November 2020

Working Paper

022.2020

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2030 Agenda
Series Editor: Sergio Vergalli

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JEL Classification: C01, C33, F63, 011, 015, 033

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Nonlinearities and the determinants of inequality: New panel evidence

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Abstract

Relying on data for a panel of 90 economies over 1970-2015 and System-GMM estimates, we extend the standard Kuznets-curve empirical framework to investigate how financial development, globalisation and technology affect income inequality. Our findings reveal the presence of significant nonlinearities, consistent with either U-shaped or inverted U-shaped relationships. As such, depending on whether a certain threshold value is achieved, the same determinants of income distribution can exert opposite effects in different countries. Globalisation is associated to increasing inequality in most advanced economies, but to falling disparities for the large majority of emerging economies. Further, while the effects for advanced economies are mixed, technology and financial development lead to increasing inequality for most emerging economies. Hence, particularly in countries in earlier stages of development, policymakers aiming at fostering growth via technological progress or financial development should also consider the nature of the trade-offs with inequality and how policy can improve them.

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Nonlinearities and the determinants of inequality: New panel evidence

1. Introduction

The economic determinants of inequality are the subject of a substantial and growing literature, reignited in the last decade by the questions on the causes and consequences of the Great Recession. Though the debate is still open, in recent years economists have reached a significant consensus on the role played by some factors as key drivers of income distribution dynamics: namely, globalisation, financial sector development and technological progress (e.g., Milanovic, 2016; Bourguignon, 2017; Nolan *et al.*, 2019). Nonetheless, many questions remain regarding the relative importance of these forces and, therefore, the appropriate policies to achieve a more egalitarian distribution of income without harming economic growth.

The large number of empirical studies in the field rely on different methodologies, estimation techniques and data. Crucially, they also often provide conflicting results – an outcome which may be due to several possible gaps in the existing empirical literature. For instance, most of the available research focuses on the abovementioned three key factors separately, thus providing only a partial view of the sources of inequality. Another estimation issue often not properly considered is variable endogeneity, due to feedback effects from income inequality to its determinants which can be associated to the various channels.[1] Most importantly, lack of a consistent treatment of nonlinearities is an additional critical issue, typically addressed only partially and with respect to individual channels (e.g., Figini and Görg, 2011; Jauch and Watzka, 2016). Nonlinear effects may, among other things, be critical to explain different findings with respect to the same inequality determinants in advanced and emerging economies – as these two groups of countries are typically characterised by a sizeable divide in terms of openness, technology and financial development. For instance, if a minimum degree of financial development is required for this driver to reduce (rather than increase) inequality, we may expect financial development to initially lead to greater income disparities in most emerging economies. This also highlights that the presence of significant nonlinearities in the relationship between inequality and its determinants bears relevant policy implications.

Against this backdrop, this paper provides several contributions to the literature on the cross-country determinants of inequality.[2] Relying on a panel of 90 advanced and emerging economies and annual data over 1970-2015, we extend the standard 'Kuznets-curve' (Kuznets, 1955) empirical framework and investigate the role played by technological progress, globalisation and financial sector development, assuming potentially nonlinear effects for all these factors. In so doing, we combine insights from two recent strands of the literature: the first comprises studies considering more than one of the main inequality determinants, but treats their effects as linear (e.g., Jaumotte *et al.*, 2013; Dabla-Norris *et al.*

[1] Several contributions in the literature have explored the mechanisms via which inequality can influence social and economic outcomes, such as economic growth (Galor and Zeira, 1993; Persson and Tabellini, 1994; Alesina and Rodrik, 1994; Aghion *et al.*, 1999; Barro, 2000; Forbes, 2000; Chen, 2003; Banerjee and Duflo, 2003); the relation between socio-political instability and investments (Alesina and Perotti, 1996); the escape from extreme poverty (Ravallion, 1997); happiness, health and well-being (Easterlin, 1974; Subramanian and Kawachi, 2006; Clark *et al.*, 2008).

[2] Studies focusing on cross-country investigations of inequality drivers include Li *et al.* (1998), Gustafsson and Johansson (1999), Barro (2000), Vanhoudt (2000), Frazer (2006), Roine *et al.* (2009) and Castells-Quintana (2018) for advanced and emerging economies. Further relevant contributions are by Fields (1979), Milanovic (2000), Odedokun and Round (2004) and Castells-Quintana and Larrú (2015), which limit the analysis to developing and emerging economies.

2015); the second includes research allowing for nonlinearities, but typically focusing on the various inequality determinants individually (e.g., Figini and Görg, 2011; Nikoloski, 2013). To deal with variable endogeneity and persistence in inequality, estimations are based on dynamic panel data specifications and System-GMM techniques (Arellano and Bover, 1995; Blundell and Bond, 1998). Furthermore, taking account of the issues relating to the ambiguous influence of technological progress, we rely on proxies for two technological categories: Investment-Specific Technology (IST), which influences directly firms' production processes but only indirectly other economic agents; General-Purpose Technology (GPT), which includes technological innovations that, contrary to IST, gradually assume widespread and direct effects on consumers' and other economic agents' incomes.

The key results of the paper support the hypothesis of significant nonlinearities for the main determinants of income inequality, with relations characterised by well-identified extreme points. This outcome has important implications for cross-country differences in inequality dynamics. Specifically, globalisation, technology and financial development are found to affect income inequality differently depending on whether countries have reached a certain threshold value – as a result, in many cases these same drivers are associated to opposite effects in advanced and emerging economies.

The remaining part of the paper is organised as follows: Section 2 presents an overview of the literature; Section 3 illustrates the data and the empirical framework used; Section 4 presents the estimation results; Section 5 investigates further the nature of nonlinearities in the relation between inequality and its determinants, and discusses the implications for advanced and emerging economies. Finally, Section 6 concludes.

2. Overview of related literature

Much of the empirical literature investigating the role of globalisation, technological progress and financial sector development as drivers of inequality leads to mixed results. For instance, focusing on the interplay between globalisation and income inequality, Gourdon *et al.* (2006), Chen (2007) and Helpman *et al.* (2017) observe that greater openness to trade is associated with an increase in wage disparities, whereas Reuveny and Li (2003) and Jaumotte *et al.* (2013) come to the opposite conclusion. Moreover, in the context of financial globalisation, Furceri and Loungani (2018) find evidence of growing income disparities associated to capital account liberalisation reforms, whereas Yu *et al.* (2011) observe a modest impact of foreign direct investment (FDI) on China's regional income inequality. Similarly, conflicting results have emerged for the finance-inequality nexus. Among others, Beck *et al.* (2007), Agnello *et al.* (2012), Hamori and Hashiguchi (2012) and Kappel (2012) provide evidence pointing to a decrease in wage disparities associated with greater financial sector development, while the findings in Jaumotte *et al.* (2013), and Jauch and Watzka (2016) support the opposite hypothesis. Additionally, with specific reference to India, Ang (2010) observes that a well-developed financial system helps to mitigate inequalities, while financial liberalisation exacerbates them.

The available evidence is even less clear-cut when it comes to the role played by technological progress, since different forms of technological innovations are typically difficult to define and measure. Considering the evidence, Iacopetta (2008) points out that price-cutting technological progress is associated to a reduction in inequality, whereas product innovations increase it. Meanwhile, studies on the so-called skill-biased effects of technology provide strong evidence that technological progress raises income inequalities between skilled and unskilled workers (Katz and Murphy, 1992; Goldin and Katz, 2009;

Chowdhury, 2010; Acemoglu and Autor, 2011). With specific reference to GPTs, Aghion *et al.* (2002) find that technology raises long-run within-group inequality boosting demand for adaptable workers and their market premium, whereas Jacobs and Nahuis (2002) observe a fall in real wages for unskilled workers. Meanwhile, He and Liu (2008) argue that IST innovations can explain the rise in wage inequality experienced since the early 1980s in the United States. Further, Krusell *et al.* (2000) find that improvements in ISTs, as proxied by the decline in the relative price of investment goods, increase the wage gap between skilled and unskilled workers. The decrease in the relative price of investment goods is also shown to explain around half of the decline in the labour share of income by Karabarbounis and Neiman (2014).

2.1 Nonlinearities and the determinants of inequality: The theory

One possible explanation for the aforementioned inconclusive empirical evidence is linked to nonlinearities, which a number of theoretical contributions have proposed as a key feature of the relationship between inequality an its main drivers.

With respect to globalisation, classic trade theory suggests a clear link between trade and inequality. The Stolper-Samuelson (1941) theorem posits that greater trade openness increases the return of the relatively abundant factor – as such, by spurring specialisation according to comparative advantage, trade leads to falling inequality in emerging economies where low-skilled labour is relatively abundant. For the same reason, trade raises skilled-labour wages and income disparities in advanced economies. Relying on a two-country (North vis-à-vis South), two-factor continuum-good model, Xu (2003) shows that these mechanisms may be nonlinear and dependent on the degree of trade openness. Since trade protection makes some potentially-tradable skill-intensive goods nontraded, in his model a tariff reduction has two effects in the South: it expands the import set, implying an inequality-reducing effect by decreasing high-skilled wages; it worsens the South's terms of trade, thus expanding its export set by improving its price competitiveness – this provides an inequality-boosting effect. The export-expansion effect can dominate import expansion, so that a tariff reduction in the South beyond a certain threshold increases both the South's and the North's skilled-labour wages. As a result, there is a U-shaped relationship between wage inequality and the tariff rate – when the tariff rate is below (above) the threshold, further trade liberalization increases (lowers) wage inequality. Other theoretical approaches, however, postulate the existence of an inverted U-shaped interplay between globalisation and inequality in emerging economies. In this regard, Helpman *et al.* (2010) develop a framework to investigate the determinants of wage distributions focusing on within-industry reallocation, labour market frictions and differences in workforce composition across firms. In their model, changes in trade openness have a nonmonotonic, inverted U-shaped effect on wage inequality – specifically, while disparities are higher in the open-economy equilibrium than in autarky, gradual trade liberalization first raises and then lowers inequality. This hump-shaped pattern is confirmed by Helpman *et al.* (2017), who extend the model in Helpman *et al.* (2010) to allow for firm heterogeneity in productivity, fixed exporting costs and worker screening. Similarly, Bellon (2018) provides a micro-founded model where, following trade liberalisation, the reallocation dynamics between heterogeneous firms and workers lead to an inverted U-shaped rise in inequality.[3] Meanwhile, focusing on a non-trade aspect of globalisation, Figini and Görg (2011) present a model in which FDI acts as a channel for technological transfers from advanced to

[3] On the various channels leading to complex skill-biased effects of trade, in particular via outsourcing and offshoring activities, see also Feenstra and Hanson (1996), Glass and Saggi (2001) and Grossman and Rossi-Hasenberg (2008) among others.

emerging economies. The early waves of FDI by multinational enterprises introduce new technologies in the host country, thus widening the wage gap between skilled and unskilled workers. But further waves of FDI allow domestic firms to imitate the multinationals' production technologies, and this is reflected in a reduction of wage disparities.

This FDI-driven diffusion mechanism exemplifies one possible nonlinear link between technology and inequality – but others have also been proposed in the literature. Theoretical approaches focusing on skill-biased technical change indicate that technological innovations are typically associated to increases in inequality (Katz and Murphy, 1992; Goldin and Katz, 2009; Acemoglu and Autor, 2011). New technologies are assumed to be complementary to high-skilled labour, resulting in higher relative demand for these workers and a growing wage gap between high- and low-skilled labour. Conversely, however, contributions tracing back to Kuznets (1955) suggest that, by disrupting existing sources of wealth, technological progress may also promote a more equal income distribution. Several studies in the literature illustrate how these opposing mechanisms can give rise to a nonlinear relationship between technology and inequality. In particular, theoretical approaches developed by Galor and Tsiddon (1997), Aghion *et al.* (1998), Helpman (1998) and Conceição and Galbraith (2012) result in an inverted U-shaped pattern. The intuition is that, when technology adoption differs between sectors and inter-sectoral labour mobility is slow and/or imperfect, technological innovations tend to initially raise inequality. This is because only a small number of workers, employed in the technologically-advanced sectors, benefit from innovations. As wages rise and more people move into the advanced sectors, inequality and per-capita GDP both tend to rise. Subsequently, when the gains from technological progress start to be shared more evenly, wage and income disparities gradually shrink too.

Theoretical frameworks developed to investigate the relationship between financial depth and inequality provide a similarly varied picture – with some studies indicating financial development reduces inequality, others pointing to inequality-widening effects and others still supporting an inverted U-shaped relationship. Contributions in the inequality-narrowing camp include Galor and Zeira (1993), who develop a model where economic growth depends on human capital investment and is influenced by the features of capital markets. One of the main results of the study is that, in the presence of financial-market imperfections and tight borrowing constraints for poor households, a country characterised by high income disparities will perpetuate cross-generational differences in human capital investments and inequality, and will grow slower than more egalitarian counterparts. Analogously, Banerjee and Newman (1993) propose a three-sector model with credit constraints in which two of the technologies require indivisible investments. In such a context, higher initial wealth inequality forces poor agents to work for entrepreneurs – the only agents who can borrow enough to invest and profit from risky but high-return projects. Consequently, both for Galor and Zeira (1993) and Banerjee and Newman (1993), a more developed and inclusive financial sector weakens the link between an individual's initial wealth and entrepreneurship, thus boosting investment and economic growth as well as narrowing income gaps. Contrary to this, several arguments have been proposed to support the inequality-widening hypothesis for financial development. Among others, Lamoreaux (1996), Rajan and Zingales (2003) and Haber (2004) argue that, even in the case of well-functioning financial institutions, only wealthier and politically connected agents will benefit from getting access to credit – so that financial-sector development may exacerbate the rich-poor income divide.[4] Similarly opposing arguments are reconciled by Greenwood and Jovanovic (1990), who show that the relationship between financial development and inequality can follow an inverted U-shaped pattern. These authors propose a model where financial sector development and economic growth are endogenously determined. In the early stages of development, only wealthier agents can afford the high fixed costs of credit to finance their investment projects. This fosters savings and economic growth, but the aggregate income gains come at the expense of a more unequal distribution. In the model, this outcome holds until credit becomes more accessible for a larger part of economic agents. Once a certain threshold financial-development is eventually surpassed, a mature financial sector promotes a more egalitarian income distribution by providing gradually wider access to financial services – so that an increasing share of less-affluent agents can share in the proceeds of growth.

Overall, therefore, while there are several reasons to expect the effects of globalisation, technological change and financial development on inequality to be nonlinear, theory-based predictions regarding the pattern of these nonlinearities are not unambiguous. As a result, this is ultimately an empirical question and in this case too, the available findings are mixed. For instance, in relation to globalisation, Dobson and Ramlogan (2009) and Jalil (2012) highlight the likely existence of a curvilinear relationship between international trade and inequality – the 'Openness Kuznets-curve' – for some Latin American countries and China. Moreover, Figini and Görg (2011) find that foreign direct investment has positive effects on wage disparities in advanced economies but a negative impact in emerging

[4] Clarke *et al.* (2006) suggest a further rationale for the positive relation between financial development and inequality. Specifically, being instrumental in fostering the development of more technologically-advanced and unequal sectors, financial development may increase overall income inequality in economies transitioning from traditional to modern production structures.

economies, noting the presence of an inverted U-shaped curve for this channel. With respect to financial development, empirical evidence supporting the inverted U-shaped hypothesis – the 'Financial Kuznets-curve' – advanced by Greenwood and Jovanovic (1990) has been provided by Clarke *et al.* (2006), Nikoloski (2013) and Jauch and Watzka (2016) both for advanced and emerging economies, as well as by Baiardi and Morana (2018, 2016) for the Euro area. In contrast, findings by Tan and Law (2012) and Brei *et al.* (2018) indicate a U-shaped pattern.

To sum up, while the theoretical literature reveals that each one of these three drivers is likely to have an impact on income inequality via nonlinear mechanisms, most empirical studies are still based on linear specifications and/or examine their effects on inequality separately – thus providing mixed empirical evidence. In what follows, we aim at filling these gaps.

3. Data and empirical framework

The empirical analysis carried out in this paper is based on a panel of annual data for 90 countries (33 advanced and 57 emerging economies) over the 1970-2015 period.[5] The countries included in the panel and the data sources are reported, respectively, in Tables A1 and A2 in the Appendix. We estimate dynamic panel data models relying on a sample of 9 (non-overlapping) five-year periods.[6] The use of five-year averages is common in the panel literature on inequality (e.g., Ostry *et al.*, 2014, Sturm and De Haan, 2015), particularly because it reduces the impact of business cycle effects and data gaps on the estimates. Moreover, averaging is especially useful in studies based on GMM estimation of macro-

[5] The time-period of analysis and the countries considered are determined by data availability.
[6] Given that the overall time-series length is 46 years, the last sub-period considers a 6-year average over 2010-2015.

panels such as ours, since it decreases the likelihood of overfitting by holding down the number of instruments.

Following much of the recent literature (e.g., Jauch and Watzka, 2016; Castells-Quintana, 2018; Baiardi and Morana, 2018), income inequality is measured by the Gini index (*Gini*) based on data from the Standardized World Inequality Database (SWIID). Our baseline models include the following regressors:

- *GDP_PC*: *Real GDP per-capita* (in thousands of 2011 US dollars). *GDP_PC* is included in the analysis to take account of the Kuznets (1955) hypothesis of an inverted-U relationship between income inequality and economic development;
- *EGI*: *KOF Economic Globalisation Index*. Ranging from 0 to 100, with higher values indicating a more globalised economy, *EGI* summarises the degree of economic and financial globalisation considering the intensity of foreign trade and financial flows, as well as restrictions such as hidden import barriers, customs tariffs and investment limitations. As such, it allows revisiting the issue of nonlinearities in the relationship between inequality and 'openness' (e.g., Dobson and Ramlogan, 2009; Figini and Görg, 2011) taking account of various aspects of globalisation;
- *GPT*: Drawing on the relevant literature, we rely on the following GPT proxies:
    - *Energy Use (tons of oil equivalent per-capita)*. Energy allows the transformation of raw materials into intermediate or final goods, and the direct provision of services for domestic and other uses. Along with these features, its pervasiveness, versatility and widespread availability make of energy use a reliable GPT proxy (e.g., Dalgaard and Strulik, 2011). Moreover, the role played by energy as an engine of industrialization and economic development (e.g., Mokyr, 1992;

Fouquet and Pearson, 1998) suggests a Kuznets-curve type of relation between *Energy Use* and *Gini* (e.g., Muller, 1988);

  - *Air Transport (passengers carried per 100 people)*. Air transport has over time evolved into a pervasive technology (Jovanovic and Rousseau, 2005; Lipsey *et al.*, 2005; Ruttan, 2006), underpinning an industry which is now a key driver of economic development, boosting employment, tourism, local businesses and international trade (e.g., OECD, 1997). The available empirical evidence is supportive of a negative correlation between *Air Transport* and income inequality (e.g., Wu and Hsu, 2012; Li and DaCosta, 2013);
  - *Mobile Cellular Subscriptions (per 100 people)*. Several studies suggest that, especially in emerging economies, mobile phone penetration can be considered an appropriate proxy for technological progress (e.g., Aker and Mbiti, 2010; Naughton, 2016). In line with the evidence in the literature (e.g., Asongu, 2015), the expected sign on the coefficient for *Mobile Cellular Subscriptions* is negative;

- *IST: Relative Price of Investment Goods*. Since IST innovations are expected to reduce the relative price of capital goods, this indicator is commonly used as an IST proxy in the literature (e.g., Krusell *et al.*, 2000). The index is constructed as the ratio of the price level of capital formation to the price level of household consumption, so that a fall in *Relative Price of Investment Goods* indicates IST progress. IST affects directly only the production side of the economy (e.g., Greenwood *et al.*, 1997; Karabarbounis and Neiman, 2014), so whether it plays a similar role with respect to GPT is an empirical question;
- *FIN*: *Financial Sector Development Index*. *FIN* is defined as private credit (by deposit money banks and other financial institutions) over GDP. The large literature using *FIN* as a

proxy for financial sector development provides consistent evidence of an inverted-U relationship with income inequality (e.g., Clarke *et al.*, 2006; Nikoloski, 2013; Jauch and Watzka, 2016).

Descriptive statistics for all variables included in the empirical analysis in the paper are reported in Table 1.

Table 1. Descriptive statistics

Variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
Gini	623	37.262	9.459	18.25	60.2
Economic Globalisation Index	758	54.276	16.2	12.82	93.069
Energy Use (per-capita)	715	2.3	2.254	0.012	17.781
Air Transport (per 100 people)	720	64.193	131.33	0	2072.789
Mobile Cellular Subscriptions (per 100 people)	773	27.865	44.284	0	168.663
Relative Price of Investment Goods	758	0.517	0.268	0.063	1.629
Financial Sector Development	723	48.496	39.448	0.146	246.187
Real GDP per-capita	758	14.507	12.922	0.436	90.497
Rate of Change of Urban Agglomerations	666	1.963	1.695	-3.209	8.034
Bureaucracy Quality	531	2.61	1.072	0	4
Human Capital Index	722	2.406	0.669	1.021	3.719
Inflation (annual %)	724	33.307	187.313	-0.516	3373.474

3.1 Panel estimations and econometric issues

Building on the theoretical contributions presented in Section 2.1 and empirical studies by, among others, Jalil (2012), Jaumotte *et al.* (2013) and Nikoloski (2013), the benchmark 'Nonlinear' model of our empirical analysis relies on the following dynamic panel specification:

$$(GINI)_{i,t} = \alpha_i + \beta_j \sum_{j=1}^{3} (GINI)_{i,t-j} + \gamma_1 EGI_{i,t} + \gamma_2 EGI_{i,t}^2 + \gamma_3 GPT_{\mathrm{i,t}} + \gamma_4 GPT_{i,t}^2 + \gamma_5 IST_{i,t} + \gamma_6 IST_{i,t}^2 + \gamma_7 FIN_{i,t} + \gamma_8 FIN_{i,t}^2 + \delta_1 (GDP_{PC})_{i,t} + \delta_2 (GDP_{PC})_{i,t}^2 + \upsilon_t + \varepsilon_{i,t} \tag{1}$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$ indicate, respectively, country and time; $GINI$ is our inequality measure; GPT and IST are the two technological progress proxies, i.e. *Energy Use, Air Transport* and *Mobile Cellular Subscriptions* as alternative GPT proxies and *Relative Price of Investment Goods* for IST; α_i indicates fixed effects, υ_t time dummies, $\varepsilon_{i,t}$ is the error term and all other variables are as defined above.[7]

For comparability purposes, we also consider a simple 'Linear' model where the main drivers of income inequality enter the dynamic panel specification only linearly, except for the terms referring to the Kuznets-curve hypothesis:

$$(GINI)_{i,t} = \alpha_i + \beta_j \sum_{j=1}^{3} (GINI)_{i,t-j} + \gamma_1 EGI_{i,t} + \gamma_2 GPT_{\mathrm{i,t}} + \gamma_3 IST_{i,t} + \gamma_4 FIN_{i,t} + \delta_1 (GDP_{PC})_{i,t} + \delta_2 (GDP_{PC})_{i,t}^2 + \upsilon_t + \varepsilon_{i,t} \tag{2}$$

As is well known, pooled OLS and fixed effects (FE) estimates of dynamic panel data models are inconsistent due to the dynamic panel bias (Nickell, 1981). This issue is particularly relevant in our case, since Monte Carlo evidence indicates that the Nickell bias may be substantial when the time-series dimension is short (e.g., Judson and Owen, 1999).

[7] Lag selection was performed with a general-to-specific procedure which, in all cases, indicated the optimal lag length as 3.

Additionally, the potential endogeneity of at least some of the regressors raises further concerns regarding the reliability of pooled OLS and FE estimates. To deal with these issues, estimations are carried out using the System-GMM (S-GMM) estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998). Just like the Difference-GMM (Arellano and Bond, 1991) estimator, S-GMM deals with variable endogeneity relying on internal instruments – but it uses both lagged levels and differences of the endogenous variables. Though neither technique has been proven to fully solve endogeneity issues (e.g., Bun and Windmeijer, 2010), these estimators represent a reliable alternative for macro-panel studies such as ours – in the context of which, obtaining valid (and robust) external instruments is very difficult. In our case, S-GMM is preferred over Difference-GMM (Arellano and Bond, 1991) because of its better performance when dealing with highly persistent variables, such as our measure of income inequality (Blundell and Bond, 2000). S-GMM estimations are carried out treating *EGI*, *GPT* and *IST* as exogenous variables, while the lags of the dependent variable, *FIN* and *GDP_PC* are considered as endogenous.

4. System-GMM estimation results

S-GMM estimates of the dynamic panel data models specified in (1) and (2) are reported in Table 2. For comparability purposes, for each model estimation the results from our baseline 'Nonlinear' specification and from its 'Linear' version are reported in two adjacent columns. This set-up is replicated for the three versions of the baseline model, each one including a different GPT proxy: *Energy Use* for Model v1, *Air Transport* for Model v2 and *Mobile Cellular Subscriptions* for Model v3. For all of the models estimated, lags of the dependent variable Gini turn out to be always strongly significant and the associated coefficients are in line with the expected high degree of persistence in inequality – thus supporting both the adoption of a dynamic panel specification and the S-GMM estimation technique. Furthermore, the outcome of the Hansen test is in line with the overall validity of the instruments and all tests for first- and second-order autocorrelation of the residuals provide evidence in favour of, respectively, rejection of the AR(1) and no rejection of the AR(2) hypotheses.

Turning to the estimation results, we start by noting that none of the 'Linear' specifications provide evidence of significant effects for the main drivers of inequality. In line with the view that neglecting nonlinearities may produce biased results, this surprising outcome is completely reversed when the analysis is carried out relying on the 'Nonlinear' specifications – for which the results turn out to be quite different.[8] In particular, the investigation of the role played by technological progress in shaping the dynamics of income inequality provides several relevant insights. Firstly, for the relationship between *Gini* and our IST proxy – *Relative Price of Investment Goods* – we obtain fairly similar results in two out of three estimations (Model v1 and v2), providing evidence of a U-shaped pattern. Note that, since a fall in *Relative Price of Investment Goods* indicates technological progress, this outcome is consistent with theoretical predictions of an inverted U-shaped relation between technology and income inequality (e.g., Aghion *et al.*, 1998; Helpman, 1998). Specifically, the negative and positive signs on, respectively, the linear and quadratic terms of *Relative Price of Investment Goods* indicate that the effects of IST innovations on inequality will depend on whether the relative price of capital is above or below a certain threshold. For countries characterised by a high relative price of capital, the relation between *Gini* and *Relative Price*

[8] This is not the case when the models are estimated relying on the pooled OLS or fixed-effects (FE) estimators, which in most cases return statistically insignificant results for both the Linear and Nonlinear specifications. To save space, the FE estimation results are reported in Table A3 in the Appendix, while the pooled OLS estimates are available upon request.

of Investment Goods is positive – i.e. these countries are located on the right-hand side of the U-shaped curve. In such a case, IST innovations leading to falls in the relative price of capital will be associated to (progressively smaller) declines in income inequality. This is consistent with a scenario in which the positive effects of IST in terms of higher labour productivity and wages outweigh its labour-substituting and skill-biased impact (e.g., Aghion, 2002; Acemoglu and Autor, 2011); when *Relative Price of Investment Goods* is low, the opposite occurs and IST innovations lead to gradually greater rises in inequality. We provide further insights on this point in Section 5.

With respect to our GPT proxies, we identify two different outcomes. The relation between *Gini* and *Energy Use* (Model v1), is characterised by an inverted U-shaped pattern in line with model predictions in Galor and Tsiddon (1997) and Aghion *et al.* (1998), among others; by contrast, *Air Transport* (Model v2) and *Mobile Cellular Subscriptions* (Model v3) are characterised by U-shaped relationships with *Gini*. These results confirm that empirical findings on the effects of GPT on inequality should be treated with caution, particularly when based on the use of a single proxy and/or assumed as linear.

Table 2. S-GMM regression results: Dependent variable is Gini Coefficient

	Model v1		Model v2		Model v3	
	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear
Gini (first lag)	1.6320***	1.5896***	1.6029***	1.4992***	1.5665***	1.5214***
	(0.0875)	(0.0993)	(0.0966)	(0.0901)	(0.1028)	(0.1621)
Gini (second lag)	-0.9353***	-0.9105***	-0.9140***	-0.8038***	-0.8448***	-0.8400***
	(0.1248)	(0.1322)	(0.1341)	(0.1246)	(0.1239)	(0.2581)
Gini (third lag)	0.2590***	0.2794***	0.2587***	0.2497***	0.2235***	0.2505*
	(0.0616)	(0.0649)	(0.0631)	(0.0592)	(0.0622)	(0.1259)
Economic Globalisation Index	-0.0061	-0.1660**	-0.0087	-0.2024***	0.0019	-0.2521**
	(0.0153)	(0.0679)	(0.0150)	(0.0567)	(0.0134)	(0.1217)
Economic Globalisation Index squared		0.0013**		0.0016***		0.0019*
		(0.0005)		(0.0004)		(0.0010)
Energy Use	-0.0617	0.3370**				
	(0.0911)	(0.1381)				
Energy Use squared		-0.0250**				
		(0.0106)				
Air Transport			-0.0011	-0.0089***		
			(0.0014)	(0.0031)		
Air Transport squared				0.0000**		
				(0.0000)		
Mobile Cellular Subscriptions					0.0001	-0.0232**
					(0.0051)	(0.0116)
Mobile Cellular Subscriptions squared						0.0001*
						(0.0001)
Relative Price of Investment Goods	0.9163	-6.1547*	0.7865	-9.1556**	0.6902	3.6106
	(0.7866)	(3.3088)	(0.7061)	(3.7221)	(0.9202)	(3.3781)
Relative Price of Investment Goods squared		4.3819**		5.8131**		-1.6525
		(2.1642)		(2.5269)		(1.5966)
Financial Sector Development	-0.0007	0.0072	0.0006	0.0226*	0.0052	0.0296*
	(0.0033)	(0.0104)	(0.0035)	(0.0127)	(0.0040)	(0.0152)
Financial Sector Development squared		-0.0000		-0.0001		-0.0001*
		(0.0001)		(0.0001)		(0.0001)
Real GDP per-capita	-0.0214	-0.0380	-0.0160	0.0379	-0.0596	-0.0409
	(0.0312)	(0.0325)	(0.0320)	(0.0324)	(0.0397)	(0.0508)
Real GDP per-capita squared	0.0003	0.0002	0.0003	-0.0002	0.0006	0.0001
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0005)
No. Observations	350	350	336	336	352	352
No. Groups	84	84	83	83	83	83
No. Instruments	65	76	68	79	64	62
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Hansen test (*p*-value)	0.3754	0.383	0.5444	0.8618	0.2507	0.3845
AR(1)	0.0055	0.0043	0.0031	0.0025	0.0063	0.0334
AR(2)	0.2613	0.238	0.2381	0.3628	0.3209	0.4043

Notes: * p<0.10, ** p<0.05, *** p<0.01. Standard errors in parentheses. Estimates are based on dynamic panel data estimation, using data averaged over five-years periods and two-step system GMM. All models instrument as endogenous the dependent variable, financial sector development and the real GDP per-capita. Time dummies are included as strictly exogenous instruments in the level equations for all specifications. Fixed-effects are removed via the forward orthogonal deviation (FOD) transformation and all models are estimated with Windmeijer (2005) finite sample correction; *p*-values are reported for Hansen, AR(1) and AR(2) tests.

For the relationship between *Gini* and the *Economic Globalisation Index* our findings are clear-cut: all the estimated models provide evidence of significant nonlinearities consistent with a U-shaped pattern. This is a somewhat surprising result in contrast with arguments in, for instance, Helpman *et al.* (2017) and the evidence supporting the existence of an 'Openness Kuznets-curve' (e.g., Dobson and Ramolgan, 2009; Jalil, 2012). It is, on the contrary, consistent with standard classical trade theory and model predictions in Xu (2003): globalisation initially reduces inequality by boosting returns to the relatively abundant factor; beyond a certain threshold, however, further liberalization increases wage inequality as high-skilled workers start to benefit comparatively more from the export-expansion effect. Meanwhile, only one specification (Model v3) provides evidence of a 'Financial Kuznets-curve', i.e. a nonlinear, inverted U-shaped relationship between inequality and *Financial Sector Development* – an outcome in line with, among others, theoretical predictions in Greenwood and Jovanovic (1990) and empirical findings in Nikoloski (2013) and Baiardi and Morana (2018, 2016). Finally, it is worth noting that *GDP_PC* and its square turn out to be not significant in all models – suggesting that the inequality determinants and specifications in Table 2 capture appropriately the mechanisms proxied by the per-capita GDP terms in the standard Kuznets-curve framework.

4.1 Robustness analysis

To assess the robustness of the results in Table 2, we now extend the model specifications using a number of control variables usually considered as possible additional determinants of inequality in the literature. Specifically, we include the following variables:

- *Rate of Change of Urban Agglomerations*. Urbanisation can play a relevant role in determining inequality dynamics at the country level.[9] Due to agglomeration economies and other externalities, cities are typically characterised by economic and job opportunities unevenly distributed in space. As a result, larger cities are generally richer but also more unequal than smaller cities and rural areas. All else constant, therefore, growing urban areas are likely to be associated to increasing inequality (United Nations, 2020). Following Castells-Quintana (2018), we control for potentially nonlinear effects of urbanisation relying on the annual average growth rate of urban agglomerations above 300,000 inhabitants within the same country;[10]
- *Human Capital*. Retrieved from the Penn World Tables, this index is constructed using average years of schooling from Barro and Lee (2013) and an assumed rate of return to education, based on Mincer-equation estimates around the world (Psacharopoulos, 1994). Evidence on the effects of human capital accumulation is ambiguous, as some studies link it to decreasing income disparities (e.g., Dabla-Norris *et al.*, 2015) while others find it widens the wage gap via skill-premium effects (e.g., Park, 1996; Goldin and Katz, 2009);
- *Bureaucracy Quality*. Constructed by the International Country Risk Guide, the index ranges between 0 and 4. Higher values correspond to lower-risk countries, where bureaucracy is more transparent and independent from political pressures. This

[9] Recent urban economics literature pointed out that further drivers of income inequality can be traced to the city level (e.g., Behrens and Robert-Nicoud, 2014; Sarkar *et al.* 2018) as well as to the regional level (e.g., Perugini and Martino, 2008; Castells-Quintana *et al.*, 2015).
[10] Rather than in growth-rate form, Castells-Quintana (2018) uses the same proxy for urban agglomeration in levels: the latter turns out to be not significant in our case.

indicator is often used as a proxy for institutional quality, which can be expected to mitigate income disparities (e.g., Chong and Gradstein, 2007);

- *Inflation (annual %)*. Higher inflation is expected to increase income inequality, as its harmful consequences typically affect to a larger extent the poor- and the middle-class (e.g., Erosa and Ventura, 2000; Albanesi, 2007).

Table 3 presents the S-GMM estimation results for the extended model specifications. Two important conclusions reached in the previous section prove to be robust to all three versions of the extended 'Nonlinear' models. The first, which is common to all estimations in Table 2, is the statistically significant U-shaped relationship between *Gini* and the *Economic Globalisation Index*. The second is that Investment-Specific Technology plays a prominent role as a determinant of inequality dynamics: *Relative Price of Investment Goods* turns out to be always significant and its U-shaped nonlinear effects are confirmed. Meanwhile, the significant but mixed evidence reported in Table 2 for the effects of GPT turns out not to be robust to the inclusion of additional controls – an outcome that reinforces the notion that IST plays a more important role than GPT as a driver of inequality trends. Moreover, just as in Table 2, there is only partial evidence (Model v5) supporting the hypothesis that *Financial Sector Development* affects inequality.

Turning to the additional control variables included in the robustness analysis, there is a persistent outcome to highlight. The relationship between *Gini* and the *Rate Change of Urban Agglomerations* is characterised by an inverted U-shaped pattern for all the estimated models. This is consistent with the hypothesis that faster-growing cities lead to increasing inequality (United Nations, 2020) but, beyond a certain threshold, the benefits from growing urbanisation outweigh its inequality-boosting effects. Finally, while *Inflation* turns out to be not significant, we find only limited evidence that *Human Capital* (Model v6) and

Bureaucracy Quality (Model v5) play a role in, respectively, increasing and reducing income inequality.

Table 3. S-GMM robustness-checks results: Dependent variable is Gini Coefficient

	Model v9		Model v10		Model v11	
Gini (first lag)	1.4544***	(0.1304)	1.4931***	(0.1332)	1.4895***	(0.1374)
Gini (second lag)	-0.8298***	(0.1729)	-0.7643***	(0.1930)	-0.8808***	(0.1929)
Gini (third lag)	0.2773***	(0.0890)	0.1825*	(0.1072)	0.2935***	(0.1093)
Economic Globalisation Index	-0.2545***	(0.0867)	-0.2773***	(0.0968)	-0.2854***	(0.1052)
Economic Globalisation Index squared	0.0020**	(0.0008)	0.0022***	(0.0008)	0.0023**	(0.0009)
Energy Use	0.0841	(0.5370)				
Energy Use squared	0.0034	(0.0353)				
Air Transport			-0.0055	(0.0051)		
Air Transport squared			0.0000	(0.0000)		
Mobile Cellular Subscriptions					0.0041	(0.0190)
Mobile Cellular Subscriptions squared					-0.0001	(0.0001)
Relative Price of Investment Goods	-13.1907***	(4.2884)	-13.8460***	(5.1508)	-11.9049**	(5.7214)
Relative Price of Investment Goods squared	7.9398***	(2.6504)	8.5532**	(3.3576)	7.0210**	(3.4940)
Financial Sector Development	0.0266	(0.0199)	0.0374***	(0.0131)	0.0218	(0.0165)
Financial Sector Development squared	-0.0001	(0.0001)	-0.0002**	(0.0001)	-0.0001	(0.0001)
Real GDP per-capita	-0.0348	(0.0752)	0.044	(0.0619)	-0.0252	(0.0673)
Real GDP per-capita squared	-0.0002	(0.0008)	-0.0004	(0.0007)	-0.0003	(0.0008)
Rate of Change of Urban Agglomerations	0.6788*	(0.4006)	0.5766**	(0.2873)	0.8568**	(0.4280)
Rate of Change of Urban Agglomerations squared	-0.1718*	(0.0956)	-0.1564***	(0.0525)	-0.2129**	(0.0869)
Bureaucracy Quality	-0.3892	(0.3281)	-0.5438*	(0.2749)	-0.4893	(0.3173)
Human Capital	0.8503	(0.7705)	0.4377	(0.5931)	1.3274*	(0.7549)
Inflation	0.0005	(0.0015)	-0.0003	(0.0012)	0.0006	(0.0015)
No. Observations	320		309		320	
No. Groups	72		72		72	
No. Instruments	67		69		69	
Time effects	Yes		Yes		Yes	
Hansen test (*p*-value)	0.7798		0.9004		0.589	
AR(1)	0.0105		0.0116		0.0103	
AR(2)	0.4611		0.7354		0.5879	

Notes: * p<0.10, ** p<0.05, *** p<0.01. Standard errors in parentheses. Estimates are based on dynamic panel data estimation, using data averaged over five-years periods and two-step System-GMM. All models instrument as endogenous the dependent variable, financial sector development, real GDP per-capita and the rate of change of urban agglomerations. Time dummies are included as strictly exogenous instruments in the level equations for all specifications. Fixed-effects are removed via the forward orthogonal deviation (FOD) transformation and all models are estimated with Windmeijer (2005) finite sample correction; *p*-values are reported for Hansen, AR(1) and AR(2) tests.

Overall, therefore, the empirical findings in this section give a clear-cut answer to the questions on the relative importance of the main determinants of inequality. Specifically, the data support the hypothesis of empirically robust effects on inequality for globalisation and investment-specific technological progress. On the contrary, there is only non-robust and/or limited evidence indicating significant effects for GPT and financial development. Moreover, our investigation brings qualified support to the view that empirical analyses of inequality determinants should be cast within a comprehensive framework – taking account of all the main drivers of inequality and, in particular, their potentially nonlinear effects. The presence of different types of nonlinearities in the relationships between inequality and its main drivers is a relevant matter from a policy perspective, as it adds a new dimension of complexity to the traditional trade-off between efficiency and equity. In this respect, therefore, our findings deserve further scrutiny.

5. Testing for monotonicity in nonlinear relationships

When both economic growth and a more equal distribution of income are policy objectives, trade-offs can arise because growth-boosting policies – such as incentives for R&D expenditure or trade liberalization measures – may result in rising income inequality via several channels, including skill-premium effects and the adoption of labour-substituting technology. For instance, such a trade-off exists when the nonlinear relationship between income inequality and globalisation is characterised by a well-identified minimum – as suggested by the estimates in Tables 2 and 3. In such a case, while globalisation initially fosters a more equal income distribution, the inequality-reducing effects of additional liberalisation measures become gradually smaller and, beyond a certain threshold value, the relationship changes sign and further integration in the global economy starts exacerbating inequality. On the contrary, when the relationship is nonlinear but also monotonic there exists no clear threshold beyond which further globalisation raises inequality: thus, there is no clear policy trade-off either. For these reasons, a formal assessment of whether the nonlinear relationships uncovered in the previous section are characterised by well-defined extreme points, i.e. a minimum or maximum within the data range, is critical for policy purposes.

To further investigate this issue, we rely on the test for U-shaped relationships proposed by Lind and Mehlum (2010) (hereafter 'LM test').[11] These authors point out that estimation of quadratic specifications may inaccurately yield an extreme point and, therefore, indicate U-shaped patterns when the true relationships are in fact characterised by convexity as well as monotonicity. In order to obtain reliable extreme points, and thus correct (inverted) U-shaped structures, the LM test checks whether the nonlinear relationship is (increasing) decreasing at low values and (decreasing) increasing at high values within the data range. In such a case, rejection of the null hypothesis of monotonicity would provide evidence in favour of (inverted) U-shaped relationships.

In this section, we carry out LM tests for U-shaped structures in Model v5 – the only specification in Table 3 providing consistent evidence of significant nonlinearities not only for *Economic Globalisation Index*, *Relative Price of Investment Goods* and *Rate of Change of Urban Agglomerations*, but also for *Financial Sector Development*.[12] The results in Table 4 are clear-cut and indicate that, in all cases, the nonlinear relationships between *Gini* and its relevant determinants are characterised by the presence of well-identified extreme points.

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[11] Among others, the LM test is employed by Arcand *et al.* (2015) and Leonida *et al.* (2015) to assess the nonmonotonic impact of, respectively, financial depth and political competition on economic growth.
[12] The LM test results for the other specifications in Table 3 reflect closely the findings obtained for Model v5. These additional results are not reported here for reasons of space, but are available upon request.

The null hypothesis of monotonicity is systematically rejected at the 5 percent significance level in favour of U-shaped patterns for *EGI* and *Relative Price of Investment Goods*, and inverted-U shapes for *Financial Sector Development* and the *Rate of Change of Urban Agglomeration*. As such, the LM-test results are consistent with the existence of well-defined threshold values beyond (or below) which the impact of the drivers of inequality changes sign.

Table 4. Tests for U-shape and Inversed U-shape relations: Model v5

Relationship	Gini and Economic Globalisation Index		Gini and Relative Price of Investment Goods		Gini and Financial Sector Development		Gini and Rate of Change of Urban Agglomeration	
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*	*Max*
Slope at	-0.222	0.123	-12.767	14.019	0.037	-0.055	1.580	-1.937
t-value	-2.904	2.169	-2.695	2.340	2.856	-2.090	2.657	-3.065
p-value	0.002	0.016	0.004	0.011	0.002	0.020	0.004	0.001
Test	H1: U shape vs. H0: Monotone or Inverse U shape		H1: U shape vs. H0: Monotone or Inverse U shape		H1: Inverse U Shape vs. H0: Monotone or U shape		H1: Inverse U Shape vs. H0: Monotone or U shape	
Overall significance	2.170		2.340		2.090		2.660	
p-value	0.016		0.011		0.020		0.004	
Extreme point	64.45		0.809		99.601		1.842	
Confidence interval	[56.795; 85.152]		[0.672; 1.131]		[75.422; 210.582]		[0.026; 3.034]	

Notes: The confidence intervals are calculated using the Fieller method.

These findings can be used to provide useful insights in terms of cross-country differences for the effects of inequality determinants, as we can establish where countries are located with respect to the thresholds – an exercise we carry out comparing the (most recent) 2010-2015 averages of the relevant variables to the estimated turning points.[13] For instance, with respect to globalisation we find that for 31 out of 65 countries the 2010-2015 average of the *Economic Globalisation Index* is higher than the estimated threshold value of 64.4, which indicates the turning point in the U-shaped relationship with *Gini* (Table 4). These countries are, thus, characterised by a positive relationship between globalisation and inequality (Figure 1). Interestingly, among these are 22 advanced economies out of a total of 24. On the contrary, 78 percent of emerging economies (32 out of 41) are positioned to the left of the *EGI* threshold in Figure 1. Thus, for these economies a growing degree of globalisation will be associated to falling income disparities. This outcome is consistent with a significant part of the literature which, in line with the predictions of classic trade theory, indicates that globalisation has affected negatively the incomes of low-skilled workers in advanced economies while benefitting the poor in emerging economies (e.g., Wood, 1995).

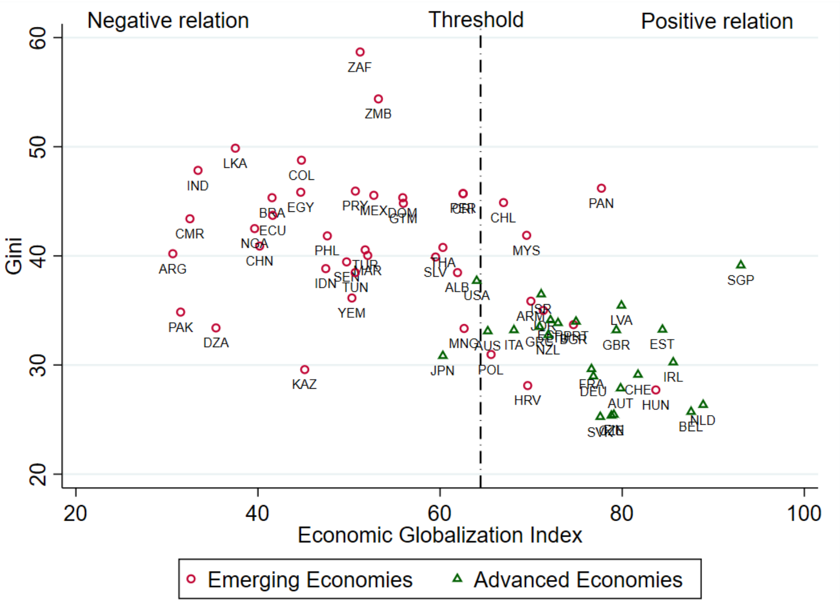

Figure 1. Location of advanced and emerging economies with respect to the estimated threshold value for *Economic Globalisation Index*.

[13] Due to gaps in the data, relying on the 2010-2015 averages as reference values for the comparisons with the estimated thresholds reduces the sample from 72 to 65 countries.

Similarly, given the U-shaped structure underpinning the relationship between *Gini* and *Relative Price of Investment Goods*, we find that 13 advanced economies are located to the right of the estimated threshold value (0.81) in Figure 2. For these economies, technological progress (as reflected by a fall in the relative price of capital) will lead to gradually smaller declines in inequality. In this respect, a striking outcome is that this is also true for only 2 emerging economies (Armenia and Kazakhstan) in our panel. For the other 39 emerging and 11 advanced economies located to the left of the threshold value for *Relative Price of Investment Goods*, the implication is that IST innovations will lead to rising income disparities. As technological progress is the main driver of long-run growth, this finding for emerging economies is consistent with the classic Kuznets-curve hypothesis that economic development will be associated to growing income disparities in its earlier stages.

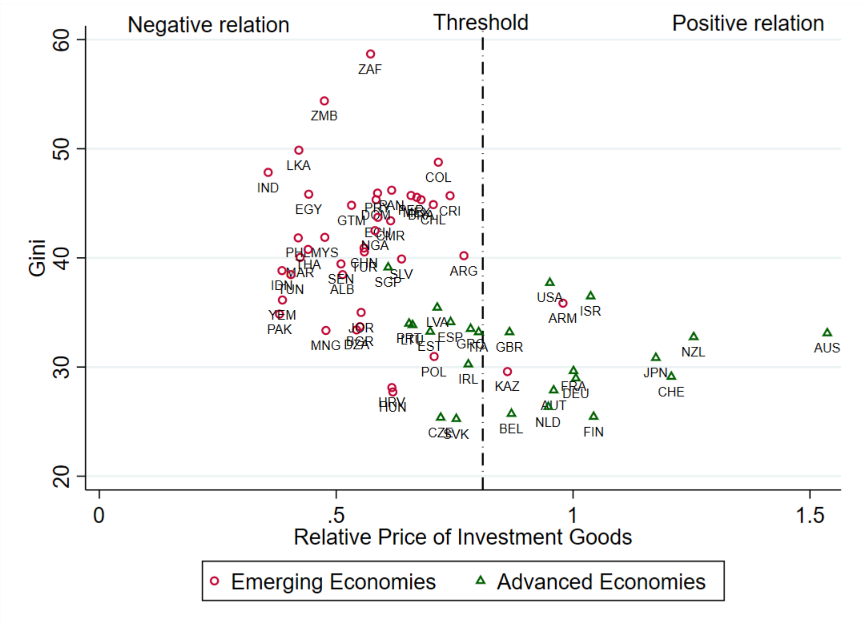

Figure 2. Location of advanced and emerging economies with respect to the estimated threshold value for *Relative Price of Investment Goods*.

For the inverted U-shaped relationship between *Gini* and *Financial Sector Development*, the turning point is estimated at a level of private credit over GDP of 99.6 percent. With respect to the latter, the advanced economies are equally split: 12 are located to the right of the threshold and are characterised by a negative relation between inequality and financial development, while the opposite is true for the remaining 12. Once again, however, the results are significantly different for emerging economies as only 5 are located to the right of the threshold in Figure 3. That is, for the vast majority (88 percent) of the emerging economies in our panel, *Financial Sector Development* is associated to an increase in *Gini*. This outcome is in line with other evidence in the literature (e.g., Nikoloski, 2013; Jauch and Watzka, 2016) and supports the hypothesis that a minimum level of financial development is required for this driver to reduce inequality.

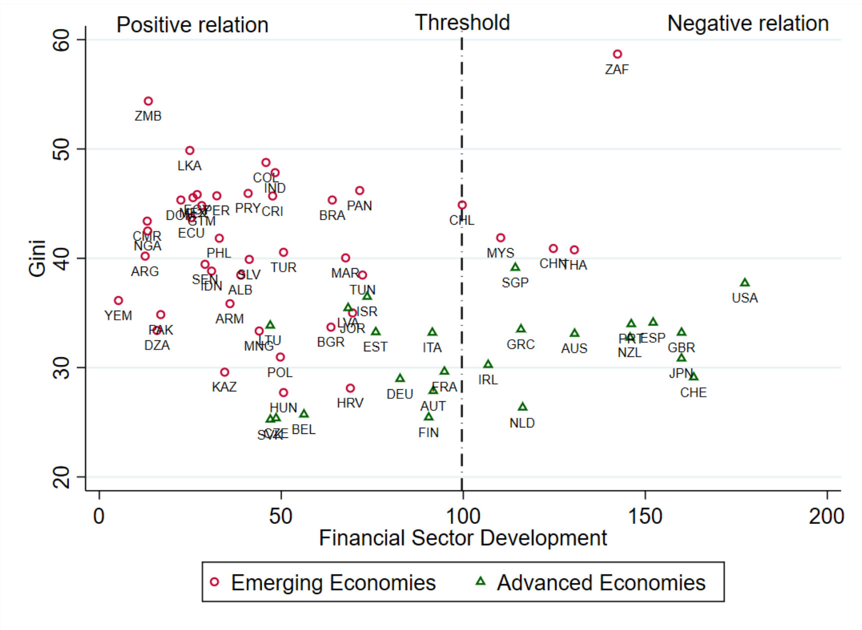

Figure 3. Location of advanced and emerging economies with respect to the estimated threshold value for *Financial Sector Development*.

Finally, for the inverted U-shaped interplay between inequality and urbanisation, the estimated threshold value for *Rate of Change of Urban Agglomerations* is 1.85 percent. With respect to this, the majority of emerging economies (26) are located in the right-hand side of Figure 4, where faster urbanisation is associated to falling inequality. This is consistent with the view that the large expected returns triggering rural-urban migration and growing urbanisation in emerging economies do translate in many cases in better incomes for low-skilled workers, thus acting as an inequality-reducing mechanism (e.g., Todaro, 1969; Nord, 1980). On the contrary, with the marginal exception of Australia and Israel, for 22 out of 24 advanced economies faster city growth is associated to growing inequality. Among others, this is in line with arguments in Bherens and Robert-Nicoud (2013) and Castells-Quintana and Royuela (2014) indicating that, due to stronger agglomeration effects leading to a relatively more developed business environment and larger shares of high-skilled labour, in advanced economies inequality can be expected to increase with urbanisation.

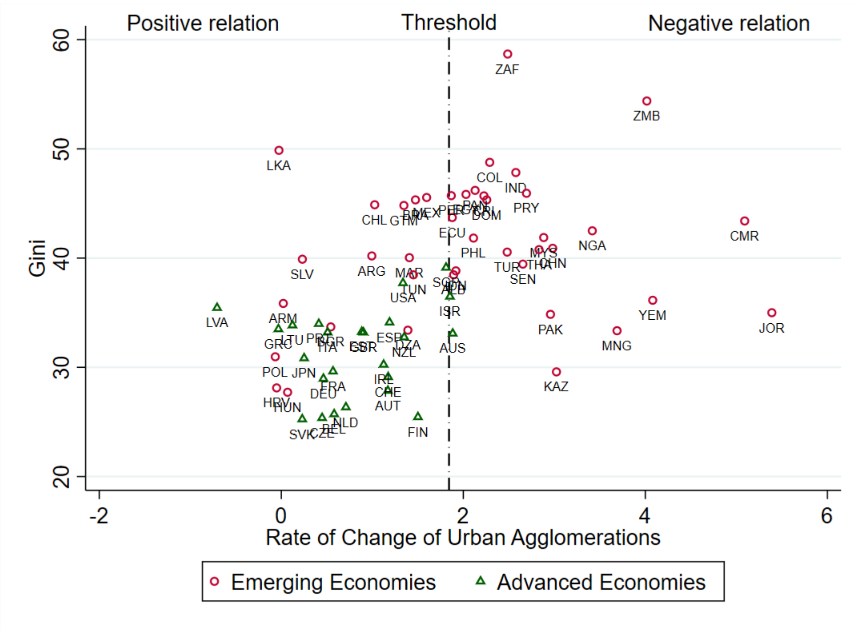

Figure 4. Location of advanced and emerging economies with respect to the estimated threshold value for *Rate of Change of Urban Agglomerations*.

To sum up, the results in this section provide a clear indication that the presence of significant nonlinearities has important implications for the relationship between income inequality and its main determinants. In particular, because of the nonlinear nature of the relation, policy trade-offs may turn out to be substantially different in advanced vis-à-vis emerging economies.

6. Conclusions

Relying on a panel dataset of annual data over the 1970-2015 period for 90 advanced and emerging economies, this paper carries out an empirical investigation of the determinants of inequality dynamics. We pay special attention to the role played by financial sector development, globalisation and technology, modelling their impact as potentially nonlinear. To take account of persistence in inequality and variable endogeneity, the empirical analysis is based on System-GMM estimations.

Our findings point to the presence of significant nonlinearities and, relying on a formal testing approach developed by Lind and Mehlum (2010), we find that the nonlinear relationships between inequality and its determinants are characterised by well-identified extreme points within the data range. This outcome indicates that the relations are non-monotonic – i.e. of either U-shaped or inverted-U shaped type – and thus subject to threshold behaviour. This has important implications for cross-country differences in inequality dynamics. Using the estimated threshold values, we show that technological progress and financial sector development are associated to increasing inequality for most emerging economies, while advanced economies turn out to be fairly evenly located on both sides of the estimated thresholds for these two determinants of inequality. Meanwhile, with respect to the role played by globalisation and urbanisation our results provide evidence of a stark contrast between advanced and emerging economies – that is, while for the large majority of emerging economies increasing globalisation and urbanisation lead to falling income disparities, they are associated to increasing inequality for most advanced economies.

Overall, therefore, our findings suggest that the mixed evidence in the literature on the role played by inequality drivers can be explained (at least to some extent) by the presence on nonlinear effects. The important implication is that the same determinants can exert opposite effects on inequality in advanced and emerging economies, as a result of the significant differences characterising these two country groups – in particular, in terms of financial development, globalisation and technology. This is especially relevant for policymakers in countries in the earlier stages of development, where policies fostering crucial engines of growth such as technological progress and financial development can also lead to worsening income inequality. Further research is needed to better understand the changing nature of these trade-offs at the individual country level, and how policy can improve them.

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Appendix

Table A1. List of countries included in the analysis

Advanced economies	Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States
Emerging economies	Albania, Algeria, Angola, Argentina, Armenia, Bahamas, Barbados, Botswana, Brazil, Bulgaria, Cameroon, Chile, China, Colombia, Costa Rica, Croatia, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Grenada, Guatemala, Hungary, India, Indonesia, Jamaica, Jordan, Kazakhstan, Lesotho, Malaysia, Mauritius, Mexico, Mongolia, Morocco, Nigeria, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Senegal, Serbia, Seychelles, South Africa, Sri Lanka, Suriname, Swaziland, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uruguay, Yemen, Zambia

Notes: Economies are defined as Advanced or Emerging following the World Economic Outlook classification (IMF, 2016)

Table A2. Data sources and coverage

Variable	Source	Time span	Countries
Gini Coefficient	Standardized World Inequality Database (SWIID), v7.1, August 2018, Solt (2016)	1970-2014	90
Economic Globalisation Index	KOF Index of Globalisation, Gygli *et al.* (2019)	1970-2015	90
Energy Use	World Development Indicators, World Bank	1970-2014	90
Relative Price of Investment Goods	Penn World Tables 9.0, Feenstra *et al.* (2015)	1970-2014	90
Air Transport	World Development Indicators, World Bank	1970-2014	88
Mobile Cellular Subscriptions	World Development Indicators, World Bank	1980-2014	88
Financial Sector Development	Financial Development and Structure Dataset, updated July 2018, Beck *et al.* (2000)	1970-2015	90
Real GDP per-capita	Penn World Tables 9.0, Feenstra *et al.* (2015)	1970-2014	90
Inflation	World Development Indicators, World Bank	1970-2015	90
Human Capital Index	Penn World Tables 9.0, Feenstra *et al.* (2015)	1970-2014	85
Rate of Change of Urban of Agglomerations	United Nations, World Urbanization Prospects (2018)	1970-2015	78
Bureaucracy Quality	The PRS Group, International Country Risk Guide (2017)	1984-2015	82

Table A3. Fixed-effects regression results: Dependent variable is Gini Coefficient

	Model v1		Model v2		Model v3	
	Linear	Nonlinear	Linear	Nonlinear	Linear	Nonlinear
Gini (first lag)	1.2141***	1.2313***	1.2061***	1.2201***	1.2180***	1.2165***
	(0.1046)	(0.1009)	(0.1061)	(0.1078)	(0.1063)	(0.1067)
Gini (second lag)	-0.6947***	-0.6725***	-0.6938***	-0.6939***	-0.6995***	-0.6803***
	(0.1208)	(0.1217)	(0.1237)	(0.1245)	(0.1234)	(0.1240)
Gini (third lag)	0.1955**	0.1905**	0.1963**	0.2032**	0.1949**	0.1881**
	(0.0827)	(0.0832)	(0.0860)	(0.0862)	(0.0843)	(0.0857)
Economic Globalisation Index	0.0112	-0.1042	0.0207	-0.0639	0.0081	-0.0925
	(0.0135)	(0.0627)	(0.0132)	(0.0637)	(0.0149)	(0.0654)
Economic Globalisation Index squared		0.0010*		0.0007		0.0009
		(0.0005)		(0.0005)		(0.0006)
Energy Use	-0.0659	0.5656				
	(0.1798)	(0.3625)				
Energy Use squared		-0.0458*				
		(0.0265)				
Air Transport			-0.0004	-0.0012		
			(0.0005)	(0.0034)		
Air Transport squared				0.0000		
				(0.0000)		
Mobile Cellular Subscriptions					0.0043	-0.0107
					(0.0052)	(0.0096)
Mobile Cellular Subscriptions squared						0.0001
						(0.0001)
Relative Price of Investment Goods	0.1405	-0.2098	0.0547	0.7785	0.0248	0.3973
	(0.5746)	(2.0017)	(0.5730)	(2.1035)	(0.5556)	(1.9349)
Relative Price of Investment Goods squared		0.1108		-0.5499		-0.2572
		(1.2237)		(1.2525)		(1.1598)
Financial Sector Development	0.0029	0.0071	0.0019	0.0108	0.0030	0.0104
	(0.0042)	(0.0080)	(0.0049)	(0.0091)	(0.0043)	(0.0092)
Financial Sector Development squared		-0.0000		-0.0000		-0.0000
		(0.0000)		(0.0000)		(0.0000)
Real GDP per-capita	-0.0049	-0.0775*	-0.0068	-0.0385	-0.0228	-0.0318
	(0.0361)	(0.0396)	(0.0346)	(0.0390)	(0.0330)	(0.0359)
Real GDP per-capita squared	0.0005	0.0011**	0.0005	0.0008*	0.0006	0.0006
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0004)
Constant	9.9793***	11.5292***	9.7199***	11.1168***	10.3067***	12.2573***
	(2.4418)	(2.8510)	(2.3791)	(2.9030)	(2.2455)	(2.9211)
No. Observations	349	349	343	343	352	352
R-squared (within)	0.6720	0.6869	0.6769	0.6838	0.6693	0.6792
Time effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: * p<0.10, ** p<0.05, *** p<0.01. Standard errors in parentheses. Estimates are based on dynamic panel data fixed-effects estimation, using data averaged over five-years periods and the regressors lagged one period.

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