Corporate Governance and Phases of Development*

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Abstract

Corporate governance distortions delay or even halt a country's transformation into a modern innovation economy. We investigate the mechanism through a growth model that allows for agency issues within firms. Governance distortions raise the cost of investment and depress the incentives to set up new firms. Modest differences in governance account for large gaps in income: A 32 percent investment cost differential explains the secular decline of Latin America income relative to that of the USA, and implies an industrialization delay of a third of a century. We obtain similar results for a large number of countries and macro-regions.

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1 Introduction

Corporate innovation is a major driver of modern growth. The centrality of the corporation in the growth process is relatively recent, however. In Prussia in the middle of the 19th

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century, Ernst Werner Siemens started up what would become one of the world's largest manufacturing and innovative company. In the USA in the second half of the 19th century, Thomas Edison established one of the most prolific industrial research and development lab, whose operations were closely related to his manufacturing enterprises. Similar undertakings occurred in several industries, giving birth to companies such as General Electric, AT&T and General Motors, to name a few, that are still thriving today. This cluster of events, often labeled the Second Industrial Revolution, marks a profound qualitative change in the mode of growth. It also marks a period where the economic fortunes of different communities (provinces, countries, regions), already diverging in the aftermath of the First Industrial Revolution, started diverging even more rapidly and widely.

While inventors and entrepreneurs abound and have abounded all over the world, some societies have been more successful than others in nurturing the rise of innovative firms that spearhead economic growth. Many argue that in the less successful societies the misalignment of interests among a firm's stakeholders slows down or even blocks altogether the firm's dynamism. Only few studies, however, attempt to identify the specific mechanisms through which poor corporate governance hinders macroeconomic development. As observed by Colin Mayer, "Corporate governance is not about enhancing shareholder value. It is about enhancing economic growth, entrepreneurship, innovation and value creation. We do not actually care about shareholder returns or shareholder value per se, except insofar as they contribute to achieving these objectives." (OECD, 2012, p. 29). With a similar focus on development, many policy makers argue that poor governance matters because it raises the cost of investment and/or makes entry of new firms more difficult. In presenting an initiative of the Africa Corporate Governance Program, a representative of the International Finance Corporation (World Bank Group) remarked that "Good corporate governance policies and practices help businesses lower their capital costs, and become competitive, profitable, and attractive for investors." (World Bank, 2015). In a similar vein, a report of the OECD Secretariat states that "One key element of improving microeconomic efficiency is corporate governance... It is thought that poor corporate governance mechanisms in [developing] countries have proved, in part, to be a major impediment to improving the competitiveness of firms. Better corporate governance, therefore, both within OECD and non-OECD countries should manifest itself in enhanced corporate performance and can lead to higher economic growth." (OECD, 1999, p. 4). Motivated by the popularity of such remarks in policy circles, and by the thinness of the literature linking the microeconomics of corporate governance to the macroeconomics of development and growth, we introduce corporate governance distortions in a Schumpeterian model of innovation-led growth. We then study how their severity affects the growth of the individual firm, the evolution of industry, the timing of the economy's transition to modern growth and thereby the whole secular path of expansion of national income.

In the model, the source of corporate governance distortions is the ability of managers to divert the firm's resources to private benefits; see, among others, Nikolov and Whited (2014) and Shleifer and Wolfenzon (2002). Specifically, we allow managers to divert cash flow and planned investment funds to their own consumption. The former reduces the distribution of dividends to shareholders and has first-order effects on the incentive to set up firms in the first place. The latter raises the cost of investing in the growth of the firm. Shareholders can partially discipline managers through incentive compensation contracts and by hiring monitoring agents (e.g., directors).

The economy starts with a given number of firms. Initially, market expansion fueled by population growth is the only source of income growth via Smithian economies of scale. Under some conditions, such market expansion eventually triggers entry of new firms and, later, in-house investment by incumbent firms. The timing of the two events has long-lasting consequences for the path of income per capita. We investigate how the governance structure of firms, an equilibrium outcome of our analysis, affects the macroeconomic equilibrium and results in different histories across countries. Because both the rate of entry and the rate of in-house innovation rise as the economy converges to its steady state, an economy with more severe corporate governance distortions enters the modern growth phase later and exhibits poorer productivity performance throughout the transition. In this sense, the timing of the take-off "imprints" on the whole subsequent evolution of the economy.

To assess how well corporate governance accounts quantitatively for the observed cross-country income dynamics, we calibrate the model to the USA for the period 1700-2008, taking 1800 as the beginning of modern growth (see, among others Lucas, 2000) and assuming the USA to be at a 10% distance from a distortion-free economy (see Iacopetta et al., 2018). Using the USA as a benchmark, we then calculate how over the same period variations in corporate governance explain the timing of the transition to modern growth and the performance afterwards of several other countries and some macro regions. The key to this exercise is that, differently from the USA, we let the model determine endogenously the take-off date for these units. We find, for instance, that the magnitude of the difference in corporate governance distortions to account for the decline of the income per capita of Latin America relative to the USA, from one to one fourth, is the equivalent of a 32 percent higher cost of in-house investment in Latin America. We also calculate that such a distortion delays modern growth by approximately a third of a century, a delay that accounts well for the end-of-period (2008) income gap. This example gives a good preview of a central theme emerging from our results: we find frictions and delays that are significantly smaller than those found in the literature. For example, in her study of the dynamics of a Hansen-Prescott model, Ngai (2004) finds that to explain a similar USA-Latin America pattern the cost of capital in Latin America would need to be 16 times that of the USA and that the implied industrialization delay would be about a century.

In the main analysis we hold all parameters and the structure of corporate governance constant throughout the transition. To test the importance of this assumption, and learn more from comparing model to data, we introduce a post-WWII shock designed to produce an improvement in corporate governance. We find that such a shock *worsens* the model's fit for Western economies, in some cases substantially. In contrast, the shock improves the model's fit for East Asian countries. We take this as an indication that our approach is on the right track: postulating a change in the business environment after WWII improves the model's fit precisely in the areas where history suggests it should, since those areas did in fact experience massive institutional changes after the war.

Two strands of literature are directly related to our paper. One is the expanding literature that uses calibration techniques to quantify the factors that allowed modern economies to achieve sustained technological progress; see, among others, Stokey (2001), Lagerlöf (2003), Lagerlöf (2006), Bar and Leukhina (2010) and Desmet and Parente (2012). Our quantitative analysis is similar in spirit to that in Lucas (2000), Ngai (2004), Parente and Prescott (2005) and, more recently, Herrendorf and Teixeira (2011). We focus on the entire secular path of income per capita from 1700 to today, stressing its highly nonlinear shape due to key take-off events. As Ngai (2004), we are particularly interested in assessing how the delays in industrialization drive contemporary income gaps. We focus, however, on the specific role of corporate governance in producing such delays.

The other strand of literature directly related to our paper links corporate decisions to macroeconomic performance and, more specifically, investigates the long-run implications for aggregate productivity of within-firm corporate governance frictions and of financial markets imperfections; see, e.g., Iacopetta et al. (2018), Aghion, Howitt and Mayer-Foulkes (2005), Cooley and Quadrini (2001). In particular, while the analytical framework that we use is similar to that of Iacopetta et al. (2018), here we expand the perspective in two main dimensions. First, we consider both advanced countries and countries at earlier stages of the development process. Second, we allow for misuse of planned investment resources, which slows down the growth of the firm.

More broadly, our analysis complements the literature that investigates how the quality of government, as well as legal and social norms, explains cross-country income divergence. Several scholars argue that in Western Europe the rule of law was already taking hold in the Middle Ages, while in other regions it developed much later and in some it never did. This suggests that the conditions for the formation of the modern innovative firm emerged unevenly around the world. In places where the rule of law was not as advanced as in Europe, business communities developed alternative arrangements based on trust that allowed production and commerce to thrive (Grief, 2006). Trust is a powerful ingredient in promoting investment because even in a sophisticated contractual environment a party's future choice is not necessarily contractible (Lins et al. 2017, Fukuyama 2014). Augmenting this historical perspective, there is now established evidence that corporate governance affects the investment of incumbent firms and the formation of new firms; see, e.g., Aghion, Van Reenen and Zingales (2013), Morck, Wolfenzon and Yeung (2005) and Fulghieri and Suominen (2012). Most importantly, such evidence highlights differences across countries in corporate governance due to differences in the local business environments.

The paper is organized as follows. In Section 2 we review the basic growth model that we borrow from the literature. In Section 3 we augment the model with corporate governance and derive our main microeconomic results. In Sections 4 and 5 we develop the macroeconomic implications of corporate governance. In section 6 we calibrate the model and perform several quantitative exercises. We conclude in Section 7.

2 The basic growth model

The model builds on the literature that integrates endogenous market structure in the theory of economic growth. In this section we set it up abstracting from corporate frictions, which we introduce later. Time is continuous and infinite. All variables are functions of time but to simplify the notation we omit the time argument unless necessary to avoid confusion. The economy is closed. The production side consists of a final sector producing a homogeneous good and an intermediate sector producing a continuum of differentiated non-durable goods.

2.1 Households

The economy is populated by a representative household with $L(t) = L_0 e^{\lambda t}$, $L_0 \equiv 1$, members, each endowed with one unit of labor. The household has preferences

$$U(t) = \int_t^{\infty} e^{-(\rho-\lambda)(\tau-t)} \log\left(\frac{C(\tau)}{L(\tau)}\right) d\tau, \quad \rho > \lambda \geq 0 \tag{1}$$

where t is the point in time when the household makes decisions, ρ is the discount rate and C is consumption. The household supplies labor inelastically and has budget constraint

$$\dot{A} = rA + wL - C, \tag{2}$$

where A is assets holding, r is the rate of return on assets and w is the wage. The intertemporal consumption plan that maximizes (1) subject to (2) consists of the Euler equation

$$r = \rho - \lambda + \dot{C}/C, \tag{3}$$

the budget constraint (2) and the usual boundary conditions.

2.2 Final producers

A competitive representative firm produces a final good that can be consumed, used to produce intermediate goods, invested in the improvement of the quality of existing intermediate goods, or invested in the creation of new intermediate goods. The final good is our numeraire. The production technology is

$$Y = \int_0^N X_i^\theta \left(Q_i L_i^\gamma \Omega^{1-\gamma} \right)^{1-\theta} di, \quad 0 < \theta, \gamma < 1 \tag{4}$$

where N is the mass of non-durable intermediate goods and L_i and Ω are, respectively, services of labor and a fixed factor. The technology features full dilution of labor across intermediate goods, reflecting the property that both labor and intermediate goods are rival inputs. The fixed factor, instead, is non-rival across intermediate goods and labor. Quality, Q_i, is the good's ability to raise the productivity of the other factors. Let P_i be the price of intermediate good i and w be the wage. The profit maximization problem yields that the final producer demands intermediate goods and labor according to:

$$X_i = \left(\frac{\theta}{P_i} \right)^{\frac{1}{1-\theta}} Q_i L_i^\gamma \Omega^{1-\gamma}; \tag{5}$$

$$L_i = \frac{\gamma (1-\theta)}{\theta} \frac{P_i X_i}{w},$$

Moreover, letting p denote the price of the fixed factor, the final producer pays

$$\int_0^N P_i X_i di = \theta Y, \quad wL = \int_0^N w L_i di = \gamma (1-\theta) Y, \quad p\Omega = (1-\gamma)(1-\theta) Y \tag{6}$$

to, respectively, suppliers of intermediate goods, labor and the fixed factor.

2.3 Intermediate producers

In line with Schumpeterian theory, we view firms as complex organizations that develop and apply specialized knowledge. Therefore, we model quality as

$$Q_i = Z_i^\alpha Z^{1-\alpha}. \tag{7}$$

In words, the contribution of good i to factor productivity downstream depends on the knowledge of firm i, Z_i, and on average knowledge, $Z = \int_0^N (Z_j/N)\, dj$. On the production side, the firm requires one unit of final output per unit of intermediate good produced and a fixed operating cost, $\phi Z_i^\alpha Z^{1-\alpha}$, also in units of final output. The firm accumulates knowledge according to

$$\dot{Z}_i = I_i, \tag{8}$$

where I_i is in-house investment in units of final good. Using (5), we define the firm's gross cash flow (revenues minus production costs) as

$$F_i = \left[(P_i - 1) \left(\frac{\theta}{P_i} \right)^{\frac{1}{1-\theta}} L_i^{\gamma} \Omega^{1-\gamma} - \phi \right] Z_i^{\alpha} Z^{1-\alpha}. \tag{9}$$

In this expression α is the elasticity of the firm's gross profit with respect to its own knowledge. The dividend flow is $\Pi_i = F_i - I_i$ and the value of the firm is

$$V_i(t) = \int_t^{\infty} e^{-\int_t^{\tau} r(v)dv} \Pi_i(\tau) d\tau. \tag{10}$$

Creating a new firm costs βX units of final output, where $X = \int_0^N (X_i/N)\, di$ is average intermediate output. The resulting free-entry condition is $V_i = \beta X$. Because of this sunk entry cost, the new firm cannot supply an already existing good in Bertrand competition with the incumbent monopolist but introduces a new intermediate good that expands product variety. The firm enters at the average knowledge level and hence at average size (this simplifying assumption preserves symmetry of equilibrium at all times, see below).

3 Corporate governance

We now extend the model to allow for frictions arising from separation of ownership and control. The literature describes managers as individuals who exploit their particular positions within the firm to pursue personal goals rather than shareholder value. To capture such a misalignment of interests, we focus on two flows of resources that managers can divert to personal gain: cash flow and investment.

3.1 Governance: Set up

Our typical firm has three constituencies with different interests. The first consists of individuals who supply the resources to set up the firm. For convenience we refer to this group in the singular as the *founder*.[1] His objective is to maximize the value of the firm. The second constituency is the firm's management. We refer to this group as the *manager*. The third constituency, which we call the *director*, consists of individuals who monitor the managers' activities. The manager's and the director's objectives are to maximize their own utility.

The governance scheme is the following. The founder hires the manager, to whom he delegates production and pricing decisions and the implementation of the firm's investment

[1] While each of the constituencies is typically a plurality of individuals, possibly with different preferences and constraints, it is easier to describe the setup assuming homogeneity within each group.

plan, and the director, to whom he delegates monitoring the manager. The investment plan specifies the time path of expenditure on product quality improvement. The founder retains control of the formulation of this plan. The manager's objective is not aligned with that of the founder because the manager can divert planned investment funds and/or cash flow to his own private benefit. We consider two devices at the founder's disposal to control the manager's moral hazard. The first is hiring the director, who can reduce directly the manager's ability to divert resources. The second device is the compensation package: the founder offers a contract that grants remuneration tied to the firm's increment of the stock of knowledge (actual investment) and to the distributed dividend flow.[2]

The assumption that the founder formulates the investment plan while the manager only executes it might seem restrictive. It is nevertheless convenient in our contest for two reasons. First, it allows us to emphasize that even when the manager controls only routine operations his actions may harm the interests of shareholders. Second, it makes the formal analysis simpler and much more transparent than the alternative of assigning the formulation of the investment plan to the manager. Indeed, precisely because the founder proposes a compensation package and maintains control of the investment plan, we can see within a coherent dynamic optimization problem the interaction between the compensation package decision and the investment choice.

To summarize, at the foundation of the firm, the principal, our founder, makes three decisions. First, he hires two agents, the manager and the director, and specifies their compensation packages taking into account their incentives and constraints. Second, he specifies the investment plan with full understanding that there will be a wedge between planned and actual investment. Third, he decides whether to set up the firm in the first place, with full understanding that there will be a wedge between the profit generated by the firm and what he receives as dividend.

3.2 Manager (agent)

The manager can divert a share $S_i^F\left(M_i^F, D_i^F\right)$ of cash flow, F_i, at utility cost $c_M^F(M_i^F) \cdot F_i$, where the function $c_M^F(M_i^F)$ is continuous, increasing and convex. The share $S_i^F\left(M_i^F, D_i^F\right)$ is increasing in the manager's effort M_i^F and decreasing in the director's effort D_i^F. The manager can also divert a share $S_i^I\left(M_i^I, D_i^I\right)$ of planned investment, I_i, at utility cost $c_M^I(M_i^I) \cdot I_i$, where the functions $S_i^I(.)$ and $c_M^I(.)$ have the same properties as the functions $S_i^F(.)$ and $c_M^F(.)$, and M_i^I and D_i^I are, respectively, the manager's and the director's efforts. Actual

[2]To keep the exposition simple we use only contracts that compensate the manager and the director in proportion to the resources subject to diversion. Other schemes are possible, of course, but they complicate matters without necessarily adding insight.

investment is thus $\dot{Z}_i = \left[1 - S_i^I\left(M_i^I, D_i^I\right)\right] \cdot I_i$. We distinguish between effort targeted at cash flow and at investment for analytical clarity.

The manager's contract specifies as compensation fractions m_i^I and m_i^F of the resources that he can divert. The manager fully consumes his income and thus his utility flow is

$$\begin{aligned} u_i^{\text{manager}} &= \left\{m_i^F \left[1 - S_i^F\left(M_i^F, D_i^F\right)\right] + \left[S_i^F\left(M_i^F, D_i^F\right) - c_M^F(M_i^F)\right]\right\} F \\ &\quad +_i \left\{m_i^I \left[1 - S_i^I\left(M_i^I, D_i^I\right)\right] + \left[S_i^I\left(M_i^I, D_i^I\right) - c_M^I(M_i^I)\right]\right\} I_i. \end{aligned}$$

At time t, he chooses for $\tau \in [t, \infty)$ the paths of price, $P_i(\tau)$, and efforts, $M_i^F(\tau)$, $M_i^I(\tau)$, that, given the paths of $m_i^F(\tau)$ and $m_i^I(\tau)$, maximize

$$V_i^{\text{manager}}(t) = \int_t^\infty e^{-\int_t^\tau r(v)dv} u_i^{\text{manager}}(\tau)\, d\tau. \tag{11}$$

This expression makes clear that the manager's objective is not the maximization of the value $V_i(t)$ in equation (10). Since this problem does not have a dynamic constraint, it reduces to a sequence of identical intratemporal problems. The first-order conditions with respect to P_i, M_i^F and M_i^I are:

$$\frac{\partial\left(P_i - 1\right)X_i}{\partial P_i} = 0 \Rightarrow P_i = \frac{1}{\theta}; \tag{12}$$

$$\left(1 - m_i^J\right)\frac{\partial S_i^J\left(M_i^J, D_i^J\right)}{\partial M_i^J} = \frac{\partial c_M^J(M_i^J)}{\partial M_i^J}, \quad J = F, I. \tag{13}$$

The compensation shares m_i^F and m_i^I discourage diversion because the manager's costly effort would be partly directed at stealing from himself.

3.3 Director (agent)

The director can mitigate the manager's diversion of resources but, because of his utility cost, requires incentives of his own. The director's compensation is a fraction d_i^F of gross profit and a fraction d_i^I of planned investment. The effort costs are $c_D^F(D_i^F)F_i$ and $c_D^I(D_i^I)I_i$, where D_i^F and D_i^I are, respectively, the efforts targeted at gross profit and at investment. The cost functions have the same mathematical properties as those of the manager. The director fully consumes his income and thus his utility is

$$\begin{aligned} u_i^{\text{director}} &= \left\{d_i^F \left[1 - S_i^F\left(M_i^F, D_i^F\right)\right] - c_D^F(D_i^F)\right\} F_i \\ &\quad + \left\{d_i^I \left[1 - S_i^I\left(M_i^I, D_i^I\right)\right] - c_D^I(D_i^I)\right\} I_i. \end{aligned}$$

At time t, given the paths $P_i(\tau)$, $M_i^F(\tau)$, $M_i^I(\tau)$, $d_i^F(\tau)$ and $d_i^I(\tau)$ for $\tau \in [t, \infty)$, the director chooses the paths $D_i^F(\tau)$ and $D_i^I(\tau)$ to maximize

$$V_i^{\text{director}}(t) = \int_t^\infty e^{-\int_t^\tau r(v)dv} u_i^{\text{director}}(\tau) d\tau. \tag{14}$$

This problem as well reduces to a sequence of identical intratemporal problems and yields

$$-d_i^J \frac{\partial S_i^J \left(M_i^J, D_i^J\right)}{\partial D_i^J} = \frac{\partial c_D^J(D_i^J)}{\partial D_i^J}, \quad J = F, I. \tag{15}$$

The compensation shares d_i^F and d_i^I determine the director's effort for the straightforward reason that doing so he protects his own income flow.

3.4 The diverting-monitoring Nash equilibrium

We think of the first-order conditions (13) and (15) as reaction functions that at time $\tau \geq t$ yield a Nash equilibrium in a simultaneous moves game between manager and director. Our first formal result is thus the following.

Proposition 1 *(Diverting-Monitoring NE)* *For $J = F, I$ assume*

$$\frac{\partial}{\partial D_i^J}\left(\frac{\partial S_i^J \left(M_i^J, D_i^J\right)}{\partial M_i^J}\right) \leq 0 \quad \text{and} \quad \frac{\partial}{\partial M_i^J}\left(-\frac{\partial S_i^J \left(M_i^J, D_i^J\right)}{\partial D_i^J}\right) \geq 0. \tag{16}$$

There exists a stealing-monitoring NE, consisting of two functions $D_i^J\left(m_i^J, d_i^J\right)$, $M_i^J\left(m_i^J, d_i^J\right)$ with the property:

$$\begin{aligned} \frac{\partial M_i^J\left(m_i^J, d_i^J\right)}{\partial m_i^J} &< 0, \quad \frac{\partial D_i^J\left(m_i^J, d_i^J\right)}{\partial m_i^J} < 0; \\ \frac{\partial M_i^J\left(m_i^J, d_i^J\right)}{\partial d_i^J} &< 0, \quad \frac{\partial D_i^J\left(m_i^J, d_i^J\right)}{\partial d_i^J} > 0. \end{aligned}$$

Accordingly, there exists the function $S_i^J\left(M_i^J\left(m_i^J, d_i^J\right), D_i^J\left(m_i^J, d_i^J\right)\right) = S_i^J\left(m_i^J, d_i^J\right)$ with the property:

$$\frac{\partial S_i^J\left(m_i^J, d_i^J\right)}{\partial m_i^J} < 0 \quad \text{and} \quad \frac{\partial S_i^J\left(m_i^J, d_i^J\right)}{\partial d_i^J} < 0.$$

Proof. See the Appendix. ■

This result summarizes the interaction between our two agents. Equations (13)-(15) define in implicit form the reaction functions of the manager and the director. The properties of these reaction functions follow solely from the concavity of the function $S_i^J\left(M_i^J, D_i^J\right)$ with respect to each argument, holding the other constant, and the convexity of the effort cost functions $c_M^J(M_i^J)$ and $c_D^J(D_i^J)$. To characterize the NE we need restrictions on the second cross-partial derivatives. We thus assume that monitoring (weakly) reduces the marginal benefit of resource diversion, the first restriction in (16), obtaining that the reaction function of the manager is (weakly) decreasing in monitoring. A well-defined, stable, NE then only requires that in $\left(M_i^J, D_i^J\right)$ space the reaction function of the manager be steeper than that of the monitor. A *sufficient* condition for this to be the case is that the reaction function of the monitor be (weakly) increasing, that is, that the marginal benefit of monitoring be (weakly) increasing in the manager's effort. This is the second restriction in (16).

To summarize, for $J = F, I$ the first-order conditions of the manager and the director yield a pair of actions (M_i^J, D_i^J) that depends on the contractual incentives $\left(m_i^J, d_i^J\right)$. We thus can write diversion as the function $S_i^J\left(M_i^J\left(m_i^J, d_i^J\right), D_i^J\left(m_i^J, d_i^J\right)\right) = S_i^J\left(m_i^J, d_i^J\right)$.

3.5 Founder (principal)

Households finance the foundation of intermediate firms covering the entry cost. Because of this role we identify them as the founder (the principal in the principal-agents part of the model). Due to the price, diversion and monitoring decisions that yield Proposition 1, the founder receives the dividend flow

$$\Pi_i^{\text{founder}} = [(1 - S_i^F(d_i^F, m_i^F))(1 - (d_i^F + m_i^F))]F_i - \left[1 + (d_i^I + m_i^I)(1 - S_i^I(d_i^I, m_i^I)\right] I_i,$$

and over horizon $\tau \in [t, \infty)$ chooses the paths of planned investment $I_i(t)$ and of the contractual instruments $m_i^F(t)$, $d_i^F(t)$, $m_i^I(t)$, $d_i^I(t)$, to maximize

$$V_i^{\text{founder}}(t) = \int_t^\infty e^{-\int_t^\tau r(v)dv} \Pi_i^{\text{founder}}(\tau)\, d\tau, \tag{17}$$

subject to the demand and technology constrained discussed above and to the participation constraints of the two agents

$$V_i^{\text{manager}}(t) \geq 0 \quad \text{and} \quad V_i^{\text{director}}(t) \geq 0.$$

The founder also decides whether to set up the firm. That is, he satisfies the participation constraint

$$V_i^{\text{founder}}(t) \geq \beta X(t), \tag{18}$$

which we argued holds with equality and yields the free-entry condition that we use to characterize the economy's dynamics. The difference between the frictionless value of the firm in equation (10) and that in equation (17) is the distorted dividend flow Π_i^{founder} in the latter, which differs from $\Pi_i = F_i - I_i$.

For future use we define the *appropriation factor* representing the share of cash flow, F_i, that accrues to the founder:

$$a_i \equiv \left[1 - S_i^F(d_i^F(\tau), m_i^F(\tau))\right]\left[1 - d_i^F(\tau) - m_i^F(\tau)\right]. \tag{19}$$

The founder's Hamiltonian then is (dropping the time argument τ for simplicity):

$$H_i^{\text{founder}} = a_i F_i + q_i \left[1 - S_i^I(m_i^I, d_i^I)\right] I_i.$$

The first-order conditions are:

$$1 - S_i^J = -\frac{\partial S_i^J(m_i^J, d_i^J)}{\partial m_i^J}\left(1 - d_i^J - m_i^J\right), \quad J = F, I; \tag{20}$$

$$1 - S_i^J = -\frac{\partial S_i^J(m_i^J, d_i^J)}{\partial d_i^J}\left(1 - d_i^J - m_i^J\right), \quad J = F, I. \tag{21}$$

The left-hand side of equation (20) is the marginal cost of increasing the manager's compensation; the right-hand side is the marginal benefit, that is, the reduction in the manager's resource diversion. Similarly, the left-hand side of equation (21) is the marginal cost of increasing the director's compensation, while the right-hand side is the marginal benefit, that is, the reduction in the manager's resource diversion due to the director's monitoring effort. Combining (20) and (21) yields

$$\frac{\partial S_i^J(m_i^J, d_i^J)}{\partial m_i^J} = \frac{\partial S_i^J(m_i^J, d_i^J)}{\partial d_i^J}, \quad J = F, I, \tag{22}$$

which says that the founder is indifferent between achieving a reduction in diversion through incentives to the manager and to the director. In this sense, the condition says that the founder plays the two agents against each other.

3.6 Governance: equilibrium outcome

We now bring all the elements derived above together, characterize the internal governance structure of the firm as an equilibrium outcome and develop its implications. The first-order conditions with respect to I_i and Z_i are:

$$q_i = \frac{1}{1 - S_i^I} + d_i^I + m_i^I > 1; \tag{23}$$

$$r_Z = \frac{a_i}{q_i}\frac{\partial F_i}{\partial Z_i} + \frac{\dot{q}_i}{q_i}. \tag{24}$$

These expressions capture the distortion of the investment decision due to the anticipated resources diversion of the manager and the associated cost of incentivizing manager and director. The first says that the founder faces higher investment costs, the second that he obtains a lower return from investment. Our key result here is as follows.

Proposition 2 *(Compensation and Investment Cost) The solution of the incentive-contract part of the founder's problem yields the following features:*

- *the contract consists of time-invariant shares* m_i^F, d_i^F, m_i^I, d_i^I;
- *consequently, the shares* S_i^F *and* S_i^I *are also time-invariant;*
- *hence, the founder's share of cash flow (appropriation factor),* a_i, *is also time-invariant;*
- *moreover, the cost of investment,* q_i, *is time-invariant.*

Proof. See the Appendix. ■

A notable property of this outcome is that a corner solution with $d_i^F = 0$ occurs if the intercept of locus (21) is higher than that of locus (22). Similar reasoning says that a corner solution with $d_i^I = 0$ also exists. The intuition is that in either occurrence the cost of curbing resource diversion via the director's monitoring effort is not worth bearing and therefore the founder does not hire him but uses only the contractual incentives m_i^F and m_i^I to affect the manager. Generalizing further, this reasoning says that a more powerful corner solution exists: under conditions that we discuss later, in the first two phases of the economy's transition founders plan zero investment and therefore offer contracts that specify $m_i^I = d_i^I = 0$. Therefore, the model produces an endogenous change of corporate governance when firms start investing in-house.

To summarize our results about corporate governance with an eye to the analysis of the macroeconomic equilibrium to follow, we note that equation (24) reduces to

$$r_Z = \frac{a_i}{q_i} \frac{\partial F_i}{\partial Z_i}, \tag{25}$$

which says that the return to in-house innovation is proportional to the marginal cash flow, with time-invariant factor of proportionality a_i/q_i. In other words, the distortion of the founder's investment decision due to misaligned incentives reduces to a time-invariant wedge. This property follows from the fact that the founder's decisions about the manager's and the director's compensation do not depend on F_i and I_i. They are thus time-separable and depend only on the moral hazard side of the problem. Moreover, the founder's participation constraint (18) yields the free-entry condition $V_i^{\text{founder}}(t) = \beta X(t)$. Taking logs and time derivatives yields the return to entry

$$r_N = \frac{\Pi_i^{\text{founder}}}{V_i^{\text{founder}}} + \frac{\dot{V}_i^{\text{founder}}}{V_i^{\text{founder}}} = \frac{1}{\beta} \frac{\Pi_i^{\text{founder}}}{X} + \frac{\dot{X}}{X}. \tag{26}$$

According to these expressions, corporate governance distortions affect the rates of return to in-house innovation and entry through the appropriation factor $a_i < 1$ and through the cost-of-investment factor $q_i = \frac{1}{1-S_i^I} + d_i^I + m_i^I > 1$.

4 General equilibrium

We now turn to the general equilibrium of our economy.

4.1 Structure of the equilibrium

Models of this class have symmetric equilibria in which firms charge the same price, $P = 1/\theta$, and have the same quality level at all times.[3] As they receive $NPX = \theta Y$ from the final producer, we have $X = \theta^2 Y/N$. Writing the production function (4) under symmetry and using this result to eliminate X, we obtain

$$Y = \theta^{\frac{2\theta}{1-\theta}} Z N^{1-\gamma} L^{\gamma} \Omega^{1-\gamma}. \tag{27}$$

This reduced-form representation of final production shows that both the mass of firms, N, and average quality, Z, drive total factor productivity. Subtracting the cost of intermediate production from final output and using (31), we let G denote GDP and obtain

$$G = Y - N\left(X + \phi Z\right) = \left[1 - \frac{\theta}{P}\left(1 + \frac{\phi Z}{X}\right)\right] Y. \tag{28}$$

Next, we use the definition of cash flow (9) to write the returns (25)-(26) as:

$$r_Z = \frac{\alpha a}{q}\left[\left(\frac{1}{\theta} - 1\right)\frac{X}{Z} - \phi\right]; \tag{29}$$

$$r_N = \frac{1}{\beta}\frac{a[(\frac{1}{\theta} - 1)X/Z - \phi] - q\dot{Z}/Z}{X/Z} + \frac{\dot{X}}{X} \tag{30}$$

These expressions show that the returns depend on the quality-adjusted *firm size*, X/Z. They thus suggest that we use $x \equiv X/Z$ as our stationary state variable in the analysis of dynamics since in this model steady-state growth is driven by exponential growth in intermediate product quality. Using (27), we have

$$x \equiv \frac{X}{Z} = \frac{1}{P} \cdot \underbrace{\frac{\theta Y}{Z}}_{\text{market size}} \cdot \underbrace{\frac{1}{N}}_{\text{market share}} = \left(\frac{\theta}{P}\right)^{\frac{1}{1-\theta}} \left(\frac{L}{N}\right)^{\gamma} \Omega^{1-\gamma}. \tag{31}$$

This expression shows the equilibrium determinants of quality-adjusted firm size. Henceforth, we call x "firm size" for short.

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[3] See Peretto (2015) for a review of the formal arguments. The conditions for symmetry in this paper are (i) the firm-specific return to in-house innovation is decreasing in Z_i (this follows from $\alpha < 1$); (ii) entrants enter at average quality Z. The first condition implies that if one holds constant the mass of firms and starts the model from an asymmetric distribution of firm sizes, then the model converges to a symmetric distribution. The second assumption ensures that entrants do not perturb such symmetric distribution.

To conclude this characterization, we note first that GDP per capita (worker) is

$$\frac{G}{L}=\left(\frac{\theta}{P}\right)^{\frac{\theta}{1-\theta}}\left[1-\frac{\theta}{P}\left(1+\frac{\phi}{x}\right)\right]N^{1-\gamma}Z\left(\frac{\Omega}{L}\right)^{1-\gamma},\quad P=\frac{1}{\theta}. \tag{32}$$

This expression decomposes GDP per capita in four terms. The first captures the role of the pricing decision in locating firms on their demand curve, thus determining their scale of activity. The second captures the role of static economies of scale, which imply that larger firms produce at lower average cost. The third captures the role of product variety and product quality, which evolve over time according to the behavior dictated by the returns discussed above. The last term captures diminishing returns to labor due to the presence of the fixed factor. Next, we highlight the two channels through which corporate governance affects household wealth, $A=\int_0^N V_i^{\text{founder}}di$. First, the dividend flow Π_i^{founder} in the valuation equation (17) depends on the micro-level, principal-agent equilibrium internal to the firm: the worse corporate governance frictions, the lower the dividend flow accruing to the founder. Second, in equilibrium the interest rate r itself depends on corporate governance frictions through their effects on the returns r_Z and r_N.

4.2 The dynamical system

We now derive the main building blocks of the economy's equilibrium system. In particular, we characterize all the needed macroeconomic variables as functions of firm size x only, a property that makes the analysis of the general equilibrium dynamics remarkably simple. Incentives to innovate and the associated evolution of market structure in the intermediate goods sector are as follows.

Lemma 1 *(Rates of Return and Firm Size Dynamics) With the definition of x in (31), the returns to innovation in (29) and (30) become:*

$$r_Z=\frac{a}{q}\alpha\left[\left(\frac{1}{\theta}-1\right)x-\phi\right]; \tag{33}$$

$$r_N=\frac{a}{\beta}\left[\left(\frac{1}{\theta}-1\right)-\frac{\phi+\frac{q}{a}z}{x}\right]+\frac{\dot{x}}{x}+z. \tag{34}$$

Firm size obeys the differential equation

$$\frac{\dot{x}}{x}=\gamma\left(\lambda-n\right). \tag{35}$$

Proof. We use the definition $x\equiv X/Z$, noting that it yields $\frac{\dot{x}}{x}=\frac{\dot{X}}{X}-z$, to rewrite (29)-(30) as (33)-(34). Next we log-differentiate (31) with respect to time to obtain (35). ■

Equations (33)-(34) highlight the role of corporate governance: *worse moral hazard, captured by lower a and/or higher q, reduces both r_Z and r_N.* They also reproduce the growth model's main property: decisions to invest depend on firm size, x. The evolution of firm size, in turn, is driven by the difference between population growth, λ, which drives the growth of the market for intermediate goods, and product proliferation, n, which fragments the market for intermediate goods in smaller submarkets (local monopolies) and thus reduces the profitability of the individual firm. Moreover, from the perspective of the firm, innovation entails a sunk cost that is economically justified only when the anticipated revenue flow is sufficiently large. Specifically, the non-negativity constraint on variety growth, $n \geq 0$, implies that there is a threshold of firm size below which entry is zero because the return is too low. The value of the threshold depends on whether entrants anticipate that in the post-entry equilibrium $z > 0$ or $z = 0$ since it affects the dividend that they expect to earn. Similarly, the non-negativity constraint on quality growth, $z \geq 0$, implies that there is a threshold of firm size below which incumbents do not invest because the return is too low. The value of the threshold depends on whether $n > 0$ or $n = 0$ since it affects the reservation interest rate of the household. We focus on the case where the threshold for variety innovation, denoted x_N, is smaller than the threshold for quality innovation, denoted x_Z. The threshold x_N has a special role that the following lemma states formally.

Lemma 2 *(Household Consumption) There are two regimes, one with no entry and one with entry. The consumption behavior of the household in the two regimes is*

$$c(x) = \begin{cases} 1 - \theta + a\theta^2 \left(\frac{1}{\theta} - 1 - \frac{\phi}{x}\right) & \frac{\phi}{\frac{1}{\theta} - 1} < x \leq x_N \\ 1 - \theta + (\rho - \lambda)\beta\theta^2 & x > x_N \end{cases}. \tag{36}$$

Proof. See the Appendix. ■

This result says that the ratio of consumption to final output, c, is an increasing function of firm size, x, up to the threshold that triggers entry, where it becomes constant. The reason is that when entry is zero incumbents earn rents that increase with firm size. Since such rents are distributed to the household as dividends, they fuel the rise of the consumption ratio. When entry is positive, in contrast, such rents are competed away and the ratio of consumption to final output is constant throughout the transition as well as in steady state. Of note is the role of the appropriation factor a. In the regime with no entry, corporate governance distortions that result in $a < 1$ depress the household's consumption-output ratio because they divert resources to managers and directors. In the regime with entry, instead, such frictions do not affect the consumption-output ratio. This difference highlights the role of the free-entry condition more than any other component of the model. When the condition does not hold and households consume all income, diversion of resources to managers and directors reduces dividends distribution and thereby the ratio of household income to final output. When the condition holds and households save, resource diversion within firms does not affect the consumption-output ratio because the endogenous adjustment in market structure yields that household income, $wL + rA$, is proportional to final output, Y. The key channel driving this result is that the free-entry condition caps equity prices at $V = \beta X$ and thus yields asset income $rA = (\rho - \lambda)\beta\theta^2 Y$. Given these two regimes, the equilibrium interest rate and growth rate are as follows.

Lemma 3 *(Interest Rate and Growth) Denote* $n \equiv \dot{N}/N$, $z \equiv \dot{Z}/Z$ *and* $g \equiv \dot{G}/G - \lambda$. *At any point in time, the interest rate is*

$$r = \begin{cases} \rho - \lambda + \left[\frac{c'(x)x}{c(x)} + 1\right]\gamma\lambda & \frac{\phi}{\frac{1}{\theta}-1} < x \leq x_N \\ \rho + z + (1-\gamma)(n-\lambda) & x > x_N \end{cases}. \tag{37}$$

Denote the elasticity of GDP with respect to firm size

$$\xi(x) \equiv \frac{\theta^2 \phi / x}{1 - \theta^2 (1 + \phi/x)}.$$

At any point in time, the growth rate of GDP per capita is

$$g = \begin{cases} [\xi(x)\gamma - 1 + \gamma]\lambda & \frac{\phi}{\frac{1}{\theta}-1} < x \leq x_N \\ z + [1 - \gamma - \gamma\xi(x)](n-\lambda) & x > x_N \end{cases}. \tag{38}$$

Proof. See the Appendix. ■

The activation thresholds and innovation rates are as follows.

Lemma 4 *(Innovation Rates and Thresholds) The thresholds of firm size that activate, respectively, variety and quality innovation are:*

$$x_N = \frac{\phi}{\frac{1}{\theta} - 1 - \frac{\beta(\rho-\lambda)}{a}}; \tag{39}$$

$$x_Z = \frac{\phi\frac{\alpha}{q} + \left(\frac{1}{\theta}-1\right)\frac{1-\gamma}{\beta} + \frac{\gamma\rho}{a} + \sqrt{\left[\phi\frac{\alpha}{q} + \left(\frac{1}{\theta}-1\right)\frac{1-\gamma}{\beta} + \frac{\gamma\rho}{a}\right]^2 - 4\left(\frac{1}{\theta}-1\right)\frac{\alpha}{q}\phi\frac{1-\gamma}{\beta}}}{2\left(\frac{1}{\theta}-1\right)\frac{\alpha}{q}}. \tag{40}$$

Focus on the case $x_N < x_Z$ *and assume*

$$\beta x > (1-\gamma)q \quad \forall x > \phi, \tag{41}$$

i.e., $\beta\phi > (1-\gamma)\,q$. *Then, for* $x > x_N$ *the equilibrium rates of innovation are:*

$$n(x) = \begin{cases} \frac{a}{\beta}\left(\frac{1}{\theta} - 1 - \frac{\phi}{x}\right) - \rho + \lambda & x_N < x \leq x_Z \\ \frac{a}{\beta}\left(\frac{1}{\theta} - 1 - \frac{\phi + \frac{q}{a} z(x)}{x}\right) - \rho + \lambda & x > x_Z \end{cases}; \tag{42}$$

$$z(x) = \begin{cases} 0 & x_N < x \leq x_Z \\ \frac{\left[\left(\frac{1}{\theta}-1\right)x - \phi\right] a \left(\frac{\alpha}{q} - \frac{1-\gamma}{\beta x}\right) - \gamma\rho}{1 - \frac{(1-\gamma)q}{x\beta}} & x > x_Z \end{cases}. \tag{43}$$

Proof. See the Appendix. ■

Finally, to complete the characterization of the macroeconomic equilibrium, we derive an all-inclusive consumption ratio that adds to household consumption the consumption of managers and directors. Recall that for simplicity we separated the agents (managers and directors) from the household, as the provider of labor and of startup funds, and assumed that managers and directors consume instantly their income flow.[4]

Lemma 5 *(Total Consumption) The economy's all-inclusive consumption is*

$$\begin{aligned} \tilde{C} &= C + N\left(C^{manager} + C^{director}\right) \\ &= C + \left[(1-a)\left[\left(\frac{1}{\theta} - 1\right)x - \phi\right] + (q-1)\,z\right] NZ. \end{aligned}$$

The all-inclusive consumption-output ratio $\tilde{c} \equiv \frac{\tilde{C}}{Y}$ *is thus*

$$\tilde{c}(x) = \begin{cases} 1 - \theta + \theta^2\left(\frac{1}{\theta} - 1 - \frac{\phi}{x}\right) & \frac{\phi}{\frac{1}{\theta}-1} < x \leq x_N \\ 1 - \theta + (\rho - \lambda)\,\beta\theta^2 + \theta^2\left[(1-a)\left(\frac{1}{\theta} - 1 - \frac{\phi}{x}\right) + (q-1)\frac{z(x)}{x}\right] & x > x_N \end{cases}. \tag{44}$$

Proof. See the Appendix. ■

The analysis developed so far provides all the elements needed to address the paper's main research question: how corporate governance distortions affect development. In the next section we study the evolution of the economy through three phases, starting from a phase of no innovation to becoming a modern *innovation economy.* The key feature of the dynamics is that at two critical junctures the economy may be trapped in a state of underdevelopment because the corporate governance distortions are too severe.

[4] Given the calibration procedure described in the next section, we solved numerically the model under the assumption that agents confer their income to a consolidated household budget and participate in a complete consumption-sharing scheme. We found that quantitatively the behavior of the economy is only marginally different from that presented here. We thus decided to focus on the setup with segregated budgets because it yields analytical results that make the paper's key mechanism transparent.

5 Phases of development

This section discusses the role of the diversion of cash flow and of investment funds in shaping the secular development path of the economy. The model produces a path consisting of three phases:

1. an initial phase where there is no innovation and the economy grows only because of exogenous population growth;

2. an intermediate phase where the economy turns on the Schumpeterian engine of endogenous innovation in response to population-led market expansion;

3. a terminal phase where economic growth acquires the features associated with the modern *innovation economy.*

5.1 Phase 1: stagnation or take-off

In the first phase there is no entry, no in-house investment and all dividends are consumed. As said, the economy grows only because of exogenous population growth. Because of its stark simplicity, this phase highlights the role of corporate governance distortions as a potential cause of stagnation: when cash flow diversion is severe, founders delay the creation of new firms or give up the undertaking altogether. The following proposition formalizes this result.

Proposition 3 *(Stagnation or Take-off) In the first phase firm size evolves according to* $\dot{x}/x = \gamma\lambda$*. The expression for* x_N *in equation (39) yields two scenarios.*

- ***Stagnation****. For* $a \leq \beta(\rho - \lambda) / \left(\frac{1}{\theta} - 1\right)$ *the activation threshold* x_N *is infinite and the economy remains forever in the regime with no innovation.*

- ***Take-off****. For* $a > \beta(\rho - \lambda) / \left(\frac{1}{\theta} - 1\right)$ *the activation threshold* x_N *is finite and the economy crosses it in finite time. Specifically, starting from initial condition* $x_0 < x_N$ *firms size follows the process* $x(t) = e^{\gamma\lambda t} x_0$ *and reaches* $x(t) = x_N$ *at time*

$$T_N = \frac{1}{\gamma\lambda} \log\left(\frac{x_N}{x_0}\right) = \frac{1}{\gamma\lambda} \log\left(\frac{\phi}{\frac{1}{\theta} - 1 - \frac{\beta(\rho-\lambda)}{a}} \frac{1}{\theta^{\frac{2}{1-\theta}} \left(\frac{L_0}{N_0}\right)^{\gamma} \Omega^{1-\gamma}}\right). \tag{45}$$

Proof. See the Appendix. ■

Equation (45) provides a key analytical insight on how the activation of Schumpeterian innovation, the model's first phase-transition, depends on the interaction between corporate governance distortions and other fundamentals of the economy, such as the population growth rate, λ, and the factor endowment, Ω. On the one hand, faster population growth favors more rapid market expansion and therefore reduces the time that it takes for the economy to enter the second phase of development, which features the costly creation of new firms that bring to market new intermediate goods (variety innovation). On the other hand, for given population growth, the timing of the first phase-transition depends on the gap between the activation threshold, x_N, and the initial position of the economy, x_0. While an improvement in corporate governance, by reducing the ratio x_N/x_0, brings forward in time the first phase-transition, it does not necessarily trigger an immediate take-off because even after the improvement it could still be that $x_N < x_0$. Similarly, economies that take off earlier are not necessarily economies with better corporate governance. An economy afflicted by worse corporate governance distortions, may still reach the first phase of development earlier if, for instance, it has a larger endowment Ω that supports a larger market for intermediate goods and thereby makes entry profitable earlier than in economies with better corporate governance.

Because we focus on a development sequence in which product proliferation sets in before in-house innovation, corporate governance distortions affect the first phase-transition only through the appropriation factor, a. Accordingly, the quantitative analysis of Section 6 explains the initial income divergence across countries only through differences in diversion of cash flow. Diversion of planned investment funds become relevant with the second phase-transition, which we study next.

5.2 Phase 2: variety expansion only or full transition

Substitution of the top line of equation (42) into equation (35) yields the law of motion of firm size in the second phase of development as the linear process

$$\dot{x} = \bar{\nu} \cdot (\bar{x}^* - x), \tag{46}$$

where:

$$\bar{\nu} \equiv \gamma \left[\left(\frac{1}{\theta} - 1 \right) \frac{a}{\beta} - \rho \right]; \quad \bar{x}^* \equiv \frac{a\gamma\phi}{\beta} \frac{1}{\bar{\nu}} = \frac{\phi}{\frac{1}{\theta} - 1 - \frac{\rho\beta}{a}} > x_N.$$

By construction $\bar{x}^*$ is the steady state that the economy reaches if it never activates in-house innovation. We thus have the following result.

Proposition 4 *(Transition to In-house Innovation) In the second phase firm size evolves according to $\dot{x} = \bar{\nu} \cdot (\bar{x}^* - x)$. The expression of x_Z in equation (40) says that two scenarios are possible.*

- ***Variety Expansion Only***. *If* $\rho \leq \frac{a}{\beta}\left(\frac{1}{\theta} - 1 - \frac{\phi}{x_Z}\right)$ *the activation threshold* x_Z *is larger than the steady state* $\bar{x}^*$ *and the economy remains forever in the regime with only variety expansion.*

- ***Full Transition***. *If* $\rho > \frac{a}{\beta}\left(\frac{1}{\theta} - 1 - \frac{\phi}{x_Z}\right)$ *the activation threshold* x_Z *is smaller than the steady state* $\bar{x}^*$ *and the economy crosses it in finite time. Specifically, firms size follows the process*

$$x(t) = x_N e^{-\bar{\nu}(T_N - t)} + \bar{x}^*\left(1 - e^{-\bar{\nu}(T_N - t)}\right). \tag{47}$$

and reaches $x(t) = x_Z$ *at time*

$$T_Z = T_N + \frac{1}{\bar{\nu}}\log\left(\frac{\bar{x}^* - x_N}{\bar{x}^* - x_Z}\right). \tag{48}$$

Proof. See the Appendix. ■

The expressions for $\bar{x}^*$ and x_Z in, respectively, equations (46) and (40) show how these two critical values of firm size vary with technology and preference parameters and with corporate governance distortions. Using those expressions, we can write the condition $\bar{x}^* > x_Z$ that determines whether the date T_Z is finite as

$$\frac{\phi\frac{\alpha}{q} + \left(\frac{1}{\theta} - 1\right)\frac{1-\gamma}{\beta} + \frac{\gamma\rho}{a} + \sqrt{\left[\phi\frac{\alpha}{q} + \left(\frac{1}{\theta} - 1\right)\frac{1-\gamma}{\beta} + \frac{\gamma\rho}{a}\right]^2 - 4\left(\frac{1}{\theta} - 1\right)\frac{\alpha}{q}\phi\frac{1-\gamma}{\beta}}}{2\left(\frac{1}{\theta} - 1\right)\frac{\alpha}{q}} < \frac{\phi}{\frac{1}{\theta} - 1 - \frac{\rho\beta}{a}}.$$

This inequality says that parameters and corporate governance distortions are such that $\dot{x} > 0$ for $x = x_Z$, that is, that firm size is strictly increasing in the whole range $[x_N, x_Z]$ and, consequently, the economy crosses the threshold x_Z in finite time. Interestingly, if the inequality fails the economy never reaches the activation threshold x_Z (regardless of whether it is finite or infinite) and converges to the steady state $\bar{x}^* < x_Z$ where there is only variety expansion and the growth rate of income per capita is $\bar{g}^* = 0$. The condition shows that such premature stopping of the economy can result from severe corporate governance distortions, especially a high cost of in-house investment. One could build a locus in (a, q) space that identifies a region in which the transition to in-house innovation occurs and one in which it does not. The location and shape of the locus depends on the micro parameters characterizing moral hazard. In this sense, the pair (a, q) propagates the micro-interactions between founder, manager and director throughout the macroeconomy, including whether it progresses to the third phase of development.

The analytical solution for the activation date T_Z in equation (48) is richer than that for T_N in equation (45) because it compounds the diversion of cash flow with the diversion of planned investment funds. Section 6 illustrates quantitatively how the interaction between the two distortions affects the dynamics of the economy. The interaction produces a variety of transition patterns, including episodes of overtaking and of permanent divergence.

5.3 Phase 3: the modern innovation economy

Substitution of the bottom line of equation (42) in equation (35) yields that in the third phase the economy follows the nonlinear differential equation

$$\dot{x} = \frac{\gamma}{\beta}\left[\beta\rho x - a\left(\left(\frac{1}{\theta} - 1\right)x + \phi\right) + qz\left(x\right)\right], \tag{49}$$

where $z\left(x\right)$ is given by the second line of equation (43). The following proposition states the main result formally.

Proposition 5 *(Transition to Modern Innovation Economy) Assume:*

$$a > \frac{\beta\left(\rho - \lambda\right)}{\frac{1}{\theta} - 1}; \tag{C1}$$

$$\rho > \frac{a}{\beta}\left(\frac{1}{\theta} - 1 - \frac{\phi}{x_Z}\right); \tag{C2}$$

$$\frac{(1-\alpha)\frac{a}{q}}{\rho} > \frac{\beta}{\left(\frac{1}{\theta} - 1\right)q} > \frac{1}{\phi}. \tag{C3}$$

Then, there is a unique equilibrium path: given $x_0 < x_N$ the economy goes through Phase 1, Phase 2, Phase 3 and converges to the steady state

$$x^* = \frac{(1-\alpha)a\phi - q\rho}{(1-\alpha)a\left(\frac{1}{\theta} - 1\right) - \beta\rho} > x_Z. \tag{50}$$

The rates of growth of quality, variety and GDP per capita are, respectively:

$$z^* = \frac{a}{q}\alpha\left[\left(\frac{1}{\theta} - 1\right)x^* - \phi\right] - \rho = \frac{\alpha}{q}\frac{\phi\beta\rho - \left(\frac{1}{\theta} - 1\right)q\rho}{(1-\alpha)\left(\frac{1}{\theta} - 1\right) - \frac{\beta\rho}{a}} - \rho > 0; \tag{51}$$

$$n^* = \left(\frac{\dot{N}}{N}\right)^* = \lambda; \tag{52}$$

$$g^* = \left(\frac{\dot{G}}{G}\right)^* - \lambda = \left(\frac{\dot{Y}}{Y}\right)^* - \lambda = z^*. \tag{53}$$

Proof. See the Appendix. ■

Condition C1 ensures that the economy crosses the threshold x_N and activates horizontal innovation (entry). Condition C2 ensures that the economy makes the full transition to the third phase with in-house quality innovation. Condition C3 ensures that the steady state x^* exists because both the numerator and the denominator of equation (50) are positive. To complete the characterization of this scenario, note that since the transition features rising firm size, x, it features a rising rate of variety innovation, $n(x)$. Under conditions C2-C3, the economy crosses the threshold x_Z at time T_Z, displays rising rates of both variety and quality innovation, $n(x)$ and $z(x)$, and converges from below to the growth rate $g^* = z^*$. To understand better the properties of the steady state, note that the household's saving behavior yields

$$r = \rho + z. \tag{54}$$

Substituting this expression in the returns to investment (33) and to entry (34) we obtain:

$$z = \frac{a}{q}\alpha \left[\left(\frac{1}{\theta} - 1 \right) x - \phi \right] - \rho; \tag{CI}$$

$$z = \frac{a}{q} \left[\left(\frac{1}{\theta} - 1 \right) x - \phi \right] - \frac{\beta}{q}\rho x. \tag{EI}$$

The first relationship, which we call the corporate investment CI locus, describes the steady-state investment rate that incumbents choose given the firm size that they expect to achieve in equilibrium. The second relationship, which we call the entry EI locus, describes the steady-state investment rate of incumbents that equalizes the return to entry and the return to in-house investment, given the value of firm size that both entrants and incumbents expect to achieve in equilibrium.

The steady state is the intersection of these two lines in (x, z) space. Existence and stability require the intercept condition that the EI curve start out below the CI curve and the slope condition that the EI curve be steeper than the CI curve. Together they say that one intersection exists, with the EI line cutting the CI line from below. The restrictions on the parameters that guarantee this configuration are those that yield the global stability of the economy's dynamics (see the Appendix for more).

The effects captured by the CI locus are straightforward. The return to in-house innovation is given by the marginal effect of knowledge accumulation on the firm's cash flow times the wedge a/q. The cost of investment, q, seemingly enters the EI locus twice but in fact the expression captures a single effect. To see this, we write the return to entry as

$$\rho + z = \frac{a}{\beta} \left[\left(\frac{1}{\theta} - 1 \right) - \frac{\phi + \frac{q}{a} z}{x} \right] + z,$$

where on the left-hand side we have the household's reservation interest rate from equation (54). Here the cost of investment, q, raises the anticipated expenditure on in-house innovation and thereby reduces the dividend flow distributed to shareholders.

The stability conditions imply that the effect of q on the EI locus dominates, yielding that for given x worse diversion planned investment reduces firm growth on both the EI and CI margins. Whether such a deterioration causes a rise or a decline of equilibrium growth depends on the relative magnitude of the shifts of the two curves. If the shift of CI is larger than the shift of EI equilibrium growth falls. According to our closed-form solutions (50) and (51), this is indeed the case. Those solutions, moreover, identify the channels: (i) q reduces the growth rate, z, for given firms size, x; (ii) q reduces firm size, x. Similarly, the solutions say that the net effect of the appropriation factor, a, on both firm size, x, and firm growth, z, is negative because stability requires $q < \beta\phi/\left(\frac{1}{\theta} - 1\right)$. This is intuitive: as the appropriation factor rises, incentives to enter are stronger and produce an equilibrium market structure with a larger mass of smaller firms that invest less.

6 Corporate governance and income dynamics

In our model countries that differ by corporate governance are observationally equivalent until the onset of innovation-led growth. This is consistent with the fact that in the pre-industrial era GDP per capita (henceforth, income for brevity) averaged over time is similar across countries. In the year 1700, for instance, income in the USA is about the same as in Latin America. Divergence starts with the first industrial revolution. In 1820, as the first wave of the industrial revolution spreads, the Latin America-USA income ratio is slightly above one half and it falls to a quarter by 2008. The divergence of Africa is even more dramatic. The corresponding income ratios in 1820 and 2008 are one third and one sixteenth. In this section we provide a quantitative assessment of the ability of corporate governance to explain such dynamics. We illustrate first how corporate governance affects entry and in-house innovation. We then calibrate the model's parameters to the USA over the period 1700-2008 and assign those parameters to several countries and macro regions to compute the corporate governance distortions, relative to the USA, that allow the model to fit the Maddison data for those countries and macro regions. Finally, we discuss whether relaxing the assumption that corporate governance remains unchanged throughout the period improves the model's fit of the data.

6.1 The micro-to-macro of corporate governance

Proposition 2 characterizes how the model's microstructure of corporate governance determines the appropriation factor, a, and the cost of investment, q. To implement that result in our quantitative analysis, we use the functional forms

$$S^J\left(M^J, D^J\right) = \sigma_1^J M^J - \sigma_2^J D^J,\ c_M^J(M^J) = \sigma_3^J \left(M^J\right)^{\sigma_4^J},\ c_D^J(D^J) = \sigma_5^J D^J + \sigma_6^J \left(D^J\right)^{\sigma_7^J}, \quad (55)$$

for $J = I, F$ and where $\sigma_i > 0$ for $i = 1, .., 7$. The left panel of Figure 1 shows the founder's decision as the intersection in $\left(m^F, d^F\right)$ space of conditions (20)-(21). As discussed, a corner solution with $d^F = 0$ occurs if the cost of curbing cash flow diversion via the director's monitoring effort is not worth bearing. The right panel of Figure 1 illustrates the founder's decision concerning diversion of planned investment. Here too the corner solution $d^I = 0$ can occur. Moreover, because firms plan zero investment in the first two phases of the economy's transition, they offer contracts that specify $m^I = d^I = 0$. As discussed, this means that the model produces an endogenous change in corporate governance structure at the time of the transition to the third phase.

Figure 2 illustrates how the appropriation factor, a, and the cost of investments, q, vary with the parameters of equations (55) and the macroeconomic propagation of changes in those parameters. For instance, the appropriation factor a is increasing in the marginal cost of cash flow diversion $\partial c_M^F(M^F)/\partial M^F$ (e.g., larger σ_4^F). As the appropriation factor rises, both rates of return to innovation rise for all values of x; see Lemma 1. In general equilibrium, both rates of innovation rise for all values of x; see Lemma 4. In steady state, both loci CI and EI shift to the right in (x, z) space; see the left graph of Figure 2b. Because the EI locus responds relatively more to the higher a, firm size rises and firms invest more aggressively, i.e., both x and z rise. Similarly, the cost of investment q is decreasing in the marginal cost of planned investment diversion $\partial c_M^I(M^I)/\partial M^I$ (e.g., larger σ_4^I). As q rises, the CI locus relatively more than the EI locus and the economy moves to a situation where both firm size and firm investment are smaller.

6.2 Calibration to the US economy

We take the USA as our baseline economy. Table 2.a shows the calibrated preference and technology parameters. The rate of population growth, $\lambda = 1.03\%$, is the average for the United States since 1880. Recall that in the model's steady state the entry rate, n, is equal to λ. Lee and Mukoyama (2015, p. 24) and Hathaway and Litan (2014, p. 2), among many others, report that this is the case in the data: the long-run entry rate in US manufacturing is statistically equal to the population growth rate. Thus, although we do not target the long-run entry rate, the model replicates it well. We set the elasticity of profit with respect to own knowledge at $\alpha = 0.33$. This value implies knowledge spillovers, $1 - \alpha$, of about 66%, which is very much in line with the estimates reported in the literature; see Baumol (2002) for an extensive discussion. We set $\theta = 0.769$ to obtain a mark-up of 30%, within the range reported in the literature for the manufacturing sector (Christopoulou and Vermeulen, 2012), which gives us price $P = \frac{1}{\theta} = 1.3$. We set the discount rate at $\rho = 3\%$. We follow Iacopetta et al. (2018), who use data discussed in Nikolov and Whited (2014) to set the appropriation factor at $a = 0.9$.

To set the remaining parameters $(\phi, \beta, \gamma, q, \Omega)$ and the initial conditions (Z_0, N_0, L_0) we follow a more articulated procedure that reflects the highly nonlinear shape of the transition path. We set without much loss of generality $L_0 = N_0 = 1$ and determine $(\phi, \beta, \gamma, q, \Omega, Z_0)$ asking the model to generate data that satisfy the following criteria.

1. The model-generated income in 1700 matches the value in the Maddison data.[5]

2. The activation of horizontal innovation (i.e., $n > 0$) occurs in 1800. In choosing this date, we follow the literature, e.g., Lucas (2000) and many others.

3. The model-generated long-run saving rate is within the range observed for the USA in recent decades. We choose a target of 11.8%; see Table 2b and the Appendix for a discussion.

4. The model-generated long-run labor share (aggregate labor income over GDP) is within the range observed for the USA in recent decades. Our specific target is 59%; see Table 2b and the Appendix for a discussion.

5. The procedure minimizes the sum of squared deviations between model-generated data and the Maddison data over the period 1990-2008. (From a geometrical point of view, this part of the calibration fits a line to the data for log-income and uses the regression's slope to obtain a constraint that the parameters must satisfy.)

6. The model-generated income in 2008 matches the value in the Maddison data (2008 is the final year of the data set).[6]

We discuss the details of the calibration in the Appendix . The procedure yields a value of long-run income growth $g = 2.21\%$. This is also the in-house investment rate, z, or,

[5] There is nothing special about the choice of 1700, other that this is the only year prior to 1820 for which Maddison reports the level of income for a large number of countries. Except for the value of Ω (see below), our calibration would not change if it started at some other year.

[6] Using as a moment the income of any year in the 1990-2008 period or a moving average over the same period changes the results only marginally.

equivalently, the growth rate of incumbent firms. The implied interest rate is $r = \rho + g = 5.21\%$. While these values were not pre-set targets for the calibration, they are in line with the values typically found in the literature. Finally, the procedure yields a value $q = 1.0720$ for the cost of in-house investment.[7]

Because of the important role of the initial conditions in determining the first phase transition, it is worth discussing some of the details of how we meet the target of the year 1800 for the activation of horizontal innovation (point 2). Given (ϕ, β, γ), which are tied to other moments, and $(\lambda, \rho, \theta, a)$, which are calibrated from outside sources, equation (45) determines T_N from the value of Ω. Starting the simulation at $t = 1700$ and using equation (45) we obtain the value of Ω that yields $T_N = 100$. The reason why we say that we can set $L_0 = N_0 = 1$ without much loss of generality is that in equation (45) we cannot disentangle the roles of (Ω, N_0, L_0) since the three enter through $x_0 = \theta^{\frac{2}{1-\theta}} (L_0/N_0)^{\gamma} \Omega^{1-\gamma}$. Nevertheless, one should keep in mind that the triplet (Ω, N_0, L_0) affects the income path. To see this, it is useful to recall that population follows the process $L(t) = L_0 e^{\lambda t}$ and write income at all future dates as

$$\frac{G(t)}{L(t)} = \theta^{\frac{2\theta}{1-\theta}} \left[1 - \theta^2 \left(1 + \frac{\phi}{\theta^{\frac{2}{1-\theta}} \left(\frac{L_0 e^{\lambda t}}{N(t)} \right)^{\gamma} \Omega^{1-\gamma}} \right) \right] \frac{N(t)^{1-\gamma} Z(t)}{\left(e^{\lambda t}\right)^{1-\gamma}} \left(\frac{\Omega}{L_0} \right)^{1-\gamma}. \tag{56}$$

Finally, we stress that given T_N and all the other parameters, equation (48) of proposition 4 generates *endogenously* the value $T_Z = 112$ as the time of activation of in-house innovation. This activation time, which is not a target of the calibration, determines when the bulk of the growth acceleration begins and thus drives the determination of the cost of in-house investment, q.

Figure 3a compares the model-generated income series to Maddison's. Figure 3b shows the two main drivers of the dynamics: when variety innovation, n, and, later, quality innovation, z, turn positive, the series become steeper as growth accelerates. The model matches quite well the data for the second half of the 20th century. For example, in the years 1950, 1975, 1990, and 2005, the model predicts 97%, 97%, 94%, and 103% of the data. It does less

[7] Recall that we set $a = 0.9$ from outside sources. In light of the micro-to-micro analysis of the previous subsection, which is based on the fact that both a and q are endogenous objects, we need to make clear how we reconcile the two levels of discipline for (a, q). The obvious constraint that one faces in using our structure to address cross-country questions is the lack of micro data consistent in both quality and coverage across countries. We are able to use micro sources only for the a of the USA and obtain q from the model. For the other countries we calibrate the pair (a, q) from macro data as described here. For the USA we check that there exist reasonable micro parameters that produce those values following the micro-to-macro procedure. The first row of Table 1 reports the values of the micro parameters for the functional forms in equation (55) consistent with $a = 0.9$ and $q = 1.0720$.

well in the 19th century, however, underpredicting the data by 10%-20% on average (see the last column of table 9).

6.3 Relative income dynamics around the world

Our main objective is to understand to what extent cross-country income differences are attributable to delays in industrialization caused by corporate governance distortions. We thus discipline our cross-country exercise in two ways. First, we use the same set of parameters for all countries, allowing them to differ only for corporate governance and, possibly, for the initial level of technology, Z_0, and the endowment, Ω. Second, in determining the pair (a, q) we impose that the growth rate of income 2.21% is the same for all countries. To see the role of this constraint, we use equation (51) to construct the isogrowth locus

$$q(a) = \frac{\alpha\phi\beta\rho}{(g^* + \rho)\left[(1-\alpha)\left(\frac{1}{\theta} - 1\right) - \frac{\beta\rho}{a}\right] + \left(\frac{1}{\theta} - 1\right)\alpha\rho}. \tag{57}$$

This expression says that q is decreasing in a; Figure 4 illustrates the quantitative relation that we obtain with our calibrated parameters for a range of values of g^*. The intuition driving this property is crucial to understand our exercises and results. The reason why the locus is downward sloping is that, as we discussed in Section 5, the appropriation factor, a, has a *negative* effect on growth because it raises the incentives to enter and thus produces an equilibrium market structure with a larger mass of smaller firms that invest less in-house. Our exercises exploit this property and postulate that better a is associated to a compensatory change in q that keeps constant the long-run growth rate, g^*. Crucially, therefore, they identify and isolate the activation dates T_N and T_Z as the key channels through which corporate governance shapes the secular path of income. The figure also suggests that allowing g^* to differ across countries would not change the results by much unless such differences are very large. We begin our exposition with a simple exercise that gives a clear first assessment of the quantitative relation between income divergence and corporate governance.

6.3.1 Example: Latin America vs. USA

At the beginning of the 18th century income in Latin America is on average about the same as in the USA. Three centuries later it is only a quarter. While many factors caused the divergence, we ask how far we can go in accounting for it with corporate governance.

We assume that Ω and Z_0 are the same in both economies so that the initial income ratio is one. The value of (a, q) on the loci in Figure 4 that matches the observed growth expansion in Latin America is $(0.68, 1.39)$ – for the USA we had obtained the value of $(0.9, 1.07)$;

see table 3. The associated delays in crossing the activation thresholds are, respectively, $\Delta T_N = 14$ and $\Delta T_Z = 35$ years. We also obtain a strong out of sample prediction: the income ratio will decline further along the transition to the steady state, from 0.24 in 2008 to 0.16. We stress again that because we are using the same set of parameters, reported in table 2a, and we assumed the same initial condition, Z_0, and endowment Ω for the two economies, the difference in income dynamics is explained exclusively by the difference in corporate governance distortions.

This example gives a good preview of a central theme emerging from our results: we find frictions and delays that are significantly smaller than those found in the literature. For example, in her study of the dynamics of a Hansen-Prescott model, Ngai (2004) finds that to explain a USA-Latin America income ratio of 6.3 on the balanced growth path the model needs the cost of capital in Latin America to be 16 times that in the USA. Such differential, moreover, produces a delay in the arrival of modern growth in Latin America of about a century.

6.3.2 General analysis

We consider several countries and a few suitably constructed macro-regions. We assign to each economy the parameters calculated for the USA (Table 2.a) but allow for economy-specific initial condition, Z_0, and endowment, Ω, to determine the economy-specific corporate governance distortions (a, q) that best match the Maddison data. The spirit of the exercise is to use the model to infer for each country the magnitude of the deviation of the pair (a, q) from that of the USA that explains the evolution of relative income in the 1700-2008 data. We express an economy's income ratio, corporate governance distortions (a, q) and activation dates (T_N, T_Z) as relative to the USA. Table 5a reports that in 1700 all European countries had higher income than the USA. We account for such initial income differences via variations in Ω and/or Z_0. In terms of the theoretical model, the endowment Ω captures features like the amount and quality (e.g., fertility) of land, the availability of fresh water, navigable rivers, access to seaports and so on. One may also conjecture that in the USA in 1700 the level of technology of intermediate firms, Z_0, was lower than in Europe. Aside from such details of interpretation, however, our procedure stresses that Ω and Z_0 have different implications for the timing of the take-off and for the calibrated values of the corporate governance distortions (a, q). Specifically, an economy with larger Ω reaches the first activation threshold, x_N, sooner. The value of Z_0, on the other hand, does not affect the take-off time but affects the determination of the values of a and q because it plays an important role in shaping the entire income path, including the crossing of the activation threshold x_Z that marks the onset of the in-house innovation phase. To explore thoroughly the role of initial conditions and assess the robustness of our results, we consider three cases.

Common endowment and initial technology We assume first that Ω and Z_0 are the same in all countries. Because there are no differences in preferences, technologies, endowments and initial conditions, the initial income ratio is one. In this specification, therefore, the differences in income, corporate governance distortions (a, q) and activation dates (T_N, T_Z) are driven by the income differences in the final period 1990-2008. On average, in Western Europe the differences in a and q are -0.07 and 0.07, respectively, and the differences in T_N and T_Z are 4 and 7, respectively. Table 4 reports our results for several Western European countries and for some macro regions. The results for Latin America (panel b.i), are the same as those reported in Table 3 because the initial income ratio in the data is one. The African region, whose income has diverged the most, exhibits the largest gaps in a, q, T_N, and T_Z: -0.35, 0.87, 28 and 113, respectively.

Common endowment, country-specific initial technology We assume now that the initial endowment Ω is the same across countries and that initial differences in income ratios are due to differences in Z_0. Specifically, all countries start in 1700 with the same Ω and a country's Z_0 relative to that of the USA is equal its income ratio in 1700. Because it allows for such differences in initial income, this specification *enriches* the role of corporate governance in accounting for the data. Specifically, if a country starts with income ratio above one, the calibrated differences in (a, q) are larger, while if the initial income ratio is below one, the calibrated differences in (a, q) are smaller. Table 4a.ii reports the results. The insight is clear: countries that start out ahead of the USA *must* have worse governance for the model to replicate the fact that they end up behind the USA at the end of the sample period. For Western Europe, for instance, the differences in a, q, T_N, and T_Z are, respectively, -0.18, 0.23, 10, and 25. In Africa the corresponding figures are -0.33, 0.74, 25, 91, quite similar to the ones for the scenario with common Z_0 across countries (Table 4b.ii).

Common initial technology, country-specific endowment Finally, we assume that Ω differs across countries while Z_0 is the same (i.e., we assign to all countries the Z_0 of the USA). A country with larger endowment is closer to the activation threshold x_N. Moreover, the higher the initial income of the country, the smaller the income expansion between 1700 and 2008 to be accounted for by the model. As a result, the calibrated corporate governance distortions tend to be worse (lower a, higher q) than in the previous case. Thus, the endowment Ω has two opposite effects on the take-off time, T_N: it reduces it by increasing the initial condition x_0; it delays it by generating a lower appropriation factor, a. To decompose the two effects, we first calculate (a, q) and (T_N, T_Z) with the income ratio observed in the data and then recalculate (T_N, T_Z) under the same pair (a, q) but using the Ω of the USA. Tables 5b and 8b report the results.

The corporate governance distortions for Western Europe appear similar to those in the previous exercise with differences in a and q of -0.19 and 0.25. The difference in T_N is now -17, meaning that Western Europe starts the transition earlier than the USA by 17 years because of the initial advantages. More specifically, the direct effect of the initial endowment pushes European industrialization forward in time by 28 years, whereas the poorer quality of governance delays it by 11 years. The net effect is the -17 years reported. Figure 5 visualizes the earlier take-off of the UK due to the larger endowment and the subsequent takeover by the USA due to the better corporate governance, especially the lower cost of investment q. In particular, while the UK's larger endowment moves the take-off forward in time by 39 years, the lower quality of governance raises T_N and T_Z by 14 and 35 years, respectively. The net effect is that the UK and the USA enter the third phase at about the same time but the USA grows faster and eventually pulls ahead.

6.3.3 Model vs. data

Technological progress has been an unrelenting force fueling income expansion over the last three centuries. Yet, political upheavals, revolutions, civil wars, global conflicts and other events, like plagues and natural disasters, disturbed the smooth transition to modern growth. The model abstracts from these factors. It is thus instructive to compare the income produced by the model to the data according to a simple metric of agreement. Tables 9-12 report the income produced by the model as a percentage of the Maddison data for selected countries and macro regions. We focus on the case of common Z_0 and country-specific endowment Ω.

Western Europe. The model replicates quite closely (within a range of 20 percent deviation) the data since 1870 for the UK, Germany and France with the noticeable exception of the post World War II decade. One way to frame this feature is that the model fails exactly where it should. For instance, in 1900, two centuries into the simulation, the model predicts income for the UK, France and Germany that is 79%, 112% and 110% of the data (see Table 9 and Figures 6 and 7). The model overpredicts the income of Continental European countries in 1820 by 20-30 percent on average. It underpredicts the income of the UK and the USA by 1 and 12 percent, respectively. The overprediction in 1820 is arguably due to the fact that in Table 5b for all countries the income ratio in 1700 is fully accounted for by the endowment. Figure 7 shows an interesting outlier: the model overpredicts by a substantial margin Italy's income both in the 19th century and in the first half of the 20th century.

Italy starts in 1700 with an income about twice as large as that of the USA, but then has a relatively poor growth performance until the end of World War II. The slow process of state formation since unification may have played a role in such dynamics (see the next section). A similar type of discrepancy between model and data occurs in countries that experienced high growth rates after WWII, such as Singapore, Japan and South Korea.

Latin America. The frequent macroeconomic crises that have characterized Latin America resulted in a less regular income time series than that of Western Europe or of the USA. Figure 8 shows that for Chile the model matches well the data in 1870 and 1950 but overpredicts 1820 and underpredicts 1900. A similar result occurs for Argentina, except that in 1950 the observed income is higher than the predicted one. In the case of Mexico the decline of income in the 19th century is likely due to the prolonged internal conflict between conservatives and liberals that followed the war of independence (Coatsworth, 2005). The model then realigns with the Mexican data in 1900 during the Porfiriato. Brazil's state formation was also achieved through independence wars that caused economic disruption (1822-25), which likely explain why its income data in the 19th century exhibit an inverted-U shape similar to that of Mexico.

Asia. Matching the time profile of income in countries such as Japan, South Korea, Singapore and China (see Figure 9 and Tables 7 and 11) is notoriously challenging because of the almost vertical take-off, never before seen in the history of the world. While our model generates rising growth rates over the transition, it still predicts a more gradual transition than the data. The pattern is therefore clear: the model lacks the elements required to delay even further the take-off and then generate an even more dramatic acceleration post take-off. We think that this is another example of the model failing precisely where it should. Recall that in our exercises we keep the fundamental parameters constant throughout and do not allow for discontinuities. Therefore, we do not allow for the removal of the forces that kept these economies stagnant. For example, we do not allow for the policies, much discussed in the literature (see, e.g., Ang and Madsen 2011), that arguably kept them stagnant and whose removal in recent decades accounts for the timing of the take-off and the extraordinary burst of income growth that we see in the data. The next section proposes an exercise that sheds further light on this component of our mechanism.

6.4 Improved corporate governance?

The previous analysis kept the corporate governance distortions constant throughout the transition. In the post-WWII period, however, several countries, especially in Asia, experienced transformations that arguably affected corporate governance. For instance, the USA imposed the dismantling of the ziabatsu system upon which Japan had built its industry. As a result, several family-dominated companies were dissolved and interlocking directorships were outlawed. Such a radical reform likely increased accountability and thereby reduced agency frictions. To explore this hypothesis, we allow for a shock that improves corporate governance in 1950. In a very precise sense, doing this exploits the micro structure of the model and stresses its importance. Specifically, we introduce unanticipated and permanent changes to the functional forms for the costs of resource diversion in equation (55) that raises a by 0.1 and lowers q by the same amount. (Incidentally, these post-shock values (a, q) turn out to be close to those of the USA. Also, the fact that the magnitudes are the same is a numerical result specific to our calibration and not a general property of the model as equation (57) and Figure 4 make clear.) Importantly, because we implement this change under the constraint that both the growth rate and the level of income at the end of the simulation remain the same, we are asking the model to produce a longer period of stagnation, because of worse corporate governance before 1950, and a more drastic acceleration of growth after 1950 due to the improvement in governance. Figure 10a shows the main result: allowing post-war Japan to benefit from the overhauling of its corporate governance gets the model closer to the data, narrowing the gap between model and data by more than 10 percentage points.

We then perform similar exercises for other countries, allowing for two shocks that raise a by either 0.05 or 0.1, respectively, and reduce q by the same magnitudes. Panels b of Tables 9-12 report for selected countries and macro regions the average absolute percentage deviation between model and data for selected years between 1820 and 2008, first for the case of (a, q) constant throughout the 1700-2008 period and then when they are subject to either one of the two shocks. The averages exclude the initial year, because by construction there is 100% fit in 1700, and 1950 to minimize the role of WWII in the comparison since the model *by design* has no feature capable of accommodating such disruption.

Table 11b shows that not only Japan but many other fast-growing Asian countries such as China, South Korea and Singapore likely benefited from reforms that improved corporate governance. In all cases, allowing for such change gets the model closer to the data. In contrast, when we allow for it in Western Europe as a macro region and in the USA the model does worse (see Table 9). Similarly, allowing for such change in the UK, Germany and France worsens the model's performance. Interestingly, we find some support for the hypothesis that improvements in corporate governance occurred in some northern European countries, most notably, Sweden, Norway, Finland, and in the Netherlands and Italy. Finally, the results in Table 8 say that neither in Latin America nor in Africa allowing for better post-war corporate governance improves significantly the model's fit of the data. Our reading of the vast literature on their development history is that in the case of Africa we need to identify and add to the model forces that delay even further the take-off. In the case of Latin America, instead, the 1950 shock occurs later than needed to improve the fit. This is in line with what history suggests: WWII was not a disruptive event for Latin America, surely not disruptive on a scale comparable to what occurred in Asia.

We conclude that explaining the dynamics of income of our macro regions and of leading economies like the USA, UK and Germany, does not require changes in fundamentals that result in better corporate governance. This conclusion is in agreement with arguments that attribute the contemporary income gaps of Latin American countries to the extractive-type of institutions that emerged in colonial times (Engerman and Sokoloff, 1997; Acemoglu and Robinson, 2012) and with the observation that modern commercial institutions, including the basic elements of the modern corporation, developed in Europe centuries priors the onset of modern growth (Goetzmann, 2016, chapter 17; Le Bris et al., 2016). Our analysis provides some support to Fukuyama's interpretation (2014, chapter 23) of Asian rapid industrialization, namely, that the executive power of the government substituted for the lack of the rule of law that in Western countries provided the foundation for modern corporate governance. The confrontation with Western colonial powers disrupted then state institutions that were formed centuries prior to contact with the West.

7 Conclusion

Several recent studies emphasize the importance of corporate governance in explaining cross-country income differences. In this paper, we developed the long-run features and implications of this view by introducing within-firm principal-agent problems among shareholders, managers and directors (monitors) in a Schumpeterian model of innovation-led growth that features a sequence of distinct phases of development. The main insight that we obtained is that poor corporate governance not only delays the onset of innovation, but can be such a forbidding barrier to an economy's take off that it traps it in stagnation. Moreover, conditional on the economy having taken off, poor corporate governance weakens incentives to innovate and thus slows down the secular growth of productivity.

To assess how well corporate governance explains quantitatively the secular dynamics of relative incomes, we calibrated the model to the USA and conducted exercises that compare the income paths of economies that converge to a common growth rate but diverge in levels, allowing only corporate governance to differ across economies. We found that overall the model fits the data remarkably well. We also found that modest differences in corporate governance produce large differences in income. We calculated, for instance, that the cost of in-house investment in Latin America, which in 2008 had income a quarter of that of the USA and is predicted to decline to 16 percent in steady state, is only 32 percent more than in the USA. This divergence, moreover, depends on a delay in the first onset of industrialization, driven by entry of new firms with no in-house investment by incumbent firms yet, of only 14 years and a further delay in the onset of in-house innovation of 35 years. This finding contrasts with previous studies that need much larger differences in the cost of capital to account for the observed income divergence over the transition to modern growth. The shape of the transition generated by the model drives our different estimate for the cost of investment. Specifically, in our framework the entry and the rate of in-house innovation pick up slowly. Consequently, a small delay in the onset of modern growth has large compounding effects on the income gap from early movers.

Our main exercises are very stark and posit a stable economic environment throughout the simulations. They thus rule out by construction events that undoubtedly played a role in generating the data. To investigate the role of this assumption in the model's ability to fit the data, we constructed a shock to the model's micro parameters that results in better corporate governance in the post-WWII period. We found that the shock improves the model's fit of the data only in Asian countries. In Western countries the fit actually worsens. We take this as an indication that we are on the right track: the model and our stark quantitative exercises seem to succeed and fail precisely were our reading of history suggests they should. Future research could investigate more specific mechanisms governing corporate governance. For instance, it could study whether the divergence in legal procedures between countries of civic and common law traditions (Balas et al., 2009) had an effect on corporate governance, and thereby on the dynamics of innovation and growth, and more generally, if it was an important factor driving the observed divergence in relative incomes.

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Table 1: Parameters of Corporate Governance

	σ_1^F	σ_1^I	σ_2^F, σ_2^I	σ_3^F, σ_3^I	σ_4^F	σ_4^I	σ_5^F, σ_5^I	σ_6^F, σ_6^I	σ_7^F	σ_7^I
USA	1.274	1.365	1	1.5	1.1	1.0485	0	0.01	1.1	1.25
Latin America	1.274	1.365	1	1.5	1.2	1.1145	0	0.01	1.1	1.25

Table 2: Calibration USA

(a) Parameters

α	γ	θ	ϕ	β	ρ	λ
0.33	0.773	0.769	0.2675	3.2	0.03	0.0103

(b) Steady State Variables (%)

s	y, g, z	r	n	*labor share*
11.8	2.21	5.21	1.03	59

(c) Initial Conditions, Governance, Thresholds

Initial Conditions (year 1700)				**Governance**		**Thresholds**	
N_0	L_0	Ω	Z_0	a	q	T_N	T_Z
1	1	1291.1	5610.7	0.9	1.0720	100	112

Table 3: Latin America

(a) Income Ratio			**(b) Governance**		**(c) Thresholds**	
1700	2008	BGP	a	q	T_N	T_Z
1	0.24	0.16	0.68	1.39	114	147

Note: The technological, preference, and demographic parameters are the same as the USA's; see table 2.a.

Table 4: Corporate Governance and Industrialization Delays

(a) Europe

Country	*(a.i) Common* Ω *and* Z_0				*(a.ii) Common* Ω*, different* Z_0			
	a	q	T_N	T_Z	a	q	T_N	T_Z
Austria	0.83	1.14	104	119	0.73	1.28	110	135
Belgium	0.83	1.14	104	119	0.72	1.30	110	137
Denmark	0.85	1.12	102	117	0.74	1.26	109	133
Finland	0.82	1.15	104	121	0.79	1.19	106	125
France	0.83	1.14	104	119	0.74	1.26	109	133
Germany	0.82	1.15	104	121	0.73	1.28	110	135
Italy	0.81	1.16	105	122	0.71	1.32	111	139
Netherlands	0.84	1.13	103	118	0.65	1.47	116	156
Norway	0.87	1.10	102	115	0.81	1.16	105	122
Sweden	0.84	1.13	103	118	0.77	1.21	107	128
Switzerland	0.86	1.04	102	116	0.76	1.23	108	129
UK	0.83	1.14	104	119	0.70	1.34	112	141
Western Europe	0.83	1.14	104	119	0.72	1.30	110	137

(b) Regions

	(b.i) Common Ω *and* Z_0				*(a.ii) Common* Ω*, different* Z_0			
	a	q	T_N	T_Z	a	q	T_N	T_Z
Western Europe (12)	0.83	1.14	104	119	0.72	1.30	110	137
Western Offshoots (4)	0.89	1.16	101	113	0.92	1.05	99	111
Latin America (8)	0.68	1.39	114	147	0.68	1.39	114	147
East Asia (16)	0.63	1.53	118	164	0.62	1.57	119	169
Africa (Total)	0.55	1.94	128	125	0.57	1.81	125	203

- Note: The technological, preference, and demographic parameters are the same as the USA's; see table 2.a. The 12 Western European Countries are listed in table 5. Western Offshoots: Australia, Canada, New Zealand, and USA. The 8 Latin American countries: Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, and Venezuela; The 16 East Asian Countries: Bangladesh, Burma, China, Hong Kong, India, Indonesia (including Timor until 1999), Japan, Malaysia, Nepal, Pakistan, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, and Thailand.

Table 5: Western Europe, common initial Z

	(a) p.c. GDP			**(b) Governance and delays** *(common Z_0, different Ω)*							
	Year			a	q	ΔT_N			ΔT_Z		
Country	1700	1820	2008			C. G.	I. C.	Total	C. G.	I. C.	Total
Austria	1.88	0.97	0.77	0.71	1.32	11	-26	-15	27	-26	1
Belgium	2.17	1.05	0.76	0.69	1.36	13	-34	-21	32	-34	-2
Denmark	1.97	1.01	0.79	0.72	1.30	10	-28	-18	25	-29	-4
Finland	1.21	0.62	0.78	0.79	1.19	6	-7	-1	13	-7	6
France	1.73	0.90	0.71	0.73	1.28	10	-22	-12	23	-22	1
Germany	1.72	0.86	0.67	0.72	1.30	10	-21	-11	25	-22	3
Italy	2.08	0.89	0.64	0.69	1.36	13	-32	–19	32	-31	1
Netherlands	4.04	1.46	0.79	0.61	1.61	20	-73	-53	62	-73	-11
Norway	1.37	0.64	0.91	0.80	1.17	5	-11	-6	11	-11	0
Sweden	1.42	0.65	0.78	0.77	1.22	7	-13	-6	16	-14	2
Switzerland	1.69	0.87	0.80	0.75	1.25	8	-20	-12	19	-21	-2
UK	2.37	1.36	0.76	0.68	1.39	14	-39	-25	35	-39	-4
W. Europe (12)	1.95	0.98	0.71	0.71	1.32	11	-28	-17	27	-28	-1

- Note: The technological, preference, and demographic parameters are the same as the USA's; see table 2.a. Δ indicates a country's or region's difference with respect to the USA estimated values.

Table 6: Latin America

	(a) p.c. GDP			(b) Governance and delays (*common Z_0, different Ω*)							
		Year		a	q		ΔT_N			ΔT_Z	
Country	1700	1820	2008			C. G.	I. C.	Total	C. G.	I. C.	Total
Argentina	1	0.57	0.35	0.71	1.31	11	0	11	27	0	27
Brazil	0.87	0.51	0.21	0.67	1.41	14	5	19	38	4	42
Chile	1	0.55	0.42	0.72	1.30	10	0	10	25	0	25
Colombia	1	0.57	0.20	0.66	1.41	15	0	15	41	0	41
Mexico	1.08	0.60	0.26	0.68	1.39	14	-3	11	35	-3	35
Peru	1	0.57	0.17	0.63	1.53	18	0	18	52	0	52
Uruguay	1	0.57	0.31	0.70	1.34	12	0	12	29	0	29
Venezuela	1	0.37	0.33	0.71	1.32	11	0	11	27	0	27
L. America (8)	1	0.57	0.24	0.68	1.39	14	0	14	35	0	35

- Note: The technological, preference, and demographic are the same as the USA's; see table 2.a. Δ indicates a country's or region's difference with respect to the USA estimated values. The ΔT_N and ΔT_Z are decomposed between the corporate governance (C. G.) and the initial condition (I.C.) effects.

Table 7: East Asia

	(a) p.c. GDP			(b) Governance and delays (*common Z_0, different Ω*)							
		Year		a	q		ΔT_N			ΔT_Z	
Country	1700	1820	2008			C. G.	I. C.	Total	C. G.	I. C.	Total
China	1.13	0.48	0.21	0.61	1.61	20	-4	16	62	-4	58
Japan	1.08	0.53	0.73	0.82	1.15	4	-3	1	9	-3	6
South Korea	1.12	0.48	0.63	0.74	1.26	9	-4	5	21	-4	17
Singapore	1.12	0.44	0.90	0.81	1.16	5	-4	1	10	-4	6
East Asia (16)	1.09	0.46	0.18	0.62	1.57	19	-3	16	57	-3	54

- Note: The technological, preference, and demographic parameters are the same as the USA's; see table 2.a. Δ indicates a country's or region's difference with respect to the USA estimated value. See note of table (4) for the complete list of the 16 East Asian countries.

Table 8: Macro-Regions

	(a) p.c. GDP			(b) Governance and delays *(common Z_0, different Ω)*							
	Year			a	q	ΔT_N			ΔT_Z		
Country	1700	1820	2008			C. G.	I. C.	Total	C. G.	I. C.	Total
W. Europe (12)	1.95	0.98	0.71	0.71	1.32	11	-28	-17	27	-28	-1
W. Offshoots (4)	0.90	0.95	0.97	0.92	1.06	-1	4	3	-1	3	2
Latin America (8)	1	0.57	0.24	0.68	1.39	14	0	14	35	0	35
East Asia (16)	1.09	0.46	0.18	0.62	1.57	19	-3	16	57	-3	54
Africa (Total)	0.80	0.33	0.06	0.56	1.87	26	7	33	101	6	107

– Note: The technological, preference, and demographic parameters are the same as the USA's; see table 2.a. Δ indicates the region's difference with respect to the USA estimated value. See note of table (4) for the complete list of countries for each of the five regions.

Table 9: Deviations from Data, Western Europe and USA

	(a) Prediction (%) (no shock)							(b) Average Deviation (%)		
	Year									
Country	1820	1870	1900	1950	1975	1990	2008	no shock	Δa (size shock)	
									0.05	*0.10*
Austria	120	116	112	199	100	92	93	10.52	5.82	10.25
Belgium	121	87	93	141	97	94	97	8.66	12.21	18.78
Denmark	120	117	119	122	100	100	107	10.87	7.79	12.73
Finland	150	157	168	164	100	93	94	31.58	28.09	24.50
France	123	112	111	146	94	93	106	11.12	10.18	15.91
Germany	129	110	102	181	94	95	104	9.70	11.85	15.93
Italy	139	149	183	208	106	93	108	32.37	25.14	22.56
Netherlands	135	126	139	153	100	99	94	18.08	11.70	11.25
Norway	157	151	177	157	115	105	100	34.61	27.96	21.32
Sweden	155	145	138	111	85	95	100	26.54	23.12	20.39
Switzerland	128	105	89	92	80	86	107	14.16	17.74	22.77
UK	99	79	81	116	107	102	100	8.40	13.80	17.64
W. Europe	121	108	109	154	101	98	106	8.14	8.93	15.69
USA	88	81	82	97	97	94	103	10.25	10.06	10.76

– Note. Panel (a): Percentage ratios between the model's prediction and the Maddison's data when Z_0 is fixed and Ω is country or region specific (see table 5). Panel (b) is the arithmentic average of the absolute deviations of the model relative to the data for the benchmark years in panel (a). It excludes the year 1950 to minimize the WWII noise on data, and the 1700 data point because, by construction, it is perfectly matched with data.

Table 10: Income Ratio Predicted by the Model, Latin American Countries

	(a) Prediction (%) (no shock)							(b) Average Deviation (%)		
	Year									
Country	1820	1870	1900	1950	1975	1990	2008	no shock	Δa (size shock)	
									0.05	*0.10*
Argentina	153	0.98	62	72	68	113	93	24.13	26.19	27.94
Brazil	161	155	200	146	85	92	96	40.85	37.77	36.84
Chile	157	101	82	104	140	123	85	25.84	25.14	24.47
Colombia	153	157	146	117	100	96	99	27.21	25.83	25.95
Mexico	148	186	118	131	90	99	104	28.11	26.71	27.86
Peru	153	151	187	88	64	113	83	24.12	39.95	38.38
Uruguay	153	57	75	72	94	103	95	22.55	24.91	27.86
Venezuela	237	225	210	48	53	88	97	72.47	67.40	64.95

– Note: The prediction refers to the estimates in table 6. See note of table (9) for further explanations.

Table 11: Income Ratio Predicted by the Model, East Asian Countries

Country	(a) Prediction (%) (no shock)							(b) Average Deviation (%)		
	Year									
	1820	1870	1900	1950	1975	1990	2008	no shock	Δa (size shock)	
									0.05	*0.10*
China	191	220	236	426	288	162	58	106	98	88
Japan	168	238	238	375	106	88	106	61	54	49
South Korea	190	245	351	565	243	118	75	112	99	86
Singapore	207	259	460	321	184	114	85	123	109	97

– Note: The prediction refers to the estimates in table 7. See note table (9) for further explanations.

Table 12: Income Ratio Predicted by the Model, Macro-Regions

Country	(a) Prediction (%) (no shock)							(b) Average Deviation (%)		
	Year									
	1820	1870	1900	1950	1975	1990	2008	no shock	Δa (size shock)	
									0.05	*0.10*
Western Europe (12)	121	108	109	154	101	98	106	8.14	8.93	15.69
Western Offshoots (4)	89	78	80	96	96	95	103	11.06	13.88	17.75
Latin America (8)	153	162	128	108	86	102	102	27.21	25.01	24.55
East Asia (16)	194	210	213	297	167	120	74	72.09	65.09	59.19
Africa (Total)	242	206	171	127	92	98	90	56.51	58.08	57.13

– Note: The prediction refers to the estimates in table 7. See note of table (9) for further explanations.

Figure 1: Governance Equilibrium

– Note: The steep descending line is the loci (m,d) that satisfies (20). The flatter line is the indifference condition (24). The description of the underlying diversion functions is in (55). A corner solution with $m^F > 0$ and $d^F = 0$ is obtained by augmenting the cost of monitoring.

Figure 2: Diversion, Corporate Governance, and General Equilibrium
(a) Diversion and Corporate Governance

(b) General Equilibrium

– Note: Parameters are in table 1, row USA. The lower bounds of the intervals for σ_4^F and σ_4^I in Panel A are also the USA baseline values.

Figure 3: Calibration USA
(a) Per capita GDP

(b) Entry and in-house innovation

– Note. The values of a and q are 0.9 and 1.0720, respectively. The year 1700 is the first data point; ten–year frequency from 1820 to 1870; yearly frequency from 1870 to 2008. Parameters values are in table 2a.

Figure 4: Isogrowth Loci and Corporate Governance

– Note: Isogrowth loci based on eq. (57). Along an isogrowth locus the growth rate of per capita GDP is constant, g^*. In the interval [0.7, 1], the slope of any of the locus is approximately minus 1 – the slope is hardly sensitive to variations in the target rate g^*. For the 2.21% locus the macro parameters are 2.a and the macroeconomic steady state variables are 2.b. The parameters σ_4^F and σ_4^I are altered to generate the couple (a, q) that maintains a constant 2.21% GDP growth rate. See table 1 for the value of remaining governance parameters.

Figure 5: USA takes over UK
(a) Per capita GDP in USA and UK

Entry and in-house innovation

– Note. The values of $(a,\ q)$ are (0.9, 1.0702) and (0.7, 1.3420) for USA and UK, respectively (see tables 2.c and 4a.ii). For common parameters values see in table 2a.

Figure 6: UK and Western Europe
(a) UK

(b) Western Europe (12 Countries)

– Note. The values of a and q are for UK 0.7 and 1.3420 and for Western Europe 0.72 and 1.3010, respectively (see table 4a.ii). For common parameters values see tables 1 and 2a.

Figure 7: European Countries
(a) Austria (b) France

(c) Germany (d) Italy

– Note. Tables 5 and 9 reports the estimates of (a, q) of each of the four countries and the model's deviations from data, respectively. For common parameters values see table 2a.

Figure 8: Latin American Countries
(a) Argentina (b) Brazil

(c) Chile (d) Mexico

– Note. Tables 6 and 10 report, respectively, the estimates of (a, q) for the four countries and the model's deviations from data. For common parameters values see table 2a.

Figure 9: Asian Countries
(a) China (b) Japan

(c) South Korea (d) Singapore

– Note. Tables 7 and 11 report, respectively, the estimates of (a, q) for the four countries and the model's deviations from data. For common parameters values see table 2a.

Figure 10: Governance Shock in 1950
(a) Japan

(b) UK

– Note. Continuous lines: constant governance. Dashed lines: in 1950 a increases by 0.1 and q adjusts to preserve the growth rate. The fit of the model improves in Japan but worsens in UK (see tables 9 and 11). For parameters values see table 2a.