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A song of ice and fire: Competitiveness in an export-led growing economy*

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Abstract

The role of the real exchange rate in explaining long-run processes of catching-up and falling-behind continues to be a question of central importance among alternative theories of growth and distribution. Existing empirical evidence suggests a positive association between exchange rates in levels and growth, especially in developing countries, though a currency depreciation has adverse effects. While these two elements have been separately incorporated into demand-led growth theories, a comprehensive assessment of the dynamic interaction between them is still missing. This article attempts to fill such a gap in the literature by developing an export-led growth model in which *price* and *non-price* competitiveness respond to the level and variation of the real exchange rate. In equilibrium, relative prices and the fundamentals of the productive structure are simultaneously determined. A more depreciated exchange rate and higher non-price competitiveness are associated with a higher rate of growth. It is shown that the interplay between a destabilising force from the goods market, and a stabilising mechanism from the labour market, might give rise to persistent and endogenous long-run cycles of structural change. Furthermore, the introduction of periodic Schumpeterian innovation waves generate irregular fluctuations similar to those observed in real data.

Keywords: *Structural change; Demand-led growth; Competitiveness; Real exchange rate.*

JEL Classification: *F43; O11; O40.*

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1 Introduction

An old concern among development economists regards the real exchange rate (RER) importance for economic growth. In general terms, the two main mechanisms through which it might affect the economic performance of a country or region are the short-run aggregate demand channel and the long-run development channel. While the earlier literature focused on macroeconomic effects through the first of them, the rise of China has renewed the interest in exploring more long-term mechanisms (for a comprehensive review of the literature, see Rapetti, 2020; Demir and Razmi, 2021). The existing empirical evidence suggests a positive association between exchange rates in levels and growth, especially in developing countries, although currency depreciations have adverse effects. These two elements have been separately incorporated into demand-led growth theories. However, to the best of our knowledge, a comprehensive assessment of the dynamic interaction between them is still missing. This article attempts to fill such a gap in the literature by developing a stylised export-led growth model in which price and non-price competitiveness respond to the level and variation of the real exchange rate.

Over the past thirty-five years, Dixon and Thirlwall (1975) model of *static* cumulative causation has offered a useful baseline framework for studying the RER-growth relationship (e.g. Pugno, 1996; Boggio, 2003; Blecker and Setterfield, 2019, pp. 388-395). The essence of the argument is that once a region gains a growth advantage, there will be a tendency to maintain it through increasing returns that growth itself induces. Taking their contribution as a starting point, we provide a novel representation of *dynamic* cumulative causation that takes into account the interaction between goods and labour markets as well as the interplay of price and non-price competitiveness. We show that, in equilibrium, the real exchange rate and the capacity of the productive structure to respond to changes in foreign demand are simultaneously determined. A more depreciated exchange rate and higher non-price competitiveness are associated with a higher growth rate, leading firms to hire more workers and, thus, increase the steady-state employment rate. Still, the economy is never in a state of rest. The interplay between a destabilising force from the goods market, and a stabilising mechanism, from the labour market may give rise to persistent and bounded fluctuations conditional to the intensity of the distributive conflict.

Endogenous and persistent long-run cycles of structural change have the following rationale. An increase in the rate of growth of exports leads to higher output, which in turn is associated with rising labour productivity through the presence of dynamic economies of scale, i.e. the so-called Kaldor-Verdoorn's law. As more workers are hired to match sales projections, we initially observe an increase in their bargaining power, damaging the profitability of an investment. Firms respond by increasing their search for labour-saving production techniques. The sum of these two processes results in firms producing more with less labour, subsequently reducing the bargaining power of the latter. Weaker and less combative workers are related to a lower rate of inflation, and, as a result, the real exchange rate depreciates. A more undervalued currency, in levels, impulses exports in two ways: on the one hand, if sustained for a sufficiently long time, it allows firms to better plan incursions into foreign markets; on the other hand, there are positive externalities that promote structural change in the form of increases in non-price competitiveness.

Such a process of cumulative causation is unstable, as it should be. The labour market and the RER enter the picture balancing growth trajectories in three different ways. First, the currency depreciation in itself damages growth in line with the empirical studies previously mentioned. Second, accelerating growth is associated with rising employment. As workers' bargaining power increases, they can obtain increases in real wages above labour productivity gains. If firms respond by rising prices, the real exchange rate may appreciate in levels, which means lower price competitiveness. Third, adjusting to the new conditions imposed by change is costly, meaning that non-price competitiveness cannot grow without limits, and price externalities decrease over time. For instance, new technologies depend on the sum of past innovations. As the productivity frontier expands, it becomes more challenging to be innovative because the techno-economic paradigm saturates as it reaches maturity (an argument in line with Perez, 2010, among others).

The remainder of the paper is organised as follows. In the next section, we provide a brief overview of the related literature. Section 3 develops a stylised model in which the world is divided between two regions: ice and fire. The first stands for a foreign country or the rest of the world. The latter corresponds to the domestic economy. Section 4 brings a set of numerical simulations that confirm we are dealing with a super-critical Hopf bifurcation and that emerging persistent fluctuations are stable. It is also shown that, with the introduction of Schumpeterian innovation waves, the model generates more complex dynamics, including irregular long-run fluctuations and sensitivity to initial conditions, similar to those observed in actual data. We conclude with some final considerations.

2 An overview of the related literature

This Section presents a brief overview of the related literature to situate our contribution in the field better. However, it goes beyond the scope of the paper to provide a comprehensive survey of the RER-growth relationship as well as the cumulative causation family of models. Textbook presentations of the latter can be found, for example, in Blecker and Setterfield (2019). Regarding the former, the reader is invited to see Demir and Razmi (2021). Rapetti (2020) provides a systematic survey of recent developments alongside panel regressions using data from the Penn World Table.

As argued in the Introduction of this paper, Dixon and Thirlwall (1975) model of *static* cumulative causation has consolidated itself over the past three decades as a useful baseline framework to study international competitiveness related issues. Building on Beckerman (1962) and Kaldor (1971), their model is static in the sense that the system admits a trivial stable attractor as an equilibrium solution (see, for example, Setterfield, 2011; Blecker, 2013). Despite its simplicity, the elegance and flexibility of this representation caught the attention of a great number of researchers. A large number of scholars have generalised its formulation in different directions and, in particular, to assess different channels through which relative prices matter for international growth differences.

Authors such as Ribeiro et al. (2016, 2017) have investigated the role of the RER to growth by differentiating between short- and long-term effects. While they provide an interesting assessment of price and non-price competitiveness exploring the effects of intermediate consumption, they maintained a somehow static approach to cumulative causation, allowing for minor adjustments towards equilibrium. Furthermore, in their representation, the labour market is not adequately included, leaving little room for a more comprehensive assessment of the distributive conflict. In similar lines, Romero (2019) proposed a growth model that embeds Schumpeterian insights into the Kaldorian narrative. Once more, labour markets are only implicitly included in the discussion that continues to be fundamentally static, anchored in the concept of a stable equilibrium solution.

Differences in the sectoral composition of the economy and cumulative causation have been explored in the seminal article by Araújo (2013). Building on a Pasinettian set-up to explain uneven development, the author disaggregated trade such that non-price competitiveness responds to both the dynamics between and within different production activities. A multisectoral cumulative causation model that allows for the interplay between price and non-price competitiveness can be found in Missio et al. (2017), with minor variations in Magacho and McCombie (2020). In this framework, a reconciliation between cumulative causation and balance-of-payments constrained views is shown to hold. Through Kaldor-Verdoorn's law, technical progress was endogenised, and the role played by aggregate demand to foster structural change is also highlighted. While this view offers a significant qualitative improvement concerning traditional macroeconomic models, out of equilibrium dynamics depend on exogenous stochastic shocks, leaving the picture somehow incomplete.[1]

Pugno (1996) was perhaps the first to provide a proper dynamic representation of the Dixon-Thirlwall narrative. Adopting a growth-cycle framework, as in Goodwin (1967), he showed how price competitiveness evolves and impacts growth, conditional to the intensity of the distributive conflict (see also Nishi, 2019). On the other hand, Boggio (2003) and Boggio and Barbieri (2017) attempted to provide a disequilibrium representation using the replicator equation. In all these cases, the labour market is explicitly formalised. They seem, nonetheless, to be more concerned with cost or price competitiveness than with aspects related to the complexity or quality of goods and services produced, i.e. non-price competitiveness. We believe this is an essential element that must be included in the discussion in light of the empirical evidence that suggests a positive association between exchange rates in levels and growth, although a currency depreciation seems to have adverse effects.

The model developed in the next Section takes into account the interaction between goods and labour markets, as well as the interplay between price and non-price competitiveness to provide a novel and *dynamic* representation of cumulative causation. We focus on three main channels through which the RER might affect economic performance. First, downward adjustments of the value of a country's money relative to the international currency are recessive. This effect means that any devaluation process intrinsically reduces output growth through the dynamic Keynesian multiplier. Second, stable relative prices over a sufficiently long time horizon allow domestic firms to better plan incursions into foreign markets, thus, resulting in higher exports. Finally, the RER, in levels, influences resource allocation, especially in developing countries. Even though it is only implicitly embodied in the model, the idea is that a more depreciated currency increases the profitability of tradables over non-tradables. Given

[1]How to obtain growth and fluctuations in a framework where structural change is endogenous to the system was R. Goodwin's life-long research program (see Punzo, 2006). The bridge between structure and dynamics was built investigating stable multisectoral production systems, similar to the approach in Araújo (2013). In this respect, our contribution provides a weaker representation of structural change but a more robust view of cumulative causation in the form of endogenous cycles in price and non-price competitiveness.

that the former is associated with increasing returns to scale, price competitiveness might foster non-price competitiveness, though this mechanism is subject to decreasing returns because innovation is costly.

3 The model

Suppose the world is divided in two regions, open to international trade, that produce goods and services which are imperfect substitutes. We will refer to the domestic economy as *fire* while *ice* stands for the rest of the world.[2] Our discussion is based on the perspective of the fire country. Of course, this classification is artificial. Still, it finds common ground in similar distinctions in the literature of uneven development, e.g. North-South (as in Botta, 2009; Sasaki, 2021) or Centre-Periphery (see Cimoli and Porcile, 2014). For presentation purposes, the model is divided into five blocks of equations: (i) price competitiveness, (ii) non-price competitiveness, (iii) demand conditions, (iv) supply conditions, and (v) distributive conditions.

3.1 Price competitiveness

To keep the exercise as simple as possible, suppose the nominal exchange rate is constant and equal to one. Then, price competitiveness, θ, is captured by the RER, that is, the ratio between foreign or ice, p_I, and domestic or fire prices, p_F. Hence, the terms-of-trade stand for a synonymous of the real exchange rate. In reality, we know the nominal exchange rate responds to monetary policy and risk perceptions. However, introducing Central Banks at this analysis stage would complicate the exercise without adding much to our story. If we manage to convince the reader of the usefulness of our approach, future research should increase the realism of the model. Unless explicitly stated otherwise, for any generic variable x, we indicate $\dot{x}$ as its time derivative. For a given quality, the goal is to supply at the lowest price:

$$\theta = \frac{p_I}{p_F} \tag{1}$$

Log-differentiating Eq. (1), we obtain that variations of this dimension of competitiveness respond to the difference in the respective rates of growth in the two regions:

$$\frac{\dot{\theta}}{\theta} = \frac{\dot{p}_I}{p_I} - \frac{\dot{p}_F}{p_F} \tag{2}$$

such that an increase in domestic prices relatively to those in ice results in a less competitive fire region.

[2]The nomenclature, as well as the title of the paper, make direct reference to the epic fantasy novels written by G. Martin. They chronicle the power struggle for the Iron Throne. *Ice* was the name of the House Stark's ancestral sword in the North, the coldest region in the narrative. *Fire*, on the other hand, was the symbol of the House Targaryen based in the South. They were known for being closer to dragons than other men. By differentiating between fire and ice regions, we follow the North-South or Centre-Periphery literature with a more contemporaneous flavour, paying tribute to the impact Martin's novel – which is still to be finished – had on popular culture in the past decade.

3.2 Non-price competitiveness

Following a similar structure as in the previous case, non-price competitiveness, ρ, is given by the ratio between quality characteristics of the good produced in the domestic economy, μ_F, and the same indicator in the ice region, μ_I. Notice that while in the previous case the goal was to offer the lowest possible price, here firms aim, for a given price, to supply at the highest quality:

$$\rho = \frac{\mu_F}{\mu_I} \tag{3}$$

Log-differentiating Eq. (3), we obtain that variations in non-price competitiveness respond to the difference in the rate of growth of the respective index in the two regions:

$$\frac{\dot{\rho}}{\rho} = \frac{\dot{\mu}_F}{\mu_F} - \frac{\dot{\mu}_I}{\mu_I} \tag{4}$$

Hence, non-price competitiveness in fire will increase as long as characteristics of its goods and services, such as their technical sophistication or quality, grow faster than in the foreign economy.

We assume, however, that once a non-price advantage is gained, it is increasingly more difficult to enlarge the gap further. That is because new technologies depend on the sum of past innovation breakthroughs. As the productivity frontier expands, the current techno-economic paradigm reaches maturity, and it becomes more challenging to be innovative (e.g. Perez, 2010). The existence of an international system of property rights, for example, imposes an increasing fee for the introduction of new goods, services or practices into the system because innovation today depends on past patented creations (see Pagano, 2014). Moreover, the capital stock of a country consists of a complex web of interlocking parts. The increase in the scale of production necessary to handle manufacturing more diversified goods and services brings costs in terms of the reorganisation of corporations, management of tangible and intangible assets, labour and legal issues, among others (Hannan et al., 2004; Andreoni and Chang, 2019).

Therefore, we suppose:

$$\begin{aligned} \frac{\dot{\mu}_F}{\mu_F} &= \beta_{\mu_F} - \beta\rho \\ \frac{\dot{\mu}_I}{\mu_I} &= \beta_{\mu_I} + \beta\rho \end{aligned} \tag{5}$$

where $\beta_{\mu_F} > 0$ and $\beta_{\mu_I} > 0$ capture the exogenous factors that impact non-price competitiveness in each individual country, and $\beta > 0$ stands as the rate of decreasing returns of product creation or differentiation. To maintain a parsimonious number of parameters in the model, we suppose it is equal in both regions.

Substituting (5) into Eq. (4), we have that the variation of non-price competitiveness is a quadratic function of current non-price attributes of the respective production structures:

$$\frac{\dot{\rho}}{\rho} = \beta_{\mu_F} - \beta_{\mu_I} - 2\beta\rho \tag{6}$$

such that $\dot{\rho}$ draws a inverted-U shaped function in ρ. It is important to notice that this non-linearity was not imposed in an *ad hoc* fashion, being rather a convenient result of simple and standard algebraic manipulation of Eq. (3).

3.3 Demand conditions

From the aggregate demand identity we have that:

$$Y = C + I + X - \theta M \tag{7}$$

where Y is output, C stands for consumption, I is investment, X are exports, and M correspond to imports. It immediately follows that a RER depreciation is associated with an increase in price competitiveness but, *ceteris paribus*, will result in a contraction of aggregate demand.

As an export-led growth model, we follow a more Kaldorian approach and recognise that exports differ from other demand components because they result from demand emanating from outside the system. The major part of consumption and investment is dependent on the growth of income itself (e.g. Thirlwall, 2002, p. 83). Hence, we assume:

$$\begin{aligned} C &= cY \\ I &= hY \\ M &= mY \end{aligned} \tag{8}$$

where c, h, and m are the marginal propensities to consume, invest, and import, respectively, such that all $\in [0, 1]$. Implicitly, we are imposing that the income elasticity of imports is equal to one. This hypothesis is not very accurate from an empirical point of view. Different estimations of the trade equations suggest income elasticities are greater than one (see, for example, Felipe and Lanzafame, 2020). Still, it allows us to simplify the algebraic steps without modifying our main narrative.

Substituting (8) into Eq. (7), we can write the level of output as a function of its autonomous component:

$$Y = \frac{X}{1 - c - h + \theta m} \tag{9}$$

such that a depreciation of the exchange rate is clearly contractionary.

It is well recognise in the literature on international economics that countries cannot sustain, in the long-run, increasing and persistent current-account imbalances. Equilibrium in the current account requires:

$$\frac{\theta M}{X} = 1 \tag{10}$$

Log-differentiating Eq. (9) and making use of (10), the rate of growth of output is equal to the difference between the rate of growth of exports and variations in relative prices:

$$\frac{\dot{Y}}{Y} = \frac{\dot{X}}{X} - \frac{\dot{\theta}}{\theta} \tag{11}$$

The expression above not only indicates that increases in price competitiveness paradoxically have an immediate negative effect on growth, but is in line with the idea that currency depreciations are recessive in nature.

We need to specify the rate of growth of exports. The amount of goods and services that the fire region sells to the rest of the world depends on price and non-price competitiveness. Regarding the former, the level of θ at a given point of time is a secondary issue. What matters is the stability of relative prices in a given time horizon that allows domestic firms to plan their incursion into foreign markets better. There is a time lag between the decision to export and the actual purchase from an international company. It depends, for a given quality, on the stability of prices. We normalised this interval to $[0, 1]$. In what concerns the non-price characteristics of goods and services exported, they are fundamentally captured by ρ. Hence, suppose:

$$X = A \exp\left(\int_0^1 \sigma\theta \, dt\right) Z^{\rho} \tag{12}$$

where Z is the level of output in the ice region, A is an arbitrary constant, and σ is the respective price elasticity. The expression above is a variant of a traditional exports function (as in Fagerberg, 1988; see also Romero and McCombie, 2016), with the only difference that prices matter over a certain interval of time.

Log-differentiating Eq. (12) and substituting the resulting expression into Eq. (11), we obtain the export-led rate of growth compatible with equilibrium in the balance-of-payments:

$$\frac{\dot{Y}}{Y} = \rho z + \sigma\theta - \dot{\theta}/\theta \tag{13}$$

such that a more depreciated RER is related to a higher rate of growth but exchange rate depreciations have a negative impact on economic performance. In this way, we are correctly capturing the effect of the so-called J-curve. A country's trade deficit will initially worsen after the depreciation of its currency with a negative impact on growth – mainly because in the near term, higher prices on imports will have a more significant impact on total nominal imports than the reduced volume of imports. A stable RER will allow firms to adjust exports to the new price conditions approximately a year after, leading to a higher output growth rate. Naturally, the same economic rationale applies to the opposite scenario. When a country experiences a currency appreciation, this would consequently result in an inverted J-curve.

Of course, in equilibrium, relative prices cannot rise or fall without limits, $\dot{\theta}/\theta = 0$. Hence, the long-run rate of growth is such that:

$$y_{bp} = \rho z + \sigma\theta \tag{14}$$

Frequently referred to as the dynamic Harrod trade-multiplier, Krugman's 45-degree rule or Thirlwall's (1979) law, Eq. (14) shows that price competitiveness might affect long-run performance through export behaviour (for a recent review of the related literature, see Blecker, 2021). Such a channel results from the fact that exports respond positively to a less volatile RER. It is not related to a process of structural change because non-price competitiveness conditions remain unchanged at this point of the analysis. The interplay between θ and ρ will be discussed later on in the model.

3.4 Supply conditions

Our narrative would remain incomplete without modelling the supply-side of this economy. Suppose the following Leontief production technology:[3]

$$Y = \min\left\{\frac{K}{\vartheta}; qeN\right\} \tag{15}$$

where K stands for the capital stock; ϑ is the capital-output ratio; $q = Y/L$ corresponds to labour productivity, with L as the amount of workers used in production; $e = L/N$ is the employment rate, and N the size of the labour force. As a simplification hypothesis, we assume ϑ is constant and compatible with normal capacity utilisation, and that the population grows at an exogenous rate n. Of course, they are only simplification assumptions. The reader might argue that such stylised facts are inappropriate for several countries, specially within the structuralist tradition. Demographic transition, for example, in developing and developed countries has increasingly been recognise to play an important role for long-run economic performance (Manfredi and Fanti, 2006; Allain, 2019). Here we limit ourselves to acknowledge that empirical evidence in this regard is somehow controversial, indicating an interesting avenue of investigation. Further research on those issues is to be encouraged.

From the dynamic efficiency conditions, it follows that the rate of employment and capital accumulation adjust to the demand-led output growth rate:

$$\begin{aligned} \frac{\dot{e}}{e} &= \frac{\dot{Y}}{Y} - \frac{\dot{q}}{q} - n \\ \frac{\dot{K}}{K} &= \frac{\dot{Y}}{Y} \end{aligned} \tag{16}$$

The first expression shows how the actual growth rate adjusts to the natural one through the labour market. An economy growing faster than the sum between the growth rate of labour productivity and the labour force will experience an increasing employment rate. This trajectory follows from the fact that firms are hiring faster than the reduction in the technical labour coefficient. Analogously, participation rates start to fall if the sum between $\dot{q}/q$ and n is higher than the pace at which production increases. On the other hand, the second expression in (16) indicates that firms adjust their capital stock following the demand-led determined growth rate.

Regarding the technical labour coefficient, we acknowledge two main mechanisms. First, following the considerable empirical evidence that gives support to the existence of dynamic economies of scale, e.g. Kaldor-Verdoorn's law (see McCombie and Spreafico, 2016; Romero and Britto, 2017), the rate of growth of labour productivity is supposed to respond to the long-run rate of growth of the economy, y_{bp}, as in Eq. (14). This fact means that RER depreciations or

[3] Notice that the Leontief production function is in a sense an accounting identity. From the static efficiency condition we have that $Y = K(Y/K) = (Y/L)(L/N)N$. Such an specification is usually adopted among demand-led growth theories to incorporate the supply side of the economy, and avoids the problematic Cobb-Douglas type of technology (for a recent critique, see Zambelli, 2018; Gechert et al., 2021)

appreciations do not impact technique choice, which uniquely responds to structural conditions. Second, we allow for feedback effects from the labour market with a two-fold motivation (a review of the related literature can be found in Tavani and Zamparelli, 2017). On the one hand, as participation rates increase, labour shortages become more frequent, and firms respond by increasing their search for labour-saving production techniques. On the other hand, an increase in the employment rate is associated with a higher bargain power of workers. As a result, it becomes more likely that they will obtain real wage increases above productivity gains, increasing the wage-share (Goodwin, 1967; Velupillai, 2006). The following fall in profitability of investment leads firms, once more, to pursue production techniques that save labour, increasing $\dot{q}/q$ (for empirical evidence in open economies, see Dávila-Fernández, 2020).

From the discussion above, we adopt a parsimonious linear behavioural rule:

$$\frac{\dot{q}}{q} = -\kappa_0 + \kappa y_{bp} + \bar{\kappa} e, \; 0 < \kappa < 1, \; 0 < \bar{\kappa} < 1 \tag{17}$$

where $\kappa_0 > 0$ is a given parameter, $\kappa \in [0, 1]$ is the so-called coefficient of Kaldor-Verdoorn, and $\bar{\kappa} > 0$ captures the sensitivity of labour productivity to the dynamics of the labour market.[4] Notice that with no growth and zero employment, the fire country experiences a reduction in labour productivity. This is in accordance with the idea that under persistently high unemployment rates, there could be a deterioration in human capital and in the capacity for learning-by-doing, with negative implications in terms of productivity rates.

3.5 Distributive conditions

The final block of equations consists in the distribution of income between inputs. A long tradition in macroeconomics has discussed how a higher employment rate is related to an improvement in the fall-back position of workers, raising their bargaining power. In such a scenario, they are able to obtain higher increases in real wages relative to labour productivity gains, leading to a higher wage-share, ϖ. Formalising this mechanism in the lines of Goodwin (1967), and those who followed (e.g. Sordi and Vercelli, 2014), would require an additional differential equation. To avoid the complications of this route, we limit ourselves to assume a linear correspondence between ϖ and e that passes the origin:

$$\varpi = \phi e, \; 0 < \phi < 1 \tag{18}$$

such that, for a zero employment rate, there is no production and the income share of labour is also equal to zero.

Recognising the role of income distribution not only for technical change but also to price dynamics (as in Velupillai, 2006), a given ϖ is associated with a certain level of distributive conflict. For example, there is a struggle between firms and workers to increase, recover or preserve their income shares. We already discussed how a higher wage-share is related to a reduction in profitability and that firms might respond by increasing their search for labour-saving pro-

[4] As demostrated by McCombie and Spreafico (2016), "the Verdoorn coefficient also *should not* be interpreted as a measure of increasing returns to scale per se" (p. 1131, emphasis added). Still, in line with the empirical evidence provided by Romero and Britto (2017), we acknowledge that it captures, at least partially, the presence of dynamic economies of scale and increases with technological intensity (complexity) of the goods produced. Hence, a higher κ is associated with a more complex productive structure.

duction techniques. Nonetheless, this is only one of the possible responses. Alternatively, firms have the option to increase prices:

$$\frac{\dot{p}_I}{p_I} = 0$$
$$\frac{\dot{p}_F}{p_F} = -\gamma_0 + \gamma\varpi, \ 0 < \gamma < 1 \tag{19}$$

where $\gamma_0 > 0$ and $\gamma > 0$ are parameters in the behavioural relationship. For simplicity, we are keeping ice prices constant. Adopting a similar behavioural rule for both regions will increase the algebraic steps without modifying our main story. Notice that deflation is a possible outcome of an extremely weak labour force. For a share of wages below γ_0/γ, prices will actually fall.

Finally, we are able to present the correspondence between price and non-price competitiveness. There is some evidence indicating that the level of the exchange rate influences resource allocation, compensating negative externalities, especially in developing countries (as in Rodrik, 2008). This channel works through structural change caused by factors such as employment shifts towards higher productivity and increasing return sectors, information-related market failures and other externalities (see Demir and Razmi, 2021). Implicitly, the idea is that a more depreciated currency increases profitability of tradables vis-a-vis non-tradables. Only the former is associated with increasing returns to scale, especially in developing countries. Thus, price competitiveness may foster non-price competitiveness. Recall from (5) that quality or product differentiation in each region were supposed to depend on the current conditions of the productive structure as well as on a variable capturing other elements exogenous to the model. We endogenise this last component:

$$\beta_{\mu_F} = \zeta\theta, \ 0 < \zeta < 1$$
$$\beta_{\mu_I} = 0 \tag{20}$$

where ζ is basically capturing the response of product differentiation to price conditions. For parsimonious reasons, we focus on the fire economy, assuming that β_{μ_I} is equal to zero, so that non-price competitiveness in the ice country only responds to ρ.[5]

3.6 The dynamic system

Substituting Eqs. (13) and (17) into the first expression in (16), and making use of Eq. (14), we obtain the dynamics of the employment rate. Adjustments in the labour market are a function of the level and the rate of change of price competitiveness, as well the level of non-price competitiveness. On the other hand, substituting (19) into Eq. (2), it is possible to see how adjustments in relative prices respond to the intensity of the distributive conflict, which in turn is conditional

[5]Adopting a $\beta_{M_I} \neq 0$ and $\dot{p}_I/p_I \neq 0$ would only increase the number of parameters in the model without adding much to our narrative. If we manage to convince the reader of the importance of this framework, future research could tackle in more explicit terms the interaction between ice and fire countries. This would likely also increase the dimension of the system, making it more interesting from a dynamic point of view.

to the state of the labour market. Last but not least, substituting (20) into Eq. (6), non-price competitiveness responds to price conditions through a structural change channel. The resulting 3-dimensional dynamic system is given by:

$$\begin{aligned}\frac{\dot{e}}{e} &= (1-\kappa)(\rho z + \sigma\theta) - \dot{\theta}/\theta - \bar{\kappa}e + \kappa_0 - n = g_1(e,\rho,\theta) \\ \frac{\dot{\theta}}{\theta} &= \gamma_0 - \gamma\phi e = g_2(e,\rho,\theta) \\ \frac{\dot{\rho}}{\rho} &= -2\beta\rho + \zeta\theta = g_3(e,\rho,\theta)\end{aligned} \tag{21}$$

In steady-state, $\dot{e} = \dot{\theta} = \dot{\rho} = 0$. This gives us as equilibrium conditions:

$$\begin{aligned}0 &= [(1-\kappa)(\rho z + \sigma\theta) - \bar{\kappa}e + \kappa_0 - n]\, e \\ 0 &= [\gamma_0 - \gamma\phi e]\, \theta \\ 0 &= [-2\beta\rho + \zeta\theta]\, \rho\end{aligned} \tag{22}$$

Ruling out the trivial case in which $e = \theta = \rho = 0$, the first expression in (22) indicates that, in equilibrium, the rate of growth of the economy will be equal to the so-called natural growth rate, i.e. sum between the rate of growth of labour productivity and the labour force. Both $\dot{Y}/Y$ and $\dot{q}/q$ are endogenous to the structural conditions of the economy, in particular, price and non-price competitiveness. Given that the RER cannot appreciate or depreciate without limits, the model is not compatible with the possibility of continuous currency depreciations. The second and third expressions show the requirements to balance the two dimensions of competitiveness in both fire and ice countries.

We, thus, can state and prove the following Proposition regarding the existence and uniqueness of an internal equilibrium solution:

Proposition 1 *The dynamic system (21) has a unique internal equilibrium solution, $P = (e^*, \theta^*, \rho^*)$, defined and given by:*

$$\begin{aligned}e^* &= \frac{\gamma_0}{\gamma\phi} \\ \theta^* &= \frac{\bar{\kappa}e^* - \kappa_0 + n}{(1-\kappa)\left(\frac{\zeta z}{2\beta} + \sigma\right)} \\ \rho^* &= \frac{\zeta\theta^*}{2\beta}\end{aligned}$$

Proof. See Mathematical Appendix A1. ■

It is interesting to notice the sign of some partial derivatives. For instance, $\partial\theta^*/\partial\kappa > 0$. This sign means that a higher Kaldor-Verdoorn coefficient is associated with greater price competitiveness, while a productive structure with low technological sophistication becomes prone to have an overvalued RER. Given the correspondence between θ and ρ, a currency appreciated results in lower quality and product differentiation. The effect of ζ on the two dimensions of competitiveness, on the other hand, is not the same. For a given equilibrium RER, it is easy to see that $\partial\rho^*/\partial\zeta > 0$, which is quite intuitive. As previously discussed, this parameter captures a channel of structural change through which prices influence the productive structure. In the limit, $\zeta = 0$ implies $\rho^* = 0$. Nonetheless, $\partial\theta^*/\partial\zeta < 0$. It follows from the fact that higher non-price competitiveness is associated with a rise in the rate of growth of exports. Firms respond by hiring more workers leading to an increase in their bargaining power. Eventually, they will increase prices, resulting, in equilibrium, in a more appreciated currency.

Such a result brings us to $\partial e^*/\partial\phi < 0$, i.e. stronger distributive conflict is related to a lower equilibrium employment rate. We want to highlight that this is not to say that strong labour unions lead to lower e. The parameter in question represents a set of institutional variables that can affect the bargaining power of workers and the way labour unions behave in the process of collective bargaining. Among them, we can list the share of workers that belong to a labour union, the level and coverage of unemployment benefits, and the centralisation of wage bargaining. This last variable is part of the so-called Calmfors-Driffill hypothesis. It states an inverted U-shape relationship between the degree of collective bargaining and the level of unemployment: As the size of trade unions increase, unemployment also increases up to the point unions begin to exercise monopoly power (see Calmfors and Driffill, 1988). The rationale is related to M. Olson's idea, in *The Rise and Decline of Nations*, that organised interests are most harmful when they do not internalise significant amounts of the costs they impose on society but become less harmful as their interest becomes encompassing enough to suffer the costs. Hence, our model implicitly represents an economy with decentralised wage bargaining.

The equilibrium rate of employment depends on the intensity of the distributive conflict. The stronger the opposition between workers and capitalists, the faster labour will translate participation rates into a higher wage-share. Firms, in turn, respond by increasing prices. The net result is an appreciation of the RER in levels that damages growth. A consequence of anaemic demand is firms hiring fewer workers to satisfy their sales prospects, thus, bringing employment rates down. When it comes to price and non-price competitiveness, they are both simultaneously determined. *Ceteris paribus*, fewer conflict societies are related to higher employment and greater price competitiveness. Notice that a similar result follows from a higher Kaldor-Verdoorn coefficient. It has been argued that κ is larger the higher the technological sophistication of the productive structure (for empirical support, see Romero and Britto, 2017). We show that more significant dynamic economies of scale allow firms in the fire country to compete in price terms. Furthermore, because of the structural change mechanism, relative prices influence non-price competitiveness in equilibrium.

Next, we turn to the investigation of the local stability properties of P. Applying the existence part of the Hopf bifurcation theorem (Gandolfo, 2009, pp. 479-483), we can state and prove the following Proposition:

Proposition 2 *The coefficients of the characteristic equation are positive as long as:*

$$\bar{\kappa} > \gamma\phi \tag{23}$$

The unique internal equilibrium solution is locally asymptotically stable in the region of the parameter space defined as:

$$(\bar{\kappa} - \gamma\phi)\, e \left[(1-\kappa)\, \sigma e \gamma\phi\theta + (\bar{\kappa} - \gamma\phi)\, e 2\beta\rho + 4\beta^2\rho^2\right] > (1-\kappa)\, z\zeta\gamma\phi e\theta\rho \tag{24}$$

If a change in one of the parameters determines the violation of this last condition, the characteristic equation possesses a pair of complex conjugate eigenvalues that become purely imaginary, while no other eigenvalues with zero real part exist. In this case, a Hopf bifurcation might occur and the system admits a family of periodic solutions.

Proof. See Mathematical Appendix A2. ■

Altogether, Propositions 1 and 2 provide, respectively, a *static* and *dynamic* representation of cumulative causation. In the first case, we refer to the determination of equilibrium and how price and non-price terms are determined simultaneously, taking into account the behaviour of firms and workers in the goods and labour markets. In the second case, it is shown that endogenous long-run cycles of structural change might emerge. Of course, the existence part of the Hopf bifurcation theorem leaves us in the dark regarding the nature of the periodic attractor. It may be unstable, in which case we refer to a sub-critical Hopf bifurcation; or it may be stable, resulting in the super-critical case.[6] Furthermore, from an economic point of view, the last condition in Proposition 2 is not very intuitive. Before proceeding, it is worth spending some time studying at least one particular case. Suppose the response of non-price competitiveness to the exchange rate is zero. This means we are blocking the structural change channel connecting price conditions to growth. We can state and prove the following Proposition:

Proposition 3 *When non-price competitiveness does not respond to the RER, i.e. $\zeta = 0$, the equilibrium solution $P = (e^*, \theta^*, \rho^*)$ is defined and given by:*

$$e^* = \frac{\gamma_0}{\gamma\phi}$$
$$\theta^* = \frac{\bar{\kappa}e^* - \kappa_0 + n}{(1-\kappa)\,\sigma}$$
$$\rho^* = 0$$

Furthermore, provided that condition (23) is satisfied, P is locally asymptotically stable.

Proof. See Mathematical Appendix A3. ■

We already anticipated that, in the model, $\zeta = 0$ implies $\rho^* = 0$. This result follows from the assumption that the autonomous component of μ_F only depends on RER, as in Eq. (20). We will come back to this point in the next Section when introducing the possibility of Schumpeterian innovation waves. Two additional findings are worth stressing. First, the internal equilibrium point is always locally stable. That is, blocking the structural change channel makes impossible the existence of long-run cycles of structural change. Such an outcome is important because shows that $\zeta > 0$ is a necessary condition for a dynamic representation of cumulative causation. Second, a strong response of exports to price conditions, σ, is related to a more appreciated equilibrium RER. Recall that, from Eq. (12), exports respond to stable prices over a certain time

[6] It is possible to demonstrate the direction of the limit cycle bifurcation analytically by relying on the first Lyapunov coefficient, l_1 (see Kuznetsov, 2004, pp. 157-194). When $l_1 > 0$, the basin of attraction of the stable focus is surrounded by an unstable cycle, characterising a sub-critical bifurcation. On the other hand, in the super-critical case, $l_1 < 0$, the stable focus becomes unstable and is surrounded by an isolated, stable closed orbit. However, the algebraic steps involved in the respective proof are quite tedious, and their economic interpretation is not straightforward. Hence, we rely on numerical simulations to determine the nature of the bifurcation.

horizon. In equilibrium, a high σ indicates that the RER required to match the rate of growth of the economy with the natural growth rate is lower. In the next Section, we present a numerical exercise to show that long-run cycles are stable and are not merely a formal curiosity, being very much likely to emerge for a combination of parameters in line with empirical evidence in the field.

4 Numerical simulations

In order to choose plausible values for the 11 parameters in the model, we have considered the evidence is given in several empirical studies. The behavioural relationship governing the rate of growth of labour productivity has been extensively estimated in the literature. There is a certain consensus that the Kaldor-Verdoorn coefficient, κ, lies in between 0.25 and 0.75 (e.g. McCombie et al., 2002; Romero and Britto, 2017). The magnitude of $\bar{\kappa}$ was chosen following Hein and Tarassow (2010) and Dávila-Fernández (2020). For the price and income elasticity of exports, we follow the extensive literature on Thirlwall's law that estimates the respective trade equations (e.g. Fagerberg, 1988; Romero and McCombie, 2016). As in Dávila-Fernández and Sordi (2019), in a stagnant economy with zero employment, labour productivity is assumed to fall at a rate of 0.01. For the behavioural equations capturing aspects of distributive conflict, we rely on the empirical literature on the growth-cycle (see Graselli and Maheshwari, 2018). Variables such as the growth rate of the rest of the world or the labour force were chosen in line with well-known macroeconomic trends.

In any case, we would like to emphasise that we are not actually calibrating a real economy, though implicitly we have a developing country in mind. The reported studies were used to have a baseline framework of the magnitudes involved:

$$z = 0.03,\ \sigma = 0.00525,\ \gamma_0 = 0.01,\ \gamma = 0.02,\ \phi = 1,\ n = 0.02$$

$$\beta = 0.02,\ \zeta = 0.04,\ \kappa_0 = 0.01,\ \kappa = 0.5,\ \bar{\kappa} = 0.03$$

such that in equilibrium:

$$(e^*, \theta^*, \rho^*) \approx (0.5; 0.85; 0.85)$$

and (24) is satisfied, i.e. the unique internal equilibrium solution is stable. Such a calibration is compatible with the fire country having an overvalued RER, $\theta^* < 1$.

Given the importance of labour productivity to Dixon and Thirlwall (1975) results, we are particularly interested in the role of dynamic economies of scale and structural change to the possibility of obtaining long-run cycles of structural change. Hence, in Fig. 1, we report, in panels (a) and (b), the 2-dimension bifurcation diagrams on ϕ, κ, and ζ. The first parameter captures the impact that increases in the employment rate have on distributive conditions. The second stands for the Kaldor-Verdoorn coefficient. Finally, ζ captures how price conditions affect non-price competitiveness and, for that reason, is taken as a proxy of a certain type of structural change. We define the following intervals:

$$\phi \in [0.75; 1.25],\ \kappa \in [0.25; 0.75],\ \zeta \in [0; 0.25]$$

The region in orange corresponds to the parameter set that results in a stable attractor, while in yellow we have those leading to periodic fluctuations. A dotted black line marks the Hopf bifurcation.

As an initial significant result, we would like to highlight the likelihood of the periodic solution to occur. When distributive conflict is sufficiently low, the equilibrium point is stable, no matter the magnitude of the Kaldor-Verdoorn coefficient or the RER's impact on the quality and differentiation of domestic production. However, as ϕ increases, we obtain a family of periodic solutions. Panel (c) presents a sort of 3-dimension bifurcation diagram. The plotted plane corresponds to the case condition (24) is satisfied with equality. For a combination of parameters above the plane, we have the dynamic system admits a periodic attractor while we obtain simple asymptotically stability below it.

To show that we are dealing with a super-critical Hopf bifurcation, Fig. 2 contrasts the case we have convergence to equilibrium, as in panel (a), to the emergence of a stable orbit around the equilibrium point in panel (b). In the first of them, we adopted our baseline calibration set of parameters. As for the second, the only modifications consist in $\kappa = 0.4$ and $\phi = 1.1$. Initial conditions are given by:

$$(e_0, \theta_0, \rho_0) = (e^* \pm 0.1, \theta^* \pm 0.1, \rho^* \pm 0.1)$$

so that we represent a situation in which we start above and below the equilibrium point. Cycles are clock-wise oriented with decreasing amplitude in panel (a). On the other hand, panel (b) indicates that both initial conditions converge to a unique orbit.[7]

Fig. 3 evaluates the robustness of the cycle to marginal changes in our parameters of interest. Panel (a) contrasts the cases in which $\kappa = 0.375$ and $\kappa = 0.4$, using our baseline parameter set up with the exception of $\phi = 1.1$. It is possible to appreciate that a reduction in the magnitude of the economies of scale is related to a more volatile system. This result suggests that countries with a small modern sector might become more prone to experience a sequence of high and low growth episodes with price and non-price competitiveness varying more over time. In panel (b), we plot the correspondent time-series of the rate of growth of output, calculated using Eq. (14). The dotted lines stand for the respective averages. We confirm that differences in terms of the equilibrium point are minor, though the same cannot be said about the magnitude of the oscillations. Variations in the long-run rate of growth of the economy, y_{bp}, are in line with the concept of cycles of structural change as well as recent empirical evidence on Thirlwall's law that applies time-varying parameters estimation techniques (see the seminal contribution by Felipe and Lanzafame, 2020).

We proceed by comparing $\phi = 1$ and $\phi = 1.11$, in panels (c)-(d), maintaining our standard calibration scenario, except $\kappa = 0.4$. As expected, a more intensive distributive conflict is related to greater oscillations, which is confirmed in terms of the rate of growth compatible with equilibrium in the balance-of-payments. Such an outcome follows basically because income distribution embeds firms response to the state of the labour market, both in terms of price and the search for labour-saving production techniques. The stronger this response is, the stronger vari-

[7] An important difference between the Hopf bifurcation, in continuous time, and the Neimark-Saker bifurcation, in discrete time, is that whereas the invariant limit cycle originating from the former consists of a single orbit, in the latter, there exist many different orbits. Our model was conceive in continuous time and, thus, we find ourselves in the first case. For a comprehesive introduction to both types of bifurcations, see Medio and Lines (2001).

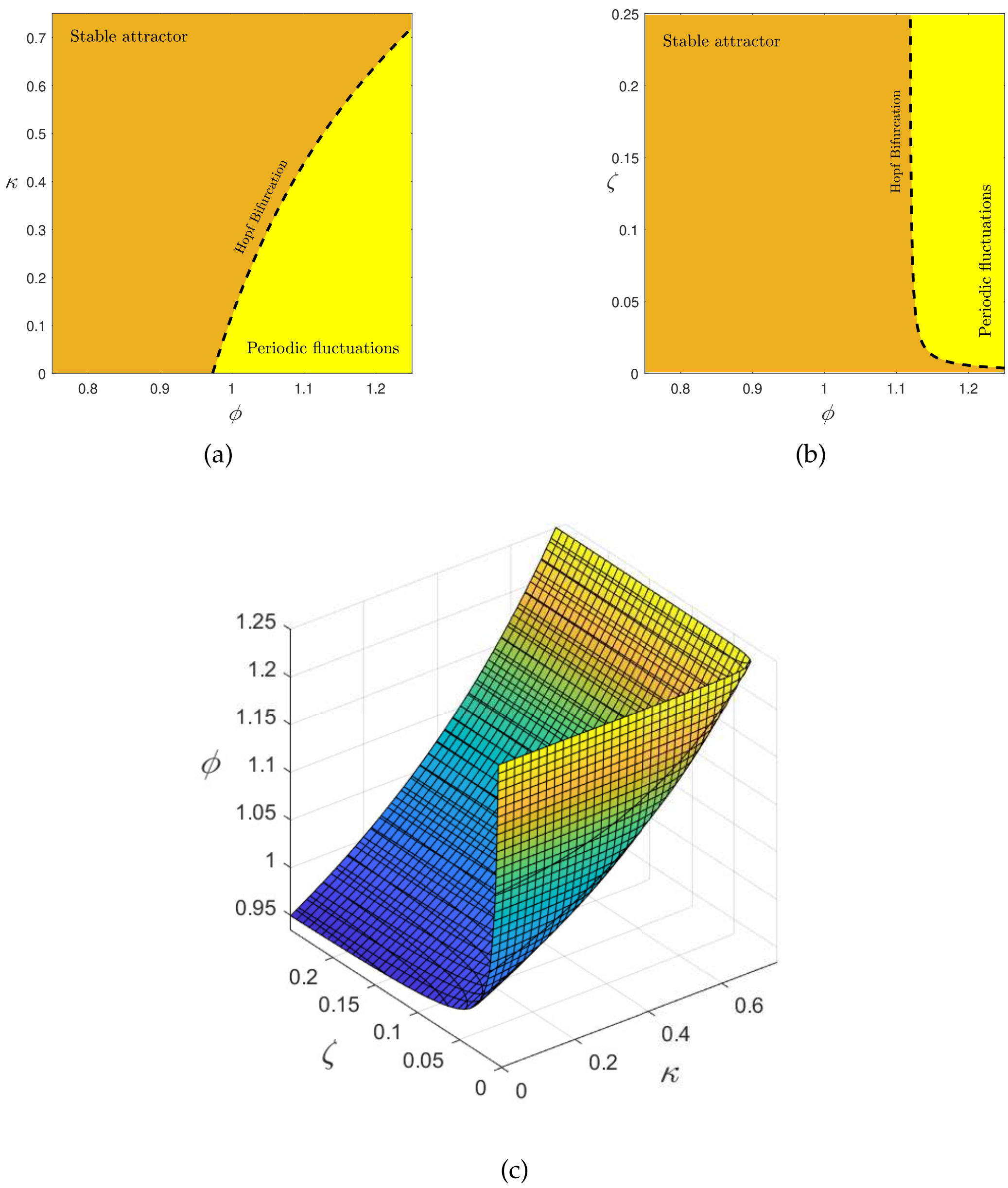
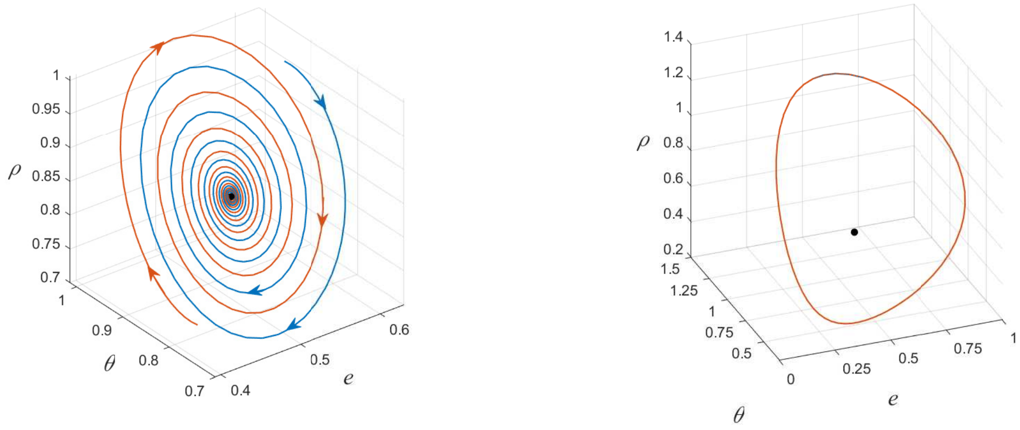


Figure 1: 2D and 3D bifurcation diagrams.



(a) (b)

Figure 2: Emergence of endogenous cycles of structural change. In panel (a) we have $\kappa = 0.5$ and $\phi = 1$ while, in panel (b), $\kappa = 0.4$ and $\phi = 1.1$.

ations in price and non-price competitiveness will be, impacting growth. Finally, panels (e)-(f) focus on the role of structural change as captured by ζ. Increasing the response of non-price to price factors does not seem to have a major impact on the orbit's size. Nonetheless, we observe important effects in the determination of the equilibrium point. A higher ζ means that a stable RER can induce more effectively increases in the quality of goods and services exported by the fire economy. As a result, we report a Pareto-superior equilibrium solution in terms of growth rates through non-price competitiveness.

The structure above allows us to differentiate between two main forces. As for the first, it consists of a dynamic representation of cumulative causation. An increase in the rate of growth of exports leads firms to increase production to match what is, in the context of this model, the only source of autonomous non-capacity creating aggregate demand. Because of dynamic economies of scale, a higher rate of growth results in higher labour productivity. *Ceteris paribus*, however, firms are able to produce more with fewer workers, reducing the participation rate. At this point, the bargaining power of workers deteriorates as well as their fall-back position. Distributive conflict slows down, followed by a reduction in the rate of inflation. The RER will depreciate, damaging growth through the direct aggregate demand channel. However, it impulses exports through two additional mechanisms: on the one hand, a more depreciated currency in levels for a sufficiently long time horizon allows firms to better plan their incursion into foreign markets; on the other hand, there is a process of structural change that allows domestic firms to gain non-price competitiveness. In both cases, exports are foster, characterising the explosive nature of cumulative causation:

$$\uparrow \frac{\dot{X}}{X} \Rightarrow\uparrow \frac{\dot{Y}}{Y} \Rightarrow\uparrow \frac{\dot{q}}{q} \Rightarrow \begin{cases} \uparrow \theta \Rightarrow\uparrow \dot{X}/X \\ \\ \uparrow \dot{\theta}/\theta \Rightarrow\downarrow \dot{Y}/Y \end{cases}$$

As a stabiliser of the system, the second force comes from the labour market. Let us think again in terms of an initial increase in the rate of growth of exports. The resulting output expansion is necessarily related to a higher employment rate because firms need to hire more workers

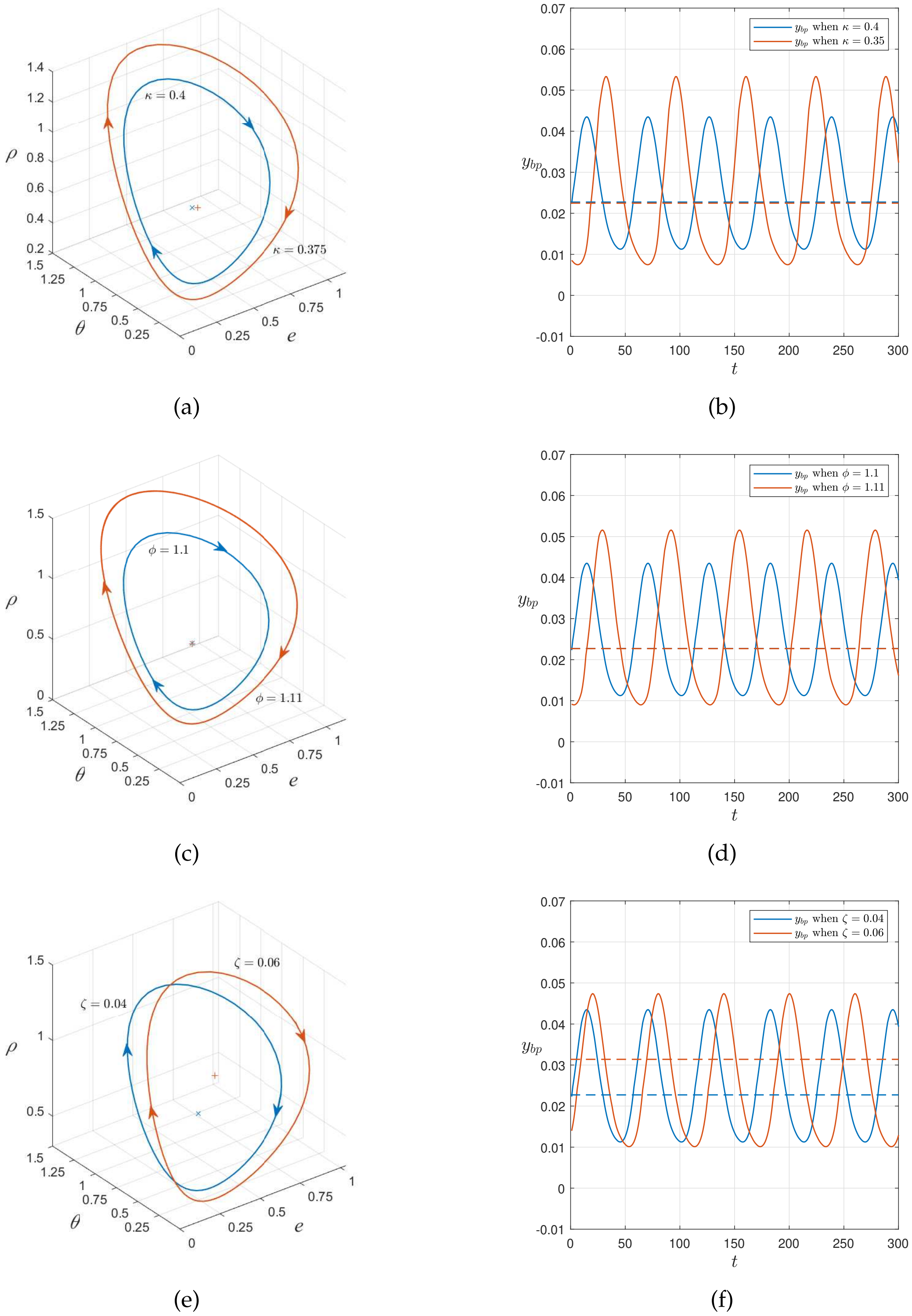


Figure 3: Robustness of the periodic attractor. Symbols $+$ and $*$ stand for the respective equilibrium points.

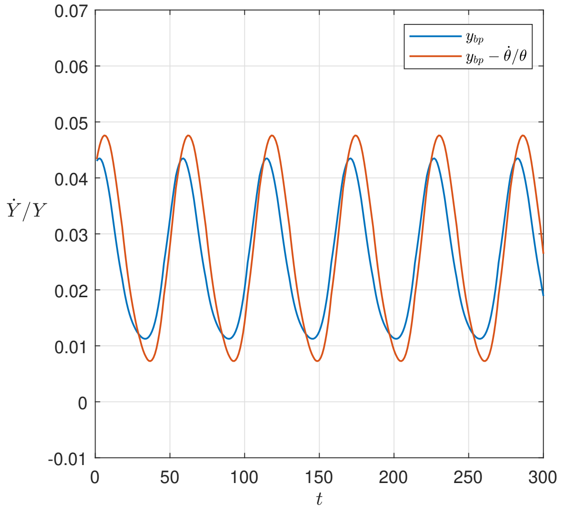


Figure 4: Comparing rates of growth with and without exchange rate variations.

to match expanding demand. As the labour market tightens, some sectors start to experience labour shortages, hand in hand with improved workers' bargaining power. Firms react in two different ways. If they increase their search for labour-saving production techniques, labour productivity improves, and we are back to the scenario described in the previous paragraph. However, to protect profit margins, they could increase prices. Higher inflation in the fire economy will appreciate the RER. During the overvaluation process, economic performance will improve through the aggregate demand channel. Nonetheless, the reduction in price competitiveness in levels will negatively impact the export plan horizon of the firm and structural change through non-price competitiveness. The following reduction in exports stabilises the initial impulse:

$$\uparrow \frac{\dot{X}}{X} \Rightarrow \uparrow \frac{\dot{Y}}{Y} \Rightarrow \uparrow e \Rightarrow \uparrow \varpi \Rightarrow \begin{cases} \downarrow \theta \Rightarrow \downarrow \dot{X}/X \\ \\ \downarrow \dot{\theta}/\theta \Rightarrow \uparrow \dot{Y}/Y \end{cases}$$

such that endogenous long-run cycles of structural change result from the interaction between these two mechanisms.

It is possible to compare the time-series of two different rates of growth. The first, in orange, is computed using Eq. (13), and corresponds to the out of equilibrium growth rate compatible with equilibrium in the balance-of-payments. The second, in blue, is its steady-state equivalent, which rules out the possibility of everlasting RER appreciations or depreciations. It was calculated as in Eq. (14). Fig. 4 depicts both and shows the former is more volatile than the latter, which intuitively makes sense. Even though the distinction might sound subtle, the mechanisms discussed throughout the paper rely on it. This is because distributive conflict depends on growth without disregard variations of the exchange rate, while Kaldor-Verdoorn's law was supposed not to depend on such medium-term dynamics. Overall, we consider the differentiation between RER in levels and variation rates is an important one, and that both should be incorporated altogether into demand-led growth models.

In recent decades, developing countries such as Argentina and Brazil have been experiencing a sharp process of deindustrialisation and negative structural change (see Palma, 2008;

Rodrik, 2016). Moreover, there is an ongoing discussion on how the rise of China in the international arena might have deepened this phenomenon (e.g. McMillan et al., 2014). Our findings could help to explain some of these patterns. Between the 1950s and the 1980s, Latin America (LA) adopted an industrialisation strategy based on Import-substitution while Asia followed a manufacturing Export-led growth model, with incentives to competition and innovation. The liberalisation reforms of the 1990s were also different in nature, with Asia promoting competitiveness and LA more concerned with maintaining the status quo. The successful strategy of the former region has allowed the consolidation of a modern sector with higher dynamic economies of scale and smoother distributive conflict. Indeed, contrasting the two regions, LA presents (i) a tendency for a more appreciated RER, (ii) lower non-price competitiveness, (iii) lower growth, (iv) lower dynamic economies of scale, (v) greater volatility. Our model is compatible with such stylised facts while distinguishing between adverse currency devaluations and the positive implications of a more depreciated RER.

The oscillations presented so far are of periodic motion. This fact, of course, is at odds with empirical evidence, which indicates the existence of irregular fluctuations, even in terms of the long-run rate of growth. For example, Felipe and Lanzafame (2020) have recently estimated y_{bp} for China applying time-varying parameter estimation techniques. They showed that the export-led framework fits well the experience of that country and that the rate of growth compatible with equilibrium in the balance-of-payments depicts aperiodic cycles of 10-15 years. As a final step, we show that the model developed in the present paper is compatible with those findings. Following Goodwin's (1951) insight that Schumpeterian innovations require investment to occur periodically, we suppose these technological waves impact the autonomous component of non-price competitiveness:

$$\beta_{\mu_F} = \zeta\theta + \psi\cos(\bar{\psi}t) \tag{25}$$

where ψ and $\bar{\psi}$ determine the shape of the respective waves. A higher value of the former is related to more robust effects on β_{μ_F}, while a greater $\bar{\psi}$ is associated with innovation waves of shorter length.

The modification above changes the nature of the dynamic system that becomes non-autonomous. A "natural" oscillation frequency interacts with an external "force" and it may results in more complex dynamics (for a similar application, see Dávila-Fernández and Sordi, 2019). Given that this paper is concerned with long-run cycles of structural change, in our numerical simulations, Schumpeterian innovations are supposed to be very slow in motion with overall minor effects:

$$\psi = 0.01, \ \bar{\psi} = 0.04$$

which is in line with the magnitudes of the remaining calibration parameters.

The view that countries are influenced irreversibly by how they have changed in the past is commonly referred to in economics as path dependence. An intuitive way to assess if the model is compatible with such a property consists in verifying whether it exhibits sensitivity to initial conditions. In fact, a dynamic system can be considered to present hysteretic behaviour when the trajectories of the endogenous variables exhibit some sort of path dependency (for a discussion, see Dosi et al., 2018). Fig. 5, panel (a), reports the emergence of a chaotic attractor in the 3-dimensional phase space when we use Eq. (25) instead of (20). Panel (b) shows how very similar initial conditions in the beginning move together but eventually result in entirely different growth trajectories, representing the statement "history matters". We thus obtain persistent and irregular fluctuations similar to those observed in real data. The long-run rate rate of growth is endogenous to price and non-price conditions that are simultaneously determined as labour and goods markets interact.

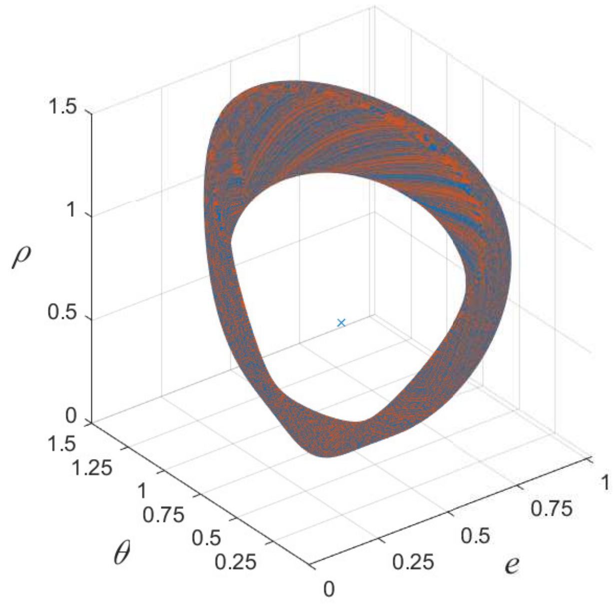
5 Final considerations

Development economists have been concerned for some time now about the role of the RER for economic growth. The existing empirical evidence suggests a positive relationship between price competitiveness in levels and economic performance. Currency devaluations, however, damage growth. While these two elements have been separately incorporated into demand-led growth theories, to the best of our knowledge, a comprehensive assessment of the interaction between them is still missing. This article filled a gap in the literature by presenting a stylised export-led growth model in which price and non-price competitiveness respond to the level and variation of the real exchange rate.

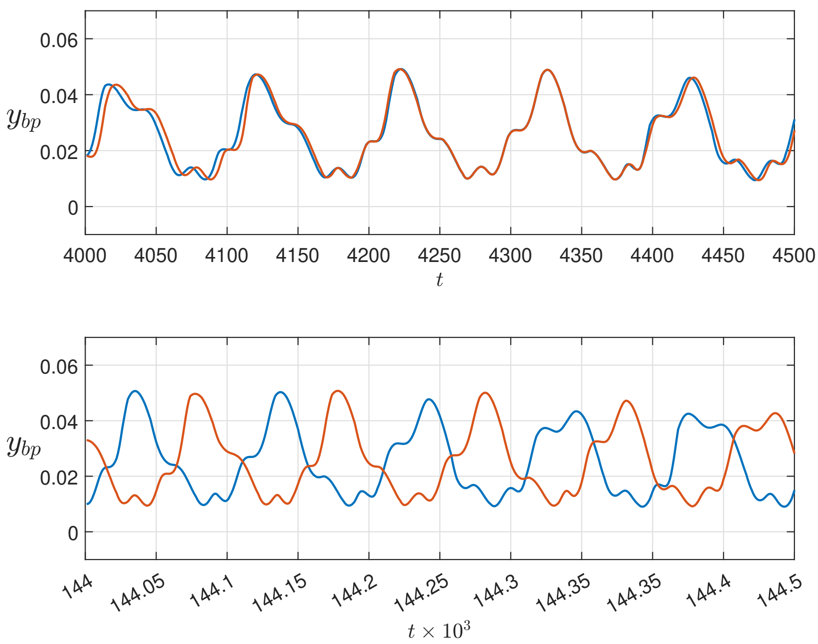
For more than thirty years, the *static* cumulative causation model by Dixon and Thirlwall (1975) has offered a baseline framework for studying the RER-growth correspondence. We have, in turn, provided a novel *dynamic* representation, allowing for the interplay between the two dimensions of competitiveness with the labour and goods market. The world was divided into two regions, *ice* and *fire*, open to international trade, that produce goods and services which are imperfect substitutes. It was shown that, in equilibrium, the RER and the capacity of the productive structure to respond to changes in foreign demand are simultaneously determined. A more depreciated RER and higher non-price competitiveness are associated with higher growth through exports. Firms hire more workers to match demand, raising the steady-state employment rate.

Still, by applying the existence part of the Hopf bifurcation theorem, we showed that endogenous cycles of structural change are likely to arise. These long-run fluctuations mean that the economy is never in a state of rest. The level of distributive conflict is crucial for such slow motion waves to appear. A combination of a strong response of income distribution to the rate of employment with a low Kaldor-Verdoorn coefficient increases the system's volatility. Given that developing economies such as Argentina or Brazil, in which there is an ongoing deindustrialisation process, are likely to experience higher conflict over the distribution of income and reduced dynamic economies of scale, our findings could help to explain their fraught performance. In more general terms, contrasting Latin America and Asia, the former region presents (i) recurrently overvalued RER, (ii) lower non-price competitiveness, (iii) lower growth, (iv) lower dynamic economies of scale, (v) greater volatility. The model developed in this paper is compatible with such broad stylised facts.

Finally, we provided a detailed description of the interplay between two different forces behind the emergence of the periodic attractor. On the one hand, the labour market works as a stabiliser, either through firms' increasing their search for labour-saving production techniques or raising domestic prices. On the other hand, the goods market embeds cumulative causation supported by structural change in which quality and product differentiation are non-neutral to



(a)



(b)

Figure 5: Path dependence when $\beta_{\mu_F} = \zeta\theta + 0.01\cos(0.04t)$. Initial conditions (i) $(e_0, \theta_0, \rho_0) = (0.625; 0.95; 0.95)$, in blue, and (ii) $(e_0, \theta_0, \rho_0) = (0.6251; 0.95; 0.95)$, in orange.

relative prices. Thus, as the economy grows faster, labour productivity increases through the Kaldor-Verdoorn effects, allowing for reduced prices that depreciate the RER. The depreciation in itself damages growth but, over a certain time horizon, a more depreciated exchange rate allows firms to plan their incursion in foreign markets better and fosters structural change. Introducing periodic Schumpeterian innovation waves generate irregular long-run fluctuations and sensitivity to initial conditions, providing a representation of the statement "history matters".

A Mathematical appendix

A.1 Proof of Proposition 1

To prove Proposition 1, recall the equilibrium conditions are given by:

$$\begin{aligned} 0 &= \left[(1-\kappa)\left(\rho z + \sigma\theta\right) - \bar{\kappa} e + \kappa_0 - n\right] e \\ 0 &= \left[\gamma_0 - \gamma\phi e\right]\theta \\ 0 &= \left[-2\beta\rho + \zeta\theta\right]\rho \end{aligned}$$

Ruling out the trivial case in which $e = \theta = \rho = 0$, we have that:

$$\rho z + \sigma\theta = -\kappa_0 + \kappa\left(\rho z + \sigma\theta\right) + \bar{\kappa} e + n \tag{A.1}$$

$$\gamma\phi e = \gamma_0 \tag{A.2}$$

$$2\beta\rho = \zeta\theta \tag{A.3}$$

It immediately follows from Eq. (A.2):

$$e^* = \frac{\gamma_0}{\gamma\phi} \tag{A.4}$$

Furthermore, notice that, rearranging Eq. (A.3):

$$\rho = \frac{\zeta\theta}{2\beta} \tag{A.5}$$

Substituting Eqs. (A.4)-(A.5) into (A.1), and solving simultaneously to θ and ρ, we have:

$$\begin{aligned} \theta^* &= \frac{\bar{\kappa} e^* - \kappa_0 + n}{(1-\kappa)\left(\frac{\zeta z}{2\beta} + \sigma\right)} \\ \rho^* &= \frac{\zeta\theta^*}{2\beta} \end{aligned}$$

A.2 Proof of Proposition 2

To prove Proposition 2, we linearise the dynamic system around the internal equilibrium solution, P:

$$\begin{bmatrix} \dot{e} \\ \dot{\theta} \\ \dot{\rho} \end{bmatrix} = \underbrace{\begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & 0 & 0 \\ 0 & J_{32} & J_{33} \end{bmatrix}}_{\text{J}} \begin{bmatrix} e - e^* \\ \theta - \theta^* \\ \rho - \rho^* \end{bmatrix}$$

where

$$J_{11} = \left.\frac{\partial g_1(e,\theta,\rho)}{\partial e}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = -(\bar{\kappa}-\gamma\phi)\, e \gtreqless 0$$
$$J_{12} = \left.\frac{\partial g_1(e,\theta,\rho)}{\partial \theta}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = (1-\kappa)\,\sigma e > 0$$
$$J_{13} = \left.\frac{\partial g_1(e,\theta,\rho)}{\partial \rho}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = (1-\kappa)\, ze > 0$$

$$J_{21} = \left.\frac{\partial g_2(e,\theta,\rho)}{\partial e}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = -\gamma\phi\theta < 0$$
$$J_{22} = \left.\frac{\partial g_2(e,\theta,\rho)}{\partial \theta}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = 0$$
$$J_{23} = \left.\frac{\partial g_2(e,\theta,\rho)}{\partial \rho}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = 0$$

$$J_{31} = \left.\frac{\partial g_3(e,\theta,\rho)}{\partial e}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = 0$$
$$J_{32} = \left.\frac{\partial g_3(e,\theta,\rho)}{\partial \theta}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = \zeta\rho > 0$$
$$J_{33} = \left.\frac{\partial g_3(e,\theta,\rho)}{\partial \rho}\right|_{e=e^E,\theta=\theta^E,\rho=\rho^E} = -2\beta\rho < 0$$

are the elements of the Jacobian matrix, J.

The characteristic equation is:

$$\lambda^3 + b_1\lambda^2 + b_2\lambda + b_3 = 0$$

where its coefficients are define and given by

$$\begin{aligned} b_1 &= -\mathrm{tr}J \\ &= -J_{11} - J_{33} \\ &= (\bar{\kappa}-\gamma\phi)\, e + 2\beta\rho \end{aligned} \tag{A.6}$$

$$\begin{aligned} b_2 &= \begin{vmatrix} J_{11} & J_{12} \\ J_{21} & 0 \end{vmatrix} + \begin{vmatrix} J_{11} & J_{13} \\ 0 & J_{33} \end{vmatrix} + \begin{vmatrix} 0 & 0 \\ J_{32} & J_{33} \end{vmatrix} \\ &= J_{11}J_{22} - J_{12}J_{21} + J_{11}J_{33} + J_{22}J_{33} \\ &= (1-\kappa)\,\sigma e\gamma\phi\theta + (\bar{\kappa}-\gamma\phi)\, e2\beta\rho \end{aligned} \tag{A.7}$$

$$
\begin{aligned}
b_3 &= -\det J \\
&= -\begin{vmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & 0 & 0 \\ 0 & J_{32} & J_{33} \end{vmatrix} \\
&= -J_{13}J_{21}J_{32} + J_{12}J_{21}J_{33} \\
&= (1-\kappa)\, ze\gamma\phi\theta\zeta\rho + 2\,(1-\kappa)\,\sigma e\gamma\phi\theta\beta\rho \\
&= (1-\kappa)\,(z\zeta + 2\sigma\beta)\,\gamma\phi e\theta\rho
\end{aligned} \tag{A.8}
$$

It immediately follows that the coefficients of the characteristic equation are positive as long as:

$$\bar{\kappa} > \gamma\phi$$

such that b_1, b_2, and $b_3 > 0$.

The sufficient condition for the local stability of (e^*, θ^*, ρ^*) is that all roots of the characteristic equation have negative real parts, which, from Routh-Hurwitz criteria, further requires:

$$b_1 b_2 - b_3 > 0 \tag{A.9}$$

Substituting Eqs. (A.6)-(A.7) into (A.9), we find that the unique internal equilibrium solution is stable as long as:

$$
\begin{aligned}
b_1 b_2 &> b_3 \\
(\bar{\kappa} - \gamma\phi)\, e \left[(1-\kappa)\,\sigma e\gamma\phi\theta + (\bar{\kappa} - \gamma\phi)\, e2\beta\rho + 4\beta^2\rho^2\right] &> (1-\kappa)\, z\zeta\gamma\phi e\theta\rho
\end{aligned}
$$

If a change in one of the parameters determines the violation of (A.9) such that $b_1 b_2 - b_3 = 0$, the characteristic equation possesses a pair of complex conjugate eigenvalues that become purely imaginary at the critical value of the parameter, while no other eigenvalues with zero real part exist. In this case, a Hopf bifurcation might occur. To complete the proof, we need to verify whether the derivative of the real part of the complex eigenvalues with respect to the bifurcation parameter is different from zero at the critical value, i.e. the so-called transversality condition. Given that in the paper we are interested in three crucial parameters, this makes the algebraic steps of the last part of the proof very long and with little economic content (they are still available under request). Therefore, we rely instead on numerical simulations to show that a super-critical Hopf bifurcation occurs.

A.3 Proof of Proposition 3

To prove Proposition 3, we proceed in two steps. First, recall that, from Proposition 1, P is defined and given by:

$$e^* = \frac{\gamma_0}{\gamma\phi}$$
$$\theta^* = \frac{\bar{\kappa}e^* - \kappa_0 + n}{(1-\kappa)\left(\frac{\zeta z}{2\beta} + \sigma\right)}$$
$$\rho^* = \frac{\zeta\theta^*}{2\beta}$$

Substituting $\zeta = 0$, it immediately follows that:

$$e^* = \frac{\gamma_0}{\gamma\phi}$$
$$\theta^* = \frac{\bar{\kappa}e^* - \kappa_0 + n}{(1-\kappa)\,\sigma}$$
$$\rho^* = 0$$

Finally, notice that ζ only appears on the right side of condition (24). This implies that the latter is always satisfied. Thus, a Hopf bifurcation cannot occur.

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