Policy Rent Seeking , Growth and Inequality in a Model with Voracity and Heterogeneous Groups

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Abstract

The voracity effect (Tornell and Lane, 1999) shows that in the presence of a weak legal framework the competition among powerful groups over a common resource (tax revenues) has perverse effects on economic growth. We investigate the economic effects of assuming that groups have different bargaining power. The introduction of heterogeneity has important consequences. First, the perverse effect of voracity on growth becomes weaker and asymmetric, as heterogeneity reveals the presence of a new mechanism that we label as the "switching effect". Secondly, with heterogeneity changes in the allocation of bargaining power across groups become a new source of voracity. Thirdly, shocks that trigger the voracity effect also have an impact on inequality. We find that the relationship between voracity, growth and inequality depends on the nature of the shock. We look for voracity among developed countries and find some suggestive evidence of its presence among OECD countries characterized by weak institutions.

Keywords: voracity effect; heterogeneous agents; growth, inequality.

1 Introduction

The "voracity effect" put forward by Tornell and Lane (1999) [TL henceforth] explains how weak institutions lead to poor growth performance, and is often quoted to account for phenomena such as procyclical fiscal policies (e.g. Lane 2003) and the natural resource curse (e.g. Van der Ploeg 2011). TL show that in economies with a weak legal framework aggregate tax revenues become a common resource over which powerful groups compete to tailor benefits to their members. In this setting, shocks that would otherwise be favorable to growth amplify the groups' rent-seeking behavior. As groups become more voracious and ask for more fiscal transfers, the tax rate is forced to increase stifling growth. The negative effect of higher taxes is so strong to overturn the initially favorable shock.

In TL groups are homogenous and have the same bargaining power when competing over discretionary fiscal redistribution. But do groups have the same negotiation power? We claim that in practice groups are different and vary in the degree to which they can extract resources from the common pool. For example, we can think of each group as representative of a category of income earners. Groups that represent employees' interests, whose salary is compulsory reported to public institutions by their employees, are much less likely to avoid or evade taxes than groups that represent self-employed interests, who may report only a part of their incomes, or groups that represent business corporation interests, that can conclude beneficial tax deals.[1] In general, rent-seeking activities can take different forms: corporate lobbies can exploit offshore tax heavens to lower their tax burden (transfer pricing); labor unions may lobby to ensure a labor legislation more favorable to their associates (dual labor market); special interest groups may lobby for high entry barrier to keep extracting monopoly rents (eg taxi drivers, notaries,. . .). Thus, voracity can show up in very different forms, that include but are not limited to corruption, high entry barrier in some sectors of the economy and a large shadow economy sector.

In this paper we take as given that property rights are not perfectly secured in the economy and instead focus exclusively on the economic effects of changes in their allocation. We also assume that the allocation of property rights is exogenous and not endogenously determined by a complex interplay between groups and the government.

We depart from the standard two-sector model with voracity by TL not only by introducing heterogeneity across groups but also by modeling differently the terms of trade. The latter deviation is justified on the ground that terms of trade shocks can be generalized to a technological shocks.

These changes modify the nature and the strength of the voracity effect. Firstly, heterogeneity reveals the presence of a second-order growth-enhancing equilibrium mechanism that weakens the perverse effects of voracity on the economy and actually makes it asymmetric. Indeed, after a shock that modifies the relative distribution of bargaining power across groups, some of them may take advantage of it by credibly asking for higher transfers, with all the others reacting by reducing their. In the end, the second effect prevails causing aggregate transfers and taxes to fall and growth to increase. Secondly, with heterogeneity we show that exogenous changes in the allocation of property rights across groups are a new source of voracity. These shocks can be interpreted as a modification of the distribution of bargaining power across groups. A new allocation may be thought as the outcome of successful lobbying activities through which some groups are able to obtain favorable laws from the government. As an example, we can include tax law changes that create loopholes for certain groups. Also, any legal prescription that de-facto limits the ability of

[1]For example, several tax deals have been investigated by the EU in 2015: FCA with the Netherlands, McDonald and Starbucks with Luxemburg, Apple with Ireland.

the public administration and/or of the judiciary power to exert an effective control on some groups' activities (eg the specific legislation about the statute of limitation in Italy and Greece reduces the probability that white-collar crimes be actually punished). We then choose to adopt the generic term of policy intervention to refer to any exogenous change in the allocation of property rights, well aware that the underlying reasons of a policy intervention and the specific form it can assume can be very diverse. Differently from technology shocks, policy interventions are under the direct control of governments. Thus, the model becomes a very flexible tool to analyze the economic effects of a wide range of policy interventions.

By introducing heterogeneity we are also able to analyze how the voracity effect impacts on inequality. We find that technology shocks induce a negative relationship between growth and inequality, as higher (lower) growth benefits (damages) mostly low-bargaining power groups. We consider policy interventions addressing inequality by affecting the dispersion but not the average of the distribution of bargaining power among groups. We find that these interventions most likely induce a positive relationship between growth and inequality as higher (lower) growth benefits (damages) mostly high-consumption groups.

With heterogeneity, an increase in the number of groups in the economy (fractionalization) does not necessarily lead to a dilution of power and to higher growth as originally predicted by TL, a result that was in sharp contrast with what found by other studies in which fractionalization (often ethnically based) worsened economic performance (Hodler 2006, Montalvo and Reynal-Querol 2005). The intuition is that with heterogeneity it is not the change in the number of groups that matters for the economic performance but the specific change in the distribution of bargaining power across groups.

A final theoretical result is that terms of trade shocks cause no longer voracity. As a whole, our results suggest that voracity might be a suitable candidate for explaining poor growth performance in middle- and high income countries plagued with weak institutions, rather than focusing on commodity-rich developing countries. Indeed, the fight over redistribution that give rise to voracity is essentially non-violent in nature and requires well established statistical and budgetary institutions that are actually more likely to be found in developed countries. In this respect, we provide some suggestive evidence that voracity is present in a subset of 23 OECD members. We first perform a cluster analysis to regroup OECD countries according to the quality of their institutions. A panel analysis then shows that countries with the weakest institutions are the most likely to engage in procyclical public spending, a known symptom of voracity.

This paper is related to several strands of the literature. The theoretical literature that investigates the relationship between growth and inequality finds that inequality can affect growth in either way. [2]In our model, the relationship between growth and inequality depends on the shocks

[2]Positively, when it acts as incentive for innovation (Lazear and Rosen 1981), allows for a quicker capital accumulation as rich people have a higher propensity to save (Kaldor 1957) and allows credit-constrained countries to

hitting the economy and on the specific characteristics of the policy intervention. Whether higher inequality goes with lower growth remains an empirical question. [3]

We provide theoretical support to political economy explanations of procyclical fiscal policy (Talvi and Vegh 2005, Alesina et al. 2008) by showing that the voracity effect remains valid in economies with heterogeneous agents. Within this literature, we are close to Woo (2009) who models inequality in terms of the degree of heterogeneity of preferences across socioeconomic groups (social polarization). His results imply a negative relationship between inequality and growth. In our model, however, preferences are homogeneous and heterogeneity is modeled as an institutional feature, so that results are not directly comparable.

We also relate to the empirical and theoretical literature on the natural resource curse (e.g. Hodler 2006, Montalvo and Reynal-Querol 2005, Easterly and Levine 1997, Alesina et al 2003, Alesina and La Ferrara 2005, Rodrik 1999). Several empirical studies quote the voracity effect to explain the negative impact of positive terms of trade shocks on growth.[4] Our results question the possibility that a terms of trade shock might actually set in a voracity effect, though it remains true that the presence of natural resources might act as a drag on growth because of other (political economy) mechanisms.

Finally the theoretical literature on the voracity effect (Tornell and Lane 1996, 1998,1999, Long and Sorger 2006, Strulik 2012a, 2012b). Strulik (2012a,2012b) challenges the practical relevance of the voracity effect. In a one-sector version of the model by TL (1996) Strulik shows that voracity arises only under very specific conditions: preferences featuring an elasticity of intertemporal substitution lower than unity, low productivity and a largely fractionated society. Long and Sorger (2006) generalize the two-sector model by TL (1999) and allow agents to be heterogeneous along several dimensions, among which the cost of appropriation of the common resource. They show that when heterogeneity involves two types of players agents, the degree of heterogeneity of appropriation costs that maximizes growth in the formal sector is not necessarily non zero. Our contribution to this literature is the following. First, we confirm one of Strulik (2012a,2012b) result for a two-sector version of the TL model: for voracity to arise preferences must feature an intertemporal elasticity of substitution below unity. Second, our results are in line with those by Long and Sorger (2006) result as we find that higher heterogeneity across groups does not necessarily decrease growth.

The structure of the paper is the following. Section 2 introduces the model with heteroge-

accumulate the minimum level of capital (human and physical) to start businesses (Barro 2000). Negatively, when it undermines the development of health and education (Perotti 1996; Galor and Moav 2004; Aghion et al 1999), causes political and social instability that impairs investment (Alesina and Perotti 1996), curtails the political capital required to implement interventions in economies that are hit by negative shocks (Rodrik 1999) or leads to a policy redistribution based on tax increases that are growth reducing (Alesina and Rodrik 1994, Tabellini and Person 1994).

[3] Most studies support the idea that inequality reduces both the pace and the persistence of growth (e.g. Perotti 1996, Berg et al 2012, Rodrik 1994), but these conclusions still lack consensus (Banerjee and Duflo 2003, Aghion, Caroli and Garcia Penalosa 1999, Halter, Oechslin and Zweimuller 2010).

[4] An incomplete list includes Bhattacharyya and Hodler (2010), Sala-i-Martin and Subramanian (2012), Cuaresma et al. (2011), Van der Ploeg (2011), Apergis and Payne (2014), Arezki and Bruckner (2012).

neous groups and define the equilibrium. Section 3 describes the voracity effect after a technology shock. Section 4 analyzes policy interventions as a new source of voracity. Section 5 presents some suggestive empirical evidence of the presence of voracity in a subsample of OECD countries.

2 The baseline model with heterogeneity in the informal sector

We follow Tornell and Lane (1999) and assume that the economy is composed of n groups and two sectors: a legal more efficient tradeable sector and an informal less efficient nontradeable sector.[5] In both sectors a sector-specific capital is the only input.

In the legal sector each group $i = 1, ..., n$ produces a tradeable non-consumption good (Y_K) with a linear technology which depends on a common technology, α, and sector-specific capital $k(i)$. Final output can either be invested to increase the stock of capital (to be available for production in the future), or exchanged on the international market for an imported consumption good at the exogenous relative price $p = \frac{P_K}{P_C}$.[6]

In the informal sector each group $i = 1, ..., n$ may produce a nontradeable consumption good, $Y_b(i)$, with a linear technology which depends on the group i specific productivity, $\beta(i)$, and sector-specific capital $b(i)$: $Y_b(i) = \beta(i)b(i)$. In the informal sector, productivity is distributed across groups according to the probability distribution $F(x) = \int_{\beta_{min}}^{\beta_{max}} f(x)dx$, with $\beta_{min} \geq 0$ and $\beta_{min} < \alpha$. $Y_b(i)$ can be either directly consumed or invested to increase the stock of informal sector capital to be available for production in the future.

In the legal sector production is subject to taxation, while in the informal sector it is tax-exempted.

The possibility of each group to extract resources from aggregate tax revenues amounts to granting it access to to the other group's capital stocks. Thus, property rights are not secured in the formal sector. Instead, capital is fully private in the informal sector. By allowing groups to have a different productivity in the informal sector, we capture the idea that groups differ in their relative bargaining power and might obtain different amount of transfers.

Fiscal policy is budget balanced as aggregate taxes equal aggregate transfers: $T = \frac{1}{p} \sum_i r(i)$, where T and $r(i)$ are, respectively, aggregate taxes and the transfers received by a generic group i. [7] Furthermore, T is a fixed proportion (τ) of output in the legal sector: $T = \tau \alpha K$. [8] Each group i

[5]In the paper the legal sector can equivalently be labeled as the tradeable/efficient sector. Similarly, the informal sector may equivalently be termed as the nontradeable/inefficient sector.

[6]Implicitly, the price of the imported consumption good, C, is defined as the numeraire in the economy

[7]As transfers are measured in units of b, while taxes are measured in units of K, aggregate taxes are premultiplied by the the relative price p.

[8]As transfers are measured in units of b, while taxes are measured in units of K, aggregate taxes are premultiplied by the the relative price p.

determines its demand for transfers $r(i)$ at the end of a discretionary bargaining process, $r(i)$ being measured in unit of the consumption good. Once aggregate demand for transfers are defined, taxes T are levied on the legal sector to balance the budget. However taxes T, being extracted from the legal sector, are defined in units of the tradeable non-consumption good Y_K, so they need to be exchanged on the international market for the imported consumption good at the international exogenous price p.

In this setting, in the legal sector individual property rights are not perfectly ensured as the process of discretionary fiscal redistribution allows each group to extract resources from other's group capital stock. Common technology is then a sufficient condition for each group i to consider the aggregate capital stock in the legal sector, $K = \sum_i k(i)$, as a common resource, so that it will focus on K rather than on individual capital stock $k(i)$ (cfr Appendix A for a formal proof). It follows that for each group the law of motion of interest in the legal sector is $\dot{K} = \alpha K - T$. Together with linear technology, this implies that in the legal sector the growth rate of output coincides with that of the aggregate capital stock , so that the two terms "growth" and "growth rate of capital" are equivalent.

Equations (1) and (2) report, respectively, the law of motion of capital in the legal and the informal sector for a generic group i.

$$\dot{K} = \alpha K - T \tag{1}$$

$$\dot{b}(i) = \beta(i)b(i) + r(i) - c(i) \tag{2}$$

We assume that technology in the legal sector is more efficient than in the informal sector for all groups: $\alpha > \beta(i+1) > \beta(i) > 0$, $\forall i = 1, ..., n-1$. We adopt the convention of using $\{\beta(i)\}$ to refer to the distribution of the informal sector productivity across groups. The subjective discount rate is $e^{-\rho t}$, $1 > \rho > 0$.

In the TL model $\dot{K} = p\alpha K - T$ rather than (1). However, the price p transforms units of K in units of b. Thus, while the term $p\alpha K$ is measured in units of b, the term T is measured in units of K. To avoid a measurement problem we must interpret p as a technology parameter and merge it into α. However, this has very relevant implications. Firstly, the nature of the voracity effect is altered as shocks to p should be interpreted as technology shocks rather than terms of trade shocks. Secondly, commodity-rich countries cease to be object of interest for empirical analysis searching for evidence of voracity.

With heterogeneity, each group chooses the path of consumption, $c(i)$, transfers, $r(i)$, aggregate stock of capital in the legal sector, K, and individual stock of capital in the informal sector, $b(i)$, to maximize the flow of instantaneous utility $U(i)$ represented by a CES function $U(i) = \frac{\sigma}{\sigma-1}c(i)^{1-\frac{1}{\sigma}}$, where $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution. In maximizing his own utility, each group i is subject to several constraints: the law of motion of aggregate capital in the legal sector (1), the law of motion of individual capital in the informal sector (2) and non-negative constraints to capital in the two sectors ($K \geq 0, b(i) \geq 0$). As a further constraint, an exogenous upper bound $\bar{x}$ is set on the level of transfers that each group can receive. [9] Formally, a generic group i solves the following maximization problem:

$$\underset{\{c(i),r(i),K,b(i)\}}{Max} L = \frac{\sigma}{\sigma-1}c(i)^{1-\frac{1}{\sigma}} + \lambda(i)\left[\alpha K - \frac{\sum_{j=1}^{n} r_{(j)}}{p}\right] + \mu(i)\left[\beta(i)b(i) + r(i) - c(i)\right] + \\ \xi(i)\left[p\bar{x}\alpha K - r(i)\right] + \gamma(i)b(i) + \varphi(i)K \quad (3)$$

In equilibrium each group belongs to either faction G_1 or faction G_2. G_1 is composed of n_1 groups, $n_1 = \{0, ..., n\}$, who do not find optimal to produce in the informal sector; G_2 is composed of the remaining $n - n_1$ groups who find optimal to produce in the informal sector. The equilibrium value n_1^* specifies how many groups are in G_1 or G_2. From resolving (3), we obtain the equilibrium conditions for the the generic group i, conditional on the parameter space $\theta_0 \in \Theta, \Theta = \{n, \alpha, \{\beta(i)\}, \sigma, \rho\}$ and n_1 (cfr. appendix B for details on how to obtain equilibrium conditions). Below are reported the equilibrium values of growth (4), transfers (5), consumption (6) and stock of capital in the informal sector (7):

$$g_K = \sigma\left(\frac{\sum_{j\in G_2}\beta(j) - \alpha + n_1\rho}{\sigma(n-1) - n_1}\right) > 0, \quad (4)$$

$$r(i) = \begin{cases} pK\left[\rho - g_K\left(\frac{\sigma-1}{\sigma}\right)\right], & \forall i \in G_1 \\ pK\left[\beta(i) - g_K\right], & \forall i \in G_2 \end{cases}, \quad (5)$$

$$g_c(i) = \begin{cases} g_K, & \sigma(\beta(i) - \rho) < g_K, \forall i \in G_1 \\ \sigma(\beta(i) - \rho), & \sigma(\beta(i) - \rho) > g_K \,\forall i \in G_2 \end{cases}, \quad (6)$$

$$b_t(i) = \begin{cases} 0, & \forall i \in G_1 \\ pK_0\left[e^{g_c(i)} - e^{g_K}\right], & \forall i \in G_2 \end{cases}. \quad (7)$$

Equilibrium conditions ensure us that for any pair (i, j), $i \in G_2$ and $j \in G_1$: $\beta(i) > \beta(j)$, $g_c(i) > g_c(j)$, $r(i) > r(j)$. [10] Groups in G_1 all share the same (growth rate of) consumption in equilibrium, g_K, which is identical to the growth rate in the legal sector. These results tell us that groups

[9] However, the analysis focuses only on interior solutions as we are interested in solution where no group does not act optimally by demanding as much as possible.

[10] From optimal conditions we have $\sigma(\beta(i) - \rho) > g_K > \sigma(\beta(j) - \rho)$ $i \in G_2, j \in G_1$. As a corollary, $\beta_{i+1} > \beta_i \iff \sigma(\beta_{i+1} - \rho) > \sigma(\beta_i - \rho)$. It follows that, let be $n - n_1$ the number of groups producing in the informal sector, in equilibrium it must be true that these $n - n_1$ groups are those with the highest β: $G_2 = \{\beta_{n_1+1}, ..., \beta_n\}$. The remaining n_1 groups are those with the lowest β:$G_1 = \{\beta_1, ..., \beta_{n_1}\}$. Also, $\beta(i) > \beta(j) \forall (i, j), i \in G_2, j \in G_1$.

in G_2 tend to be more productive than groups in G_1, and that they also receive higher transfers and benefit from a higher (growth rate of) consumption. Intuitively, groups with a relatively higher productivity dispose of a greater bargaining power in the redistribution process or, analogously, enjoy of a beneficial allocation of property rights. More specifically, while an additional unit of transfers has the same cost for each group which consists of a marginal increase in the common tax rate τ, the benefit gets higher the higher the productivity of the group in the informal sector. Thus, a relatively higher β permits a group to obtain relatively greater transfers. It is then a natural to interpret $\{\beta(i)\}$ as the distribution of relative bargaining power across groups or, analogously, to think of it as a specific allocation of property rights. As $\{\beta(i)\}$ is exogenous, we consider it as determined by institutional factors and we adopt the generic term of policy intervention to refer to any exogenous change in it, well aware that the underlying reasons of what we term a policy intervention and the specific form it can assume can be very diverse.

We observe in equation (4) that in equilibrium growth is not affected by the terms of trade (p) which are no longer a source of voracity. Only shocks to α and $\{\beta(i)\}$ provoke voracity as they modify the groups' rent-seeking behavior. [11]

The introduction of heterogeneity has relevant implications on the analysis of the economic impact of varying the number of groups in the economy (fractionalization). Theoretically, the introduction of a new group in the economy produces two opposite effects. On one side, each group reduces its rent-seeking activity (demand for transfers) because it perceives its market power diluted. On the other side, each group internalizes less the economic cost of its actions and then intensifies its rent-seeking behavior. In TL it is the first effect that prevails and fractionalization improves growth. In other studies, it is the second effect that dominates and increasing the number of groups leads to a worse economic performance (eg Hodler 2006, Montalvo and Reynal-Querol 2005). However, the result in TL is driven by the fact that the distribution $\{\beta(i)\}$ is unaffected by the number of groups. With heterogeneity fractionalization can lead to either better or worse growth depending on the specific way an extra-group alters the distribution $\{\beta(i)\}$. Thus, it is not possible to state unequivocally the final economic effect of fractionalization as it is necessary to precise how the distribution $\{\beta(i)\}$ is modified by the introduction of an extra group. It also implies that within the model it is more interesting to directly analyse the economic impact of a modification of$\{\beta(i)\}$ while living n unchanged.

[11] Parameter constraints from equilibrium conditions confirm one of Strulik's (2012) result even for a two-sector model: voracity is compatible only insofar as preferences are characterized by $\sigma > 1$, that is an intertemporal elasticity of substitution greater than 1. Indeed, equilibrium conditions constraint $\sigma \in \left(\frac{\alpha}{\alpha-\rho}, \frac{\beta_1}{\beta_1-\rho}\right)$. More specifically, to have $g_K > 0$ it is necessary that $\sigma > \frac{n_1}{n-1}$, where $\frac{n_1}{n-1} \in \left(0, \frac{n}{n-1}\right)$. Trasversality condition on K requires both $\frac{n}{n-1} < \frac{\alpha}{\alpha-\rho} < \sigma$ and $g_K\left(\frac{\sigma-1}{\sigma}\right) - \rho < 0$. Trasversality conditions on $\dot{b(i)}$ imply $\beta(i) > g_C(i) > g_K, \forall i \in G_2$, $\sigma < \frac{\beta_1}{\beta_1-\rho}$ and $g_C(j) = g_C = g_K \forall j \in G_1$. For equilibria with $n_1 < n$, to have $g_c(i) \geq 0$ it is necessary that $\beta(i) > \rho$. Accordingly, $\alpha > \beta_i > \rho$, and $\frac{\alpha}{\alpha-\rho} > 1$. Cfr Appendix B.

The equilibrium value n_1^*

Equilibrium conditions (4)-(7) take n_1 as given. However, to fully characterize the general equilibrium we need to determine the equilibrium value n_1^*, which is endogenously determined as the value that maximizes g_K:

$$n_1^* = \underset{\{n_1\}}{argmax}\, g_K(n_1 \mid \Theta),$$

where $g_K(n_1)$ highlights that growth is a function of n_1, the number of groups that are in G_1.

Intuitively, with heterogeneity each groups has an extra degree of freedom as it may decide whether or not to produce in the informal sector, taking as given the behavior of the other groups. Its choice depends on what alternative grants it higher consumption and transfers. Thus, its optimal choice always implies higher transfers, and so it is a credible "threat" for all the others, who react by reducing their demand for transfers. As they do in an uncoordinated way, aggregate transfers go down, taxes can be reduced, and growth improves.

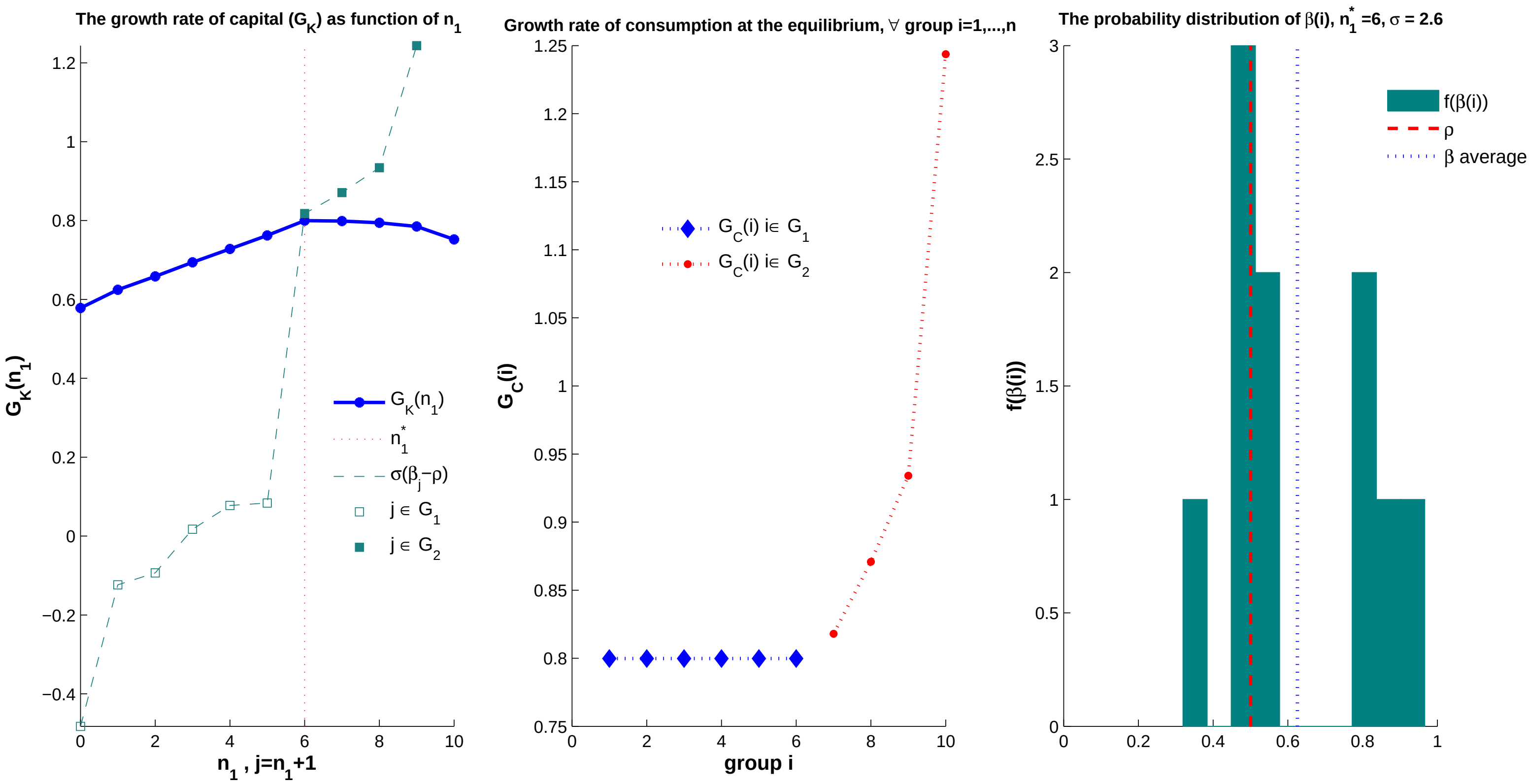
More specifically, let's assume without loss of generality an initial equilibrium that is characterized by $n_1 = n_1^*$, with $G_1 = \{1, ..., n_1^*\}$ and $G_2 = \{n_1^* + 1, ..., n\}$. If a group $j \in G_2$ switches to G_1 then n_1 and and g_K would increase only if $\sigma\,(\beta(j) - \rho) < g_K(n_1)$, as it holds:

$$\frac{\partial g_K}{\partial n_1} = \left(\frac{g_K(n_1) - \sigma\,(\beta\,(n_1 + 1) - \rho)}{(\sigma\,(n-1) - n_1)}\right) \geq 0 \Longleftrightarrow g_K \leq \sigma\,(\beta(j) - \rho) \tag{8}$$

However, equilibrium condition (6) prescribes that for any $j \in G_2$ it must hold $\sigma\,(\beta(j) - \rho) > g_K(n_1^*)$. This optimal condition tells us that j has higher consumption in G_2 ($\sigma\,(\beta(j) - \rho)$) than in G_1 ($g_K(n_1^*)$). Thus, there is no $j \in G_2$ that would switch to G_1. Moreover, if it did so, by (8) g_K would decrease. Similarly, equilibrium conditions imply that for any $w \in G_1$ it must hold $\sigma\,(\beta\,(w) - \rho) < g_K$. Thus, there is no $w \in G_1$ that would be better off by switching to G_2. Also, if it did so, by (8) g_K would decrease. It follows that g_K is maximized at n_1^*.

Figure 1 shows how the equilibrium value $n_1 \in [0, n]$ is endogenously determined at $n_1^* = 6$ for the following parametrization $\theta \in \Theta$: $\{\beta(j)\} \sim U\,[0, 1]$, $\alpha = 1.05$, $\rho = 0.5$, $\sigma = 2.6$, $n = 10$. The right panel shows the specific drawn from $\{\beta(j)\}$, a uniform distribution defined over the interval $[0, 1]$. The left panel draws the function $g_K(n_1)$, the growth rate of consumption of groups in G_1, and the function $\sigma\,(\beta\,(j) - \rho)$, the growth rate of consumption of groups in G_2 (on the x-axis we report both j and n_1, where for consistency $j = n_1 + 1$). Clearly, $g_K(n_1)$ is maximized at $n_1 = 6$, on the right of the point where $\sigma\,(\beta\,(j) - \rho)$ crosses from below $g_K(n_1)$. For $j = 7, ..., 10$, $\sigma\,(\beta\,(j) - \rho) > g_K(n_1^*)$, which means that these groups consume more in G_2. The reverse holds for $j = 1, ..., 6$: for these groups $\sigma\,(\beta\,(j) - \rho) < g_K(n_1^*)$, so that they consume more in G_1. Finally, the middle panel sums up the equilibrium growth rate of consumption, $g_c(j)$, of all the groups for $n_1^* = 6$.

Figure 1: The path toward the equilibrium n_1^*, an example with $\beta_i \sim U\,[0,1]$,$\alpha = 1.05$, $\rho = 0.5$,$\sigma = 2.6$



Inequality

With heterogeneity in equilibrium the growth rate of consumption, $g_c(i)$, may differ across groups. We then use its variance, $\sigma^2_{g_C}$, to measure the degree of inequality within the economy:[12]

$$\sigma^2_{g_C} = \frac{1}{n}\sum_{i=1}^{n}\left(g_C(i) - \bar{g}_C\right)^2,$$

where $g_c(i) = \begin{cases} g_K & , i = 1, ..., n_1 \\ \sigma\left(\beta(i) - \rho\right) & , i = n_1 + 1, ..., n \end{cases}$ reports the growth rate of consumption for the groups and $\bar{g}_C = \frac{n_1}{n} g_K + \left(\frac{1}{n}\right)\sum_{j\in G_2}\sigma\left(\beta(j) - \rho\right)$ is the average growth rate of consumption

[12]Within the model we opt for measuring inequality through consumption as it more easily captures difference in income across groups that pass through transfers and production in the informal sector. Moreover, empirically studies based on US data find that income inequality appears to be correlated with consumption inequality , though quantitatively there is no clear consensus (eg. Kreuger and Perri 2006) Vs Aguiar and Bils (2015)).

across all groups. After some manipulation, $\sigma^2_{g_C}$ can also be expressed as follows (cfr. Appendix C)

$$\sigma^2_{g_C} = F\left(\alpha, \bar{\beta}_{G_2}, \sigma^2_{\beta_{G_2}}, n_1\right), \tag{9}$$

where $\bar{\beta}_{G_2}$ and $\sigma^2_{\beta_{G_2}}$ are the average and the variance of the conditional distribution of informal sector productivity of groups in G_2.

Welfare

The welfare of a generic group i is defined as the presented discounted value of present and future utility:

$$W(i) = \int_0^\infty e^{-\rho t} \frac{\sigma}{\sigma - 1} \left(c_t(i)\right)^{1-\frac{1}{\sigma}} dt.$$

Using equilibrium conditions (cfr. Appendix D) we can compute the welfare of a generic group i, which depends on the faction it belongs to:

$$W(i) = \begin{cases} \frac{\sigma}{\sigma-1} \left(pK_0\right)^{1-\frac{1}{\sigma}} \left(\frac{g_K(1-\sigma)}{\sigma} + \rho\right)^{-\frac{1}{\sigma}} & , i \in G_1 \\ \frac{\sigma}{\sigma-1} \left(\beta(i) - g_c(k)\right)^{-\frac{1}{\sigma}} \left[b_0(i) + pK_0\right]^{1-\frac{1}{\sigma}} & , i \in G_2 \end{cases}.$$

Results not surprisingly reflect what already found in (6). Welfare is identical among groups in G_1 as it it depends, similarly to what observed for $g_c(i)$, on g_K and not on the group-specific productivity. Instead, the welfare of each group $i \in G_2$ depends uniquely on the group specific informal sector productivity, $\beta(i)$, and to a higher $\beta(i)$ corresponds a higher welfare. Finally, the welfare of any group $i \in G_2$ is never inferior to that of a group $j \in G_1$: $W_2(i) \geq W_1, \forall i \in G_2$.

To computing the aggregate welfare W we adopt an egalitarian approach and assume that each group has the same weight. Below we report a generic case with n_1 groups in G_1 and $n - n_1$ groups in G_2.

$$W = \sum_{j=1}^{n_1} W_1(j) + \sum_{k=n_1+1}^{n} W_2(k) = \sum_{j=1}^{n_1} \left[\int_0^\infty e^{-\rho t} \frac{\sigma}{\sigma - 1} \left(c_j(t)\right)^{1-\frac{1}{\sigma}} dt\right] + \sum_{k=n_1+1}^{n} \left[\int_0^\infty e^{-\rho t} \frac{\sigma}{\sigma - 1} \left(c_k(t)\right)^{1-\frac{1}{\sigma}} dt\right]$$

3 Technology shocks, voracity and heterogeneous groups

In this section we show how the introduction of heterogeneous groups modifies the voracity effect triggered by a technology shock. Our main result is that with heterogeneity a new adjustment mechanism arises that weakens the perverse effects of voracity, though it is not powerful enough to cancel it out. Theoretically, by relaxing the assumption of homogeneity across groups, we may have equilibria in which groups do not behave identically, that is equilibria where only some groups produce in the informal sector. After a shock, it is then possible that in the new equilibrium the number of groups producing in the informal sector change. This effect could not obviously occur with homogeneous groups. Thus, the voracity effect can now be broken up into two components, that we label as the direct effect and the switching effect. The former corresponds to the standard mechanism originally identified by TL. The switching effect arises with heterogeneous groups and is a second-order growth-enhancing equilibrium mechanism. It is growth-enhancing because it improves growth independently of the kind and the sign of the shock hitting the economy, so that it moderates the perverse economic effects of voracity and makes it asymmetric. It is of second-order because it cannot overcome the direct effect.

After a positive technological shock that increases productivity α the direct effect works as follows. The shock tends to initially boost both output and tax revenues in the legal sector. As extra resources are potentially available to redistribution, group become more voracious and ask for higher transfers. However, as in the legal sector aggregate output is a common good but transfers are group specific, each group does not fully internalize the impact of its increased demand for transfers on growth. It follows that transfers increases proportionally more than productivity α, forcing a rise in the tax rate (τ) to balance the budget. Figure 2 shows the monotonic increasing relationship between α and the tax rate τ: as α increases the tax rate τ that is required to balance the budget tends to increase and approach 1. Actually, the increase in the tax rate is so powerful to overwhelm the initial increase in productivity and the growth rate of both capital and output in the legal sector drops.

With homogenous groups voracity includes the direct effect alone. With heterogeneous groups, however, the drop in growth may trigger a "switching effect": some groups that previously did not produce in the informal sector might now find convenient to do it. That is, at least one group might be willing to switch from G_1 to G_2. In such a case, the switching group(s) would ask for more transfers, and their request is a "credible threat" for the other groups as they are acting optimally. All other groups would then react by reducing their demand for transfers. As a whole, the switching effect causes aggregate transfers to drop, though it is not powerful enough as to cancel out the initial increase in aggregate transfers caused by the direct effect. The switching effect is always beneficial to growth and sets in whenever a shock causes at least one group to switch, be it either from G_1 to G_2 or from G_2 to G_1.

More formally, after a permanent positive technological shock ($\alpha \uparrow : \alpha' > \alpha$) we may decompose voracity into a "direct effect", $\frac{\partial g_K}{\partial \alpha}$, and a "switching effect" $\left(\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial \alpha}\right)$:

$$\underbrace{\frac{dg_K}{d\alpha}}_{voracity\, effect} = \underbrace{\frac{\partial g_K}{\partial \alpha}}_{direct\, effect} + \underbrace{\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial \alpha}}_{switching\, effect} \tag{10}$$

As $g_K = \alpha - \frac{\sum r_i}{pK}$, we may interpret the analysis in terms of aggregate transfers $(\sum r(i))$.[13] Equations (11) to (15) provide analytical expressions of the two effects under the assumption that ω groups switch from G_1 to G_2 after the shock. [14]

$$\frac{\partial g_K}{\partial \alpha} = 1 - \frac{1}{pK}\frac{\partial \sum_{i=1}^{n} r(i)}{\partial \alpha} = \frac{-\sigma}{\sigma(n-1) - n_1^*} < 0 \tag{11}$$

$$\frac{\partial r(i)}{\partial \alpha} = pK \begin{cases} \frac{\sigma}{\sigma(n-1)-n_1^*} > 0 & , i \in G_2 \\ \frac{\sigma - 1}{\sigma(n-1)-n_1^*} > 0 & , i \in G_1 \end{cases} \Rightarrow \frac{\partial \sum r(i)}{\partial \alpha} > 0 \tag{12}$$

$$\frac{d\sum r(i)}{dn_1} = \frac{1}{\sigma(n-1) - n_1^*} \sum_{i=n_1^*+1}^{n_1^*+\omega} \left[\sigma\left(\beta(i) - \rho\right) - g_k(n_1^* + \omega)\right] > 0 \tag{13}$$

$$\frac{dn_1}{d\alpha} \leq 0 \tag{14}$$

$$-\frac{d\sum r(i)}{dn_1}\frac{dn_1}{d\alpha} \geq 0 \tag{15}$$

By the direct effect, an increase in α decreases g_K (11) , because the rise in aggregate transfers overcomes that in productivity$\left(1 - \frac{1}{pK}\frac{\partial \sum r(i)}{\partial \alpha} < 0\right)$. In addition to the direct effect, we may have the switching effect if the drop in g_K induces at least one group to switch between factions, which would imply a change in the equilibrium value of n_1(from $n_1^*$to n_1^{**},$n_1^* < n_1^{**}$). A group will switch only if it is better off by switching , that is if its consumption increase. In this case of positive shock to α only groups in G_1 may increase consumption by switching to G_2. [15] If $i \in G_1$, before the shock it holds $\sigma\left(\beta(j) - \rho\right) < g_K(n_1^*)$, which implies that consumption the group would receive in G_2 $(\sigma\left(\beta(j) - \rho\right))$ is less than that it would receive in G_1 $(g_K(n_1^*))$. As g_K decreases, there might be at least a group $i \in G_1$ that is now better off in G_2 because $\sigma\left(\beta(j) - \rho\right) > g_K(n_1^{**})$. If there is no group who finds it optimal to switch to G_2 then $\frac{\partial n_1}{\partial \alpha} = 0$ and the switching effect is null.

Without loss of generality, we assume that ω groups switch from G_1 to G_2: in the new equilibrium $n_1^{**}\left|\theta' < n_1^* \right|\theta$. By (8) , g_K increases as n_1 moves towards n_1^{**}, that is $g_k(n_1^{**}) > g_k(n_1^* + s), (n_1^{**} - n_1^*) > s > 0$. [16] As a whole, the switching effect increases growth (14).

The switching effect describes a mechanism through which groups take advantage of the fact

[13] $\frac{\partial g_K}{\partial \alpha} = 1 - \frac{1}{pK}\frac{\partial \sum r(i)}{\partial \alpha}$ and $\frac{\partial g_K}{\partial n_1} = -\frac{1}{pK}\frac{\partial \sum r(i)}{\partial n_1}$.

[14] Each variable is implicitly conditional to the new parameter space $\theta' \in \Theta, \theta' = \left\{n, \alpha', \{\beta(i)\}, \sigma, \rho\right\}$.

[15] It happens if $g_K(n_1^* \,|\theta) > \sigma\left(\beta_i - \rho\right) > g_K(n_1^{**} \,|\theta')$. At the same time, no $j \in G_2$ will find it optimal to switch as it remains valid before and after the shock the condition : $\sigma\left(\beta_j - \rho\right) > g_K(n_1^* \,|\theta')$. Indeed, if $j \in G_2$, then before the shock it held $\sigma\left(\beta(j) - \rho\right) > g_K(n_1^*)$, and $j \in G_2$ will switch to G_1 only if after the shock $\sigma\left(\beta(j) - \rho\right) < g_K(n_1^{**})$. As the technological shock ($\alpha \uparrow$) leaves unaffected the left hand term $\sigma\left(\beta(j) - \rho\right)$ but decreases the right hand term g_K(by the direct effect), the inequality is preserved and there is never a switch from G_2 to G_1.

[16] In terms of aggregate transfers, as n_1 decreases also aggregate transfers decrease (13). Indeed, for each of the ω groups it holds $\left[\sigma\left(\beta(i) - \rho\right) - g_k(n_1^* + q)\right] < 0$, $i = n_1^* + 1, ..., n_1^* + \omega$, which implies $-\frac{\partial \sum r(i)}{\partial n_1} < 0$.

that their relative bargaining power in the redistribution of the common resource changes after a shock. Groups whose relative bargaining power increase can credibly demand for higher transfers, and switch between factions in equilibrium. At the same time, however, all other groups whose relative bargaining power is reduced will accordingly decrease their demand for transfers. The net effect is a contraction of the aggregate demand for transfers which reduces taxes and boosts growth.

As heterogeneity is essential for such a mechanism to arise, we find that the assumption of homogeneity might overstate the perverse economic effects of voracity. However, the switching effect can never cancel out the perverse effect of voracity implied by the direct effect. Indeed, for the switching effect to set in a drop in g_K must occur in the first place.[17].

A further characteristic of the switching effect is that it always tends to increase growth, independently of the sign of the technological shock. Indeed, even when α decreases g_K increases because of the switching effect. [18] Thus, while the switching effect reduces the perverse economic impact of the direct effect after a positive technological shock, it instead amplifies it after a negative shock. Thus, voracity gets asymmetric because of the switching effect.

Figure 3 shows the impact of voracity on the equilibrium values of g_K and n_1[19]. In the figure we increase α from the value of 1.1 to 6.5 in four steps. On the vertical axes, we draw the function $g_K(n_1 \,|\alpha)$ that relates growth with n_1, the number of groups in G_1, conditional to a specific value of α. On the horizontal axis we report n_1. In figure 3 we consider four different values of α, and four curves. The black solid line is the highest and corresponds to $g_K(n_1 \,|\alpha)$ with α=1.1; the green solid line is the lowest and corresponds to $g_K(n_1 \,|\alpha)$ with α=6.5. Each curve also reports a solid dot that highlights n_1^*, the number of groups in G_1 in equilibrium for the specific value of α. As α increases from 1.1 to 5.8, $g_K(n_1 \,|\alpha)$ shifts downwards from the black solid line to the blue solid line. At the higher value of α corresponds a lower growth but n_1^* is unaffected, which implies that there is no switching effect. The red dotted line with red arrows illustrate the decreasing path of g_K as α increases. If α increases further from 5.8 to 6.3, $g_K(n_1 \,|\alpha)$ keeps shifting downwards, and we move from the blue solid line to the purple solid line. Again, growth is lower but now n_1^* passes from 6 to 4, that is now a switching effect adds to the direct effect.

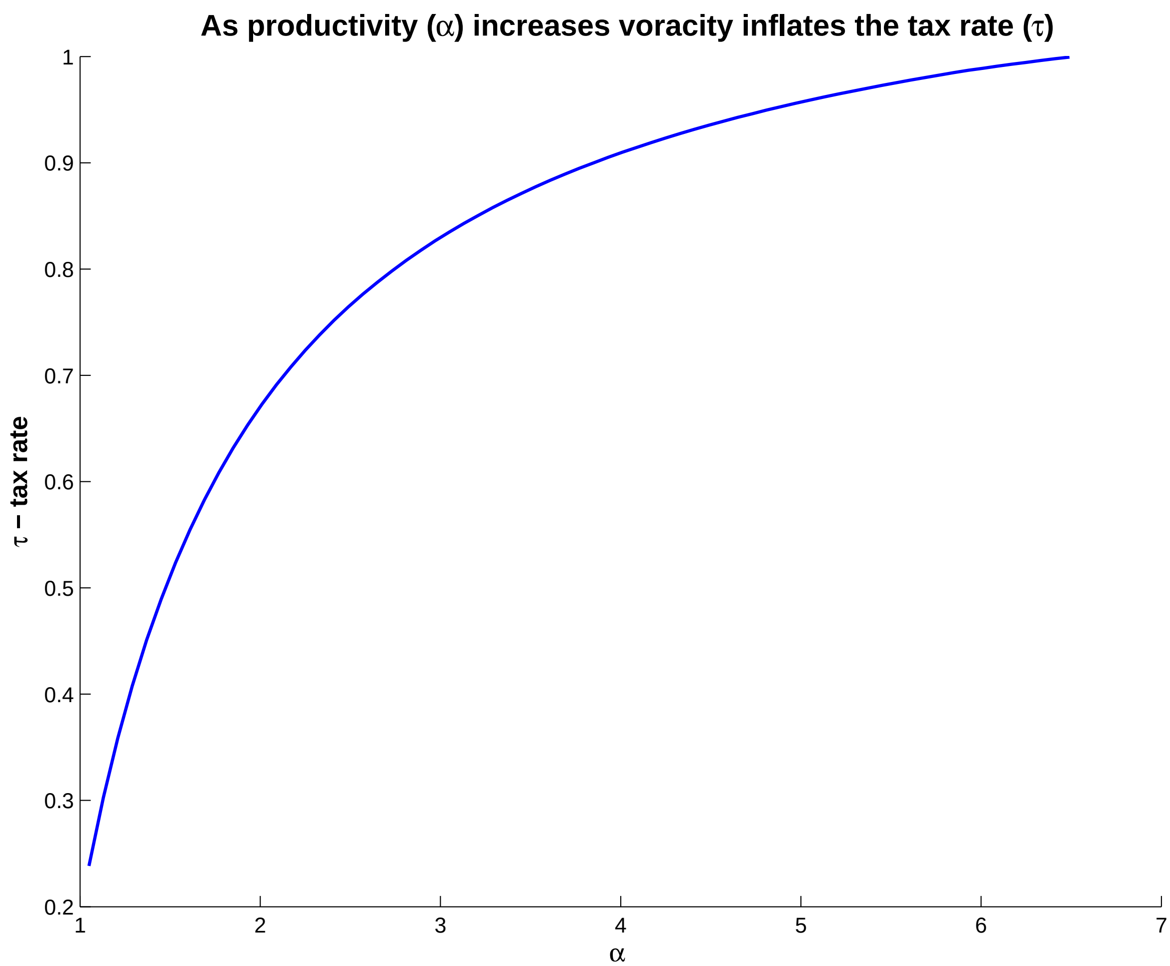
In figure 4 we decompose voracity into the direct and the switching effect for both a positive (right panel) and a negative technological shock to α (left panel). On the vertical axis we draw the function $g_K(n_1 \,|\alpha)$ that relates growth with the number of groups in G_1 conditional to a specific value of α. On the horizontal axis we report n_1. On the right panel the initial equilibrium growth is given by the black solid curve $g_K(n_1 \,|\alpha_{low})$ at $n_1^* = 6$. A positive technology shock then increase α_{low} to α_{high} and we have lower growth in equilibrium, as can be seen by the value of the blue

[17]As the switching effect sets in if $g_K(n_1^* \,|\theta) > \sigma(\beta_i - \rho) > g_K(n_1^{**} \,|\theta')$, the improvement in g_K due to the switching effect cannot be greater than$\sigma(\beta_i - \rho) - g_K(n_1^{**} \,|\theta')$

[18]When α decreases, if $\exists i \in G_2$ who finds optimal to switch to G_1, that is if it holds the condition $g_K\left(n_1^* \middle|\theta'\right) - \sigma(\beta(i) - \rho) > 0$, then the switching effect increases g_K : $\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial \alpha} \propto -\frac{\partial \sum r_i}{\partial n_1}\frac{\partial n_1}{\partial \alpha} > 0$, $\frac{\partial \sum r_i}{\partial n_1} < 0$, $\frac{\partial n_1}{\partial \alpha} > 0$.

[19]Figures 3 and 4 are computed for the same parametrization adopted for figure 1

Figure 2: Voracity and technology: an increase in α forces the tax rate τ to increase



solid curve $g_K(n_1 | \alpha_{high})$ at $n_1^{**} = 4$. The dotted purple line which connects $g_K(n_1 | \alpha_{low})$ and $g_K(n_1 | \alpha_{high})$ both calculated at $n_1^* = 6$ measures the direct effect, with the downwards arrows pointing to the direction of the change in growth. As the increase in α causes a change in the number of groups in G1 in equilibrium, from$n_1^* = 6$ to $n_1^{**} = 4$, we also have the switching effect. It is quantified on the same curve $g_K(n_1 | \alpha_{high})$ as the distance between the value it takes at $n_1^* = 6$, the old equilibrium value, and $n_1^{**} = 4$, the new equilibrium value. Graphically, the switching effect is given by the red dotted line with upwards red arrows that point to the direction of the change in growth. Figure 4 easily shows that voracity is asymmetric: the direct effect increases g_K after a negative shock to α and decreases it after a positive shock to α.

Voracity and inequality The voracity effect caused by technological shocks induces a negative correlation between growth and inequality (cfr appendix D). Intuitively, it happens because voracity does not impact the consumption of groups in G_2, while it reduces that of groups in G_1 that depends on g_K. As before the shocks it holds $g_c(j) > g_c(i), i \in G_1, j \in G_2$, it follows that the gap in (the equilibrium growth rate of) consumption between groups is exacerbated by positive technological shocks. Figure 5 sums up the economic impact of a technological shock to α on growth (top-left panel), inequality (top-right panel), n_1^*, and (the growth rate of) consumption of the groups (bottom-right panel).

Voracity and welfare When voracity is induced by technological shocks, the aggregate welfare moves in the same direction of g_K. More specifically, when the shock increases g_K the welfare of any $i \in G_1$ rises as well, while that of any $j \in G_2$ is unaffected.

4 Policy interventions and the Voracity Effect

4.1 How do policy interventions affect growth?

Governments may attempt to intervene on the activity in the informal sector through specific legislation that impact the groups' incentives to produce in it or, equivalently, the group's bargaining power. Our model can be used to analyze the potential impact of a policy intervention on economic growth (g_K) and inequality (σ^2_{gC}) in the society, in economies plagued by weak institutions. At the same time, we acknowledge two limitations on the use of the model for such purposes. Firstly, our model takes as given $\{\beta(i)\}$, the distribution of bargaining power across groups, and focus exclusively on the economic effects of changes to it. Secondly, we also assume that the government can exogenously modify $\{\beta(i)\}$, so that the model cannot properly does not take into account the complex interplay between groups and the government.

In the model a policy intervention is defined as a modification of the distribution $\{\beta(i)\}$ that,

Figure 3: The voracity effect

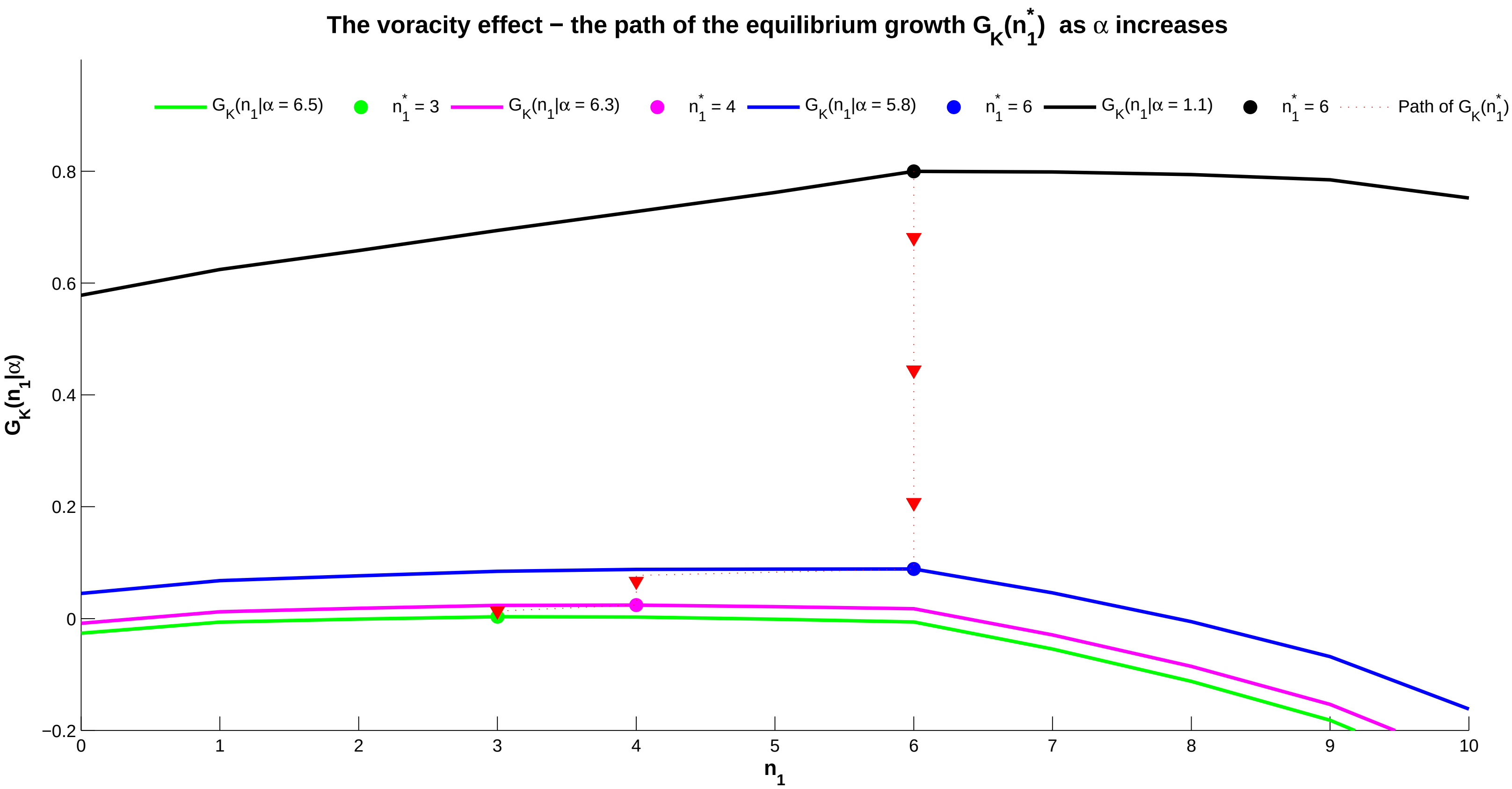


Figure 4: Unraveling the Voracity effect: the direct effect and the switching effect

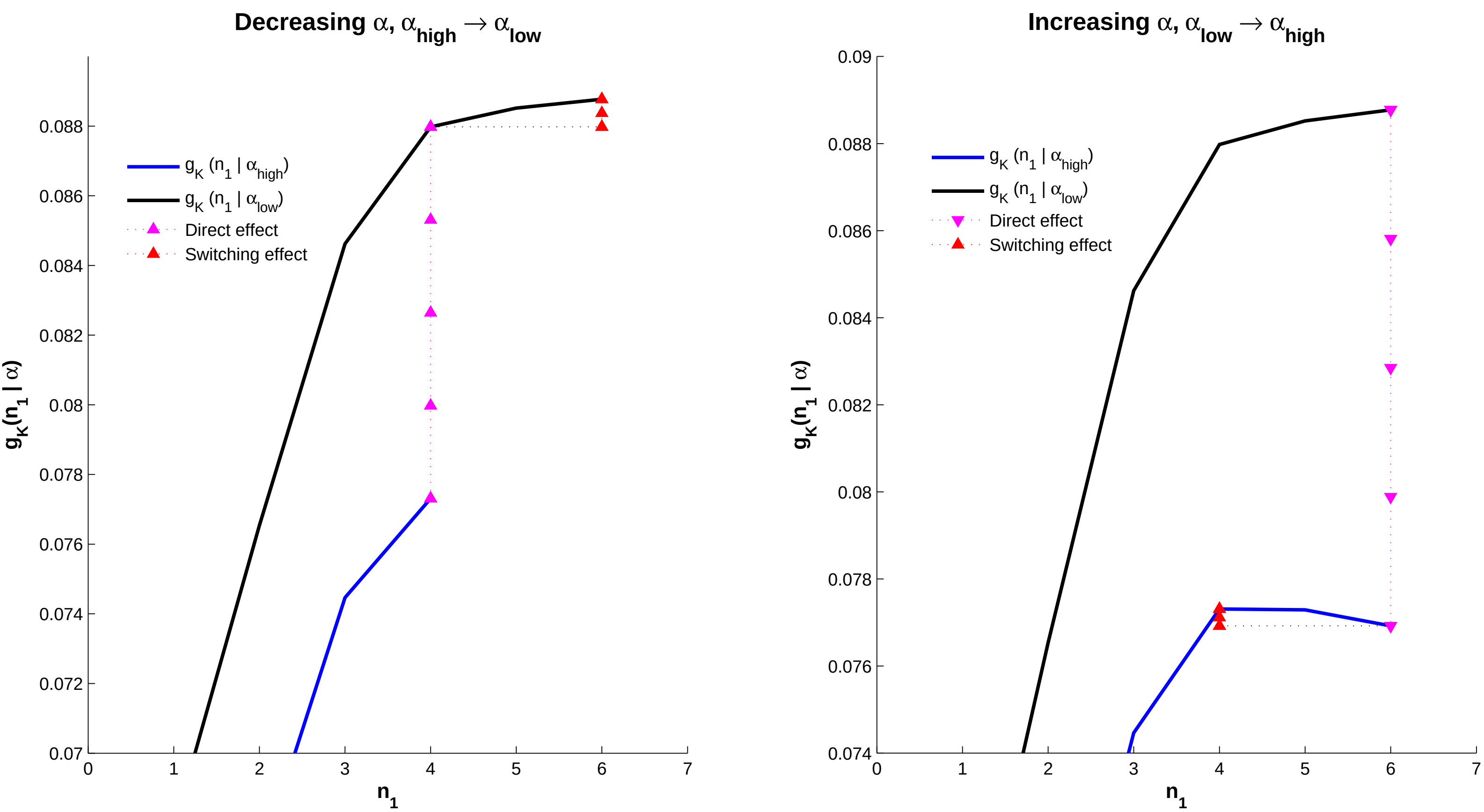
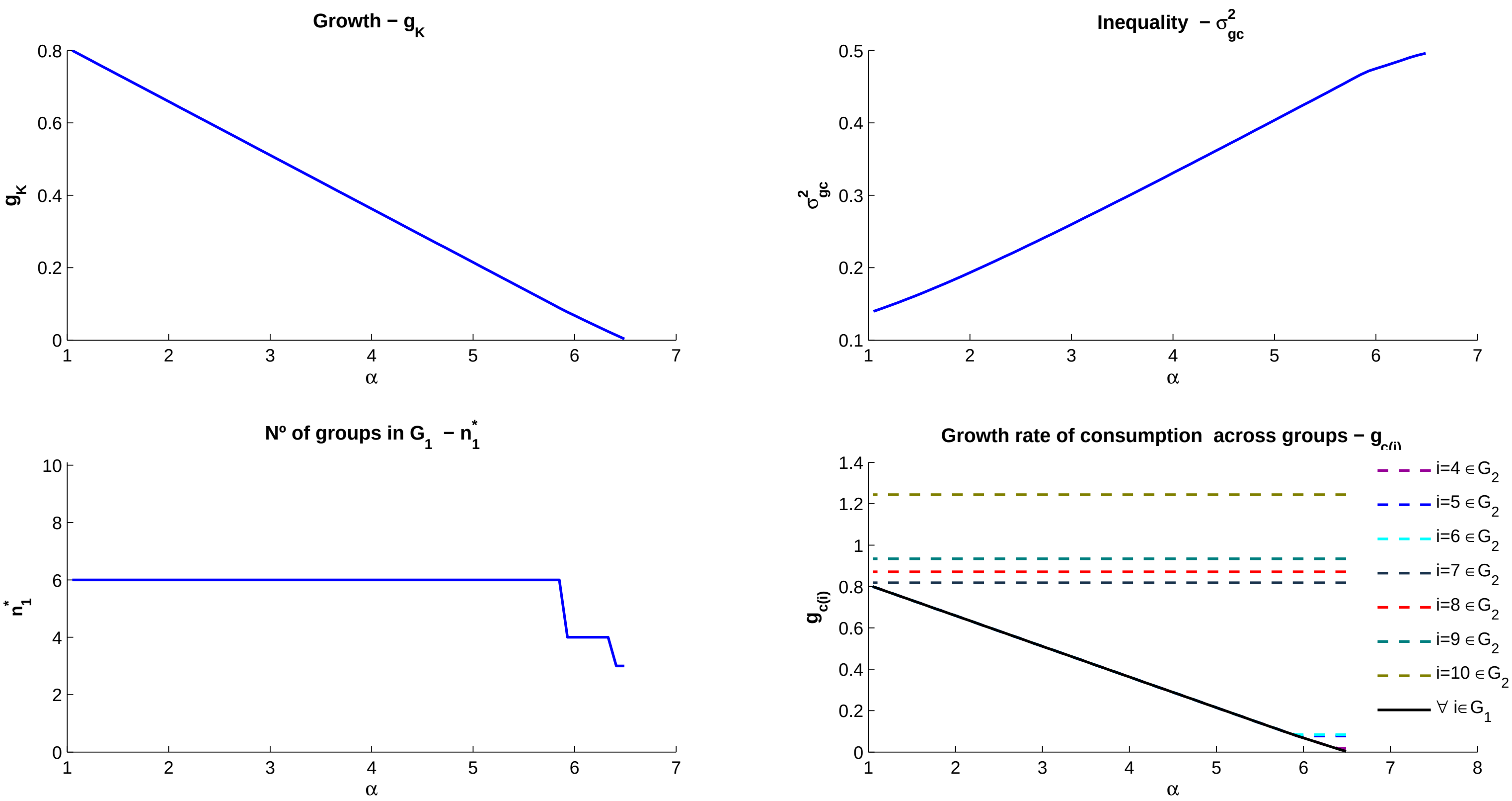


Figure 5: The economic impact of technological shocks .



ceteris paribus, controls the distribution of the bargaining power across groups or, alternatively, the incentive each group has to produce in the informal sector. These interventions, by affecting the groups' rent-seeking behavior can make them more or less voracious. Fore example, they increase growth when they entail a reduction in the aggregate demand for transfers, and vice versa.

In the next subsections we focus on two kinds of policy interventions. The first alters the productivity of a single group, $\beta(i)$. This exercise allows us to understand the basic mechanism through which policy interventions affect growth and inequality and, at the same time, provide us with insights on what would be the effects of more complex policy interventions, which can be thought of as linear combinations of a series of basic ones. Moreover, as usually governments have a limited amount of political capital that can be used for policy interventions , it is realistic to conceive policy interventions with a very narrow scope.

The second policy intervention, instead, considers a pure change in the variance of $\{\beta(i)\}$ while leaving its average unchanged. This policy intervention is of interest because it singles out the importance of modeling heterogeneity. If changes in the variance of $\{\beta(i)\}$ alone had no relevant effects on growth and inequality, we could easily disregard the degree of heterogeneity in the society as not an important and evaluate policy interventions by concentrating on how they affect the average.

4.2 A basic policy intervention

A policy intervention that modifies the informal sector productivity of a single group ($\beta(i)$) is not uncommon. For example, Italy's budget law approved on October 2015 raised the limit on cash transactions and reinstated the possibility of cash payments for rents. Both measures have been criticized as may be seen as fueling the shadow economy. However our model shows that is an economy with weak institutions such a policy may lead to higher growth. The same argument might be put forward for a government that, instead, tries to reduce production in the informal sector and, because of reduced political capital, is able to affect only a single group in the hope to give an example to the others. We might label it as "hit one to educate a hundred" kind of policy intervention.

The intuition is that the overall economic effect of a basic policy intervention is driven by how react the groups that not directly affected. In our experiment group i increases its relative bargaining power at the expenses of all the others. Thus, if the intervention boosts the demand for transfers of group i, it decreases that of all the others. As the latter effect dominates the former, aggregate transfers drop, taxes are reduced and growth increases.

Both the direct effect and the switching effect of this policy boost growth. The switching effect may set in if one or more groups stop producing in the informal sector because of the higher g_K. As observed in the previous section, the switching effect is a second-order growth-enhancing equilibrium mechanism through which the economy exploits heterogeneity to improve its adjustment to shocks.

Given the vector $\{\beta\} = \{\beta(1), ..., \beta(n)\}$, which describes the distribution of productivity in the formal sector across the n groups, we define as policy intervention any government intervention that modifies $\{\beta\}$ into $\left\{\beta^{'}\right\} = \left\{\beta^{'}(1), ..., \beta(^{'}n)\right\}$. Thus the basic policy intervention that increases the productivity of a single group i is defined by $\left\{\beta^{'}\right\} = \left\{\beta(1), ..., \beta^{'}(i)..., \beta(n)\right\}$. This basic policy intervention is beneficial to growth (g_K) only if $i \in G_2$, that is if the group affected is already engaged in the informal sector. To prove it, we first look at the direct effect , which is given by $\frac{\partial g_k}{\partial \beta(i)}$:

$$\frac{\partial g_k}{\partial \beta(i)} = \begin{cases} 1 > \frac{\sigma}{\sigma(n-1)-n_1} > 0 & , i \in G_2 \\ 0 & , i \in G_1 \end{cases}.$$

The direct effect finds the apparently counterintuitive result that increasing the bargaining power of a single group i actually enhances growth, insofar as $i \in G_2$. To understand it we have to look at $\left(\frac{\partial r(j)}{\partial \beta(i)}\right)$, that is at how the demand for transfers $r(i)$ changes when $i \in G_2$:

$$\frac{\partial r(j)}{\partial \beta(i)} = pK \begin{cases} 1 - \frac{\sigma}{\sigma(n-1)-n_1} > 0 & , j = i, j \in G_2 \\ -\frac{\sigma}{\sigma(n-1)-n_1} < 0 & , j \neq i, j \in G_2 \\ -\frac{(\sigma-1)}{\sigma(n-1)-n_1} < 0, & j \neq i, j \in G_1 \end{cases}.$$

The expression above shows that because of its relatively higher bargaining power, group i increases its demand for transfers. However, at the same time the interventions de facto lowers the relative bargaining power of all other groups who then decrease their transfers. Notably, groups inG_2 suffer from a reduction in transfers that is larger than that of groups in G_1. As a whole, aggregate transfers fall, the tax rate ensuring budget balance goes up and growth augments:

$$\frac{\partial\left(\sum_{j=1}^{n} r(j)\right)}{\partial \beta(i)} = pK\left(-\frac{\sigma}{\sigma\,(n-1) - n_1}\right) < 0,$$

$$\frac{\partial\,(g_K)}{\partial \beta(i)} = -\frac{1}{pK}\frac{\partial\left(\sum_{j=1}^{n} r(j)\right)}{\partial \beta(i)} > 0.$$

As the direct effect increases g_K, one or more groups might find optimal to stop producing in the informal sector and switch from G_2 to G_1. In such a case the number of groups producing only in the legal sector would increase, that is $\frac{\partial n_1}{\partial \beta(i)} > 0$, $n_1^{**} > n_1^{*}$, where n_1^{**} is the new equilibrium value for n_1. As observed in section 3, the switching effect would reinforce growth and $\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial \beta(i)} > 0$.

When the policy intervention increases the productivity of a group $i \in G_1$ the direct effect is null. However, the switching effect can still set in if i switches from G_1 to G_2, so that even in

Table 1: The effect on growth of a basic policy intervention

$\beta'(i) > \beta(i)$	Direct effect	Switching effect
$i \in G_1$	0	$\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial \beta(i)} \geq 0$
$i \in G_2$	$\frac{\partial g_K}{\partial \beta(i)} > 0$	$\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial \beta(i)} > 0$

this case growth would increase. [20] Table 1 sums up the different cases through which this policy intervention impacts growth.

Our results warn against possible counterproductive results from policy interventions that aim to reduce the size of the informal sector. Indeed, by decreasing group's i bargaining power, all other groups would become more voracious to get hold of the resources left by the weaker group i. Even if group i actually reduces its transfers, all other groups would increase theirs. The final effect is that the aggregate transfers increase, taxes augment and growth drops.

The impact of this policy intervention on inequality is ambiguous. Indeed, by increasing the productivity of the group i the average $\bar{\beta}' = \bar{\beta} + \frac{1}{n}\sum \beta(i)$ of $\left\{\beta'\right\}$ is by construction higher than the average $\bar{\beta}$ in $\{\beta\}$. However, the variance $\sigma^2_{\beta'}$ of $\left\{\beta'\right\}$ may be either higher or lower than the variance σ^2_{β} of $\{\beta(i)\}$. [21] Thus, it is not possible to establish an unambiguous relationship between growth and inequality.

Finally, we can consider the welfare effects of the basic policy intervention. As we show in appendix ??, any policy intervention that increases g_K increases the welfare of any group $i \in G_1$, and any policy intervention that increases $\beta(j)$, $j \in G_2$ impact positively $W_2(j)$. Intuitively, if a policy intervention increases the consumption of a group it also increases its welfare. By (6) the growth rate of consumption of groups in G_1 is equal to g_K in equilibrium, and that of $j \in G_2$ is proportional to $\beta(j)$. Table 1 shows that a basic policy reform that increases a single group ($\beta(i)$) may not decrease aggregate welfare, which will surely increase either directly via $\beta(j)$, $j \in G_2$ or indirectly via g_K.

4.3 Polarizing Policy interventions

In this section we consider policy interventions that affect σ^2_{β}, the volatility of $\{\beta(i)\}$, but not its average $\bar{\beta}$. The purpose of this experiment is twofold: firstly, by modifying only the volatility

[20] This happens when: $g_K(n_1^* | \theta) > \sigma(\beta_i - \rho)$ and $g_K(n_1^* \left| \theta' \right.) < \sigma\left(\beta_i' - \rho\right)$. In the new equilibrium $n_1^{**} < n_1^*$, or $\frac{\partial n_1}{\partial\{\beta_i\}} < 0$, g_K is decreasing in n_1 $\left(\frac{\partial g_K}{\partial n_1} < 0\right)$, and $\frac{\partial g_K}{\partial n_1}\frac{\partial n_1}{\partial\{\beta_i\}} > 0$.

[21] For increases in β_j small enough ($d\beta_i$ going towards 0), $\frac{d\sigma^2_{\beta}}{d\beta(i)} \propto \left(\beta(i) - \bar{\beta}\right)$: σ^2_{β} increases if $\beta(i) > \bar{\beta}$, and vice avers. For non infinitesimal changes in $\beta(i)$, $\frac{d\sigma^2_{\beta}}{d\beta(i)} = d\beta_j\left(\frac{1}{n^2} + \left(\frac{n-1}{n}\right)^2\right) + 2\left(\frac{n-2}{n}\right)\left(\beta(i) - \bar{\beta}\right)$: σ^2_{β} increases even when $\beta_i < \bar{\beta}$ if the size of the increase, $d\beta_j$, is large enough.

of $\{\beta(i)\}$ we single out the economic relevance of heterogeneous groups; secondly, it allows us to analyze the relationship between inequality and growth. More formally, this policy induces a new distribution $\{\beta'(i)\}$, where $\forall i\ \beta'(i) - \bar{\beta} = (1+c)\left(\beta(i) - \bar{\beta}\right),\ c > 0$. The average of the new distribution $\{\beta'(i)\}$ is unaffected, $\bar{\beta}' = \bar{\beta}$[22]; the variance increases, $\sigma^2_{\beta'} > \sigma^2_{\beta}$,$\sigma^2_{\beta'} = (1+c)^2\sigma^2_{\beta}$.[23]

If we implement a intervention that increases σ^2_{β}, we would observe that any group i whose productivity was initially greater than the average $\left(\beta(i) > \bar{\beta}\right)$ becomes more productive, while any group j whose productivity was initially below the average $\left(\beta(j) < \bar{\beta}\right)$ becomes less productive. Thus, after the intervention the economy gets more polarized as groups tend to end up with either a very high or a very low bargaining power.

We find that a polarizing intervention boosts growth and is most likely to increase inequality by tilting most of the benefit of the intervention to the groups that produce in the informal sector. The intuition for the increase in growth is similar to what already observed about basic policy interventions. The groups whose productivity is below the average are predominantly in G_1 and they would not modify their behavior for a lower bargaining power. On the contrary, the groups whose productivity increases are predominantly in G_2, and they would each increase their demand for transfers. However, at the same time each group reacts to an increase in the demand for transfers by others by reducing its own demand. In the end, it is the latter effect that predominates, so that aggregate transfers diminish, reducing taxes and boosting growth. Formally, the direct effect of a polarizing policy intervention is:

$$\frac{\partial g_K}{\partial\{\beta\}} = -\frac{\partial\sum r(i)}{\partial\{\beta\}} = \frac{\sigma c\left((n-n_1)\left(\bar{\beta}_{G_2} - \bar{\beta}\right)\right)}{\sigma(n-1) - n_1} > 0.$$

The switching effect would then add to the direct effect and increase growth further.

A polarizing intervention by construction augments $\bar{\beta}_{G_2}$ and $\sigma^2_{\beta_{G_2}}$, which both can be shown to increase inequality $\sigma^2_{g_C}$(cfr. appendix C). Intuitively, an increase in $\bar{\beta}_{G_2}$, ceteris paribus, increases on average the equilibrium growth rate of consumption only of groups in G_2, while that of groups in G_1 is unaffected. Accordingly, inequality increases. Similarly, an increase in $\sigma^2_{\beta_{G_2}}$increases , ceteris paribus, inequality among groups in G2, which then translates to inequality in the all economy. The only uncertainty comes from the eventual change in n_1, whose effect on $\sigma^2_{g_C}$ is ambiguous. However, insofar as changes in n_1 are driven by the switching effect, which is of second order, inequality is most likely to increase for most parametrizations. [24]

Figure 6 shows the economic effects of a polarizing intervention for the parametrization specified

[22]as $\sum\beta' = \sum\left[(1+c)\left(\beta - \bar{\beta}\right) - +\bar{\beta}\right] = \sum\beta + c\sum\left(\beta - \bar{\beta}\right) = \sum\beta$, as $\sum\left(\beta - \bar{\beta}\right) = 0$,

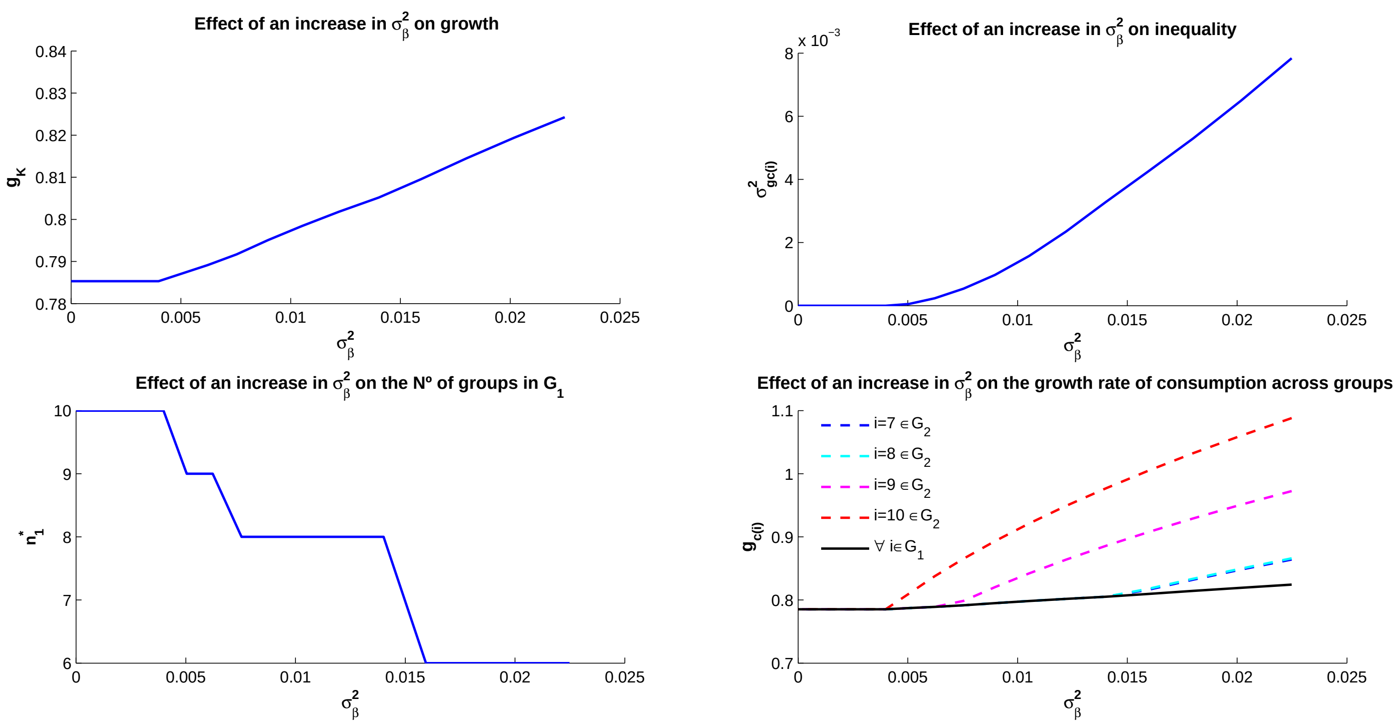
[23]Implicitly, it exists a $\bar{c} = \frac{\alpha - \beta(n)}{(\beta(n) - \bar{\beta})}$ beyond which the assumption $\alpha > \beta(n)$ would be violated. Thus, we constrain $c < \bar{c}$.

[24]For example, inequality increases when it is implemented on an initial equilibrium with all groups in G_2 $(n_1 = 0)$ and no switching effect. In such a case $Var\left(g_c^{'}(i)\right) = (1+c)^2\,Var\left(g_c(i)\right)$. If, instead, the initial equilibrium is one in which all groups are in G_1, $n_1 = n$, this policy either increases inequality or leaves it unchanged.

in section 2. We observe that a higher degree of heterogeneity increases both growth (top-left panel) and inequality (top-right panel), while it tends to decrease n_1 (bottom-left panel). In this example, polarizing interventions increase the aggregate welfare as well as the welfare of any group. By boosting g_K, the welfare of any group $i \in G_1$ increases. By increasing $\beta(j)$, $\forall j \in G_2$, the welfare of any j increases as well. [25] However, the increase of inequality underlines that the benefits of the intervention in terms of welfare and consumption are mostly reaped by high-β groups (bottom-right panel).

[25] In general, it is always true that a polarizing policy increases the welfare of groups in G_1. However, the welfare of a group $i \in G_2$ will increases only if $\beta(j) > \bar{\beta}$

Figure 6: **Figure - The economic impact of polarizing policy interventions**



5 Empirical evidence

In this section we provide suggestive evidence of the presence of voracity among advanced countries. We first classify 21 OECD countries into clusters on the basis of different measures of quality of institutions. We next perform a panel estimation to detect if countries in the cluster with weaker institutions are more likely to show sign of procyclical public spending, which is considered a well-known sign of voracity (Alesina et al. 2008).

5.1 Do advanced economies have weak institutions?

Weak institutions are the inner source of the voracity effect. However, it would be misleading to think of voracity as operating exclusively in developing economies. The fight over redistribution that give rise to voracity is essentially non-violent in nature and requires well established statistical and budgetary institutions that are actually more likely to be found in developed countries.

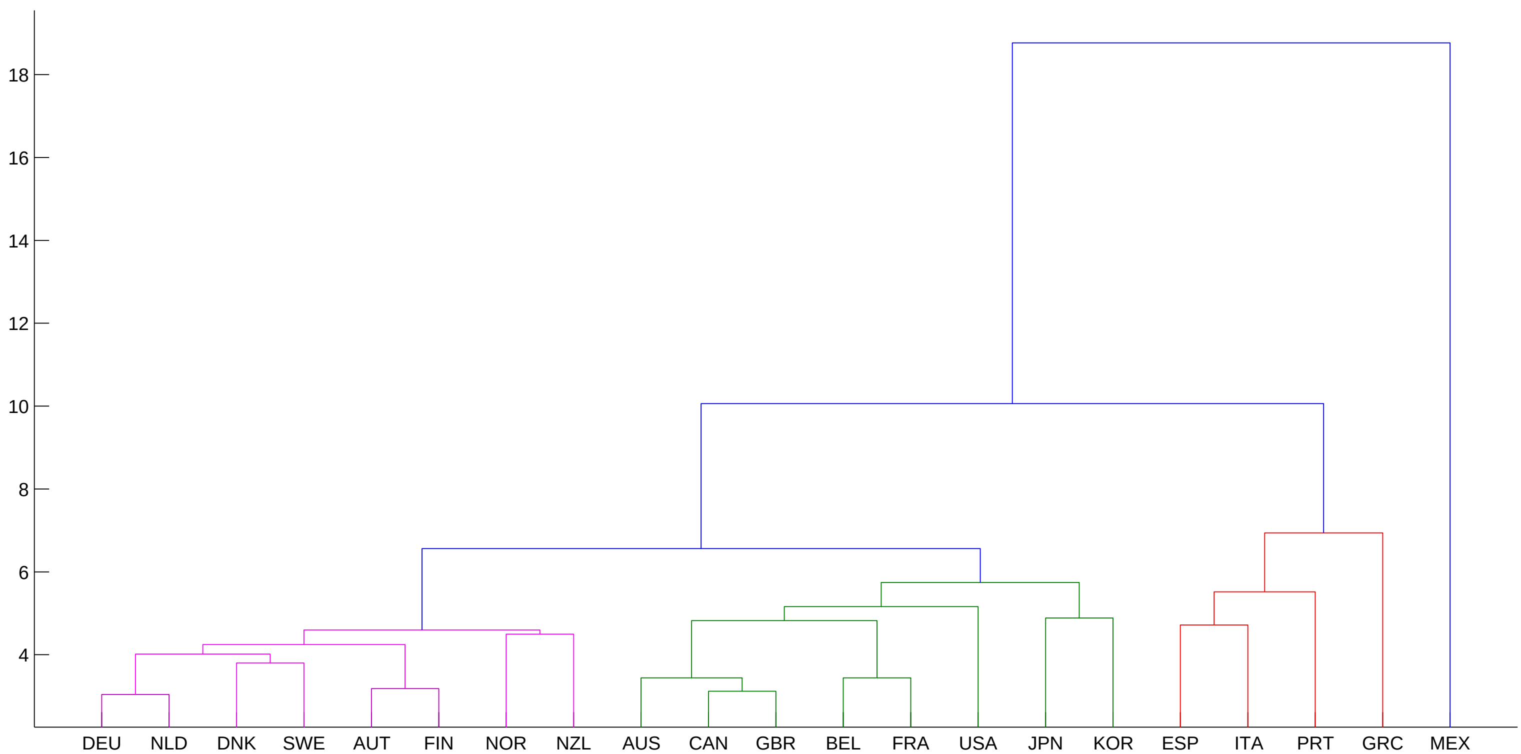
To provide some evidence of the presence of weak institutions among developed economies we take into account 21 OECD countries and three different measures of quality of institutions: the 2015 Rule of Law Index by the World Justice Program; the Rule of Law Index by the World Bank over the period 1996-2013; the size of the shadow economy estimated by Schneider et al (2010) over the period 1999-2007. [26] [27] Measuring institutional quality is a complex task fraught with uncertainty, so we opt for considering three measures each computed with a different methodology and developed by a different institutions. We use these measures to perform a hierarchical cluster analysis as to find how similar, or how distant, advanced countries are in terms of quality of institutions. Results are reported in the dendrogramme in figure 7.

Three different clusters stand out: the first one (in purple) includes the countries of the so-called core of the European Union (Germany, Austria and the Netherlands), the four Scandinavian countries and New Zealand; the second cluster (in green) consists of the USA, three Commonwealth countries (UK, Canada and Australia), France, Belgium, and two Asian countries (Japon and Korea); the third cluster (in red) is composed of four Southern Europe countries (Italy, Spain, Portugal and Greece). Finally, Mexico stands alone as a clear outlier. In the dendrogramme, each pair of objects, in our case countries or group of countries, is connected by an upside-down u-shaped line.

[26] The 2015 rule of law index by the World Justice Program covers 54 subfactors and 102 countries. It can be downloaded at http://worldjusticeproject.org/rule-of-law-index. The World Bank's "Rule of Law" index captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Data are available at http://databank.worldbank.org/data/reports.aspx?source=worldwide-governance-indicators# The estimates of the size of the shadow economy are taken from Schneider et al (2010) https://openknowledge.worldbank.org/bitstream/handle/10986/3928/WPS5356.pdf?sequence=1

[27] The countries are: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Germany (DEU), Denmark (DNK), Spain (ESP), Finland (FIN), France (FRA), Great Britain (GBR), Greece (GRC), Italy (ITA), Japon (JPN), South Korea (KOR), Mexico (MEX), Netherland (NLD), Norway (NOR), New Zealand (NZL), Portugal (PRT), Sweden (SWE) and United States (USA).

Figure 7: OECD countries are very diverse as to the level of rule of law



The height of this link measures the distance between the two objects.

The cluster analysis clearly highlights sharp differences across OECD countries as to the quality of institutions, with countries in the third cluster being most likely those with the weakest institutions. In figure 7 we compare the economic performance of OECD countries over the period 2000-2014 (GDP per capita growth rate, annual average, source IMF). It is suggestive, though admittedly not conclusive, that the countries in the third cluster tend to record the worse growth performance.

5.2 Procyclical public spending among OECD countries

We check if a specific form of voracity, procyclical public spending, is at work among advanced countries. We consider 21 high income OECD countries and group them following previous results from the clusters analysis. Cluster 1 includes eight countries: Germany, Netherlands, Denmark, Sweden, Austria, Finland, Switzerland and New Zealand. Cluster 2 includes nine countries: Australia, UK, USA, Japan, Korea, Belgium, France, Canada and Ireland. Cluster 3 includes four countries: Spain, Italy, Greece and Portugal. [28]To estimate the degree of cyclicality of public spending within a cluster we estimate the following equation:

$$g_{it}^{c} = \beta^{c} y_{it}^{c} + u_{it}^{c} \tag{16}$$

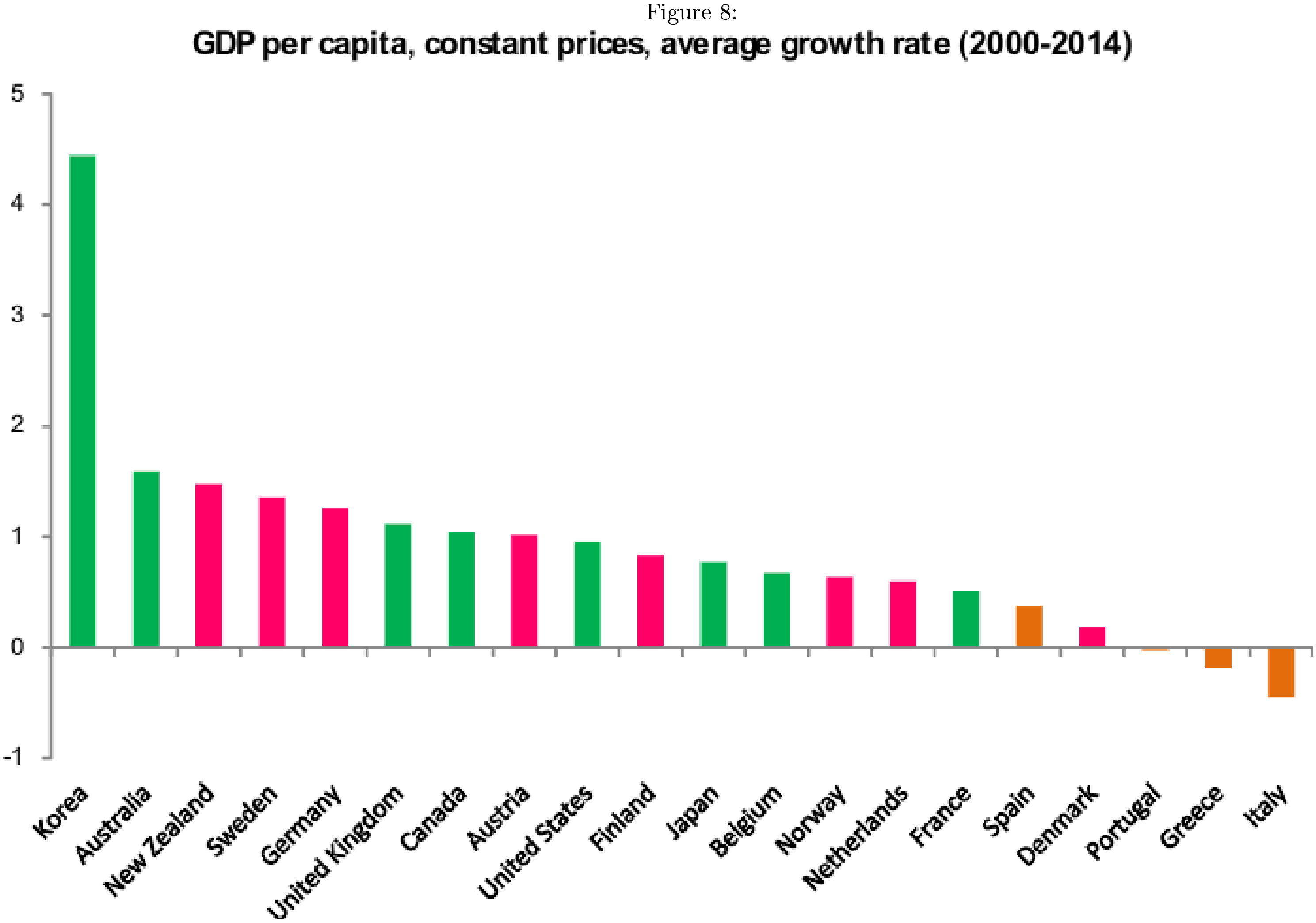
where g_{it}^{c} and y_{it}^{c} are, respectively, the growth rate of public spending and the GDP growth rate at time t of country i , and country i belongs to cluster c. Data are annual and range in the interval 1980-2011. Both g and y are transformed into real terms by dividing the current value in national currency by the GDP deflator. All data are from the OECD Economic Outlook 2011. Our object of interest is the coefficient β, which captures the degree of cyclicality of public spending. On the ground that the average growth rate of public spending should be zero when GDP growth is zero, we impose the constant to be zero. It is well known that in measuring the cyclical response of spending it must be taken into account the endogeneity of output to changes in the budget. Several instruments have been proposed to overcome the problem of endogeneity, leading to mixed evidence on the sign of the cyclical response. We take into account the most important instruments proposed by the literature.

An identification method robust to the presence of weak instruments has not yet been developed for panel IV estimators. We then resort to a two-step procedure. In its first stage, we compute the (HAC robust) LM test for weak instruments by Kleibergen and Paap (2006).[29] In the second

[28]Because of data availability, there are 2 differences with respect to the country classification emerging from the cluster analysis. In group 1 Norway is replaced by Switzerland, while in group 2 we add Ireland. Norway is excluded from this analysis because of data availability. Switzerland and Ireland were excluded from the cluster analysis because they were not covered by all measures of the quality of institutions. However, cluster analysis based on a reduced number of measures associated Norway to the first cluster and Ireland to the second cluster.

[29]The null hypothesis is that the true significance level of hypothesis tests is below 10%, 15%, 20% or 25% when

Figure 8:



GDP per capita, constant prices, average growth rate (2000-2014)
5
4
3
2
1
0
-1
Korea
Australia
New Zealand
Sweden
Germany
United Kingdom
Canada
Austria
United States
Finland
Japan
Belgium
Norway
Netherlands
France
Spain
Denmark
Portugal
Greece
Italy

stage we report a continuous updating estimator (CUE) of β that is a GMM-like HAC robust version of a LIML estimator. CUE usually provides more reliable point estimates and inferences with weak instruments than GMM or LIML (Hansen et al 1996). To identify the effect of the cycle on public spending we consider instruments that follow different rationales. Firstly, two "lags" of GDP (eg. Gali and Perotti 2001). Secondly, four instruments related to external economic events: the growth rate of a reference economy (growth G7), the "ETR" external trade shock (Jaimovich and Panizza 2007), the "US Fed funds" rate multiplied by a measure of domestic capital account openness (Ilzetski and Vegh 2008), and a commodity price index. As a final instrument, we propose a new instrument based on development "aid flows" (Claeys and Maravalle 2015).[30]

We first use each instrument individually not to fall in the trap of many instruments and not to exacerbate weak identification problem that would arise by considering several instruments that share the same underlying rationale (Murray 2006). In table 1 we report results for instruments that did not reject the null of hypothesis of being weak according to the KP LM test. Table 1 reports the following models : model (1) is a pooled OLS, models (2) to (4) are panel estimations with fixed effect using a single instrumental variable, respectively "time lags", "Growth G7" and "ETS"; model (5) consider the former three instruments all together, that is : "lags", "Growth G7", "ETS". Models including "US Fed Funds Rate" and a commodity price index are not reported as the hypothesis of being weak cannot be rejected. Model (6) is a panel estimation using "aids flows" as the single instrumental variable and model (7) includes all not weak instrumental variables. Each model is estimated separately for each of the three clusters of countries specified above.

Each column of table 2 refers to a different model and shows the estimate of β (first row), its t-statistics in brackets (second row), the sample size (third row), the KP LM test (fourth row row) and the p-value of the J-statistic (fifth row).

Consistently across models, cluster 3 tends to have the highest estimate of β, it is usually positive and statistically significant in model (2) and (6). This suggest that countries in cluster 3 engaged in procyclical public spending. In cluster 1, instead, public spending has almost always a negative sign, though it is statistically significant only in model (5) and (7). This suggests that these countries in cluster 1 have followed a countercyclical fiscal policy. Finally, evidence is mixed for cluster 2, as the sign of β is negative and statistically significant in model (5) , while positive and statistically significant in model (2).

the nominal value is 5%. These critical values change with the number of endogenous variables and the number of instruments.

[30] As development aid is mostly determined by a country's particular political and economic link to target countries, there is sufficient idiosyncratic variation in aid flows

Table 2

Test of cyclical public spending, cluster 1 (8 countries)

	(1) Pooled OLS	(2) Lags	(3) Growth G7	(4) ETS	(5) All but aids	(6) Aid Flows	(7) All
GDP Growth	0.66***	-0.00725	-0.140	-0.270	-0.25*	0.365	-0.21*
	(7.61)	(-0.03)	(-0.78)	(-1.34)	(-1.71)	(1.56)	(-1.5)
N	291	280	291	216	216	283	216
KP LM Test	na	8.9	90	20	24.4	22.7	27.5
Hansen J-statistic	na	0.03	na	na	0.21	na	0.19

Test of cyclical public spending, cluster 2 (9 countries)

	(1) Pooled OLS	(2) Lags	(3) Growth G7	(4) ETS	(5) All but aids	(6) Aid Flows	(7) All
GDP Growth	0.844***	0.937**	-0.305	-0.199	-0.24**	0.224	-0.16
	(12.90)	(2.78)	(-1.95)	(-1.34)	(-2.0)	(1.27)	(-1.5)
N	349	331	349	251	249	324	243
KP LM Test	na	11.6	214	115	38.7	57.6	61.7
Hansen J-statistic	na	0.04	na	na	0.35	na	0.4

Test of cyclical public spending, cluster 3 (4 countries)

	(1) Pooled OLS	(2) Lags	(3) Growth G7	(4) ETS	(5) All but aids	(6) Aid Flows	(7) All
GDP Growth	1.020***	0.766**	0.300	-0.00414	0.13	0.949**	0.26
	(8.49)	(2.64)	(1.01)	(-0.02)	(0.58)	(2.67)	(1.17)
N	132	126	132	101	99	101	85
KP LM Test	na	16.5	56	42.4	76.5	14.7	61.2
Hansen J-statistic	na	0.01	na	na	0.33	na	0.08

t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$ .Stock-Yogo critical values of the maximal LILM size for the KP LM test:
1 instruments (columns (3) to (6)) : 16,38 (10%), 8.96 (15%), 6.66 (20%), 5.53 (25%) ; 2 instruments (column (2)): 8.68 (10%), 5.33 (15%), 4 instruments (Column (7)) : 5.44 (10%), 3.87 (15%), 3.3 (20%), 2.58 (25%).

6 Conclusion

In this article we investigate the impact on growth and inequality of assuming, in an otherwise standard model with voracity à la TL, that groups have different bargaining power when competing over the redistribution of a common resource (tax revenues). In this two-sector model, where the legal sector is subject to taxation while the informal sector is tax-exempted, for each group the marginal benefit of an additional unit of fiscal transfers is fully private, while the marginal cost (extra taxation) is shared among all groups. TL show that in such an economy, favorable economic shocks may end up damaging growth. This happens because these shocks, by increasing the size of the common resource, induce the groups to increase disproportionally their demand for fiscal transfers (they become more voracious), which in turn requires an increase in the tax rates that stifles growth.

We allow for heterogeneity in their relative bargaining power across groups or, alternatively, in the relative incentive to produce in the informal sector. We take the distribution as exogenous, and analyze what are the effects of changes in such distribution on growth and inequality. Heterogeneity also allows us to analyze inequality.

We find that heterogeneity moderates the perverse economic effect of voracity on growth, though it can never eliminates it, as it reveals the presence of a second-order adjustment mechanism that we label as the switching effect. The switching effect is an adjustment mechanism in the economy that take advantage of heterogeneity and may arise after a shock that modifies the distribution of the relative bargaining power among groups. As some groups may credibly demand for higher transfers, all the others, by perceiving that their negotiation power is relatively lower, decrease their transfers. The net effect is that the aggregate transfers drop, allowing taxes to be reduced and growth to increase.

We also characterize the nature of voracity and show that only shocks that modify technology in either of the two sectors, i.e. modify the size of the common resource or the relative distribution of the bargaining power across groups, may provoke voracity. We then exclude terms of trade shocks from the possible sources of voracity.

We find that the shocks that provoke voracity may establish different relationship between growth and inequality. Our model predicts that shocks to the technology in the legal sector induce a negative correlation between growth and inequality and low consumption groups suffer the most from lower growth. On the other hand, policy interventions need to be exactly specified to establish a clear relationship between growth and inequality. We propose a specific kind of intervention that we label as polarizing to show a intervention that redistributes the benefits mainly to high consumption groups and so increase both growth and inequality.

Our model is then very flexible tool to analyze the impact of specific policy interventions on growth and inequality in economies plagued by weak institutions. Finally, we adopt a cluster analysis to provide empirical evidence of the presence of weak institutions among developed OECD countries, and estimate a panel data to provide some suggestive evidence that voracity is present among OECD countries with the weakest institutions.

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APPENDIX A

In this appendix we show that if groups share the same technology in the formal sector they are indifferent between maximizing with respect to aggregate capital stock K or individual capital stock $k(i)$.

Let's initially assume that groups may differ in their level of productivity in both sectors: Equations (A.1) and (A.2) reproduce, respectively, the law of motion of capital in the legal and the informal sector:

$$\dot{k}(i) = \alpha(i)k(i) - T(i) \tag{A.1}$$

$$\dot{b}(i) = \beta(i)b(i) + r(i) - c(i) \tag{A.2}$$

Without loss of generality, we assume that $\alpha(i+1) > \alpha(i) > \alpha(1) > \beta(i+1) > \beta(i) > 0$, $\forall i = 1, ..., n-1$. The subjective discount rate is $e^{-\rho t}$, $1 > \rho > 0$. Fiscal policy is budget balanced: $p\sum_{i=1}^{n} T(i) = \sum_i r(i)$, where $T(i)$ and $r(i)$ are, respectively, the tax paid and the transfers received by a generic group i. $T(i)$ are a fixed proportion (τ) of a group's output in the legal sector: $T(i) = \tau\alpha(i)k(i)$.

The only difference with the model in the main text is that equation (A.1) replaces $\dot{K} = \alpha K - T$. We can define $\alpha = \frac{\sum_{i=1}^{n}\alpha(i)k(i)}{K}$, $K = \sum_{i=1}^{n} k(i)$, and reformulate the the expressions in term of growth rates: $g_K(i) = \frac{\dot{k}(i)}{k(i)}$ and $g_K = \frac{\dot{K}(i)}{K(i)}$. Thus, a sufficient condition for each group to be indifferent between maximizing with respect to individual or aggregate capital is that $g_K(i) = g_K$, which occurs when the growth rate of the relative share of capital is 0. It is easy to show that such a sufficient conditions is satisfied when either $\alpha(i) = \alpha$ or $\tau = 1$. To see it , let's consider

$$g_{\frac{k(i)}{K}} = \frac{\dot{\left(\frac{k(i)}{K}\right)}}{\left(\frac{k_i}{K}\right)} = \left(\frac{k\dot{(i)}}{k_i}\right) - \frac{\dot{K}}{K}$$

Starting from $\dot{k}(i) = \alpha(i)k(i) - \frac{\alpha(i)k(i)}{\sum_j \alpha(j)k(j)}\frac{\sum_j r(j)}{p}$ and $\dot{K} = \sum_j \alpha(j)k(j) - \frac{\sum_j r(j)}{p}$, after some manipulation we obtain:

$$g_{\frac{k(i)}{K}} = \alpha(i) - \frac{\alpha(i)}{\sum_j \alpha(j)k(j)}\frac{\sum_j r_j}{p} - \sum_i \alpha(i)\frac{k(i)}{K} + \frac{\sum_j r(j)}{pK}.$$

It is then easy to verify that sufficient conditions for $g_{\frac{k(i)}{K}} = 0$ are

$$\tau = \frac{\sum_j r(j)}{p}\frac{1}{\sum_j \alpha(j)k(j)} = \frac{\sum_j \alpha(j)k(j)}{\sum_j \alpha(j)k(j)} = 1 \tag{A.3}$$

and

$$\alpha(i) - \sum_j \alpha(j)\frac{k(j)}{K} = \frac{\sum_j r(j)}{p}\left(\frac{1}{K} - \frac{\alpha(i)}{\sum_j \alpha(j)k(j)}\right) = 0 \tag{A.4}$$

Both conditions in (A.4) are fulfilled when $\alpha(i)\sum_j k(j) = \sum_j \alpha(j)k(j)$, which has a nontrivial solution ($K \neq 0$) for $\alpha(j) = \alpha(i) = \alpha$.

APPENDIX B - Equilibrium conditions

In equilibrium we have j groups in G_1, $j = 1, ..., n_1$, and w groups in G_2, $w = n_1 + 1, ..., n$, with $n_1 \in \{0, ..., n\}$. A generic group i chooses the path of consumption, $c(i)$, transfers, $r(i)$, aggregate stock of capital in the legal sector, K, and individual stock of capital in the informal sector, $b(i)$, to maximize the present discounted value of the flow of instantaneous utility $U(i) = \frac{\sigma}{\sigma-1}c(i)^{1-\frac{1}{\sigma}}$, where $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution and $e^{-\rho}$ is the discount factor, $1 > \rho > 0$. Utility maximization is subject to the following constraints:

- Non-negative constraints to capital in the two sectors ($K \geq 0, b(i) \geq 0$)
- The law of motion of capital in the legal sector, $\dot{K} = \alpha K - T(i)$,
- the law of motion of capital in the informal sector: $\dot{b}(i) = \beta(i)b(i) + r(i) - c(i)$.
- Also, an exogenous upper bound $\bar{x}$ on the level of transfers that each group can receive: $r(i) < p\bar{x}\alpha K$.

Moreover, the following transversality conditions have to be taken into account:

- $lim_{t\to\infty} e^{-\rho t}\lambda_i(t)K^*(t) = 0$
- $lim_{t\to\infty} e^{-\rho t}\mu_i(t)b_i^*(t) = 0$

It follows that the Lagrangian looks as follows:

$$L = \frac{\sigma}{\sigma-1}c(i)^{1-\frac{1}{\sigma}} + \lambda(i)\left[\alpha K - \frac{\sum_j r_j}{p}\right] + \mu(i)\left[\beta(i)b(i) + r(i) - c(i)\right] + \xi(i)\left[p\bar{x}\alpha K - r(i)\right] + \gamma(i)b(i) + \varphi(i)K$$

We obtain the first order conditions for a generic group i from solving $\underset{\{c(i),r(i),K,b(i)\}}{Max} L$

- $[c(i)]$: $c(i)^{-\frac{1}{\sigma}} = \mu(i) \rightarrow g_c(i) = \frac{\dot{c(i)}}{c(i)} = -\sigma\frac{\dot{\mu}(i)}{\mu(i)}$
- $[r(i)]$: $\mu(i) - \lambda(i)\frac{1}{p} - \xi(i) = 0$

  For interior solutions $\forall i, \xi(i) = 0 \leftrightarrow r(i) < \bar{x}p\alpha K \rightarrow \mu(i) = \frac{\lambda(i)}{p}$ and $\frac{\dot{\mu}(i)}{\mu(i)} = \frac{\dot{\lambda}(i)}{\lambda(i)}$.

- $[b(i)]$: $-\dot{\mu}(i)+\rho\mu(i)=\beta(i)\mu(i)+\gamma(i)$
  - $i\in G_1:\gamma(i)\neq 0\Leftrightarrow b(i)=0,\dot{b}(i)=0$
  - $i \in G_2 : \gamma(i) = 0 \Leftrightarrow b(i) \geq 0\begin{cases} \frac{\dot{\mu}(i)}{\mu(i)}=\rho-\beta(i)\rightarrow g_c(i)\neq g_c(j),\, if\, \beta(i)\neq\beta(j) \\ g_c(i)=\frac{\dot{c(i)}}{c(i)}=-\sigma\frac{\dot{\mu}(i)}{\mu(i)}\end{cases} \rightarrow$ $g_c(i)=\sigma\left(\beta(i)-\rho\right)$
- $[K]$: $-\dot{\lambda}(i)+\rho\lambda(i)=\lambda(i)\alpha-\lambda(i)\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}+\xi(i)\bar{x}\alpha p+\varphi(i)$
  - $\frac{\dot{\lambda}(i)}{\lambda(i)}=\rho-\alpha+\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}$, note that $\begin{cases}\xi(i)=0, & r(i)<\bar{x}\alpha pK\\ \varphi(i)=0, & K>0\end{cases}$

General Conditions holding for $i\in G_2$(n-n1 groups),$\gamma(i)=0$, $\dot{b}(i)=0>0$

- $\frac{\dot{c(i)}}{c(i)}=-\sigma\frac{\dot{\mu}(i)}{\mu(i)}=-\sigma\left(\rho-\beta(i)\right)\rightarrow c_i(t)=c_i(s)e^{-\sigma(\rho-\beta(i))(t-s)}$,

$$g_c(i)=\sigma\left(\beta(i)-\rho\right) \tag{B1}$$

- $\frac{\dot{\mu}(i)}{\mu(i)}=\frac{\dot{\lambda}(i)}{\lambda(i)}=\rho-\alpha+\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}=\rho-\beta(i)$

$$\sum_{j\neq i}\frac{\partial r_j}{\partial K}=p\left(\alpha-\beta(i)\right)\Rightarrow \alpha p-\sum_{j}\frac{\partial r_j}{\partial K}=\frac{\partial r_i}{\partial K}-p\beta(i),\forall i\in G_2 \tag{B2}$$

- $\frac{\partial r_i}{\partial K}-\frac{\partial r_k}{\partial K}=p\left[\beta(i)-\beta(k)\right],\forall\,(i,k)\in G_2$
  - if $\beta(i)>\beta(k)\Leftrightarrow\frac{\partial r_i}{\partial K}>\frac{\partial r_k}{\partial K}$

  We guess a solution for $r(i)$ that is linear in the aggregate production of the efficient sector: $r(i)=x(i)K$

$$x(i)-x(k)=p\left[\beta(i)-\beta(k)\right],\forall(i,k)\in G_2 \tag{B3}$$

.

General Conditions holding for $i\in G_1$(n1 groups): $\dot{b}(i)=0$.

- $[c(i)]$: $c(i)^{-\frac{1}{\sigma}}=\mu(i)\rightarrow g_{c(i)}=\frac{\dot{c(i)}}{c(i)}=-\sigma\frac{\dot{\mu}(i)}{\mu(i)}$
- $[r(i)]$: $\mu(i)-\lambda(i)\frac{1}{p}-\xi(i)=0$
  - For interior solutions ($\forall i,\xi(i)=0\leftrightarrow r(i)<\bar{x}p\alpha K$)$\rightarrow\mu(i)=\frac{\lambda(i)}{p}$ and $\frac{\dot{\mu}(i)}{\mu(i)}=\frac{\dot{\lambda}(i)}{\lambda(i)}$

- $[b(i)]$: $-\dot{\mu}(i)+\rho\mu(i)=\beta(i)\mu(i)+\gamma(i)$
  - $\gamma(i)\neq 0 \Leftrightarrow b(i)=0, \dot{b}(i)=0$
- $[K]$: $-\dot{\lambda}(i)+\rho\lambda(i)=\lambda(i)\alpha-\lambda(i)\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}+\xi(i)\bar{x}\alpha p+\varphi(i)$
  - $\frac{\dot{\lambda}(i)}{\lambda(i)}=\rho-\alpha+\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}$, note that $\begin{cases}\xi(i)=0, & r(i)<\bar{x}\alpha pK\\ \varphi(i)=0, & K>0\end{cases}$

By $\dot{b}(i)=\beta(i)b(i)+r(i)-c(i)$, it follows:

- $r(i)=c(i)$ and $\frac{\dot{r}(i)}{r(i)}=\frac{\dot{c}(i)}{c(i)} \Longleftrightarrow g_c(i)=g_r(i)$.
- As before, $g_c=\frac{\dot{c}(i)}{c(i)}=-\sigma\frac{\dot{\mu}(i)}{\mu(i)}=-\sigma\frac{\dot{\lambda}(i)}{\lambda(i)}=\frac{\dot{r}(i)}{r(i)}$

Thus the FOC becomes $-\frac{\dot{\lambda}(i)}{\lambda(i)}=\frac{1}{\sigma}\frac{\dot{r}(i)}{r(i)}=\alpha-\rho-\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}$. As the solution is in the form $r(i)(K,b(i))\Rightarrow \dot{r}(i)=\frac{\partial r(i)}{\partial K}\left(\alpha K-\frac{1}{p}\sum_j r_j\right)$. It follows that $\frac{\partial r(i)}{\partial K}(\alpha K-\frac{1}{p}\sum_j r_j)=\sigma r(i)\left(\alpha-\rho-\frac{\sum_{j\neq i}\frac{\partial r_j}{\partial K}}{p}\right)$.

Let's assume $r(i)(K,b(i))=x_iK \Rightarrow x_i(\alpha K-\frac{1}{p}\sum_j x_jK)=\sigma x_iK\left(\alpha-\rho-\frac{\sum_{j\neq i}x_j}{p}\right)\Rightarrow$

$$\sum_j x_j-\sigma\sum_{j\neq i}x_j=\left(\alpha\left(1-\sigma\right)+\sigma\rho\right)p, \forall i\in G_1 \tag{B4}$$

$$x_i=x_k=x\,\forall\left(i,k\right)\in G_2 \tag{B.5}$$

$$g_c(i)=g_r(i)=g_K \tag{B.6}$$

Finding the policy function $r(i)=r(K,b(i))$

Assuming for each group a solution $r(i)=x(i)K$, from B.2 and B.3 we have that for groups in G_2 :

$$x(i)=x(j)+p\left[\beta(i)-\beta(j)\right], \forall\left(i,j\right)\in G_2 \tag{B.7}$$

and

$$\sum_{k\neq i}\frac{\partial r(k)}{\partial K}=\sum_{k\neq i}x(k)=p\left(\alpha-\beta(i)\right), \forall i\in G_2 \tag{B.8}$$

And from the equilibrium condition {B.4} and {B.5} for all n_1 groups $(z,w)\in G_1$

$$\sum_{k=1}^{n}x(k)-\sigma\sum_{k\neq z}^{n}x(k)=p\left(\alpha(1-\sigma)+\sigma\rho\right), \forall z\in G_1 \tag{B.9}$$

$$x(z) = x(w) = x, \forall\, (z, w) \in G_1 \tag{B.10}$$

From (B.7) and (B.8) and (B.10) we obtain a condition for each group $i \in G_2$

$$\sum_{k \neq i, i \in G_2} x(k) = (n - n_1 - 1)\left[x(i) - p\beta(i)\right] + p \sum_{j=n_1+1}^{n} \beta(j) + n_1 x = \alpha p \tag{B.11}$$

From (B.9) and (B.10) we obtain a condition for each group $i \in G_2$

$$x\left[\frac{(1-\sigma)n_1 + \sigma}{1-\sigma}\right] + (n - n_1)\left[x(i) - p\beta(i)\right] + p \sum_{j \in G_2} \beta(j) = \frac{p\left(\alpha(1-\sigma) + \sigma\rho\right)}{1-\sigma} \tag{B.12}$$

From [B.12]-[B.11] we obtain the following condition for each group in G_1, $[x(i) - p\beta(i)] = \frac{\sigma}{1-\sigma}\left[p\rho - x\right], i \in G_2$, which plugged again in [B.12] leads to the policy function $\forall z \in G_1$:

$$x(z) = x = p\left[\rho - g_K\left(\frac{\sigma - 1}{\sigma}\right)\right]. \tag{B.13}$$

$$r(z) = xK > 0$$

Plugging [B.13] into [B.11] and [B.12] we obtain the policy function $\forall i \in G_2$:

$$x(i) = p\left[\beta(i) - g_K\right]. \tag{B.14}$$

The equilibrium growth rate of capital g_K

From $\dot{K} = \alpha K - \frac{\sum_j r_j}{p}$ using equations (B.13) and (B.14) we obtain

$$\dot{K} = K\sigma\left(\frac{\sum_{j \in G_2} \beta(j) - \alpha + \rho n_1}{\sigma\left(n-1\right) - n_1}\right)$$

$$g_K = \sigma\left(\frac{\sum_{j \in G_2} \beta(j) - \alpha + \rho n_1}{\sigma\left(n-1\right) - n_1}\right) \tag{B.15}$$

Where $g_K > 0$ is ensured by $\sigma > \frac{n_1}{n-1}$ and $\alpha < \rho n$.

Trasversality condition for K, $i \in G_1$ $(n_1 > 1)$

From $\frac{\dot{\lambda}(i)}{\lambda(i)} = -\frac{1}{\sigma}\frac{\dot{K}}{K} \rightarrow \lambda_t(i) = \lambda_s(i)e^{-\frac{1}{\sigma}(g_K)(t-s)}$. Then the transversality condition [TC hereafter] becomes

$$lim_{t\to\infty}\lambda_s(i)K_s e^{\left[g_K\left(1-\frac{1}{\sigma}\right)-\rho\right](t-s)}$$

To respect the TC we require

$$\left(g_K\left(1-\frac{1}{\sigma}\right)-\rho\right) < 0.$$

The TC is automatically respected for $\sigma < 1$ as $\begin{cases} g_K < \rho\left(\frac{\sigma}{\sigma-1}\right), & \sigma > 1 \\ g_K > \rho\left(\frac{\sigma}{\sigma-1}\right), & \sigma < 1 \end{cases}$. For $\sigma > 1$, it requires the following constraints:

$$\sigma\left[(n-n_1)\,\bar{\beta}_{G2} - \alpha - \rho\,(n-n_1-1)\right] - \left((n-n_1)\,\bar{\beta}_{G2} - \alpha\right) < 0$$

which is always respected when the following parameter constraints are imposed:

- if $(n-n_1)\,\bar{\beta}_{G2} - \alpha > 0$ (This case is feasible only for $n_1 = \{n, n-1\}$)
  1. and $(n-n_1)\,\bar{\beta}_{G2} - \alpha - \rho\,(n-n_1-1) > 0$. Then the TC is satisfied for $\alpha > \bar{\beta}_{G2} > \rho$.
  2. and $\left(\bar{\beta}_{G2} - \alpha\right) + (n-n_1-1)\left(\bar{\beta}_{G2} - \rho\right) < 0$. Then the TC is satisfied for $\sigma > \frac{((n-n_1)\bar{\beta}_{G2}-\alpha)}{[(n-n_1)\bar{\beta}_{G2}-\alpha-\rho(n-n_1-1)]} (< 0)$.
- if $(n-n_1)\,\bar{\beta}_{G2} - \alpha < 0$ (This is a feasible case but for $n_1 = 0$).
  1. and $n_1 < n$. The TC is then satisfied for $\sigma > \frac{(\alpha-(n-n_1)\bar{\beta}_{G2})}{[\alpha-(n-n_1)\bar{\beta}_{G2}+\rho(n-n_1-1)]} (\leq 1)$.
  2. and $n_1 = n$. the TC is then satisfied for $\sigma > \frac{\alpha}{\alpha-\rho}$,$\alpha > \rho$.

Trasversality condition for K, $i \in G_2$ $(n_1 < n)$

From $\frac{\dot{\lambda}(i)}{\lambda(i)} = \rho - \beta(i) \rightarrow \lambda_i(t) = \lambda_i(s)e^{(\rho-\beta(i))(t-s)}$. Then the TC becomes

$$lim_{t\to\infty}\lambda_s(i)K_s e^{(g_K-\beta(i))(t-s)} = 0$$

The TC is satisfied for $(g_K - \beta(i)) < 0$, which is always true because equilibrium conditions require$\beta(i) > g_c(i) > g_K, \forall i \in G_2$.

Trasversality condition b(i) , $i \in G_2$

The TC $lim_{t\to\infty}e^{-\rho t}\mu_i(t)b_i^*(t) = 0$ requires to find expressions for $b_i^*(t)$ and $\mu_i(t)$.

From $\dot{b}(i) = \beta(i)b(i) + r(i) - c(i)$, and using $c_i(t) = c_i(s)e^{-\sigma(\rho-\beta(i))(t-s)}$, $g_c(i) = \sigma\left(\beta(i) - \rho\right)$, $r(i)$ and g_K we obtain:

$$b_t(i) = e^{\beta(i)(t-s)}\left[b_s(i) - pK_s\left(e^{(g_K-\beta(i))(t-s)} - 1\right) - \frac{c_s(i)}{\sigma\left(\beta(i)-\rho\right)-\beta(i)}\left(e^{(\sigma(\beta(i)-\rho)-\beta(i))(t-s)} - 1\right)\right]$$

From ${c_i}^{-\frac{1}{\sigma}} = \mu_i$ we obtain

$$\mu_i(t) = c_i(s)^{-\frac{1}{\sigma}}e^{(\rho-\beta(i))(t-s)}$$

replacing $b_i^*(t)$ and $\mu_i(t)$ in the TC and setting $s = 0$ we obtain:

$$lim_{t\to\infty}c_0(i)\left[b_0(i) + pK_0 + \frac{c_0(i)}{\sigma\left(\beta(i)-\rho\right)-\beta(i)} - pK_0e^{(g_K-\beta(i))t} - \frac{c_0(i)}{\sigma\left(\beta(i)-\rho\right)-\beta(i)}e^{(g_c-\beta(i))t}\right] = 0$$

The TC is satisfied when

- $b_0(i) + pK_0 + \frac{c_0(i)}{\sigma(\beta(i)-\rho)-\beta(i)} = 0$

$$c_0(i) = \left(\beta(i) - \sigma\left(\beta(i)-\rho\right)\right)\left[b_0(i) + pK_0\right]$$

- $(g_K - \beta(i)) < 0$, or $\beta(i) > g_K$.

1. $(\sigma\left(\beta(i)-\rho\right) - \beta(i)) < 0$, or $\beta(i) > g_c(i) \implies$

$$\sigma < \frac{\beta(i)}{\beta(i)-\rho},\ \beta(i) > \rho.$$

The law of motion for b(i)

Using $c_0(i) = \left(\beta(i) - \sigma\left(\beta(i)-\rho\right)\right)\left[b_0(i) + pK_0\right]$

$$b_t(i) = b_s(i)e^{g_c(i)(t-s)} + pK_s\left[e^{g_c(i)(t-s)} - e^{g_K(t-s)}\right]$$

If we consider the $b_s(i) = 0$ at s=0, then $b(i) > 0\ \forall i \in G_2$ implies

$$g_c(i) > g_K. \tag{B.16}$$

Similarly, $b(j) = 0$ implies $\forall j \in G_1$

$$g_c(j) = g_K. \tag{B.17}$$

Showing $g_b(i) = g_c(i) = \sigma\left(\beta(i) - \rho\right), i \in G_2$

From $g_b(i) = \frac{\dot{b_t(i)}}{b_t(i)} = \beta(i) + \frac{r_t(i)}{b_t(i)} - \frac{c_t(i)}{b_t(i)}$, and using

- $r_t(i) = pK_t\left(f_1(par)\right.$ and $K_t = K_s e^{g_K(t-s)}$
- $b_t(i) = b_s(i)e^{g_c(i)(t-s)} + pK_s\left(e^{g_c(i)(t-s)} - e^{g_K(t-s)}\right)$ for $s = 0$ and $b_s(i) = 0... = pK_s\left(e^{g_c(i)t} - e^{g_K t}\right)$
- $c_t(i) = c_s(i)e^{g_c(i)(t-s)} = \left[\beta(i) - \sigma\left(\beta(i) - \rho\right)\right]\left[b_0(i) + pK_0\right]e^{g_c(i)t}$ for $s = 0$ and $b_s(i) = 0$

we obtain

$$g_b(i) = \beta(i) + \frac{pK_0 e^{g_K(i)t}}{pK_0\left(e^{g_c(i)t} - e^{g_K t}\right)}\Upsilon_1 - \left[\beta(i) - \sigma\left(\beta(i) - \rho\right)\right]\frac{pK_0 e^{g_c(i)t}}{pK_0\left(e^{g_c(i)(t-s)} - e^{g_K(t-s)}\right)},$$

where Υ_1 is a function of parameters. As

- $\underset{t\to\infty}{lim}\frac{e^{g_K(i)t}}{\left(e^{g_c(i)t} - e^{g_K t}\right)} = 0$ and $\underset{t\to\infty}{lim}\frac{e^{g_c(i)t}}{\left(e^{g_c(i)t} - e^{g_K(i)t}\right)} = 1$

We then obtain that

$$\underset{t\to\infty}{lim}\, g_b(i) = \sigma\left(\beta(i) - \rho\right)$$

APPENDIX D - Voracity and inequality

After a technology shock, the direct effect of voracity induce a positive correlation between growth and inequality. Let $\theta = \{n, \alpha, \{\beta(i)\}, \sigma, \rho\}$ and$\theta' = \left\{n, \alpha^{'}, \{\beta(i)\}, \sigma, \rho\right\}$ be the parameter vector before and after the technological shock and let $n_1$be the equilibrium number of groups in G_1 before the shock. The direct effect implies no change in n_1 , so for it to induce a positive correlation between growth and inequality it is enough to demonstrate that $Var\left(g_c^{'}\left|n_1, \theta'\right.\right) > Var\left(g_c\left|n_1, \theta\right.\right)$ if $\alpha^{'} > \alpha$ and $Var\left(g_c^{'}\left|n_1, \theta'\right.\right) < Var\left(g_c\left|n_1, \theta\right.\right)$ if $\alpha^{'} < \alpha$.

By definition we have:

$$Var\left(g_c\right) = \frac{1}{n}\sum_i\left(g_c(i) - \bar{g}_c\right)^2\ ,\ Var\left(g_c^{'}\right) = \frac{1}{n}\sum_i\left(g_c^{'}(i) - \bar{g}_c^{'}\right)^2.$$

After some manipulation, we can rewrite $Var\left(g_c^{'}\left|n_1, \theta'\right.\right)$ as:

$$Var\left(g_c^{'}\left|n_1, \theta'\right.\right) = Var\left(g_c\left|n_1, \theta\right.\right) + \frac{n_1}{n}\left(\frac{(n - n_1)}{n}\right)\left(g_K^{'} - g_K\right)\left[\left(g_K^{'} - \sigma\left(\bar{\beta}_{G2} - \rho\right) + g_K - \sigma\left(\bar{\beta}_{G2} - \rho\right)\right)\right].$$

As the term $\left[\left(g_K^{'} - \sigma\left(\bar{\beta}_{G2} - \rho\right) + g_K - \sigma\left(\bar{\beta}_{G2} - \rho\right)\right)\right] < 0$, whether $Var\left(g_c^{'}\left|n_1, \theta'\right.\right)$ is greater or smaller than $Var\left(g_c\left|n_1, \theta\right.\right)$ depends on the sign of $\left(g_K^{'} - g_K\right)$, and in turn on the sign of the shock:

$$\left(g_K^{'} - g_K\right)\begin{cases} > 0, & \alpha^{'} < \alpha \\ < 0, & \alpha^{'} > \alpha \end{cases}$$

It then follows that $Var\left(g_c^{'}\left|n_1, \theta'\right.\right) > Var\left(g_c\left|n_1, \theta\right.\right)$ if $\alpha^{'} > \alpha$ and $Var\left(g_c^{'}\left|n_1, \theta'\right.\right) < Var\left(g_c\left|n_1, \theta\right.\right)$ if $\alpha^{'} < \alpha$.

The switching effect can not reverse the sign of the correlation between growth and inequality conditional to shock to α as it is weaker than the direct effect.

Polarizing interventions and Inequality

We defined a polarizing intervention as the government intervention that induces a new distribution $\{\beta'(i)\}$, where $\forall i$ we have$\beta'(i) - \bar{\beta} = (1+c)\left(\beta(i) - \bar{\beta}\right)$, $c > 0$. The average of the new distribution $\{\beta'(i)\}$ is unaffected, $\bar{\beta} = \bar{\beta}'$, but the variance increases, $\sigma^2_{\beta'} > \sigma^2_{\beta}$,$\sigma^2_{\beta'} = (1+c)^2\sigma^2_{\beta}$. In this appendix we show that a polarizing intervention that increases σ^2_{β} has ambiguous effects on inequality, that is $\sigma^2_{g_c^{'}} \lesseqqgtr \sigma^2_{g_c}$.

By using

$\sigma^2_{g_c} = \frac{1}{n}\sum_i \left(g_c(i) - \bar{g_c}\right)^2$, $g_c(i) = \begin{cases} g_K & ,i = 1, ..., n_1 \\ \sigma\left(\beta(i) - \rho\right) & ,i = n_1 + 1, ..., n \end{cases}$, $\bar{g}_c = \frac{n_1}{n} g_K + \left(\frac{1}{n}\right)\sum_{j\in G_2}\sigma\left(\beta(j) - \rho\right)$,

and $\sigma^2_{g_c^{'}} = \begin{cases} g_K + \frac{\sigma c (n-n_1)\left(\bar{\beta}_{G_2} - \bar{\beta}\right)}{\sigma(n-1) - n_1} & ,i = 1, ..., n_1 \\ \sigma\left(\beta(i) - \rho\right) + c\sigma\left(\beta(i) - \bar{\beta}\right) & ,i = n_1 + 1, ..., n \end{cases}$,

after some computations we find the following expression for $\sigma^2_{g_c^{'}}$:

$$\sigma^2_{g_c^{'}} = \sigma^2_{g_c} + \frac{1}{n}\left(n_1\left(\Delta g_K - \Delta\bar{g_c}\right)^2 + 2n_1\left(\Delta g_K - \Delta\bar{g_c}\right)\left(g_K - \bar{g_c}\right) + \sum_{i=n_1+1}^{n}\left(\Delta g_c\left(i\right) - \Delta\bar{g_c}\right)^2 + \sum_{i=n_1+1}^{n} 2\left(g_c\left(i\right) - \bar{g_c}\right)\left(\Delta g_c\left(i\right) - \Delta\bar{g_c}\right)\right)$$

Where $\triangle g_c(i) = \sigma c\left(\beta_i - \bar{\beta}\right)$, $\triangle g_K = \frac{\sigma c\left((n-n_1)\left(\bar{\beta}_{G_2} - \bar{\beta}\right)\right)}{\sigma(n-1) - n_1}$, $\Delta\bar{g_c} = \bar{g}_c^{'} - \bar{g}_c = \Xi > 0$, $\Xi = \frac{\sigma c(n-n_1)\left(\bar{\beta}_{G_2} - \bar{\beta}\right)}{\sigma(n-1) - n_1} * \frac{\sigma(n-1)}{n}, \frac{(n-n_1)}{\sigma(n-1) - n_1}\frac{\sigma(n-1)}{n} < 1$.

The first three elements , $n_1\left(\Delta g_K - \Delta\bar{g_c}\right)^2$, $2n_1\left(\Delta g_K - \Delta\bar{g_c}\right)\left(g_K - \bar{g_c}\right)$ and $\sum_{i=n_1+1}^{n}\left(\Delta g_c\left(i\right) - \Delta\bar{g_c}\right)^2$ are greater than zero as $\left(\Delta g_K - \Delta\bar{g_c}\right) = \frac{\sigma c(n-n_1)\left(\bar{\beta}_{G_2} - \bar{\beta}\right)}{\sigma(n-1) - n_1}\left(\frac{n - \sigma(n-1)}{n}\right) < 0$, and$\left(g_K - \bar{g_c}\right) = \left(\frac{n-n_1}{n}\right)\left(g_K - \sigma\left(\bar{\beta}_{G2} - \rho\right)\right) < 0$.

However, the sign of $\sum_{i=n_1+1}^{n} 2\left(g_c(i)-\bar{g_c}\right)\left(\Delta g_c(i)-\Delta \bar{g_c}\right)$ is ambiguous as it depends on

$$\left(\Delta g_c(i)-\Delta \bar{g_c}\right)\begin{cases} <0, & \beta(i)<\bar{\beta}+\left(\bar{\beta}_{G_2}-\bar{\beta}\right)\frac{\sigma(n-1)}{n}\frac{(n-n_1)}{\sigma(n-1)-n_1} \\ >0, & \beta(i)>\bar{\beta}+\left(\bar{\beta}_{G_2}-\bar{\beta}\right)\frac{\sigma(n-1)}{n}\frac{(n-n_1)}{\sigma(n-1)-n_1} \end{cases}, \frac{\sigma(n-1)}{n}\frac{(n-n_1)}{\sigma(n-1)-n_1}<1.$$

Appendix ?? - Welfare

In computing the aggregate welfare we adopt an egalitarian criteria and give to each group the same weight. The following expression considers the aggregate welfare for a general case in which n_1 groups are in G_1 and $n-n_1$ groups are in G_2:

$$W=\sum_{j=1}^{n_1} W_1(j)+\sum_{k=n_1+1}^{n} W_2(k)=\sum_{j=1}^{n_1}\left[\int_0^{\infty} e^{-\rho t}\frac{\sigma}{\sigma-1}\left(c_j(t)\right)^{1-\frac{1}{\sigma}}dt\right]+\sum_{k=n_1+1}^{n}\left[\int_0^{\infty} e^{-\rho t}\frac{\sigma}{\sigma-1}\left(c_k(t)\right)^{1-\frac{1}{\sigma}}dt\right]$$

We use the following equilibrium conditions: $c_k(t)=r_k(t)=\left(\frac{(\sigma-1)\left(\alpha-\sum_{j\in G_2}\beta(j)\right)+\sigma\rho(n-n_1-1)}{\sigma(n-1)-n_1}\right)pK(t)$, $K_t=K_s e^{g_K(t-s)}$, and $g_K=\sigma\left(\frac{\sum_{j\in G_2}\beta(j)-\alpha+\rho n_1}{(\sigma(n-1)-n_1)}\right)$, to compute $W_1(j), j\in G_1$:

$$W_1(j)=\frac{\sigma}{\sigma-1}\left(pK(0)\right)^{1-\frac{1}{\sigma}}\left(\frac{g_K(1-\sigma)}{\sigma}+\rho\right)^{-\frac{1}{\sigma}}.$$

We use the following equilibrium conditions: $c_j(0)=\left(\beta(j)-g_c(j)\right)\left[b_j(0)+pK(0)\right]$, $b_t(j)=\left[b_s(j)+pK_s\right]e^{g_c(j)(t-s)}-pK_t$ and $g_c(j)=\sigma\left(\beta(j)-\rho\right)$, to compute $W_2(k), k\in G_2$:

$$W_2(k)=\frac{\sigma}{\sigma-1}\left(\beta(k)-g_c(k)\right)^{-\frac{1}{\sigma}}\left[b_i(0)+pK(0)\right]^{1-\frac{1}{\sigma}}$$

Finally, it is easy to show that $W_2(j)-W_1\geq 0$, as

$$W_2(j)-W_1=\left(pK(0)\right)^{1-\frac{1}{\sigma}}\frac{\sigma}{\sigma-1}\left[\left(\beta(j)-g_c(j)\right)^{-\frac{1}{\sigma}}-\left(\frac{g_K(1-\sigma)}{\sigma}+\rho\right)^{-\frac{1}{\sigma}}\right]\geq 0,$$

where the sign is ensured by $g_c(j)-g_K>0, \forall j\in G_2$ and $\frac{\sigma-1}{\sigma}>0$.
Finally, any policy intervention that increases g_K increases the welfare of any group $i\in G_1$

$$\frac{\partial W_1}{\partial\{\beta\}}=\left[pK(0)\right]^{1-\frac{1}{\sigma}}\left(\frac{g_K(1-\sigma)}{\sigma}+\rho\right)^{-\frac{1}{\sigma}-1}\frac{\partial g_K}{\partial\{\beta\}}>0,$$

and any policy intervention increasing $\beta(j)$, $j\in G_2$ increases as well $W_2(j)$:

$$\frac{\partial W_2(j)}{\partial\beta_j}=\left[b_i(0)+pK(0)\right]^{1-\frac{1}{\sigma}}\left(\beta(j)-g_c(j)\right)^{-\frac{1}{\sigma}-3}>0.$$

APPENDIX E

A standard benchmark against which compare results from the model presented in the main text is to consider the case in which property rights are secured even in the legal sector (alternatively, because there is only a group) and we label this case as the one with strong institutions. At the benchmark, there are no potential gain from rent-seeking behavior and no group produces in the inefficient sector, so that $\dot{b}(i) = b(i) = 0, \forall i$. Accordingly $r(i) = c(i), \forall i = 1, ..., n$. Moreover, as there are no externality, net transfers are zero and $T(i) = r(i)/p$.

Formally, the social planner problem becomes (non negative constraints are omitted)

$$\underset{\{c(i),r(i),k(i),b(i)\}}{Max} L = \frac{\sigma}{\sigma - 1} c(i)^{1-\frac{1}{\sigma}} + \lambda(i) \left[\alpha k(i) - \frac{c(i)}{p} \right]$$

From solving the model we get the following equilibrium conditions for consumption and capital:

$$c(i) = c = p \left[\alpha \left(1 - \sigma \right) + \sigma \rho \right] k(i)$$

$$k_i \left(t \right) = k_i \left(s \right) e^{\sigma(\alpha - \rho)(t-s)}$$

To be able to compare results from the model presented in the text and the benchmark, it is necessary that the two models be defined on the same parameter space. However, the benchmark is defined for $\sigma < \frac{\alpha}{\alpha-\rho}$.while the model with weak institutions is defined for $\sigma > \frac{\alpha}{\alpha-\rho}$. Thus, there is no possible parametrization $\theta \in \Theta$ for which the two model can be compared, which implies that the model with strong institutions cannot be considered as a benchmark.

Appendix C - Inequality

By introducing heterogeneity, the equilibrium growth rate of consumption, $g_c(i)$, may differ across groups, and we use its variance, $\sigma^2_{g_C}$, to measure the degree of inequality within the economy:

$$\sigma^2_{g_C} = \frac{1}{n} \sum_{i=1}^{n} \left(g_C(i) - \bar{g}_C \right)^2 .$$

Using $g_c(i) = \begin{cases} g_K & , i = 1, ..., n_1 \\ \sigma \left(\beta(i) - \rho \right) & , i = n_1 + 1, ..., n \end{cases}$ and $\bar{g}_C = \frac{n_1}{n} g_K + \left(\frac{1}{n} \right) \sum_{j \in G_2} \sigma \left(\beta(j) - \rho \right)$, the average growth rate of consumption, after some computations, $\sigma^2_{g_C}$ can also be expressed as follows:

$$\sigma_{gC}^2 = \left(\tfrac{n-n_1}{n}\right)\left[\tfrac{n_1}{n}\left(\tfrac{\sigma}{(\sigma(n-1)-n_1)}\right)^2\left((n-\sigma(n-1))\,\bar{\beta}_{G2}-\alpha+(n-1)\,\rho\sigma\right)^2+\sigma_{\beta_{G_2}}^2\right]^{\ 2},$$

where $\bar{\beta}_{G_2}$ and $\sigma_{\beta_{G_2}}^2$ are the average and the variance of the distribution $\{\beta(i)\}$ conditional to $i \in G_2$. Two special cases are: $\sigma_{gC}^2 = 0$ for $n_1 = n$, while $\sigma_{gC}^2 = \sigma_{\beta_{G_2}}^2$ for $n_1 = 0$.

Synthetically, we can express it as:

$$\sigma_{gC}^2 = F\left(\overset{-}{\alpha}, \overset{+}{\bar{\beta}}_{G_2}, \overset{+}{\sigma}{}_{\beta_{G_2}}^2, \overset{\pm}{n}_1\right).$$

A policy intervention that increases $\bar{\beta}_{G2}$, ceteris paribus, tends to increase inequality:

$$\frac{\partial \sigma_{gC}^2}{\partial \bar{\beta}_{G2}} \propto \left((n-\sigma(n-1))\,\bar{\beta}_{G2}-\alpha+(n-1)\,\rho\sigma\right)(n-\sigma(n-1)) > 0,$$

with$\left((n-\sigma(n-1))\,\bar{\beta}_{G2}-\alpha+(n-1)\,\rho\sigma\right) < 0 \rightarrow \frac{n\bar{\beta}_{G2}-\alpha}{(n-1)(\bar{\beta}_{G2}-\rho)} < \frac{\alpha}{\alpha-\rho} < \sigma < 0$, $(n-\sigma(n-1)) <$ 0

A policy intervention that increases $\sigma_{\beta_{G_2}}^2$, ceteris paribus, tends to increase inequality

$$\frac{\partial \sigma_{gC}^2}{\partial \bar{\beta}_{G2}} \propto \sigma^2 > 0.$$

Changes in n_1 (switching effect) have no clear impact on inequality.

$$\frac{d\sigma_{gC}^2}{dn_1} = \frac{\sigma^2}{n^2\left(\sigma\left(n-1\right)-n_1\right)^2}\left[(n-1)\,\sigma\,(n-2n_1)+n_1 n\right]\left((n-\sigma(n-1))\,\bar{\beta}_{G2}-\alpha+(n-1)\,\rho\sigma\right)^2 - \frac{1}{n}\sigma^2 Var\left(\beta_{G2}\right) \gtreqless 0,$$

as $\left[(n-1)\,\sigma\,(n-2n_1)+n_1 n\right] \gtreqless 0$ over the feasible parameter space.

APPENDIX G - An algorithm to determine n_1^*

To uniquely determine n_1^* given a parametrization $\theta \in \Theta$ and the equilibrium conditions we can use the following algorithm. We start by checking if equilibrium conditions are satisfied for $G_2 = \{\emptyset\}$ and $n_1 = n$, that is when no group produces in the informal sector. If $g_K(n_1 = n-1) > \sigma\,(\beta(i) - \rho)$ for at least one group $i = 1, ..., n$, then $n_1 = n$ it is not an equilibrium.

- Without loss of generality, we initially check the group with highest productivity, $\beta\,(n)$, has it has the greatest incentive to produce in the informal sector.

- If $g_K(n-1) > \sigma(\beta(n) - \rho)$, then $n_1^* = n$ is an equilibrium, as $\beta(n) > \beta(n-1) > ... > \beta(1)$ and no other group may be better off by producing in the informal sector.
- If, $g_K(n-1) < \sigma(\beta(n) - \rho)$, then the n-th group switches from G_1 to G_2 and, by (8) , g_K increases.[31]

If we find that $n_1^* \neq n$, we then pass to consider the case $n_1 = n - 1$ and check if the group with the second highest productivity in the informal sector, $\beta(n-1)$, respects equilibrium conditions.

- If $g_K(n-2) < \sigma(\beta(n-1) - \rho)$ then $n_1^* = n - 1$, otherwise, we set $n_1 = n - 2$ and keep checking.

It is worth noting that, as $\sigma(\beta(n) - \rho) > \sigma(\beta(n-1) - \rho)$, if $\sigma(\beta(n-1) - \rho) > g_K(n-2)$, then it must hold $\sigma(\beta(n) - \rho) > g_K(n-2)$. More generally, if the i-th group finds it optimal to start producing in the informal sector, even if by switching between factions it increases g_K, any group $j > i$, such that $\beta(j) > \beta(i)$, will continue to produce in the informal sector.

- If $(g_K(0) < \sigma(\beta(1) - \rho) < ... < \sigma(\beta(n) - \rho))$ then all groups are better off producing in the informal sector and $G_2 = \{1, ..., n\}$,$n_1^* = 0$.

As a corollary, any change in $\{\beta(i)\}$ that leads to a transition from the initial equilibrium characterized by the pair $\{n_1^*, \theta_0\}$ to a new equilibrium characterized by the pair$\{\theta_1, n_1^{**} \neq n_1^*\}$, implies that: $g_k(n_1^* \mid \theta_0) \geq g_k(n_1^{**} \mid \theta_0)$, $g_k(n_1^{**} \mid \theta_1) \geq g_k(n_1^* \mid \theta_1)$ and $g_k(n_1^* \mid \theta_0) \gtreqless g_k(n_1^* \mid \theta_1)$.

[31] As n_1 is defined in a discrete domain (natural numbers) it might be possible that $g_K(n_1) < \sigma(\beta_i - \rho) < g_K(n_1 - 1)$. We then impose that the equilibrium condition has to be checked ex-post so that the group i will produce in the informal sector if $\sigma(\beta_i - \rho) > g_K(n_1 - 1)$.