

# Financial Frictions and the Persistence of History: A Quantitative Exploration

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We quantitatively analyze the role of financial frictions and resource misallocation in explaining development dynamics. Our model economy with financial frictions converges to the new steady state slowly after a reform triggers efficient reallocation of resources; the transition speed is half that of the conventional neoclassical model. Furthermore, in the model economy, investment rates and total factor productivity are initially low and increase over time. We present data from the so-called miracle economies on the evolution of macro aggregates, factor reallocation, and establishment size distribution that support the aggregate and micro-level implications of our theory.

The development dynamics of the so-called miracle economies are characterized by (i) sustained growth of per capita income and total factor productivity (TFP) and (ii) investment rates that increased over time. These growth facts are not explained by standard growth models. In the neoclassical model, such transitions can be considered only as a transition from an initial state with low capital stock to a steady state with high

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capital stock. This transition is characterized by a fast convergence—even the economic miracles seem three times slower compared with a calibrated neoclassical model—and investment rates that monotonically decrease over time. Furthermore, for a neoclassical model, TFP is an exogenously given input, and hence it offers no insight into TFP dynamics.

The objective of our paper is to provide a theory of TFP dynamics and use it to build a quantitative framework for understanding the process of economic development. To this end, we incorporate two important features of the economic miracles into the standard growth model. First, their growth accelerations followed large-scale economic reforms that reduced distortions in the economy and led to reallocation of resources across sectors and plants, as we empirically establish in this paper. Second, the financial markets of the miracle economies remained largely underdeveloped until the latter stages of their economic transitions, as evidenced by their low ratios of external finance to gross domestic product (GDP).

In our model, transitional dynamics are endogenously determined by the extent of resource misallocation in the prereform economy and the degree of imperfections in financial markets. Our model generates (i) persistent growth in per capita output and TFP and (ii) investment rates that are initially low but rise over time. In particular, the model's transition speed is half that of the conventionally calibrated neoclassical model, and the distance between the model transition and the output and investment rate data is reduced by 40–75 percent relative to the neoclassical model.

More specifically, our model has individual-specific technology (or entrepreneurship) and financial frictions. In the model, individuals differ in their entrepreneurial productivity and choose each period whether to be an entrepreneur and operate their technology or to work for a wage. This occupational choice allows for endogenous entry into and exit from the production sector. We model financial frictions in the form of collateral constraints by assuming imperfect enforceability of contracts.

Motivated by the historical accounts of the miracle economies, we model the growth acceleration episodes as a process triggered by a large-scale economic reform that removes important sources of resource misallocation. We operationalize this idea by building on the recent literature that emphasizes the role of idiosyncratic distortions/wedges (Restuccia and Rogerson 2008; Hsieh and Klenow 2009; Bartelsman, Haltiwanger, and Scarpetta 2013). In particular, our prereform economy is the steady state of an economy subject to an exogenous process of idiosyncratic taxes and subsidies that distort individuals' production decisions. We do not view the idiosyncratic distortions literally as taxes and subsidies. Rather, they are a parsimonious means of modeling individual/sector/

size-specific policies, regulations, trade restrictions, and entry barriers that distort the allocation of resources across production units. The large-scale reform in the model is then a once-and-for-all elimination of all such taxes and subsidies. We also note from the historical accounts that (i) these reforms were implemented amid underdeveloped financial markets and (ii) the ensuing growth accelerations were not accompanied by a commensurate improvement in the financial markets.

We quantitatively discipline our model in two steps. First, we calibrate the parameters that are invariant across countries and over time so that our undistorted, perfect credit model economy matches the US data on standard macroeconomic aggregates, earnings distribution, establishment size distribution, and establishment dynamics. Second, with regard to the reform-related parameters, the degree of an economy's financial frictions is calibrated to the data on external finance-to-GDP ratios, and the distribution of prereform idiosyncratic distortions is chosen to match the changes in TFP and capital-to-output ratios between the year of the reform and the twentieth postreform year.

We then use our model to quantify the role of initial resource misallocation and financial frictions in explaining the actual time paths of GDP, TFP, and investment rates along the growth accelerations or economic miracles in the data. In addition, we explore the sensitivity of the model's transitional dynamics to alternative calibrations of key parameters: the span of control, the persistence of shocks, and the distribution of idiosyncratic distortions in the initial, prereform state.

Our main exercise analyzes the transitional dynamics triggered by a sudden, unexpected reform that eliminates idiosyncratic distortions while financial frictions remain intact. This stark exercise is designed to highlight the transitional dynamics that are wholly endogenous and intrinsic to the model. The model transition has three important features. First, the economic transition is gradual. Following the reform, GDP grows at an annualized rate of 3.6 percent for 18 years, and it takes 10.5 years for the capital stock to cover half the distance to the new, postreform steady state—almost twice as long as the comparably calibrated neoclassical transition. Second, the model generates endogenous dynamics of TFP, which increases by 5 percent per year for 8 years, although there is no further exogenous change after the reform. Third, the investment rate rises over time, peaking 6 years after the reform. These rich dynamics reflect the process of unwinding much of the resource misallocation in the prereform economy that is slowed by the frictions in financial markets.

In the prereform economy, resources are misallocated partly because of the financial frictions but also because of idiosyncratic distortions. Subsidized entrepreneurs run larger operations and have more income and wealth than is warranted by their true productivity, while the oppo-

site is true for taxed entrepreneurs. The sudden reform initiates a process of massive resource reallocation, but underdeveloped financial markets act as a bottleneck: It takes time for productive but poor entrepreneurs to save the collateral needed to start a business and operate at the efficient scale. This gradual reallocation—the entry and expansion of productive but poor entrepreneurs and the downsizing and exit of incompetent, previously subsidized ones—manifests itself in the slow pace of the transition overall and, more important, in the persistent TFP dynamics.

The investment rate dynamics are also explained by the gradual reallocation. Our calibration of the idiosyncratic distortions implies that initially productive entrepreneurs tend to be poor and financially constrained. Since wealth, by means of collateral constraints, enables entry and expansion of business, both their returns to saving and their saving rates are high. On the other hand, while those with low entrepreneurial productivity tend to be wealthier, they are either workers or unconstrained, small-scale entrepreneurs; hence their returns to saving are much lower. Accordingly, they have low saving rates. Because of the initial wealth distribution and the collateral constraints, the productive, high-saving entrepreneurs account for only a small share of the aggregate income immediately after the reform. The aggregate saving rate is an income-weighted average of the saving rates of the two groups and, as a consequence, is initially low. Over time, productive entrepreneurs, with their high saving rates, account for larger shares of wealth and income, and the aggregate saving rate rises. Eventually, the diminishing marginal returns to capital take over, and even the saving rates of productive entrepreneurs, who are less likely to be constrained now, start to fall over time, spanning the downward arc of the aggregate saving rate. Of course, in a closed economy, aggregate investment must equal aggregate saving, and the investment rate dynamics are identical to the hump-shaped saving rate dynamics.

In subsequent exercises, we show that our transitional dynamics require both frictions in financial markets and a reform that removes some sources of distortions. First, with perfect financial markets, the model is isomorphic to the neoclassical model, and a reform can result only in the neoclassical dynamics regardless of initial conditions. Intuitively, without financial frictions, the wealth distribution is irrelevant for production decisions, and there is no misallocation of capital or entrepreneurial talent (see Sec. III.C.1). On the other hand, if the transition is triggered not by the removal of distortions but by a proportional improvement in production technology, the transitional dynamics are very similar to the neoclassical dynamics, even in the presence of severe financial frictions, because there is no required reallocation of resources along the transition (see Sec. III.C.2).

To highlight the endogenous dynamics of the model, in our exercises we drastically simplify actual reform episodes, which tended to be more protracted affairs and even to be prone to temporary reversals. Moreover, while financial market reforms were implemented much later and even more gradually than the removal of individual/sector/size-specific distortions, financial markets did improve over time.<sup>1</sup> Our framework can readily incorporate these facts, and indeed we consider a sudden elimination of idiosyncratic distortions followed by a gradual financial market reform, which further strengthens our results (see Sec. III.C.3). The financial markets are at their worst exactly when misallocation is at its peak (i.e., at the beginning of the transition), and our gradual reallocation mechanism plays an even bigger role early in the process. Furthermore, the continued improvement in financial markets in the latter stages of transitions results in even more persistent growth in GDP, TFP, and investment rates.

We provide a quantitative analysis of the macroeconomic dynamics following large-scale reforms. At the same time, the rich microeconomic heterogeneity in our model yields some salient micro-level implications that can be confronted with available data. In particular, the model predicts a spike in the reallocation of resources after the reform and a gradual increase in the size of the average establishment along the transition. We compile available data and present evidence consistent with these model predictions (see Sec. IV).

*Related literature.*—Our study of the development dynamics of the miracle economies relates to a recent literature on growth accelerations (Pritchett 2000; Hausmann, Pritchett, and Rodrik 2005; Jones and Olken 2008). Works in this literature use statistical techniques to identify structural breaks in economic growth and document the variables that correlate with growth accelerations. Large-scale economic reforms, as measured by Sachs and Warner (1995), are statistically significant predictors of sustained growth accelerations. Furthermore, consistent with our findings, the literature shows that the earlier stages of growth accelerations are driven by TFP growth, which partly reflects more efficient labor reallocation, with capital accumulation playing a relatively minor role (Jones and Olken 2005). We complement this literature with an in-depth study of seven postwar miracle episodes, all of which are identified as incidents of sustained growth accelerations by the literature. We document that all these growth accelerations followed large-scale reforms. We then quanti-

<sup>1</sup> Measured in both the de jure and the de facto sense, domestic financial market reforms lagged behind the removal of size-dependent or industry-specific distortions. Indeed, in policy circles, the removal of idiosyncratic distortions is categorized as a “first-generation” reform, while domestic financial markets are considered “second-generation” reforms, which consist of institutional reforms aimed at enhancing transparency and good governance in financial markets and corporate sectors (Camdessus 1999; Navia and Velasco 2003).

tatively analyze the role of resource reallocation and financial development and present further empirical evidence on the reallocation of resources across sectors and plants following the reforms.

Christiano (1989) and King and Rebelo (1993) point out that the neoclassical transitional dynamics are inconsistent with the observed growth experiences of economic miracles. They also study whether modified versions of the neoclassical growth model can account for the observed dynamics. The modifications include nonhomothetic preferences, adjustment costs, and a broader notion of capital, all of which lead to some counterfactual implications for investment rates, interest rates, or relative prices of installed capital and new investment goods. More recently, Chen, İmrohoroglu, and İmrohoroglu (2006) reconcile the neoclassical growth model with the postwar growth experience of Japan. They feed into the neoclassical model the realizations of the measured TFP path as an exogenous process and show that the resulting dynamics are consistent with the data. In this context, we view our paper as an attempt to provide a theory of the TFP dynamics along the transitional paths based on the interaction of financial frictions and the initial misallocation of resources.

More recently, the disappointing growth experiences of postcommunist countries have motivated many researchers to study economic transitions. This literature focuses on the reallocation of factors from state to private enterprises, with a particular emphasis on worker flows and labor market frictions (Blanchard 1997). Our theory would imply that capital and entrepreneurial talents were inefficiently aligned during the communist era and that financial frictions delayed efficient reallocation of capital even after the liberalization.<sup>2</sup> Atkeson and Kehoe (1997) also attribute the delayed transition of these economies to misallocation of capital. In their model, capital cannot be swiftly reallocated across firms because it takes time for new private firms to accumulate complementary organizational capital.

We build on the theoretical literature that considers financial frictions as a central issue on economic development.<sup>3</sup> We develop this idea in empirically useful ways by studying the transitional dynamics and the stationary equilibria of a broader class of quantitatively oriented models with financial frictions. Giné and Townsend (2004) and Jeong and Townsend (2007, 2008) have pioneered quantitative analysis for this class of models. They estimate and calibrate models to the growth experience of Thailand. We share their interest in studying the role of financial frictions

<sup>2</sup> In the communist economies, the allocation of capital was as likely to be determined by the distribution of power as by productivity. See Blanchard (1997) and Roland (2000) and the references therein. Calvo and Coricelli (1992) argue that credit market frictions inhibited efficient reallocation of capital in Poland after the liberalization.

<sup>3</sup> See Banerjee and Duflo (2005) for an exhaustive review of this literature.

on transitional dynamics. However, in our main exercise we abstract from financial deepening, which is the main driving force of their transitional dynamics. Instead, we emphasize how the joint distribution of ability and wealth evolves endogenously over time under financial frictions after a reform eliminates important sources of misallocation.<sup>4</sup>

## I. Motivating Facts

We present five common characteristics of the so-called miracle economies. First, in most of these episodes, the pace of economic growth accelerated following large-scale, economywide reforms. Second, even the miracles are protracted affairs, taking several decades to catch up with the richest economies. Third, a significant fraction of the economic growth is explained by the sustained growth in TFP. Fourth, the investment-to-output ratios are hump shaped, increasing in the early stages of the growth acceleration and falling in the latter phases. Finally, these economies' financial markets have remained underdeveloped for the better part of the transitions.

To be more specific, we document the aggregate development dynamics of China, Japan, Korea, Malaysia, Singapore, Taiwan, and Thailand. These economies belong to the top decile in terms of average growth rates during the 1960–2000 period. Furthermore, for each of the seven economies, a large-scale economic reform marks the beginning of the growth acceleration.<sup>5</sup>

*Large-scale reforms.*—Our perusal of the complex histories of the seven countries and their reforms led to the following reform dates: China, 1992; Japan, 1949; Korea, 1961; Malaysia, 1968; Singapore, 1967; Taiwan, 1959; and Thailand, 1983. We also tried a purely statistical procedure to identify the beginning of growth accelerations following Hausmann et al. (2005) and Jones and Olken (2008), and we obtained strikingly similar dates. In fact, Hausmann et al. confirm that the beginning of many such acceleration episodes coincides with large-scale economic reforms. We proceed with our event-based approach because it allows us to be more explicit

<sup>4</sup> More specifically, our model incorporates forward-looking saving decisions and heterogeneity in returns to capital across entrepreneurs, both of which the aforementioned authors abstract from.

<sup>5</sup> The other economies in the top decile are Hong Kong, Ireland, and Romania, which we exclude from our analysis. Hong Kong is excluded because we could not identify large-scale reforms that could be used to date the beginning of their growth accelerations. Romania is not included because it was a nonmarket economy until the early 1990s and because its data exhibit erratic patterns. Ireland's economic transformation followed the reforms in the late 1980s and the early 1990s that substantially liberalized local financial markets and international capital flows. In this regard, the Irish experience is sufficiently different from those of the other countries and is not considered here. Nevertheless, our framework can be readily extended to accommodate such financial market reforms and capital account liberalizations as demonstrated in Secs. III.C.3 and III.C.4.



about the underlying events and policies that led to growth accelerations. Appendix A provides a summary of these reform episodes for each country.

All the reforms identified above entailed large and broad changes in the economic structure. While each reform episode has idiosyncratic characteristics, these reforms involve the dismantling of import substitution regimes, the introduction of export-oriented policies (e.g., broadly applied tax and credit advantages for exporters that did not distort the relative prices of tradables in the world market), and a substantial retrenchment of the government's intervention in the economy. Another common component is the promotion of private firms' entry through a variety of measures, such as the deregulation of labor markets and the simplification of tax codes. In essence, the reforms resulted in more market-oriented economies, leading more productive firms and sectors to expand and unproductive ones to contract. Naturally, these facts, together with more quantitative evidence on resource reallocation discussed in Section IV, have guided our modeling of large-scale reforms. We consider the prereform state as an economy stricken by rampant idiosyncratic distortions or static wedges—as in Restuccia and Rogerson (2008)—and model a reform as the elimination of these idiosyncratic distortions that triggers macroeconomic transitions.

*Postreform transition dynamics.*—Figure 1 presents the main features of the economic miracles; see Appendix B for the construction of the time series. The unweighted average across the seven economies is shown with a thick solid line. For each economy, year 0 on the horizontal axis is its date of large-scale reforms and, hence, the beginning of its economic transition. A point on the horizontal axis therefore corresponds to different calendar years for different countries.

The top-left panel shows the evolution of the per-worker output in each country relative to the US value in each period. All the economies exhibit large and persistent output gains, which appear slow when considered through the lens of the neoclassical growth theory. A reasonably calibrated neoclassical model—a capital share of one-third, a discount factor of 0.96, an intertemporal elasticity of substitution of 0.67, and a depreciation rate of 0.06—predicts that it should take fewer than 6 years for aggregate capital stock to cover half the distance to the steady state. The data suggest a half-life of at least 15 years.<sup>6</sup>

As shown in the bottom-left panel, a significant fraction of the output gains is explained by aggregate productivity gains. Note that the stan-

<sup>6</sup> To calculate the half-life in the data, we first need to establish the long-run level of aggregate capital. We define it as the average over years 35–40 after the reforms. Over this interval, the per-worker capital relative to the United States was stagnant on average, growing by less than 0.5 percent per year. We then compute the half-life as the time it took aggregate capital to reach the halfway point between its initial (prereform) level and its long-run level.



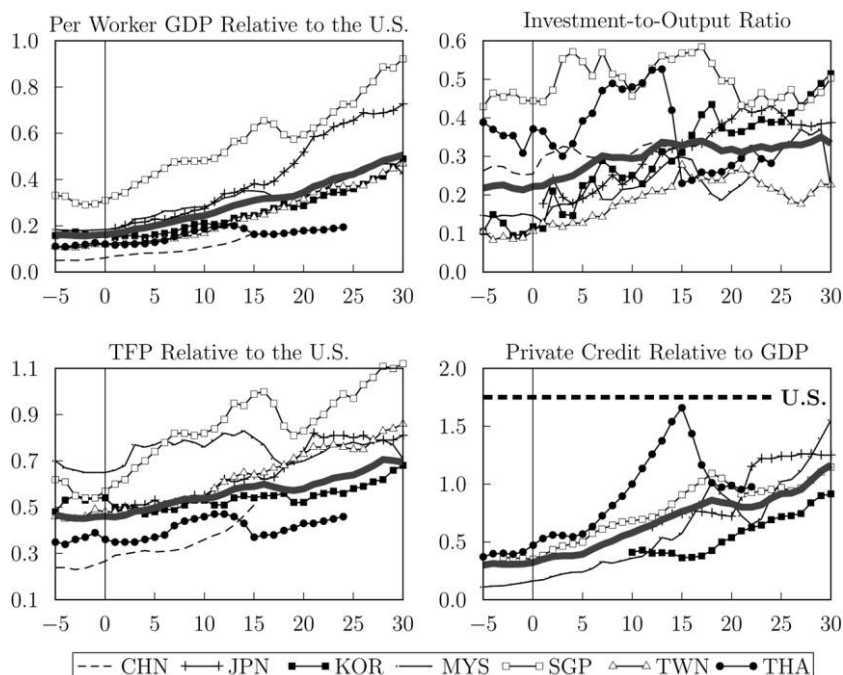


FIG. 1.—Transitional dynamics from the economic miracles. In each panel, all available series for the seven economies are shown; the thick solid line is the unweighted average across all countries. See Appendix B for a detailed description of the data. The horizontal axes show years, and year 0 corresponds to each economy's reform date.

dard neoclassical model—for which TFP is an exogenously given process—has nothing to say about the TFP dynamics.<sup>7</sup>

The top-right panel depicts the behavior of investment rates. In a neoclassical model, the investment rates are monotonically decreasing along the transition to a steady state. In the data, investment rates actually start low and rise in the early stages of transitions. Only in the latter stages do investment rates decrease as predicted by the standard theory.

Finally, as shown in the bottom-right panel, these economies are characterized by low levels of financial development as measured by the ratio of external finance to GDP. Our external finance measure is the sum of private credit owed to depository and other financial institutions as reported in Beck, Demirgüç-Kunt, and Levine (2000). For comparison, the average of this ratio for the United States during the 1990–2005 period is 1.75 (the dashed line). The evolution of this indicator shows that financial development is achieved only in the latter phases of transitions.

<sup>7</sup> TFP for each country is relative to the US value in each period. We net out the contribution of human capital in our TFP construction. See App. B for more detail.

The average external finance-to-GDP ratio across countries during the first 20 years of transitions is less than 0.6.<sup>8</sup>

In the next section, we construct a model with financial market imperfections and resource misallocation to capture and explain these observed development dynamics.

## II. Model

We propose a model with individual-specific technologies and imperfect financial markets to study the role of the misallocation and reallocation of resources in macroeconomic transitions. In each period, individuals choose either to operate an individual-specific technology (i.e., to become an entrepreneur) or to work for a wage. Individuals are heterogeneous with respect to their entrepreneurial productivity and wealth. Our model generates endogenous dynamics for the joint distribution of entrepreneurial productivity and wealth, which come to be crucial for understanding macroeconomic transitions.

Imperfection in financial markets is modeled with a collateral constraint on capital rental proportional to an individual's financial wealth. This rental limit applies equally to all individuals in the economy.

In this section, we do not consider idiosyncratic distortions or wedges. We introduce them into our model in Section III.A.2 to construct the prereform economy.

*Heterogeneity and demographics.*—Individuals live indefinitely and are heterogeneous with respect to their wealth  $a$  and their entrepreneurial productivity or ability  $e \in \mathcal{E}$ , with the former being chosen endogenously by forward-looking saving decisions. An individual's entrepreneurial ability follows a stochastic process. In particular, individuals retain their ability from one period to the next with probability  $\psi$ . With probability  $1 - \psi$ , individuals lose the current ability and draw a new entrepreneurial ability. The new draw is from a time-invariant ability distribution and is independent of the individual's previous ability level. The  $1 - \psi$  shock can be thought of as the arrival of a new technology making existing production processes obsolete or less profitable.

We denote by  $\mu(e)$  the mass of type  $e$  individuals in the invariant distribution, with  $e$  assumed to be a discrete random variable. We denote by  $G_t(e, a)$  the cumulative distribution function (cdf) for the joint distribution of ability and wealth at the beginning of period  $t$ . For notational convenience,  $G_t(a|e)$  is the associated cdf of wealth for a given

<sup>8</sup> One exception is Thailand, which reformed its financial sector earlier than other economies (Townsend 2010). The sharp reversal around year 15 in the Thai series coincides with the 1997 financial crisis.

ability type  $e$ . The population size of the economy is normalized to one, and there is no population growth.

*Preferences.*—All individuals discount their future utility using the same discount factor  $\beta$ . The preferences over the consumption sequence from the point of view of an individual in period  $t$  are represented by the following expected utility:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{c_s^{1-\sigma} - 1}{1-\sigma}.$$

*Technology.*—In any given period, individuals can choose either to work for a wage or to operate an individual-specific technology; we label the latter option as entrepreneurship. We assume that an entrepreneur with talent  $e$  who uses  $k$  units of capital and hires  $l$  units of labor produces according to a production function  $f(e, k, l)$ , which is assumed to be strictly increasing in all arguments and strictly concave in capital and labor, with  $f(0, k, l) = 0$ . To be more specific, we use

$$f(e, k, l) = e(k^\alpha l^{1-\alpha})^{1-\nu}, \quad (1)$$

where  $1 - \nu$  is the span-of-control parameter. Accordingly,  $1 - \nu$  represents the share of output going to the variable factors. Of this output, fraction  $\alpha$  goes to capital and  $1 - \alpha$  goes to labor.

Throughout the paper, we assume that entrepreneurial ability is inalienable and that there is no market for entrepreneurial talents (potentially because of severe agency problems that we do not model explicitly).

*Financial markets.*—Productive capital is the only asset in the economy. There is a perfectly competitive financial intermediary that receives deposits and rents out capital to entrepreneurs. The return on deposited assets (i.e., the interest rate in the economy) is  $r_t$ . The zero-profit condition of the intermediary implies that the rental price of capital is  $r_t + \delta$ , where  $\delta$  is the depreciation rate.

We assume that entrepreneurs' capital rental  $k$  is limited by a collateral constraint  $k \leq \lambda a$ , where  $a \geq 0$  is individual financial wealth and  $\lambda$  measures the degree of credit frictions, with  $\lambda = \infty$  corresponding to perfect credit markets and  $\lambda = 1$  to financial autarky, where all capital must be self-financed by entrepreneurs. The same  $\lambda$  applies to everyone in a given economy.

Our specification captures the common prediction from models of limited contract enforcement: The amount of credit is limited by individuals' wealth. At the same time, its parsimoniousness—the fact that financial frictions are captured by one single parameter,  $\lambda$ —allows us to

analyze the quantitative effects of financial frictions on aggregate transitional dynamics without losing tractability.<sup>9</sup>

In this paper, we focus on within-period credit, or capital rental, for production purposes and do not allow borrowing for intertemporal consumption smoothing; that is, we impose  $a \geq 0$ . This constraint is binding only for individuals who choose to be workers; it has no direct bearing on the behavior of entrepreneurs, who need to hold assets for production because of the collateral constraint  $k \leq \lambda a$ .

*The individual's problem.*—The problem of an individual in period  $t$  can be written as

$$\max_{\{e_s, a_{s+1}\}_{s=t}^{\infty}} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{c_s^{1-\sigma} - 1}{1 - \sigma} \quad (2)$$

subject to

$$c_s + a_{s+1} \leq \max\{w_s, \pi(e_s, a_s; w_s, r_s)\} + (1 + r_s)a_s \quad \forall s \geq t,$$

where  $e_t$ ,  $a_t$ , and the sequence of wages and interest rates  $\{w_s, r_s\}_{s=t}^{\infty}$  are given, and  $\pi(e, a; w, r)$  is the profit from operating an individual technology. This indirect profit function is defined as

$$\pi(e, a; w, r) = \max_{l, k \leq \lambda a} \{f(e, k, l) - wl - (\delta + r)k\}.$$

Note that the collateral constraint  $k \leq \lambda a$  is taken into account. Similarly, we denote the input demand functions by  $l(e, a; w, r)$  and  $k(e, a; w, r)$ .

The max operator in the budget constraint stands for the occupation choice. A type  $e$  individual with current wealth  $a$  will choose to be an entrepreneur if his profit as an entrepreneur,  $\pi(e, a; w, r)$ , exceeds his labor income as a wage earner,  $w$ . This occupational choice can be represented by a simple policy function. Type  $e$  individuals decide to be entrepreneurs if their current wealth  $a$  is higher than the threshold wealth  $\underline{a}(e)$ , where  $\underline{a}(e)$  solves

$$\pi(e, \underline{a}(e); w, r) = w.$$

Intuitively, individuals of a given ability choose to become entrepreneurs only if they are wealthy enough to overcome the collateral constraint

<sup>9</sup> Our collateral constraint can be derived from the following limited enforcement problem. Consider an individual with financial wealth  $a \geq 0$  deposited in the financial intermediary at the beginning of a period. Assume that he rents  $k$  units of capital and then can abscond with fraction  $1/\lambda$  of the rented capital. The only punishment is that he will lose his financial wealth  $a$  deposited in the intermediary. In particular, he will not be excluded from any future economic activity. He is even allowed to instantaneously deposit the stolen capital  $k/\lambda$  and continue as a worker or an entrepreneur. In the equilibrium, the financial intermediary will rent capital only to the extent that no individual will renege on the rental contract, implying  $k/\lambda \leq a$ .

and run their businesses on a profitable scale. Similarly, individuals of a given wealth level choose to become entrepreneurs only if their ability is high enough.<sup>10</sup>

It is important to note that, with perfect credit markets, an individual's occupational choice will depend only on his entrepreneurial productivity,  $e$ . That is, there will be a cutoff level  $e_m$  such that  $\underline{a}(e) = 0$  for  $e \geq e_m$  and  $\underline{a}(e) = \infty$  for  $e < e_m$ .

*Competitive equilibrium.*—Given  $G_0(e, a)$ , a competitive equilibrium consists of allocations  $\{c_s(e_t, a_t), a_{s+1}(e_t, a_t), l_s(e_t, a_t), k_s(e_t, a_t)\}_{s=t}^\infty$  for all  $t \geq 0$ , sequences of joint distribution of ability and wealth  $\{G_t(e, a)\}_{t=1}^\infty$ , and prices  $\{w_t, r_t\}_{t=0}^\infty$  such that

1. given  $\{w_t, r_t\}_{t=0}^\infty$ ,  $e_t$ , and  $a_t$ ,  $\{c_s(e_t, a_t), a_{s+1}(e_t, a_t), l_s(e_t, a_t), k_s(e_t, a_t)\}_{s=t}^\infty$  solves the individual's problem in equation (2) for all  $t \geq 0$ ;
2. the labor, capital, and goods markets clear at all  $t \geq 0$ ; in particular,

$$\sum_{e \in \mathcal{E}} \mu(e) \left[ \int_{\underline{a}(e; w_t, r_t)}^\infty l(e, a; w_t, r_t) G_t(da|e) - G_t(\underline{a}(e; w_t, r_t)|e) \right] = 0$$

(labor market),

$$\sum_{e \in \mathcal{E}} \mu(e) \left[ \int_{\underline{a}(e; w_t, r_t)}^\infty k(e, a; w_t, r_t) G_t(da|e) - \int_0^\infty a G_t(da|e) \right] = 0$$

(capital market);

3. the joint distribution of ability and wealth  $\{G_t(e, a)\}_{t=1}^\infty$  evolves according to the equilibrium mapping

$$\begin{aligned} G_{t+1}(a|e) &= \psi \int_{u \leq a} \int_{a_{t+1}(e, v) = u} G_t(dv|e) du \\ &\quad + (1 - \psi) \sum_{\hat{e} \in \mathcal{E}} \mu(\hat{e}) \int_{u \leq a} \int_{a_{t+1}(\hat{e}, v) = u} G_t(dv|\hat{e}) du. \end{aligned}$$

*Perfect credit benchmark.*—With perfect capital rental markets, individuals' wealth is irrelevant for production decisions and the production side of our model aggregates. This aggregate production function represents the optimal allocation of individuals to entrepreneurship and of capital and labor to active entrepreneurs.

The aggregate production function simplifies to the following equation, with  $K$  denoting the aggregate capital stock:

<sup>10</sup> An individual's entrepreneurial productivity/ability ( $e$ ) may be so low that he will never choose to be an entrepreneur. In this case,  $\underline{a} = \infty$ .

$$F(K) = A(\mu)K^{\alpha(1-\nu)}, \quad (3)$$

$$A(\mu) = \max_{e_m, 0 \leq \iota \leq 1} \left[ \sum_{e > e_m} \mu(e) e^{1/\nu} + \iota \mu(e_m) e_m^{1/\nu} \right]^\nu \\ \times \left[ \sum_{e < e_m} \mu(e) + (1 - \iota) \mu(e_m) \right]^{(1-\nu)(1-\alpha)}.$$

Here  $A(\mu)$  embodies the effect of the distribution of entrepreneurial ability on aggregate output. The threshold level for entrepreneurship is  $e_m$ . Given that we are assuming a discrete distribution of  $e$ , the choice of  $\iota$  allows for the possibility that it may be optimal to assign only a fraction of the marginal ability types to entrepreneurship.

### III. Quantitative Analysis

The central objective of this paper is to construct a quantitative model of economic development that can capture and explain the rich macroeconomic transitional dynamics observed in the data. Motivated by the historical accounts of the seven miracle economies, we model the transitional dynamics as a process catapulted by a large-scale economic reform eliminating important sources of resource misallocation in the economy. We operationalize this idea by building on the recent literature that emphasizes the role of idiosyncratic distortions (Restuccia and Rogerson 2008; Hsieh and Klenow 2009; Bartelsman et al. 2013). In particular, our prereform state is the steady state of an economy in which individuals are subject to an exogenous process of idiosyncratic taxes and subsidies. We then model the large-scale reform as a once-and-for-all elimination of all such taxes and subsidies. We emphasize that these idiosyncratic taxes and subsidies are merely a means of generating the prereform state in a disciplined manner. They stand in for the industrial policies, protectionism, entry barriers, sector/size-dependent policies, and a web of onerous and often contradictory regulations, to name just a few, that have hindered economic development for many years. We also note from the historical accounts that these reforms were implemented amid underdeveloped financial markets.

#### A. Calibration

As a first step to quantify our theory, we calibrate a set of structural parameters—preferences, technology, distribution of entrepreneurial ability—that remain invariant throughout. We then calibrate a set of

parameters that may change over the course of transitions; these parameters govern idiosyncratic distortions and financial frictions. The robustness of our results to the particular calibration strategy adopted here is explored in Section III.C.5.

### 1. Parameters Invariant across Time and Economies

The entrepreneurial ability  $e$  is assumed to be a truncated and discretized version of a Pareto distribution whose probability density is  $\eta e^{-(\eta+1)}$  for  $e \geq 1$ .<sup>11</sup> Each period, an individual retains his previous entrepreneurial ability with probability  $\psi$ . With probability  $1 - \psi$ , he draws a new ability realization from the  $e$  distribution. This way,  $\psi$  controls the persistence of ability, while  $\eta$  determines the dispersion of the entrepreneurial productivity or ability in the population.

We here determine seven parameter values: two technological parameters,  $\alpha$  and  $\nu$ ; the depreciation rate  $\delta$ ; two parameters describing the ability process,  $\psi$  and  $\eta$ ; the relative risk aversion coefficient  $\sigma$ ; and the subjective discount factor  $\beta$ .<sup>12</sup>

We let  $\sigma = 1.5$  following the standard practice. The 1-year depreciation rate is set at  $\delta = 0.06$ . We choose  $\alpha = 0.33$ . We are thus left with three relatively nonstandard parameters— $\nu$ ,  $\eta$ , and  $\psi$ —and the subjective discount factor,  $\beta$ . We calibrate them using as many relevant moments in the US data. The moments are the employment share of the top decile of establishments by size, the earnings share of the top 5 percent of the population, the exit rate of establishments, and the real interest rate.

More specifically, we calibrate our model with perfect capital markets ( $\lambda = \infty$ ) to match these moments in the United States. We allow for the possibility that the average entrepreneurial productivity in the United States is higher than in less developed economies, reflecting human capital and exogenous aggregate productivity differences.<sup>13</sup> As the primary mechanism of our model concerns the allocation of resources among heterogeneous producers, our calibration and results are not affected by

<sup>11</sup> We discretize the support of the ability distribution into 40 grid points:  $\mathcal{E} = \{\bar{e}_1, \dots, \bar{e}_{40}\}$ . Denoting the cdf of the original Pareto distribution by  $M(e) = 1 - e^{-\eta}$ , we choose  $\bar{e}_1$  and  $\bar{e}_{38}$  such that  $M(\bar{e}_1) = 0.633$  and  $M(\bar{e}_{38}) = 0.998$ . Indexing the grid points by  $j$ , we construct  $\bar{e}_j$  to be equidistant from  $j = 1, \dots, 38$ . The largest two values on the grid are given by  $\bar{e}_{39}$  and  $\bar{e}_{40}$ , which satisfy  $M(\bar{e}_{39}) = 0.999$  and  $M(\bar{e}_{40}) = 0.9995$ . Finally, the corresponding probability mass  $\mu(\bar{e}_j)$  for  $2 \leq j \leq 40$  is given by  $[M(\bar{e}_j) - M(\bar{e}_{j-1})]/M(\bar{e}_{40})$  and  $\mu(\bar{e}_1) = M(\bar{e}_1)/M(\bar{e}_{40})$ .

<sup>12</sup> Recall that the entrepreneurial production technology is  $e(k^\alpha l^{1-\alpha})^{1-\nu}$ .

<sup>13</sup> That is, for the United States, the following production function can be used with  $A_{US} > 1$ :

$$f(e, k, l) = A_{US} e(k^\alpha l^{1-\alpha})^{1-\nu}.$$



such cross-country differences in the mean level of entrepreneurial productivity.<sup>14</sup>

Column 1 of table 1 shows the four relevant moments in the US data. The decile with the largest establishments in the United States (measured by employment) accounts for 67 percent of the total employment in 2000. We target the earnings share of the top 5 percent of the population (30 percent in 1998) and an annual establishment exit rate of 10 percent reported in the US Census Business Dynamics Statistics. Finally, as the target interest rate, we pick 4.5 percent per year.

Column 2 of table 1 shows the moments simulated from the calibrated model. Even though all four moments in the model economy are jointly determined by the four parameters, they tend to be differentially informative about the four parameters. Given the span-of-control parameter  $1 - \nu$ , the tail parameter of the entrepreneurial productivity distribution  $\eta$  can be inferred from the tail (or concentration at the top) of the employment distribution.<sup>15</sup> We can then infer  $\nu$  from the earnings share of the top five percentiles of the population. Top earners tend to be entrepreneurs both in the data and in our model, and  $\nu$  controls the share of output that goes to entrepreneurial input. These two parameters are set at  $\nu = 0.21$  and  $\eta = 4.15$ . The parameter  $\psi = 0.894$  leads to an annual exit rate of 10 percent in the model. Note that  $1 - \psi$  is larger than 0.1 because a fraction of those hit by the idea shock choose to remain in business: Entrepreneurs exit only if their newly drawn ability is below the equilibrium cutoff level. Finally, the model requires a discount factor of  $\beta = 0.904$  to attain an interest rate of 4.5 percent per year.

## 2. Parameters for Idiosyncratic Distortions and Financial Frictions

We model the initial condition of our transition exercises as the joint ability-wealth distribution in a stationary equilibrium under financial frictions and idiosyncratic distortions. We model the latter as individual-specific or idiosyncratic taxes/subsidies/wedges on output ( $\tau_{yi}$ ) that distort the static profit-maximization problem of entrepreneur  $i$  into

$$\max_{l_i, k_i \leq \lambda a_i} (1 - \tau_{yi}) e_i (k_i^\alpha l_i^{1-\alpha})^{1-\nu} - w l_i - (\delta + r) k_i.$$

<sup>14</sup> It is possible to introduce exogenous differences across countries in the higher-order moments of the entrepreneurial productivity distribution. The difficulty here is that the available data do not provide enough guidance or discipline on the direction and magnitude of cross-country variations in these moments. Even without exogenous differences in the higher-order moments of the underlying ability distribution, however, the financial frictions and idiosyncratic distortions in our model alter the distribution of ability among active entrepreneurs across economies.

<sup>15</sup> Our assumption is that one entrepreneurial operation in the model is one establishment in the data.

TABLE 1  
CALIBRATION

	US Data (1)	Model (2)	Parameter (3)
Top 10% employment	.67	.67	$\eta = 4.15, \nu = .21$
Top 5% earnings	.30	.30	$\eta = 4.15, \nu = .21$
Establishment exit rate	.10	.10	$\psi = .894$
Real interest rate	.045	.045	$\beta = .904$

The important distinction is that our financial frictions apply equally to everyone in the economy— $\lambda$  has no individual subscript—while  $\tau_{yi}$  is individual specific and is indexed by  $i$ . We could alternatively assume that idiosyncratic distortions take the form of taxes/subsidies on capital or labor input and still obtain similar results.

We reiterate here that  $\tau_{yi}$ 's are merely a parsimonious means of operationalizing the prereform distortions and their removal through a reform. We need not view them literally as taxes or subsidies.<sup>16</sup>

For the sake of parsimoniousness, we assume that  $\tau_y$  is a random variable with only two possible outcomes:  $\tau_+$  ( $\geq 0$ ) and  $\tau_-$  ( $\leq 0$ ). Also, the probability of being taxed for a type  $e$  individual,  $\Pr\{\tau_y = \tau_+ | e\}$ , is assumed to be  $1 - \exp\{-qe\}$ . Finally, we assume that the idiosyncratic distortions are also governed by the same  $\psi$  shock that determines the persistence of the entrepreneurial productivity. In fact, individuals in the prereform economy draw a new  $\tau_y$  exactly when they draw a new  $e$ .

Now we have three parameters,  $\tau_+$ ,  $\tau_-$ , and  $q$ , which are then chosen to match the following three moments. First, measured TFP relative to the United States increases by one-third after 20 years of postreform transitions when averaged across the seven transition episodes studied in Section I. Second, the capital-to-output ratios increase by 37 percent over the same 20-year span.<sup>17</sup> Finally, we impose a balanced budget on the prereform stationary equilibrium, requiring the tax revenues to equal the subsidy expenditures. While we do not think of the idiosyncratic distortions literally as taxes and subsidies, we consider this assumption a sensible benchmark. In the end, we have  $\tau_+ = 0.5$ ,  $\tau_- = -0.15$ , and  $q = 1.55$ , which implies that 14 percent of the population is eligible for a subsidy rate of 15 percent and the rest of the population is subject to a tax rate of 50 percent on their output.

As for the financial frictions parameter, we pick  $\lambda = 1.35$ , which corresponds to a steady-state external finance-to-GDP ratio of 0.6 in an econ-

<sup>16</sup> One interpretation is that the private returns to entrepreneurial productivity are distorted idiosyncratically by misguided government policies and interventions.

<sup>17</sup> The idea is that we fix the magnitude of long-run changes in TFP and capital-to-output ratios and evaluate the speed and shape of the model's transitional dynamics.

omy without idiosyncratic distortions. This number is the time average of the cross-country average external finance-to-GDP ratios over the period that begins 5 years before and ends 25 years after the reforms in Section I. In Section III.C.3, we also consider a gradual financial development (i.e., a sequence of  $\lambda$ 's that increase over time) that matches the evolution of the external finance-to-GDP ratios in the data.

Given the calibrated parameters, we compute the stationary equilibrium with idiosyncratic distortions and financial frictions. The resulting joint distribution of wealth and entrepreneurial productivity,  $G_0(e, a)$ , is the initial condition of our benchmark transition exercises in Section III.C.1. This joint distribution is characterized by more misallocation of wealth across the entrepreneurial productivity types compared with the stationary distribution of an economy without idiosyncratic distortions.

### *B. Long-Run Impact of Financial Frictions*

We first show the long-run effect of financial frictions on the equilibrium output, aggregate TFP, and interest rate.<sup>18</sup> We vary  $\lambda$ —the parameter governing the enforcement of capital rental contracts—from one (financial autarky) to  $\infty$  (perfect credit), which spans external finance-to-GDP ratios from zero to 1.74. This is the empirically relevant range. In Beck et al. (2000), the bottom quartile of the cross-country distribution of external finance-to-GDP ratios is 0.13, while this ratio for the United States, one of the most financially developed economies, is 1.75. The parameter  $\lambda$  itself has no immediate empirical counterpart. Hence we plot our model simulations against the endogenous external finance-to-GDP ratios implied by a given  $\lambda$  on the horizontal axis of figure 2. The equilibrium external finance-to-GDP ratio is monotonically increasing in  $\lambda$ , with a lower  $\lambda$  corresponding to more financial frictions. There are no idiosyncratic distortions in this analysis since we focus on the marginal effect of financial frictions in the long run.

The left panel of figure 2 plots the GDP and TFP in the steady state for a given  $\lambda$ . They are normalized by their respective values in the perfect credit case. In our model, the variation in financial frictions can reduce output per worker by 30 percent from the perfect credit level. This is tantamount to about half of the difference in output per worker between Mexico and the United States. The magnitude is nevertheless sizable, considering that we vary only one factor—financial markets—across countries. As in the data, the per capita income differences in our model are primar-

<sup>18</sup> For the model, TFP is defined as  $Y(K^\alpha L^{1-\alpha})^{-1}$ , with  $\alpha = 0.33$ . Here  $Y$  is aggregate output,  $K$  is aggregate capital, and  $L$  is the size of the labor force, which is normalized to one. This TFP construction is consistent with the TFP computation in the data (see App. B).

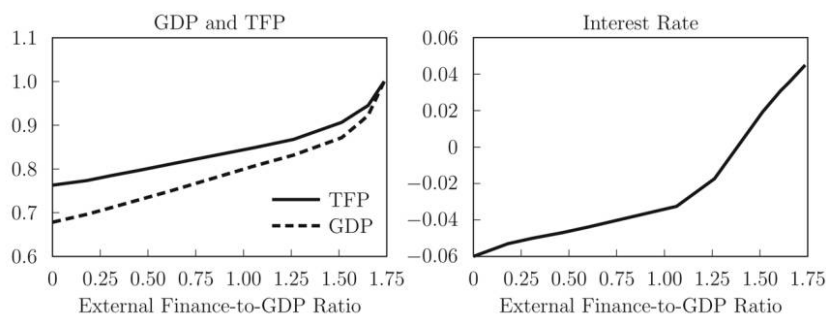


FIG. 2.—Long-run effect of financial frictions. The horizontal axes show the model-implied long-run external finance-to-GDP ratio for a given  $\lambda$ . The GDP and TFP series on the left panel are normalized by their respective values in the perfect credit economy ( $\lambda = \infty$ ).

ily accounted for by differences in TFP. Financial frictions can reduce aggregate TFP by 24 percent in our model.

These effects reflect the distortions on production decisions at the intensive and the extensive margins. Intuitively, financial frictions distort the allocation of productive capital among entrepreneurs in operation. Those with binding collateral constraints will operate at inefficiently small scales. Financial frictions also distort the entry and exit decisions of entrepreneurs: Productive but poor entrepreneurs delay entry until they can overcome financing constraints, and incompetent but wealthy ones remain in business. Such misallocation is captured in aggregate productivity measures and explains the lower output in economies with financial frictions.

The right panel of figure 2 shows that equilibrium interest rates are lower in economies with tighter collateral constraints (and hence less external financing). Tight collateral constraints (i.e., low  $\lambda$ 's), with other things held constant, restrict entrepreneurs' demand for capital (because  $k \leq \lambda a$ ) and at the same time increase their self-financing needs and hence saving rates (i.e., a larger supply of capital). Therefore, the equilibrium interest rate is lower. This prediction of our model is consistent with empirical findings and the prevalence of "financial repression" in less developed countries (McKinnon 1981).<sup>19</sup> The magnitude of the long-run impact of financial frictions in our model suggests that

<sup>19</sup> This result does not contradict the fact that the cost of capital could be higher in countries with higher financial intermediation costs. First, economies with higher intermediation costs tend to have a higher spread between deposit and lending rates. We could introduce this feature into our model without much difficulty, but it would not change our main results. Second, the quantity-constrained entrepreneurs in our model can be considered as being subject to a prohibitively high marginal (shadow) rental rate of capital.

they may also have a significant impact on macroeconomic transitions, which we confirm in the next section.

Before we proceed, we briefly discuss what parameterization or calibration of our economy is essential for financial frictions to have sizable effects on the stationary equilibrium. In particular, we focus on two parameters:  $\psi$ , which controls the persistence of shocks, and  $\eta$ , which controls the dispersion of entrepreneurial productivity.<sup>20</sup>

Shock persistence has two disparate effects. First, it determines what fraction  $(1 - \psi)$  of individuals will redraw their ability. If the economy is in a steady state, it can be interpreted as a measure of how much resource reallocation is needed each period, with a lower  $\psi$  implying more reallocation of production factors. Second, it determines the likelihood of talented but poor entrepreneurs overcoming collateral constraints over time by accumulating collateral (i.e., self-financing). It takes time to accumulate wealth or collateral; if the individual productivity is not persistent and hence the profitable opportunities are only short lived, self-financing is a less effective substitute for credit markets.

Therefore, with other things held equal, the less persistent the shocks are, the larger the impact of financial frictions. This intuition becomes even clearer in extreme cases. If the shock is completely permanent (i.e.,  $\psi = 1$ ), financial frictions have no impact whatsoever on the steady state: All the talented entrepreneurs eventually overcome the financial frictions by accumulating sufficient collateral, and there is no need to reallocate such resources among producers. At the other extreme, we worked out a version of our model with  $\psi = 0$ , where ability shocks are purely independent and identically distributed over time, again with all other parameters held constant. Going from perfect credit ( $\lambda = \infty$ ) to financial autarky ( $\lambda = 1$ ), we find a 61 percent drop in the steady-state GDP, which is nearly twice the impact of financial frictions in our calibration of  $\psi = 0.894$ .

The other parameter of interest is  $\eta$ , which controls the degree of heterogeneity in entrepreneurial productivity. The adverse effect of financial frictions in our model materializes through two channels: the misallocation of entrepreneurial talent (extensive margin) and the misallocation of capital (intensive margin). If there is more heterogeneity and dispersion in entrepreneurial ability (a lower  $\eta$ ), there is a larger extent to which talent can be misallocated, and hence the effect of financial frictions will be larger.<sup>21</sup>

<sup>20</sup> In Sec. III.C.5 we discuss the sensitivity of the transitional dynamics to these parameters.

<sup>21</sup> More dispersion in entrepreneurial ability necessitates more dispersion in the efficient scale of operation. As a result, there is also a larger extent to which capital can be misallocated among active entrepreneurs, leading to a larger impact of financial frictions along the intensive margin.

To quantify this intuition, we worked out a version of our model with  $\eta = 6.225$ , which implies less dispersion in entrepreneurial talent, with all other parameters held fixed at their levels in Section III.A.1. This 50 percent increase in  $\eta$  (from 4.15) translates into less concentration in the establishment size distribution. With perfect credit markets, the decile of the largest establishments accounts for 45 percent of the total employment, down from 67 percent in Section III.A.1. Now, going from perfect credit ( $\lambda = \infty$ ) to financial autarky ( $\lambda = 1$ ), we find a 27 percent drop in the steady-state GDP; that is, the impact of financial frictions on long-run GDP is about 15 percent smaller with  $\eta = 6.225$  than with  $\eta = 4.15$ .

### C. *Postreform Transition Dynamics*

#### 1. Benchmark Exercise: Removal of Idiosyncratic Distortions

In this exercise, we study the transitional dynamics triggered by a sudden, unexpected reform that eliminates all idiosyncratic distortions.<sup>22</sup> Once the reform is implemented, everyone correctly understands that it is a permanent change. We assume that domestic financial frictions remain the same (at  $\lambda = 1.35$ ) throughout the transition period. The reform experiences of the countries studied in Section I are consistent with this sequencing of reforms. Measured in both the *de jure* and the *de facto* sense, domestic financial market reforms lagged behind the removal of size-dependent or industry-specific taxes and subsidies (so-called first-generation reforms).

This is a very stark exercise, and it simplifies actual reform episodes, which tended to be more gradual. The removal of idiosyncratic distortions was often a protracted affair, even prone to temporary reversals in some cases. In addition, while financial market reforms were implemented much later and even more gradually than the first-generation reforms, financial markets did improve over time. Our framework can incorporate these facts, and indeed we consider a gradual financial development in Section III.C.3, which further strengthens our results.

Any additional exogenous dynamics regulated by the pace of reforms will provide more degrees of freedom and hence only help us even more closely match the empirical patterns of Section I. The advantage of our stark exercise is that the dynamics following the reform are wholly endogenous and intrinsic to the model, providing a theory of transitional dynamics built on resource misallocation and financial frictions.

<sup>22</sup> In the appendix of the working paper version of this paper (Buera and Shin 2010), we describe the numerical algorithms for computing the stationary equilibria and the transitional dynamics of the model.

Figures 3 and 4 show the transitional dynamics following the stark reform. We collate the model simulation results (black solid lines) with two other series: (i) the corresponding data from Section I (gray solid lines) and (ii) the transitional dynamics from a standard neoclassical model that is comparably calibrated (dotted lines). To be more specific, we use a version of our model with perfect capital rental markets ( $\lambda = \infty$ ), which is isomorphic to the standard neoclassical model. We then apply the calibration strategy of Section III.A.2 for  $\tau_+$ ,  $\tau_-$ , and  $q$  to construct the initial condition of this perfect credit transition: After 20 years of transition, TFP is one-third higher and the capital-to-output ratio is 37 percent higher, while the taxes and subsidies net out in the prereform steady state.

In figures 3 and 4, aggregate output, capital stock, and TFP are normalized by their respective levels in the prereform economy. Investment rates are reported as deviations from their prereform levels.

Three facts stand out. First, our model transition to the new steady state is slower than the neoclassical dynamics. As the left panel of figure 4 shows, it takes 10.5 years for capital stock to cover half the distance to the new steady state in our model, while it takes only 5.5 years in the comparable neoclassical model. In fact, the capital stock in the model is indistinguishable from the data for up to 7 years following the reform.

Second, the model generates endogenous TFP dynamics, although there is no additional exogenous change after the reform in year 0. This reflects more efficient reallocation of resources over time at both the extensive and the intensive margins as production shifts from the previously subsidized entrepreneurs to the productive entrepreneurs previously impeded by idiosyncratic taxes. The reallocation is gradual as it is intermediated through imperfect financial markets. On the contrary, with perfect credit markets, our model aggregates into a standard neoclassical growth model, which is devoid of endogenous TFP dynamics aside from the instantaneous jump reflecting the removal of the idiosyncratic distortions.<sup>23</sup>

Third, the model investment rate is hump shaped, in contrast to the monotonically decreasing pattern of the neoclassical model. This reflects the evolution of the joint distribution of wealth and entrepreneurial productivity, as well as individuals' heterogeneous saving behavior. We now explore these three facts in more detail.

In the prereform steady state, our initial condition for the transition, resources are misallocated partly because of the financial frictions and, more important, because of the idiosyncratic distortions. Subsidized

<sup>23</sup> The TFP of the perfect credit economy in the center panel of fig. 3 does show some movements. These dynamics are an artifact of the discrepancy between the capital elasticity we use for TFP computation,  $\alpha = 0.33$ , and the true elasticity of the aggregate production function,  $\alpha(1 - \nu) = 0.26$  (see eq. [3] and n. 18).



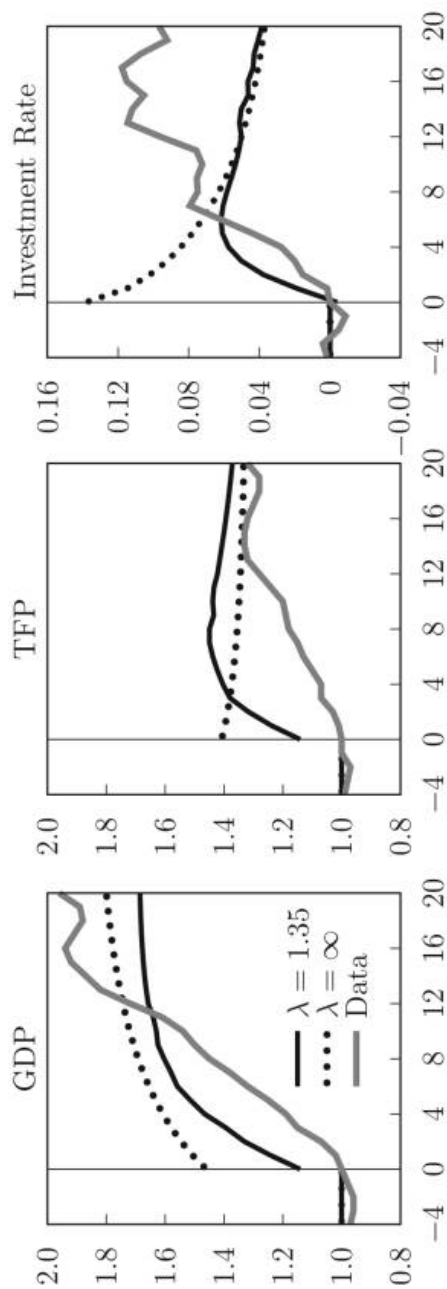


FIG. 3.—Benchmark transition: GDP, TFP, and investment rate. The black solid lines are the transitions from the benchmark exercise. For comparison, the transitional dynamics of a comparable neoclassical model are shown by the dotted lines, and the average of the economic miracles from Section I is represented by the gray lines (see App. B). The GDP and TFP series are normalized by their respective prereform values. Investment rates are shown as deviations from their prereform levels. The horizontal axes show years, and year 0 corresponds to the reform date.

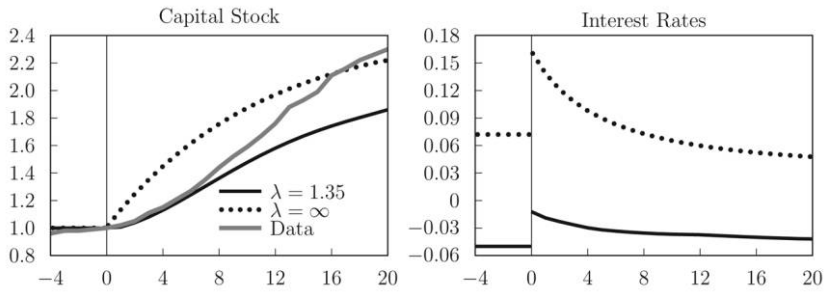


FIG. 4.—Benchmark transition: capital and interest rate. The black solid lines are the transitions from the benchmark exercise. Comparable neoclassical transition dynamics are shown by the dotted lines, and the evolution of the capital stock in the data, averaged across the miracle economies, is plotted by a gray solid line in the left panel (see App. B). The capital stock series are normalized by their respective prereform values. The horizontal axes show years, and year 0 corresponds to the reform date.

entrepreneurs run larger operations and accumulate more wealth than is warranted by their true productivity, while the opposite is true for taxed entrepreneurs. Idiosyncratic distortions also distort entry into entrepreneurship, propping up incompetent entrepreneurs with subsidies and restraining talented ones with taxes.

As we move forward from year 0, once the reform eliminates idiosyncratic distortions, resources are reallocated more efficiently. Reallocation occurs along two margins. First, capital and labor are reallocated among existing entrepreneurs (intensive margin). In addition, more productive entrepreneurs previously taxed out of entrepreneurship will enter into business, while previously subsidized incompetent entrepreneurs will exit (extensive margin). The reallocation along these two margins occurs gradually over time and is slowed by the frictions in the financial market: It takes time for a talented but poor entrepreneur to save the collateral needed to start a business and operate at a profit-maximizing scale.

This efficient reallocation process is reflected in the aggregate TFP, which increases over time. Because the reallocation is subject to the financial frictions, the increase in TFP exhibits protracted endogenous dynamics that reflect the interaction between the initial misallocation and financial frictions. GDP also increases following the reform, largely mirroring the early increase in TFP (during the first 6 years) and the accumulation of capital later (the next 15 years or so).

Figure 5 shows more detail of the reallocation at the extensive and the intensive margins. The left panel shows the average entrepreneurial productivity ( $e$ ) among active entrepreneurs, normalized by its prereform value. The average  $e$  increases gradually over time, reflecting the exit of the incompetent entrepreneurs who lose their subsidy and the entry of the productive entrepreneurs previously kept out by idiosyncratic taxes. The exits are not instantaneous because subsidized entrepre-

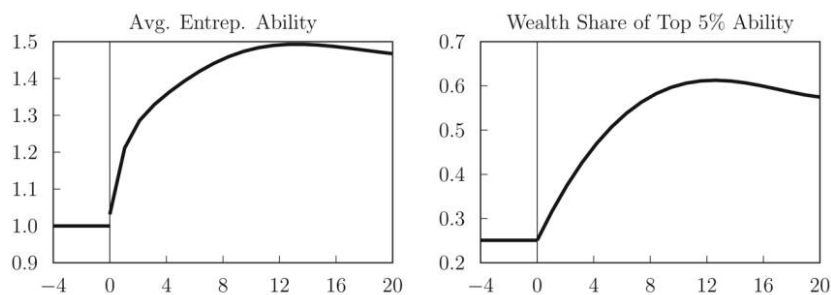


FIG. 5.—Benchmark transition at a disaggregate level. The left panel shows the average entrepreneurial productivity ( $e$ ) among active entrepreneurs in each period, normalized by its value in the prereform economy. The right panel plots the fraction of wealth held by the top 5 percent of the  $e$  distribution. The horizontal axes show years, and year 0 corresponds to the reform date.

neurs tend to be rich in the prereform economy, and their wealth offers them an advantage in entrepreneurship in the presence of the collateral constraints. Similarly, the entries are not instantaneous because taxed entrepreneurs tend to be poor in the prereform economy, and they need to save enough collateral to start producing on a profitable scale.

The reallocation of production factors at the intensive and the extensive margins influences—and is influenced through collateral constraints by—the evolving wealth distribution. The right panel of figure 5 shows the fraction of aggregate wealth held by those in the top 5 percent of the entrepreneurial productivity distribution.<sup>24</sup> Those in this group are either active or soon-to-be entrepreneurs after the reform. Our calibration of the idiosyncratic distortions implies that, immediately after the reform, such high- $e$  individuals tend to be relatively poor and financially constrained. Since wealth, by means of collateral constraints, enables entry and expansion of business, both their returns to saving and their saving rates are high. On the other hand, while those with low entrepreneurial productivity tend to be relatively wealthier, they are either workers or unconstrained small-scale entrepreneurs, and hence their returns to saving are much lower. As for workers, their wage will increase over time, and they will run down their wealth or try to borrow. As for entrepreneurs who lose their subsidies, their wealth will stop providing collateral services as they downsize and exit from entrepreneurship, and they too will run down their wealth. That is, they have low, even negative, saving rates. With such differences in saving rates, the wealth share of the top 5 percent of the  $e$  distribution rapidly rises from 25 percent in the prereform economy to 60 percent in 10 years. In our model, entrepreneurial profits are affected by wealth by means of the collateral constraint; as a result, the income share

<sup>24</sup> With the stochastic productivity process, the identities of those in this group change over time.

of these high- $e$  individuals parallels their wealth share (not shown in the figure).<sup>25</sup>

These very forces shape the hump in the investment rate dynamics. Note first that, since our model is a closed economy, the aggregate investment rate must equal the aggregate saving rate. We find it more illuminating to work with the saving side of the equation as follows. Because of the initial wealth distribution and the collateral constraints, the productive, high-saving entrepreneurs account for only a small fraction of the aggregate income in the early postreform periods. The aggregate saving rate is an income-weighted average of the individual saving rates, and as a consequence it starts low. Over time, the high- $e$ , high-saving entrepreneurs account for larger fractions of wealth and income, and the aggregate saving rate rises. Eventually, the diminishing marginal returns to capital take over, and even the saving rates of the high- $e$  entrepreneurs, who are now less likely to be financially constrained, start to fall over time, spanning the downward arc of the aggregate saving rate.

These investment rate dynamics are embedded in the transition of aggregate capital, which barely increases for the first 2 years following the reform, only to accelerate later and eventually decelerate into the new steady state. It takes 10.5 years to cover half the distance to the new steady state, which is almost half the speed of the comparably calibrated neoclassical model (i.e., our model with perfect credit markets).

By contrast, with perfect credit markets, once the idiosyncratic distortions are eliminated, the evolution of the wealth distribution is irrelevant for transitional dynamics except for the first moment (aggregate capital). Thus, any misallocation in the initial condition is irrelevant for transitional dynamics. The standard features of the neoclassical transitions are confirmed (the dotted lines in figs. 3 and 4). First, the transition is fast, with a half-life of 5.5 years for the aggregate capital stock. Second, since the initial capital stock is now less than half of the new steady-state level, the marginal product of capital is high initially and falls over time with capital accumulation. This explains the monotonically decreasing interest rates—from an unrealistically high level—and the same pattern in the investment rate.

In table 2 we quantify and compare the performance of our model with and without financial frictions by measuring the distance between the model transition dynamics and the data from the economic miracles. We use root mean squared errors as our distance measure. The dis-

<sup>25</sup> Figure 5 also agrees with a unique micro-level prediction of our model. Although the unavailability of data rules out direct empirical evidence on average entrepreneurial productivity or wealth shares by entrepreneurial ability, in Sec. IV we present indirect evidence of fig. 5 by compiling data on the evolution of the average establishment size during the economic miracles.

TABLE 2  
MODEL DISTANCE TO DATA, RELATIVE TO PERFECT CREDIT TRANSITION

	Output	Investment Rate	TFP
5 years	.51	.23	.76
20 years	.70	.64	1.01

tance between the benchmark transition with financial frictions and the data (i.e., the black and the gray lines in fig. 3) is then divided by the distance between the perfect credit transition and the data (i.e., the dotted and the gray lines). We compute this relative root mean squared error for output, investment rates, and TFP (reported columnwise in table 2). We consider the first five postreform years (first row of table 2) and then the first 20 years (second row), equally weighting all periods to compute the root mean squared errors.

The transitional dynamics of our model with financial frictions are significantly closer to the data than are the perfect credit or neoclassical dynamics. The model is particularly successful in the early stages of the transitions, reducing the distance by about 50 percent for output, 75 percent for investment rates, and 25 percent for TFP.<sup>26</sup> The performance is weaker if we consider the entire 20 years of the postreform transitions. The root mean squared error is smaller with financial frictions than without—by 30 percent for output and 35 percent for investment rates—but the model with financial frictions does not do a better job of explaining the TFP dynamics. Our model performs better in the short run than in the medium run because we are modeling the reform of year 0 as too precipitous an event: the unanticipated once-and-for-all elimination of all idiosyncratic distortions. As shown in Section III.C.3, introducing a gradual exogenous dynamics into the model can generate a more protracted dynamic and, as a consequence, enhance the overall fit of the model to the data.

In summary, the rich dynamics in the benchmark exercise are driven by the financial frictions slowing the reallocation of initially misallocated resources. In the absence of financial frictions, initial misallocation becomes irrelevant as soon as idiosyncratic distortions are eliminated, and our model aggregates to a standard neoclassical growth model. In other words, the history of misallocation does not persist.

<sup>26</sup> The relative distance for investment rates may sound impressive, but it still does not do justice to the model’s capability of generating the right shape that eludes the standard neoclassical model.

## 2. Initial Condition without Idiosyncratic Distortions: Technology Shock

We now show that the initial misallocation of wealth and entrepreneurial ability is also necessary for the rich transitional dynamics in the benchmark exercise. To emphasize the interaction between initial misallocation and financial frictions, we construct an initial condition with the same degree of misallocation as the new steady state. Achieving the same degree of resource misallocation before and after the transition requires us to rule out any reform that reduces idiosyncratic distortions. However, we still need to devise a way to (i) generate the difference between the initial and the new steady states and (ii) trigger the transition from the former to the latter state. We use a permanent, proportional change in the entrepreneurs' production functions. Since our interest is in isolating the role of initial misallocation, we hold fixed the degree of financial frictions before and after the transition at  $\lambda = 1.35$ , as in our benchmark exercise.

More specifically, we construct the initial condition by computing the steady state of an economy with  $\lambda = 1.35$  and no idiosyncratic distortions. Starting from this initial condition, we assume that the economy is hit in year 0 by a sudden, unexpected permanent technology shock that increases all individuals' productivity proportionately by one-third, the magnitude by which the measured TFP increased in the transition of Section III.C.1. Figure 6 shows the resulting transitional dynamics.

Compared with the benchmark exercise, the transition is faster; aggregate capital covers half the distance to the new steady state in 8 years (rather than 10.5), although the degree of financial frictions is the same in both exercises ( $\lambda = 1.35$ ). What is more interesting, the investment rate jumps up and declines over time, as in the neoclassical transition. Furthermore, because the degree of misallocation is constant over time here (i.e., no change in idiosyncratic distortions or  $\lambda$ ), the measured TFP exhibits no meaningful endogenous dynamics aside from the jump caused by the exogenous aggregate productivity shock.

In summary, this exercise considers a transition along which the degree of misallocation is constant. The transitional dynamics are qualitatively similar to the neoclassical dynamics, even though the transition is subject to financial frictions. Since there is no notion of misallocation being unwound through the imperfect financial market, financial frictions have little impact on the transition dynamics. In other words, there is no history to be prolonged by financial frictions.

The rich dynamics of Section III.C.1 capture the interaction between the force unwinding the initial misallocation (e.g., a reform that removes idiosyncratic distortions) and the financial frictions that slow this force. If either is missing, the transitions are at least qualitatively indistinguishable from standard neoclassical dynamics.

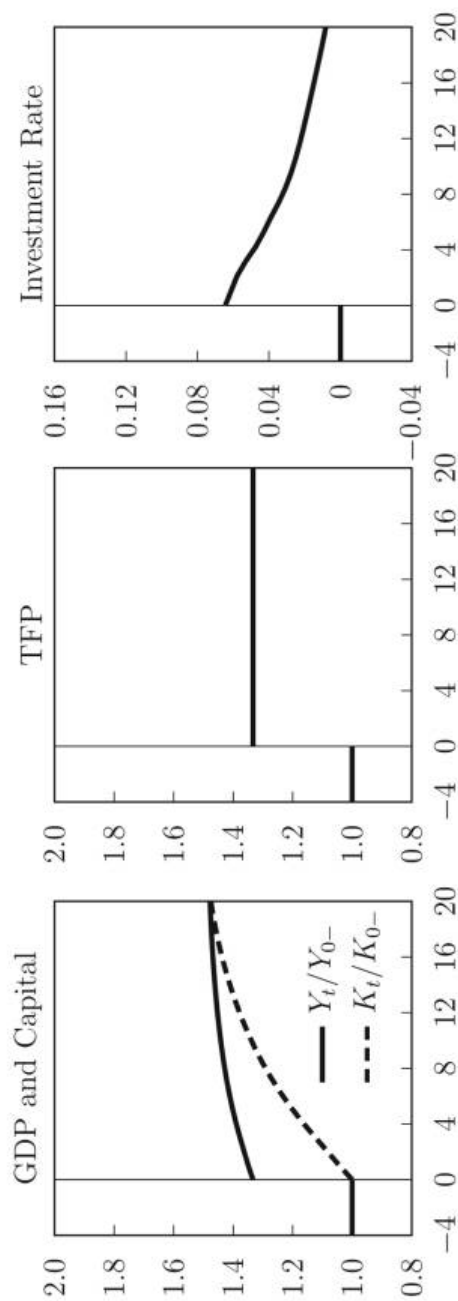


FIG. 6.—Transition with no reduction in misallocation. GDP, capital, and TFP are normalized by their respective values in the initial state. Investment rates are shown as deviations from the initial level. The horizontal axes show years, and year 0 marks the arrival of the positive aggregate productivity shock.



### 3. Reform and Financial Development

The benchmark exercise assumes that idiosyncratic distortions are eliminated all at once and that financial frictions remain the same throughout. These assumptions are made to better understand and emphasize the endogenous transition dynamics intrinsic to the model. At the same time, we acknowledge that actual reforms tended to be more gradual and domestic financial markets did improve over time—albeit at a slower pace than reforms in other dimensions. Here, we relax the second assumption and incorporate an exogenous financial development process, which is calibrated to the observed increase in measures of financial intermediation along the growth experiences in Section I.

To match the external finance-to-GDP ratio in the prereform period, we begin with  $\lambda = 1.13$ . We assume that the prereform economy is the steady state with  $\lambda = 1.13$  and with idiosyncratic distortions. The idiosyncratic distortions are calibrated to the same set of moments as in Section III.A.2. In year 0, we maintain the assumption that all idiosyncratic distortions are removed at once. In addition, we assume now that  $\lambda$  increases linearly from 1.13 to 1.55—where it then stays permanently—over the next 20 years, which implies an increase in the external finance-to-GDP ratio from 0.3 to 0.86, which also takes 20 years in the data. We assume that individuals in the model have perfect foresight about this exogenous  $\lambda$  process.

Figure 7 shows the transitional dynamics. The results are qualitatively similar to the benchmark results in Section III.C.1. With a linearly increasing  $\lambda$ , this exercise has more financial frictions than the benchmark exercise exactly when the economy has the most misallocation (i.e., right after the reform). Not surprisingly, the reallocation and the transitions are slower here, especially immediately following the reform. It takes 13 years (rather than 10.5) for the aggregate capital to reach the halfway point to the new steady state. The investment rate also rises more gradually than in the benchmark exercise since the more severe financial frictions in early stages slow the growth of productive but poor entrepreneurs.

Following the lines of the calculations in table 2, table 3 shows the distance between the transitional dynamics of this section and the data, relative to the distance between the perfect credit transition and the data. A comparison of tables 2 and 3 shows that the gradual financial development significantly improves the model fit across the board, with the exception of the 5-year investment rates. The improvement is especially remarkable in the medium run (20 years) because now the additional exogenous dynamics in  $\lambda$  prolong the reallocation process even further than in the benchmark exercise.

In summary, this exercise makes two points. First, our framework is rich enough that we can accommodate the exogenous paths of financial

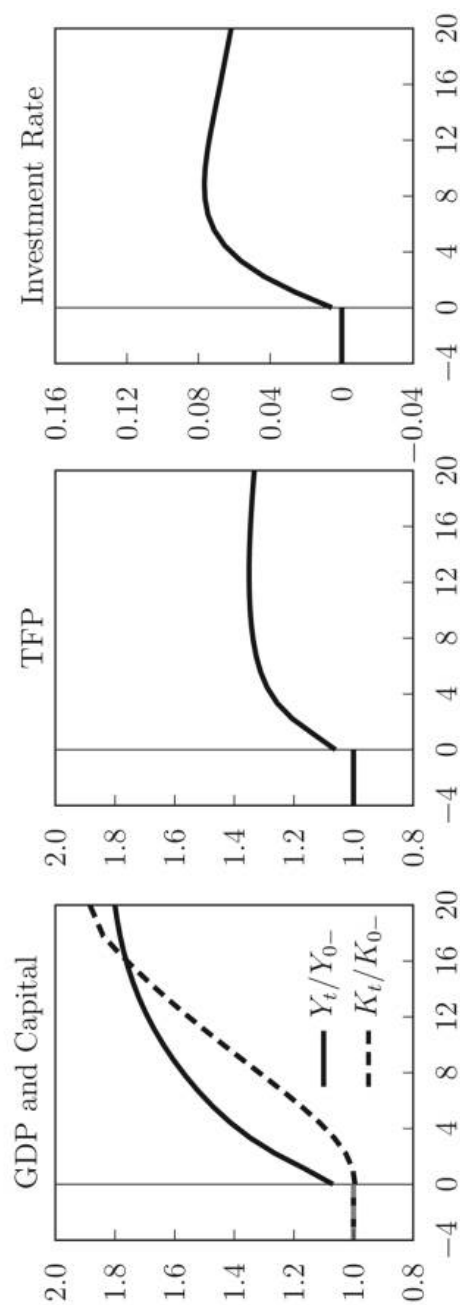


FIG. 7.—Transitional dynamics with gradual financial development. GDP, capital, and TFP are normalized by their respective values in the prereform state. Investment rates are shown as deviations from the prereform level. The horizontal axes show years, and year 0 marks the elimination of all idiosyncratic distortions and the beginning of the linear trend in  $\lambda$ .

TABLE 3  
MODEL DISTANCE TO DATA, RELATIVE TO PERFECT CREDIT TRANSITION FOR THE CASE OF  
REFORM AND FINANCIAL DEVELOPMENT

	Output	Investment Rate	TFP
5 years	.34	.28	.43
20 years	.47	.45	.59

frictions and, similarly, of the reforms that reduce idiosyncratic distortions. Second, the gradual financial development in the data strengthens our quantitative results, as it implies that financial markets are at their worst precisely when the economy has the most misallocation to be unwound through them.

4. Postreform Transition with Capital Flows

So far, we have considered only general equilibrium models of economic transitions. Financial frictions limit entrepreneurs’ external sources of capital and give such constrained entrepreneurs an extra reason to save: self-financing. As shown in Section III.B, the effects on the demand and supply in the capital market drive down the equilibrium interest rate.

If we assume that the world interest rate is determined by a large country with fully developed financial markets (i.e., perfect credit markets), this rate is—at 4.5 percent per year—higher than the interest rates along the benchmark transition (see the right panel of fig. 4). This implies that, if an economy in transition were to open up to capital flows, capital would flow out of it. We study the impact of the higher interest rate and the resulting capital outflows on the postreform transitional dynamics by executing the benchmark exercise for a small open economy.

We use the same initial condition as in our benchmark exercise in Section III.C.1. That is, we assume that the economy is closed before year 0. In year 0, a reform eliminates all idiosyncratic distortions and liberalizes capital flows at the same time, taking as given the prevailing world interest rate. We also assume that local financial frictions remain as before ( $\lambda = 1.35$ ) throughout the transition. Finally, we assume that labor is not mobile across countries.<sup>27</sup>

Figure 8 shows the results for the transitional dynamics. The most important implication for the open-economy transition is that capital flows out: At the new high interest rate, the demand for capital by domestic entrepreneurs falls far short of the asset holdings of domestic residents (i.e., the supply of capital), and the excess capital goes overseas. In fact, the capital used for domestic production is smaller here than in

<sup>27</sup> This section is related to another paper of ours (Buera and Shin 2011a), in which we study the interaction between local and international financial markets.

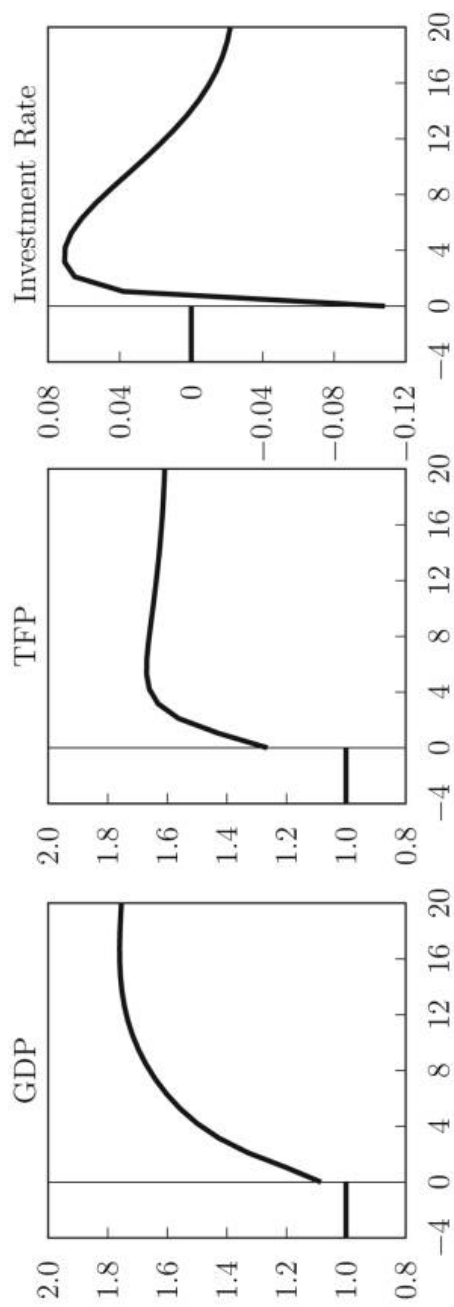


FIG. 8.—Transitional dynamics of a small open economy. GDP and TFP are normalized by their respective values in the prereform state. Investment rates are shown as deviations from the prereform level. The horizontal axes show years, and year 0 is the timing of the reform that removes all idiosyncratic distortions and opens the economy to international capital flows.

the benchmark closed-economy exercise, both during the transition and in the new steady state, primarily because of the higher capital rental rate. On the other hand, TFP is higher in the open-economy case than in the closed-economy benchmark for two reasons. First, the higher capital rental rate, other things held equal, makes entrepreneurship less profitable, which drives out entrepreneurs with marginal productivity. Second, the higher interest rate allows the poor but talented entrepreneurs to save faster as they receive more interest income. Both forces imply better allocation of entrepreneurial talents into active entrepreneurship, which is then reflected in the aggregate TFP.

## 5. Sensitivity Analysis

We now explore the robustness of our results to alternative calibration strategies. We first consider different degrees of resource misallocation in the prereform states. We then vary the span of control ( $1 - \nu$ ) and the parameter controlling the persistence of entrepreneurial productivity ( $\psi$ ) to investigate their impact on the transition dynamics.

*Initial conditions.*—From the discussion in Section III.C.2, we conclude that the misallocation of capital and talent in the initial condition is an important determinant of the transitional dynamics of the model. In Section III.A.2, we constructed the initial misallocation by imposing idiosyncratic distortions on the prereform economy.<sup>28</sup> For the benchmark exercise in Section III.C.1, in the prereform economy 14 percent of the population is eligible for a subsidy rate of 15 percent ( $\tau_- = -0.15$ ) and the rest of the population is subject to a tax rate of 50 percent on their output ( $\tau_+ = 0.5$ ). The idiosyncratic taxes and entrepreneurial productivity are positively correlated through  $q$ , implying that less productive individuals are more likely to be subsidized. In fact, more than 20 percent of the lowest-productivity types receive subsidies, while less than 1 percent of those in the top five productivity percentiles receive them.

It is natural to question the sensitivity of the transitional dynamics of the model to the changes in initial conditions. In particular, we ask whether the model still generates a slow transition, endogenous dynamics of TFP, and hump-shaped investment rates with different values of  $\tau_+$ ,  $\tau_-$ , and  $q$ .

To address this question, we consider two new distributions of idiosyncratic distortions in which taxes are lower and even smaller fractions of the population receive larger subsidies. In the first case, we simply lower the tax rate to  $\tau_+ = 0.4$  and then choose the subsidy rate,  $\tau_- =$

<sup>28</sup> The initial condition is constructed with three parameters ( $\tau_+$ ,  $\tau_-$ , and  $q$ ) to satisfy as many moment conditions: a TFP increase of 33 percent and a 37 percent increase in the capital-to-output ratio over 20 years of postreform transitions, and a balanced government budget in the prereform periods.

−0.79, and the parameter governing the probability of being taxed for a given  $e$  type,  $q = 2.89$ , to satisfy two moment conditions: The TFP in the postreform steady state is one-third higher than in the prereform initial state, and the government budget is balanced in the prereform economy. These parameters imply that less than 4 percent of the population receives the now-larger subsidy and the subsidy is even more concentrated among the low-productivity types. In the second case, we consider idiosyncratic taxes that are even lower and subsidies that are even more concentrated by setting  $\tau_+ = 0.3$  and then recalibrating  $\tau_- = -2.6$  and  $q = 5.94$  to satisfy the same two moment conditions. In this case, less than 1 percent of the population receives subsidies, and the recipients are even more likely to have low entrepreneurial productivity.

As shown in figure C1 in Appendix C, the transitional dynamics emanating from these two new initial conditions closely mimic our benchmark result. The transition is slower than in the neoclassical growth model, with the aggregate capital stock taking 10 and 8 years, respectively, to cover half the distance to the new steady state. There also are endogenous dynamics of TFP, mirroring the efficient reallocation of capital and entrepreneurial talent, whose speed is limited by the financial frictions.

Although the aggregate TFP in all three cases (the benchmark and the two new initial conditions) is constructed to be the same initially, the degrees of misallocation at the microeconomic levels are different. Intuitively, since the highest-productivity types are taxed the most in all three cases, lower taxes imply less misallocation of capital and talent despite the more skewed subsidies. This helps explain the behavior of investment rates. As noted in Section III.C.1, the initial misallocation of capital is the cause of the initial rise in investment rates. With lower taxes and less misallocation in the initial condition, the investment rate series flattens out. Indeed, with  $\tau_+ = 0.3$ , the investment rates are monotonically decreasing over time. However, as figure C1 shows, the capital-to-output ratios for the initial conditions with a lower  $\tau_+$  are too high compared with the data.<sup>29</sup>

*Span of control.*—In the calibration in Section III.A.1, we jointly determine the span of control ( $1 - \nu = 0.79$ ) and the tail parameter of the talent distribution ( $\eta = 4.15$ ) to match the concentration of earnings and employment in the US data. We concede that, in contrast to the model, not all top earners are entrepreneurs in the data and ask how the transitional dynamics will change with different values of these two parameters.

<sup>29</sup> Recall that the prereform TFP is calibrated to be the same across the three cases, but their initial capital stock and output are different because we have relinquished our moment condition on the capital-to-output ratios to consider different values of  $\tau_+$ .

In particular, we recalculate the transitional dynamics for two additional economies, one with a larger span of control and the other with a smaller span of control. In both cases, we ignore earnings concentration as a target moment, but we recalibrate the tail parameter of the talent distribution so that, with perfect credit, we match the employment concentration in the US data. The first of these two economies has  $1 - \nu = 0.88$  and  $\eta = 7.01$ ; the other has  $1 - \nu = 0.72$  and  $\eta = 3.16$ . Intuitively, with other things held equal, a larger span of control implies more employment concentration at the top, and we need smaller dispersion in the entrepreneurial talent distribution (i.e., higher  $\eta$ ) to match the employment data. To construct their prereform states, we fix  $\tau_+ = 0.5$ , which is the value in our benchmark exercise. We then choose the subsidy rates ( $\tau_-$ ) and the parameter controlling the type-specific probability of being taxed ( $q$ ) so that (i) the TFP in the postreform steady state is one-third higher than in the initial condition and (ii) the government budget is balanced in the prereform economy. The corresponding  $\tau_-$  and  $q$  are reported in Appendix C.

We find that the span-of-control parameter has a significant impact on the speed of the postreform transitions. As figure C2 in Appendix C shows, the transitions are faster with the smaller span of control and higher entrepreneurial income share ( $1 - \nu = 0.72$ ). The output, TFP, capital, and investment rate are all accelerated versions of the respective series in the benchmark exercise, with the half-life of aggregate capital almost 2 years shorter. The reason is as follows. The postreform transition is a process of reallocating capital and entrepreneurial talent more efficiently, and, in the presence of financial frictions, self-financing by productive entrepreneurs is an important element of this process. A smaller span of control means a larger income share for entrepreneurs, which in turn implies that constrained entrepreneurs can accumulate assets more quickly to overcome collateral constraints.

The opposite is true with a larger span of control. In this case, the dynamics of output, TFP, and capital are all substantially slower than in the benchmark exercise, with the half-life of aggregate capital longer by more than 2 full years. We note that, if we were to use a larger span-of-control parameter, which is often favored in the literature (Cagetti and De Nardi 2006; Restuccia and Rogerson 2008), our model would perform even better in terms of explaining the slow transitions in the data. However, the larger span of control produces an investment rate series that is too flat—albeit still hump shaped—compared with the data.

*Persistence of entrepreneurial productivity.*—The probability of an individual retaining his entrepreneurial productivity from one period to the next,  $\psi$ , has an important impact on the evolution of the joint distribution of wealth and talent in our model. Through the collateral constraint, this parameter then determines the degree to which capital and



entrepreneurial talent are misallocated in the stationary equilibrium and the speed with which the initial misallocation of resources unwinds.

As discussed in Section III.B and in a related paper (Buera and Shin 2011b), persistent shocks (i.e., higher  $\psi$ ) help productive entrepreneurs overcome financial constraints over time through self-financing, and the adverse impact of financial frictions on the long-run macroeconomy decreases with  $\psi$ .<sup>30</sup> On the other hand, Moll (2012) uses a related model and shows that transitional dynamics are slower when shocks are more persistent.

In our benchmark exercise, we calibrate  $\psi = 0.894$  to match the annual establishment exit rate in the United States (0.1). Acknowledging the possibility that the shock persistence may not be best identified by this rate, we consider  $\psi = 0.788$ , which halves the average duration of entrepreneurial productivity relative to the benchmark, and  $\psi = 0.945$ , which doubles the average duration. In each case, we construct the initial condition by fixing  $\tau_+ = 0.5$  and then choosing  $\tau_-$  and  $q$  to (i) make the TFP in the new steady state one-third higher than in the initial condition and (ii) balance the government budget in the prereform state. The implied  $\tau_-$  and  $q$  are reported in Appendix C.

We find that the transitions are faster with the lower  $\psi$  and slower with the higher  $\psi$ . The differences in speed are rather moderate; the half-life of aggregate capital differs at most by 1 year (see fig. C3 in App. C).

Considering the extreme cases of  $\psi = 0$  and  $\psi = 1$  may be useful in understanding these differences. Recall that the postreform transition involves the reallocation of wealth from incompetent, previously subsidized entrepreneurs to productive but poor entrepreneurs. When  $\psi = 0$ , after the first postreform period, wealth and ability are always uncorrelated. In this sense, all the reallocation of wealth that is bound to happen along the transition is completed in just one period. To the contrary, when  $\psi = 1$ , the entrepreneurial productivity is constant over time. The reallocation of wealth occurs only through the asset accumulation of those talented entrepreneurs who are initially undercapitalized and the asset decumulation of those who are incompetent but initially wealthy. Clearly, this is a gradual process.

## 6. Summary of Transition Exercises

The rich transitional dynamics observed during the economic miracles cannot be explained by the standard neoclassical model. We account for these dynamics as a process of unwinding resource misallocation, the

<sup>30</sup> In the extreme case of  $\psi = 1$ , where entrepreneurial productivity is constant over time, all entrepreneurs eventually accumulate enough wealth to operate at their unconstrained optimal scale. That is, financial frictions have no long-run impact on aggregate output or TFP.

speed of which is determined by the degree of imperfections in financial markets.

We have shown that two ingredients are responsible for the rich transitional dynamics. First, there must exist some misallocation to be unwound over time. Second, such reallocation must be intermediated through a financial market with frictions. In the benchmark exercise in Section III.C.1, the removal of idiosyncratic distortions in year 0 constitutes the former situation, and the collateral constraint of  $\lambda = 1.35$  embodies the latter. As a result, we obtain endogenous transitional dynamics that are similar to those in the data.

We have also considered a reform exercise with perfect credit markets. The economy is isomorphic to the standard neoclassical model, as are the resulting transitional dynamics. In the exercise in Section III.C.2, the degree of misallocation does not change during the transition from the prereform to postreform periods. Although there are financial frictions throughout the transition, there is no reallocation process to complete, and the postreform transitions are qualitatively and quantitatively similar to the standard neoclassical dynamics. In Section III.C.3, we have shown how the model can incorporate exogenous dynamics—of financial frictions or idiosyncratic distortions—to better match the transitional dynamics in the data.

#### IV. Evidence in Micro-Level Data

Our model provides a quantitative framework for the macroeconomic transitions following large-scale growth-enhancing reforms. In addition, the microeconomic heterogeneity in our model produces many micro-level implications that the standard neoclassical model with a representative firm cannot address. In this section, we evaluate some of these implications against available data.

Because of the idiosyncratic distortions in the prereform economy, productive entrepreneurs are more likely to be taxed, and hence they control a smaller fraction of the aggregate capital and labor than is warranted by their productivity. Following a reform that removes such distortions, capital and labor are reallocated toward more productive producers. (Recall the discussion of fig. 5.) The reallocation of resources toward productive entrepreneurs entails an increase in the average establishment size along the postreform transitions, because higher entrepreneurial productivity implies a larger scale of production, all else equal.

In this section, we present evidence supporting our model in these dimensions. First, in the data from the reform episodes, we show a substantial and persistent reallocation of production factors across different industrial sectors and from state-owned production units to those in

the private sector. Second, we document a persistent rise in the average establishment size in the years following the reforms. Finally, we consider direct measures of idiosyncratic distortions and their evolution in China and India.

*Reallocation after reforms.*—As described in Appendix A, one salient theme for all the reform episodes is the dismantling of import substitution regimes, that is, tariffs and subsidies protecting relatively inefficient sectors. More broadly, the reforms were market oriented in the sense that they involved a substantial retrenchment of the government's intervention in the economy. Some evidence of resource reallocation from entrepreneurs in previously protected industries to those in export-oriented sectors and from state-owned enterprises to those in the private sector is to be expected.

First, in the absence of plant-level data on factor reallocation, we construct and report measures of the reallocation of labor and production across manufacturing sectors using all available data. In particular, we use the United Nations Industrial Development Organization (UNIDO) data on the employment share of two-digit manufacturing sectors. The data are available for five of the seven miracle economies we study: China, Japan, Korea, Malaysia, and Singapore. We compute the gross reallocation of labor across two-digit manufacturing sectors by summing the absolute values of the year-to-year changes in each industry's employment share. For Taiwan, which is not included in the UNIDO data, we use its sector-level GDP data to compute an analogous measure of reallocation across manufacturing sectors. The left panel of figure 9 shows the labor reallocation measures for the six countries after normalizing the measures by their respective long-run average (the average over years 20–40 after each reform). The gray solid line is the unweighted average across the six countries. The reallocation measures are highest around the reform date (year 0), between one-and-a-half and three times their long-run values, with the cross-sectional average twice its long-run value. The measures then decline over time.<sup>31</sup>

For comparison, we also show the labor reallocation along our benchmark transition in Section III.C.1. Our model is a one-sector model, and we cannot construct an identical sectoral reallocation measure. Instead, we compute the year-to-year gross reallocation of labor across establishments, which is then normalized by its level in the new steady state (plotted with a black solid line in the left panel of fig. 9). The labor

<sup>31</sup> The long-run average of our gross labor reallocation measure is 5 percent averaged across the six countries; this average is larger than that of the United States. Over the postwar periods, our average gross labor reallocation measure for the United States is 2.5 percent, with a standard deviation of 1 percent. There is no clear time trend for the United States, although our measure is highest, unsurprisingly, right after the Second World War.

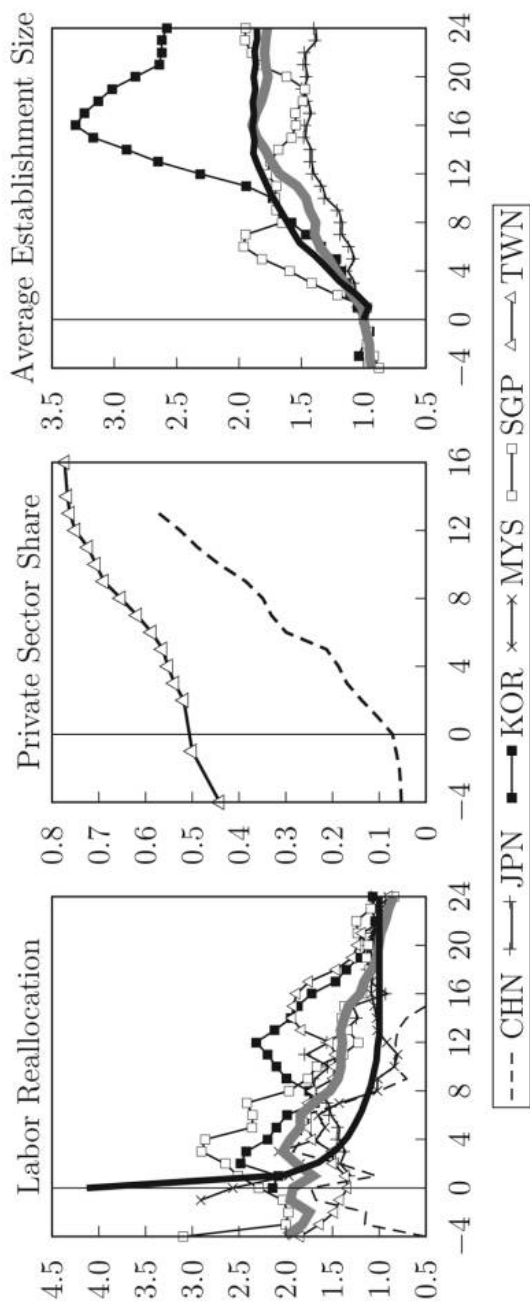


FIG. 9.—Micro-level evidence. Labor reallocation is normalized by the respective long-run levels. The center panel shows the fraction of industrial production (Taiwan) and employment (China) accounted for by the private sector. The average establishment size is normalized by the respective prereform levels. The solid black lines in the left and the right panels show the model predictions, while the solid gray lines show the unweighted average across the countries for which data are available. See Appendix B for a detailed description. The horizontal axes show years, and year 0 corresponds to each economy's reform date.

reallocation measure during the first few years after the reform is quite high; it starts from four times its long-run value. While not directly comparable, the labor reallocation measures in the data and in the model confirm that the mechanisms in our theory at least qualitatively capture the reallocation of production factors across production units following large-scale reforms.<sup>32</sup>

As for the observation that the reforms diminished governments' control of production activities, the relevant data are available only for China (in terms of employment) and Taiwan (in terms of industrial production; see the center panel of fig. 9). In both cases, the growth of the private sector accelerates after the reform (year 0), with a particularly sharp break for China. Within 10 years of the reform, the fraction of Taiwanese industrial production accounted for by private enterprises rises from 50 percent to 75 percent.<sup>33</sup> For the same time horizon in China, the fraction of employment accounted for by private enterprises rises from about 5 percent to more than 40 percent. In summary, consistent with the underlying mechanism of our model, the reform episodes identified in Section I had an important impact not only on the aggregate measures (e.g., GDP and TFP) but also on the measures designed to capture the economic changes at a more disaggregate level.

*Evolution of average establishment size.*—Also lending support to the mechanisms emphasized in our theory is the evolution of the establishment size distribution after reforms. We define the size of an establishment as the number of its employees. In our model, the unconstrained maximal-profit scale of an establishment is positively correlated with the operating entrepreneur's productivity. If the prereform distribution of wealth and entrepreneurial productivity is characterized by substantial misallocation between them, then immediately following the reform, productive entrepreneurs will be financially constrained and hence will operate either small plants or none at all. On the other hand, wealthy and unconstrained entrepreneurs tend to be not as talented and choose to operate commensurately small establishments. Over time, as productive entrepreneurs accumulate wealth and overcome the financing constraints, they will operate larger establishments, thereby driving up the average establishment size.

<sup>32</sup> In the data, the reallocation measure is often high even before our identified reform dates (year 0). This may be an indication that reforms did not occur as suddenly as in our exercises but instead were a more gradual and anticipated process. In some instances, this may also reflect the fact that reforms followed periods of turmoil. In our model, we can generate more labor reallocation in the prereform economy by making the idiosyncratic distortions less persistent, which is an avenue we have not explored. Recall that, in our model, the same  $\psi$  shock determines the persistence of the entrepreneurial productivity and the idiosyncratic distortions in the prereform steady state (see Sec. III.A.2).

<sup>33</sup> Schmitz (1996) shows that the rise of private enterprises is observed in all industrial sectors.

The right panel of figure 9 shows the postreform dynamics of the average establishment size in our model (the black solid line, normalized by the prereform average establishment size). The average establishment size increases by 80 percent over the 14 years following the reform, reflecting the reallocation of production factors to the most productive entrepreneurs. We also show the time series of the average manufacturing plant size in Japan, Korea, and Singapore, the three countries for which data are available.<sup>34</sup> The average manufacturing plant size increased after the reforms in all three countries.<sup>35</sup> The average plant size (gray solid line) increased by 80 percent over the 15 years following the reform, which conforms with our model's prediction. However, the two series are not directly comparable because the average size in the model is computed using all plants in the economy, unlike its empirical counterparts.

A similar pattern emerges in Thailand, for which we have data on employment by firm size bins. While the data are available only since 1988, 5 years after the identified reform, they show a substantial increase in the fraction of workers employed in firms with more than 100 employees (from 21 percent in 1988 to 41 percent in 1998); the data also show a corresponding decline in the fraction of workers employed in firms with fewer than 10 employees (from 58 percent to 39 percent).

In summary, our model of macroeconomic transitions has a clear prediction on the evolution of the average scale of production units, which is consistent with all available data. This is a dimension about which the standard neoclassical model with a representative firm has nothing to offer.

*Reduced-form measures of distortions.*—Finally, we discuss some direct evidence on idiosyncratic distortions that was recently made available. Detailed micro data are needed to measure establishment-level distortions. Few such data sets exist, and not all of them are readily accessible or reliable. Hsieh and Klenow (2009) use the manufacturing census data of China and India and compute plant-level distortions based on value added and inputs.<sup>36</sup> Note that their measure captures both purely idiosyncratic distortions (e.g., idiosyncratic taxes/subsidies,  $\tau_{yi}$ ) and systematic distortions in the economy (e.g., financial frictions,  $\lambda$ ).

Hsieh and Klenow (2009) find significantly more plant-level distortions in China and India than in the United States. Their findings provide qualitative support for our modeling choice of idiosyncratic distortions

<sup>34</sup> We normalize the data by their reform year values to address the fact that the set of plants over which the average size is calculated varies across these countries; see App. B for more detail.

<sup>35</sup> The overshooting in the Korean data around year 16 coincides with the country's promotion of heavy and chemical industries during the late 1970s, which was eventually abandoned.

<sup>36</sup> Their measure of a plant's wedge or distortions is a geometric average of its marginal revenue products of capital and labor, demeaned by the average of this quantity across all plants within the same (narrowly defined) industry.

and financial frictions: Our benchmark miracle economy has substantially more micro-level distortions both before (because of idiosyncratic distortions and financial frictions) and after (because of financial frictions alone) the transitions than the perfect credit economy modeled after the United States, even though the degree of distortions and misallocation in the benchmark economy decreases substantially after the reform.

Hsieh and Klenow's data, however, cannot directly determine whether there are significant reductions in plant-level distortions after large-scale reforms. The Chinese data are for 1998, 2001, and 2005, while our reform year for China is 1992. That is, their observation begins 6 years after the reform. Nevertheless, they do report a decrease in the dispersion of marginal revenue products—the degree of plant-level distortions—over time in the Chinese manufacturing sector. For example, the difference in marginal revenue products between a plant in the 90th percentile and one in the 10th percentile declines by 28 log points by 2005. This reduction in plant-level distortions and misallocation is reflected in the aggregate TFP, and Hsieh and Klenow compute that this channel explains about 2 percent annual growth in measured TFP. This finding is consistent with our model in which even the effects of once-and-for-all reforms manifest themselves over a prolonged period because of financial frictions. Also, a gradual removal of idiosyncratic distortions could be introduced into our model to better explain this finding.<sup>37</sup>

The preceding measurement exercises are useful because they provide a sense of the magnitude of the distortions and misallocation in the economy. However, alone they offer no insights into the underlying policies or other causes responsible for the misallocation and the particular reforms that reduced them over time.<sup>38</sup> We supplement these reduced-form measurements with a detailed review of historical accounts of the reform episodes in Appendix A, with particular attention to actual changes in specific policies.

## V. Concluding Remarks

We incorporate financial frictions and heterogeneous producers into an otherwise standard neoclassical growth model and quantify the role of financial frictions and resource misallocation in economic development. We find that financial frictions have a large impact along the transition to the steady state, prolonging the adverse consequences of the initial resource misallocation—hence the use of the phrasing “the persistence of history” in this paper's title. Our model economy converges slowly to

<sup>37</sup> Bartelsman et al. (2013) also find evidence that in the Eastern European economies, idiosyncratic distortions diminished along the postcommunist transitions.

<sup>38</sup> Hsieh and Klenow indicate that some of the distortions can be traced to state ownership of plants (China) and licensing and size restrictions (India).



the steady state; investment rates and TFP start low and rise over time. These are all salient features of the economic miracles.

However, the model transition is not slow enough compared with the data from the growth acceleration episodes. The TFP dynamics in the data appear particularly protracted. One explanation is that the large-scale reforms were cumulative and were implemented gradually over several years, as suggested by our review of the reform history. Gradual reforms can be incorporated into our framework to further slow the model transitions. However, the challenge then becomes whether the time paths of the reforms, in the absence of direct quantifiable measures of policy distortions, can be quantitatively disciplined.

Our quantitative framework can be applied more broadly to the study of macroeconomic transition dynamics following major events or aggregate shocks that jolt an economy out of its initial steady state. The postcommunist transitions are a relevant example, given the rampant resource misallocation during the communist era and the abrupt liberalizations that followed. The transition paths of various Eastern European countries show diverse patterns, which in our framework can be quantitatively explained by the differences in their degree of initial misallocation; in the depth, breadth, and pace of their reforms and liberalizations; and in the degree of local financial market frictions.

Another example, perhaps more readily relatable to our exercise, is the recent growth acceleration of Vietnam. Its growth path after the large-scale reforms of 1989 shares many features with our seven economic miracles, both at the aggregate and at the micro levels. The reforms drastically curtailed government intervention in the economy and promoted the private sector. However, the financial markets in Vietnam have remained largely underdeveloped to the present. As a result, we observe a sustained period of massive resource reallocation across sectors and from state-owned to private enterprises, which also coincided with gradual increases in aggregate investment rates, TFP, and the average size of establishments.

## Appendix A

### Historical Accounts of Reforms

In this appendix, we expand our discussion in Section I and describe the reforms that preceded the growth accelerations in the seven economies we study. In each case, we select as the reform date the year in which the major reforms were announced: China, 1992; Japan, 1949; Korea, 1961; Malaysia, 1968; Singapore, 1967; Taiwan, 1959; and Thailand, 1983. In reality, these reforms unfolded over a few years; therefore, different years could have been selected. The empirical facts highlighted in Section I are robust to such considerations.<sup>39</sup>

<sup>39</sup> Examples of sensible alternatives are as follows: 1953 for Japan, when it regained full sovereignty; 1971 for Malaysia, when the New Economic Policy provided further incentives



*China.*—After a decade in which reforms had primarily been focused on the agricultural sector and rural areas, the second phase of farther-reaching reforms was inaugurated in 1992, when the Chinese Communist Party endorsed the “socialist market economy” as the guiding principle of China’s economic reform. These reforms espoused a less restricted growth of private enterprises, extending beyond rural township and village enterprises and those in special development zones. They also expanded and further liberalized special development zones and eliminated price controls. During the 1990s, China pushed ahead with trade liberalization and eventually reached a free-trade agreement with the United States in 1999 and joined the World Trade Organization in 2001. See Qian (2000) and Chow (2007) for a detailed description.

*Japan.*—The immediate postwar period was characterized by the government’s direct control of the economy (priority production system) under the tutelage of the occupation authority. These policies were broadly based on the economic arrangements that had prevailed in the prewar period. Factor markets, production, and foreign trade were all directly controlled by the government through explicit targets and subsidies. In 1949, under the US influence, Japan introduced a drastic fiscal adjustment program, which included the elimination of subsidies and price controls and the restoration of private channels of international trade that bypassed government agencies. The role of the government shifted from directing production to promoting more efficient technologies (industrial rationalization plans) and export through tax and credit advantages. See Johnson (1982) and Kosai (1988) for more detail.

*Korea.*—In the first 8 years after the Korean War, Korea relied on an import-substitution development strategy. In this period, the economy depended heavily on foreign aid and was characterized by large fiscal deficits, high inflation, and anemic economic growth. In 1961, a new political regime came to power through a military coup and embarked on a period of aggressive export promotion that replaced previous inward-looking import-substitution policies. This was achieved mainly by combining a free-trade regime for exporters, who were now allowed to freely import intermediate inputs and equipment, with high tariffs for final goods. This phase was followed by a burst of more interventionist policies in the late 1970s (the heavy and chemical industry drive). Since 1982, Korea has pursued broader liberalization of trade and capital flows and has reversed the credit and tax incentives for large industrial groups. See Stern et al. (1995), Kim and Leipziger (1997), and Hong (2002) for more detail.

*Malaysia.*—In the first decade following its independence from Britain in 1957, the Malaysian government intervened extensively in the economy to promote rural development and implemented an import-substitution development strategy. The Investment Incentives Act of 1968 signaled a shift away from import substitution to export promotion. The Malaysian government accelerated the shift with the New Economic Policy of 1971. Export incentives were given to new industries, mainly through the designation of export processing zones and free-trade zones. After the brief and unsuccessful state-sponsored heavy industry promotion in the early 1980s, the 1985–86 recession triggered a second round

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to exporters; and 1981 for Thailand, when the government started to gradually adopt export promotion policies.

of market liberalizations aimed at private-sector growth. See Salleh and Meyanathan (1997) for more detail.

*Singapore.*—During the decade leading to its formal independence in 1965, Singapore pursued import-substitution policies, with housing development and construction playing an important role. In 1967, following the failed attempt at integrating with Malaysia (1963–65), the government had to abandon import substitution as a growth strategy for a city-state with no natural resources. At that point, the government switched its investment promotion efforts toward export-oriented manufacturing. Direct incentives to exporters included concessionary tax rates on export profits. Trade was continuously liberalized, and by 1973, all quotas and almost all import tariffs were eliminated. See Soon and Tan (1997) for more detail.

*Taiwan.*—The first decade following the retreat from mainland China witnessed a pervasive intervention of the government in the economy. The state controlled half of the industrial production, and its trade policies discouraged imports and exports (e.g., dual exchange rate regime). In 1959, Taiwan drafted and implemented the Nineteen-Point Program of Economic and Financial Reform. Its central objectives were to promote private-sector investment and to gradually diminish the role of the government in industrial production and trade. The import licensing system was dismantled and tax advantages were granted to exporters. In the late 1970s, Taiwan briefly reverted to import-substitution policies, promoting the capital-intensive heavy and petrochemical industries. These new import-substitution policies prevailed until 1982. Since then, the government has broadly liberalized the economy and pursued market-oriented policies. See Ranis (1979), Scott (1979), and Dahlman and Sananikone (1997) for more detail.

*Thailand.*—Until the early 1980s, Thailand subscribed to inward-looking policies, favoring consumer goods industries and capital-intensive industries over the agricultural sector (e.g., high tariffs and export taxes on rice). In 1981, the government began to institute policies promoting export. Export taxes were reduced and exchange rate controls were eased. At the same time, an effort to rationalize tariffs was initiated. Starting in 1983, the bias in favor of capital-intensive industries was removed, and export projects were given priority through credit and tax advantages. The government streamlined customs procedures and abolished unnecessary regulations, expediting the export process. Trade liberalization continued through the late 1980s and early 1990s. Furthermore, Thailand undertook extensive domestic financial market liberalization and capital account liberalization in the late 1980s. See Christensen et al. (1997) and Townsend (2010) for more detail.

## Appendix B

### Data

*Note to figure 1.*—Per-worker GDP relative to the United States corresponds to real GDP chain per worker from the Penn World Tables 6.3. Investment-to-output ratios are the investment share of real GDP, also from the Penn World Tables. We define TFP as  $y/(k^{1/3}h^{2/3})$ , where  $y$  is per-worker GDP,  $k$  is the stock of capital per worker, and  $h$  is the stock of human capital per worker. Capital stock series are constructed using the perpetual inventory method and an initial steady-state assumption. In particular, the initial stock of capital is given by  $K_0 = I_0/(\bar{g} + \delta)$ ,

where  $I_0$  is the real investment in the first year with data and  $\bar{g}$  is the average growth rate of the first 10 years with data. We assume a depreciation rate of  $\delta = 0.06$ . Following Bernanke and Gürkaynak (2001), we measure the stock of human capital per worker using a standard Mincerian framework, assuming a return of 13.4 percent per year for the first 4 years of schooling, 10.1 percent for the next 4 years, and 6.8 percent for the years thereafter. The data for years of schooling are for the total population 25 years of age or older from the November 12, 2010, update of the Barro-Lee (2010) Educational Attainment Dataset. Private credit to GDP corresponds to the private credit by deposit money banks and other financial institutions over GDP in the 2006 update of the Financial Development and Structure Database (Beck et al. 2000). In each panel, we also show the unweighted average across the seven economies. We deal with the unbalanced nature of our panel as follows. First, we calculate the unweighted average for the balanced time block of the panel. We then extrapolate this series forward and backward using the average growth rate across all the countries with available data for a given year.

*Note to figure 3.*—The solid gray line in the left panel plots the unweighted average GDP per worker adjusted for human capital (i.e.,  $y/h$  in the notation of the note to fig. 1 above) over the seven countries. The unweighted average TFP and investment rate series shown in the middle and the right panels are from figure 1.

*Note to figure 4.*—The left panel plots the unweighted average stock of capital per worker adjusted for human capital (i.e.,  $k/h$  in the notation of the note to fig. 1 above) over the seven countries.

*Note to figure 9.*—Our labor reallocation measure is the sum of the absolute value of year-to-year changes in each industry's employment share. We use the UNIDO data on the employment share of two-digit manufacturing industries. The data needed to construct our measure are available for six of the seven countries we study. Thailand is the exception because its employment data are missing for too many intermediate years. For Japan, we also draw on the data from table 8.6 of the Historical Statistics of Japan (<http://www.stat.go.jp/english/data/chouki/index.htm>) for the early years not covered by UNIDO. For Taiwan, we use data on GDP by sector to calculate an analogous measure with the data from Directorate General of Budgets, Accounting, and Statistics.

The private-sector share for Taiwan is the share of the private sector in industrial production (i.e., mining and manufacturing). The data for the years 1961–73 are from various volumes of the *Statistical Abstract of the Republic of China* published by the Directorate General of Budgets, Accounting, and Statistics. For 1953, 1958, and 1975, the data are from Ranis (1979). For China, the private-sector share is the share of the private sector in total employment. Private-sector employment is the sum of employment in joint owned economic units, limited-liability corporations, share-holding economic units, foreign-funded economic units, overseas Chinese from Hong Kong, Macau, and Taiwan funded economic units, private enterprises, and self-employed individuals. Public-sector employment is the sum of employment in state-owned units, collective-owned units, and cooperative units. The Chinese data are from various years of the *China Statistical Yearbook* published by the National Bureau of Statistics of China.

The average establishment size is defined as employment per establishment. The Japanese data cover all plants with more than four employees, except for the

period between 1963 and 1976, when they include all plants. For this reason, we rescale the Japanese numbers for 1963–76 to minimize the squared sum of the distance between the 1962 and 1963 values and the distance between the 1976 and 1977 values. The data are from table 8.6 of the Historical Statistics of Japan. The Korean data are from the Mining and Manufacturing Survey (eighth rev.; <http://kosis.kr/eng/>) and include plants with five or more employees. For Singapore, plants employing 10 or more workers are included. The data for Singapore are from various volumes of the *Yearbook of Statistics* published by the Singapore Department of Statistics. We normalize the data by their respective reform year values to address the variation across these countries for the set of plants over which the average size is calculated.

## Appendix C

### Sensitivity Analysis

This appendix shows the figures of the transitional dynamics discussed in Section III.C.5. Recall that we explore the robustness of our results to alternative specifications of prereform states, span of control, and shock persistence.

*Initial conditions.*—In addition to the benchmark exercise in Section III.C.1, we consider transitions starting from two different initial conditions. The prereform state of the benchmark exercise is constructed with  $\tau_+ = 0.5$ ,  $\tau_- = -0.15$ , and  $q = 1.55$  (see Sec. III.A.2). The first alternative prereform state (initial condition 1) is generated by  $\tau_+ = 0.4$ ,  $\tau_- = -0.79$ , and  $q = 2.89$ . The second (initial condition 2) is for  $\tau_+ = 0.3$ ,  $\tau_- = -2.6$ , and  $q = 5.94$ .

The benchmark transition is shown in figure C1 with a solid line, while the transitions from initial conditions 1 and 2 are represented by a dotted line and a dashed line, respectively. The top-left panel shows the aggregate output along the transitions, following the reform in year 0. All three output series are normalized by the output level in the prereform state of the benchmark exercise. This normalization is chosen to visually confirm the fact that all three transitions eventually arrive at the same steady state. (The transitions differ only in terms of initial conditions.) Similarly, TFP and aggregate capital are also normalized by their respective levels in the initial condition of the benchmark exercise. Note that one of the moment restrictions is the long-run change in TFP after the reform. As a result, the TFP of all three transitions starts from the same initial level. The investment rates are shown as deviations from the investment rate in the prereform economy of the benchmark exercise.

*Span of control.*—The benchmark exercise has  $\nu = 0.21$  (see table 1). Here we consider the cases with  $\nu = 0.12$  and  $\nu = 0.28$ . For  $\nu = 0.12$ , we recalibrate  $\eta = 7.01$ ,  $\tau_- = 0.05$ , and  $q = 1.89$ . For  $\nu = 0.28$ , we have  $\eta = 3.16$ ,  $\tau_- = -1.0$ , and  $q = 2.51$ .

The benchmark transition is shown in figure C2 with a solid line. The cases for  $\nu = 0.12$  and  $\nu = 0.28$  are plotted with a dotted line and a dashed line, respectively. The top-left panel shows the three output series normalized by their levels in the respective prereform states. We use this normalization because these transitions have different initial conditions and different steady states. The TFP and capital series are normalized in the same manner. Investment rates are shown as deviations from their respective prereform levels.

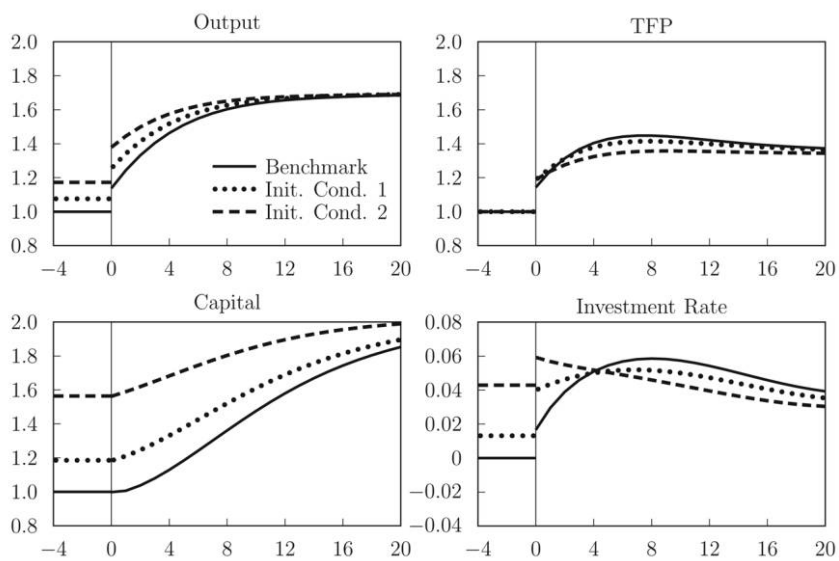


FIG. C1.—Transitions with alternative initial conditions

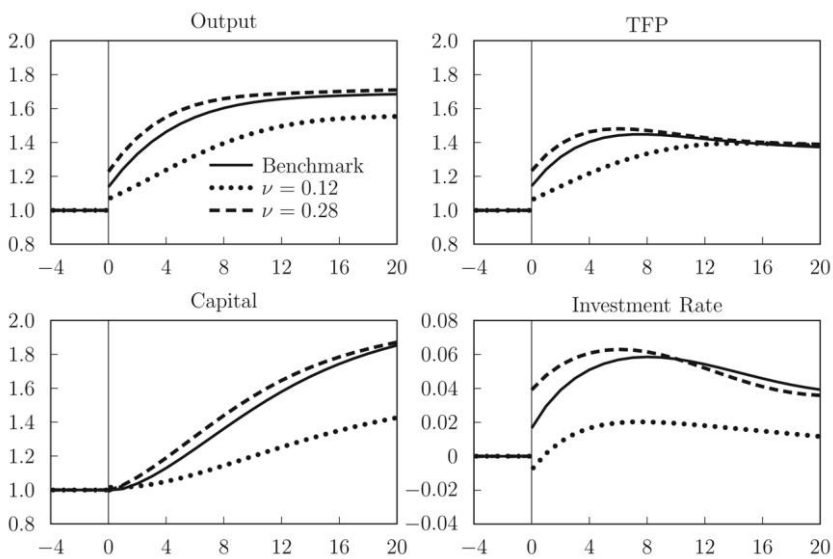


FIG. C2.—Transitions with alternative span of control

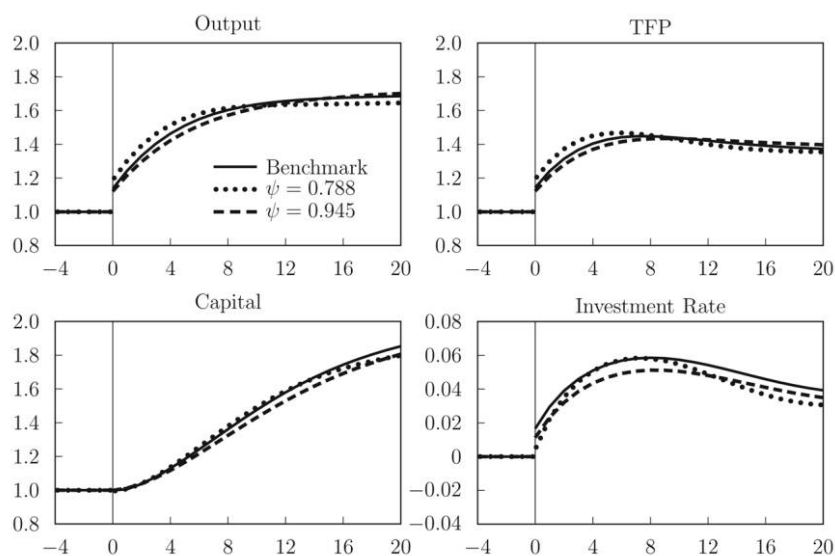


FIG. C3.—Transitions with alternative shock persistence

*Persistence of entrepreneurial productivity shock.*—The benchmark exercise has  $\psi = 0.894$  (see table 1). Here we consider the cases for  $\psi = 0.788$  and  $\psi = 0.945$ . For  $\psi = 0.788$ , we recalibrate  $\tau_- = -0.4$  and  $q = 1.79$ . For  $\psi = 0.945$ , we use  $\tau_- = -0.25$ , and  $q = 1.39$ .

The benchmark transition is shown in figure C3 with a solid line. The cases for  $\psi = 0.788$  and  $\psi = 0.945$  are plotted with a dotted line and a dashed line, respectively. The output, TFP, and capital series are all normalized by their values in the respective initial conditions. Investment rates are shown as deviations from their levels in the respective initial conditions.

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