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Innovation, growth and financial markets

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Abstract We review some of the literature at the intersection of innovation, financial markets, and economic growth. We explore two key questions: (i) How financial markets interact with innovation; (ii) what type of quality transformations are brought about by innovation. A special emphasis is given to questions that stem from the 2008 economic and financial crisis, and to subjects further developed in the articles collected in this issue.

Keywords Financial shocks · Connectivity · Value of innovation · Industrial transformation · Schumpeterian approach

JEL Classification G01 · G34 · L16 · O31 · O33

1 Introduction

This paper discusses the literature at the intersection of innovation, financial mar-kets, and economic growth. There are two interrelated objectives: one is to connect more explicitly the themes that are investigated in the papers collected in this issue[1] and point out gaps that could be further developed, while a second objective, in the

[1]This issue draws its inspiration from the 8th European Meeting on Applied Evolutionary Economics, held in Sophia Antipolis on June 10–12, 2013, on the premises of SKEMA Business School.

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traditional spirit of the Journal of Evolutionary Economics, is to promote the interaction between different streams of economic literature. Hence we have selected contributions that have tackled similar questions but with different methodologies.

We connect the themes by focusing on two key questions: (i) how financial markets interact with innovation, and (ii) what type of transformations are brought about by innovation. The first question was already posed by the young Schumpeter who considered money, credit and finance as essential to the innovation process: "credit is essentially to the creation of purchasing power for the purpose of transferring it to the entrepreneur" (Schumpeter 1912, 107). The second question originates from the observation that bursts of technological progress can lead to higher inequality and that this could increase the risk of financial crisis.

As for the methodological objective, we connect the papers collected in this issue through a Schumpeterian approach, whenever this is applicable. When studying the functioning of the financial markets, a subject rather neglected by the Schumpeterian literature, we discuss the search literature, which, we will argue, presents interesting similarities with the papers collected here.

Inspired by Russo et al. (2016), we begin by discussing why credit can have a destabilizing effect on the economy. We focus especially on the role of inequality. In a pioneering work, Benabou (1996) conjectured that a country with a more unequal distribution of wealth and an underdeveloped financial system could exhibit poorer macroeconomic performance. We note a substantial shift in the literature after the 2008 crisis. For instance, we will look at household debt as a key channel through which income and wealth inequality can trigger a big crisis, as observed in 2008.

Section 2, taking the lead from Jacob Leal et al. (2016), elaborates on how the design of trading algorithms can spur a financial crisis. It then discusses more in detail the choices of market makers and investors in an over-the-counter model following the now popular approach of Duffie et al. (2005).

Section 3 links the working of financial markets with corporate governance. Gaffeo and Massimo (2016) study the implications of a shock that hits a node of the interbank network system under alternative regulations on mergers and acquisitions (M&A). Mergers are one way of bringing managerial discipline within the firm, which many believe is a good way of promoting investments in innovation. The section is mostly devoted to exploring further this statement. In a classic work, Manne (1965) identified three ways in which the market for corporate control can solve managerial abuses or inefficiencies: proxy fights, friendly mergers, and hostile takeovers. We then integrate issues of managerial disciplines within a Schumpeterian model, following closely Iacopetta et al. (2014). In this section, we also discuss the difficulties of following the propagation mechanism of a shock, such as the one presented by Gaffeo and Massimo (2016), when firms are different in size and there are strong asymmetries in the configuration of the network that links them.

The survey then approaches the issue of distortions and externalities that arise from the fact that knowledge is a public good. Section 4 briefly presents Babutsidze's (2016) approach to innovation that abstracts from the public good part of the general knowledge and concentrates on its cumulativeness at the firm level. We then use Gray and Grimaud (2016) as a starting point for discussing more broadly the

price of innovation and knowledge. It has been recognized for a long time that the market price for innovation is far from one that would generate an efficient outcome. Gray and Grimaud approached the question from a theory point of view in a monopolistic competition model. In such an environment, typically the incentive to generate innovation is based on the flow of profits the innovation generates. Nevertheless, the overall value for the society of the innovation can be much larger. In Section 4 there are two related aspects we consider, the sequentially of the innovation process (Marengo and Zeppini 2016) and, starting from the insights of Sanditov and Saurabh (2016), the interaction between human capital and technological change.

In the last section, we broaden the time horizon and consider radical transformations associated with the arrival of new technologies. In Lorentz et al. (2016), changes in the pattern of consumption drive structural change in production and labor productivity. The mechanisms they investigate in fact build on two large strands of literature. One studies the role of non-homothetic preferences in generating transformation in the composition of production. The other investigates the process of technological change that occurs with the dissemination of new technologies. We will focus mostly on this second stream of literature, although at the end we close the circle by reviewing the classic work of Matsuyama (2002). This, in the same spirit of Lorentz et al., proposes a story in which growth – fueled by the arrival of new industries and by learning by doing – is triggered by transformations in consumption patterns.

2 Financial markets, growth, and inequality

Building on two earlier works (Riccetti et al. 2014; Russo et al. 2014), Russo et al. (2016) present a simulation based analysis that shows that consumer credit can have a destabilizing effect on the economy. In the presence of consumer credit, on average there are more crises, more aggregate volatility, higher unemployment and also more inequality. Their work adds to a body of literature that challenges the classic dichotomy between fairness and efficiency. The link between consumption demand and income distribution is done by assuming that the propensity to save is related to individual's wealth and that consumers may borrow to compensate for a temporary decline in income or wealth.

Despite the fact that the role of inequality in the relationship between finance and growth represents a relatively recent line of research, in a pioneering work, Benabou (1996) conjectured that a country with a more unequal distribution of wealth and an underdeveloped financial system could exhibit poorer macroeconomic performance. The idea is that when financial markets are inefficient, the returns across investment projects are not equalized. The greater the level of inequality, the larger the return differentials, and the bigger the loss in potential aggregate output. In this perspective, greater financial development is expected to reduce inequality by eliminating financial imperfections (such as information and transactions costs). This can especially benefit the poor who lack collateral and credit histories, thus relaxing their credit constraints and promoting the growth of their income.

Since the 1980s, when inequality started to soar again in the United States, a few economists have highlighted the potentially adverse aggregate demand effects of rising inequality and pointed to the macroeconomic risks associated with excessive household debt and caused by income inequality. At that time, however, most economists either ignored the macroeconomic implications of inequality or explicitly welcomed the increasing availability of personal credit as an efficient market response to a higher demand by households for insurance against a higher dispersion of the transitory component of income.

The mechanisms through which financial development can enhance growth and reduce inequality have been studied theoretically by Galor and Zeira (1993), and then further examined by Aghion and Bolton (1997). But the theoretical production has been lacking until recently. An impetus arrived rather from the more empirical literature. During the 1990s and until 2003, consumption inequality remained essentially flat, according to the data used by Krueger and Perri (2006).

Following Katz and Autor (1999), they regressed income and consumption on a number of characteristics (years of education, experience, interaction terms between experience and education, race, sex, and dummies for managerial/professional occupation, and region of residence). These characteristics explain about 25 % of the cross-sectional variation of income and consumption in 1980. Krueger and Perri (2006) denoted the cross-sectional variance explained by these characteristics as "between-group" inequality and the residual variance as "within-group" inequality. Based on these definitions, they found that, for consumption, the between-group component displayed an increase similar in magnitude to that of income. But for the within-group component, the increase in consumption inequality (around 3 %) was much smaller than the increase in income inequality (around 16 %). They concluded that within-group inequality was mainly transitory or somehow insurable, whereas changes in between-group inequality reflected permanent, or uninsurable, changes in distribution.

Other authors, by contrast, have analyzed the link between rising levels of income inequality and household debt and macroeconomic instability from a more explicitly Keynesian perspective (e.g. Palley 1994; Dutt 2006; Stockhammer 2012). In recent years there has been a proliferation of books supporting the view that inequality was a root cause of the 2008 financial crisis (Rajan 2010; Reich 2010; Galbraith 2012; Stiglitz 2012). But there is also a nascent body of more formal academic literature that has critically assessed the link between inequality and crisis theoretically and empirically (e.g. Atkinson and Morelli 2010, 2011; Kumhof and Ranciere 2010; Kumhof et al. 2012; Lucchino and Morelli 2012; Bordo and Meissner 2012). For example, Beck et al. (2007) demonstrated that the development of financial intermediaries and the improvement of their quality reduces income inequality. Moreover, by expanding the opportunities of access to credit, a more developed financial system can also improve the efficiency of capital allocation, increase agents' productivity and free resources for welfare.

However, this is not the only possible link between inequality and financial development. The latter, in fact, could result in higher income inequality if the rich (who already have access to credit) benefit more than proportionally from the expansion of credit opportunities. According to this second viewpoint, the poor tend to rely

on informal sources of financing, such as family connections. Thus, improvements in the formal financial sector do not affect their ability to implement investment opportunities. Indeed, Greenwood and Jovanovic (1990) put forth the idea of a possible nonlinear relationship between financial development, income inequality, and economic development.

Claessens and Perotti (2007) have reviewed the cross-country evidence on these issues, and argue that, in countries with historically high inequality, financial development distorts the institutional environment by favoring the financial sector. In turn, the financial sector is able to appropriate all the benefits of the greater access to financial services and also prevent financial reforms that could promote a more equal distribution of income and wealth. The higher initial inequality produces unequal access to finance, and then leads to unequal opportunities, which in turn reinforces the initial economic inequality. In such a scenario, institutional and political factors, such as political accountability, are critical for the success of financial reforms that redistribute the gains from financial development.

Now we turn to the attempt made by Kumhof and Ranciere (2010) and Kumhof et al. (2015) to explain the potential role played by income and wealth inequality in triggering the 1929 and the 2008 recessions. One important fact they document is the evolution of the debt-to-income ratio at the top and the bottom of the income and wealth distributions in the pre-crisis years 1983–2007. If in 1983 the top wealth group was more indebted than the bottom group, in 2007 it was the reverse: the debt-to-income ratio was twice as high in the bottom group than the top group (in the bottom group it was 140 %). How does such a dynamic in the debt-to-income ratio translate into a dramatic drop in production? Kumhof et al. (2015) provided an explanation in a model with two types of agents. On the one side there are "investors" who use their savings either to increase their stock of physical capital or to make loans. On the other side there are "workers" who can borrow loans from investors. Population is normalized to 1. A fraction χ are investors and the remaining fraction $1-\chi$ are workers. Aggregate production is represented by a standard Cobb-Douglas production function: $y_t = A\left(\chi \Delta_t^k k_{t-1}\right)^{\alpha}(1-\chi)^{1-\alpha}$ where A is a scalar and Δ_t^k captures the arrival of a negative shock. In normal times $\Delta_t^k = 1$, whereas in bad times $\Delta_t^k = \gamma_t^k < 1$. Physical capital is accumulated according to $k_t = (1-\delta)\Delta_t^k k_{t-1} + I_t$. The budget constraint of the investor is $c_t^i = r_t \Delta_t^k k_{t-1} + \Delta_{l_t} d_{t-1} - q_t d_t - I_t$ where d_t is the price of a bond that gives one in the following period $(t+1)$. There could be different reasons of why households want to allocate funds both on capital accumulation and loans. Kumhof and Ranciere (2010) simply assumed that both types of wealth enter into the utility function. Turning attention now the 'workers' side, their budget constraint is $c_t^w = w_t + l_t q_t - \Delta_t^l l_{t-1}$ where l_t stands for loan and w_t is the wage at time t. The term Δ_t^l is meant to capture a bad shock. It is equal to 1 in good times a to $\gamma_t^l < 1$ in times of crisis. A crucial assumption, partly based on the work of Schneider and Tornell (2000), is that the workers' default probability, π_t, is increasing according to a logistic function on the debt-to-income ratio, that is, on the ratio $\frac{l_t}{w_t - s_t}$ where s_t accounts for the interest payment on the outstanding loans (i.e. $s_t = 1/q_t - 1$). This is how the mechanism works. Imagine that the level of income of investors increases while that of the workers declines. Consumption smoothing implies that workers will try to borrow more in order to prevent a drop in consumption (the preferences are such

that there is a minimum level of consumption). Then a crisis event takes place with a certain probability π_t, which is increasing in the workers' debt-to-income ratio. In a calibration exercise they estimate that the crisis probability is 5 % at a leverage of 150 %, which is about the size recorded in 2007 for the bottom wealth group. The collapse of output is taken to be 10 % with a probability of 10 %, implying an output collapse of 2.7 %, a bit short of what is found in the data after the crisis, that is, between 3 and 4 %. In short, a higher debt leverage is the unintended result of good luck on the side of investors (high income individuals) who have a preference for keeping wealth and making loans to the workers. This increase in credit supply allows workers (low and middle-income households) to sustain higher consumption levels. As loans accumulate, however, so does, the probability of a crisis (π_t) which would lead to a contraction in the real economy. An obvious limit of this framework is the absence of a measure of involuntary employment. Here the only way to have a reduction in output is to invoke some sudden decline the use of the existing stock of capital. Therefore, the baseline shock of 10 % may be an overestimate of what it takes to account for a 2.7 % decline in output.

3 Market makers

With the advent of information technologies, the speed of trade accelerated dramatically. If at the end of WWII the average US share was held by an investor for a length of about four years, that window fell to around eight months by the year 2000 and to only two months in 2008 (Haldane 2011). Perhaps a more startling way of looking at the accelerated speed of transactions is the time it takes to a trading platform to execute an order. Here the scale is fractions of a second. Ironically, the age of high speed has made geographical location more relevant, because the time needed to execute an order depends on the proximity to a major trading platform. The squeezing of execution time and the more intensive use of complex algorithms is believed to have had an important role in Flash Crashes, such as the one occurred on May 6th 2010. In this crash, it has been estimated that as much as $1 trillion in equity market value evaporated in half-an-hour. How such crashes can occur is strongly debated in the literature. Jacob Leal et al. (2016) offers an interesting insight into the phenomenon by focusing on the asymmetry between high and low frequency traders.

Regulators and governments are constantly under pressure to limit the possible damages of high frequency trade without taking away its potential benefits. Their numerical elaborations show that the more sophisticated traders (high-frequency traders) tend to fuel the volatility of the market because their activities increase the bid-ask spread and because they tend to synchronize sales on the limit order book.

There is a growing interest in monetary institutions in evaluating alternative methodological approaches that can explain sudden reactions of the financial markets to shocks. Because standard macroeconomic models assume that exchanges are made in perfectly working centralized markets, they are not well suited in assessing the role of the frequency of trade or of individuals' heterogeneity in a financial crisis. The search tradition, however, is closer to the agent-based approach followed by Jacob Leal et al. (2016), as it put at the center stage of the analysis the

interactions among heterogeneous individuals. To illustrate the similarity between the two approaches, we have chosen an over-the-counter trading model that explains how the bid-ask spread of market-makers is related to the frequency of meetings. The discussion is based on Duffie et al. (2005) who presented a variant of the coconuts model of Diamond (1982) and of Kiyotaki and Wright (1989).

There are two types of agents: Investors (I) and market-makers (M). Investors can produce a divisible good (service good) and can hold at most one unit of an indivisible asset. An investor has a high (r_h) or low (r_l) evaluation of an asset. In Jacob Leal et al., the main difference across investors is the preference about the frequency of trade. Nevertheless, as it will be clarified, differences across agents in the evaluation of an asset have implications for its trade frequency. The evaluation state $j = \{l, h\}$ is governed by a Poisson process of parameter ω_j. Market-makers buy assets from investors and off-load their assets in a frictionless interdealer market. Therefore, they never hold assets. We look first at the gains from trade when two investors meet. A necessary condition for them to trade is that one has the asset and the other does not. Furthermore it must be that the investor that holds the asset is in state $j = l$ (gives a low evaluation) whereas the other investor is in state $j = h$ (it gives a high evaluation). In all other circumstances, the two investors part ways and wait for next match. The main interest here is to understand under what conditions trade between two investors occurs. Let $V_{i,j}$ be the investor's value function when he holds i assets, where $i = \{0, 1\}$ in state j. Clearly, when an investor sells his asset he gets a gain $p_I - \Delta_l$ where p_I is the selling price and $\Delta_l = V_{1,l} - V_{0,l}$. Similarly, the investor on the other side of the trade gains $\Delta_h - p_I$, where $\Delta_h = V_{1,h} - V_{0,h}$, and the total surplus of the bilateral trade is $S_I = \Delta_h - \Delta_l$. A share of this surplus θ_1 goes to the seller (the agent that enters the trade with one unit of an asset) and the remaining fraction $\theta_0 = 1 - \theta_1$ goes to the buyer. Hence, $\theta_1 S_I = p_I - \Delta_l$, and $\theta_0 S_I = \Delta_h - p_I$. This accounts for the gains from the I's perspective. What is the outcome of a meeting between I and M? Obviously, a trade between the two occurs only when I enters with an asset in a state $j = l$ (wishes to sell) or I enters with no assets in a state $j = h$ (wishes to buy). If I gets the asset pays to M an ask price p_A. In the reverse situation, the investor I receives a bid price p_B and gives away one unit of the asset. When M uploads an asset on the interdealer market the bilateral gain is $p_M - \Delta_l$, where p_M is the interdealer market price. Similarly, if the market-maker buys on behalf of the investor an asset on the interdealer market, the total bilateral gain is $\Delta_h - p_M$.

Finally we can turn to the computation of the spread $p_A - p_B$, that is, the gain of the market-maker on the two-leg operation. Let θ_M be the share of the bilateral surplus captured by M. Then this agent earns $\theta_M(\Delta_h - p_M) = p_A - p_M$ in one leg of the trade and $\theta_M(p_M - \Delta_l) = p_M - p_B$ on the other leg. Summing by parts the last two equations, we obtain the spread: $p_A - p_B = \theta_M(\Delta_h - \Delta_l) > 0$. It is now clear, that to understand the forces behind the spread, one needs to disentangle the mechanisms that affect Δ_h and Δ_l, the change in the value function of the high- and low-investor, respectively, triggered by the acquisition of an asset. The trading decisions are easy to describe. The purchase (sale) on the interdealer market will be done by M as long as the bilateral surplus is non-negative, that is, $\Delta_h \geq p_M$ ($\Delta_l \leq p_M$). But what is not easy is to determine the value of Δ_h and Δ_l, as these are affected by the investors'

trading strategies, which in turn depend on the frequency of matching. The bounded-rationality approach of agent based models devises rules agents follow as a proxy for Δ_h and Δ_l. This is an important and useful simplification, for it allows to obtain the evolution of the trade. In fact, the literature has not studied yet the dynamics of Duffie et al. (2005). Imagine then that Δ_h and Δ_l are known. Then it is possible to follow the distribution of assets across the population of investors. Let $\mu_{i,j}$ be a measure of the investors carrying $i = \{0, 1\}$ assets in state $j = \{l, h\}$. The number of investors is normalized to one, and a fraction s of them carries one asset at each point in time. Hence $\mu_{1,l} + \mu_{1,h} = s$ and $\mu_{0,l} + \mu_{0,h} + \mu_{1,l} + \mu_{1,h} = 1$. The Poisson rates that govern meetings between investors, and between investors and market makers, are α_I, and α_M, respectively. Then, in the steady state, the dynamic programming equation for an investor that holds one unit of the assets and is in state $j = l$ is

$$\rho V_{1,l} = r_l + \alpha_I \mu_{0,h} \theta_1 S_I + \alpha_M \tau_B (p_B - \Delta_l) + \omega_1 (V_{1,h} - V_{1,l}),$$

where ρ is the discount rate. This arbitrage condition says that the flow of payoff for an I holding one asset in a low state is the flow of utility generated by the asset r_l, plus the expected share of surplus in case of a successful match with another investor or with a market-maker. The choice trading variable τ_B is equal to one if $(p_B - \Delta_l) > 0$ and is equal to zero otherwise. The last term simply accounts for the windfall gain due to a change of the state from $j = l$ to $j = h$. Three similar dynamic equations can be obtained for investors holding an asset when $j = 0$ and for I not holding any asset in state $j = l$ or $j = h$.

This solution is quite general for these types of problems. For instance, if $\alpha_M = 0$ all trade is decentralized we are in the environment similar to Kiyotaki and Wright (1989). This case applies, for instance, to markets for specialized derivatives. Conversely, if $\alpha_I = 0$, the dynamical system is much simpler because it does not depend on $\mu_{i,j}$. This fits well to trading in markets such as NASDAQ. In this special case, Duffie et al. (2005) show that the spreads are decreasing in α_M and increasing in θ_M (see their Theorem 2). Jacob Leal et al. (2016) can be considered a case of $\alpha_I = 0$, but with an important difference: market-makers have unequal access to the inter-dealer market depending on wether the dealers are closer or further away from the core of the trading platform.

4 Market discipline

During the 2008 crisis, a major decline in the value of collateral assets, especially real estate, led to a deterioration of the credit relationships between firms and, arguably, caused a drop in total credit and investment. Gaffeo and Massimo (2016) argue that consolidation activities are useful to improve the resilience of the financial system to shocks and that therefore must be included in the list government tolls for prudential regulation. Complementary work inspired by Kiyotaki and Moore (1997) has looked at the link between credit crunch and innovation. When entrepreneurs cannot fully commit to repay their lenders, the availability of collateralizable assets eases their access to credit (Kiyotaki and Moore 1997). But credit relationships can

enhance the benefits of collateral. For example, lenders who establish long run relationships with entrepreneurs can better monitor their assets and, hence, recover more value from asset repossession (Diamond and Rajan 2001). An implication of these two arguments is that shocks that depress the value of collateral assets or weaken the credit relationships have the effect of dampening total investment as firms have more limited access to external finance (Kiyotaki and Moore 1997; Holmstrom and Tirole 1996).

Gaffeo and Massimo (2016) study the implications of a shock that hits a node of the interbanking network system under alternative regulations on mergers and acquisitions (M&A). The objective is to understand whether the phenomenon of contagion is sensitive to M&A licensing policies. In particular, they focus on three types of activities: (i) vertical merger, which assumes that there is only one large bank in the system that can acquire other banks; (ii) horizontal merger, whereby the shares of the target bank are evenly distributed to a number of banks entering in the transaction; (iii) semi-horizontal merger, which allows only two small banks to be part of a transaction.

Their work builds on two large strands of the literature. One has investigated how contagion depends on the interaction at the micro level. Gaffeo and Massimo (2016) propose a contagion mechanism based on an Erdos Rényi network model. We review other approaches that have been used in the literature to describe the propagation of micro shocks. The second theme is the reasons behind mergers and acquisitions. Gaffeo and Massimo (2016) motivate their study with the observation that both in Europe and in the US, the banking sector is now highly concentrated, partly the result of a series of mergers and acquisitions. Understanding the reasons behind the M&A can help rationalize the configuration of a network. Indeed, we will claim that the network should be extended to include also the relationship "within" companies. In particular, we will present the view that sees M&A as a market control mechanism that competes with monitoring mechanisms with the firm. In this we refer to the literature spurred by Manne (1965), who identified three ways in which the market for corporate control can solve managerial abuses or inefficiencies: proxy fights, friendly mergers, and hostile takeovers.

4.1 Micro shocks and crisis

Understanding how the type of banking connectivity affect contagion is a challenging topic, for the results are often difficult to anticipate by looking at the structure of the network. For instance, Allen and Gale (2000) showed that ring networks, although they are naturally very sparse, are more prone to systematic failure than a complete financial network.

In pioneering work on the subject, Jovanovic (1987) and Durlauf (1993) showed how strong complementarities across firms translate firm level shocks into aggregate fluctuations. These works challenged Lucas' (1977) diversification argument, according to which we should not be bothered with microeconomic shocks for they simply average out and therefore have a negligible effect on aggregate output. The basic idea is that if one of the n sectors of the economy is hit by a shock, the magnitude of such a shock on the aggregate economy is proportional to the factor $1/\sqrt{n}$.

As the number of sectors increases, a sector specific shock vanishes at the macroeconomic level. Alternatively, one could interpret n as the number of firms. This logic, however, does not take into account the specific linkages across different firms or sectors. Because firms are linked to one another in many different ways (heterogeneity in connectivity), some firms are more important than others. The failure of one of them, due for instance to a micro shock, might endanger the stability of the system. In a stylized setup, consider an inter-firm credit network. Each firm has a number of creditors and debtors. If a firm defaults, its creditors' balance sheets come under strain, and this in turn might induce their failure. Thus, default is contagious. If the initially defaulted firm has few small creditors, its troubles can be easily contained and its failure will have only marginal effects on the economic system. However, if the originally defaulted firm is large and has multiple creditors, the system dynamics might be very different, causing the failure of the entire network.

The vulnerability of a network to a micro shock depends on its topology. Consider two networks: one is "dense", as its nodes have a high number of connections, and the other is "sparse" as it has few connections. Fewer connections contribute to the robustness of the network, because when a node fails it puts strain only on a few other nodes. However, a dense network can also be resilient. This is because even though the shock is passed to many nodes, the strength of the shock that hits each of the neighboring nodes is weaker due to the diversification of the originally failed node.

The work on network stability originates from the seminal contribution of Albert et al. (2000), who analyzed two types of shocks to a networked system: a random failure, meaning that any of the nodes can be hit by the shock with equal probability, and a targeted attack, where the most influential nodes are attacked first. For both scenarios, Albert et al. (2000) calculated the minimum share of the nodes destruction that causes the system to fail. These shares allowed them to compare the networks resistance across different topologies. They found that real-world networks (such as the scale-free structures commonly documented in financial markets) are resistant to random shocks, but susceptible to targeted ones. Other types of networks (small-world structures) turned out to be more susceptible to random shocks.

Albert et al. (2000) inspired a number of researchers to study contagion and systemic risks. For instance, Gaffeo and Massimo (2016) provide an application on mergers and acquisitions. The approach has been adopted by policy-makers as well (ECB 2010). Unlike Albert et al. (2000), whose work is highly abstract, follow-up works (Stiglitz (2010), Gai et al. (2011), Battiston et al. (2012), Acemoglu et al. (2012), Acemoglu et al. (2015); among others) provided a range of contextualizations of linkages among economic entities (credit networks, trade networks, ownership networks, etc.) as well and a number of interpretations of the micro-shock hitting the system (bank failure, country default, etc.).

4.2 Market for corporate control

As we mentioned at the beginning of this section, there is a literature that goes back at least to Manne (1965) arguing that an active market for corporate control is essential to the smooth working of a modern economy. A key premise underlying this work is that there is a positive correlation between managerial efficiency and the market value

of equity shares. Corporate control would be an efficient instrument in the hands of high quality management teams to gain control of large re- sources in a short time. Inefficient managers are replaced with more able managers. Furthermore, it creates discipline on the incumbent managers and solicits more efforts from them. In principle, it gives also more power to the shareholders to discipline managers who otherwise might be tempted to take actions to the detriment of the shareholders. Although there are many ways in which the managers can extract private benefits, two of these seem to be more frequent (see, e.g., Khanna 2000; Morck et al. 2005; Campbell and Keys 2002; Choi and Cowing 1999): Empire building benefits, whereby the manager derives private benefits from investing beyond what shareholders' value maximization calls for, and resource diversion, where the manager siphons resources of the firm. Iacopetta et al. (2014) integrated these governance frictions in a Schumpeterian model where growth is driven both by the foundation of new firms that offer new intermediate products and by investments of incumbent firms in the quality of existing intermediate products. The discipline on management is solved internally through a package compensation scheme whereby the shareholders try to align the managers' interest by offering them a stake of the firm.

Manne (1965) identified three ways in which the market for corporate control can solve managerial abuses or inefficiencies, as mentioned above: proxy fights, friendly mergers, and hostile takeovers. A proxy fight occurs when a group of shareholders tries to persuade the remaining shareholders to act in concert in order to unseat the existing board of directors. One might think that a proxy fight is inexpensive because it can be carried out by a shareholder with a relatively small stake in the firm. In practice, proxy fights are difficult to win because shares are often dispersed among many shareholders (see Bhattacharya 1997). In a survey study, Prowse (1995) concluded that, in the U.S., around 80 percent of mergers are friendly transactions and in Germany it is even higher (90 %).

There are a number of strategic reasons for this. The acquiring firm believes that the transaction will increase profits by favoring cost reduction, or diminishing competition in the market. The two companies the earnings of which are uncorrelated might partly insulate themselves from an industry shock. One of the two companies could have a privileged access to capital, or a better managerial team, or other resources that can be shared by the two companies. But there are also nonstrategic reasons. One, already discussed, is the empire building motive. The buyer purchases a target mainly for the sake of managing a larger enterprise, and not to increase the profitability. It could also be that the management of the target company stands to receive a large payment as a reward for giving up control. Equilar (2007) reported that the average CEO of a large U.S. company received about $29 million in cash and equity following a change of control. Indeed, research shows that the benefits of the merger tends to go to the target, even in the case of hostile bids (see Goergen and Renneboog 2004 and Eckbo 2009).

A hostile takeover takes place when there is a conflict between the acquirers and the target about the terms of the transaction, about the identity of the management, or more generally about the most efficient policies to be implemented after the merger. Manne (1965) placed a lot of trust on the capacity of the market to weed out inefficient management through hostile takeovers. The idea is that the acquirers unseat

the target management by appealing directly to the target company shareholders. The empirical literature, however, has not produced evidence indicating that hostile takeovers have led to significant changes in the management efficiency. There is in fact a free- rider argument elaborated by Grossman and Hart (1980) that may explain why hostile takeovers are not good discipline devices. The observation is quite intuitive. If an existing shareholder of the target company expect that after the takeover the value of the company would go up, he will sell his shares at a higher price—consistent with the new more effective policies that the new management will implement. But then every shareholder should hold onto the shares, unless the price is consistent with the post-takeover value. As the acquirers anticipate this strategy of the target company shareholders, they will not have an incentive to initiate the transaction, for all the surplus will go to the target. Of course some other nonstrategic reasons (empire building, for instance) could still tempt the acquirers to proceed with the takeover. Prowse (1995) points out that in the U.S. and U.K., hostile takeover bids are more frequent than in France, Germany and Japan. Why such differences? Regulatory restriction does not seem to be the explanation. In fact, there are few explicit restrictions on takeover attempts in France, Japan, or Germany. Allen and Gale (2004) believe that the explanation for the difference in takeovers between U.S. and U.K. relative to France, Japan, and Germany has more to do with cross shareholdings, which are much more diffused in these three countries (especially Japan) than in U.S. and U.K.

There are also mechanisms within the firm that help reduce corporate moral hazard and managerial inefficiency, as an alternative to mergers and acquisitions. These internal mechanisms have a strong policy relevance. Many governments have enacted policies that have protected business group affiliates, allowing them to disclose limited information to financial markets. The advocates of these policies claim that the aggressive investment policies of large business group affiliates have fueled rapid growth of several countries, such as Korea, Indonesia, Thailand, Brazil, Chile, and Japan. Opponents of these types of policies maintain that these have forestalled competition and inhibited entrepreneurship. Iacopetta et al. (2014) studied the consequences of these policies. In particular, they considered the moral hazard actions of managers in situations in which they can engage in resource diversion or undertake empire building actions. They considered how corporate influence both entrepreneurship, that is, the ease with which new firms can enter product markets, and the speed at which incumbent firms grow. Scholars (see, e.g., Fulghieri and Suominen 2012; Hyytinen et al. 2002) have in fact documented the profound effects that corporate governance reforms have had on the market structure of various countries in recent decades, influencing the ease with which new firms break into markets.

5 The value of innovation

The work of Gray and Grimaud (2016) enters into fascinating issue of setting a price for innovation. It has been recognized for a long time that the market

price for innovation is far from one that would generate an efficient outcome. Gray and Grimaud approach the question from a theory point of view in a monopolistic competition model. In such an environment, typically the incentive to generate innovation is based on the flow of profits from the innovation. Nevertheless, the overall value for the society of the innovation can be much larger. The authors develop an elegant framework to obtain a price associated with the social value of an innovation. Specifically, they provide three equilibrium solutions: A market solution, labelled Schumpeterian equilibrium, a socially-optimal solution, and a third one based on Lindahl pricing the novelty of the paper. The Lindahl equilibrium differs from the other two because innovation is priced according the user's shadow value (i.e. the marginal profitability of a piece of knowledge) and because the innovator is compensated for all knowledge that is embodied in his innovation. In the Lindahl equilibrium, rival goods are priced at marginal cost, as in the socially-optimal equilibrium. Their analysis compares the Lindahl equilibrium with the Schumpeterian and the Social optimum equilibria from the welfare point of view, aiming at identifying and solving market distortions. A source of the welfare difference across equilibria has to do with the appropriation of the returns to quality. The production function they use for the final good sector implies that private returns to quality are lower than the social returns, because there are positive externalities associated with investments in quality. As a result, firms' investments in quality are below what would be socially desirable.

A second source of distortion is fueled by entry externalities. A potential new entrant does not account in its entry decision for the positive effects of having a larger number of varieties in the final good production function. As this effect is not priced, entrance is lower than is socially desirable. But there is also a countervailing mechanism. A potential new entrant does not consider the "business-stealing" effect, that is, the reduction of the market shares of the incumbent firms caused by its entrance. This force may lead to excessive entry. In fact, in an Aghion-Howitt type of model, there is a potentially more important inefficiency related to the entrance of a new firm: the destructive effect on the incumbent. The new firm, by building on the knowledge of the incumbent, will be able to obtain profits partly on knowledge developed by earlier innovators. As a result, the market may generate too much incentive for entry relative to the social optimum. A related phenomenon was already emphasized by Dasgupta and Stiglitz (1980). They demonstrated that R&D expenditures can be excessive in terms of social welfare because competing firms duplicate and rush to get ahead of one another's innovation programs as a way to win the innovation race.

The Dasgupta-Stiglitz type of externalities as well as the Aghion-Howitt mechanism of knowledge appropriation of a new comer from an existing firm partly offset the tendency of a competitive equilibrium of producing too little knowledge investments because of the knowledge externalities. It is quite challenging to decompose empirically the value each piece of knowledge that allows a firm to generate profits.

Many attempts have been made in trying to assess the importance of social and private returns to knowledge. Baumol (2002), for instance, tackled the question from two points of view. One is historical. Imagine that the rise of productivity since the Industrial Revolution occurred largely because of the contribution of innovation. In

the U.S., per capita GDP has increased more than nine times since 1870, implying that approximately 90 % of current GDP is due to innovation carried out after 1870. In fact, the contribution may be even larger if one considers that technological progress was already quite advanced in 1870. On the investment side, we know that a fraction less than 30 % of the GDP has been devoted to investments, of which only a fraction of it (15 %) was spent on R&D. If there is free entry in the innovation business, one would then expect that the benefits of innovation privately appropriated would be no more than 4.5 % of the GDP. Therefore, more than 80 % of the benefits of technological advances spillover to the rest of the economy. Baumol also cross-checked this conclusion with available estimates of private and social return to innovation elaborated by previous work on the subject and concluded that the ratio between the private and social rate of return is around 1/5. More recently, Iacopetta et al. (2014) arrived a similar estimate of about 83 % of uncompensated external benefits.

6 Human capital and technological progress

Since the work of Nelson and Phelps (1966), a sizeable literature has investigated the links between human capital and technological progress from a variety of perspectives. Documenting empirically the contribution of human capital to innovative activity has been elusive for several reasons. First, there are measurement errors in assessing the quantity of human capital. Second, there is no accepted methodology on how to aggregate human capital across individuals (Galli and Legros 2012). At a more macro level, Arnold (1998), Funke and Strulik (2000), and Lloyd-Ellis and Roberts (2002), and Iacopetta (2010, 2011) proposed models that merge the view that the growth of modern economies is based on the accumulation of human capital (Uzawa 1965; Lucas 1988; Rebelo 1991) with the view that emphasizes R&D investments (Romer 1990; Grossman and Helpman 1991; Aghion and Howitt 1992). To simplify the characterization of the dynamics, Funke and Strulik (2000) and Iacopetta (2011) assumed that both the innovation and the human capital sector depend only on the stock of human capital. Kosempel (2004) introduced cross-externalities in the education and innovation sector, but assumed that the saving rate was exogenous and firms allocated a fixed fraction of output to research and development. In Iacopetta (2011), as much as in Kosempel, innovation and education mutually reinforce one another, and the innovation and saving choices are endogenous, although the dynamical system becomes more complex and it can be solved only numerically.

In Sanditov and Saurabh (2016), human capital is embodied in the inter-personal relationships among the participants. The study identifies individuals who bridge distant social spaces as the main promoters of contributions toward public good production. Consequently, small-world-like network structures nurture high average contribution toward a public good. Next, we turn to the concept of absorptive capacity, an important ingredient Sanditov and Saurabh (2016) analysis. Then we will discuss cumulativeness of knowledge, path dependence and sequential innovation to introduce the main issues studied in Babutsidze (2016) and Marengo and Zeppini (2016).

6.1 Absorptive capacity and cumulativeness of knowledge

Nelson (1959) observed that new knowledge is a public good as it can be exploited by individuals who have not contributed to its production. A problem associated with this aspect of knowledge production is that firms may under invest in R&D relative to the social optimum. Other inefficiencies in knowledge development have been conjectured by scholars who emphasize the role of the knowledge complexity (Pavitt 1987; Malerba and Orsenigo 2000). They observed that the knowledge placed in public domain is not equally useful to different firms and that this may explain the difference in technological progress across industries. They also observe that the skill set in firm's possession determines the usefulness of public knowledge for this particular firm. The idiosyncrasy of the skills has been documented, for example, by Milgrom and Roberts (1990).

More generally, people refer to the concept of absorptive capacity to explain the heterogeneity of investment rates across firms. The concept of absorptive capacity has been formally presented in the pioneering work by Cohen and Levinthal (1989). The authors presented a simple model where the firm's private R&D efforts increase not only its knowledge, but also its capacity to absorb the external (i.e. public) knowledge. Public knowledge is created through the spillovers from private R&D activities. As a result, firms have a dual incentive to invest in R&D. First, because generated new knowledge directly increases firm's earnings, and second, because increased absorptive capacity augments the usefulness of the publicly available knowledge. In Sanditov and Saurabh (2016), the appropriation of the publicly available knowledge depends on the inter-personal network across participants. Hence, different network structures are varyingly successful in encouraging individual. contributions to the public good (i.e. knowledge).

Others have argued that it is not only the skill sets that can be idiosyncratic across firms, but also the knowledge itself (Dosi 1997; Cowan et al. 2000). This is the view that considers the existence of the secrecy and strict patent laws. According to this stream of research, innovation need not contribute to the enhancement of the public knowledge. However, it can contribute to increasing not only the knowledge base of the innovator, but its ability to innovate further (akin to the literature on positive feedbacks discussed later).

The cumulativeness of knowledge as the determinant of the firm's success has been put forward by Malerba (2002). In this setup, certain innovations are highly cumulative in that their marginal contribution to firm's knowledge stock is high, whi‘le some other innovations' marginal contribution is negligible. Therefore, environments with highly cumulative knowledge nurture fewer and larger firms compared to their non-cumulative knowledge counterparts. The innovation model presented in Babutsidze (2016) abstracts from the public good part of the general knowledge and concentrates instead on its cumulativeness at the firm level. Findings therein highlight that the relationship between knowledge cumulativeness and innovation patterns is non-monotonic, as previously believed (Breschi et al. 2000). The work highlights the notion that the highly-cumulative knowledge environment encourages innovation due to fast expansion of the knowledge base of the innovators. However,

the not-cumulative knowledge environment encourages further innovation, due to the size advantage the innovator obtains.

6.2 Path dependence and sequential innovation

The cumulativeness of the knowledge at an aggregate level has profound implications for the development path of the industry. Cumulativeness implies positive feedback loops from profits back to innovative practices. One implication of this phenomenon is path dependence. Starting from the seminal work of Arthur (1989), positive feedback loops have been at the core of the technology choice models. Higher R&D expenditures increase the chance of successful innovation and, therefore, increase the profit of the firm. Higher profits allow firms to invest even more in R&D, which further increases firm's profits. The positive feedback from firm's profits to R&D expenditure essentially represents the increasing return to innovation that gives advantage to already successful firms. Arthur (1989) described how the dynamics of such systems can be determined by "random" events at the inception of the industry. When presented the choice between two technological products with consumption network effects, early consumers' choices affect greatly the choices of subsequent consumers. The firm that is successful at the early stages of industry development obtains a substantial advantage over competitors. In Babutsidze's contribution, strong cumulativeness of knowledge almost guarantees to early innovators the success at the equilibrium state.

An alternative and perhaps equally popular way to model path dependence in economics has been by using Polya urns. In these models, colored balls are drawn from an urn. After every draw, an additional ball of the drawn color (together with the one drawn) is returned to the urn. This is the mechanism to generate increasing returns. In order to allow for innovation in this simple choice model, Hoppe (1984) suggested a way to add a new ball of previously non-existing color (innovation) to the urn. Although such systems still exhibit path dependence and strong influence of sequentially, they also allow for study of innovation. Marengo and Zeppini (2016) belong to this modeling tradition. They extend Hoppe-Polya model by adding increasing returns to innovation—innovation increases the likelihood of further innovation in subsequent periods.

Path dependence in innovation process has implications for optimal patent protection and de- sign. Indeed, the cumulative process of knowledge almost inevitably creates situations in which some innovative feature of a new product builds on existing patented knowledge. Therefore, there is an issue of accounting for the relative contribution of two sequential innovators into the latest commercial product. Gray and Grimaud (2016), as was mentioned in Section 5, analyze how the value of a patent is split between sequential innovators. Another recent work on the subject is Chu et al. (2012). They looked at effects the distribution of surplus between two sequential innovators have on horizontal and vertical innovation. They modified the Grossman and Helpman (1991) model in two ways. First, the horizontal dimension is not fixed but can grow over time. Second, in order to consider the division of profit between sequential innovators along the quality dimension, they assumed, along the lines of O'Donoghue and Zweimļler (2004), that the most recent innovator infringes

the patent of the previous innovator. The main question is: How does the splitting rule of profits between innovators affect the growth rate of the economy and welfare? Because there are two dimensions of innovations, the answer is quite articulated. The share of profits transferred by the new entrant (latest innovator) to the incumbent (the previous innovator) depends on the existing patent legislation and the severity of the judicial system to punish patent infringements.

A policy reform that strengthens existing patent holder protection tends to discourage a new entrant on the vertical innovation race. But it makes relatively more attractive horizontal innovation. Here a new entrant always captures 100 % of the profits until the innovation is challenged by a newcomer, and in such a case the level of protection would be stronger after the policy reform. Therefore, the overall effect is ambiguous both in terms of growth and welfare. In a calibration exercise, they found that strengthening the property rights tend to reduce the growth rate of the economy because the stifling effect on vertical innovation dominates the propulsive effect on horizontal innovation. Nevertheless, this result does not imply that welfare is necessarily worsened because having access to a larger variety of products may compensate for the lower pace at which existing products improve.

7 Industrial transformation and patterns of consumption

Lorentz et al. (2016) study how changes in the patterns of consumption drive structural change in production and labor productivity. It links two large strands of literature. One studies the role of non-homothetic preferences in generating transformation in the composition of production. The other investigates the process of technological change that occurs with the dissemination of new technologies. For the first strand of the literature, Bertola et al. (2006) provided a comprehensive and analytical overview. As for the second stream of literature, Herrendorf et al. (2015) linked economic growth and transformations, but did not discuss the Schumpeterian point of view. We will fill this gap by describing the transformation of an economy the growth of which initially is driven only by market expansion (Smithian Growth) into a Schumpeterian economy where both quality improvements and product variety are present. We then connect the two strands of literature by discussing Matsuyama (2002) that, in the same spirit of Lorentz et al. (2016), proposed a story in which the arrival of new industries is triggered by transformation in the patterns of consumption.

7.1 Market size and innovation

Technological progress has been represented as variety expansion (Romer 1990), quality improvements (Aghion and Howitt 1992), or a combination of both (Grossman and Helpman 1991). These works and their extensions, however, have been applied to study environments where the qualitative characteristics of production do not change. A recent flow of work in the Schumpeterian tradition has taken interest in explaining structural changes. It has been theorized that some aspects of the innovation process emerge as the economy moves along its development path and

that the expansion of the market is the initial force that propels the economy towards more advanced forms of innovation. Economic historians have argued for a long time that the nature of knowledge creation and the structure of production do change over time. Baumol (2002) observed that a large share of innovation is performed in a "routinized" form within existing firms. But Mokyr (2010) noticed that sustained and continuous innovation resulting from systematic R&D carried out by professional experts was not at all common until the Industrial Revolution. To give more insights on the progressive transformation of the economy along the development path, we follow closely Peretto (2015) who traced the transformation of a Smithian economy into a Schumpeterian one.

The main premise is that the two engines of growth - horizontal and vertical innovation - respond to distinct characteristics of the historical evolution of the economy. Peretto's interpretation of the Schumpeterian approach is that it is not market size *per se* that matters but its contribution to the size of the firm. Conversely, given the size of the average firm, the expansion of the market favors the entrance of new firms as the rents of incumbent firms become more important. This is more in line with Smith's account of development. The economy may stay for a long time in a pre-innovation state. The only noticeable dynamic force in this early stage of development is population expansion that induces greater demand of goods.

As the economy evolves, two additional forces contribute to growth. One is the expansion of the quality of intermediate goods. An intermediate firm will invest in quality up to the point in which its private return is equal to the market interest rate return on assets. (If the expected profits are not large enough relative to the existing interest rate, no investments are devoted to quality improvement.) A second action comes from the decision to enter the market. Imagine that the firm's cost of entry is proportional to its scale of production. If the cost of entry is too high relative to the expected flow of profits generated by the firm, no new firm is created. But the value of the firm is increasing in the volume of demand.

This is crucial mechanism in this class of models that trigger the onset of horizontal innovation. Consider an economy that starts out in a situation where there is no entry and firms earn rents. As population becomes large enough, the rents of incumbent firms become large enough to justify the entry cost of new firms. When this happens, the savings rate starts to go up and the growth rate of final output exhibits a moderate positive trend. Notice that the entrance of new firms dissipates part of the rents that incumbent firms would have otherwise obtained. Nevertheless, the pressure coming from the expansion of the population is enough to maintain an upward trend on the size of the firm. It should be kept in mind that in this model what matters for innovation (in quality) is the size of the firm, not that of the market. If this expands at a slower pace than the rate of entry of new firms, the size of the firm becomes smaller. When the firm's size reaches a minimum threshold, so that the profit rate is comparable to the rate of return to assets, the economy enters the third and last stage of development.

As is typical of the Schumpeterian tradition, the action that comes from the demand side is rather limited. In this case, it comes from population expansion. If an economy with a larger population creates a larger market for an industry, it is more

likely that incumbent firms invest more. But the entrance of new firms depends crucially on the entry cost, which is taken to be proportional to the size of the firm. Next we bring the demand side more to the center stage of the analysis, and see how the qualitative transformation of the economy is related to the structure of preferences.

7.2 Inequality, learning by doing, and industry structure

We turn now to the crucial question raised by Lorentz et al. (2016) of how the features of the demand affect the structural changes in the industry. We complement their work by following the approach suggested by Matsuyama (2002), who depicted the process of development as a Flying Geese pattern: A series of industries takes off one after another fueled by a rising level of income. The phenomenon of Matsuyama is well-known since the work of Katona (1964). In the past, even rich societies were highly segmented when it comes to patterns of consumption. The great majority of the population struggled for mere existence. Today, in a large number of countries, the majority of the population enjoys goods that were once considered luxuries (travel, recreation, durable goods). What is interesting in Matsuyama's work is that the timing at which the take-off happens and the variety of products that eventually will be produced depends on inequality. The basic mechanism of the model is the following. Households are identical except for their initial income. They have identical, non-homothetic preferences of a range of consumer goods. As their income increases, they can afford to buy a larger range of consumer goods. This is quite different than any of the Schumpeterian models presented in this article, where income is always equally spread across the existing range of goods.

If in a Schumpeterian model as in Peretto (2015) what is important for the entry decision is the firm's size in relation to the cost of entry, in Matsuyama (2002) it is the number of households that can afford a new good that matters. The arrival of a new good depends crucially on dynamic learning in existing industries. As the price of existing goods goes down with the volume of production, a mechanism similar to the one used by Arrow (1962), more and more real income is freed up for new products. The learning is specific to the industry and there is no inter-industry spillover of learning-by-doing. A key feature of the model is the trickle- down effect. When high-income households buy luxury goods it helps in reducing its price and therefore makes it affordable to the low-income households. But there is also a trickle-up effect. When the price of a luxury good is low enough to attract low-income consumer, the expansion of production fuels a further decline of the price which frees up additional resources of the high-income households that can be used to purchase a new luxury good. This second mechanism is usually called trickle-up effect. The productivity gains in one industry sets in a new industry.

For the trickle-up and trickle-down effects to be alive, some income inequality is needed. If there is too much equality, the economy will trapped into poverty. In a perfectly equal society, there is no minimum critical mass of individuals that can set in the trickle-down effect. On the other hand, with too much inequality, neither the trickle-down nor the trickle-up effect would set in. It is useful to look these mechanisms in a more formal way.

Households have hierarchical preferences over J + 1 goods. Let I be the endowment in terms of labor, p_i the price good $j \leq J$. In the utility function there is also leisure, which in fact is a residual consumption good: its utility is low enough compared to any other good so that it is consumed only if the residual budget is too small to buy an additional good j. Imagine that $I > p_0$ so that $c = 1$. Then a household with an endowment I will enjoy a utility $U = 1 + k + \eta l$ with $l = I - P_k \geq 0$, and where $P_k = \sum_{j=1}^{k} p_j$. The term P_k can be interpreted as the minimum level of income that induces consumption of good k. Clearly, the demand curve moves in steps. An additional household's income induces demand for a manufacturing good only when it pushes the household's income above a threshold. From the individual demand curve it is easy to obtain the aggregate demand for good j. Let F be the distribution of income across households. Specifically, $F(I)$ is the fraction of the households whose income is less than or equal to I. All units are in terms of labor. Hence, differences in income across individuals are due to differences in skills. The total labor supply is $L = \int I dF(I)$. Assuming that there is a continuum of households in the unit interval, the aggregate demand for good j is simply $C_j = 1 - F(P_j)$. Two aspects of this demand function are obvious to grasp: (i) the upper bound of the demand for good j is 1; (ii) the size of the demand depends on income distribution. The smaller the share of the population that has a level of income of at least P_j the more modest the demand for good j.

A third aspect is a dynamic one. If a small share of the population can reach a level of income P_j industry j moves slowly on the learning curve. In particular, Matsuyama assumed that the amount of labor needed to produce one unit of good j goes down with the accumulated experience $Q_j(t)$. This goes up with the current level of production C_j but also there is some losses of past knowledge, that is $\dot{Q}_j(t) = \delta_j[C_j(t) - Q_j(t)]$. As noted above, there is no cross-industry learning. Nevertheless, it is clear that, if the most sophisticated good is good k, fast learning in any industry $j \leq k$ will facilitate the arrival of good $k + 1$ as well as the its rapid expansion. But the reverse is not true. Learning in the newest industry does not affect the demand for older vintages.

This property is in sharp contrast with most Schumpeterian models. As was noted in Section 6.1, horizontal expansion is associated with a business-stealing effect. A new firm that enters the market takes some of the demand from firms operating in other industries. In an Aghion and Howitt environment, the stealing is even greater for the incumbent firm in the same industry. In the literature with sequential innovators reviewed in Section 5.2, the stealing is moderated through patent sharing agreements. In Matsuyama, the independence of the demand of older vintages from the learning-by-doing in the most recent industry, is a crucial property in order to characterize the system as a recursive dynamical system. A somewhat inconvenient aspect of the model is the presence of multiple equilibria. Even worse, when multiple equilibria are present, the stable fixed-point is inferior from a welfare perspective than any of the other unstable fixed-points. In other words, in any of the other steady states a larger fraction of households would enjoy a larger number of consumer goods than in the one where the economy converges.

In brief, while an environment where the pace of arrival of new industries depend on the structure of preferences is more appealing, it also poses challenges. The main

difficulty is to characterize the dynamics. A way out is to use the approach of agent-based models. Nevertheless, it is important to be alert to what Matsuyama clearly demonstrates: it is easy to have multiple equilibria.

8 Conclusion

In this final section we offer a few thoughts on further points that could be developed, building on the works reviewed in this paper. In discussing the links between finance, growth, and inequality, we discovered an important shift, before and after the 2008 crisis, in the type of questions explored in the literature. Before the crisis, the emphasis was on the mechanisms through which an unequal distribution of income or wealth can depress the aggregate level of production. The financial sector could exacerbate the negative effects of inequality on growth because individuals do not have equal access to it. Therefore, the poor, who are the most financially constrained, may not enjoy any benefits from an improvement in the working of the financial markets. The post-2008 literature, however, has brought a new element: the economy's reaction to inequality depends on shocks that occur in the financial market, and, in fact, some of the inequality itself could be the direct effect of the poor functioning of the financial system. A mechanism that was reviewed is the following: the rise of income inequality causes a progressive upward movement of the debt-to-asset ratio of the middle and lower income group. If this goes up unchecked, a crisis can follow causing a contraction in the real economy. A gap we have noticed the pre and post-crisis literature is that the models are built from different point of view. Before the crisis, the starting point tended to be long-run growth models, usually with some simple endogenous growth (for instance, learning by doing), while in the post-crisis literature, the issues are framed in short-run macro models. In future research we may learn more of the short and long run effect of a credit crunch by integrating big financial shocks into model economies where growth is driven by innovation. In such a context, one could ask, for instance, if the propagation mechanism of a shock is different depending of the source of innovation, or on the structure of the markets for new goods, and so on.

Compliance with Ethical Standards

Conflict of interests The authors declare that they have no conflict of interest.

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