J_{33} &\equiv \left.\frac{\partial}{\partial \ell}\dot{\ell}\right|_{ss} = \Theta\frac{1}{\ell}\left[\alpha\Gamma_{ss}\cdot\frac{\partial\dot{q}}{\partial \ell}-\frac{\partial\dot{x}}{\partial \ell}\right] = \Theta\frac{1}{\ell^{ss}}\left[\alpha\Gamma_{ss}\cdot J_{13}-J_{23}\right]<0. && \text{(C.114)} \end{aligned}$$

Hence, the linearized system reads

$$\begin{aligned}
\dot{q} &\approx J_{11}^{(+)}\left(q-q^{ss}\right)-1\cdot\left(x-x^{ss}\right)+J_{13}^{(-)}\left(\ell-\ell^{ss}\right) && \text{(C.115)}\\
\dot{x} &\approx J_{21}^{(-)}\left(q-q^{ss}\right)+0\cdot\left(x-x^{ss}\right)+J_{23}^{(+)}\left(\ell-\ell^{ss}\right) && \text{(C.116)}\\
\dot{\ell} &\approx J_{31}^{(+)}\left(q-q^{ss}\right)+J_{32}^{(-)}\left(x-x^{ss}\right)+J_{33}^{(-)}\left(\ell-\ell^{ss}\right) && \text{(C.117)}
\end{aligned}$$

As it is common in 3-by-3 dynamic systems, the signs of the eigenvalues of (C.115)-(C.117) need to be verified numerically to confirm conditional stability (in this case, saddle-manifold stability) of the steady-state $(x^{ss}, q^{ss}, \ell^{ss})$. All parameter constellations that we have considered, including those of the numerical simulations discussed in the main text, confirm convergence of the economy towards $(x^{ss}, q^{ss}, \ell^{ss})$ following a regular path. This is not surprising since the parametric reduced system $[\dot{q}(\ell), \dot{x}(\ell)]$ – which can be obtained by treating $\ell$ as a parameter – is isomorphic to the neoclassical model and indeed displays saddle-point stability: given $\ell \approx \ell^{ss}$, equations (C.99)-(C.100) reduce to

$$\begin{aligned}
\dot{q} &\approx \bar{a}\cdot\frac{1-\alpha+\alpha\ell^{ss}}{\left(\ell^{ss}\right)^{\alpha}}\cdot q^{\alpha}-x-\theta q\\
\dot{x} &\approx x\cdot\left[\alpha\bar{a}\left(\ell^{ss}\right)^{1-\alpha}\cdot q^{\alpha-1}-(\rho+\theta-n)\right]
\end{aligned}$$

which can be easily shown to display saddle-point stability due to $\left.\partial\dot{x}/\partial x\right|_{ss}=0$ and $\left.\partial\dot{x}/\partial q\right|_{ss}<0$.

# D Endogenous Productivity (Model III)

**Profit-maximzing conditions in Model III.** Since firms take the learning-by-doing spillover (34) as given, the profit-maximizing conditions with respect to capital and labor in the two sectors yield

$$\begin{aligned}
r_k(t) &= \alpha a_M(t)\,a_\ell(t)^{1-\alpha}\left(\frac{K_M(t)}{\ell(t)\,N(t)}\right)^{\alpha-1}=p_s(t)\cdot\alpha a_S\left(\frac{K_S(t)/N(t)}{1-\ell(t)}\right)^{\alpha-1} && \text{(D.1)}\\
w(t) &= (1-\alpha)\,a_M(t)\,a_\ell(t)^{1-\alpha}\left(\frac{K_M(t)}{\ell(t)\,N(t)}\right)^{\alpha}=p_s(t)\cdot(1-\alpha)\,a_S\left(\frac{K_S(t)/N(t)}{1-\ell(t)}\right)^{\alpha} && \text{(D.2)}
\end{aligned}$$

Solving (D.1) and (D.2) for $\frac{a_M a_\ell{}^{1-\alpha}}{p_s\cdot a_S}$ yields

$$\begin{aligned}
\frac{a_M(t)\,a_\ell(t)^{1-\alpha}}{p_s(t)\cdot a_S} &= \left(\frac{K_M(t)}{\ell(t)\,N(t)}\right)^{1-\alpha}\left(\frac{K_S(t)/N(t)}{1-\ell(t)}\right)^{\alpha-1}, && \text{(D.3)}\\
\frac{a_M(t)\,a_\ell(t)^{1-\alpha}}{p_s(t)\cdot a_S} &= \left(\frac{K_M(t)}{\ell(t)\,N(t)}\right)^{-\alpha}\left(\frac{K_S(t)/N(t)}{1-\ell(t)}\right)^{\alpha},
\end{aligned}$$

from which it follows that firms in both sectors will emply capital and labor in the same proportions: the sectoral capital ratios are given by

$$\frac{K_M(t)}{\ell(t)\,N(t)}=\frac{K_S(t)}{N(t)\,(1-\ell(t))}=\kappa(t)\ \text{ in each } t. \qquad \text{(D.4)}$$

Plugging (D.4) back into (D.3), and recalling that $a_\ell(t)=a_\ell(0)\cdot\kappa(t)^{\nu}$, we have

$$a_M(t)\,a_\ell(t)^{1-\alpha}=p_s(t)\cdot a_S, \qquad \frac{\dot{p}_s(t)}{p_s(t)}=g_M+\nu(1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)}. \qquad \text{(D.5)}$$

Expression (D.5) shows that the price of services grows at the same rate as the comprehensive TFP index of the manufacturing sector, which includes an exogenous component, $g_M$, and an endogenous component, $\nu(1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)}$. The endogenous component in (D.5) implies that shocks affecting capital accumulation will affect the dynamics of the price of services and, hence, the dynamics of the expenditure shares via equation (A.11). This does not happen in Model I, where the growth rate of $p_s$ only has an exogenous component. Also note, for future reference, that the ratio between the capital rental rate and the wage rate is

$$\frac{r_k(t)}{w(t)} = \frac{\alpha}{1-\alpha} \cdot \frac{1}{\kappa(t)} \tag{D.6}$$

and that the rental rate of capital, given the spillover function $a_\ell = \kappa^\nu$, can be equivalently written as

$$r_k(t) = \alpha a_M(t) a_\ell(t)^{1-\alpha} \kappa(t)^{\alpha-1} = \alpha a_M(t) \kappa(t)^{\alpha+\nu(1-\alpha)-1}. \tag{D.7}$$

For future reference, note that equal capital-labor intensities imply the following levels of output in the two sectors:

$$M(t) \equiv a_M(t) a_\ell(t)^{1-\alpha} \cdot \kappa(t)^\alpha \cdot \ell(t) N(t), \tag{D.8}$$

$$S(t) \equiv a_S \cdot \kappa(t)^\alpha (1-\ell(t)) N(t). \tag{D.9}$$

**Dynamic system and steady state results for Model III**. The equilibrium path of the economy is determined by the joint dynamics of individual expenditures, $x$, and capital per worker, $\kappa$, given by (B.9)-(B.10) just like in Model I:

$$\begin{aligned}
\frac{\dot{x}(t)}{x(t)} &= r_k(t)(1-\psi) - \theta - (\rho - n), \\
\frac{\dot{\kappa}(t)}{\kappa(t)} &= r_k(t)\frac{1-\psi}{\alpha} - \theta - (1-\psi)\frac{x(t)}{\kappa(t)}.
\end{aligned}$$

In Model III, the above system can be transformed into a normalized system exhibiting a steady-state by dividing both $x$ and $\kappa$ with respect to $a_M^{\frac{1}{1-\alpha-\nu(1-\alpha)}}$. Defining the convenient variables

$$x_B(t) \equiv \frac{x(t)}{a_M(t)^{\frac{1}{1-\alpha-\nu(1-\alpha)}}} \text{ and } \kappa_B(t) \equiv \frac{\kappa(t)}{a_M(t)^{\frac{1}{1-\alpha-\nu(1-\alpha)}}} \tag{D.10}$$

we can write the rental rate of capital (D.7) as

$$r_k(t) = \alpha \kappa_B(t)^{\alpha+\nu(1-\alpha)-1}. \tag{D.11}$$

Defining the growth rate of $a_M^{\frac{1}{1-\alpha-\nu(1-\alpha)}}$ as

$$g^{**} \equiv \frac{1}{a_M(t)^{\frac{1}{1-\alpha-\nu(1-\alpha)}}} \frac{\mathrm{d}a_M(t)^{\frac{1}{1-\alpha-\nu(1-\alpha)}}}{\mathrm{dt}} = \frac{g_M}{1-\alpha-\nu(1-\alpha)}, \tag{D.12}$$

we can rewrite system (B.9)-(B.10) in terms of normalized variables as

$$\frac{\dot{x}_B(t)}{x_B(t)} = \alpha \kappa_B(t)^{\alpha+\nu(1-\alpha)-1}(1-\psi) - \theta - (\rho-n) - g^{**}, \tag{D.13}$$

$$\frac{\dot{\kappa}_B(t)}{\kappa_B(t)} = \kappa_B(t)^{\alpha+\nu(1-\alpha)-1}(1-\psi) - \theta - (1-\psi)\frac{x_B(t)}{\kappa_B(t)} - g^{**}. \tag{D.14}$$

System (D.13)-(D.14) is isomorphic to the standard one-sector neoclassical growth model. On the one hand, the steady state locus $\dot{x}_B = 0$ in (D.13) defines a unique non-trivial stationary rental rate of capital as well as a stationary level of "normalized" capital per worker,

$$\dot{x}_B = 0 \to r_k^{ss} \equiv \alpha \left(\kappa_B^{ss}\right)^{\alpha+\nu(1-\alpha)-1} = \frac{g^{**} + \theta + (\rho - n)}{1-\psi}, \quad \text{(D.15)}$$

$$\dot{x}_B = 0 \to \kappa_B^{ss} \equiv \left[\frac{\alpha (1-\psi)}{g^{**} + \theta + (\rho - n)}\right]^{\frac{1}{1-\alpha-\nu(1-\alpha)}}. \quad \text{(D.16)}$$

The steady state $\dot{\kappa}_B = 0$ in (D.14), on the other hand, defines a stationary locus for "normalized" expenditure per capita that is a hump-shaped function in the $\kappa_B$–$x_B$ plane,

$$\dot{\kappa}_B = 0 \to x_B^{ss} = \kappa_B^{\alpha+\nu(1-\alpha)} - \frac{\theta + g^{**}}{1-\psi}\kappa_B. \quad \text{(D.17)}$$

The simultaneous steady state is thus characterized by a constant ratio between (non-normalized) individual expenditures and capital per worker

$$\dot{x}_B = \dot{\kappa}_B = 0 \to \frac{x_B^{ss}}{\kappa_B^{ss}} = \left(\kappa_B^{ss}\right)^{\alpha+\nu(1-\alpha)-1} - \frac{g^{**} + \theta}{1-\psi} = \frac{\rho - n + (1-\alpha)(g^{**} + \theta)}{\alpha (1-\psi)} \equiv \frac{x^{ss}}{\kappa^{ss}}. \quad \text{(D.18)}$$

The saddle-point stability of the simultaneous steady state $\dot{x}_B = \dot{\kappa}_B = 0$ is proved following the same steps as in Model I. Denoting $\bar{\alpha} \equiv \alpha + \nu(1-\alpha)$, the linearized system reads

$$\dot{x}_B \simeq 0 \cdot \left(x_B - x_B^{ss}\right) + (\bar{\alpha} - 1)(1-\psi)\,\alpha \left(\kappa_B^{ss}\right)^{\bar{\alpha}-2} \cdot \left(\kappa_B - \kappa_B^{ss}\right), \quad \text{(D.19)}$$

$$\dot{\kappa}_B \simeq -(1-\psi) \cdot \left(x_B - x_B^{ss}\right) + (\rho - n) \cdot \left(\kappa_B - \kappa_B^{ss}\right), \quad \text{(D.20)}$$

and its eigenvalues are given by the solution to

$$\lambda_B^2 - \lambda_B (\rho - n) + (\bar{\alpha} - 1)(1-\psi)^2 \alpha \left(\kappa_B^{ss}\right)^{\bar{\alpha}-2} = 0,$$

that is, two real eigenvalues of opposite sign:

$$\lambda_B = \frac{\rho - n \pm \sqrt{(\rho - n)^2 + (1-\bar{\alpha})(1-\psi)^2 \alpha \left(\kappa_B^{ss}\right)^{\bar{\alpha}-2}}}{2}. \quad \text{(D.21)}$$

Therefore, the simultaneous steady state $\dot{x}_B = \dot{\kappa}_B = 0$ is saddle-point stable and admits a unique equilibrium path converging to the steady state point $(x_B^{ss}, \kappa_B^{ss})$ where $x_B^{ss}$ is given by (D.17) and $\kappa_B^{ss}$ is given by (D.16). The stationarity of $x_B^{ss}$ and $\kappa_B^{ss}$ implies that the non-normalized variables, $x$ and $\kappa$ grow at the same rate given by the growth rate of $a_M(t)^{\frac{1}{1-\alpha-\nu(1-\alpha)}}$ defined in (D.12):

$$\lim_{t\to\infty} \frac{\dot{x}(t)}{x(t)} = \lim_{t\to\infty} \frac{\dot{\kappa}(t)}{\kappa(t)} = \frac{1}{1-\alpha-\nu(1-\alpha)} g_M \equiv g^{**}. \quad \text{(D.22)}$$

The convergence of $\kappa_B$ to $\kappa_B^{ss}$ implies, by (D.15), the long-run rental rate

$$\lim_{t\to\infty} r_k(t) = \frac{g^{**} + \theta + (\rho - n)}{1-\psi} \equiv r_k^{ss}. \quad \text{(D.23)}$$

For future reference, note that the stable arm of the linearized system (D.19)-(D.20) is given by the equation

$$\frac{\kappa_B(t) - \kappa_B^{ss}}{x_B(t) - x_B^{ss}} = \frac{\bar{\lambda}_B - 0}{(\bar{\alpha} - 1)(1-\psi)\,\alpha \left(\kappa_B^{ss}\right)^{\bar{\alpha}-2}} \equiv \phi > 0 \quad \text{(D.24)}$$

where $\bar{\lambda}_B$ is the negative root in (D.21), and the positive sign of $\phi$ follows from $\bar{\alpha} < 1$. Hence, for given $\kappa_B(0)$, the initial level of $x_B$ will satisfy

$$x_B(0) \approx x_B^{ss} + 2\frac{(\bar{\alpha}-1)(1-\psi)\,\alpha\,(\kappa_B^{ss})^{\bar{\alpha}-2}}{\rho - n - \sqrt{(\rho-n)^2 - (\bar{\alpha}-1)(1-\psi)^2\,\alpha\left(\kappa_B^{ss}\right)^{\bar{\alpha}-2}}} \cdot \left(\kappa_B(0) - \kappa_B^{ss}\right) \qquad \text{(D.25)}$$

and normalized capital will approach the steady state according to

$$\kappa_B(t) - \kappa_B^{ss} \approx \left(\kappa_B(0) - \kappa_B^{ss}\right) \cdot e^{\bar{\lambda}_B \cdot t} \qquad \text{(D.26)}$$

where

$$\bar{\lambda}_B = \frac{\rho - n - \sqrt{(\rho-n)^2 - (\bar{\alpha}-1)(1-\psi)^2\,\alpha\left(\kappa_B^{ss}\right)^{\bar{\alpha}-2}}}{2} < 0. \qquad \text{(D.27)}$$

**Proof of Proposition 4 (Model III versus Model I with $g^* = g^{**} = \bar{g}$).** In the model comparison of subsection 3.3, we have the same parameter $\alpha$ and the same long-run growth rate of per capita expenditures and incomes $g^* = g^{**} = \bar{g}$. By setting the respective spillover parameters $\nu^I = 0$ and $\nu^{III} > 0$, the respective rates of exogenous TFP growth are set according to

$$\begin{aligned} g_M^I &= (1-\alpha)\,\bar{g}, && \text{(D.28)} \\ g_M^{III} &= (1-\alpha)\left(1-\nu^{III}\right)\bar{g}, && \text{(D.29)} \end{aligned}$$

Therefore, the respective overall TFP growth rates are

$$(\dot{a}/a)^I = g_M^I \text{ and } (\dot{a}/a)^{III} = g_M^{III} + \nu^I (1-\alpha)(\dot{\kappa}/\kappa)^{III}. \qquad \text{(D.30)}$$

In the long run, both rates are equal, $(\dot{a}/a)^I = (\dot{a}/a)^{III} \to (1-\alpha)\,\bar{g}$. During the transition, the gap in TFP growth rates is

$$(\dot{a}/a)^{III} - (\dot{a}/a)^I = \nu^{III} \cdot \left[(\dot{\kappa}/\kappa)^{III} - \bar{g}\right], \qquad \text{(D.31)}$$

where the last term follows from (D.28)-(D.29) and (D.30). Along any regular path in which capital per worker $\kappa$ grows and the rental rate $r_k$ declines during the transition, $(\dot{\kappa}/\kappa)^{III}$ must approach $\bar{g}$ monotonically from above, so that $\nu^{III} \cdot \left[(\dot{\kappa}/\kappa)^{III} - \bar{g}\right] > 0$ must hold during the whole transition. Hence,

$$(\dot{a}/a)^{III} > (\dot{a}/a)^I, \qquad \text{(D.32)}$$

that is, TFP growth is faster during the whole transition with $\nu = \nu^{III} > 0$ (i.e., Model III) than with $\nu = 0$ (i.e., Model I). Consider now the transitional interest rates. From (D.7), we can rewrite the rental rate of capital as

$$r_k(t) = \alpha a_M(t)\, a_\ell(t)^{1-\alpha}\,\kappa(t)^{\alpha-1} = \alpha a(t)\,\kappa(t)^{\alpha-1}, \qquad \text{(D.33)}$$

so that its transitional growth rate equals

$$\frac{\dot{r}_k(t)}{r_k(t)} = \frac{\dot{a}(t)}{a(t)} - (1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)}. \qquad \text{(D.34)}$$

In the model comparison of subsection 3.3, we have different growth rates of $r_k$ between Model III and Model I with $g^* = g^{**}$. First, as shown in (D.31), the transitional TFP growth term $(\dot{a}/a)$ is higher in Model III. Second, the transitional growth of $\kappa$ is determined by the stable root of the dynamic system (D.19)-(D.19) – in particular, the term $(1-\alpha)(\dot{\kappa}/\kappa)$ converges to $(\dot{a}/a)$ at the same speed at which $\kappa_B$ converges to $\kappa_B^{ss}$. The speed of convergence is $\left|\bar{\lambda}_B\right|$, given by expression (D.27). In this respect, note that identical parameters between Model III and Model I with $g^* = g^{**}$ imply that all the parameters appearing in $\bar{\lambda}_B$ are the same in the two models except for $\bar{\alpha} \equiv \alpha + \nu(1-\alpha)$ and for

$$\left(\kappa_B^{ss}\right)^{\bar{\alpha}-2} = \left[\frac{g^{**} + \theta + (\rho - n)}{\alpha(1-\psi)}\right]^{\frac{2-\bar{\alpha}}{1-\bar{\alpha}}}, \tag{D.35}$$

where the right hand side is given by (D.16). Since $\frac{\partial}{\partial\bar{\alpha}}\left(\frac{2-\bar{\alpha}}{1-\bar{\alpha}}\right) > 0$, it is easy to show that

$$\frac{\partial\bar{\lambda}_B}{\partial\bar{\alpha}} > 0 \tag{D.36}$$

Since $\bar{\alpha}$ is positively affected by $\nu$, it takes higher values in Model III than in Model I with $g^* = g^{**}$. Hence, result (D.36) implies that $\bar{\lambda}_B < 0$ is higher in Model III then in Model I, which means a smaller convergence speed in absolute value,

$$\left|\bar{\lambda}_B\right|^{III} < \left|\bar{\lambda}_B\right|^{I}. \tag{D.37}$$

Going back to (D.34), it follows that $\frac{\dot{r}_k(t)}{r_k(t)}$ is higher in Model III than in Model I because $(\dot{a}/a)$ is higher and because $(1-\alpha)(\dot{\kappa}/\kappa)$ converges to $(\dot{a}/a) \to \bar{g}$ at slower speed. In other words, along regular paths, the rental rate of capital is 'flatter' during the transition because it exhibits a smaller rate of decline in Model III than in Model I. The corollaries of this result are that capital accumulation proceeds faster in Model I than in Model III during the whole transition,

$$(\dot{\kappa}/\kappa)^{III} < (\dot{\kappa}/\kappa)^{I}, \tag{D.38}$$

and that, given the same initial conditions $\kappa(0)$ and $a(0)$ in the two models, the rental rate of capital is higher in Model III than in Model I during the whole transition,

$$r_k^{III}(t) > r_k^{I}(t), \tag{D.39}$$

which in turn implies faster expenditure growth by the Euler equation (6),

$$(\dot{x}/x)^{III} < (\dot{x}/x)^{I}. \tag{D.40}$$

**Employment shares in Model III**. From (A.3), we can write individual expenditures divided by capital per worker as in (B.26), where we can substitute the production function $s = a_S\kappa^{\alpha}(1-\ell)$ as well as $a_M {a_\ell}^{1-\alpha} = p_s a_S$ from (D.5), to obtain

$$\frac{x(t)}{\kappa(t)} = \left[1 + \left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}\right] \cdot a_M(t)\,\kappa(t)^{\alpha+\nu(1-\alpha)-1} \cdot (1-\ell(t)), \tag{D.41}$$

Recalling that $r_k(t) = \alpha a_M(t)\,\kappa(t)^{\alpha+\nu(1-\alpha)-1}$, expression (D.41) yields

$$1-\ell(t) = \frac{1}{1+\left(\frac{\gamma}{1-\gamma}\right)^{\sigma} \cdot p_s(t)^{\sigma-1}} \cdot \alpha \cdot \frac{x(t)}{\kappa(t)} \cdot \frac{1}{r_k(t)}. \tag{D.42}$$

Since $p_s(t) = a_M(t)/a_S$ grows indefinitely at the positive rate shown in (D.5), the limit of the above expression as $t \to \infty$ is given by

$$\lim_{t\to\infty}(1-\ell(t)) = \alpha \cdot \lim_{t\to\infty}\left(\frac{x(t)}{\kappa(t)}\right) \cdot \frac{1}{r_k^{ss}}, \tag{D.43}$$

where the asymptotic expenditure-capital ratio is, from (D.18), equal to

$$\lim_{t\to\infty}\left(\frac{x(t)}{\kappa(t)}\right)=\frac{\rho-n+(1-\alpha)(g^{**}+\theta)}{\alpha(1-\psi)} \tag{D.44}$$

Subtituting (D.44) in (D.43) as well as $r_k^{ss}$ from (D.23), we obtain

$$\lim_{t\to\infty}(1-\ell(t))=\frac{(1-\alpha)(g^{**}+\theta)+(\rho-n)}{g^{*}+\theta+(\rho-n)}\equiv 1-\ell^{ss}, \tag{D.45}$$

which implies

$$\frac{\ell^{ss}}{1-\ell^{ss}}=\alpha\frac{g^{**}+\theta}{(1-\alpha)(g^{**}+\theta)+(\rho-n)}. \tag{D.46}$$

Regarding the transitional dynamics of employment shares, defining the convenient variable

$$\wp(t)\equiv p_s(t)+[\gamma/(1-\gamma)]^{\sigma}\cdot p_s(t)^{\sigma}$$

we can rewrite individual expenditures (A.3) as

$$x(t)=\left[p_s(t)+\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma}\right]\cdot s(t)=\wp(t)\,\kappa(t)^{\alpha}(1-\ell(t)) \tag{D.47}$$

Time-differentiation of (D.47) gives

$$\frac{\dot{x}(t)}{x(t)}=\frac{\dot{\wp}(t)}{\wp(t)}+\alpha\frac{\dot{\kappa}(t)}{\kappa(t)}-\frac{\dot{\ell}(t)}{1-\ell(t)}. \tag{D.48}$$

The growth rate of $\wp(t)$ can be written as

$$\frac{\dot{\wp}(t)}{\wp(t)}=\Gamma(t)\frac{\dot{p}_s(t)}{p_s(t)}\text{ where }\Gamma(t)\equiv\frac{1+\sigma\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}}{1+\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}}<1, \tag{D.49}$$

so that (D.48) becomes

$$\frac{\dot{x}(t)}{x(t)}=\Gamma(t)\frac{\dot{p}_s(t)}{p_s(t)}+\alpha\frac{\dot{\kappa}(t)}{\kappa(t)}-\frac{\dot{\ell}(t)}{1-\ell(t)}. \tag{D.50}$$

Substituting $\dot{p}_s/p_s=g_M$ from (14) and rearranging terms, we obtain

$$\frac{\dot{\ell}(t)}{\ell(t)}=-\frac{1-\ell(t)}{\ell(t)}\left[\frac{\dot{x}(t)}{x(t)}-\alpha\frac{\dot{\kappa}(t)}{\kappa(t)}-\Gamma(t)\frac{\dot{p}_s(t)}{p_s(t)}\right]. \tag{D.51}$$

**Consumption share effect: derivation of (38)**. From (5), the expenditure share of manufactured consumption goods is

$$x^M(t)\equiv\frac{c(t)}{p_s(t)\,s(t)}=\left(\frac{\gamma}{1-\gamma}\right)^{\sigma}\cdot p_s(t)^{\sigma-1}.$$

Therfore, using (D.5), the growth rate of $x^M(t)$ is given by

$$\frac{\dot{x}^M(t)}{x^M(t)}=-(1-\sigma)\frac{\dot{p}_s(t)}{p_s(t)}=-(1-\sigma)\frac{\dot{a}(t)}{a(t)}=-(1-\sigma)\left[g_M+\nu(1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)}\right],$$

which is equation (38) in the main text. As shown in (D.31), the transitional TFP growth term $(\dot{a}/a)$ is higher in Model III than in Model I with $g^* = g^{**}$. Therefore, the manufacturing (services) expenditure share declines (increases) faster in Model III than in Model I.

**Capital diversion effect: derivations and comparison of Model III versus Model I with $g^* = g^{**}$.** Since $K_S = \kappa(1-\ell)$ and $K_M = \kappa\ell$, the growth rate of capital used by service producers relative to capital used by manufacturers equals

$$\frac{\dot{K}_S(t)}{K_S(t)} - \frac{\dot{K}_M(t)}{K_M(t)} = -\frac{\dot{\ell}(t)}{1-\ell(t)} - \frac{\dot{\ell}(t)}{\ell(t)} = -\frac{2-\ell(t)}{1-\ell(t)}\ell(t) \cdot \frac{\dot{\ell}(t)}{\ell(t)}. \tag{D.52}$$

Using (D.51) to substitute the growth rate of $\ell(t)$ in (D.52), we obtain

$$\frac{\dot{K}_S(t)}{K_S(t)} - \frac{\dot{K}_M(t)}{K_M(t)} = (2-\ell(t))\left[\frac{\dot{x}(t)}{x(t)} - \alpha\frac{\dot{\kappa}(t)}{\kappa(t)} - \Gamma(t)\frac{\dot{p}_s(t)}{p_s(t)}\right], \tag{D.53}$$

where $\Gamma(t)$ is defined in (D.49). Rearranging terms and using (D.5) to substitute the growth rate of $p_s$, we have

$$\frac{\dot{K}_S(t)}{K_S(t)} - \frac{\dot{K}_M(t)}{K_M(t)} = (2-\ell(t))\left[\frac{\dot{x}(t)}{x(t)} - \frac{\dot{\kappa}(t)}{\kappa(t)} + (1-\Gamma(t))\frac{\dot{a}(t)}{a(t)} + (1-\alpha)\frac{\dot{\kappa}(t)}{\kappa(t)} - \frac{\dot{a}(t)}{a(t)}\right]$$

and recalling (D.34), we can rewrite (D.53) as

$$\frac{\dot{K}_S(t)}{K_S(t)} - \frac{\dot{K}_M(t)}{K_M(t)} = (2-\ell(t))\left\{\frac{\dot{x}(t)}{x(t)} - \frac{\dot{\kappa}(t)}{\kappa(t)} + (1-\Gamma(t))\frac{\dot{p}_s(t)}{p_s(t)} - \frac{\dot{r}_k(t)}{r_k(t)}\right\} \tag{D.54}$$

where each of the terms in square brackets converges to zero in the long run.[45] During the transition, we can compare each term in Model III versus Model I with $g^* = g^{**}$ as follows. First, in view of result (D.39), the interest rate on financial assets $r_q = (1-\psi)r_k - \theta$ is higher in Model III during the whole transition: this implies from (6) that the growth rate of expenditures $\dot{x}/x = r_q - (\rho - n)$ is higher in Model III during the whole transition. Second, we have already shown in (D.38) that $\dot{\kappa}/\kappa$ is lower in Model III during the whole transition, so that the whole term in the first square bracket $[(\dot{x}/x)-(\dot{\kappa}/\kappa)]$ is higher in Model III during the whole transition. Next, the third term represents the impact of growing service prices, $\dot{p}_s/p_s = \dot{a}/a$, on the relative demand for sectoral outputs and thereby on the producers' relative demand for inputs: since $(\dot{a}/a)$ is higher in Model III during the whole transition – see result (D.31) above – the second term in square brackets is higher in Model III. The last term, $\dot{r}_k/r_k$, is the only one introducing a potential ambiguity in the comparison because the rate of decline of the interest rate is actually smaller in Model III than in Model I, as shown in above. It is however unlikely that, for reasonable parameter values, the transitional impact of $-(\dot{r}_k/r_k)$ more than compensates for the cumulative impact of all the other variables in the right hand side of (D.54): the instantaneous variation of interest rates $\dot{r}_k/r_k$ is an extremely small number, and its differential gap between Model III and Model I is even smaller. Hence, for $-(\dot{r}_k/r_k)$ sufficiently small, all the terms in curly brackets in (D.54) imply that capital diversion is stronger in Model III than in Model I during the whole transition to the respective steady states. This result is confirmed in several numerical simulations including the one described in Figure 2, where the service share of capital use becomes dominant much earlier in Model III than in Model I.

[45] The first term in square brackets approaches zero as $x/\kappa$ reaches a steady state in the long run. From (D.49), $\lim_{t\to\infty}\Gamma(t) = 1$, which implies that the second term in square brackets vanishes asymptotically. The third term is also zero in the long run as interest rates reach their steady states.

**Special case with fully endogenous growth: derivation of expression (40)**. Setting $a_M(t) = 1$ and $\nu = 1$, in the profit-maximizing condition of manufacturing firms (D.7), the marginal product of capital under the hypothesis $\nu = 1$ reads

$$r_k(t) = \alpha a_M(t) \, a_\ell(t)^{1-\alpha} \, \kappa(t)^{\alpha-1} = \alpha.$$

From (9), the return to private wealth is $r_q(t) = \alpha(1-\psi) - \theta$, which can be substituted in the Euler equation (6) to obtain (40) in the text.

# E Empirical analysis

## E.1 Sector classification

Industries are classified into four major sectors (agriculture, manufacturing, services and government) according to the methodology outlined in Appendix A of Herrendorf et al. (2014, pp. 932-933). Employment data are aggregated by the BEA according to SIC code from 1969-2000, and by NAICS code from 2001-2016. Table 7 shows how BEA employment data is classified into sector. Output data are aggregated by the BEA according to SIC code from 1963-1996, and by NAICS code from 1997-2017. Table 8 shows how BEA output data is classified into sector.

## E.2 Timing of bank branching deregulation

The year of bank branching deregulation in each state is taken from Amel (1993), Jayaratne and Strahan (1996), Krozsner and Strahan (1999), and Beck et al. (2010). Following this literature, we take the year of deregulation to be the year that a state allowed bank branching by merger and acquisition (M&A). Table 9 lists the year of deregulation for each state.

## E.3 Difference-in-differences regressions with pre-1997 data

Table 10 replicates Table 3, restricted to pre-1997 data. This is to avoid the discontinuity in the data when the BEA switched from aggregating data by SIC code to aggregating data by NAICS code. None of these results directly contradict the results found in Section 5.2; that is, there are no coefficients that are estimated to be significantly positive using one dataset and significantly negative using the other dataset. However, some coefficients that are significant when estimated using the full dataset are not significant when estimated using the restricted dataset, and vice versa. Nonetheless, the estimates of 'Time*Dereg.' are significantly positive for services and significantly negative for manufacturing across both datasets.

## E.4 Pooled ridge ASCM and staggered SCM estimates when finance is excluded

One criticism of empirical studies like the one conducted in this paper is that results merely demonstrate the increasing size of the financial sector following financial deregulation. While existing literature has cast doubt on this interpretation (for example, Jerzmanowski (2017) finds that TFP growth in the manufacturing sector accelerated following bank branching deregulation), as an additional robustness check we re-estimate the pooled ridge ASCM and staggered SCM results after removing finance from the totals (SIC code H[46]). When calculating shares

[46] None of the synthetic control studies presented in this paper run as far as 1997, so the results presented here do not require us to remove finance on the basis NAICS codes.

Table 7: Classification of BEA employment data into sector

| Sector | SIC Code (1969-2000) | NAICS Code (2001-2016) |
|---|---|---|
| Agriculture | Farm employment ([01-02]) | Farm employment (111-112) |
| | Agricultural services, forestry, and fishing ([07-09]) | Forestry, fishing, and related activities (113-115) |
| Manufacturing | Mining (B) | Mining, quarrying, and oil and gas extraction (21) |
| | Construction (C) | Construction (23) |
| | Manufacturing (D) | Manufacturing (31-33) |
| Services | | Utilities (22) |
| | | Wholesale trade (42) |
| | | Retail trade (43-45) |
| | | Transportation and warehousing (48-49) |
| | | Information (51) |
| | | Finance and insurance (52) |
| | Transportation and public utilities (E) | Real estate and rental and leasing (53) |
| | Wholesale trade (F) | Professional, scientific, and technical services (54) |
| | Retail trade (G) | Management of companies and enterprises (55) |
| | Finance, insurance, and real estate (H) | Administrative and support and waste management and remediation services (56) |
| | Services (I) | |
| | | Educational services (61) |
| | | Health care and social assistance (62) |
| | | Arts, entertainment, and recreation (71) |
| | | Accommodation and food services (72) |
| | | Other services (except government and government enterprises) (81) |
| Government | Government and government enterprises | Government and government enterprises |

Table 8: Classification of BEA output data into sector

| Sector | SIC Code (1963-1996) | NAICS Code (1997-2017) |
|---|---|---|
| Agriculture | Agriculture, forestry, and fishing (A) | Agriculture, forestry, fishing, and hunting (11) |
| Manufacturing | Mining (B)<br>Construction (C)<br>Manufacturing (D) | Mining, quarrying, and oil and gas extraction (21)<br>Construction (23)<br>Manufacturing (31-33) |
| Services | Transportation and public utilities (E)<br>Wholesale trade (F)<br>Retail trade (G)<br>Finance, insurance, and real estate (H)<br>Services (I) | Utilities (22)<br>Wholesale trade (42)<br>Retail trade (44-45)<br>Transportation and warehousing (48-49)<br>Information (51)<br>Finance, insurance, real estate, rental, and leasing (52-53)<br>Professional and business services (54-56)<br>Educational services, health care, and social assistance (61-62)<br>Arts, entertainment, recreation, accommodation, and food services (71-72)<br>Other services (except government and government enterprises) (81) |
| Government | Government and government enterprises | Government and government enterprises |

Table 9: Timing of M&A bank branching deregulation

| State | Code | Dereg. Year | State | Code | Dereg. Year |
|---|---|---|---|---|---|
| Alabama | AL | 1981 | Montana | MT | 1990 |
| Alaska | AK | <1963 | Nebraska | NE | 1985 |
| Arizona | AZ | <1963 | Nevada | NV | <1963 |
| Arkansas | AR | 1994 | New Hampshire | NH | 1987 |
| California | CA | <1963 | New Jersey | NJ | 1977 |
| Colorado | CO | 1991 | New Mexico | NM | 1991 |
| Connecticut | CT | 1980 | New York | NY | 1976 |
| Delaware | DE | <1963 | North Carolina | NC | <1963 |
| District of Columbia | DC | <1963 | North Dakota | ND | 1987 |
| Florida | DL | 1988 | Ohio | OH | 1979 |
| Georgia | GA | 1983 | Oklahoma | OK | 1988 |
| Hawaii | HI | 1986 | Oregon | OR | 1985 |
| Idaho | ID | <1963 | Pennsylvania | PA | 1982 |
| Illinois | IL | 1988 | Rhode Island | RI | <1963 |
| Indiana | IN | 1989 | South Carolina | SC | <1963 |
| Iowa | IA | 1999 | South Dakota | SD | <1963 |
| Kansas | KS | 1987 | Tennessee | TN | 1985 |
| Kentucky | KY | 1990 | Texas | TX | 1988 |
| Louisiana | LA | 1988 | Utah | UT | 1981 |
| Maine | ME | 1975 | Vermont | VT | 1970 |
| Maryland | MD | <1963 | Virginia | VA | 1978 |
| Massachusetts | MA | 1984 | Washington | WA | 1985 |
| Michigan | MI | 1987 | West Virginia | WV | 1987 |
| Minnesota | MN | 1993 | Wisconsin | WI | 1990 |
| Mississippi | MS | 1986 | Wyoming | WY | 1988 |
| Missouri | MO | 1990 | | | |

Table 10: Difference-in-differences regressions (pre-1997 dataset)

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Services Share of Employment (%) | Services Share of Output (%) | Man. Share of Employment (%) | Man. Share of Output (%) |
| Deregulation | 0.116 | 0.620*** | −0.564*** | −1.572*** |
| | (0.100) | (0.205) | (0.151) | (0.267) |
| Time | −0.449*** | 1.199*** | 0.993*** | −1.474*** |
| | (0.048) | (0.135) | (0.088) | (0.179) |
| Dereg.*Time | 0.175*** | 0.193*** | −0.239*** | −0.278*** |
| | (0.017) | (0.027) | (0.025) | (0.032) |
| Constant | 35.908*** | 65.631*** | 43.312*** | 8.877*** |
| | (0.779) | (2.566) | (1.284) | (3.353) |
| Observations | 1,054 | 1,288 | 1,054 | 1,288 |
| $R^2$ | 0.975 | 0.912 | 0.919 | 0.878 |
| Adjusted $R^2$ | 0.974 | 0.906 | 0.913 | 0.871 |

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Difference-in-differences OLS estimates of the effect of bank branching deregulation on structural composition, accounting for year and state fixed effects. Standard errors clustered at the state level in parentheses. 'Deregulation' is a dummy that is equal to 1 when a state has deregulated, and equal to 0 otherwise. 'Time' is the time in years since deregulation (this variable takes a negative value prior to deregulation). The year of deregulation is excluded for each state. States that deregulated prior to 1963 are excluded (Alaska, Arizona, California, Delaware, the District of Columbia, Idaho, Maryland, Nevada, North Carolina, Rhode Island, South Carolina and South Dakota). Data is restricted to the pre-1997 BEA dataset (aggregated by SIC code).

Table 11: Pooled ridge ASCM results (excluding finance)

| Outcome Variable | Mean Gap | Mean Percentile Rank | $p$-Value | Validity $p$-Value |
|---|---|---|---|---|
| Services share of employment (excl. finance) (%) | 1.903 | 0.718 | 0.008*** | 0.740 |
| Services share of output (excl. finance) (%) | 1.562 | 0.659 | 0.058* | 0.862 |
| Man. share of employment (excl. finance) (%) | −2.466 | 0.292 | 0.012** | 0.921 |
| Man. share of output (excl. finance) (%) | −3.202 | 0.338 | 0.053* | 0.536 |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Results from a pooled ridge ASCM study requiring a minimum of 3 states in the donor pool, a minimum of 5 years of pre-treatment data, and 10 years of post-treatment data, where finance is excluded. 'Mean Gap' is the mean gap between the treated state and the synthetic state 10 years after deregulation across the 9 deregulation events fitting the specification. 'Mean Percentile Rank' is calculated as in equation (42), 10 years after deregulation. '$p$-Value' indicates how statistically different 'Mean Percentile Rank' is from 0.5. The null hypothesis is that 'Mean Percentile Rank' is equal to 0.5, and thus that deregulation has no effect. 'Validity $p$-Value' indicates how statistically different the mean percentile rank of the MSPE prior to deregulation is from 0.5. The null hypothesis is that the mean percentile rank of the MSPE is equal to 0.5, and thus that the treated states have synthetic counterparts that are just as good as those of the placebo states, in which case the pooling is valid.

Table 12: Staggered SCM results (excluding finance)

| Outcome Variable | Effect | Standard Error | $p$-Value |
|---|---|---|---|
| Services share of employment (excl. finance) (%) | 2.124 | 0.638 | 0.001*** |
| Services share of output (excl. finance) (%) | 1.785 | 1.135 | 0.116 |
| Man. share of employment (excl. finance) (%) | −3.718 | 1.120 | 0.001*** |
| Man. share of output (excl. finance) (%) | −5.401 | 1.194 | 0.000*** |

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Results from a staggered synthetic controls study requiring a minimum of 3 states in the donor pool, a minimum of 5 years of pre-treatment data, and 10 years of post-treatment data, where finance is excluded. 'Effect' is the estimated effect of deregulation on the outcome variable – relative to the counterfactual of no deregulation – 10 years after deregulation across the 9 deregulation events fitting the specification. 'Standard Error' is the jackknifed standard error of this estimated effect, and '$p$-Value' indicates how statistically different 'Effect' is from 0 based on the standard error. The null hypothesis is that bank branching deregulation has no effect.

of output or employment, finance was excluded from both the numerator (in the case of services shares) and the denominator. That is, 'the manufacturing share of employment' in this appendix should be interpreted as 'manufacturing employment as a share of (total employment minus finance employment)'.

Table 11 is the same as Table 5, but excluding finance. The results are consistent with those presented in the main body of the paper: all the observed effects run in the same direction, and they are all significant at or near the 5% level. Figure 8 and Table 12 are the same as Figure 7 and Table 6 respectively, but excluding finance. Again, the results are consistent with those presented earlier: all of the results run in the expected direction, and while the increase in the services share of output is not quite significant here – as was also true of the main staggered SCM results – the other estimates are statistically significant.

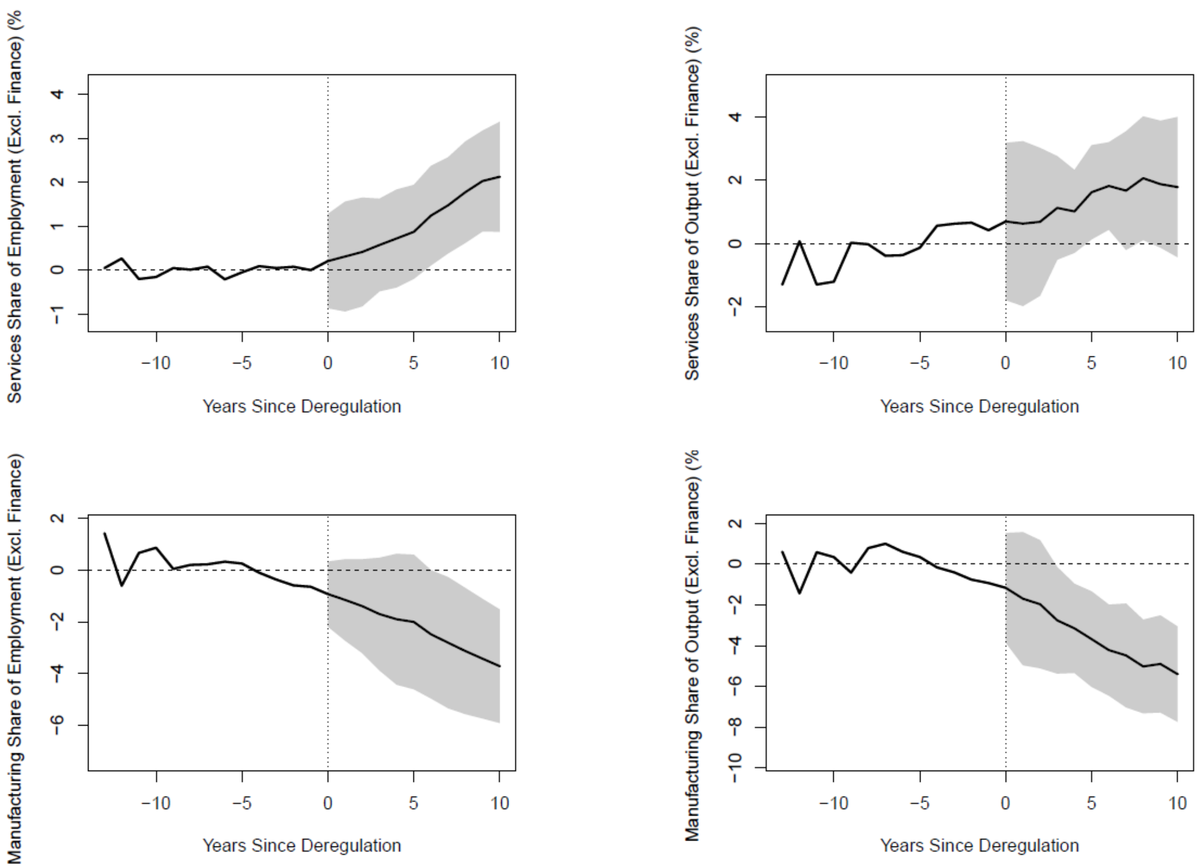


Figure 8: 'Gap plots' of the results of a staggered synthetic controls study estimating the effect of bank branching deregulation on structural change, partially pooled across multiple U.S. states, where finance is excluded. Plots show the share of the economy accounted for by each sector, relative to the synthetic counterfactual of no deregulation. 95% confidence intervals are shaded in grey.