DISSERTATION

ESSAYS ON SECULAR STAGNATION, INCOME AND WEALTH DISTRIBUTION, AND EMPLOYMENT

Submitted by

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In partial fulfillment of the requirements

For the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Summer 2023

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ABSTRACT

ESSAYS ON SECULAR STAGNATION, INCOME AND WEALTH DISTRIBUTION, AND EMPLOYMENT

After the publication of Piketty's *Capital in the XXI Century* and Robert Gordon's *The Rise and Fall of American Growth*, mainstream economics has shifted its attention to the distribution of income and wealth and how they interact with economic growth. This dissertation focuses on the interaction between distribution and secular stagnation, as well as the ultimate long run effects on employment at the macro level. The first chapter empirically investigates the short -and long- run interaction between labor productivity and real wages and their ultimate impact on the labor market for a panel of 25 OECD countries. The second chapter presents a theoretical and empirical model of secular stagnation, income and wealth distribution, and employment in the Classical-Marxian tradition. In this model, institutional or technological shocks to income distribution lower the wage share, increase wealth inequality and decrease the income-capital ratio in the long run. The ultimate effect on long run employment depends on the relative strength of the response of labor-augmenting technical change vis-à-vis the response of real wage growth to labor market institutions. An empirical test of the model using time-series data for the US (1960-2019) appears to support its main implications. The third chapter extends the second chapter's model by endogenizing the growth rate of the labor force to employment in an open economy. The model is more appropriate for economies at the low or middle stages of development, where the labor force depends significantly on demographic factors like high variations in the birth rate or immigration. I then empirically test the model using time-series data from China (1990-2019) and India (1970-2019) to validate the framework.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to God, who was always with me in this process, and without Him, nothing in my life would be possible. I also sincerely thank my doctoral committee, which consists of Dr. Daniele Tavani, Dr. Ramaa Vasudevan, Dr. Elissa Braunstein, and Dr. Stephen Koontz, for your valuable guidance and comments that made completing my doctoral dissertation possible.

In particular, I extend special thanks to my doctoral advisor, Dr. Daniele Tavani, an outstanding advisor and professor and a wonderful human being. I feel honored to have been his advisee and student, and I think any student would feel very fortunate to have his academic guidance. From the day I went to his office to ask him to be my doctoral advisor, Dr. Daniele was always very kind and patient. I thank Dr. Daniele for believing in me and his time and effort in guiding me academically. I would also like to point out that my second doctoral chapter, "Secular Stagnation: A Classical-Marxian View," was co-authored with Dr. Daniele Tavani. Likewise, my third doctoral chapter, "Income Distribution, Wealth Inequality, and Growth in Labor Abundant Economies: A Classical Model," which is an extension of the second chapter, had significant input from Dr. Daniele Tavani.

To my dear classmates and friends, thank you very much for the study hours we spent together and the several lovely informal meetings we had outside of class. You were my second family during these years.

And I thank Colorado State University for its excellent organization and inclusive and diverse environment, which made me feel in a safe and pleasant space from my first day of classes. That is something I will always greatly appreciate.

DEDICATION

I dedicate this dissertation to my beloved family: my father, Manuel Zenadio Cruz Padilla; my mother, Maria de Jesus Luzuriaga Villarreal; my three sisters: Maria Isabel Cruz, Priscila Cruz, and Paola Cruz; my brother-in-law, Juan Ariel Hurtado; my nephew, Josue Cruz; my niece, Daniela Cruz; my niece, Danna Hurtado; and my nephew, Juan Manuel Hurtado. I am immensely blessed to have such a loving family; the love that binds us together goes beyond space-time.

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Chapter 1

Labor Productivity, Real Wages, and Employment in OECD Economies

1.1 Introduction

This paper provides an empirical investigation of the relationship between labor productivity (LP), real wages (RW), and employment (EMP) in a panel of OCED countries. The ultimate goal is to evaluate competing theories of growth and distribution. According to classical political economy -especially the classical-Marxian theory of induced technical change (Foley et al., 2019, Ch. 7)- as well as post-Keynesian economics, changes in RW should cause LP to increase. Rising RW reduces profitability, inducing profit-seeking capitalist firms to invest in labor-saving technical changes to decrease the share of wages in total costs. In heterodox theories, economists working in the classical-Marxian and post-Keynesian traditions have explored the implications of induced technical change for the relationship between income distribution and LP. The idea of induced technical change originated with Hicks (1932), according to whom firms would have incentives to save on a production factor if their share in the firms' cost increased. Kennedy (1964) formalized this idea and showed that a rising share of wages in a firm's cost would result in a stronger bias toward labor. Recently, induced technical change has witnessed a comeback: Foley (2003), Julius (2005), Tavani (2012a, 2013a), and Zamparelli (2015) are some examples of recent literature in this vein. Thus, one of the questions of this work is to test whether OECD economies as a group have adopted labor-saving technologies to respond to changes in average labor costs.

My results show a positive association running from RW to LP and vice versa, suggesting evidence of induced technical change in the OECD economies in the last decades since increased labor compensation might have sustained LP growth, further raising RW and living standards. This positive relationship from RW to LP would indicate that rising labor costs have incentivized these economies to incorporate labor-saving technological innovation, raising output per hour worked. For its part, the positive association from LP to RW is required to maintain a constant labor share in balanced growth, therefore matching the Kaldor (1955) stylized facts. It also supports the bargaining theory, which can coexist with the inclusion of induced technical innovations (Tavani, 2012a, 2013a) and efficiency wages theory.

This bidirectional relationship between LP and RW does not appear to back the marginal productivity theory, where unidirectional causality from LP to RW is enough to ensure that the wage share remains constant in the long run. It is an essential result of this paper. Suppose one takes the neoclassical growth model seriously. In that case, LP will grow exogenously to maintain a constant wage share in the long run, and RW must grow at the same rate. Therefore, the marginal theory predicts unidirectional causality between LP and RW. Vice versa, classical-Marxian-induced bias in technical change indicates that increases in a measure of distribution (RW in this case) should induce firms to adopt more labor-saving technologies, thus increasing LP. However, for the wage share to remain constant in the long run, RW must grow in line with LP. Therefore, the empirical results lend support for the induced technical change hypothesis over the neoclassical theory.

A second relevant question addressed in this paper is whether increases in LP or RW growth occur at the expense of EMP or not. With a downward-sloping labor demand curve, the effect of exogenous increases in RW should be negative, at least in the short run. But if LP eventually keeps up with rising RW, so that unit labor costs do not change, the effect on EMP might vanish in the long run. On the other hand, labor-saving technical change that increases LP may either generate job destruction or job creation in the long run. It is plausible to expect job destruction temporarily, but labor reallocation may offset the initial adverse effects of rising LP on EMP in aggregate terms.

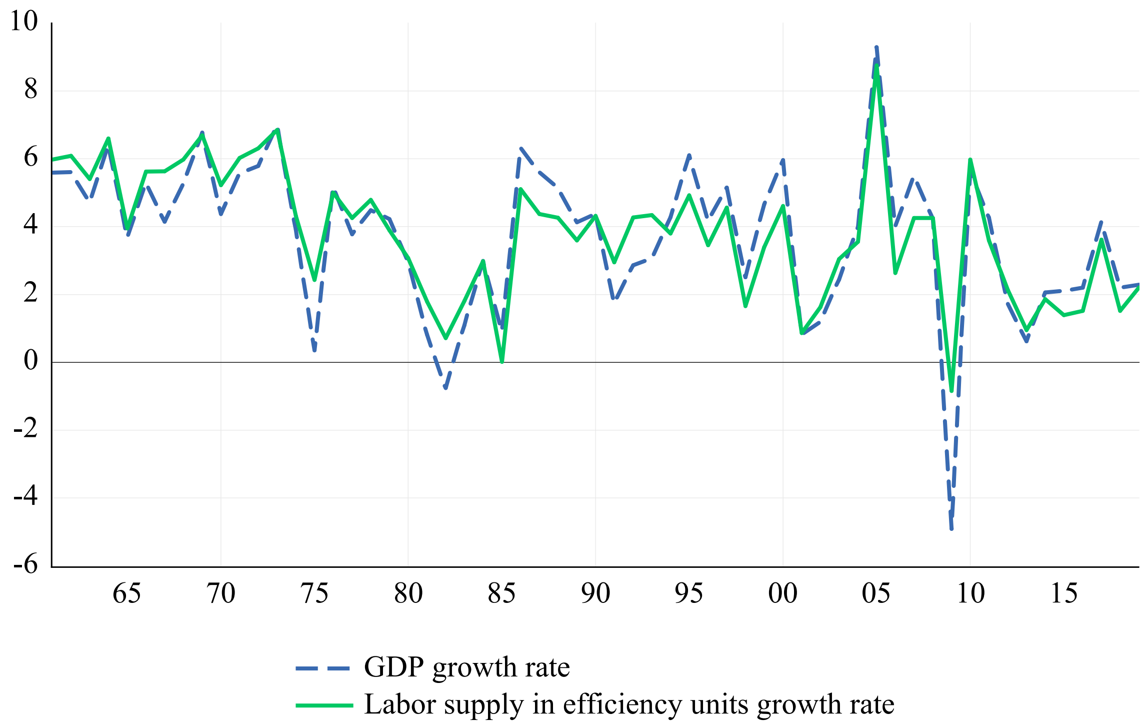
I empirically found that EMP is weakly exogenous in this three-variable system (Tables 2 and 3), so other factors different from LP and RW mainly explain its long run trajectory, supporting evidence that OECD countries have been labor-constrained -with a weakly exogenous employment-to-population ratio in balanced growth- as a group for the period under analysis. It is the second key finding of this paper.

Another fact that supports labor constraints in OECD countries is that these economies appear to be in a mature stage for the period under analysis, where the long run growth rate of a mature economy is constrained by labor supply in efficiency units (Skott et al., 2022). Figure 1.1 shows that OECD economies significantly fit a long run Harrodian balanced growth condition, $g = \alpha + n$, where the left-hand side (g) is the GDP growth rate, and the right-hand side is the labor supply in efficiency units, equal to the labor productivity growth (α) plus the growth rate of the labor force (n). The coefficient of correlation between the GDP growth rate and the growth rate of the effective labor force in OECD economies is 0.91 on average.[1]

Thus, the interrelation between LP, RW, and EMP is complex, and several economic theories explain the causality from each of them to the others based on different theoretical frameworks. (See Table 1.1). Moreover, their effects could be positive, negative, or ambiguous, depending on the economy, sector, and temporal horizon under analysis. Knowing the responses of these variables to the other ones' changes is a significant input for economic policy decisions in the labor market.

The paper is organized as follows. Section 1.2 provides a brief literature review on LP, RW, and EMP. Section 1.3 outlines the data and methodology used to estimate each variable's short and long run effects on the others. Section 1.3.2 reports the empirical results, sensitivity analyses, and robustness checks. Section 1.5 concludes.

[1] The coefficients of correlation for every country are Australia (0.83), Austria (0.74), Belgium (0.92), Canada (0.82), Chile (0.89), Colombia (0.85), Denmark (0.77), Finland (0.85), France (0.88), Germany (0.85), Iceland (0.91), Ireland (0.81), Italy (0.88), Japan (0.96), Luxembourg (0.97), New Zealand (0.77), Norway (0.98), South Korea (0.92), Spain (0.67), Sweden (0.82), Switzerland (0.92), The Netherlands (0.89), The United Kingdom (0.79), The United States (0.47), and Türkiye (0.93).



Notes: The series are obtained from Penn World Table 10.01 and correspond to the sample's average of the 25 OECD countries. For Real GDP, I used *rgdpo*. Labor supply in efficiency units growth rate is the summation of labor productivity growth and labor force growth. Labor productivity per hour is calculated by the following formula: $100 * (rgdpo/emp) * (1/avh)$. The labor force is proxied by the series *pop*, the total population. All series are expressed in percentage points. For the following countries, the period considered was shortened due to the availability of data: Iceland (1966-2019); and Luxembourg, New Zealand, and Türkiye (1971-2019).

Figure 1.1: GDP growth and labor supply in efficiency units growth rates, 1961-2019

1.2 Related Literature

An important question unaddressed in the literature that only analyzes the LP-RW nexus without considering the labor market is whether increasing RW and corresponding LP changes imply job creation or job destruction on balance: whether EMP rises or falls when workers get more productive. For instance, an increase in LP could have an ambiguous effect on EMP because greater efficiency would reduce labor demand or because a higher output would encourage firms to hire more workers due to a potential demand expansion. Conversely, lower EMP could incentivize workers to increase their

Table 1.1: Causality among labor productivity, real wages, and employment

Causality	Sign	Theory
LP → EMP	$(-)$	Efficiency gains lead to a reduction in labor demand
	$(+)$	Positive output effect on employment
LP → RW	$(+)$	Bargaining theory Marginal productivity theory
RW → LP	$(+)$	Induced technical change Shirking model Fairness model Adverse selection model Turnover model
RW → EMP	$(-)$	Higher labor cost causes labor substitution
EMP → LP	$(-)$	Less productive workers are fired first Workers increase effort to secure jobs
EMP → RW	$(+)$	Higher labor demand implies an increase in labor prices

Source: Own elaboration, adapted and extended from Wakeford (2004).

effort to secure their jobs. And concerning the RW-EMP nexus, an RW increase raises labor costs causing factor substitution, so a decrease in EMP.

In the same way, an EMP increase would strengthen union bargaining power, leading to growth or maintaining workers' compensation in most cases. Consequently, like in the LP and RW analysis case, in the LP-RW-EMP relationship, several authors have reached different conclusions in the interaction of these three variables, depending on the economy and sector investigated, the period covered, and the econometric approach used.

Regarding the long run relationship between LP and EMP and LP and RW, Bhattacharya et al. (2011) examined the Indian manufacturing sector performing single-equation approaches ECM and FMOLS. These authors determined that LP-RW and LP-EMP are panels cointegrated for all industries and show unmistakable evidence of increasing EMP and RW boost LP for periods 1973-1974 and 1999-2001. Habanabakize et al. (2019), conducting an ECM, investigated both the short and long run effects of LP, RW, and investment spending on EMP absorption rates in South Africa between 1995Q1 to 2019Q1. These authors showed unidirectional positive causation from LP to EMP absorption and unidirectional negative causation from RW to EMP absorption. Additionally, the authors affirmed the existence of a positive relationship between LP, EMP absorption, and investment spending but a negative effect from RW to EMP absorption in the long run.

Other authors have used unemployment (UNM) as a variable interacting with LP and RW. Wakeford (2004), applying an ECM and a Granger non-causality approach, explored the long and short run links of these three, finding cointegration between LP and RW, but UNM was not connected to the other two variables in the long run. In other words, UNM has little or no effect in terms of restraining RW growth. RW impacts LP negatively in the short run, but LP is not statistically significant in explaining RW variations. However, Wakeford affirmed that "not much can be said about unemployment in the short run owing to the construction of the unemployment data series."

Karaalp-Orhan (2017) found a significant and positive impact from RW and UNM to LP, in the long run, using ECM and the Toda-Yamamoto methodologies. The EWT is supported since RW has a positive effect on LP. There is a positive association between UNM and LP. Consequently, the author suggested that a rise in RW and UNM rate may induce higher LP by increasing the probability and costs of job loss. Additionally, the causality test indicated unilateral causation from UNM to RW and bidirectional causation between UNM and LP.

Similar approaches for RW and EMP have been addressed with a third variable. For instance, Blundell et al. (2014) concluded that wage flexibility and workforce composition have not significantly affected LP growth in the United Kingdom. However, the fall or freeze in RW due to a rise in labor supply would explain the drop in LP growth during and after the 2008-09 Great Recession. On the other hand, Szymczak and Wolszczak-Derlacz (2022) found that higher relative global value chains are negatively correlated with RW and EMP.

Finally, other works have studied EMP but related to the gap between LP and RW. For instance, Fedderke and Mariotti (2002) determined that the difference between RW and LP's growth rates is associated negatively with EMP. Junankar and Madsen (2004) proved that RW and LP's wage gap is correlated positively with higher UNM. For its part, Klein (2012) evidenced that LP growth outpaced by rapid RW growth played an essential role in suppressing EMP creation in South Africa between 2008Q1 to 2011Q2. And a more recent study by Gajewski and Kutan (2021) found that a higher presence of multinational corporations is associated with higher LP but lower RW.

1.3 Data and Methodology

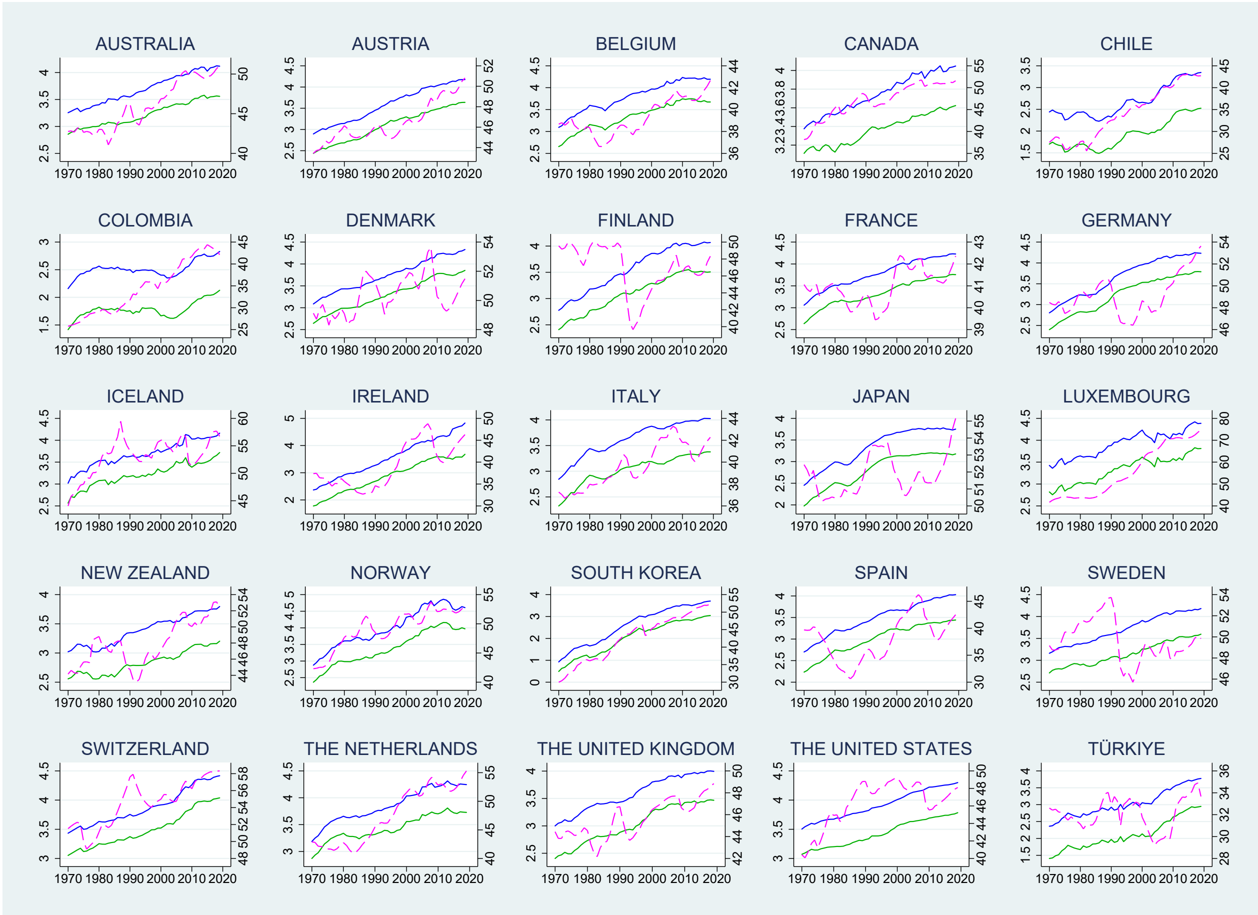
1.3.1 Description of the Variables

This study uses annual data from 1970 to 2019 from the Penn World Tables version 10.01. The series used to construct the variables are the following: output-side real GDP at chained PPPs (in mil. 2017US$) (*rgdpo*), the share of labor compensation in GDP at current national prices (*labsh*), number of persons engaged (in millions) (*emp*), the average annual hours worked by persons engaged (*avh*), and population (in millions) (*pop*). Then, using these series, I construct the following variables: the logarithm of labor productivity per hour at constant 2017 purchasing power parity (LPH), the logarithm of the average real wage per hour at constant 2017 purchasing power parity (RWH), and employment to population ratio (EPOP). (See Appendix A.1). The dataset is a balanced panel that includes 25 OECD countries [2]. Figure 1.2 plots each of these three series for each country.

1.3.2 Empirical Strategy

This paper's empirical strategy determines whether a long run relationship exists among the three variables of interest, LPH, RWH, and EPOP. After demonstrating cointegration, I estimated the speed of adjustment to the long run equilibrium in both the cases where endogenous and exogenous variables compose the system and when all the system variables are endogenous.

[2] Australia, Austria, Belgium, Canada, Chile, Colombia, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Japan, Luxembourg, New Zealand, Norway, South Korea, Spain, Sweden, Switzerland, The Netherlands, The United Kingdom, The United States, and Türkiye.



*N*ote: LPH is the blue line, RWH is the mid-green line, and EPOP is the dashed line and is on the right axis.

Figure 1.2: LPH, RWH, and EPOP for the 25 OECD countries

Regarding the single-equation approach, prior assumptions are needed to test the corresponding economic theories in the context of including the effects of EPOP in the distribution between LPH and RWH. For example, the marginal productivity theory affirms that increases in RWH are only possible if LPH rises first, without giving room for an inverse relationship from RWH to LPH. Therefore, I identified RWH as the dependent variable and LPH and EPOP as the independent variables because the objective is to test this income distribution theory, including EPOP as a control for the impacts of the labor market.

The opposite association from RWH to LPH is explored by the induced technical change and efficiency wages theories, as mentioned in the introductory section. Each one has different micro-foundations to explain the channels of this directional causality. For instance, the spirit of induced technical change is that when firms see their wage share fall, their incentives to incorporate labor-saving innovations in their production processes lessen. It is detrimental to the whole economy because LPH growth will diminish in the long run generating secular stagnation. The idea of induced technical change is that distribution comes first and not last in the causal links between the forces producing stagnation. Since my distribution variable is labor compensation and the ultimate effect is on LP behavior, I set LPH as the dependent variable and RWH and EPOP as the independent variables.

And the third single-equation estimates the short run associations of LPH and RWH on EPOP. For EPOP as a dependent variable, I did not estimate long run parameters because EPOP is weakly exogenous in this system, as shown in Tables 1.2 and 1.3 in the empirical results section.

In addition to the identification mentioned above, it is unavoidable to understand the nature of the variables and their interaction to select the appropriate econometric approaches. LPH, RWH, and EPOP are integrated of order one, *I(1)*, meaning that they are not stationary in levels but after taking their first differences. (See Appendix A.2). Since there exists one linear combination of these variables that is *I(0)* (see Table 1.4), I must include an error correction term (ECT) to incorporate the deviations from the long run relationship to avoid any misspecifications.

Since my objective is to estimate both short and long run parameters and eliminate any unobserved time-invariant components, given that my three variables are *I(1)*, I ran ECMs for LPH and RWH as dependent variables for the single-equation approach. Additionally, for this case, I ran dynamic ordinary least squares (DOLS) regressions to correct potential serial correlation and asymptotic endogeneity and fully modified ordinary least squares

(FMOLS) regressions to deal with any long run correlation between stochastic regressor innovations and the cointegrating equation as a robustness check.

For the third single-equation estimation, I used an ARDL model since it captures the dynamic effects of lagged dependent and also independent variables and eliminates serial correlation in residuals when sufficient and optimal lags of all variables are included.

Concerning the multi-equation approach, I performed a restricted panel VECM, identifying the ECT for the EPOP equation to be equal to zero. (See Appendix A.16). It is a reasonable restriction since it is consistent with the findings in Tables 1.2 and 1.3, where LPH and RWH do not significantly impact EPOP in the long run. The advantage of this specification is that it resolves any potential identification problem in a statistical sense, and it delivers impulse response functions (IRFs) that plot the dynamics of each variable to a shock of the other one without requiring prior assumptions on the direction of causality. Section 1.4.7 demonstrates robustness in my results between the single and multi-equation approaches.

1.3.2.1 Panel ECM

Consider the generalized panel ARDL (p, q) form:

$$y_{it} = \mu_i + \sum_{j=1}^{p} \gamma_{ij} y_{i,\, t-j} + \sum_{j=0}^{q} \beta'_{ij} x_{i,\, t-j} + \varepsilon_{it} \tag{1.1}$$

Where *y* is the dependent variable of the *i*th cross-section unit: LPH, RWH, or EPOP; x_{it} is a *kx1* vector of unit-specific regressors that are allowed to be purely *I(0)* or *I(1)* or cointegrated, which in this case, it is a vector that contains the other two variables different to the dependent variable; μ_i is a unit-specific fixed effect, *i*=1, 2,...N are indexes of panels, *t*=1, 2,...T are indexes of time, *p* and *q* are the optimal lags of the dependent and independent(s) variable(s), respectively, and ε_{it} is a Nx1 vector of disturbances or errors. Time trends and other fixed regressors could be included.

If the panel cointegration tests demonstrate a long run relationship among the variables when y_{it} is a dependent variable, I include an ECT. Therefore, my ECMs extend equation 1.1 as follows:

$$y_{it} = \mu_i^y + \sum_{j=1}^{p} \gamma_{ij}^* \Delta y_{i,\ t-j} + \sum_{j=0}^{q} \beta_{ij}^{\prime *} \Delta x_{i,\ t-j} + \xi_i ECT^y + \varepsilon_{it}^y \tag{1.2}$$

Where,

Δ: Operator of first differences

γ_{ij}^* and β_{ij}^*: Short run dynamic coefficients

$\gamma_{ij}^* = -\sum_{m=j+1}^{p} \gamma_{im}$, j=1, 2,..., p-1

$\beta_{ij}^* = -\sum_{m=j+1}^{q} \beta_{im}$, j=1, 2,..., q-1

$\xi_i = -\left(1 - \sum_{j=1}^{p} \hat{\gamma}_{ij}\right)$: Speed of adjustment parameter with an expected negative sign

ECT=$[y_{i,\ t-1} - \theta_i'\ x_{it}]$: Error correction term

$\theta_i = \frac{\sum_{j=0}^{q} \beta_{ij}}{1-\sum_{j=1}^{p} \gamma_{ij}}$: Vector of long run coefficients

The literature on dynamic heterogeneous panels identifies several approaches to estimating equations 1.2. On the one hand, we have the dynamic fixed effects (DFE) estimator, which could be used when the time-series data for each group are pooled, and only the intercepts are allowed to differ across panels. This specification assumes that the slope coefficients and error variances are identical, meaning that all panel responses are the same in the long and short run. This estimator would generate inconsistent and misleading results if the slope coefficients exhibit heterogeneity across panels.

On the other hand, we have the mean group (MG) estimator proposed by Pesaran and Smith (1995). Contrary to the DFE, the MG estimator allows the intercepts, slope coefficients, and error variances to differ across panels. This specification estimates separate regressions for each group and calculates a simple arithmetic average of the coefficients. This estimator produces consistent estimates of the parameters' average under the assumption that both the intercepts and the slopes vary across panels, allowing heterogeneity in short and long run relationships. And in the middle, we have the pooled mean group (PMG) estimator proposed by Pesaran et al. (1999). This estimator combines pooling and averaging of coefficients allowing the intercepts, short run coefficients, and error variances to differ across panels like the MG estimator but constrains the long run coefficients to be the same across panels like the DFE estimator.

1.3.2.2 Panel DOLS and Panel FMOLS

As a robustness check, I ran panel DOLS, extensions of the Saikkonen (1992) and Stock and Watson (1993) DOLS time-series estimator to panel data form. This approach augments the cointegrating regression with lags and leads of the short run terms. Thus, serial correlation and asymptotic endogeneity are corrected, making the cointegrating equation's error term orthogonal to stochastic regressor innovations. I also performed panel FMOLS regressions, extensions of the Phillips and Hansen (1990) FMOLS time-series estimator to panel data form. This approach provides asymptotically unbiased estimators that eliminate problems caused by the long run correlation between stochastic regressor innovations and the cointegrating equation.

Both DOLS and FMOLS are implemented using pooled (P), pooled weighted (PW), and grouped (G) specifications. While the first and second specifications consider the 'within dimension' of the panel, the third one is based on the 'between dimension.' Therefore, in addition to the three ECM specifications to obtain short and long run estimations, I present six long run estimators: pooled DOLS (Kao and Chiang, 2001), pooled weighted DOLS (Mark and Sul, 1999, 2003), grouped DOLS (Pedroni, 2001b), pooled FMOLS (Phillips and Moon, 1999), pooled weighted FMOLS (Kao and Chiang, 2001; Pedroni, 2001a), and grouped FMOLS (Pedroni, 2001a,b).

1.4 Empirical Results

1.4.1 Panel Unit Root Tests

I performed several panel unit root tests with different specifications to know the variables' stationary nature robustly. The tests used are the following: (Breitung, 2001; Breitung and Das, 2005), Fisher-type test that combines the p-values from panel-specific unit root tests employing the four methods proposed by Maddala and Wu (1999) and developed by Choi (2001), Harris and Tzavalis (1999), Im et al. (2003), and Levin et al. (2002). Appendix A.2 shows that the null hypotheses of unit root presence are not rejected for the levels' variables in most cases. But when these variables are expressed in first differences, the null hypotheses are rejected either at 1% or 5% significance. Therefore, I can conclude that LPH, RWH, and EPOP are integrated of order one, or *I(1)*.

1.4.2 Panel Cointegration Tests

After concluding that LPH, RWH, and EPOP are all *I(1)*, if there is a linear combination of the three *I(1)* variables that is stationary, *I(0)*, the series are said to be cointegrated (Engle and Granger, 1987), so long run estimators can be computed. For this purpose, I conducted Pedroni's cointegration test, which output is displayed in Table 1.2. This table shows the statistics for Pedroni's tests for each series as a dependent variable and the other two as independent variables. When LPH is the dependent variable, the test rejects the null hypothesis of no cointegration in eight out of eleven cases, either at a 1%, 5%, or 10% significance level. When RWH is the dependent variable, the test rejects the same null hypothesis in six out of eleven cases, either at 1% or 5% level. However, when EPOP is the dependent variable, the evidence suggests that the null hypothesis can be rejected only in three out of eleven statistics, meaning that EPOP is weakly exogenous. In other words, EPOP might be affected by LPH or RWH only in the short run but not in the long run. The implication is that the long run trajectory of EPOP should be explained by other factors different from LPH and RWH.

As a robustness check for cointegration, I also performed the Westerlund cointegration test (Westerlund, 2005). This test confirms weak exogeneity of EPOP and cointegration when RWH is the dependent variable. However, the test for LPH is ambiguous since half of the statistics reject the null hypothesis of no cointegration while the other two do not. (See Table 1.3).

Additionally, I ran the Fisher panel cointegration test (Fisher, 1992; Maddala and Wu, 1999), which is system-based for the entire panel set. The advantage of this test is that it tells us whether cointegration exists or not and how many cointegration equations are in the system. In both the trace and the maximum eigenvalue tests, I reject the null hypothesis that cointegration does not exist. However, I failed to reject the null hypothesis that there is, at most, one cointegrating equation. Therefore, I confirm that cointegration is present and one cointegrating equation exists in the three-variable system. Finally, I selected the Bayesian information criterion for the Pedroni and Fisher panel cointegration tests because it is considered more effective for model selection than its competitors, such as the Akaike information criterion. (Koehler and Murphree, 1988; Cavanaugh and Neath, 1999; Medel and Salgado, 2013). (See Table 1.4).

1.4.3 Structural Break Tests in Cointegrated Panel

Before estimating long run associations in the cointegrated panel, it is relevant to test the existence of potential structural breaks because the model parameters could significantly change over time. Knowing the date of the breaks provides valuable information about the possible factors that have explained the relationship among the variables of interest in different decades.

I used the Ditzen et al. (2021) methodology, which allows testing the existence of multiple possible structural breaks without selecting a particular date a priori. Appendix A shows that no structural break was detected in the cointegrated panel. It is because the null hypothesis of no structural break is not rejected, even establishing different minimal

Table 1.2: Pedroni's panel cointegration test for LPH, RWH, and EPOP

Test	Dependent variable		
	LPH	RWH	EPOP
Weighted statistics			
v-statistic	0.81	1.58*	1.20
ρ-statistic	-1.90**	-2.06**	0.82
PP-statistic	-2.80***	-3.08***	0.42
ADF-statistic	-5.58***	-6.21***	-1.83**
Unweighted statistics			
v-statistic	1.68**	3.32***	0.71
ρ-statistic	0.39	-0.33	0.85
PP-statistic	0.65	-0.22	0.28
ADF-statistic	-2.19***	-2.61***	-1.39*
Group statistics			
ρ-statistic	0.40	0.03	2.07
PP-statistic	-0.84	-1.13	1.26
ADF-statistic	-3.54***	-3.75***	-2.94***

Notes: The null hypothesis is "no cointegration." The weighted and unweighted panel statistics' alternative hypothesis is "cointegration in all panels with common autoregressive coefficients in the residuals.". The group statistics' alternative hypothesis is "cointegration in a subset of panels with panel-specific autoregressive coefficients in the residuals." The deterministic specification includes a constant in the test equation and no deterministic trend. The optimal number of lags is chosen based on the Bayesian information criterion. The Parzen kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West procedure. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

segment lengths in percent between two possible breaks. Therefore, even when one or a small group of countries could experience a structural break in a particular year, there is no evidence that it would significantly change the parameters in the panel as a group.

1.4.4 Long and Short Run Associations in the Single Equation Regressions

Since cointegration is present when LPH and RWH are dependent variables, and there are no statistically significant structural breaks that could bias the parameters over time, I proceeded to estimate equation 1.2 for LPH and RWH as follows:

$$\Delta LPH_{it} = \mu_i + \sum_{j=1}^{p-1} \gamma_{ij}^{*} \Delta LPH_{i,\,t-j} + \sum_{j=0}^{q-1} \beta_{i1}^{*} \Delta RWH_{i,\,t-j} + \sum_{j=0}^{q-1} \beta_{i2}^{*} \Delta EPOP_{i,\,t-j} + \xi_{it} ECT^{LPH} + \varepsilon_{it} \tag{1.3}$$

Table 1.3: Westerlund's panel cointegration test for LPH, RWH, and EPOP

Test	Dependent variable		
	LPH	RWH	EPOP
Demean	-1.42*	-1.99**	0.71
Some	-3.18***	-3.44***	-1.92**
Trend	-0.93	0.12	0.88
All panels	-2.44***	-2.52***	-0.75

Notes: The null hypothesis is "no cointegration." The demeaned, some, and trend panel statistics' alternative hypothesis is "some panels are cointegrated." All panels' alternative hypothesis is "all panels are cointegrated." ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

Table 1.4: Fisher's panel cointegration test for LPH, RWH, and EPOP

	Trace test	Maximum eigenvalue test
None	123.00***	100.70***
At most 1	60.61	47.88
At most 2	76.53***	76.53***

Notes: Probabilities are computed using asymptotic chi-square distribution. Two lags interval in first differences is chosen based on the Bayesian information criterion. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

$$\Delta RWH_{it} = \mu_i + \sum_{j=1}^{p-1} \gamma_{ij}^{*} \Delta RWH_{i,\ t-j} + \sum_{j=0}^{q-1} \beta_{i1}^{*} \Delta LPH_{i,\ t-j} + \sum_{j=0}^{q-1} \beta_{i2}^{*} \Delta EPOP_{i,\ t-j} + \xi_{it} ECT^{LPH} + \varepsilon_{it} \tag{1.4}$$

Appendix A, based on the Bayesian information criterion, shows that the optimal lag for equations 1.3 and 1.4 in both cases is ECM(1,1,1). And according to the Hausman tests in Appendix A.5, the best ECM for equation 1.3 is PMG, and the more appropriate for equation 1.4 is DFE.

The results in Table 1.5 show long run relationship running from RWH and EPOP jointly to LPH since the error correction terms (ECT) are statistically significant at a 1% level. The PMG specification -the best among the ECMs, according to the Hausman test in Appendix A.5- supports the efficiency wages theory or alternative theories of distribution-led growth, where a rise in RWH induces LPH to increase by raising job loss costs: a 1% increase in RWH leads to a 1.03% increase in LPH in the long run. These results are robust to several specifications. On the other hand, EPOP does not seem to be significantly associated with LPH in the short run, but in the long run, its negative association is very mild.

Table 1.6 presents analogous results where RWH is the dependent variable and the other two are exogenous. Considering the DFE specification, based on Appendix A.5, a 1% increase in LPH is associated with a rise in RWH by 0.81%. It suggests that firms are willing to raise their labor costs less than proportionally to their workers' productivity gains, backing the performance-based pay and bargaining theories. Additionally, this output indicates that a rise in EPOP -lower unemployment- pushes wages up, but its association is marginal. [3]

Table 1.5: ECM, DOLS, and FMOLS models for LPH as the dependent variable

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
RWH	1.03***	0.97***	1.09***	1.02***	1.05***	1.09***	1.02***	0.99***	1.09***
	(0.008)	(0.130)	(0.040)	(0.021)	(0.011)	(0.053)	(0.026)	(0.001)	(0.013)
$EPOP$	-0.002***	-0.01	-0.01*	-0.01***	-0.01***	-0.001***	-0.01***	-0.03***	-0.01***
	(0.001)	(0.023)	(0.004)	(0.001)	(0.001)	(0.004)	(0.002)	(0.001)	(0.001)
ECT	-0.13***	-0.20***	-0.05***						
	(0.032)	(0.037)	(0.012)						
SR									
RWH_{t-1}	0.71***	0.65***	0.84***						
	(0.038)	(0.037)	(0.020)						
$EPOP_{t-1}$	0.71***	0.65***	0.84***						
	(0.001)	(0.001)	(0.001)						
$Constant$	0.07***	0.18***	0.03***						
	(0.017)	(0.034)	(0.008)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

[3] This time-series cross-section exercise pertains to the short and long run association between the corresponding variables, controlling for observables as well as time-invariant characteristics. The estimated coefficients are robust to different econometric approaches and specifications; however, the results are not to be interpreted as causal, strictly speaking, given the absence of some source of quasi-variation.

Table 1.6: ECM, DOLS, and FMOLS models for RWH as the dependent variable

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
LPH	0.92***	0.79***	0.81***	0.85***	0.88***	0.90***	0.85***	0.88***	0.90***
	(0.009)	(0.043)	(0.030)	(0.017)	(0.013)	(0.024)	(0.021)	(0.001)	(0.008)
$EPOP$	0.003***	0.02***	0.008***	0.00	0.002*	0.005**	0.00	0.02***	0.005***
	(0.001)	(0.005)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
ECT	-0.14***	-0.23***	-0.07***						
	(0.028)	(0.032)	(0.012)						
SR									
LPH_{t-1}	0.69***	0.61***	0.73***						
	(0.040)	(0.047)	(0.019)						
$EPOP_{t-1}$	-0.001	0.003**	0.002**						
	(0.001)	(0.001)	(0.001)						
$Constant$	-0.05***	-0.16***	-0.01*						
	(0.013)	(0.035)	(0.007)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

1.4.5 Sensitivity Analysis for the Long and Short Run Association in the Single Equation regressions

Since the Esping-Andersen (1990) work, several welfare state typologies have come up in the literature based on different methodologies and criteria. To measure my results' sensitivity in 25 OECD countries, I carried out the same regressions as Tables 1.5 and 1.6 using three distinct subgroups of countries based on Powell et al. (2020): liberal, conservative, and social democratic. This analysis is relevant since labor market institutions might significantly influence the degree of unionization and terms of trade, affecting the employment rate (Egger et al., 2015) or the dynamics between wages and productivity (Duque et al., 2006). Therefore, variables such as EMP, RW, and LP could behave differently depending on the welfare typology.

Five out of six ECMs have ECM(1,1,1) as their optimal lag length, as in Tables 1.5 and 1.6, except for the social democratic subgroup when LPH is the dependent variable, where the optimal lag length is ECM(1,2,2): one lag for LPH, and two lags for RWH and EPOP. Overall, the parameters estimated in Tables 1.5 and 1.6 do not substantially differ when I replicate the regressions for each subgroup of countries, showing that, in general, similar conclusions can be applied to OECD economies disregarding their welfare state typology. See Appendices A.6 to A.13.

1.4.6 Panel ARDL for Employment-to-Population Ratio

Since there is no cointegration when EPOP is the dependent variable, I only specified the short run ARDL model. My reparametrized panel ARDL (p, q) from equation 1.1 for this case is the following:

$$\Delta EPOP_{it} = \mu_i + \sum_{j=1}^{p-1} \gamma_{ij}^{*} \Delta EPOP_{i,\ t-j} + \sum_{j=0}^{q-1} \beta_{i1}^{*} \Delta LPH_{i,\ t-j} + \sum_{j=0}^{q-1} \beta_{i2}^{*} \Delta RWH_{i,\ t-j} + \varepsilon_{it} \tag{1.5}$$

Appendix A.14 shows that the optimal lag length for equation 1.5 is three. Therefore, equation 1.5 is run using three lags for each independent variable. Table 1.7 shows that an increase in LPH is positively associated with EPOP, meaning that greater efficiency might trigger economic activity in the short run, giving room for more jobs. It is relevant to mention that Autor and Solomons (2018) found evidence that industries experiencing faster productivity growth saw their EMP fall; however, aggregate EMP grew dramatically in the countries analyzed by these authors. Considering that my data is aggregate -includes all sectors-, a significant portion of the positive association of LPH on EPOP of my result would be driven by reallocation of labor moving from technologically advancing to lagging sectors, especially between not close substitute sectors.

On the other hand, an increase in RWH is negatively associated with EPOP, probably due to factor substitution caused by higher labor costs in the short run. Appendix A.15

shows the Wald tests for the joint significance of the lags of LPH and RWH. These tests confirm that LPH and LRW lags are jointly associated in explaining the model's short run dynamics.

Table 1.7: Short run ARDL model for Δ EPOP as the dependent variable and Δ LPH and Δ RWH as independent variables

Variable	Coefficient
$EPOP_{t-1}$	0.54*** (0.030)
$EPOP_{t-2}$	-0.07*** (0.034)
$EPOP_{t-3}$	-0.02 (0.023)
LPH_{t-1}	3.94*** (0.090)
LPH_{t-2}	1.64* (0.907)
LPH_{t-3}	1.61* (0.903)
RWH_{t-1}	-2.52*** (0.963)
RWH_{t-2}	-2.07** (0.960)
RWH_{t-3}	-1.25 (0.953)
$Constant$	0.07*** (0.026)

Notes: Standard errors in parenthesis.
***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

1.4.7 Panel Vector Error Correction Model (VECM)

As a robustness check of the results found for the panels ECM, DOLS, FMOLS, and ARDL, I assumed an entirely endogenous system in this section but imposing the ECT for equation 6 below equal zero since the cointegration tests demonstrated that EPOP is weakly exogenous in this system. The advantage of this approach is that it does not require a priori assumptions on the direction of causality, and the identification problem is solved in a statistical sense. The dynamic of the variables can be assessed using IRFs that plot the response of each variable to one standard innovation in another one while holding other things constant.

The endogenous three-equations system to be estimated is the following:

$$\Delta LPH_{it} = \mu_i + \sum_{j=1}^{p-1} \gamma_{ij}^{*} \Delta LPH_{i,\, t-j} + \sum_{j=0}^{q-1} \beta_{i1}^{*} \Delta RWH_{i,\, t-j} + \sum_{j=0}^{q-1} \beta_{i2}^{*} \Delta EPOP_{i,\, t-j} + \xi_{it} ECT^{LPH} + \varepsilon_{it} \tag{1.3}$$

$$\Delta RWH_{it} = \mu_i + \sum_{j=1}^{p-1} \gamma_{ij}^{*} \Delta RWH_{i,\, t-j} + \sum_{j=0}^{q-1} \beta_{i1}^{*} \Delta LPH_{i,\, t-j} + \sum_{j=0}^{q-1} \beta_{i2}^{*} \Delta EPOP_{i,\, t-j} + \xi_{it} ECT^{LPH} + \varepsilon_{it} \tag{1.4}$$

$$\Delta EPOP_{it} = \mu_i + \sum_{j=1}^{p-1} \gamma_{ij}^{*} \Delta EPOP_{i,\, t-j} + \sum_{j=0}^{q-1} \beta_{i1}^{*} \Delta LPH_{i,\, t-j} + \sum_{j=0}^{q-1} \beta_{i2}^{*} \Delta RWH_{i,\, t-j} + \xi_{it} ECT^{EPOP} + \varepsilon_{it} \tag{1.6}$$

If the previous analysis results are robust, I would expect the speed of adjustment parameters when LPH and RWH are the dependent variables to be statistically significant. On the other hand, since there is no cointegration when EPOP is the dependent variable, I constraint the $\xi_{it} ECT^{EPOP} = 0$ in equation 1.6. Appendix A.16 shows the LR test for binding restriction, where the null hypothesis $\xi_{it} ECT^{EPOP} = 0$ is not rejected. It confirms that EPOP is weakly exogenous, meaning that this variable does not adapt to the long run deviations, and LPH and RWH are making the adjustment.

The optimal lag length for a panel VECM should be the optimal lag order for a panel VAR minus one. Appendix A.17 suggests six lags for the panel VAR based on three out of five information criteria; therefore, I should select five for the panel VECM. Consistent with appendix A.17, serial autocorrelation is detected in panel VECM when I used one, two, three, and four lags, but it is not present anymore when I incorporated the fifth lag. At lag five, I could not reject the null hypothesis of "no serial correlation at lag h" and the null hypothesis of "no serial correlation at lags 1 to h" at 5% and even 10% significance. Consequently, I chose five lags for this three-variables model. Appendix A.18 presents the VEC residual serial correlation LM tests for five lags in the panel VECM.

Additionally, Appendix A.19 shows the VEC residual Portmanteau test for autocorrelation as a robustness check, concluding no serial correlation in the VECM with five lags.

Appendix A.20 displays the panel VECM results. The error correction terms for LPH and RWH as dependent variables are statistically significant at 1% significance. Still, their adjustment speeds are lower than those in the ECM.

Regarding the short run associations, the Wald tests shown in Appendix A.21 confirm what I found in the single-equation regressions in Tables 1.5 and 1.6, where a double relationship exists between LPH and RWH in the short run. Also, the PMG regression in Table 1.5 shows an insignificant association from EPOP to LPH, and regression DFE in Table 1.6 displays a significant relationship running from EPOP to RWH in the short run. And consistent with Appendix A.15, both LPH and RWH have a statistically significant association with EPOP in the short run.

To evaluate the stability of the panel VECM, I need to obtain the roots of the characteristic polynomial. For a k-variables model with r cointegrating equations, the companion matrix will have $k - r$ unit eigenvalues. If the system's stability holds, the remaining eigenvalues' moduli must be less than one. In this case, since $k = 3$ and $r = 1$ as found in Fisher's cointegration test, this system must have at most two imposed unit roots, and the rest of the eigenvalues must be inside the unit circle. Appendix A.22 supports the system's stability.

Figure 1.3 presents each variable's responses to the other two variable impulses. I use the generalized impulse specification to construct an orthogonal set of innovations that do not depend on the VECM ordering (Pesaran and Shin, 1998). The IRFs confirm what I find in most single-equation specifications: ECM, DOLS, and FMOLS. There is a two-way relationship between LPH and RWH, and these effects are positive and permanent in the long run. EPOP is negatively associated with LPH and positively associated with RWH. Still, their association seems much smaller in magnitude, but contrary to the single-equation approach, they are not statistically significant.

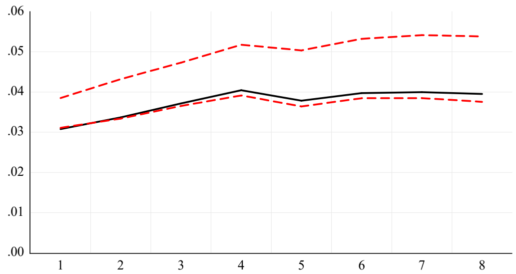
Regarding the associations of LPH and RWH on EPOP, while the former is positive, the latter is negative, consistent with the ARDL model results. However, it seems like only LPH has a significant temporary impact on EPOP in the medium run. Since the variables under study modeled in the VECM are *I(1)*, they are not mean-reverting; therefore, it is expected that some shocks would not die out over time. Additionally, notice that the scale of the vertical axis of responses of EPOP is different because this variable is expressed in percentual points while LPH and RWH are in logarithms.

1.4.8 Robustness Check: Labor Productivity Per Worker and Real Wage Per Worker

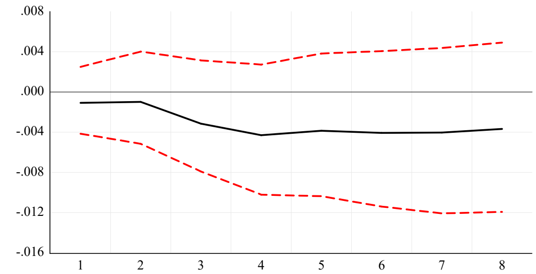
Alternative ways to measure LPH and RWH are labor productivity per worker (LPW) and average real wage per worker (RWW). Appendix A.23 shows how these two variables are constructed using PWT 10.01. Since several countries in the panel do not have data for average annual hours worked by persons engaged in the 60s, I performed the regression for LPH, RWH, and EPOP for 1970-2019. However, for constructing LPW and RWW, the variable average annual hours worked is not needed, and I could extend this robustness check using a longer period, 1960-2019.

These three variables are non-stationary in levels but stationary in the first differences. The panel cointegration tests -Pedroni, Westerlund, and Fisher- deliver the same conclusions: there exists one cointegrating equation in the system, and it is present only when LPW and RWW are dependent variables while EPOP is weakly exogenous. Like in the LPH and RWH cases, the optimal lag length for their ECMs when LPW and RWW are the dependent variables, using the Bayesian information criterion, is ECM(1,1,1). Regarding the ARDL for EPOP as the dependent variable, the optimal lag length is also three. See Appendices A.24 to A.29.

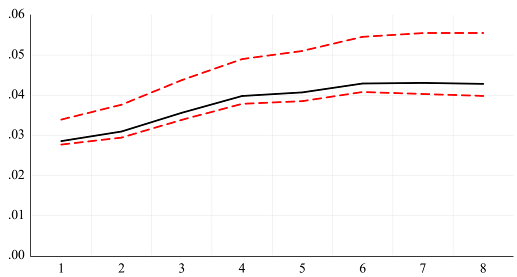
Tables 1.8 and 1.9 replicate Tables 1.5 and 1.6, but for LPW and RWW as dependent variables, showing that results are very similar when using measures of LP and RW in



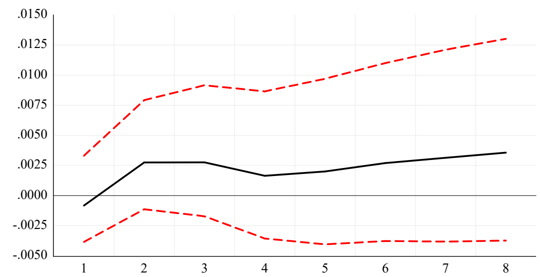
(a) Response of LPH to RWH



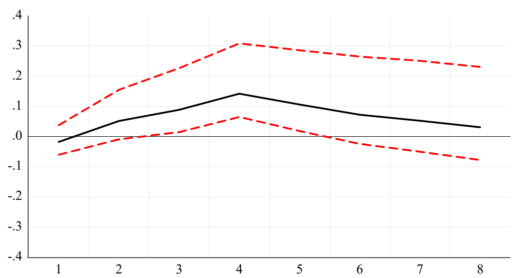
(b) Response of LPH to EPOP



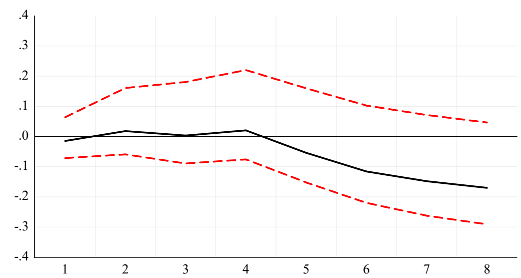
(c) Response of RWH to LPH



(d) Response of RWH to EPOP



(e) Response of EPOP to LPH



(f) Response of EPOP to RWH

Figure 1.3: Impulse responses to generalized one standard deviation innovations, 95% confidence interval using Hall's percentile bootstrap with 1000 bootstrap repetitions

terms of hours worked or per worker. Concerning the short run association of LPW and

Table 1.8: ECM, DOLS, and FMOLS models for LPW as the dependent variable

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
RWW	1.08***	1.14***	1.11**	1.09***	1.07***	1.04***	1.09***	1.09***	1.03***
	(0.001)	(0.069)	(0.038)	(0.005)	(0.008)	(0.048)	(0.006)	(0.001)	(0.003)
$EPOP$	-0.02***	-0.03	-0.01	-0.01***	-0.001***	0.005	-0.01***	-0.001***	0.005***
	(0.002)	(0.028)	(0.004)	(0.001)	(0.002)	(0.014)	(0.001)	(0.001)	(0.001)
ECT	-0.06***	-0.18***	-0.04***						
	(0.016)	(0.038)	(0.010)						
SR									
RWW_{t-1}	0.83***	0.70***	0.88***						
	(0.031)	(0.037)	(0.017)						
$EPOP_{t-1}$	0.001	0.002*	-0.002**						
	(0.001)	(0.001)	(0.001)						
$Constant$	0.03***	0.10*	-0.01						
	(0.007)	(0.055)	(0.014)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

RWW on EPOP, Table 1.10 replicates Table 1.7, delivering the same conclusion: a positive association running from LPW on EPOP and a negative association from RWW on EPOP.

1.5 Concluding Remarks

This paper contributes to the literature about the interaction between LP, RW, and EPOP in the OECD countries, using two broad approaches: 1) with exogenous and endogenous terms and 2) restricting the system to only endogenous variables as a robustness check.

Regarding the association between LP and RW, the results show a bidirectional relationship, supporting the induced technical change, efficiency wages, and bargaining theories over the marginal productivity for the OECD countries considered in my sample as a group, including employment as the third variable in this system. The positive association

Table 1.9: ECM, DOLS, and FMOLS models for RWW as the dependent variable

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
LPW	0.84***	0.81***	0.79**	0.91***	0.93***	0.96***	0.91***	0.91***	0.96***
	(0.013)	(0.039)	(0.033)	(0.038)	(0.006)	(0.014)	(0.005)	(0.001)	(0.003)
$EPOP$	0.01***	0.01***	0.01**	0.01***	0.01***	-0.03	0.01***	0.002***	-0.004***
	(0.002)	(0.004)	(0.003)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.001)
ECT	-0.08***	-0.20***	-0.06***						
	(0.016)	(0.032)	(0.010)						
SR									
LPW_{t-1}	0.74***	0.63***	0.76***						
	(0.037)	(0.041)	(0.016)						
$EPOP_{t-1}$	0.001	-0.001	0.002***						
	(0.001)	(0.001)	(0.001)						
$Constant$	0.70***	0.03	0.08***						
	(0.012)	(0.061)	(0.013)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

of this double relationship is statistically significant in both the short and long run, as the long run effects are a little more substantial in magnitude. A 1% increase in RWH is associated with a rise in LPH between 0.65% to 0.84% in the short run and between 0.95% to 1.09% in the long run. And 1% increase in LPH is associated with a rise in RWH between 0.61% to 0.73% in the short run and 0.79% to 0.91% in the long run, depending on the econometric specification.

On the other hand, EPOP is weakly exogenous in this three-dimensional system, meaning that this variable does not adapt to the long run deviations, and LP and RW make the long run adjustment. It suggests that OECD economies as a group have been labor-constrained during the study period.

Table 1.10: Short run ARDL model for Δ EPOP as the dependent variable and Δ LPW and Δ RWW as independent variables

Variable	Coefficient
$EPOP_{t-1}$	0.53***
	(0.023)
$EPOP_{t-2}$	-0.06**
	(0.031)
$EPOP_{t-3}$	-0.02
	(0.027)
LPW_{t-1}	3.92***
	(0.850)
LPW_{t-2}	1.83**
	(0.859)
LPW_{t-3}	1.43*
	(0.856)
RWW_{t-1}	-2.39***
	(0.907)
RWW_{t-2}	-2.09***
	(0.905)
RWW_{t-3}	-1.79**
	(0.903)
$Constant$	0.08***
	(0.023)

Notes: Standard errors in parenthesis.
***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

Concerning the association running from LPH to EPOP, I find that, in aggregate terms, increases in LPH are associated with higher economic activity, so more employment in the economy. However, this effect is probably led by the reallocation of workers moving from sectors technologically intensive to lagging sectors, especially between not very close substitute sectors.

With respect to the relationship running from RWH to EPOP, my results support a factor substitution effect generating job destruction only in the short run due to higher labor costs. However, in the long run, EPOP gets back to its trend, suggesting that reallocation offsets the initial adverse impact.

Finally, the parameters found in the single-equation models are robust to several econometric specifications. The association coefficients and their significance do not substantially vary when the sample is divided into different welfare state typology groups: liberal, conservative, and social democratic. Parameters are also robust when using alternate measures of LP and RW. Lastly, the single-equation and multi-equation approaches consistently find a positive short and long run double relationship between LPH and RWH. Both approaches are also consistent in demonstrating a not significant association running from LPH and RWH to EPOP in the long run, confirming weak exogeneity of EPOP in the three-dimensional system.

Chapter 2

Secular Stagnation: A Classical-Marxian View

2.1 Introduction

The publication of Thomas Piketty's *Capital in the XXI Century* (Piketty, 2014) revived the interest of the mainstream of the economics profession in questions of distribution of income and wealth. The combination of path-breaking data work on the historical increase in the capital-income ratio and the top wealth share —the latter occurring after the 1980s— and the use of the familiar Solow (1956) growth model to provide a comprehensive understanding of rising inequality and stagnation made a lasting mark both in the profession and the public. A complementary argument is made in Gordon (2015), who used basically the same modeling framework but emphasized the forces at play that may have contributed to the growth slowdown, i.e., a reduction in g.

The combined neoclassical argument is now part of the economics toolbox: an exogenous reduction in the growth rate of the economy—be that because of declining fertility, the exhaustion of path-breaking scientific discoveries, diminishing returns to information and communication technology, the decline in new startups, a decline in net investment—increases the difference $r - g$, between the rate of return to wealth and the growth rate of income: the implication is that the capital-income ratio rises. Factor substitution along a neoclassical production function provides a link from the capital-income ratio to the functional distribution of income: provided that the elasticity of substitution between capital and labor be higher than one, a rise in the capital-income ratio determines an increase in the share of profits and consequently a reduction in the wage share. These "Piketty-Gordon" facts have been widely documented in the literature: see Petach and Tavani (2021) for a recent illustration and discussion.

This paper aims to present an alternative viewpoint that builds on decades of work and debates between heterodox economists. Scholars working in the classical-Marxian (CM) tradition, in the post-Keynesian (PK) tradition and in the Sraffian supermultiplier (SSM) tradition have been concerned with questions of distribution for a long time before Piketty's blockbuster tome. PK authors especially have produced important work that challenges the causal account by neoclassical economists introducing the question of the distribution of wealth (Pasinetti, 1962) in established demand-driven growth models in the neo-Kaleckian and neo-Goodwinian tradition (Ederer and Rehm, 2020a,b; Taylor et al., 2020). The key issue in this literature is the relationship between the distribution of wealth and the distributional features of aggregate demand. On the other hand, recent important contributions to the secular stagnation debate from the SSM perspective can be found in Serrano et al. (2020); Di Bucchianico (2021a,b): the main difference is that in both neo-Kaleckian and neo-Goodwinian models long run aggregate demand is endogenous to distribution; while in the SSM models this is not the case.

Our goal is to present a complementary heterodox argument that, without denying the importance of aggregate demand for growth and distribution, operates at the same level of abstraction of Piketty and Gordon, namely that the economy is constrained by supply forces and profit-driven accumulation in the long run. This is a first reason why our approach is grounded in the CM tradition: the assumption of Say's law holding in the long run and the notion that capital accumulation is ultimately constrained by profits are common in Ricardo and Smith, and in recent and contemporary work in the Marxian tradition (see for example Harris, 1978; Marglin, 1984; Duménil and Lévy, 2000; Foley et al., 2019).[4] Differently from neoclassical economics, we take seriously the Cambridge critique of capital theory that refuted the notion of instantaneous factor substitution along an aggregate production function (Cohen and Harcourt, 2003; Felipe and McCombie,

[4]Of course, both Malthus and Marx famously disputed the validity of Say's law; nevertheless it is customary in the heterodox literature to refer to "classical" to those models where savings and investment are always equal by assumption. See the relevant chapters in Blecker and Setterfield (2019); Foley et al. (2019).

2013) and focus instead of the CM viewpoint that "capital-labor substitution" is in fact the result of *biased technological change* (Foley et al., 2019, Ch.7-9) that is driven by the firm-level incentives to introduce labor-augmenting innovations to respond to increases in the wage share (Hicks, 1932; Kennedy, 1964; von Weiszacker, 1966; Drandakis and Phelps, 1966; Foley, 2003; Julius, 2005; Zamparelli, 2015). This is another reason why our contribution is rooted in CM economics: the notion that labor-augmenting technical change is a "weapon" in the capital-labor conflict, and that therefore the distribution of income between wages and profits influences and responds to technological progress is already present in Marx (1894) but also features prominently in Shah and Desai (1981) and Julius (2005). Finally, unlike neoclassical economics and despite our acceptance of Say's law, we do not presuppose that the economy always operates at full employment of labor in the long run. This is another element that our argument has in common with the CM framework, where there is no mechanism guaranteeing that wage flexibility will clear the labor market: this implication arises from the fact that long run factor shares depend on induced technical progress—and are therefore endogenous, but for different reasons than in the neoclassical model—and not on capital-labor substitution along a neoclassical production function.

Our argument goes as follows. Consider the long run "Harrodian" balanced growth condition $g = \gamma + n$, where g is the accumulation rate, and γ and n are respectively the growth rate of labor productivity and the growth rate of the labor force. The long run accumulation rate depends on the profit rate, equal to the income-capital ratio u times the profit share. Institutional changes —especially globalization (Kiefer and Rada, 2015), trade liberalization (Dube and Reddy, 2014), declining workers' bargaining power and unionization (Tavani, 2012b, 2013b; Farber et al., 2021), but also financialization (Hein, 2013; Hein and Dodig, 2014; Hein, 2019)— that occurred since the 1980s have put downward pressure on the labor share and upward pressure on the profit share.[5] The falling share of labor lessens the incentives on behalf of firms to introduce labor-augmenting innovations, which in turn depresses the long run growth rate of the economy. Moreover, it increases the wealth share of households whose incomes are mostly made up of profits ("capitalists"), given the reduction in the funds available for savings and wealth accumulation by wage-earning households ("workers"). On the other hand, the decline in the share of wages puts pressure on capital accumulation, which is profit-driven: but the long run growth rate, which is tied up to labor productivity growth through the Kennedy-Weiszacker induced technical change channel, has fallen. Restoring balanced growth requires a decline in the income-capital ratio u (or equivalently an increase in the capital-income ratio, as in Piketty and Gordon).

The final portion of our argument concerns the economy's long run employment rate. The balanced growth condition $g = \gamma + n$ guarantees that the economy operates with constant unemployment in the long run; but the steady state employment rate is endogenous, and its response to changes in income shares is ambiguous because it depends on the forces at play both in the labor market and the bias of technological progress. In the theoretical model we present below, and with a nod to the familiar terminology in neo-Kaleckian economics, we identify both the possibility of a *wage-led* and a *profit-led* employment regime, depending on a simple condition on two parameters representing the response of technological change vs. real wage growth to labor market institutions

Given the theoretical ambiguity in the response of the long run employment rate to labor-crushing institutions, we finally carry an empirical test of our argument using time-series data for the United States (1960-2019). First, we estimate a vector error-correction model (VECM) using the income-capital ratio, the top 1% wealth share, the wage share, and the employment-population ratio to account for the endogeneity of all four variables of

[5]Our model concerns the real side of the economy only, and as such cannot explain the role of financialization in the decline of the labor share. We report financialization as one of the causes of such decline for completeness.

interest; then, we 'run an experiment' on the model, using impulse responses to inspect the response of the income-capital ratio, the top wealth share, and the prime-age employment-population to a negative one-standard deviation shock to the wage share. We find empirical support for our theory: an adverse shock to the wage share produces a long run decline in the income-capital ratio and a long run increase in the top wealth share. Moreover, the employment-population ratio declines, thus pointing to the U.S. employment regime being wage-led over the period under consideration.[6]

Thus, the main contribution of this paper is to present a simple but comprehensive account of supply-side secular stagnation in the CM tradition. Our model combines insights from several strands of the heterodox literature —the Pasinetti theorem, the Kennedy-Weiszacker theory of biased technical change as opposed to factor substitution, and the distributive conflict at the heart of the Goodwin model— into a unified thought framework that can be used to inform a progressive policy agenda aimed at ameliorating the conditions of working people. To our knowledge, this is the first paper that considers the simultaneous effects of shocks that affect the distribution of income on the distribution of wealth, the income-capital ratio, and the employment rate. Our argument is similar to the neo-Kaleckian viewpoint that the functional distribution of income comes first, and not last, in the causal links between the forces producing stagnation and inequality in the Neoliberal era. The main difference is that these causal links hold true even in an economy that is assumed to be supply-constrained. As such, the point of our contribution is also in part *rhetorical*, in that we show that a progressive role for redistributive policies in fostering growth while reducing inequality arises through the effect of such policies on the potential growth path of an economy.[7] In this regard, we find even more striking the empirical

[6]Stockhammer (2008) argues that the Goodwin model in fact implies an exogenous long run employment rate that closely mirrors the textbook 'natural' rate of unemployment. Despite ours being a model of the supply side, and despite the modeling of the labor market follows the Goodwin dynamics, the fact that the long run employment rate is endogenous to distribution implies that there is not a fixed natural rate of unemployment.

[7]It goes without saying that this does not imply that we believe that, in fact, demand is not relevant for the potential growth and distribution path of an economy. As examples of an analysis of the role of aggregate

finding that the U.S. employment-population ratio appears to be wage-led in the long run: it implies that labor-friendly institutional changes aimed at reversing the decline of the wage share will have progressive supply-side effects on fostering growth and reducing inequality without necessarily being detrimental to employment.

2.2 Secular Stagnation: Related Literature

The observation that an economy may experience low economic growth and high unemployment for long periods is well-routed in the history of economics. Alvin Hansen (Hansen, 1939) coined the concept of secular stagnation to express his preoccupation with grim U.S. growth prospects and slow recovery after the Great Depression due to, among other reasons, a shortage of impetus of opportunities and new investments. Since then, the world has changed significantly. Changes in demography, financial development, changes in income distribution between labor income and capital income, and technology have played a crucial role in the composition of employment, real wages, and productivity, impacting economic growth and unemployment.

Several theories have emerged to explain the possibility of prolonged stagnation. The literature is vast, but we will focus on demand-side and supply-side secular stagnation from a mainstream standpoint and the countering post-Keynesian perspective for this analysis. Beginning with the demand-side mainstream explanation, Summers (2014a,b) has revamped the term secular stagnation to explain the growth slowdown in advanced economies such as the United States, Europe, and Japan during the last three decades. Summers's explanation is rooted in the loanable funds theory and amounts to a situation where demand and supply for savings translate into a negative equilibrium real interest rate. Under this scenario, the zero lower bound on the nominal interest rate is the relevant constraint on the policy contributing to economic stagnation. According to Summers

demand in classical-Marxian models of growth and distribution, see Petach and Tavani (2019); Tavani and Petach (2021); Petach and Tavani (2022).

(2015), the low equilibrium occurs due to decreased investment demand and an increased supply of savings. He argues that the former is explained by slow population growth in the more developed countries, a decline in the relative price of capital goods, and the problem of cutting-edge technology companies dealing with excess cash. The latter is explained, according to Summers, by large reserves accumulated in developing countries, an increase in propensity to save due to higher inequality, more rigorous collateral requirements due to financial crisis, and the increased costs of financial intermediation. Therefore, Summers (2015) alludes to an "inverse Say's law" where lack of demand leads to a lack of supply.

While Summers concludes that secular stagnation occurs when the desired level of savings exceeds the level of investment and monetary policy is constrained by the zero lower bound, Gordon (2015) and Pagano and Sbracia (2018) discuss that secular stagnation can also be explained through the supply side. These authors focus more on potential real GDP growth, labor productivity growth, and aggregate hours of work as significant variables to explain secular stagnation. (Gordon, 2015) argues that slow productivity growth in the past decade is due to three main reasons: (a) the business methods and installed capacity in the "dot.com" era characterized by meaningful productivity growth have faced diminishing returns; (b) the decline in net investment ratio to capital stock and the decrease in the information and communication technologies price deflator; and (c) the fall in the rate of new business start-ups. The Gordon account of secular stagnation is complementary to that presented by Piketty (2014), where an exogenous reduction in the growth rate g is responsible for the increase in the capital-income ratio and the falling wage share through high elasticity of substitution between capital and labor. Similarly, Ramey (2020) argues that the US economy has experienced a technologically-driven productivity slowdown more than demand-side secular stagnation. Yet another supply-side argument hinges on the role played by an aging population (Hansen, 1939; Gordon, 2015, 2016). The idea is that an aging population reduces the size of the labor force and productivity and generates higher savings relative to investment. A contrary perspective can be found in

Acemoglu and Restrepo (2017). They not only find no evidence of a negative association between changes in age structure and GDP per capita changes but a positive and robust relationship in some econometric specifications. They show that countries with higher shares of aging populations are the ones that adopted more industrial robots. However, they recognize that they cannot establish causality between these two variables nor that the adoption of robots is necessarily the channel that offsets the potential adverse effect of population aging on economic growth. Therefore, these authors suggest that one possible explanation for the positive relationship mentioned above is that "technology adjusts to undo this potential negative effect." Indeed, Acemoglu (2010) shows that labor scarcity leads to the adoption of automation processes that increase aggregate output when technology is strongly labor-saving but discourages technological advances when technology is strongly labor complementary.

Heterodox perspectives on the issue have questioned the notion of a natural interest rate that equalizes investment and savings in the loanable funds market at full employment levels (Wicksell, 1898; Keynes, 1930) well as the money neutrality proposition. In this vein, Palley (2018, 2019) presents the *investment saturation* hypothesis as a critique of the zero lower bound economics. Palley asserts that negative nominal interest rates, even if feasible, might be unable to resolve the problem of unemployment due to demand shortages. If a negative nominal interest rate does not consistently achieve full employment, the zero lower bound will not cause Keynesian unemployment and stagnation. Palley's main point is that investment could become unresponsive to a lower interest rate if the returns on non-reproduced assets —fiat money, land, minerals, precious metals, rent streams from firms, and intellectual property— dominate the return to investment. The reason is that lower interest rates may result in bidding up the price of non-reproduced assets rather than increasing investment. In other words, since non-reproduced assets compete with investment projects, the interest rate is not necessarily set by the demand and supply forces in a loanable funds market but by the Keynesian liquidity preference. Thus, the link between the interest rate and the savings-investment equilibrium could be broken. Similarly, Taylor (2017), using a national account decomposition for the United States, shows that the loanable funds theory is inconsistent with real-world data. According to Taylor, saving is mostly a residual quantity; moreover, higher interest rates might reduce saving "by forcing business to increase financial transfers to other sectors." Based on U.S. data, Taylor also demonstrates that the private sector's decisions are not very sensitive to interest rates.

A different strand of heterodox explanations draws from the Kaleckian and Steindlian tradition, according to which the rise of financialization is a significant factor in depressing the economy (Hein, 2013; Hein and Dodig, 2014; Hein, 2019). The first main channel found empirically in this literature is the decline in the labor share of income, especially low-income households, which directly affects overall consumption. These arguments build on contributions to the neo-Kaleckian model by Amitava Dutt (and especially Dutt, 1984, 2006). The second one is the bias to favor short run profits in the non-financial sector (see also Davis, 2016, 2017, 2018) that incentivizes financial investment at the expense of real investments. Hein rejects the idea of a single interest downward-sloping capital demand curve that, together with a supply of loanable funds curve in a more-than-one-good economy, clears the capital market at full employment level through a natural interest rate. Additionally, he argues that savings adjust to investment through income growth and changes in capacity utilization. This author also emphasizes the importance of social classes and the role of institutions in secular stagnation. In this latter respect, our perspective is similar.

The Harrodian approach has also been used to analyze the factors behind secular stagnation from a post-Keynesian viewpoint. Skott (2016) argues that public debt is not a problem in itself; however, it can be a significant burden for the economy when it reaches excessive levels. In that sense, one of the main points of Skott's contributions is to show a causal relation running from low economic growth to high public debt. Hence, fiscal policy —functional finance à la Lerner (1943)— must play an essential role in making the economy tend to full employment and avoid secular stagnation. Also, Skott supports the importance of more equitable income distribution since the higher the degree of inequality, the more elevated the public debt-GDP ratio.

From a structural Keynesian perspective, Palley (2012) alleges that stagnation in growth and wages and the Great Recession of 2008 are rooted in the neoliberal system and the growth model adopted in the late 1970s and early 1980s. According to Palley, even when financial deregulation played a crucial role in the Great Recession, the cause was the slow recovery and fragile expansion after mid-2001 due to the trade deficit that displaced domestic production and jobs and the acceleration of offshoring that closed local factories in the U.S. The weak exit from that recession caused the Federal Reserve to lower rates to 1% in mid-2003, which triggered the housing price bubble a couple of years later.

Palley (2012) also argues that before 1980, the US economy was characterized by a robust aggregate demand sustained by rising wages growing with productivity, which significantly contributed to full employment. However, after 1980, the new growth model abandoned the commitment to full employment as inflationary, weakening the link between wages and productivity and substituting wage growth as the engine of demand growth for a rising indebtedness and asset price inflation model.

While our paper focuses on a supply-side perspective, our argument is complementary to the contributions focusing on demand forces to explain complex phenomena like secular stagnation. For instance, Storm (2017) argues that the decline in total factor productivity, significantly explained by labor productivity growth -between 73% to 88%, is influenced by demand factors. Storm asserts that an unsatisfactory demand is, in turn, the consequence of a dualistic growth of the American economy with a "stagnant " sector that acts as an employer of last resort and a "dynamic" sector that loses jobs. On the other hand, Kiefer et al. (2020) present a measure of potential output that builds on the interaction between capacity utilization —that is, aggregate demand— and income shares, and show that the decline in US potential output, which predates the Great Recession of 2008, coincides with the decline in the labor share of income. Finally, our analysis draws conclusions regarding profit-led income-capital ratio vis. a vis. wage-led labor productivity growth dynamics that are somewhat similar to Palley (2013).

Our contribution draws from recent developments in the classical-Marxian tradition to offer an account of secular stagnation that, like Piketty and Gordon, emphasizes the role played by real —as opposed to financial— variables and supply forces. Our aim is not to deny the importance of financial factors and demand: rather, the goal is to present a perspective on the problem that operates at the same level of abstraction as the neoclassical explanations but is complementary to the post-Keynesian, Kaleckian, and Sraffian viewpoints.

2.3 Model: Setup

We consider a one-sector closed economy without government. Time is continuous, and the total population is assumed constant and normalized to one for simplicity. We also assume away capital depreciation as well as household debt. Finally, given that the model is one-sector, we normalize the price of the single good produced in the economy to one throughout.

2.3.1 Production, Income Distribution, and Wealth Accumulation

The economy is populated by two types of households. "Workers" (denoted by the superscript w in what follows) supply labor services inelastically to firms, earn both labor and capital income, consume and save. "Capitalists" (denoted by the superscript c) own capital stock, earn only profit incomes, consume and save. For the sake of simplicity, assume that neither type of capital depreciates. Output per worker y, homogeneous with capital stock, is produced using fixed proportions of capital per-worker $k \equiv k^c + k^w$ and labor: $y = \min\{A, uk\}$, where u denotes the output-capital ratio, endogenous to the model, and A is the stock of labor-augmenting technology, also endogenously growing over time. Let r be the uniform rate of return on capital, endogenous to the model but given to each household: both types of households are price-taking in goods and factor markets.

Through their savings, workers participate in the accumulation of capital in the economy (Pasinetti, 1962). The introduction of workers' savings in a CM model is motivated both by theoretical and empirical reasons. At the theoretical level, Michl (2009) has motivated saving by workers justified through life-cycle considerations. From an empirical standpoint, the analysis by Saez and Zucman (2016) has shown that the saving rate for bottom 90% of wealth owners in the US averages 5% per year between the 1930s and the Great Recession. Let the workers' propensity to save, constant throughout, be denoted by $s^w \in (0,1)$. Importantly for the analysis, not all workers will be employed at any given point in time: the number of employed workers is equal to labor demand by firms which, due to the Leontief production technology, is not elastic to the wage. This implies that movements in the real wage are not enough to clear the labor market. The employment rate in the economy is $e \equiv uk/A$ (recall that the labor force is normalized to one). Therefore, total workers' savings, in turn, equal to workers' investment in new capital stock $\dot{k}^w$, is:

$$\dot{k}^w = s^w \left[\frac{w}{A} uk + rk^w \right] \tag{2.1}$$

Next, denote the capitalists' share of wealth by $\phi \equiv k^c/(k^c + k^w) \in [0,1]$ so that $k^c = \phi k$. Letting the labor share (endogenous in the model) be denoted by $\omega \equiv w/A$, simple algebra delivers the workers' accumulation rate as:

$$g^w \equiv \frac{\dot{k}^w}{k^w} = s^w u \left[\frac{\omega}{1-\phi} + (1-\omega) \right] \tag{2.2}$$

On the other hand, capitalist households only earn profit income out of the capital they own. With a constant propensity to save $s^c \in (0,1)$, the capitalists' accumulation rate satisfies the usual Cambridge equation:

$$g^c = s^c r = s^c u(1-\omega) \tag{2.3}$$

Using equations (2.2) and (2.3), the economy-wide accumulation rate will be a weighted average of the growth rates of capital stock for the two types of households:

$$\begin{aligned} g &= \phi g^c + (1-\phi)g^w \\ &= u\left[s^w + \phi(1-\omega)(s^c - s^w)\right] \end{aligned} \tag{2.4}$$

Equation (2.4) emphasizes the profit-driven nature of capital accumulation, even with worker saving. Indeed, everything else equal the economy's accumulation rate decreases in the wage share, and increases in the profit share.

Two clarifications are in order before moving on. First, the classical political economists often reasoned in terms of an institutionally given, "conventional" *real wage*, also given low growth rates in pre-industrial economies. In growing economies, a fixed real wage coupled with rising labor productivity implies a uniformly falling wage share. For this reason, Foley et al. (2019) present a modification of the basic classical one-sector model that features a conventional *wage share*, providing a model closure that is more appropriate for economies with growing labor productivity. Here, however, the wage share is not fixed exogenously, but responds endogenously to the interaction between technological factors i.e. the bias of technical change Kennedy (1964); von Weiszacker (1966, described below), as well as institutional factors affecting the real wage (Tavani, 2012b, 2013b).[8] Second, we assume Say's law to hold at all times, which means that we rule out any behavioral explanation for investment demand as independent of the supply of savings in the economy. This is common in the classical-Marxian literature (see the relevant chapters in Harris, 1978; Marglin, 1984; Blecker and Setterfield, 2019; Foley et al., 2019), but importantly it does

[8]Note also that we will be closing the model with a Goodwin (1967) Phillips curve: this is enough to determine the time-path of the real wage given initial conditions. See Section 2.3.4.

not necessarily require the existence of a banking sector where loanable funds are traded with the real interest rate playing the role of equilibrating saving and investment. Here, the long run rate of return to capital is determined endogenously but residually from the accounting relation $r = u(1-\omega)$, given the income-capital ratio u, and the share of profits $1-\omega$, but markedly *not* from a saving-investment equilibrating mechanism. As such, and as is standard in one-sector CM models, in our model there is no banking sector and investment is passive: whatever sources of funds are available from savings, they are automatically accumulated in the form of new capital. Again, one of our goals in this paper is to show that secular stagnation can emerge from labor-crushing distributional changes —and not from exogenous reductions in the growth rate like in neoclassical explanations— even accepting the premises of a supply-constrained economy in the long run.

2.3.2 Technical Change: The Induced Innovation Hypothesis

We turn now to specify the evolution of technology through induced innovation. Following Kennedy (1964); Drandakis and Phelps (1966); Funk (2002); Julius (2005); Zamparelli (2015), we suppose that firms have access to a menu of technological improvements that potentially can increase both the output-capital ratio (at a rate χ) and labor productivity (at a rate γ). However, there are trade-offs between improving along one technological dimension versus the other. Such trade-offs are summarized by a twice-continuously differentiable, strictly decreasing, strictly concave *innovation possibility frontier* (Kennedy, 1964, IPF henceforth), which can be written in an explicit form as:[9]

$$\gamma = f(\chi), \;\; f_\chi < 0, f_{\chi\chi} < 0 \tag{2.5}$$

[9] Strict concavity of the IPF synthetically captures the increasing difficulty in adopting factor-augmenting technologies (Funk, 2002), and is mathematically convenient because it will lead to an interior solution of the firm's problem.

Firms choose a profile of technological improvements to maximize the rate of reduction in unit costs, or equivalently the rate of change in the profit rate, subject to the constraint given by the IPF (see Julius, 2005; Tavani, 2012b): as discussed in Sasaki (2008) and Tavani and Zamparelli (2017), this is in fact equivalent to the classical choice of technique criterion one can find, for example, in Okishio (1961) that involves maximizing the profit rate at a given real wage.

As shown in Kennedy (1964); Julius (2005); Tavani (2012b); Foley et al. (2019, Ch.7), the firm's program amounts to maximizing a weighted average of the growth rates of factor-augmenting technologies, the weight being the shares of labor and capital: $(1 - \omega)\chi + \omega f(\chi)$. The solution, an implicit function defined by the first-order condition $-f_\chi = (1 - \omega)/\omega$, yields a dependence on the relative growth rates of capital- and labor-augmenting technologies on factor shares, and in particular a direct (inverse) relation between labor (capital) productivity growth and the labor share.

We also assume an exogenous shift parameter, denoted by z, that affects the curvature and intercept of the IPF, and therefore the firm's choice of factor-augmenting technical change. In particular, we assume that the partial derivatives of factor-augmenting technologies are such that $\chi_z > 0, \gamma_z \geq 0$, which guarantees that the long run labor share will be increasing in z. Moreover, following Petach and Tavani (2021) and Rada et al. (2022), we interpret z as any policy or institutional variable positively affecting the labor share.[10] Thus, the growth rates of capital- and labor-augmenting technologies can be written as:

$$\chi = \chi(\omega; z); \quad \gamma = f[\chi(\omega; z)] \tag{2.6}$$

[10] Tavani (2012b, 2013b) has provided microeconomic foundations for this result that use the generalized Nash (1950) bargaining solution to determine the real wage at the firm level. In these models, z is explicitly derived as a combination of the workers' reservation wage, in turn influenced by labor market institutions such as unemployment compensations or minimum wages, and the workers' bargaining power. Our argument presents a simplified, reduced form version that shares the same conclusions but retains the familiar Goodwin (1967) real-wage Phillips curve and corresponding macroeconomic determination of real wages.

with $\chi_\omega < 0$, and correspondingly $\gamma_\omega > 0$.[11]

Observe that induced innovation in this framework plays a similar role to what would be factor substitution in a neoclassical aggregate production function: higher labor costs induce more labor-saving and less capital-saving technologies. However, and as noted already in the literature, capital-labor substitution occurs through technological progress and not diminishing marginal products. Importantly, the induced innovation hypothesis: (a) does not suffer from the well-known issues with aggregating across different capital goods highlighted in the Cambridge controversy,[12] and (b) does not imply that wage flexibility will clear the labor market, given that in every period the underlying technology is Leontief.

Hence, the evolution of the income-capital ratio is governed by induced innovation, and satisfies:

$$\dot{u} = \chi(\omega; z)u \tag{2.7}$$

To sharpen our conclusions, we postulate linear versions of both growth rates of factor-augmenting technologies that generalize the specifications by Petach and Tavani (2021):

$$\chi(\omega; z) = z - \beta\omega; \quad \gamma(\omega; z) = \alpha[z - \chi(\omega; z)] \tag{2.8}$$

The parameter α, describing the sensitivity of labor productivity growth to labor market institutions and the wage share, is crucial in what follows: see Section 2.4.

[11] See Rada et al. (2022) for a discussion of the above assumption for both Classical and Keynesian models of growth and distribution.

[12] Kennedy (1973) shows that, unlike neoclassical factor substitution, induced bias in a model with differentiated capital goods is immune from the reswitching problem.

2.3.3 Dynamics: Wealth Distribution

Consider next the capitalist share of wealth ϕ. Its law of motion over time obeys the replicator equation:

$$\dot{\phi} = \phi(g^c - g) \tag{2.9}$$

which, using (2.3) and (2.2), gives after simple manipulation:

$$\dot{\phi} = \phi u \left[(1-\phi)(1-\omega)(s^c - s^w) - s^w \omega\right] \tag{2.10}$$

2.3.4 Dynamics: Income Shares and Employment Rate

To close the model, we follow Goodwin (1967) in specifying the interaction between the labor market and real wages. We assume that real wages follow a Phillips-style curve: $\dot{w}/w = f(e;z)$ with $f_e > 0, f_z > 0$. Given induced bias in technical change, the evolution of the labor share obeys:

$$\dot{\omega} = \left[f(e;z) - \gamma(\omega;z)\right]\omega \tag{2.11}$$

To characterize the steady state and policy implications in what follows, we assume a linear version of the Phillips curve: $f(e;z) = -\lambda + \delta e + \mu z$, with $\lambda > 0, \delta > 0, \mu > 0$. The Goodwin (1967) specification is obtained as a special case where $\mu = 0$.

Finally, the evolution of the employment rate is obtained by differentiation of its very definition. Given the assumed constancy of the labor force, we have that:

$$\begin{aligned} \dot{e} &= (\chi + g - \gamma)e \\ &= \left\{\chi(\omega;z) + u\left[s^w + (1-\omega)\phi(s^c - s^w)\right] - \gamma(\omega;z)\right\} e \end{aligned} \tag{2.12}$$

Equations (2.7), (2.10), (2.11), and (2.12) form a 4-dimensional dynamical system describing the growth and distribution path of this stylized economy. The endogenous variables are:

(i) the functional distribution of income ω; (ii) the employment rate e; (iii) the distribution of wealth between the two classes ϕ, and (iv) the income-capital ratio u.

2.4 Steady State

We now turn to characterize the steady state of the model. Start from equation (2.7): setting $\dot{u} = 0$ delivers the long run labor share as

$$\omega_{ss} = \frac{z}{\beta} \tag{2.13}$$

increasing in the policy/institutional parameter z. In a graph with the employment rate e on the horizontal axis and the wage share ω on the vertical axis, the long run labor share is a horizontal line at z/β: a positive (negative) shift in the institutional parameter z moves the long run labor share up (down). See Figure 2.1.

Note further that the labor share evolves endogenously to its long run value (2.13) to ensure a Harrod-neutral path of technological change where labor productivity grows but the income-capital ratio is constant (Kennedy, 1964; Drandakis and Phelps, 1966; Julius, 2005).

Next, setting $\dot{\omega} = 0$ in equation (2.11) gives the employment nullcline

$$e(\omega; z) = \frac{\lambda + \alpha\beta\omega - \mu z}{\delta} \tag{2.14}$$

which is upward-sloping in the labor share everything else equal. However, a change in the policy variable z shifts the employment rate nullcline in the opposite direction, since $\partial e/\partial z = -\mu/\delta < 0$. In the (e, ω) plane in Figure 2.1, a decline in z shifts the employment nullcline down and right. Therefore, the ultimate effect on equilibrium employment depends on the relative magnitude of the response of income distribution to a policy change *vis à vis* the employment response. This is because both curves shift following a change in the policy variable z. In fact, once the employment equation is evaluated at the steady state value for the labor share, it pins down the long run employment rate as

$$e_{ss} = \frac{\lambda + (\alpha - \mu)z}{\delta} \tag{2.15}$$

and the effect of the labor market parameter z on employment depends on the sign of $\alpha - \mu$.[13] If $\alpha > \mu$, a positive shock to the wage share will increase the long run employment rate: in a nod to the familiar terminology in demand-driven models, we will refer to this case as a wage-led employment regime in what follows. Conversely, if $\alpha < \mu$, the long run employment rate responds negatively to shocks to the wage share: we will refer to this case as profit-led. The economic intuition has to do with the relative magnitude of the response of induced bias as opposed to labor market conflict to changes in labor institutions. The parameter α captures how strongly the firm's choice of the direction of technical change responds to an increase in the wage share; since the growth rate of labor productivity anchors the long run growth rate of the economy, higher values of α imply that growth becomes wage-led to a higher extent. The parameter μ, on the other hand, captures how strong is the effect of labor market institutions on labor market conflict, as described by the real-wage Phillips curve. An increase in μ creates more pressure on real wage growth, which everything else equal depresses the profit-driven accumulation rate and employment. The relative magnitude of the two effects determines whether the accumulation response to labor market institutions is stronger or weaker than the technical change response and the ultimate effect of z on long run employment.

Further, imposing $\dot{\phi} = 0$ in equation (2.10), we find the nullcline relating the distribution of wealth to factor shares:

$$1 - \phi(\omega) = \frac{s^w}{s^c - s^w} \left(\frac{\omega}{1 - \omega} \right) \tag{2.16}$$

[13]We also assume that $\delta > \lambda + (\alpha - \mu)z > 0$ so that the long run employment rate is bounded above by one.

which captures that the capitalists' share of wealth and the labor share of income are inversely related, as it is intuitive. Substituting from (2.13) we find the long run wealth distribution in terms of parameters only:

$$1 - \phi_{ss} = \frac{s^w}{s^c - s^w}\left(\frac{z}{\beta - z}\right) \tag{2.17}$$

Given that $1 - \phi_{ss}$ is the worker's wealth share, implies that a positive (negative) shock to the institutional parameter z will increase (decrease) the workers' share of wealth: an increase in the labor share increases the funds available to worker to accumulate capital stock and therefore increase their share in the economy's total wealth.

Finally, imposing a steady state in equation (2.12) gives the following nullcline relating the long run output/capital ratio to the wage share and capitalist wealth share as follows:

$$u(\phi, \omega) = \frac{\alpha\beta\omega}{s^w + \phi(1-\omega)(s^c - s^w)} \tag{2.18}$$

Notice that the long run income-capital ratio increases in the wage share and decreases in the capitalist share of wealth. The economic intuition is the following: workers have a higher propensity to consume, which implies that an increase in their share of income results in more consumption demand. Such additional demand must be met by production, which implies that the output-capital ratio increases. Similarly, a higher capitalist wealth share increases the economy-wide saving-to-capital ratio in equation (2.14) above, and reduces total consumption-to-capital —and therefore the output-capital ratio u— everything else equal.

To find the long run solution in terms of parameters only, plug in equations (2.13) and (2.17). After some algebra, we find:

$$u_{ss} = \frac{\alpha\beta z}{s^c(\beta - z)} \tag{2.19}$$

Thus, the long run income-capital ratio is increasing in the policy variable z, while decreasing in the capitalist saving rate s^c. The similarity with the "paradox of costs" and the "paradox of thrift" in neo-Kaleckian economics is suggestive but misleading in this context. In a wage-led demand-driven model such as the neo-Kaleckian framework, both redistribution toward wages and a lower saving rate will determine an increase in the income-capital ratio (aggregate demand) without harming accumulation. Conversely, the supply constraint is binding here, and both an decrease in the saving rate and an increase in the labor share of income via a positive shock to z will lead to an increase in the income-capital ratio, but at the expenses of short run accumulation: there is no paradox of thrift. On the other hand, it is true that a version of the paradox of costs work in our model, but it operates through the adverse effect of labor-crushing shocks on the endogenous long run growth rate, and not on aggregate demand.

2.4.1 Comparative Statics and Policy Implications

The model's main exogenous variables of interest are the parameter describing labor market institutions z and the two classes' propensity to save, s^c and s^w. We study the comparative statics effect of each variable in turn.

Start with a change in the institutional parameter z: it will produce a change of the same sign in the long run wage share (equation 2.13), workers' wealth share (equation 2.17), the long run growth rate of labor productivity (equation 2.8), and income-capital ratio (equation 2.19). As already noted, the ultimate effect on employment is ambiguous: it depends on whether the response of technical change to income distribution is stronger or weaker than the extent of labor market conflict on wage growth. Whenever $\alpha > \mu$, the long run employment rate is wage-led and there is no tradeoff between long run productivity growth and employment: a shift in labor market institutions that lowers z, and therefore is adverse to labor, reduces the long run wage share, the growth rate of labor productivity, *and* employment. This scenario is displayed in the left panel of Figure 2.1. Conversely, If $\alpha < \mu$, long run employment is profit-led: in this case, a capital-friendly shift in labor market institutions has a positive effect on long run growth while a negative impact on long run employment. This case is shown in the right panel of Figure 2.1.

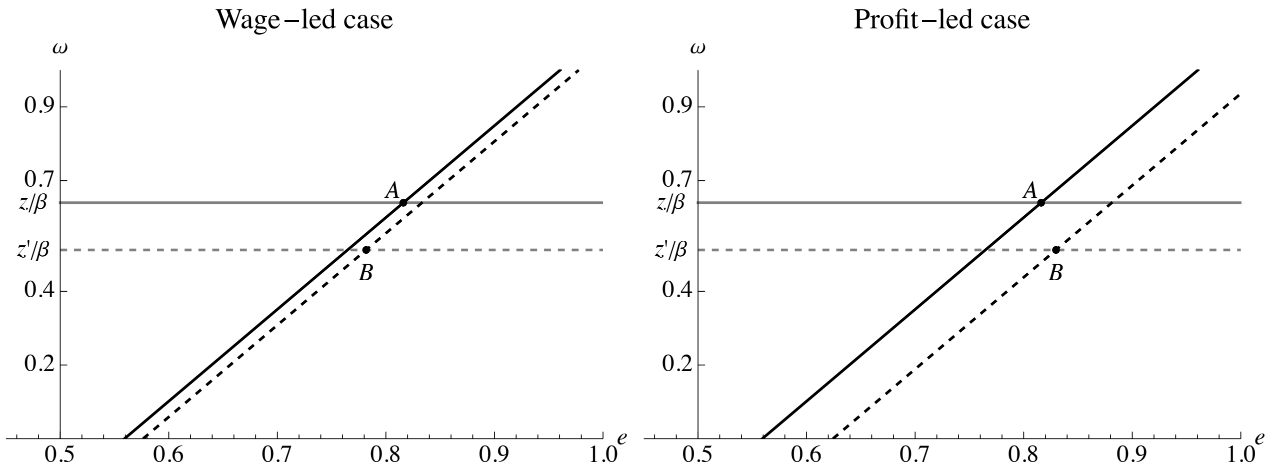


Figure 2.1: The effect of a reduction in the labor market parameter z in the wage-led *vs.* profit-led steady state

As argued in Petach and Tavani (2021), this simple model provides some interesting political economy insights on the secular stagnation and inequality that have plagued advanced economies, especially the United States, in the Neoliberal era. A shift toward labor-crushing institutions —because of globalization, trade liberalization, or the decline in workers' bargaining power and deunionization— which is responsible for the decline in the labor share, also has reduced the long run growth rate of labor productivity because of the lessened incentives for firms to invest in labor-augmenting technologies. The decline in the labor share has in turn determined a reduction in the workers' wealth share, because labor income —the main source of income for workers— has declined as a share of total income, thus lowering the funds available to workers for wealth accumulation. A worsening of labor market institutions also has the ultimate effect of reducing the income-capital ratio (increasing the capital-income ratio) for the following reason. The decline in the labor share puts pressure on the capitalists' accumulation rate: because of the Pasinetti theorem, the capitalist accumulation rate $s^c u(1-\omega) = g^c$ is equal to the economy's growth rate g in balanced growth. However, the long run growth rate of labor productivity is wage-led, and has fallen. Restoring the balanced growth condition $g = \gamma(\omega)$ —which guarantees Harrodian stability in the labor-market— requires a decline in the long run income-capital ratio. Finally, the ultimate effect on long run employment can be either positive or negative, as described already and shown in Figure 2.1.

Next, consider the effect of the capitalist saving propensity s^c on the long run of the model. Given that the long run wage share only depends only on z, it will be unaffected by a change in the saving rate; so will steady state employment. Conversely, a change in the capitalist saving rate will affect both the long run capitalist share of wealth and the long run income/capital ratio. Everything else equal, a higher capitalist propensity to save out of profits puts pressure on the capitalist accumulation rate, which increases their share (and reduces the workers' share) in total wealth. Given that the long run wage share is unaffected by the change, labor productivity growth has not changed. Thus, the capital stock has grown more than income, which explains the reduction in the long run income/capital ratio.

Finally, and perhaps strikingly, a change in the workers' saving rate s^w only influences the long run distribution of wealth while leaving the steady state value of every other endogenous variable unaltered. This is not surprising in light of the Pasinetti theorem. But, of course, there will be effects along the transitional dynamics: they are explored in the simulations below.

2.5 Transitional Dynamics and Numerical Simulations

A formal analysis of the local stability properties of the model's steady state is provided in Appendix B.1. Even though the model is stylized enough to be studied analytically, it is informative to carry a series of simulations exercises in order to showcase the adjustment dynamics following a shock to the parameters of interest, namely z, s^w, s^c. Notably, the simulations are meant to be illustrative of the qualitative properties of the dynamics and not to provide an exact representation of an economy's response to a series of shocks. In order to calibrate the two classes' saving rates, we follow Saez and Zucman (2016) and set the capitalists' saving rate equal to 35% and the workers' saving rate at around 7.5%. We fix z at 0.025 and internally calibrate β at .039 in order to obtain a steady state wage share of 64% in the baseline model. We then fix $\delta = 0.073$, in line with estimates of the slope of the Phillips curve for the United States, and $\alpha = 0.75$. In the wage-led model, μ is set at 0.25, and λ is internally calibrated to return a steady state prime-age employment/population ratio of about 80% —the pre-2008 value in the United States— in the baseline. In the profit-led model, $\mu = 0.95$, which requires recalibrating λ to match the steady state employment rate. All simulations assume that the economy is in steady state at time zero when a shock to either parameter occurs.

In the first simulation, we reduce the labor market parameter z by 5% in both the wage-led and profit-led models. A visual representation of the simultaneous shifts in the wage share and employment nullclines (equations 2.13 and 2.14) corresponding to the two cases is already represented in Figure 2.1, obtained using the calibration described above. The actual transitional dynamics are displayed in Figure 2.2, where the shocked trajectories are displayed as solid lines while the baseline trajectory are shown as dashed lines. The comparison illustrates a critical implication of the model: income shares, the wealth distribution, and the income-capital ratio converge to the same values in both the profit-led and the wage-led model, while of course, the trajectory and the ultimate value of employment depend on whether it is wage-led or profit-led. The difference matters: in the wage-led case there is no trade-off between a labor-friendly change in income distribution and employment, while in the profit-led case such a trade-off does exist.

In the second set of simulations, displayed in Figure 2.3, we increase the capitalists' saving rate s^c by 5% at time zero (left panel), and the workers' saving rate by the same amount in the right panel. As already explained above, an increase in s^c reduces the

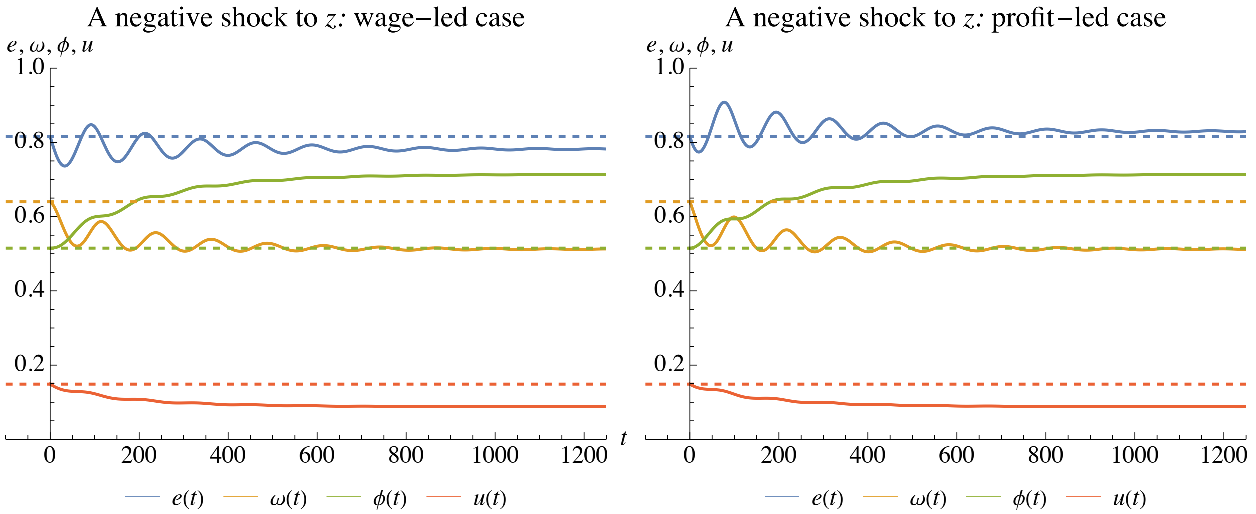


Figure 2.2: Simulations: a 5% time-zero reduction in z

income-capital ratio while it increases the long run capitalist share of wealth; while an increase in s^w only affects the distribution of wealth (in favor of workers) in the long run.

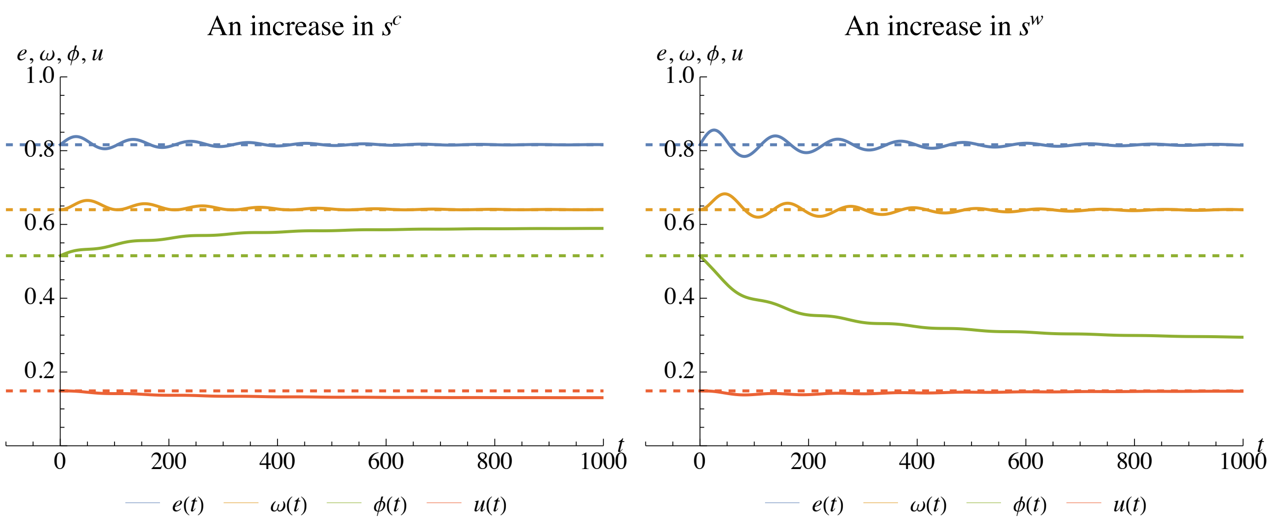


Figure 2.3: Simulations: a 5% time-zero increase in capitalists' and workers' saving rates

The comparative statics of reducing the capitalist saving rate offers an interesting comparison with a similar exercise in Michl and Tavani (2022). They use a reduced form technical progress function that depends on the growth rate of capital stock per capita and the wage share. They find that a reduction in the capitalist saving (which they call 'capitalization') rate will, in fact, lower long run employment. The capital channel is precluded from operating by assumption in this paper, because technical progress responds only to income shares via induced technical change and is invariant to capital accumulation.

2.6 Wealth Redistribution

Zamparelli (2017) has shown that, in a neoclassical economy with high elasticity of substitution between capital and labor, tax policy can be used to implement any wealth distribution among the two classes. The same is true here, despite the fixed-coefficients technology in production. Let us introduce a government that taxes capitalists' profit incomes proportionally at a rate τ and rebates the proceedings to workers in the form of subsidies. The capitalists' and workers' accumulation rates modify as follows:

$$g^c = s^c u(1-\omega)(1-\tau) \tag{2.20}$$

$$\begin{aligned} g^w &= s^w \frac{uwk/A + rk^w + \tau r k^c}{k^w} \\ &= s^w \frac{u}{1-\phi}\left[1-\phi(1-\omega)(1-\tau)\right] \end{aligned} \tag{2.21}$$

After factoring terms, the evolution of the capitalist wealth share modifies to:

$$\dot{\phi} = \phi u \left\{ s^c(1-\omega)(1-\phi)(1-\tau) - s^w[1-\phi(1-\omega)(1-\tau)] \right\} \tag{2.22}$$

Next, using the steady state wage share from equation (2.13), the two-class equilibrium delivers the following capitalist wealth share as a function of the tax rate:

$$\phi_{ss}(\tau) = \frac{s^c(\beta - z)(1-\tau) - s^w \beta}{(\beta - z)(1-\tau)(s^c - s^w)} \tag{2.23}$$

which reduces to (2.17) for $\tau = 0$ as in the baseline model. Now, the government can fix the tax rate in order to implement the desired distribution of wealth, given the two classes' saving propensities and the parameters determining the long run share of labor. Differentiating with respect to τ, we find that, intuitively, the long run capitalist wealth share decreases in the tax rate:

$$\frac{\partial \phi_{ss}}{\partial \tau} = -\frac{s^w \beta(\beta - z)(s^c - s^w)}{[(\beta - z)(1-\tau)(s^c - s^w)]^2} < 0$$

Finally, the tax rate τ^* that implements the long run wealth distribution targeted by the policymaker ϕ^* is simply

$$\tau^* = 1 - \frac{s^w \beta}{(\beta - z)[s^c - \phi^*(s^c - s^w)]} \tag{2.24}$$

Petach and Tavani (2021) have provided some back-of-the-envelope calculations about various tax rates necessary to reduce wealth inequality in the United States. They have argued that both the effective corporate tax rate and the effective estate tax rate should be increased substantially to reduce the U.S. top wealth share to its value in 1978, the lowest since 1920s.

There is an important difference in policy implications with the neoclassical model, however: there, capital gains taxation will reduce wealth concentration and the capital-income ratio by reducing the difference $r - g$ and, with an elasticity of substitution higher than one, will increase the labor share. Here, capital gains taxation will reduce wealth concentration and lower the capital-income ratio (increase u in equation 2.16), *but will not have an effect on the labor share of income*. Therefore, our analysis implies that a tax on capital gains will certainly be effective at taming wealth inequality; but reversing the decline of the labor share requires specific policies aimed at strengthening the distributive position of the working class.

2.7 Empirical Evidence for the United States (1960-2019)

In addition to the numerical simulations, we performed an empirical exercise for the United States (1960-2019), using the following data: the income-capital ratio, the top 1% share of wealth, the employment-population ratio, and the labor share. We thus have an endogenous, four-variable, time-series system that we can estimate using standard econometric methods. We then run an 'experiment' on the estimated model. After estimating short and long run relations, we negatively shock the labor share by a one-standard deviation, and plot impulse responses for the top wealth share, the income-capital ratio, and the employment-population ratio.[14]

The income-capital ratio is calculated by dividing the variable *cgdpo* by *cn* from Penn World Table 10.0.[15] The top 1% of net personal wealth is obtained from the World Inequality Database (WID). It must be said that the translation from the capitalist wealth share in the theoretical model to the top 1% wealth share is not straightforward: the notion of wealth in our model does not include financial wealth as already stated, while the WID calculations include financial appreciation. However, to our knowledge there are no measures of wealth inequality that are perfectly comparable with our theoretical capitalist wealth share; and earnings by the top 1% are mostly related to profits rather than wages. For these reasons, while imperfect, we believe that using the top 1% wealth share is useful toward an empirical validation of our model. The prime-age employment-population ratio (for workers of 25 to 54 years of age) is taken from the U.S. Bureau of Labor Statistics, and retrieved from Federal Reserve Economic Data (FRED). And the labor share is obtained

[14] Our estimation is a standard vector error-correction model (VECM) and does not allow for the time-varying regime of income-capital ratio and distribution in Carrillo-Maldonado and Nikiforos (2022). However, our conclusions are broadly in line with theirs.

[15] Both of these measures are calculated in real terms in the PWT, with *cgdpo* being real output from the supply side and *cn* being real capital stock (there is a separate price level for capital in the PWT). As such, our measure of the income-capital ratio is by construction removed from appreciation effects due to mere financial forces.

from series *labsh* from Penn World Table 10.0. All these four variables are expressed in percentage points.

The main goal of the exercise is to evaluate the system's response to an exogenous negative shock to the wage share, which would correspond to a test of the main predictions of our theory against the available data. As a reminder, our theory leads to the testable implication that a negative shock to the wage share determines: (a) a decline in the income-capital ratio; (b) an increase in the top wealth share; (c) either a positive (profit-led) or negative (wage-led) response of employment.

Appendix B.2 shows that all the four variables are non-stationary in levels but stationary in first differences, even in the presence of possible structural breaks. in Appendix B.3 displays detailed trace and maximum eigenvalue tests for the Johansen cointegration test. We run this test without a linear deterministic trend in data, but with an intercept in the cointegrating equation. The trace and the maximum eigenvalue tests support that one cointegrating equation exists at a 5% significance level.

Based on the five information criteria in in Appendix B.4, there is no consensus on the optimal lag length for the vector autoregressive (VAR) model. We, therefore, selected three lags for the vector error correction model (VECM) since it was the minimum number of lags to have no serial autocorrelation of residuals in our model. Since this is a cointegrated endogenous system, we run the following VECM with three lags and one cointegrating equation (see Table 2.1 for details on the notation):

$$\begin{aligned}
\Delta u_t &= \sigma_{u0} + \sum_{j=1}^{k-1} \tau_{uj} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{uj} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{uj} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{uj} \Delta \omega_{t-j} + \xi_u ECT_u + \upsilon_t^u \\
\Delta \phi_t &= \sigma_{\phi 0} + \sum_{j=1}^{k-1} \tau_{\phi j} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{\phi j} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{\phi j} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{\phi j} \Delta \omega_{t-j} + \xi_\phi ECT_\phi + \upsilon_t^\phi \\
\Delta e_t &= \sigma_{e0} + \sum_{j=1}^{k-1} \tau_{ej} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{ej} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{ej} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{ej} \Delta \omega_{t-j} + \xi_e ECT_e + \upsilon_t^e \\
\Delta \omega_t &= \sigma_{\omega 0} + \sum_{j=1}^{k-1} \tau_{\omega j} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{\omega j} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{\omega j} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{\omega j} \Delta \omega_{t-j} + \xi_\omega ECT_\omega + \upsilon_t^\omega
\end{aligned}$$

Table 2.1: Notation of the VECM

Notation	Description
Δ	First-difference operator
σ_{i0}	Constant term of variable *i*
k	Optimal lag length for the VAR specification
ξ_i	Speed of adjustment parameter of variable *i*
ECT_{it}	Error correction term of variable *i*
υ_t^i	Disturbance or error term of variable *i*

Concerning the joint long run effects, the error correction terms (ECTs) for the income-capital ratio, the top 1% wealth share, and labor share are negative and statistically significant (see Table 2.2. The system converges to equilibrium at a speed of 52.2%, 14.4%, and 24.9% annually when the three variables mentioned above are shocked, respectively. The ECT for employment-population ratio is not statistically significant (p-value = 0.19, not shown in the table), meaning that the employment-population ratio is weakly exogenous in the cointegrating relations.

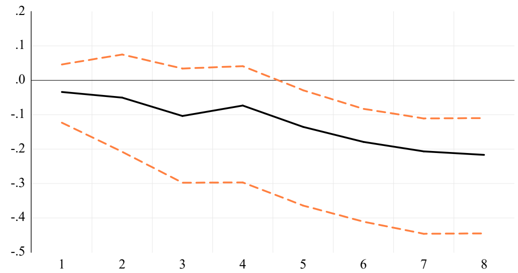
Appendix B.5 and Appendix B.6 provide evidence of the absence of serial autocorrelation of residuals, and Appendix B.7 shows that residuals are homoskedastic. Appendix B.8 demonstrates that the model is stable since the roots of the characteristic polynomial lie within the unit circle: this is equivalent to the eigenvalues in the Jacobian having negative real parts in the continuous-time theoretical model. In Appendix B.8 three unit roots are expected because we have four endogenous variables ($n = 4$) and one cointegrating equation ($CE = 1$). The number of unit roots imposed by the VECM specification is equal to $n - CE = 3$.

2.7.1 Impulse Responses

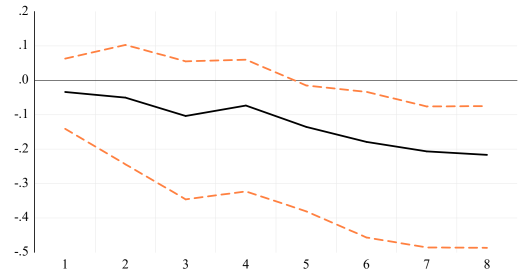
Figure 2.4 shows the responses of u, ϕ, and e to an orthogonal set of negative innovations in the residuals of the labor share ω. By using the generalized impulses specification, the innovations do not depend on the VECM ordering ignoring the correlations in the residuals (Pesaran and Shin, 1998)

In the impulse responses plotted in Figure 2.4, the effect of an exogenous negative shock to ω, which would be equivalent to an decrease in the policy parameter z in equation 2.13, does not die out over time but leads to new steady state values for all three variables.[16] We use Hall's percentile bootstrap (Hall, 1992) with 1000 bootstrap repetitions to compute the confidence intervals for the IRF's. The impact on u is negative as expected from equation 2.19, and the effect on ϕ is positive, as implied by equation 2.17. The long run effect on e could be either positive or negative in the theoretical model, depending on the relative magnitude of the parameters α and μ: our time-series exercise suggests that the employment regime in the United States over the period under consideration is wage-led. Note that, for the first three or four periods depending on the variable under consideration, the confidence intervals cross zero on the vertical axis. But statistical significance of the responses is achieved after at most four periods, consistent with the fact that our theoretical predictions pertain to the long run.

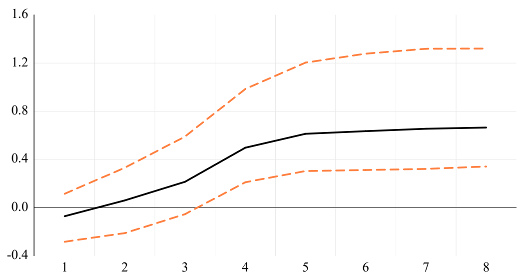
[16]Since we are working with annual data, one period corresponds to a year in the plots.



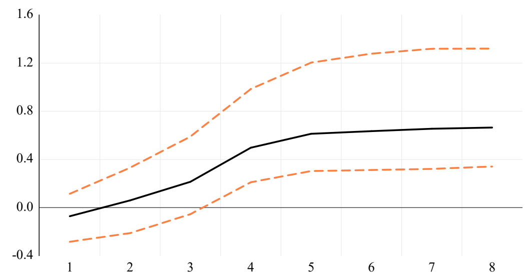
(a) Response of u (90% C.I.)



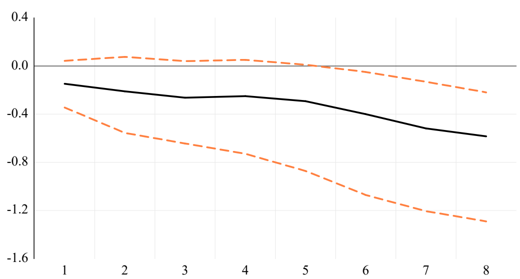
(b) Response of u (95% C.I.)



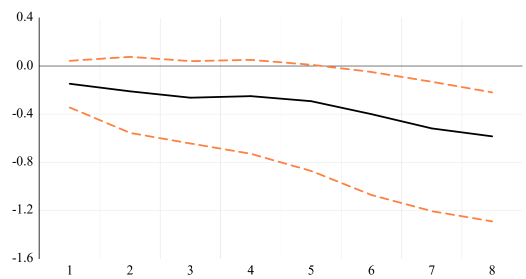
(c) Response of ϕ (90% C.I.)



(d) Response of ϕ (95% C.I.)



(e) Response of e (90% C.I.)



(f) Response of e (95% C.I.)

Note: Confidence intervals are calculated using Hall's percentile bootstrap with 1000 bootstrap repetitions.

Figure 2.4: Generalized impulse responses of u, ϕ, and e to a negative one-SD innovation in ω using Hall's percentile bootstrap.

In Appendix B.9, we generate impulse responses using Hall's studentized bootstrap (Hall, 1986) with 1000 bootstrap repetitions and 500 double bootstrap repetitions as a robustness check. These results confirm our findings in Figure 2.4.

2.8 Concluding Remarks

This chapter presented a simple but comprehensive model of secular stagnation, income and wealth distribution, and employment drawing from contemporary work in the classical-Marxian tradition, and extending Petach and Tavani (2021). Similarly to to the well-known neoclassical account (Piketty, 2014; Gordon, 2015), in our model the economy is constrained by supply forces in the long run; however, rather than presupposing full employment, exogenous growth, and high elasticity of substitution between capital and labor, our framework emphasizes the preeminence of the functional distribution on both capital accumulation and technological change. The former is profit-driven, while the latter is conflict- (or wage-) driven by induced bias in technology (Kennedy, 1964; Shah and Desai, 1981; Julius, 2005; Zamparelli, 2015).

We argued that labor-suppressing institutional shocks initially foster capital accumulation g, which is profit-driven. However, in the long run, the growth rate of the economy —which ultimately depends on labor-productivity growth γ, in turn related to income shares through induced technical change— falls due to the lessened incentive to adopt labor-augmenting technologies, given that the labor share has fallen. Thus, the income-capital ratio must fall to restore the balanced growth condition $g = \gamma$.

We also emphasized the evolution of the distribution of wealth, revisiting the Pasinetti (1962) theorem that ties up to our argument through the inverse long run relationship between the wage share and the top wealth share on the one hand, and between the top wealth share and the income-capital ratio on the other. Differently from previous contributions, we also explicitly studied the evolution of the employment rate and its relationship to the functional income distribution in the long run: we identified two forces at work in determining the ultimate response of employment to shocks to the wage share, namely the strength of the induced technical change channel as opposed to the pure labor-market conflict channel. Correspondingly, we were able to identify a wage-led and a profit-led employment regime in the long run depending on the relative strength of the two channels.

We ran a time-series test of the model using U.S. data (1960-2019). In particular, our interest is in the response of the income-capital ratio, the top wealth share, and the employment-population ratio to an exogenous negative shock to the wage share. Our theoretical model appears to do reasonably well for the period under consideration. Following a negative one-standard-deviation shock to the wage share, the impulse response functions display a long run effect of the same sign on the income-capital ratio and an opposite-sign impact on the top wealth share. Both these effects are as expected from the theory. The long run effect on employment appears to be the same sign of the shock to the wage share, thus suggesting that the long run employment regime in the US has been wage-led over the sample period.

Importantly, our explanation of secular stagnation and inequality does not feature a role for aggregate demand but emphasizes technological (i.e., supply) forces. Our model features a long run where growth is wage-led through technological change; and it features the possibility of a wage-led employment regime in the long run —similarly to the possibility of long run wage-led economic activity (capacity utilization) in neo-Kaleckian economics— that appears to be supported by the empirical evidence pertaining to the period under consideration.

Finally, the main policy implication is that, even in a supply-constrained economy, labor-friendly redistribution policies that increase the labor share of income will reduce wealth inequality while at the same time increasing economic growth and long run employment; while a tax on capital gains —which will be undoubtedly effective at reducing wealth inequality— may fall short at reversing the decline in the labor share, and therefore will have no effect on either the long run employment rate or the growth rate.

Table 2.2: Vector error correction model with u, ϕ, e, and ω as endogenous variables

	Dependent variable							
		u		ϕ		e		ω
LR								
	ϕ	-0.2028***	u	-4.9309***	u	-36.52***	u	-2.0146***
		(0.0391)		(0.8388)		(7.6388)		(0.2911)
	e	-0.0033	e	0.0161	ϕ	62.16***	ϕ	0.4086***
		(0.0363)		(0.1458)		(12.0096)		(0.0932)
	ω	-0.4964***	ω	2.4476***	ω	152.15***	e	0.0066
		(0.0861)		(0.5918)		(35.83)		(0.0685)
	trend	-0.0735***	*trend*	0.3622***	*trend*	22.52***	*trend*	0.1480***
		(0.0164)		(0.1160)		(5.7813)		(0.0251)
	ECT	-0.5224***	ECT	-0.1436***	ECT	0.0014	ECT	-0.2485***
		(0.1893)		(0.0674)		(0.0010)		(0.1156)
SR								
	Δu_{t-1}	0.7467***	Δu_{t-1}	-0.8675*	Δu_{t-1}	1.3036***	Δu_{t-1}	0.8867***
		(0.2564)		(0.4504)		(0.4328)		(0.3155)
	Δu_{t-2}	0.2062	Δu_{t-2}	0.7599	Δu_{t-2}	-0.6327	Δu_{t-2}	0.3983
		(0.2999)		(0.5269)		(0.5063)		(0.3691)
	Δu_{t-3}	-0.2408	Δu_{t-3}	0.2516	Δu_{t-3}	-0.1483	Δu_{t-3}	-0.2751
		(0.2316)		(0.4068)		(0.3909)		(0.2850)
	$\Delta\phi_{t-1}$	0.0702	$\Delta\phi_{t-1}$	0.2145	$\Delta\phi_{t-1}$	-0.0089	$\Delta\phi_{t-1}$	0.0751
		(0.0819)		(0.1438)		(0.1382)		(0.1007)
	$\Delta\phi_{t-2}$	-0.0411	$\Delta\phi_{t-2}$	0.1779	$\Delta\phi_{t-2}$	0.0327	$\Delta\phi_{t-2}$	-0.0063
		(0.0789)		(0.1385)		(0.1331)		(0.0970)
	$\Delta\phi_{t-3}$	-0.1451*	$\Delta\phi_{t-3}$	-0.0224	$\Delta\phi_{t-3}$	-0.0340***	$\Delta\phi_{t-3}$	0.0325
		(0.0788)		(0.1385)		(0.1331)		(0.0970)
	Δe_{t-1}	-0.1577	Δe_{t-1}	0.0854	Δe_{t-1}	0.1320	Δe_{t-1}	-0.3686***
		(0.1422)		(0.2498)		(0.2400)		(0.1750)
	Δe_{t-2}	0.0852	Δe_{t-2}	-0.8894***	Δe_{t-2}	0.4536*	Δe_{t-2}	-0.1761
		(0.1525)		(0.2678)		(0.2574)		(0.1876)
	Δe_{t-3}	0.2587*	Δe_{t-3}	0.1798	Δe_{t-3}	0.0833	Δe_{t-3}	0.2737
		(0.1544)		(0.2712)		(0.2606)		(0.1900)
	$\Delta\omega_{t-1}$	-0.2223*	$\Delta\omega_{t-1}$	0.0604	$\Delta\omega_{t-1}$	-0.1924	$\Delta\omega_{t-1}$	0.2116
		(0.1286)		(0.2259)		(0.2171)		(0.1582)
	$\Delta\omega_{t-2}$	-0.1046	$\Delta\omega_{t-2}$	0.1973	$\Delta\omega_{t-2}$	-0.1291	$\Delta\omega_{t-2}$	0.2854*
		(0.1247)		(0.2190)		(0.2105)		(0.1534)
	$\Delta\omega_{t-3}$	-0.2572***	$\Delta\omega_{t-3}$	-0.2128	$\Delta\omega_{t-3}$	-0.3493	$\Delta\omega_{t-3}$	-0.0411
		(0.1254)		(0.2204)		(0.2118)		(0.1544)
	Constant	-0.0357	Constant	0.2173	Constant	0.0340	Constant	-0.0602
		(0.0817)		(0.1436)		(0.1380)		(0.1006)

Notes: LR stands for long run, and SR for short run. Standard error in parenthesis, ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

Chapter 3

Income Distribution, Wealth Inequality, and Growth in Labor Abundant Economies: A Classical Model

3.1 Introduction

An exacerbated wealth concentration is one of the macroeconomic issues emerging and open economies have faced in the last decades, including the two more currently populated countries in the world: China and India. The following facts have characterized the previous decades in these two economies: (a) a declining income-capital ratio, (b) a rise in the top 1% net personal wealth for China and top 1% net personal income for India, (c) a slightly decreasing trend for the share of labor compensation in China, and a more pronounced downward trend in India, (d) an increase in the employment-population ratio from the 1970s followed by a deceleration in the 1990s, and a subsequent fall of this ratio from around 2005, most marked in India, (e) a rise of the labor productivity growth followed by a slowdown after the Great Recession in 2008-2009, being this change more evident in India, and (f) a more pronounced imbalance has been experienced in the external sector since the 1980s: predominantly a surplus in China and a deficit in India. Figures 3.1 and 3.2 plot these series.

Most inequality studies have been associated with the more advanced economies. However, countries transitioning through meaningful demographic changes have seen their inequality increase in the last decades and economic growth decelerate in more recent years. These phenomena are generally more potent in economies where the size of the labor force imposes a substantial constraint on the growth process, holding other things constant. In that context, this paper contributes to the literature by presenting an open-economy model to explain increases in inequality and variations in the labor market from the post-Keynesian and Classical-Marxian perspectives following Cruz and Tavani (2022) but adapted to economies where labor supply is not a hard constraint on economic growth. Thus, our model is more appropriate for economies where a significant endogeneity between employment and population growth is present due to labor movements from rural to urban/modern sectors or considerable immigration from other countries.

Appendix C.4 displays the coefficients of naïve OLS regressions of population growth on employment growth, comparing China and India with high-income OECD economies. China and India have exhibited a positive and statistically significant relationship between their population and employment growth rates for the last six decades, which is uncommon to sustain for a long time in mature economies like OECD countries. It hints that these emerging economies could absorb the new labor supply while increasing overall productivity and shifting to more productive employment. Appendix C.5 shows that China and India have transitioned to economies with much higher relative value added in the industrial and service sectors while decreasing their relative participation in the agricultural sector. From the demand side, these transitions have been accompanied by substantial increases in the gross fixed capital formation (GFKF) as a percentage of the GDP of these two countries compared to most OECD economies, as Appendix C.6 suggests. For example, China and India have doubled their relative size of GFKF since the decade of the 1960s: China from 20.4% to 43.0% and India from 16.1% to 30.1%. And considering the changes from the 1970s, the jumps in GFKF between the decade of 1970-1979 and the period 2010-2021 by 16.2% and 12.4% for China and India, respectively, are considerably high compared to the experienced by OECD countries for the same period. As expected, the increases in GFKF have been strongly linked to significant increases in their gross domestic savings (GDS) since the decade of the 1960s: China from 27.1% to 46.7% and India from 8.2% to 30.8% for the same period, as shown in Appendix C.8. Also, considering the changes in GDS from the 1970s, the differences of 10.1% and 18.3% in China and

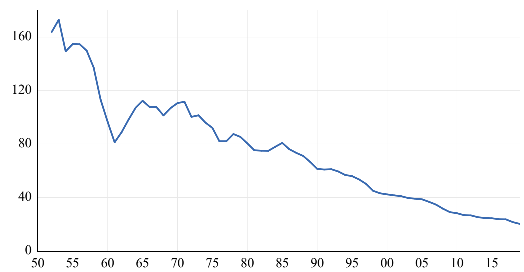
India, respectively, are high compared to OECD countries except for South Korea, whose variation was 12.9%.

Another key factor to consider is China's rapid urbanization process in the last half-century. Its urban population increased from 17.4% in 1970 to 61.4% in 2020, one of the most significant increases worldwide. (See Appendix **??**). This sectoral change from rural areas concentrated in the agricultural sector to industry and services sectors has significantly explained China's rise in per capita income growth and aggregate productivity growth. (Wang and Conesa, 2022; Golley and Zheng, 2015; Ercolani and Wei, 2011; Wei and Hao, 2010). This migration process was fueled during the 1990s by expanding export-oriented sectors, especially in eastern regions. Interestingly, there is evidence that in the long run, the driving force of rural-urban migration is intra-provincial migration more than inter-provincial migration since the former is more likely to settle permanently in cities within their home province. (Su et al., 2018; Cai and Wang, 2008; Yang, 2000).

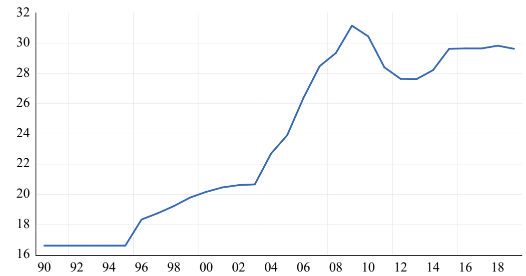
For its part, India's urbanization process has been more modest over the same period. A possible explanation is that a densely populated country like India, more than expanding new cultivable land, bet heavily on changes in agricultural technology such as that initiated in the labor-intensive "Green Revolution" in the late 1960s. This revolution resulted in an appreciable increase in labor demand due to multiple cropping and using fertilizers. India's urbanization rate is expected to increase by 18 percentage points from 2020 to 2050, similar to China's expected increase of 18.6 percentage points for the same period.

These stylized facts in developing countries such as China and India are an excellent input to empirically test our theoretical model adapted to developing economies where labor supply is not a hard constraint on economic growth.

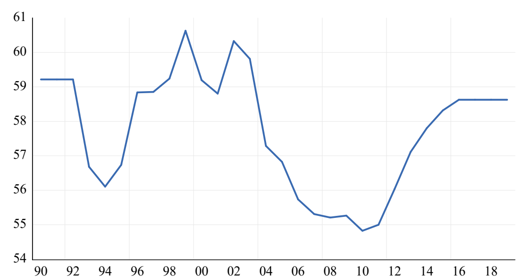
This chapter is organized as follows. Section 3.2 outlines the main elements of the model, and section 3.3 displays the steady state results. Section 3.4 provides responses of endogenous variables to variations in exogenous parameters and their policy implications. Section 3.5 reports empirical results by performing an econometric exercise for a cointegrated endogenous system. Section 3.6 extends the theoretical model by taking the trade balance as endogenous. Finally, Section 3.7 summarizes the main findings.



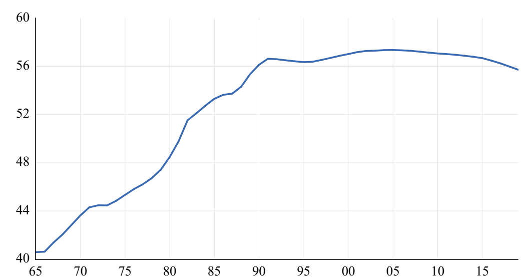
(a) Income-Capital Ratio, 1952-2019



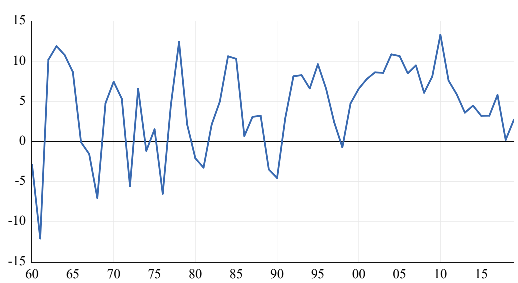
(b) Top 1% Net Personal Wealth, 1990-2019



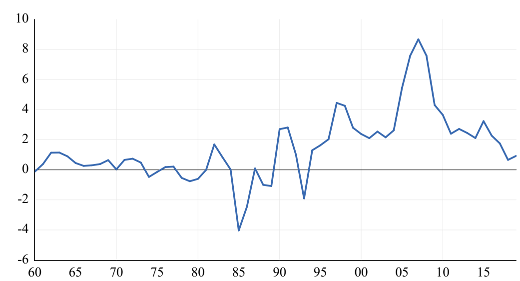
(c) Share of Labor Compensation, 1990-2019



(d) Employment-Population Ratio, 1965-2019



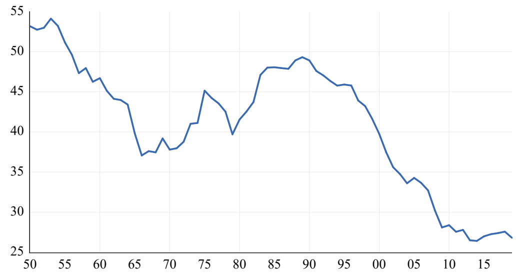
(e) Labor Productivity Growth, 1953-2019



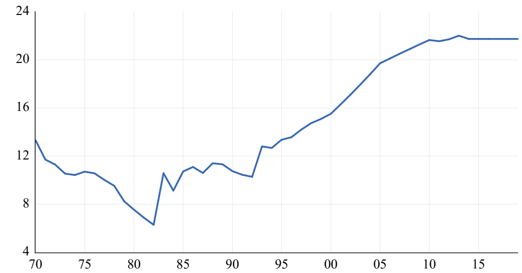
(f) Net Exports as a Percentage of GDP, 1960-2019

Notes: Income-capital ratio is obtained by dividing *cgdpo* by cn from Penn World Table 10.01. The top 1% of net personal wealth is obtained from World Inequality Database. The share of labor compensation is the series *labsh* obtained directly from Penn World Table 10.01. The employment-population ratio is obtained by dividing *emp* by *pop* from Penn World Table 10.01. The labor productivity per worker growth is the interannual percent change of labor productivity per worker calculated by the following formula: $100 * (rgdpo/emp)$ from Penn World Table 10.01. Net exports as a percentage of GDP are calculated by subtracting exports of goods and services (% of GDP) from imports of goods and services obtained from World Development Indicators. All series are expressed in percentage points.

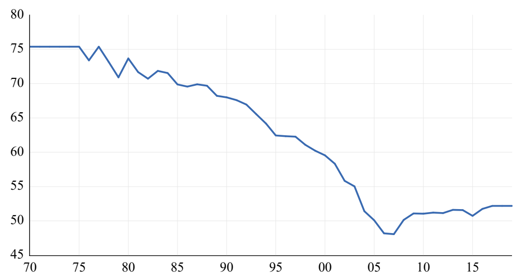
Figure 3.1: China's stylized facts



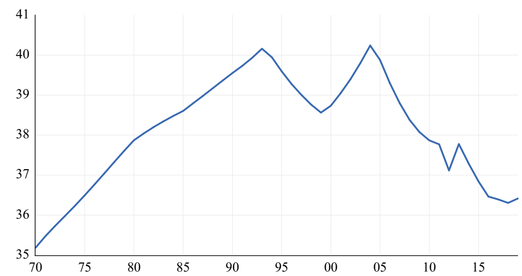
(a) Income-Capital Ratio, 1950-2019



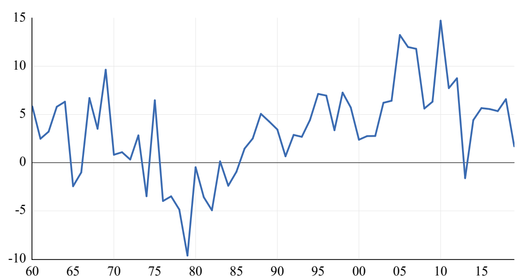
(b) Top 1% Net Personal Wealth, 1970-2019



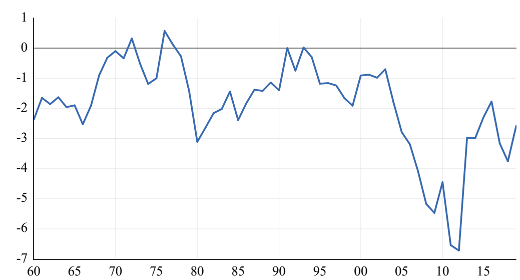
(c) Share of Labor Compensation, 1970-2019



(d) Employment-Population Ratio, 1970-2019



(e) Labor Productivity Growth, 1951-2019



(f) Net Exports as a Percentage of GDP, 1960-2019

Notes: Income-capital ratio is obtained by dividing *cgdpo* by cn from Penn World Table 10.01. The top 1% of net personal wealth is obtained from World Inequality Database. The share of labor compensation is the series *labsh* obtained directly from Penn World Table 10.01. The employment-population ratio is obtained by dividing *emp* by *pop* from Penn World Table 10.01. The labor productivity per worker growth is the interannual percent change of labor productivity per worker calculated by the following formula: $100 * (rgdpo/emp)$ from Penn World Table 10.01. Net exports as a percentage of GDP are calculated by subtracting exports of goods and services (% of GDP) from imports of goods and services obtained from World Development Indicators. All series are expressed in percentage points.

Figure 3.2: India's stylized facts

3.2 Main Elements of the Model

We set a one-sector open economy without government. Time is continuous, and the rate of population growth is assumed endogenous to the employment-population ratio. We also consider away capital depreciation and household debt to avoid unnecessary complications. Finally, we normalize the price of the single good produced to one.

3.2.1 Production, Income Distribution, and Wealth Accumulation

Two types of households populate the economy. In what follows, "Workers," denoted by superscript w, provide labor services to firms inelastically, consume and save, and earn labor and capital income. "Capitalists," denoted by superscript c, also consume and save, and own capital stock, and make profit incomes only. As already mentioned, we assume that neither type of capital depreciates. Output per worker y, homogeneous with capital stock, is produced using fixed proportions of capital per worker $k \equiv k^c + k^w$ and labor: $y = \min\{A, uk\}$, where u denotes the output-capital ratio, endogenous to the model, and A is the stock of labor-augmenting technology, also endogenously growing over time. Let r be the uniform rate of return on capital endogenous to the model, where r is given to each type of household, which are price-taking in goods and factor markets.

Workers participate in accumulating capital in the economy through their savings. Let their constant propensity to save be denoted by $s^w \in (0, 1)$. Importantly: not all workers will be employed at any given time, so the number of employed workers is equal to firms' labor demand, which, due to the Leontief production technology, is not elastic to the wage, implying that the labor market does not clear. The employment rate in the economy is $e \equiv uk/AN$ (recall that the growth rate of the labor force is endogenous to the employment-population ratio). Therefore, total workers' savings, in turn, equal to workers' investment in new capital stock $\dot{k}^w$, is:

$$\dot{k}^w = s^w \left[\frac{w}{A} uk + rk^w \right] \tag{3.1}$$

Denote the capitalists' share of wealth by $\phi \equiv k^c/(k^c + k^w) \in [0,1]$ so that $k^c = \phi k$. In the model, the labor share is endogenous and is designated by $\omega \equiv w/A$. Simple algebra provides the accumulation rate for workers as follows:

$$g^w \equiv \frac{\dot{k}^w}{k^w} = s^w u \left[\frac{\omega}{1-\phi} + (1-\omega) \right] \tag{3.2}$$

Capitalist households only earn profit income out of the capital they own. Based on $s^c \in (0,1)$, a constant propensity to save, the capitalist accumulation rate is as follows:

$$g^c = s^c r = s^c u(1-\omega) \tag{3.3}$$

To obtain the economy-wide accumulation rate in an open economy without government, we use the following national account identity: $Y = C + I + NX$. Letting $Y - C = S = s^c + s^w$, $I = \dot{K}$, and $g = \dot{K}/K$, after simple algebra, we have the following expression:

$$g = \phi g^c + (1-\phi) g^w - u\theta \tag{3.4}$$

Where $\theta = \frac{NX}{Y}$ denotes the trade balance as a percentage of GDP. For now, assume that it is a parameter: we will relax this assumption below.

Plugging equations 3.2 and 3.3 into 3.4, we can express the economy-wide accumulation rate as follows:

$$g = u \left[s^w + \phi(1-\omega)(s^c - s^w) - \theta \right] \tag{3.5}$$

Even with worker savings, equation 3.5 emphasizes the profit-driven nature of capital accumulation. Everything else being equal, the economy's accumulation rate decreases in wage share and increases in profit share.

3.2.2 Technical Change: The Induced Invention Hypothesis

The evolution of technology through an induced invention will be discussed next. Based on Kennedy (1964), Drandakis and Phelps (1966), Funk (2002), and Julius (2005), we assume that firms have access to a menu of technological improvements that may increase both output-capital (at a rate χ) and labor productivity (at a rate γ). There are, however, trade-offs between improving along one technological dimension versus another. This trade-off is summarized by Kennedy's twice-continuously differentiable, strictly decreasing, strictly concave invention possibility frontier (Kennedy, 1964), which is expressed as follows:

$$\gamma = f(\chi), \;\; f_\chi < 0, f_{\chi\chi} < 0 \tag{3.6}$$

As discussed in Julius (2005) and Tavani (2012a), firms select a profile of technological improvements to maximize the reduction in unit costs or, equivalently, the change in the profit rate, subject to the innovation possibility frontier (IPF) constraint. According to Sasaki (2008) and Tavani and Zamparelli (2017), this is equivalent to the classical choice of technique criterion, as described in Okishio (1961), which involves maximizing profit at a given real wage.

Kennedy (1964), Julius (2005), Tavani (2012a), and Foley et al. (2019, Ch. 7)) demonstrate that the firm's strategy involves maximizing the weighted average of the growth rates of factor-augmenting technologies, the weight being the share of labor and capital: $(1-\omega)\chi + \omega f(\chi)$. An implicit function defined by the first-order condition $f_\chi = (1-\omega)/\omega$ yields a dependency on factor shares of capital and labor-augmenting technologies based on the relative growth rates of capital and labor-augmenting technologies, especially a direct (inverse) relationship between growth in labor productivity (capital) and growth in labor share.

Our examination also assumes the presence of an exogenous shift parameter, denoted by z, that affects the curvature and intercept of the IPF, thereby affecting the firm's selection of a factor-augmenting technical change. A particular assumption is that the partial derivatives of factor-augmenting technologies are such that $\chi_z > 0$ and $\gamma_z \geq 0$, thus guaranteeing an increase in the long run labor share in z. [17] Furthermore, we interpret z as any policy or institutional variable that positively impacts the labor share, as Petach and Tavani (2021) and Rada et al. (2022) proposed. Consequently, the growth rates of capital-augmenting and labor-augmenting technologies can be expressed as follows:

$$\chi = \chi(\omega; z); \quad \gamma = f[\chi(\omega; z)] \tag{3.7}$$

Where, $\chi_\omega < 0$, and correspondingly $\gamma_\omega > 0$.[18]

Based on this framework, it can be observed that induced invention plays a similar role to factor substitution with a neoclassical aggregate production function: higher labor costs lead to more labor-saving technologies and lower capital-saving technologies. Nevertheless, as noted in the literature, capital-labor substitution occurs through technological advancements rather than through the decline of marginal products. Notably, the induced invention hypothesis does not suffer from the well-known issues associated with aggregating across different capital goods raised in the Cambridge controversy. [19] Also, the induced invention hypothesis does not imply wage flexibility will clear the labor market, given that the underlying technology is Leontief in every period.

[17] Tavani (2012b, 2013b) has provided microeconomic foundations for this result that use the generalized Nash (1950) bargaining solution to determine the real wage at the firm level. In these models, z is explicitly derived as a combination of the workers' reservation wage, in turn influenced by labor market institutions such as unemployment compensations or minimum wages, and the workers' bargaining power. Our argument presents a simplified, reduced form version that shares the same conclusions but retains the familiar Goodwin (1967) real-wage Phillips curve and corresponding macroeconomic determination of real wages.

[18] See Rada et al. (2022) for a discussion of the above assumption for both Classical and Keynesian models of growth and distribution.

[19] Kennedy (1973) shows that, unlike neoclassical factor substitution, induced bias in a model with differentiated capital goods is immune from the reswitching problem.

Thus, induced invention governs the evolution of the income-capital ratio in the following way:

$$\dot{u} = \chi(\omega; z)u \tag{3.8}$$

Our conclusions are strengthened by providing linear versions of both growth rates of factor-augmenting technologies that generalize the functional forms proposed by Petach and Tavani (2021):

$$\chi(\omega; z) = z - \beta\omega; \quad \gamma(\omega; z) = \alpha[z - \chi(\omega; z)] \tag{3.9}$$

In what follows, the parameter α, which describes the sensitivity of labor productivity growth to labor market institutions and wage share, is crucial.

3.2.3 Dynamics: Wealth Distribution

The next point to consider is the capitalist share of wealth, where its replicator's law of motion over time is as follows:

$$\dot{\phi} = \phi(g^c - g) \tag{3.10}$$

Plugging equations 3.3 and 3.5 into equation 3.10, and after simple some algebra:

$$\dot{\phi} = \phi u\left[(1-\phi)(1-\omega)(s^c - s^w) - s^w\omega + \theta\right] \tag{3.11}$$

3.2.4 Dynamics: Income Shares and Employment

By specifying the interaction between the labor market and real wages, we close the model following Goodwin (1967). The real wages are assumed to follow a Phillips-style curve: $\dot{w}/w = f(e; z)$ with $f_e > 0$, $f_z > 0$. Due to the induced bias in technological change, the evolution of the labor share follows the following pattern:

$$\dot{\omega} = \left[f(e; z) - \gamma(\omega; z)\right]\omega \tag{3.12}$$

We use a linear version of the Phillips curve to characterize the steady state and policy implications: $f(e;z) = -\lambda + \delta e + \mu z$, with $\lambda > 0, \delta > 0, \mu > 0$. The Goodwin (1967) specification is obtained as a special case where $\mu = 0$.

To determine the evolution of the employment rate, we proceed by differentiating its very definition. Assuming the labor force is not constant, and its growth rate, $n = \frac{\dot{N}}{N}$, is a linear function of the employment rate, $n = \bar{n} + \xi e$, we have the following::

$$\begin{aligned} \dot{e} &= (\chi + g - \gamma - n)e \\ &= \{\chi(\omega; z) + u\left[s^w + \phi(1-\omega)(s^c - s^w)\right] - \gamma(\omega; z) - (\bar{n} + \xi e)\}\, e \end{aligned} \tag{3.13}$$

A four-dimensional dynamical system is described by equations 3.8, 3.11, 3.12, and 3.13 with respect to the growth and distribution paths of an economy. The endogenous variables are (i) the income-capital ratio u; (ii) the distribution of wealth between the two classes ϕ; (iii) the functional distribution of income ω; and (iv) the employment rate e.

3.3 Steady State

In this section, we describe the steady state of the model as well as the major implications for policy over the long run. Start from equation 3.8. In the long run, setting $\dot{u} = 0$ yields the labor share as follows:

$$\omega_{ss} = \frac{z}{\beta} \tag{3.14}$$

which is increasing in the policy/institutional parameter z. In a graph with the employment rate e on the horizontal axis and the wage share ω on the vertical axis, the long run labor share equals $\frac{z}{\beta}$: a positive (negative) shift in the labor market parameter z moves the long run labor share up (down). Moreover, the labor share is expected to evolve endogenously to its long run value (equation 3.14) in such a way that the income-capital ratio remains constant while labor productivity grows (Kennedy, 1964; Drandakis and Phelps, 1966; Julius, 2005).

Next, setting $\dot{\omega} = 0$ in equation 3.12 gives the employment nullcline:

$$e(\omega; z) = \frac{\lambda + \alpha\beta\omega - \mu z}{\delta} \tag{3.15}$$

increasing in labor share, everything else equal. As a result of changes in the policy variable z, the employment rate nullcline moves in the opposite direction, since $\partial e / \partial z < 0$. The employment nullcline shifts to the left as z increases in a (e, ω) plane. This effect depends, however, on the relative magnitude of the response of the income distribution to a policy change compared with the response of employment to the policy change. This is because both curves shift when the policy variable z is changed. Once the employment equation is evaluated at the steady state value for the labor share, it is possible to determine the long term employment rate as follows:

$$e_{ss} = \frac{\lambda + (\alpha - \mu) z}{\delta} \tag{3.16}$$

A labor market parameter z has a direct effect on employment depending on the sign of the difference $\alpha - \mu$. When $\alpha > \mu$, an increase in the wage share will lead to a rise in the long run unemployment rate, the following discussion will refer to this case as "wage-led." Alternatively, if $\alpha < \mu$, the long run employment rate is negatively affected by shocks to the wage share: this case is referred to as being "profit-led." A vital element of this economic intuition is the response of induced bias to changes in labor institutions compared to the response of labor market conflict to such changes. The parameter α captures how strongly the firm's choice of the direction of technical change responds to an increase in the wage share; higher values of α imply that growth is increasingly wage-driven since labor productivity anchors the long run growth rate of the economy. In contrast, the parameter μ captures how strong the impact of labor market institutions on labor market conflict is, as described by the real-wage Phillips curve. When μ increases, there is more pressure on real wage growth, which decreases the profit-driven accumulation rate and employment, assuming all other factors are equal. Depending on the relative magnitude of the two effects, the accumulation response to labor market institutions may be stronger than the technical change response, and the long run employment effect of z may be weaker.

Further, imposing $\dot{\phi} = 0$ in equation 3.11, we find the nullcline relating the wealth distribution to factor shares as:

$$\phi(\omega) = 1 - \frac{s^w \omega - \theta}{(s^c - s^w)(1-\omega)} \tag{3.17}$$

which captures that the capitalists' share of wealth decreases in the labor share of income as it is intuitive. Plugging equation 3.14 into equation 3.17, the long run wealth distribution is the solution

$$\phi_{ss} = 1 - \frac{s^w z - \beta\theta}{(s^c - s^w)(\beta - z)} \tag{3.18}$$

Given that ϕ_{ss} is the capitalists' wealth share, equation 3.18 implies that a positive (negative) shock to the parameter z will decrease (increase) the capitalists' share of wealth. It is intuitive as an increase (decrease) in the labor share increases (decreases) the funds available to workers (capitalists) to accumulate capital stock. Another feature that stands out is the direct effect of an increase in the trade balance on the capitalist share of wealth.

Imposing a steady state in equation 3.13, we set $\dot{e} = \dot{u} = 0$. From $\dot{u} = 0$ we have that $\chi(\omega; z) = 0$, which implies that $z = \beta\omega$. Then, the following nullcline relating the long run output-capital ratio to the wage share, capitalist wealth share and employment rate is as follows:

$$u(\phi, e, \omega) = \frac{\alpha\beta\omega + \bar{n} + \xi e}{s^w + \phi(1-\omega)(s^c - s^w)} \tag{3.19}$$

An increase in workers' share of income is expected to result in an increase in consumer demand. It is based on the economic intuition that workers have a higher propensity to consume. To satisfy such additional demand, production must increase, which implies an increase in the output-capital ratio. Like equation 3.5, a higher capitalist wealth share increases the ratio of savings to capital across the entire economy. The reduction of the consumption-to-capital ratio and, as a result, the output-capital ratio, when all other factors are equal, is achieved by this measure.

To find the long run solution, plug equations 3.14, 3.16, and 3.18 into 3.19. After some simple algebra, we find:

$$u_{ss} = \frac{\beta \left\{ \alpha z + \bar{n} + \xi \left[\frac{\lambda + (\alpha - \mu) z}{\delta} \right] \right\}}{s^c \ (\beta - z)} \tag{3.20}$$

Consequently, the long run income-capital ratio is increasing in the policy variable z and decreasing the capitalist saving rate s^c. The similarity with the "paradox of costs" and the "paradox of thrift" in neo-Kaleckian economies is suggestive but misleading in this context. Redistribution toward wages and a lower saving rate both increase the income-capital ratio (aggregate demand) without affecting accumulation in wage-driven demand-driven models such as the neo-Kaleckian framework. Alternatively, the supply constraint is binding here, and both a decrease in the saving rate and an increase in the labor share of income as a result of a positive change in z will result in a positive increase in the income-capital ratio, but at the expense of short run accumulation: there is no paradox of thrift. In contrast, in our model, we observe a version of the paradox of costs, but it is through the adverse impact of labor-crushing shocks on the endogenous growth rate over the long run rather than on aggregate demand.

3.4 Changes in Exogenous Parameters and Policy Implications

The effects of exogenous technological or institutional (z) and demographic (ξ, $\bar{n}$) factors and the external sector (θ) have significant policy implications in countries with mild labor constraints to deal with secular stagnation. For their part, workers' propensity to save (s^w) and capitalists' propensity to save (s^c) are fundamental in explaining inequality in these economies. Thus, we provide the comparative statics effect of each exogenous parameter on our endogenous variables of interest.

A positive change in the labor market parameter z will produce an increase in the share of labor compensation and the income-capital ratio. At the same time, our model suggests that a rise in this institutional parameter will trigger a redistributive effect in society, decreasing capitalists' relative share of wealth. The net impact on employment could be either positive or negative, depending on the sensitivity of the response of technical change to income distribution (α) and the sensitivity of the extent of labor market conflict on wage growth (μ). (See Table 3.1 for these results and Appendix C.3 for calculation). If the response of technical change to income distribution (extent of labor market conflict on wage growth) is greater in magnitude, the employment rate, in the long run, will be wage-led (profit-led). The policy implication is that no conflict exists between increased employment and long run productivity growth if an economy fits a wage-led employment regime. Conversely, a trade-off between increased employment and capital-friendly policies in the labor market is present if a more profit-led employment regime characterizes a non-labor-constrained economy.

Cruz and Tavani (2022) demonstrated that for a labor-constrained country such as the United States, labor-friendly redistribution policies that increase the share of labor compensation – through a rise in parameter z- positively impact labor productivity growth, ultimately boosting the long run growth rate of the economy. The mechanism is that increases in labor costs induce firms to incorporate labor-saving innovations, which translates into higher labor productivity growth rates in the long run. Thus, an increase in parameter z has a positive and direct effect on wage share (ω) and amplifies the income-capital ratio (u) numerator with its subsequent positive growth. Additionally, a rise in the wage share, the primary source of income for workers, increases their capacity for wealth accumulation, so capitalists' relative wealth share (ϕ) decreases.

Table 3.1: Comparative statics: effects of exogenous parameters on endogenous variables

Parameter	u_{ss}	ϕ_{ss}	ω_{ss}	e_{ss}
z	+	-	+	$\pm$
s^c	-	+	0	0
s^w	0	-	0	0
α	+	0	0	+
μ	-	0	0	-
β	-	+	-	0
ξ	+	0	0	0
δ	-	0	0	-
λ	+	0	0	+
$\bar{n}$	+	0	0	0
θ	0	+	0	0

Note: Expressions for partial derivatives are presented in Appendix C.3

Regarding the capitalists' propensity to save (s^c), when it increases, it pressures the capitalist accumulation rate, pushing the capitalists' wealth share up in the long run, as shown in equation 3.18. On the other hand, the long run wage share is in the function of z and β only, as shown in equation 3.14; therefore, an increase in s^c will not impact labor productivity growth or income. Thus, if the capital stock goes up and income does not significantly change in the face of a rise in capitalists' propensity to save, it is expected that an increase in s^c to lead to a decline in the income-capital ratio, other things equal, as shown in equation 3.20. Concerning the workers' propensity to save (s^w), on a balanced growth path, it has no significant effect on the income-capital ratio, employment, or labor share but only on the long run wealth distribution, as shown in equation 3.18. It is consistent with Pasinetti's theorem, where even if both capitalists' and workers' saving rates are positive, the equilibrium rate of profits is orthogonal to the saving behavior of the working class.

With respect to the endogeneity between population growth and employment, the exogenous parameter ξ measures the degree of labor constraint an economy experiences, where the higher this parameter, the less labor constrained an economy is. Suppose a country can significantly absorb increases in its labor force in its labor market through the generation of productive employment. In that case, this economy will tend to have higher growth rates since increases in the labor force slightly restrict its income. Therefore, a positive influence of ξ is expected on the income-capital ratio in the long run, as shown in equation 3.20.

Finally, in an open economy, the exogenous parameter θ, the net exports-income ratio, positively impacts the capitalists' wealth share. Since net exports are nothing but the difference between national savings (S) and domestic investment (I), the parameter θ increases as the gap between S and I increases. If national savings grow faster than domestic investment, and given that $s^c > s^w$, as shown in equation 3.18, it is expected θ to have a positive effect on ϕ at the steady state.

3.5 Empirical Evidence for China and India

We conducted empirical exercises for China (1990-2019) and India (1970-2019) using the following four endogenous variables. First is the income-capital ratio. Second, the top 1% of net personal wealth for China and the top 1% of net personal income for India -a proxy for the capitalist share of wealth due to a lack of long data on wealth share in India. Third, the employment-population ratio, and fourth, the wage share. [20] This exercise aims to evaluate the four dynamical system's responses to an exogenous shock to the wage share to test our theory's main predictions. We expect a positive shock to the wage share to generate a rise in the income-capital ratio, a decline in the top wealth or income share, and either a positive or negative reaction of employment to a shock to the wage share. If

[20] The income-capital ratio is calculated by dividing the variable *cgdpo* by *cn* from Penn World Table 10.01. The top 1% of net personal wealth and top 1% of net personal income are obtained from the World Inequality Database. The employment-population ratio is obtained by dividing the variable *emp* by *pop* from Penn World Table 10.01. And wage share is obtained from series *labsh* from Penn World Table 10.01. All these four variables are expressed in percentage points. We tried to estimate the model with earlier data starting from 1978 for China, but series wage share and top wealth shares are reported flat in the decade of the 80s, which significantly distorts the econometric exercise. While acknowledging this limitation for China, we maintain that the empirical bite of the model after 1990 provides a useful test for our theory.

employment's response is positive (negative), it is interpreted as a wage-led (profit-led) employment regime.

Appendix C.9 shows that all four variables are non-stationary in levels but stationary in the first-difference. Based on three out of five information criteria in Appendix C.10, three is the optimal lag length for the vector autoregressive (VAR) model in China, and one is optimal for a VAR model in India. Appendix C.11 displays detailed trace and maximum eigenvalue tests for the Johansen cointegration test. Both tests support the existence of one cointegrating equation at a 1% significance level.

Since the four main variables in our theoretical model are endogenous, and the empirical exercise demonstrates the existence of a cointegrating equation in the system, we must include an error correction term in our VAR model. Therefore, we estimate a vector error correction model (VECM) as follows:

$$
\begin{aligned}
\Delta u_t &= \sigma_{u0} + \sum_{j=1}^{k-1} \tau_{uj} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{uj} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{uj} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{uj} \Delta \omega_{t-j} + \xi_u ECT_u + \upsilon_t^u \\
\Delta \phi_t &= \sigma_{\phi 0} + \sum_{j=1}^{k-1} \tau_{\phi j} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{\phi j} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{\phi j} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{\phi j} \Delta \omega_{t-j} + \xi_\phi ECT_\phi + \upsilon_t^\phi \\
\Delta e_t &= \sigma_{e0} + \sum_{j=1}^{k-1} \tau_{ej} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{ej} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{ej} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{ej} \Delta \omega_{t-j} + \xi_e ECT_e + \upsilon_t^e \\
\Delta \omega_t &= \sigma_{\omega 0} + \sum_{j=1}^{k-1} \tau_{\omega j} \Delta u_{t-j} + \sum_{j=1}^{k-1} \zeta_{\omega j} \Delta \phi_{t-j} + \sum_{j=1}^{k-1} \eta_{\omega j} \Delta e_{t-j} + \sum_{j=1}^{k-1} \psi_{\omega j} \Delta \omega_{t-j} + \xi_\omega ECT_\omega + \upsilon_t^\omega
\end{aligned}
$$

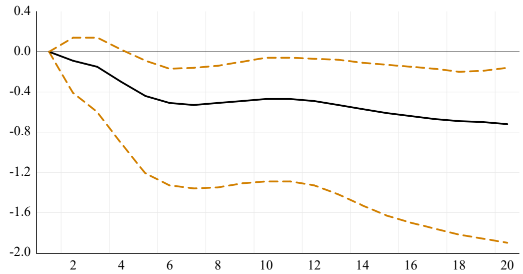
Where Δ is a first-difference operator, σ_{i0} is a constant term of variable i, k is the optimal lag length for the VAR specification, ξ_i is the speed of adjustment parameter of variable i, ECT_i is the error correction term of variable i, and υ_t^i is a disturbance error term of variable i. Appendices C.12 and C.13 show the VECM for China and India, respectively. Since three lags were the optimal lag length for the VAR model for China, as mentioned before, we substrated one lag for its VECM, resulting in a VECM with two lags for this country. For its part, even when one lag for the VAR model in India was suggested as optimal, it was necessary to include up to three lags in its VECM to remove serial autocorrelation. Therefore, we selected a VECM with three lags as the best specification for India.

Both VECMs are free of serial autocorrelation of residuals, as shown in AppendicesC.14 and C.15., and residuals are homoscedastic, as displayed in Appendix C.16. Appendix C.17 provides evidence that residuals are multivariate normal for China; however, it is not the case for India, where residuals are not normally distributed. Concerning the stability of the models, since we have four endogenous variables ($n = 4$) and one cointegrating equation ($CE = 1$), our VECMs are stable because they do not present more than three unit roots ($n - CE = 3$). (See Appendix C.18.)

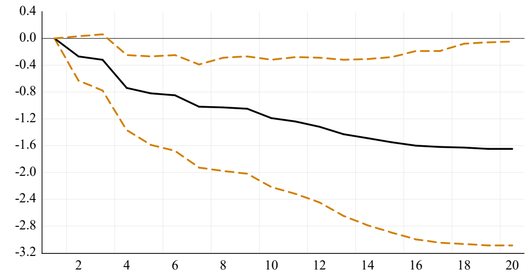
3.5.1 Impulse Responses

The impulse response functions (IRFs) of u, ϕ, and e to one standard deviation exogenous shock in the residuals of ω are presented in Figure 3.3 for China and India. Positive innovations in ω are interpreted as any policy or institutional changes that positively impact the share of labor compensation via an increase in the parameter z. The long run dynamics and the direction of the IRFs support our predictions: a negative shock on parameter z has a negative effect on u, a positive impact on ϕ, and either a positive or negative effect on e which depend on the relative magnitude of parameters α and μ. (See Table 3.1). According to Figure 3.3, China has performed a profit-led employment regime in the last three decades. This output also shows that a wage-led employment regime has characterized India over the previous five decades. We conducted Hall's percentile bootstrap (Hall, 1992) with 1000 bootstrap repetitions to compute the 95% confidence intervals.

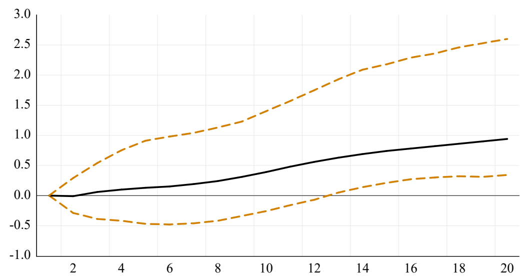
As a robustness check, we also generate IRFs using Hall's studentized bootstrap (Hall, 1986), where their confidence intervals are calculated with 1000 bootstrap repetitions and



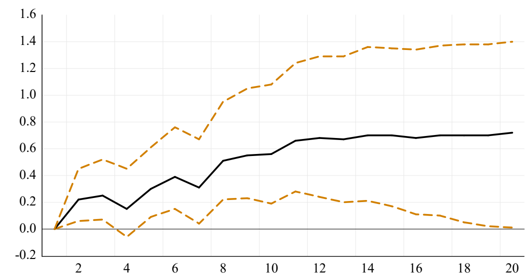
(a) China: response of u



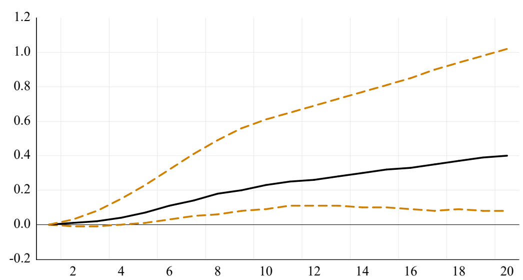
(b) India: response of u



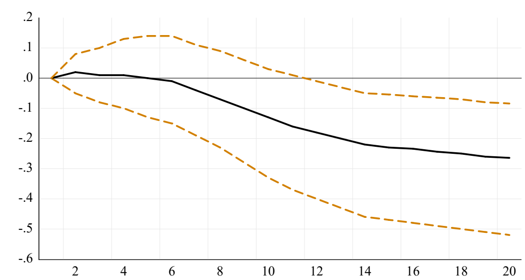
(c) China: response of ϕ



(d) India: response of ϕ



(e) China: response of e



(f) India: response of e

Note: The 95% confidence intervals are calculated using Hall's percentile bootstrap with 1000 bootstrap repetitions.

Figure 3.3: Responses of u, ϕ, and e to non-factorized negative one standard deviation innovation in ω using Hall's percentile bootstrap.

500 double bootstrap repetitions. These IRFs confirm our findings in Figure 3.3. (See Appendix C.19).

3.6 A Simple Extension: Endogenous Trade Balance

Since this model pertains to an open economy, it is relevant to formally characterize how a shock to the income distribution affects the share of wealth in the context of an endogenous trade balance, so we relax the assumption that θ es a simple exogenous parameter.

An increase in ω represents a rise in the production costs for firms, which makes exports less competitive in international markets. At the same time, since $s^w < s^c$, an increment in ω will positively impact aggregate consumption and imports. Thus, the relative increase in the price of domestic goods and services with respect to those of the international market generates an appreciation of the real exchange rate, negatively impacting the trade balance, θ, all else constant.

We assume that the trade balance as a percentage of GDP follows a linear function of the wage share:

$$\theta = \theta_0 - \theta_1 \omega \tag{3.21}$$

Plugging equation 3.21 into 3.17:

$$\phi'(\omega) = 1 - \frac{s^w \omega - (\theta_0 - \theta_1 \omega)}{(s^c - s^w)(1 - \omega)} \tag{3.22}$$

Generating the new long run capitalists' share of wealth in an endogenous trade balance environment, ϕ'_{ss}:

$$\phi'_{ss} = 1 - \frac{s^w z - \beta\theta_0 + \theta_1 z}{(s^c - s^w)(\beta - z)} \tag{3.23}$$

Therefore, for any $0 < \omega < 1$, a positive shock in the institutional or technological parameters z will produce an amplified -in absolute terms- negative effect on the capitalists' share of wealth ϕ in an open economy with endogenous trade balance:

$$\left|\frac{\partial \phi'_{ss}}{\partial z}\right| = \left|-\frac{\beta\left[s^w - (\theta_0 - \theta_1)\right]}{(s^c - s^w)(\beta - z)^2}\right| > \left|\frac{\partial \phi_{ss}}{\partial z}\right| = \left|-\frac{\beta\left[s^w - \theta\right]}{(s^c - s^w)(\beta - z)^2}\right|$$

3.7 Conclusion

This work presents an open-economy model of income distribution, wealth inequality, employment, and growth from a post-Keynesian and Classical-Marxian perspective, adapted to economies experiencing mild labor supply constraints on economic activity. Contrary to some mainstream views, our model does not rely on assumptions like exogenous growth or full employment in the long run since there is no mechanism to guarantee that wage flexibility will clear the labor market. Additionally, we do not incorporate the restrictive assumption that the elasticity of substitution between labor and capital must be greater than one to explain the increase in wealth concentration in labor-abundant economies. Instead, our model mechanism describes the rise in wealth concentration and income distribution dynamics based on the tension between profit-driven capital accumulation and wage-driven labor-augmenting technical change.

Central to our model is the inverse relationship between the top of the wealth share and both the income-capital ratio and the wage share in the long run. In the latter case, when the net exports as a percentage of GDP (θ) is considered an endogenous variable, we demonstrated that the effect of a positive shock in the institutional or technological parameter (z) on the decline in wealth concentration is augmented in open economies. In that line, our theoretical argument is that income distribution comes first, not last, in the causal links between the forces producing a rise in wealth concentration in the last decades.

One of the innovations in the theoretical model, endogenizing the labor force to the employment rate, is that the output-capital ratio at the steady state also depends on the parameters that influence the employment rate in the long run. Among these parameters, we have ξ, the degree of labor constraint an economy experiences. The higher the parameter ξ, the less labor constrained an economy is. Therefore, one of the theoretical findings of this model is that having a less labor-constrained economy gives more room for an economy to achieve higher economic growth rates.

Regarding the inclusion of the external sector in the analysis, the model represents this innovation by the parameter θ, the net exports as a percentage of GDP. This parameter has a positive effect on increasing the share of the wealth of 'capitalists.' Interestingly, when the net export as a percentage of GDP is not considered a simple exogenous parameter anymore but an endogenous variable to the wage share, the model shows that a positive shock in the institutional or technological parameters z will generate an amplified -in absolute terms- negative effect on the capitalists' share of wealth ϕ in an open economy with endogenous trade balance. In other words, labor-friendly policies that push the wage share up intensify their redistributive effects in open economies with a positive trade balance.

Concerning employment, we constructed a condition where the employment rate is a function of the parameter z. However, the ultimate impact on the labor market is theoretically ambiguous, and it will depend on the sign of the difference between the sensitivity of labor productivity growth to labor market institutions and the sensitivity of real wage growth to labor market institutions. If this sign is positive, we identify that economy as one where a wage-led employment regime prevails. Conversely, a negative sign is associated with a profit-led employment regime, implying a trade-off between long run labor productivity growth and employment.

To complement our theoretical model, we conducted a time-series exercise for China and India to test our predictions using real-world data. The empirical tests are consistent with the expected dynamics of our endogenous variables, where an exogenous and positive shock to the wage share generates a positive response to the income-capital ratio and a decline to the top share of wealth. Regarding the employment regime, China appears to adjust to a profit-led case, and India is wage-led for the period under analysis.

Finally, the main policy implication is that labor-friendly policies that raise the wage share in labor-abundant economies with mild labor supply constraints will positively affect economic growth -higher output-capital ratio- while achieving a more equitable distribution of wealth.

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Appendix A

Appendices for Chapter 1

A.1 Construction of the labor productivity per hour worked at constant 2017 purchasing power parity (LPH), average real wage per hour worked at constant 2017 purchasing power parity (RWH), and employment-population ratio (EPOP)

Labor productivity per hour worked at constant 2017 purchasing power parity (LPH)

$$LPH = ln\left(\frac{rgdpo}{emp * avh}\right) = ln\left(\frac{rgdpo}{h}\right)$$

Average real wage per hour worked at constant 2017 purchasing power parity (RWH)

$$RWH = ln\left(\frac{rgdpo * labsh}{emp * avh}\right) = ln\left(\frac{rgdpo * labsh}{h}\right)$$

Employment-population ratio (EPOP)

$$EPOP = 100 * \left(\frac{emp}{pop}\right)$$

Notes: *rgdpo*: Output-side real GDP at chained PPPs (in mil. 2017US$). Output-side real GDP allows a comparison of productive capacity across countries and over time. *labsh*: Share of labor compensation in GDP at current national prices. Reports the share represented by labor income in GDP in terms of the prices in that period (i.e., current prices). *emp*: Number of persons engaged (in millions). "Per person engaged" in PWT includes all persons aged 15 years and over, who during the reference week performed work, even just for one hour a week, or were not at work but had a job or business from which they were temporarily absent. It includes self-employed persons. *pop*: Population (in millions). Reports population data by country from the World Bank and United Nations sources. *avh*: Average annual hours worked by persons engaged. *h*: Average annual hours worked.

A.2 Panel unit root tests for LPH, RWH, and EPOP in levels and first differences

Test	Specification	LPH	RWH	EPOP	ΔLPH	ΔRWH	ΔEPOP
Breitung	None	19.45	18.28	7.56	-16.07***	-16.10***	-15.48***
	C	15.72	14.94	6.63	-9.78***	-9.04***	-13.64***
	C & T	5.55	5.39	2.20	-14.98***	-13.57***	-12.81***
Fisher	Inv. χ^2, ADF	25.62	25.38	33.36	55.29	64.40*	74.82**
	Inv. normal, ADF	4.11	4.53	2.52	-0.68	-1.97**	-3.30***
	Inv. logit t, ADF	4.24	4.75	2.50	-0.70	-1.90**	-3.10***
	Modi. inv. χ^2, ADF	-2.44	-2.46	-1.66	0.53	1.44*	2.48***
HT	None	1.01	1.01	1.00	0.50***	0.45***	0.50***
	C	0.98	0.98	0.99	0.27***	0.26***	0.45***
	C & T	0.90	0.91	0.91	0.35***	0.34***	0.47***
IPS	C	0.16	0.51	0.93	-23.52***	-22.00***	-16.57***
	C & T	1.27	0.47	-3.53***	-23.88***	-22.30***	-14.47***
LLC	unadjusted t	22.83	19.21	5.50	-18.53***	-19.14***	-19.66***
	adjusted t	22.50	18.92	5.42	-18.27***	-18.87***	-19.37***
	C & T	-0.36	-1.40*	-5.03***	-23.86***	-22.99***	-15.12***

Notes: The null hypothesis for the Breitung, Harris-Tsavalis (HT), and Levin-Lin-Chu (LLC) tests is that panels contain unit roots, and their alternative hypothesis is that panels are stationary. The null hypothesis for the Fisher-type tests is that all panels contain unit roots, and their alternative hypothesis is that at least one panel is stationary. The null hypothesis for the Im-Pesaran-Shin (IPS) test is that all panels contain unit roots, and their alternative hypothesis is that some panels are stationary. I chose the optimal lags for the Im-Pesaran-Shin, and the Levin-Lin-Chu tests based on the Bayesian information criterion. Operator Δ before the name of the variables denotes that the variable is expressed in first-differences, None: no constant and no trend, C: constant, and C & T: constant and intercept. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.3 Sequential tests for multiple breaks at unknown break-points

		Statistic	C.V.(1%)	C.V.(5%)	C.V.(5%)
TRIM: 25%	F(1 l 0)	0.02	7.17	5.28	4.48
	F(2 l 1)	0.02	8.17	6.09	5.25
	F(3 l 2)	0.01	8.40	6.49	5.74
TRIM: 20%	F(1 l 0)	0.02	7.46	5.49	4.68
	F(2 l 1)	0.02	8.35	6.28	5.46
	F(3 l 2)	0.22	8.71	6.73	5.95
	F(4 l 3)	0.01	8.86	7.11	6.25
TRIM: 15%	F(1 l 0)	0.02	7.68	5.74	4.91
	F(2 l 1)	0.02	8.42	6.47	5.70
	F(3 l 2)	0.01	8.86	7.01	6.14
	F(4 l 3)	0.01	9.34	7.42	6.45
	F(5 l 4)	0.01	9.59	7.64	6.74
TRIM: 10%	F(1 l 0)	0.02	8.10	6.13	5.18
	F(2 l 1)	0.02	8.79	6.92	6.09
	F(3 l 2)	0.01	9.15	7.37	6.60
	F(4 l 3)	0.01	9.49	7.73	6.89
	F(5 l 4)	0.01	9.81	8.06	7.18
	F(6 l 5)	0.00	10.04	8.28	7.34
	F(7 l 6)	0.00	10.15	8.41	7.54
	F(8 l 7)	0.00	10.44	8.54	7.71
TRIM: 5%	F(1 l 0)	0.02	8.32	6.45	5.51
	F(2 l 1)	0.02	8.99	7.25	6.39
	F(3 l 2)	0.01	9.33	7.71	6.86
	F(4 l 3)	0.01	9.61	8.08	7.22

Notes: Null hypothesis: No structural break. TRIM is the minimal segment length in percent between two breaks. The test statistic uses the non-parametric estimator of Pesaran (2006). C.V. are the critical values of the statistics at 1%, 5%, and 10% significance levels.

A.4 Selection of the ECM models for LPH and RWH as dependent variables

Dependent variable: LPH		Dependent variable: RWH	
BIC	Specification	BIC	Specification
-4.9593	(1,1,1)	-5.0171	(1,1,1)
-4.8429	(1,2,2)	-4.9425	(2,1,1)
-4.8395	(2,1,1)	-4.8667	(1,2,2)
-4.7434	(2,2,2)	-4.8332	(3,1,1)
-4.7233	(3,1,1)	-4.7786	(2,2,2)
-4.6292	(3,2,2)	-4.7161	(4,1,1)
-4.6018	(1,3,3)	-4.6711	(3,2,2)
-4.5994	(4,1,1)	-4.6347	(1,3,3)
-4.5123	(4,2,2)	-4.5577	(4,2,2)
-4.5042	(2,3,3)	-4.5392	(2,3,3)
-4.3745	(3,3,3)	-4.4145	(3,3,3)
-4.3495	(1,4,4)	-4.3853	(1,4,4)
-4.2611	(2,4,4)	-4.3003	(4,3,3)
-4.2559	(4,3,3)	-4.2977	(2,4,4)
-4.1328	(3,4,4)	-4.1797	(3,4,4)
-4.0340	(4,4,4)	-4.0875	(4,4,4)

Notes: BIC: Bayesian information criterion.

A.5 Hausman tests for the entire panel

Group	Dep. var.	MG vs. PMG	MG vs. DFE	DFE vs. PMG	Decision
All panel	LPH	0.68	0.00	0.01	PMG is preferred
	RWH	8.07**	0.00	6.03***	DFE is preferred

Notes: Statistics are obtained from a $\chi^2_{df} = 2$ distribution, where $\chi^2_{df} = 2 = (b - B)'[Vb - VB]^{-1}(b - B)$. The null hypothesis (Ho) is that the difference in coefficients is not systematic, and the alternative hypothesis (Ha) is that the null hypothesis is not true. b: consistent under the Ho and Ha, and B: inconsistent under Ha and efficient under Ho. In MG vs. PMG, the Ho implies that PMG is preferred over MG. In MG vs. DFE, the Ho implies that DFE is preferred over MG. In DFE vs. PMG, the Ho implies that PMG is preferred over DFE. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.6 Selection of the ECM models for LPH as the dependent variable for liberal, conservative, and social democratic economies

Liberal		Conservative		Social Democratic	
BIC	Specification	BIC	Specification	BIC	Specification
-4.9936	(1,1,1)	-5.9754	(1,1,1)	-4.6971	(1,2,2)
-4.8969	(1,2,2)	-5.8740	(2,1,1)	-4.6833	(1,1,1)
-4.8865	(2,1,1)	-5.8541	(1,2,2)	-4.6205	(2,2,2)
-4.8061	(3,1,1)	-5.7881	(3,1,1)	-4.5929	(2,1,1)
-4.7923	(2,2,2)	-5.7838	(2,2,2)	-4.5368	(1,3,3)
-4.7229	(3,2,2)	-5.7012	(4,1,1)	-4.5309	(3,1,1)
-4.7168	(1,3,3)	-5.6900	(3,2,2)	-4.5132	(3,2,2)
-4.6991	(4,1,1)	-5.6611	(1,3,3)	-4.4213	(4,2,2)
-4.6239	(4,2,2)	-5.6084	(2,3,3)	-4.4196	(2,3,3)
-4.6170	(2,3,3)	-5.6022	(4,2,2)	-4.4179	(4,1,1)
-4.5350	(1,4,4)	-5.5323	(3,3,3)	-4.3365	(1,4,4)
-4.5286	(3,3,3)	-5.5118	(1,4,4)	-4.3099	(3,3,3)
-4.4286	(2,4,4)	-5.4454	(4,3,3)	-4.2148	(4,3,3)
-4.4248	(4,3,3)	-5.4337	(2,4,4)	-4.2016	(2,4,4)
-4.3262	(3,4,4)	-5.3383	(3,4,4)	-4.1013	(3,4,4)
-4.2287	(4,4,4)	-5.3015	(4,4,4)	-4.0293	(4,4,4)

Notes: BIC: Bayesian information criterion

A.7 Selection of the ECM models for RWH as the dependent variable for liberal, conservative, and social democratic economies

Liberal		Conservative		Social Democratic	
BIC	Specification	BIC	Specification	BIC	Specification
-5.1296	(1,1,1)	-5.9134	(1,1,1)	-4.8573	(1,1,1)
-5.0489	(2,1,1)	-5.8634	(2,1,1)	-4.7947	(2,1,1)
-4.9907	(3,1,1)	-5.7754	(3,1,1)	-4.7876	(1,2,2)
-4.9464	(1,2,2)	-5.7602	(1,2,2)	-4.7093	(3,1,1)
-4.8843	(2,2,2)	-5.7307	(2,2,2)	-4.6966	(2,2,2)
-4.8572	(4,1,1)	-5.7021	(4,1,1)	-4.6137	(3,2,2)
-4.8000	(3,2,2)	-5.6462	(3,2,2)	-4.5997	(4,1,1)
-4.7729	(1,3,3)	-5.5890	(4,2,2)	-4.5864	(1,3,3)
-4.7227	(2,3,3)	-5.5757	(1,3,3)	-4.5552	(2,3,3)
-4.7137	(4,2,2)	-5.5474	(2,3,3)	-4.5062	(4,2,2)
-4.6293	(3,3,3)	-5.4595	(3,3,3)	-4.4638	(1,4,4)
-4.5552	(1,4,4)	-5.4222	(1,4,4)	-4.4140	(3,3,3)
-4.5314	(4,3,3)	-5.4096	(4,3,3)	-4.3728	(2,4,4)
-4.4970	(2,4,4)	-5.3628	(2,4,4)	-4.3053	(4,3,3)
-4.4020	(3,4,4)	-5.2578	(3,4,4)	-4.2399	(3,4,4)
-4.3003	(4,4,4)	-5.2501	(4,4,4)	-4.1856	(4,4,4)

Notes: BIC: Bayesian information criterion.

A.8 ECM, DOLS, and FMOLS models for LPH as the dependent variable for liberal economies

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
RWH	1.08***	1.18***	1.12*	1.12***	1.07***	1.06***	1.10***	1.08***	1.06***
	(0.024)	(0.139)	(0.682)	(0.029)	(0.027)	(0.101)	(0.032)	(0.001)	(0.018)
$EPOP$	-0.01***	-0.01	-0.07	0.003	-0.001***	0.007	0.003	-0.02***	-0.007***
	(0.003)	(0.011)	(0.110)	(0.002)	(0.002)	(0.008)	(0.002)	(0.001)	(0.001)
ECT	-0.10***	-0.17***	-0.01						
	(0.035)	(0.046)	(0.019)						
SR									
RWH_{t-1}	0.69***	0.64***	0.77***						
	(0.057)	(0.056)	(0.038)						
$EPOP_{t-1}$	-0.00	0.00	-0.002*						
	(0.002)	(0.002)	(0.001)						
$Constant$	0.07***	0.13**	0.027						
	(0.022)	(0.054)	(0.017)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.9 ECM, DOLS, and FMOLS models for RWH as the dependent variable for liberal economies

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
LPH	0.88***	0.77***	0.48**	0.85***	0.87***	0.92***	0.83***	0.85***	0.92***
	(0.017)	(0.071)	(0.194)	(0.020)	(0.022)	(0.043)	(0.024)	(0.001)	(0.015)
$EPOP$	0.02***	0.02***	0.04*	0.001	0.00	0.005	0.003	0.03***	0.004***
	(0.003)	(0.004)	(0.019)	(0.002)	(0.002)	(0.004)	(0.002)	(0.001)	(0.001)
ECT	-0.10***	-0.21***	-0.05**						
	(0.030)	(0.040)	(0.019)						
SR									
LPH_{t-1}	0.66***	0.56***	0.67***						
	(0.063)	(0.059)	(0.036)						
$EPOP_{t-1}$	-0.00	-0.002	0.002						
	(0.002)	(0.002)	(0.001)						
$Constant$	-0.08***	-0.12*	-0.01						
	(0.027)	(0.063)	(0.016)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.10 ECM, DOLS, and FMOLS models for LPH as the dependent variable for conservative economies

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
RWH	1.10***	0.95***	1.09***	1.10***	1.09***	1.09***	1.12***	1.13***	1.08***
	(0.058)	(0.267)	(0.042)	(0.021)	(0.027)	(0.033)	(0.024)	(0.002)	(0.014)
$EPOP$	-0.06*	0.03	-0.004	-0.004***	-0.005***	-0.005*	0.002	-0.02***	-0.005***
	(0.032)	(0.076)	(0.007)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)
ECT	-0.03***	-0.10	-0.05***						
	(0.012)	(0.065)	(0.019)						
SR									
RWH_{t-1}	0.85***	0.77***	0.84***						
	(0.031)	(0.058)	(0.031)						
$EPOP_{t-1}$	0.004	0.005	-0.001						
	(0.003)	(0.004)	(0.001)						
$Constant$	0.09***	0.12***	0.03**						
	(0.030)	(0.031)	(0.012)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.11 ECM, DOLS, and FMOLS models for RWH as the dependent variable for conservative economies

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
LPH	0.78***	0.69***	0.84***	0.88***	0.91***	0.90***	0.87***	0.87***	0.91***
	(0.056)	(0.114)	(0.040)	(0.016)	(0.022)	(0.028)	(0.016)	(0.001)	(0.010)
$EPOP$	0.04**	0.04*	0.005	0.001	0.003*	0.003	0.00	0.007***	0.004***
	(0.015)	(0.020)	(0.005)	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)	(0.001)
ECT	-0.06***	-0.13**	-0.07***						
	(0.018)	(0.061)	(0.021)						
SR									
LPH_{t-1}	0.89***	0.81***	0.86***						
	(0.038)	(0.059)	(0.031)						
$EPOP_{t-1}$	-0.002	0.005*	0.001						
	(0.002)	(0.003)	(0.001)						
$Constant$	-0.08***	-0.11***	-0.007						
	(0.022)	(0.035)	(0.012)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.12 ECM, DOLS, and FMOLS models for LPH as the dependent variable for social democratic economies

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
RWH	1.02***	0.88***	1.08***	1.10***	1.13***	1.06***	1.10***	1.09***	1.07***
	(0.029)	(0.115)	(0.053)	(0.024)	(0.035)	(0.020)	(0.029)	(0.001)	(0.013)
$EPOP$	-0.01***	-0.006	-0.002	-0.004**	0.002	-0.006***	-0.004*	-0.001	-0.006***
	(0.003)	(0.011)	(0.006)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
ECT	-0.14**	-0.24***	-0.09***						
	(0.058)	(0.080)	(0.031)						
SR									
RWH_{t-1}	0.73***	0.62***	0.89***						
	(0.055)	(0.103)	(0.065)						
RWH_{t-2}	-0.001	0.01	0.01						
	(0.031)	(0.043)	(0.046)						
$EPOP_{t-1}$	0.009***	0.006	0.01***						
	(0.002)	(0.005)	(0.002)						
$EPOP_{t-2}$	-0.02***	-0.02***	-0.02***						
	(0.003)	(0.004)	(0.003)						
$Constant$	-0.01	0.11	0.04						
	(0.008)	(0.074)	(0.026)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.13 ECM, DOLS, and FMOLS models for RWH as the dependent variable for social democratic economies

Model Specif.	ECM PMG	ECM MG	ECM DFE	DOLS P	DOLS PW	DOLS G	FMOLS P	FMOLS PW	FMOLS G
LR									
LPH	0.91***	0.81***	0.81***	0.87***	0.85***	0.94***	0.87***	0.87***	0.93***
	(0.015)	(0.078)	(0.037)	(0.018)	(0.022)	(0.017)	(0.024)	(0.001)	(0.013)
$EPOP$	0.02**	0.01**	0.006	0.001	0.001	0.006***	0.00	0.00	0.005***
	(0.004)	(0.005)	(0.005)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
ECT	-0.13**	-0.24***	-0.11***						
	(0.051)	(0.054)	(0.030)						
SR									
LPH_{t-1}	0.61***	0.50***	0.54***						
	(0.075)	(0.074)	(0.041)						
$EPOP_{t-1}$	0.00	0.001	0.003*						
	(0.003)	(0.003)	(0.002)						
$Constant$	-0.15**	-0.12	0.001						
	(0.060)	(0.083)	(0.022)						

Notes: For the ECM specifications, the optimal number of lags is chosen based on the Bayesian information criterion, and a constant is included as a fixed regressor. For all the DOLS specifications, the optimal lags and leads are chosen based on the Bayesian information criterion. The lag specification for the long run variance is based on the Bayesian information criterion. The Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used. The coefficient covariance matrix for the pooled DOLS is calculated assuming homogeneous variances. The individual covariances for the grouped DOLS are calculated using a rescaled OLS method. For all the FMOLS specifications, the Bartlett kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West automatic procedure, and degrees-of-freedom adjustment is used to calculate their long run variances. The coefficient covariance matrix for the pooled FMOLS is calculated assuming homogeneous variances. Standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.14 Autoregressive lag order selection criteria for ARDL model with EPOP as a dependent variable and LPH and RWH as independent variables

Lag	LogL	LR	FPE	AIC	BIC	HQ
0	-3553.80	NA	32.6	6.3232	6.3366	6.3283
1	-1252.57	4586.09	0.5466	2.2339	2.2518	2.2407
2	-1093.32	317.10	0.4126	1.9526	1.9749	1.9610
3	-1087.06	12.45*	0.4087	1.9432	1.9700*	1.9533*
4	-1085.56	2.98	0.4083*	1.9423*	1.9736	1.9541
5	-1085.32	0.48	0.4089	1.9437	1.9794	1.9572

Notes: * Indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at a 5% level). FPE: Final prediction error. AIC: Akaike information criterion. BIC: Bayesian information criterion. HQ: Hannan-Quinn information criterion. Endogenous variable: EPOP. Exogenous variables: constant, LPH, and RWH.

A.15 Wald tests for the short run ARDL model for LPH, RWH, and EPOP

Null hypothesis	$\chi^2_{df=3}$
$\Delta EPOP_{t-1} = \Delta EPOP_{t-2} = \Delta EPOP_{t-3} = 0$	387.5***
$\Delta LPH_{t-1} = \Delta LPH_{t-2} = \Delta LPH_{t-3} = 0$	27.7***
$\Delta RWH_{t-1} = \Delta RWH_{t-2} = \Delta RWH_{t-3} = 0$	22.6***

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.16 LR test for binding restriction in the VECM

Null hypothesis	Test statistic	Prob.
$\xi_i ECT^{EPOP} = 0$	$\chi^2 = 0.1589$	0.6902

A.17 VAR lag order selection criteria for endogenous variables LPH, RWH, and EPOP

Lag	LogL	LR	FPE	AIC	BIC	HQ
0	-3391.4	NA	1.51E-01	6.6231	6.6376	6.6286
1	3280.9	13292.4	3.41E-07	-6.3783	-6.3206	-6.3564
2	3476.4	388.4	2.37E-07	-6.7423	-6.6413*	-6.7040
3	3507	61.4	2.27E-07	-6.7853	-6.6409	-6.7305*
4	3517.1	19.1	2.27E-07	-6.7866	-6.5989	-6.7153
5	3540.3	45.6	2.20E-07	-6.8143	-6.5833	-6.7266
6	3551.2	21.4*	2.20E-07*	-6.8180*	-6.5437	-6.7138
7	3559.6	16.4	2.20E-07	-6.8167	-6.4991	-6.6962
8	3565.6	11.8	2.21E-07	-6.8110	-6.4501	-6.6740
9	3569.8	8.1	2.23E-07	-6.8015	-6.3973	-6.6481

Notes: *Indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at a 5% level). FPE: Final predictor error. AIC: Akaike information criterion. BIC: Bayesian information criterion. HQ: Hannan-Quinn information criterion. Endogenous variables: LLP, LRW, and EPOP.

A.18 VECM residual serial correlation LM tests

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	7.4855	9	0.5867	0.8318	(9, 2623.7)	0.5867
2	7.9446	9	0.5397	0.8829	(9, 2623.7)	0.5397
3	5.4512	9	0.7933	0.6055	(9, 2623.7)	0.7933
4	14.6768	9	0.1002	1.6331	(9, 2623.7)	0.1002
5	7.8257	9	0.5518	0.8697	(9, 2623.7)	0.5518

Notes: Null hypothesis: No serial correlation at lag h.

Lag	LRE*stat	df	Prob.	Rao F-stat	df	Prob.
1	7.4855	9	0.5867	0.8318	(9, 2623.7)	0.5867
2	15.1820	19	0.6494	0.8433	(18, 3041.0)	0.6494
3	20.4501	27	0.8113	0.7569	(27, 3131.4)	0.8114
4	30.1679	36	0.7417	0.8375	(36, 3159.2)	0.7417
5	40.4740	45	0.6639	0.8991	(45, 3167.6)	0.6639

Notes: Null hypothesis: No serial correlation at lags *1* to *h*.

A.19 VECM residual Portmanteau tests for autocorrelation

Lags	Q-stat.	Prob.	Adj. Q-stat.	Prob.	df
1	0.22	-	0.22	-	-
2	0.67	-	0.67	-	-
3	1.68	-	1.08	-	-
4	2.40	-	2.41	-	-
5	3.95	-	3.97	-	-
6	17.67	0.2222	17.76	0.2180	14
7	26.87	0.2614	27.02	0.2551	23
8	39.01	0.1836	39.25	0.1768	32

Notes: Null hypothesis is "No residual autocorrelation up to lag *h*". Test is valid for lags larger than the VECM lag order."

A.20 Panel VECM for △LPH, △RWH, and △EPOP as dependent variables

		Dependent variable				
		ΔLPH		ΔRWH		$\Delta EPOP$
LR						
	RWH	0.7912** (0.4562)	LPH	1.2618*** (0.6000)	LPH	- -
	$EPOP$	-0.0502 (0.0363)	$EPOP$	-0.0634 (0.0435)	RWH	- -
	ECT	-0.0053*** (0.0014)	ECT	-0.0040*** (0.0010)	ECT	0.0000 (0.0000)
SR						
	ΔRWH_{t-1}	-0.0414 (0.0579)	ΔLPH_{t-1}	0.0066 (0.0499)	ΔLPH_{t-1}	3.9053*** (0.9001)
	ΔRWH_{t-2}	0.1600*** (0.0582)	ΔLPH_{t-2}	0.0602 (0.0505)	ΔLPH_{t-2}	1.6909*** (0.9106)
	ΔRWH_{t-3}	0.0483 (0.0593)	ΔLPH_{t-3}	0.0701 (0.0515)	ΔLPH_{t-3}	1.4947 (0.9276)
	ΔRWH_{t-4}	-0.1826*** (0.0592)	ΔLPH_{t-4}	0.0923** (0.0518)	ΔLPH_{t-4}	1.0761 (0.9336)
	ΔRWH_{t-5}	-0.0759 (0.0624)	ΔLPH_{t-5}	0.1300*** (0.0557)	ΔLPH_{t-5}	0.8505 (1.0034)
	$\Delta EPOP_{t-1}$	0.0001 (0.0018)	$\Delta EPOP_{t-1}$	0.0056*** (0.0017)	ΔRWH_{t-1}	-2.3075*** (0.9685)
	$\Delta EPOP_{t-2}$	-0.0036** (0.0020)	$\Delta EPOP_{t-2}$	-0.0037*** (0.0019)	ΔRWH_{t-2}	-2.6082*** (0.9736)
	$\Delta EPOP_{t-3}$	-0.0007 (0.0020)	$\Delta EPOP_{t-3}$	-0.0016 (0.0019)	ΔRWH_{t-3}	-0.5540 (0.9910)
	$\Delta EPOP_{t-4}$	0.0008 (0.0020)	$\Delta EPOP_{t-4}$	0.0017 (0.0019)	ΔRWH_{t-4}	-3.4552*** (0.9899)
	$\Delta EPOP_{t-5}$	0.0004 (0.0018)	$\Delta EPOP_{t-5}$	0.0017 (0.0017)	ΔRWH_{t-5}	-0.8180 (1.0438)
	Constant	0.0166*** (0.0018)	Constant	0.0124*** (0.0016)	Constant	0.1100*** (0.0294)

Notes: LR stands for long run, and SR for short run. Standard error in parenthesis.***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.21 Wald tests for the short run associations in the panel VECM

Null hypothesis	Dependent variable	$\chi^2_{df=5}$
$\Delta RWH_{t-1} = \Delta RWH_{t-2} = ... = \Delta RWH_{t-5} = 0$	ΔLPH	22.2***
$\Delta EPOP_{t-1} = \Delta EPOP_{t-2} = ... = \Delta EPOP_{t-5} = 0$	ΔLPH	6.0
$\Delta LPH_{t-1} = \Delta LPH_{t-2} = ... = \Delta LPH_{t-5} = 0$	ΔRWH	13.0**
$\Delta EPOP_{t-1} = \Delta EPOP_{t-2} = ... = \Delta EPOP_{t-5} = 0$	ΔRWH	15.6***
$\Delta LPH_{t-1} = \Delta LPH_{t-2} = ... = \Delta LPH_{t-5} = 0$	$\Delta EPOP$	29.6***
$\Delta RWH_{t-1} = \Delta RWH_{t-2} = ... = \Delta RWH_{t-5} = 0$	$\Delta EPOP$	29.1***

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.22 Roots of the characteristic polynomial

Root	Modulus
1.0000	1.0000
1.0000	1.0000
0.9857	0.9857
0.6284 - 0.2642 *i*	0.6817
0.6284 + 0.2642 *i*	0.6817
0.6791	0.6791
0.2155 + 0.6221 *i*	0.6584
0.2155 - 0.6221 *i*	0.6584
-0.5019 - 0.4119 *i*	0.6493
-0.5019 + 0.4119 *i*	0.6493
0.4038 + 0.4835 *i*	0.6299
0.4038 - 0.4835 *i*	0.6299
-0.1332 - 0.5643 *i*	0.5797
-0.1332 + 0.5643 *i*	0.5797
-0.5278	0.5278
-0.3498 - 0.3425 *i*	0.4896
-0.3498 + 0.3425 *i*	0.4896
0.0987	0.0987

Notes: VECM imposes two unit roots.
Endogenous variables: LPH, RWH, and EPOP.

A.23 Construction of the labor productivity per worker at constant 2017 purchasing power parity (LPW) and the average real wage per worker at constant 2017 purchasing power parity (RWH)

Labor productivity per worker at constant 2017 purchasing power parity (LPW)

$$LPW = ln\left(\frac{rgdpo}{emp}\right)$$

Average real wage per worker at constant 2017 purchasing power parity (RWW)

$$RWH = ln\left(\frac{rgdpo * labsh}{emp}\right)$$

Notes: *rgdpo*: Output-side real GDP at chained PPPs (in mil. 2017US$). Output-side real GDP allows a comparison of productive capacity across countries and over time. *labsh*: Share of labor compensation in GDP at current national prices. Reports the share represented by labor income in GDP in terms of the prices in that period (i.e., current prices). *emp*: Number of persons engaged (in millions). "Per person engaged" in PWT includes all persons aged 15 years and over, who during the reference week performed work, even just for one hour a week, or were not at work but had a job or business from which they were temporarily absent. It includes self-employed persons. *pop*: Population (in millions). Reports population data by country from the World Bank and United Nations sources.

A.24 Panel unit root tests for LPW, RWW, and EPOP in levels and first differences

Test	Specification	LPW	RWW	EPOP	ΔLPW	ΔRWW	ΔEPOP
Breitung	None	21.24	20.65	6.42	-17.7***	-17.2***	-17.5***
	C	16.42	15.80	6.24	-13.2***	-11.5***	-14.3***
	C & T	7.20	7.37	4.02	-19.3***	-17.4***	-13.5***
Fisher	Inv. χ^2, ADF	20.05	37.42	33.54	67.6**	91.4***	83.8***
	Inv. normal, ADF	3.29	2.40	2.33	-2.6***	-4.2***	-3.9***
	Inv. logit t, ADF	3.42***	2.64	2.36	-2.4***	-4.1***	-3.7***
	Modi. inv. χ^2, ADF	-2.20	-1.26	-1.65	1.8**	4.1***	3.4***
HT	None	1.00	1.00	1.00	0.4***	0.4***	0.5***
	C	0.98	0.98	0.99	0.1***	0.1***	0.5***
	C & T	0.93	0.93	0.93	0.2***	0.2***	0.5***
IPS	C	-2.74***	-2.79***	1.19	-27.0***	-23.7***	-18.4***
	C & T	1.79	1.45	-2.6***	-27.9***	-25.3***	-16.9***
LLC	unadjusted t	25.86	19.95	4.58	-20.2***	-19.3***	-22.0***
	adjusted t	25.57	19.72	4.52	-20.0***	-19.1***	-21.8***
	C & T	-0.72	-1.79**	-5.5***	-29.3***	-25.9***	-19.1***

Notes: The null hypothesis for the Breitung, Harris-Tsavalis (HT), and Levin-Lin-Chu (LLC) tests is that panels contain unit roots, and their alternative hypothesis is that panels are stationary. The null hypothesis for the Fisher-type tests is that all panels contain unit roots, and their alternative hypothesis is that at least one panel is stationary. The null hypothesis for the Im-Pesaran-Shin (IPS) test is that all panels contain unit roots, and their alternative hypothesis is that some panels are stationary. I chose the optimal lags for the Im-Pesaran-Shin, and the Levin-Lin-Chu tests based on the Bayesian information criterion. Operator Δ before the name of the variables denotes that the variable is expressed in first-differences, None: no constant and no trend, C: constant, and C & T: constant and intercept. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.25 Pedroni's panel cointegration test for LPW, RWW, and EPOP

Test	Dependent variable		
	LPW	RWW	EPOP
Weighted statistics			
v-statistic	1.01	3.21***	1.34*
ρ-statistic	-3.22***	-2.54***	0.69
PP-statistic	-3.83***	-3.12***	0.45
ADF-statistic	-6.99***	-5.81***	-0.81
Unweighted statistics			
v-statistic	2.60***	4.18***	0.66
ρ-statistic	-0.44	-0.90	0.48
PP-statistic	-0.04***	-0.61	0.05
ADF-statistic	-0.75***	-0.78	0.16
Group statistics			
ρ-statistic	-0.71	-0.90	1.75
PP-statistic	-1.69**	-1.84**	1.20
ADF-statistic	-4.27***	-4.01***	-1.68**

Notes: The null hypothesis is "no cointegration." The weighted and unweighted panel statistics' alternative hypothesis is "cointegration in all panels with common autoregressive coefficients in the residuals.". The group statistics' alternative hypothesis is "cointegration in a subset of panels with panel-specific autoregressive coefficients in the residuals." The deterministic specification includes a constant in the test equation and no deterministic trend. The optimal number of lags is chosen based on the Bayesian information criterion. The Parzen kernel is selected as a spectral estimation method with a bandwidth set by the Newey-West procedure. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.26 Westerlund's panel cointegration test for LPW, RWW, and EPOP

Test	Dependent variable		
	LPW	RWW	EPOP
Demean	-2.34***	-2.54***	1.03
Some	-3.41***	-3.65***	-2.07**
Trend	-2.47***	-1.29*	1.55*
All panels	-2.67***	-2.72***	-1.26

Notes: The null hypothesis is "no cointegration." The demeaned, some, and trend panel statistics' alternative hypothesis is "some panels are cointegrated." All panels' alternative hypothesis is "all panels are cointegrated." ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.27 Fisher's panel cointegration test for LPW, RWW, and EPOP

	Trace test	Maximum eigenvalue test
None	110.30***	87.66***
At most 1	58.85	45.25
At most 2	79.04***	79.04***

Notes: Probabilities are computed using asymptotic chi-square distribution. Two lags interval in first differences is chosen based on the Bayesian information criterion. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

A.28 Selection of the ECM models for LPW and RWW as dependent variables

Dependent variable: LPW		Dependent variable: RWW	
BIC	Specification	BIC	Specification
-5.1284	(1,1,1)	-5.2259	(1,1,1)
-5.0328	(1,2,2)	-5.1662	(2,1,1)
-5.0238	(2,1,1)	-5.0654	(1,2,2)
-4.9554	(2,2,2)	-5.0624	(3,1,1)
-4.9292	(3,1,1)	-5.0247	(2,2,2)
-4.8549	(3,2,2)	-4.9486	(4,1,1)
-4.8285	(1,3,3)	-4.9207	(3,2,2)
-4.8184	(4,1,1)	-4.8616	(1,3,3)
-4.7531	(2,3,3)	-4.8179	(4,2,2)
-4.7493	(4,2,2)	-4.7952	(2,3,3)
-4.6495	(3,3,3)	-4.7008	(3,3,3)
-4.6026	(1,4,4)	-4.6456	(1,4,4)
-4.5429	(4,3,3)	-4.6056	(2,4,4)
-4.5363	(2,4,4)	-4.5932	(4,3,3)
-4.4325	(3,4,4)	-4.4789	(3,4,4)
-4.3558	(4,4,4)	-4.4286	(4,4,4)

Notes: BIC: Bayesian information criterion.

A.29 Autoregressive lag order selection criteria for the ARDL model with EPOP as a dependent variable and LPW and RWW as independent variables

Lag	LogL	LR	FPE	AIC	BIC	HQ
0	-4344.74	NA	32.6588	6.3240	6.3354	6.3283
1	-1468.33	5736.09	0.4984	2.1416	2.1568	2.1473
2	-1276.61	382.06	0.3777	1.8642	1.8832	1.8713
3	-1269.97	13.21*	0.3746*	1.8560*	1.8788*	1.8645*
4	-1269.19	1.56	0.3747	1.8563	1.8829	1.8662
5	-1269.18	0.01	0.3753	1.8577	1.8881	1.8691

Notes: * Indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at a 5% level). FPE: Final prediction error. AIC: Akaike information criterion. BIC: Bayesian information criterion. HQ: Hannan-Quinn information criterion. Endogenous variable: EPOP. Exogenous variables: constant, LPW, and RWW.

Appendix B

Appendices for Chapter 2

B.1 Stability analysis

Linearization of the dynamical system around the Pasinetti steady state where $\phi_{ss} \in (0,1)$ yields, independently of the sign of $\alpha - \mu$, a Jacobian matrix with the following sign structure:

$$\begin{bmatrix} \dot{u} \\ \dot{\phi} \\ \dot{\omega} \\ \dot{e} \end{bmatrix} = \begin{bmatrix} 0 & 0 & - & 0 \\ 0 & - & - & 0 \\ 0 & 0 & - & + \\ + & + & - & 0 \end{bmatrix} \begin{bmatrix} u - u_{ss} \\ \phi - \phi_{ss} \\ \omega - \omega_{ss} \\ e - e_{ss} \end{bmatrix}$$

with the following entries in the Jacobian matrix:

$$\begin{aligned}
J_{13} &= \frac{\partial \dot{u}}{\partial \omega}|_{ss} = -\frac{\alpha\beta^2 z}{s^c(\beta - z)} && < 0 \\
J_{22} &= \frac{\partial \dot{\phi}}{\partial \phi}|_{ss} = -\frac{\alpha z}{s^c}\left[\frac{(s^c - s^w)(\beta - z) - s^w z}{\beta - z}\right] && < 0 \\
J_{23} &= \frac{\partial \dot{\phi}}{\partial \omega}|_{ss} = -\frac{(s^c - s^w)(\beta - z) - s^w z}{(s^c - s^w)(\beta - z)}\frac{\alpha\beta s^w z}{s^c(\beta - z)^2} && < 0 \\
J_{33} &= \frac{\partial \dot{\omega}}{\partial \omega}|_{ss} = -\alpha z && < 0 \\
J_{34} &= \frac{\partial \dot{\omega}}{\partial e}|_{ss} = \frac{\delta z}{\beta} && > 0 \\
J_{41} &= \frac{\partial \dot{e}}{\partial u}|_{ss} = \left[\frac{s^c(\beta - z)}{\beta}\right]\left[\frac{\lambda + (\alpha - \mu)z}{\delta}\right] && > 0 \\
J_{42} &= \frac{\partial \dot{e}}{\partial \phi}|_{ss} = \alpha z\left(\frac{s^c - s^w}{s^c}\right)\left[\frac{\lambda + (\alpha - \mu)z}{\delta}\right] && > 0 \\
J_{43} &= \frac{\partial \dot{e}}{\partial \omega}|_{ss} = -\beta\left\{(1+\alpha) + \frac{\alpha z}{s^c(\beta - z)^2}\left[(s^c - s^w)(\beta - z) - s^w z\right]\right\}\left[\frac{\lambda + (\alpha - \mu)z}{\delta}\right] && < 0 \\
J_{11} &= J_{12} = J_{14} = J_{21} = J_{24} = J_{31} = J_{32} = J_{44} = 0
\end{aligned}$$

For local stability, the eigenvalues of J_{ss} must have uniformly negative real parts. Petach and Tavani (2021) have already proven the local stability of the 3-dimensional subsystem in (u, ω, ϕ) under $\mu = 0$. Notice however that the terms in square brackets in J_{42} and J_{43} are nothing but the steady state employment rate, which is positive no matter whether $\alpha - \mu \gtreqless 0$, with the implication that all the signs in the Jacobian are unambiguous, no matter whether the model is wage-led or profit-led. Thus, it is sufficient to show that the fourth eigenvalue is negative. In order to do so, consider that the equations describing the evolution of u and ϕ do not communicate with the equation tracing the evolution of employment: the implication is that we can focus on the interaction between ω and e in the Jacobian, i.e, the submatrix formed by the entries $\begin{bmatrix} J_{33} & J_{34} \\ J_{43} & J_{44} \end{bmatrix}$ in the bottom right of the full Jacobian. Such minor has the following sign structure: $\begin{bmatrix} - & + \\ - & 0 \end{bmatrix}$ that delivers a negative trace and positive determinant, which implies that the fourth eigenvalue of J is negative as required.

B.2 Unit root tests

Test	Specification	u	ϕ	e	ω	Δu	$\Delta\phi$	Δe	$\Delta\omega$
ADF	None	1.68	1.20	1.34	-0.89	-6.01***	-6.27***	-4.57***	-6.19***
	C	-0.82	-0.20	-2.07	-1.52	-6.24***	-6.34***	-4.83***	-6.18***
	C & *T*	-3.41*	-2.03	-2.08	-2.23	-6.18***	-6.53***	-4.94***	-6.13***
PP	None	2.07	1.02	1.71	-0.89	-5.86***	-6.26***	-4.49***	-6.20***
	C	-0.69	-0.16	-1.71	-1.75	-6.23***	-6.34***	-4.67***	-6.20***
	C & *T*	-2.75	-1.82	-1.25	-2.59	-6.14***	-6.52***	-4.66***	-6.14***
Breakpoint	*C*	-3.56	-2.49	-3.94	-3.21	-6.95***	-7.44***	-6.30***	-6.53***
	C & *T*: break: *C*	-4.43	-4.15	-4.06	-2.63	-7.00***	-7.74***	-6.55***	-6.66***
	C & *T*: break: *T*	-4.21	-4.24	-3.86	-2.42	-6.46***	-6.93***	-5.46***	-6.17***
	C & *T*: break: *C* & *T*	-4.47	-4.41	-4.07	-2.95	-7.01***	-7.78***	-5.96***	-6.78***

Notes: ADF: Augmented Dickey-Fuller, PP: Phillips-Perron, Breakpoint: unit root test in the presence of a break. *C*: Constant, *T*: Trend. The null hypothesis is that the variable has a unit root, while the alternative hypothesis is that the variable is stationary. The lag length for the ADF test is based on the Bayesian information criterion. The Barlett kernel is selected as the spectral estimation method with a bandwidth set by the Newey-West procedure for the PP unit root test. Breakpoint unit root tests use innovation outlier as its break type, the Dickey-Fuller mint-t as breakpoint selection, and the Bayesian information criterion is used to select their optimal lag length. Operator Δ before the name of the variables denotes that the variable is expressed in first-differences. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

B.3 Johansen cointegration test

Hypothesized No. of cointegrating equations	Trace		Max. Eigenvalue	
	Statistic	Prob.	Statistic	Prob.
None	62.5563	0.0073	29.4754	0.0384
At most 1	33.0808	0.0830	18.5498	0.1540
At most 2	14.5311	0.2545	10.1313	0.3225
At most 3	4.3998	0.3558	4.3998	0.3558

Notes: The test does not allow a linear deterministic trend, but an intercept in the cointegrating equation.

B.4 Model selection

Lag	Log L	LR	FPE	AIC	BIC	HQ
0	-421.15	N.A.	110.30	16.05	16.20	16.11
1	-157.98	477.23	0.0097	6.72	7.46*	7.00
2	-129.91	46.61*	0.0062	6.26	7.60	6.78*
3	-113.48	24.80	0.0063	6.24	8.18	6.99
4	-95.73	24.11	0.0062*	6.18	8.71	7.15
5	-77.94	21.48	0.0064	6.11*	9.23	7.31
6	-70.96	7.37	0.0103	6.45	10.17	7.88
7	-59.08	10.76	0.0149	6.61	10.92	8.27

Notes: * Indicates lag order selected by the criterion. L.R.: sequential modified L.R. test statistic (tests at a 5% level). FPE: Final prediction error. AIC: Akaike information criterion. BIC: Bayesian information criterion. HQ: Hannan-Quinn information criterion. Endogenous variables: output-capital ratio, top 1% wealth share, the share of labor compensation, and the employment-population ratio.

B.5 VECM residual serial correlation LM tests

Lag	LRE stat.	df	Prob.	Rao F-stat.	df	Prob.
1	10.79	16	0.8222	0.66	(16, 107.6)	0.8231
2	7.71	16	0.9571	0.47	(16, 107.6)	0.9573
3	12.48	16	0.7102	0.77	(16, 107.6)	0.7114

Note: Null hypothesis: No serial correlation at lag h

Lag	LRE stat.	df	Prob.	Rao F-stat.	df	Prob.
1	10.79	16	0.8222	0.66	(16, 107.6)	0.8231
2	27.28	32	0.7043	0.84	(32, 115.9)	0.7102
3	37.32	48	0.8674	0.74	(48, 106.0)	0.8770

Note: Null hypothesis: No serial correlation at lags 1 to h

B.6 VECM residual correlation Portmanteau tests

Lags	Q-statistic	Prob.	Adj. Q-stat.	Prob.	df
1	2.28	-	2.32	-	-
2	4.62	-	4.75	-	-
3	9.63	-	10.05	-	-
4	28.05	0.5155	29.87	0.4203	29
5	40.40	0.6669	43.44	0.5381	45
6	50.41	0.8314	54.65	0.7039	61

Notes: Null hypothesis: No residual autocorrelation up to lag h.
Tests are valid only for lags larger than the VECM lag order.

B.7 VECM White heteroskedasticity test

Chi-square stat.	Degrees of freedom	Prob.
244.72	260	0.7435

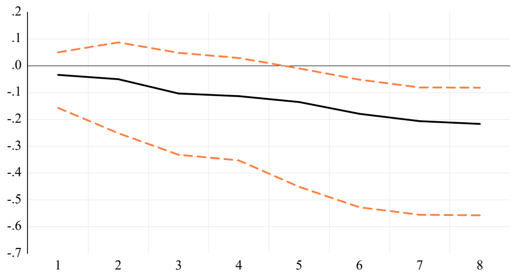
Notes: The null hypotheses are no heteroskedasticity. White heteroskedasicity test does not include cross terms.

B.8 Roots of the characteristic polynomial of the VECM

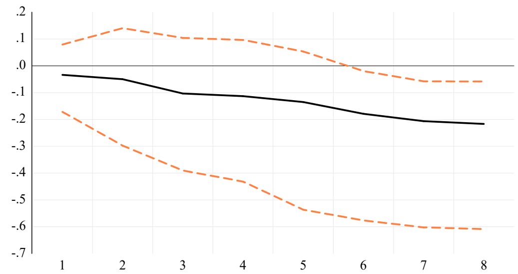
Root	Modulus
1.0000	1.0000
1.0000 - 3.60e - 16 i	1.0000
1.0000 + 3.60e - 16 i	1.0000
0.6520 - 0.4764 i	0.8075
0.6520 + 0.4764 i	0.8075
-0.6263 - 0.4125 i	0.7499
-0.6263 + 0.4125 i	0.7499
0.6666 - 0.0379 i	0.6677
0.6666 + 0.0379 i	0.6677
0.3404 - 0.5488 i	0.6459
0.3404 + 0.5488 i	0.6459
-0.6437	0.6437
0.2034 - 0.5389 i	0.5760
0.2034 + 0.5389 i	0.5760
-0.2199 - 0.2128 i	0.3060
-0.2199 + 0.2128 i	0.3060

Note: VECM imposes three unit roots. Endogenous variables: u, ϕ, e, and ω.

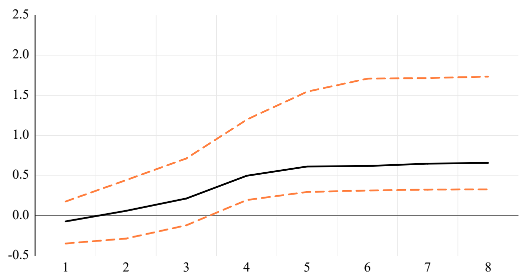
B.9 Generalized impulse responses of u, ϕ, and e to a negative one standard deviation innovation in ω using Hall's studentized bootstrap.



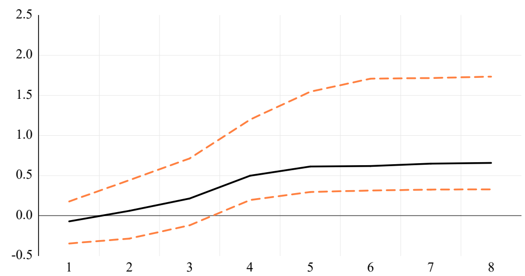
(a) Response of u (90% C.I.)



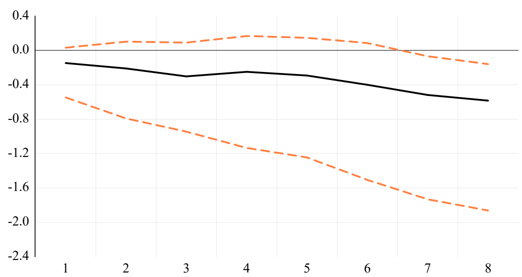
(b) Response of u (95% C.I.)



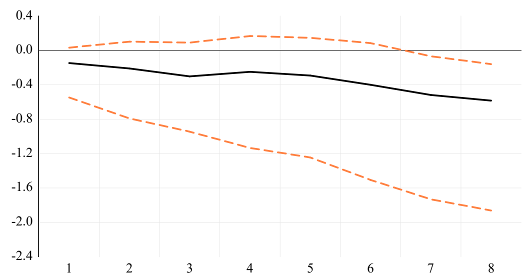
(c) Response of ϕ (90% C.I.)



(d) Response of ϕ (95% C.I.)



(e) Response of e (90% C.I.)



(f) Response of e (95% C.I.)

Note: Confidence intervals are calculated using Hall's studentized bootstrap with 1000 bootstrap repetitions and 500 double bootstrap repetitions.

Appendix C

Appendices for Chapter 3

C.1 Stability analysis

Linearization of the dynamical system around the Pasinetti steady state where $\phi_{ss} \in (0,1)$ yields, independently of the sign of $\alpha - \mu$, a Jacobian matrix with the following sign structure:

$$\begin{bmatrix} \dot{u} \\ \dot{\phi} \\ \dot{\omega} \\ \dot{e} \end{bmatrix} = \begin{bmatrix} 0 & 0 & - & 0 \\ 0 & - & - & 0 \\ 0 & 0 & - & + \\ + & + & - & - \end{bmatrix} \begin{bmatrix} u - u_{ss} \\ \phi - \phi_{ss} \\ \omega - \omega_{ss} \\ e - e_{ss} \end{bmatrix}$$

with the following entries in the Jacobian matrix:

$$\begin{array}{lllllll}
J_{13} & = & \frac{\partial \dot{u}}{\partial \omega}|_{ss} & = & -\frac{\beta^2\left\{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}}{s^c(\beta-z)} & < & 0 \\
J_{22} & = & \frac{\partial \dot{\phi}}{\partial \phi}|_{ss} & = & -\frac{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]}{s^c}\left[\frac{(s^c-s^w)(\beta-z)-s^w z}{\beta-z}\right] & < & 0 \\
J_{23} & = & \frac{\partial \dot{\phi}}{\partial \omega}|_{ss} & = & -\left[\frac{(s^c-s^w)(\beta-z)-s^w z}{(s^c-s^w)(\beta-z)}\right]\frac{\beta^2 s^w\left\{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}}{s^c(\beta-z)} & < & 0 \\
J_{33} & = & \frac{\partial \dot{\omega}}{\partial \omega}|_{ss} & = & -\alpha z & < & 0 \\
J_{34} & = & \frac{\partial \dot{\omega}}{\partial e}|_{ss} & = & \frac{\delta z}{\beta} & > & 0 \\
J_{41} & = & \frac{\partial \dot{e}}{\partial u}|_{ss} & = & \left[\frac{s^c(\beta-z)}{\beta}\right]\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right] & > & 0 \\
J_{42} & = & \frac{\partial \dot{e}}{\partial \phi}|_{ss} & = & \left\{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}\left(\frac{s^c-s^w}{s^c}\right)\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right] & > & 0 \\
J_{43} & = & \frac{\partial \dot{e}}{\partial \omega}|_{ss} & = & -\left\{\frac{\beta[\lambda+(\alpha-\mu)z]}{\delta}\right\}\left\{(1+\alpha)+\frac{\left\{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}[(s^c-s^w)(\beta-z)-s^w z]}{s^c(\beta-z)^2}\right\} & < & 0 \\
J_{44} & = & \frac{\partial \dot{e}}{\partial e}|_{ss} & = & -\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right] & < & 0
\end{array}$$

$$J_{11} = J_{12} = J_{14} = J_{21} = J_{24} = J_{31} = J_{32} = 0$$

For local stability, the eigenvalues of J_{ss} must have uniformly negative real parts. Petach and Tavani (2021) have already proven the local stability of the 3-dimensional subsystem in (u, ω, ϕ) under $\mu = 0$. Notice however that the terms in square brackets in J_{41}, J_{42}, J_{43}, and J_{44} are nothing but the steady state employment-population ratio, which is positive no matter whether $\alpha - \mu \gtreqless 0$, with the implication that all the signs in the Jacobian are unambiguous, no matter whether the model is wage-led or profit-led. Thus, it is sufficient to show that the fourth eigenvalue is negative. In order to do so, consider that the equations describing the evolution of u and ϕ do not communicate with the equation tracing the evolution of employment: the implication is that we can focus on the interaction between ω and e in the Jacobian, i.e, the submatrix formed by the entries $\begin{bmatrix} J_{33} & J_{34} \\ J_{43} & J_{44} \end{bmatrix}$ in the bottom right of the full Jacobian. Such minor has the following sign structure: $\begin{bmatrix} - & + \\ - & - \end{bmatrix}$ that delivers a negative trace and positive determinant, which implies that the fourth eigenvalue of J is negative as required.

$$TrJ = J_{11} + J_{22} + J_{33} + J_{44} < 0$$
$$DetJ = J_{13}J_{22}J_{34}J_{41} > 0$$
$$P_mJ = J_{22}(J_{33}J_{44} - J_{34}J_{43}) - J_{23}(J_{32}J_{44} - J_{34}J_{42}) - J_{13}(J_{31}J_{44} - J_{34}J_{41}) < 0$$

C.2 Calibration of parameters

It is valuable to perform the calibration of the parameters and endogenous variables to simulate transitional dynamics following a shock to the various parameters of interest, namely z, s^w, s^c, even though the model can be studied analytically.

We followed the Chinese Household Income Project 2013 report to calibrate the two classes' saving rates for China. We set the capitalists' saving rate equal to 47% and the workers' saving rate at around 20%. We fixed z at 0.075 and internally calibrated β at 0.13 to obtain a steady state wage share of 58% in the baseline model. We then fixed δ = 0.05, which is the naïve point estimate of the slope of the Phillips curve for China using real wage growth and the employment-population ratio series, and α = 0.67. In the profit-led model, μ was set at 0.77, and λ is internally calibrated to be equal to 0.04 to return a steady state employment-population ratio of about 0.57 in the baseline. The parameters ξ = 0.40 and $\bar{n}$ = 0.0043 are obtained by the naïve slope and intercept of the regression of total population growth on employment. The parameter θ = 0.0295 is calculated from the average of net exports as a percentage of GDP for the period under analysis. All simulations assume that the economy is in a steady state at time zero when a shock to either parameter occurs.

Regarding India, we also fixed z at 0.075 and calibrated β at 0.12 to match the steady state wage share of 0.63. We estimated the capitalists' saving rate to equal 0.39 and the workers' saving rate to be around 0.11. The parameter δ = 0.14 is the slope of the naïve regression using a linear version of the Phillips curve. The parameter α = 0.42 was internally calibrated to match the steady state labor productivity growth = 0.03 for India under the period analyzed. The parameter μ was set at 0.33, and λ is internally calibrated to be equal to 0.05 to return a steady state employment-population ratio of about 0.38. The parameters ξ = 0.30 and $\bar{n}$ = 0.0129 are obtained by the naïve slope and intercept of the regression of total population growth on employment, and the parameter θ = -0.0192 is calculated using the same criterion for China. Notice that the sign for the net export as a percentage of GDP for India is negative.

C.3 Calculation for comparative statics

$$
\begin{aligned}
\frac{\partial u_{ss}}{\partial z} &= \frac{\beta\left\{\alpha\beta+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}}{s^c(\beta-z)^2} &> 0 \\
\frac{\partial u_{ss}}{\partial s^c} &= -\frac{\beta\left\{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}}{s^c(\beta-z)} &< 0 \\
\frac{\partial u_{ss}}{\partial \alpha} &= \frac{\beta z(\delta+\xi)}{s^c\delta(\beta-z)} &> 0 \\
\frac{\partial u_{ss}}{\partial \mu} &= -\frac{\beta\xi z}{s^c\delta(\beta-z)} &> 0 \\
\frac{\partial u_{ss}}{\partial \beta} &= -\frac{z\left\{\alpha z+\bar{n}+\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]\right\}}{s^c(\beta-z)^2} &< 0 \\
\frac{\partial u_{ss}}{\partial \xi} &= \frac{\beta\xi\left[\frac{\lambda+(\alpha-\mu)z}{\delta^2}\right]}{s^c(\beta-z)} &> 0 \\
\frac{\partial u_{ss}}{\partial \delta} &= -\frac{\beta\left[\frac{\lambda+(\alpha-\mu)z}{\delta}\right]}{s^c(\beta-z)} &< 0 \\
\frac{\partial u_{ss}}{\partial \lambda} &= \frac{\beta\xi}{s^c\delta(\beta-z)} &> 0 \\
\frac{\partial u_{ss}}{\partial \bar{n}} &= \frac{\beta}{s^c(\beta-z)} &> 0 \\
\frac{\partial \phi_{ss}}{\partial z} &= -\frac{\beta(s^w-\theta)}{(s^c-s^w)(\beta-z)^2} &< 0 \\
\frac{\partial \phi_{ss}}{\partial s^c} &= \frac{s^w z-\beta\theta}{(s^c-s^w)^2(\beta-z)} &> 0 \\
\frac{\partial \phi_{ss}}{\partial s^w} &= -\frac{s^c z-\beta\theta}{(s^c-s^w)(\beta-z)} &< 0 \\
\frac{\partial \phi_{ss}}{\partial \beta} &= \frac{z(s^w-\theta)}{(s^c-s^w)(\beta-z)^2} &> 0 \\
\frac{\partial \phi_{ss}}{\partial \theta} &= -\frac{\beta}{(s^c-s^w)(\beta-z)} &> 0 \\
\frac{\partial \omega_{ss}}{\partial z} &= \frac{1}{\beta} &> 0 \\
\frac{\partial \omega_{ss}}{\partial \beta} &= -\frac{z}{\beta^2} &< 0 \\
\frac{\partial e_{ss}}{\partial z} &= \frac{\alpha-\mu}{\delta} &\pm 0 \\
\frac{\partial e_{ss}}{\partial \alpha} &= \frac{z}{\delta} &> 0 \\
\frac{\partial e_{ss}}{\partial \mu} &= -\frac{z}{\delta} &< 0 \\
\frac{\partial e_{ss}}{\partial \delta} &= -\frac{\lambda+(\alpha-\mu)z}{\delta^2} &< 0 \\
\frac{\partial e_{ss}}{\partial \lambda} &= \frac{1}{\delta} &> 0
\end{aligned}
$$

$$\frac{\partial u_{ss}}{\partial s^w} = \frac{\partial u_{ss}}{\partial \theta} = 0$$

$$\frac{\partial \phi_{ss}}{\partial \alpha} = \frac{\partial \phi_{ss}}{\partial \mu} = \frac{\partial \phi_{ss}}{\partial \xi} = \frac{\partial \phi_{ss}}{\partial \delta} = \frac{\partial \phi_{ss}}{\partial \lambda} = \frac{\partial \phi_{ss}}{\partial \bar{n}} = 0$$

$$\frac{\partial \omega_{ss}}{\partial s^c} = \frac{\partial \omega_{ss}}{\partial s^w} = \frac{\partial \omega_{ss}}{\partial \alpha} = \frac{\partial \omega_{ss}}{\partial \mu} = \frac{\partial \omega_{ss}}{\partial \xi} = \frac{\partial \omega_{ss}}{\partial \delta} = \frac{\partial \omega_{ss}}{\partial \lambda} = \frac{\partial \omega_{ss}}{\partial \bar{n}} = \frac{\partial \omega_{ss}}{\partial \theta} = 0$$

$$\frac{\partial e_{ss}}{\partial s^c} = \frac{\partial e_{ss}}{\partial s^w} = \frac{\partial e_{ss}}{\partial \beta} = \frac{\partial e_{ss}}{\partial \xi} = \frac{\partial e_{ss}}{\partial \bar{n}} = \frac{\partial e_{ss}}{\partial \theta} = 0$$

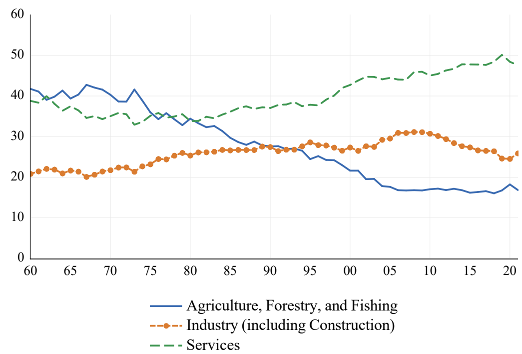
C.4 Coefficients of population growth on employment growth

Country	1960-2019	1970-2019	1980-2019	1990-2019	2000-2019
China	0.39***	0.40***	0.32***	0.40***	0.22***
India	0.23***	0.30***	0.28***	0.18***	0.11**
Australia	0.09**	0.06**	0.04	0.03	0.04
Austria	0.01	0.10**	0.10*	-0.04	0.04
Belgium	0.05*	0.07*	0.07*	-0.004	-0.05
Canada	0.03	0.03**	0.004	-0.05	-0.02
Colombia	0.07	0.07*	0.04	0.03	0.01
Czechia	0.05*	0.05*	0.05*	0.05	0.05
Denmark	0.04	-0.002	-0.01	0.001	-0.01
Finland	-0.03***	-0.03***	-0.03***	0.03***	0.03**
France	-0.04	-0.005	-0.02	-0.02	-0.04
Germany	-0.04	-0.04	-0.05	-0.09	0.06
Iceland	0.01	-0.01	-0.01	-0.03	-0.03
Italy	-0.04	0.01	0.06	0.01	-0.02
Japan	0.22***	0.14	0.06	-0.02	-0.11
Latvia	0.01	0.01	0.01	0.01	0.001
Lithuania	-0.03	-0.03	-0.03	-0.03	0.002
Netherlands	0.04	0.01	0.02*	0.03	-0.01
Norway	0.01	0.02	0.03	0.05	0.06
Poland	0.01	0.01	-0.03	-0.02*	0.01
Portugal	0.08**	0.07*	0.03	0.03	0.01
Slovenia	0.03	0.03	0.03	0.03	-0.03
South Korea	0.21***	0.14**	0.05	0.05	0.11
Spain	0.02	0.02	0.04	0.07	0.09
Sweden	-0.02	-0.02	-0.02	-0.02	-0.01
Switzerland	0.22***	0.09*	0.01	0.07	0.14*
United Kingdom	0.06*	0.06*	0.05	0.04	-0.12
United States	0.01	0.004	0.01	0.01	-0.04

Source: Own elaboration based on Penn World Table 10.01. The population annual growth rate was calculated using the series *pop*, and the yearly growth employment rate was calculated using the series *emp*. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

C.5 Value added by sector as a percentage of GDP, 1960-2019

(a) China



(b) India

Source: Own elaborations based on World Development Indicators, World Bank.

C.6 Gross fixed capital formation as a percentage of GDP

Country	1960-69	1970-79	1980-89	1990-99	2000-09	2010-21	Δ10s-70s
China	20.4	26.8	29.0	31.2	37.8	43.0	16.2
India	16.1	17.6	21.9	25.1	31.4	30.1	12.4
Australia	30.9	28.1	27.6	24.6	26.4	25.3	-2.8
Austria	-	28.5	24.8	25.6	23.6	23.5	-5.0
Belgium	-	25.9	20.4	21.9	22.2	23.2	-2.6
Canada	23.1	23.3	22.3	19.8	21.4	23.4	0.2
Colombia	16.9	16.0	17.6	19.8	19.5	21.3	5.3
Czechia	-	-	-	29.5	29.4	26.1	-
Denmark	24.7	24.2	20.0	19.7	21.6	20.3	-3.9
Finland	-	29.3	27.4	22.1	22.9	22.9	-6.4
France	25.1	25.2	22.5	21.0	21.9	22.5	-2.7
Germany	-	26.2	23.5	23.8	20.2	20.6	-5.6
Iceland	-	33.0	25.1	20.9	24.9	19.0	-14.1
Italy	-	25.2	23.1	20.1	21.1	18.1	-7.0
Japan	-	37.0	33.0	31.9	26.0	24.6	-12.4
Latvia	-	-	-	19.2	28.5	22.3	-
Lithuania	-	-	-	21.8	22.7	19.6	-
Netherlands	26.1	24.1	21.6	21.8	21.5	20.1	-4.0
Norway	-	32.1	28.1	22.5	20.8	23.9	-8.1
Poland	-	-	-	21.4	20.5	19.0	-
Portugal	-	27.8	28.2	25.0	24.1	17.3	-10.5
Slovenia	-	-	-	25.2	26.6	19.3	-
South Korea	17.2	27.3	30.4	35.7	30.8	30.1	2.8
Spain	-	25.7	22.3	23.0	27.3	19.1	-6.5
Sweden	30.8	26.9	25.5	21.9	22.7	23.9	-2.9
Switzerland	-	-	30.8	27.8	26.9	26.3	-
United Kingdom	-	24.3	22.1	18.9	17.4	17.0	-7.3
United States	-	22.3	23.0	21.1	21.9	20.2	-2.1

Source: Own elaboration based on World Development Indicators, World Bank. Notes: Column Δ10s-70s is the difference between 2010-21 and 1970-79. Gross fixed capital formation includes land improvements, plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. According to the 1993 SNA, net acquisitions of valuables are also considered capital formation.

C.7 Gross domestic savings as a percentage of GDP

Country	1960-69	1970-79	1980-89	1990-99	2000-09	2010-21	Δ10s-70s
China	27.1	36.7	35.0	39.6	44.2	46.7	10.1
India	8.2	12.5	15.7	23.9	29.9	30.8	18.3
Australia	30.6	28.8	25.6	24.3	25.0	25.9	-3.0
Austria	-	28.5	24.5	25.6	27.4	27.6	-0.9
Belgium	-	27.7	21.2	25.5	26.9	25.0	-2.7
Canada	22.9	23.3	23.7	21.2	25.2	22.1	-1.2
Colombia	17.7	19.7	20.6	18.4	17.0	17.4	-2.2
Czechia	-	-	-	29.8	31.3	32.5	-
Denmark	23.9	22.8	22.0	25.8	27.7	27.6	4.8
Finland	-	30.5	29.1	26.5	29.6	23.0	-7.5
France	27.8	27.0	22.0	22.6	22.9	22.0	-5.0
Germany	-	23.8	21.0	24.6	25.3	27.1	3.3
Iceland	-	29.2	24.2	21.3	20.3	24.1	-5.1
Italy	-	25.0	22.6	22.6	21.4	20.3	-4.6
Japan	-	36.8	33.2	32.8	27.2	24.2	-12.6
Latvia	-	-	-	11.8	19.2	21.3	-
Lithuania	-	-	-	12.6	15.4	21.0	-
Netherlands	29.3	27.7	26.3	28.5	29.0	30.2	2.5
Norway	-	31.5	32.8	30.3	37.6	34.8	3.3
Poland	-	-	-	20.3	18.1	22.3	-
Portugal	-	19.1	19.9	17.9	15.9	16.5	-2.5
Slovenia	-	-	-	24.5	27.6	26.5	-
South Korea	8.7	22.5	33.0	17.7	33.9	35.4	12.9
Spain	-	25.0	21.4	21.8	24.3	22.0	-3.1
Sweden	29.6	26.8	25.3	25.4	28.6	28.3	1.5
Switzerland	-	-	32.5	31.9	33.4	36.0	-
United Kingdom	-	13.5	13.8	15.5	15.8	16.0	2.4
United States	-	22.6	21.6	20.3	17.5	17.4	-5.2

Source: Own elaboration based on World Development Indicators, World Bank. Notes: Column Δ10s-70s is the difference between 2010-21 and 1970-79. Gross domestic savings are calculated as GDP less final consumption expenditure (total consumption).

C.8 Percentage of the population at mid-year residing in urban areas

Country	1970	2020	2050	Δ1970-2020	Δ2020-2050
China	17.4	61.4	80.0	44.0	18.6
India	19.8	34.8	52.8	15.1	18.0
Australia	84.0	86.2	91.0	2.2	4.7
Austria	65.3	58.7	70.9	-6.5	12.2
Belgium	93.8	98.1	98.9	4.2	0.8
Canada	75.7	81.6	87.3	5.9	5.7
Colombia	56.6	81.4	88.8	24.8	7.4
Czechia	64.4	74.1	82.2	9.7	8.1
Denmark	79.7	88.1	92.3	8.4	4.2
Finland	63.7	85.5	90.0	21.8	4.5
France	71.1	81.0	88.3	9.9	7.4
Germany	72.3	77.5	84.3	5.2	6.9
Iceland	84.9	93.9	95.8	9.0	1.9
Italy	64.3	71.0	81.1	6.8	10.0
Japan	71.9	91.8	94.7	19.9	2.9
Latvia	60.7	68.3	75.9	7.6	7.6
Lithuania	49.6	68.0	78.1	18.5	10.1
Netherlands	61.7	92.2	96.6	30.6	4.4
Norway	65.4	83.0	90.2	17.6	7.3
Poland	52.1	60.0	70.4	7.9	10.3
Portugal	38.8	66.3	79.3	27.5	13.0
Slovenia	37.0	55.1	68.8	18.1	13.6
South Korea	40.7	81.4	86.4	40.7	5.0
Spain	66.0	80.8	88.0	14.8	7.2
Sweden	81.0	88.0	93.2	6.9	5.2
Switzerland	73.8	73.9	81.4	0.1	7.4
United Kingdom	77.1	83.9	90.2	6.8	6.3
United States	73.6	82.7	89.2	9.1	6.5

Source: Own elaboration based on United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision, Online Edition.

C.9 Unit root tests

Test	Specification	u	ϕ	e	ω	Δu	$\Delta\phi$	Δe	$\Delta\omega$
China									
	None	-1.54	0.97	-1.72*	-0.16	-2.78***	-2.70***	-3.6***	-2.8***
ADF	*C*	-0.61	-1.17	0.19	-2.15	-3.15**	-3.03**	-3.8***	-2.7*
	C & *T*	-2.46	-2.17	1.69	-2.48	-3.48*	-3.45*	-4.4***	-5.4***
	None	-1.30	1.62	-0.33	-0.15	-2.70***	-2.71***	-3.8***	-4.2***
PP	*C*	-0.18	-0.83	-0.84	-1.89	-3.05**	-3.06**	-3.9***	-4.1***
	C & *T*	-3.19	-1.70	0.82	-1.72	-7.99***	-5.87***	-4.6***	-4.1**
	C & *T*: break: *C*	-2.01	-3.84	-3.31	-3.04	-4.67**	-4.90**	-5.5***	-8.4***
Breakpoint	*C* & *T*: break: *T*	-3.92	-3.69	-1.54	-3.74	-5.20**	-5.43***	-13.9***	-9.7***
	C & *T*: break: *C* & *T*	-4.23	-4.22	-3.59	-3.36	-5.35***	-4.48*	-13.6***	-9.5***
India									
	None	-0.84	1.24	0.15	-2.83	-4.68***	-7.57***	-4.0***	-3.9***
ADF	*C*	-0.12	0.19	-1.78	-0.74	-4.74***	-7.90***	-4.0***	-6.7***
	C & *T*	-2.29	-3.25*	-1.36	-1.19	-5.20***	-8.06***	-4.8***	-6.7***
	None	-0.83	1.16	0.29	-2.51*	-4.82***	-7.54***	-4.0***	-6.3***
PP	*C*	-0.12	0.01	-1.90	-0.77	-4.86***	-7.80***	-3.9***	-6.8***
	C & *T*	-2.07	-3.25*	-1.14	-1.61	-5.33***	-8.06***	-4.9***	-6.8***
	C & *T*: break: *C*	-3.43	-2.93	-3.53	-2.56	-5.93***	-12.5***	-5.6***	-8.0***
Breakpoint	*C* & *T*: break: *T*	-3.87	-3.72	-3.29	-2.94	-6.10***	-12.5***	-5.5***	-9.5***
	C & *T*: break: *C* & *T*	-3.57	-3.29	-3.56	-2.67	-6.10***	-9.31***	-5.1***	-7.9***

Notes: ADF: Augmented Dickey-Fuller, PP: Phillips-Perron, Breakpoint: unit root test in the presence of a break. *C*: Constant, *T*: Trend. The null hypothesis is that the variable has a unit root, while the alternative hypothesis is that the variable is stationary. The lag length for the ADF test is based on the Bayesian information criterion. The Barlett kernel is selected as the spectral estimation method with a bandwidth set by the Newey-West procedure for the PP unit root test. Breakpoint unit root tests use innovation outlier as its break type, the Dickey-Fuller mint-t as breakpoint selection, and the Bayesian information criterion is used to select their optimal lag length. Operator Δ before the name of the variables denotes that the variable is expressed in first-differences. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

C.10 Model selection

Country	Lag	LogL	LR	FPE	AIC	BIC	HQ
China	0	-193.6	NA	26.80	14.64	14.83	14.70
	1	-51.2	232.12	0.0023	5.27	6.23	5.56
	2	-15.7	47.38*	0.0006	3.83	5.55*	4.34
	3	5.8	22.21	0.0005*	3.43*	5.92	4.17*
India	0	-417.2	NA	715.66	17.92	18.08	17.98
	1	-183.9	417.05*	0.0691*	8.68*	9.46*	8.97*
	2	-172.7	18.07	0.0862	8.88	10.30	9.41
	3	-157.9	21.49	0.0942	8.93	10.98	9.70

Notes: * Indicates lag order selected by the criterion. LR: sequential modified LR test statistic (each test at a 5% level). FPE: Final prediction error. AIC: Akaike information criterion. BIC: Bayesian information criterion. HQ: Hannan-Quinn information criterion. Endogenous variables: output-capital ratio, top 1% wealth share, employment-population ratio, and the share of labor compensation.

C.11 Johansen cointegration tests

Country	No. of C.E.	Trace		Max. Eigenvalue	
		Statistic	p-value	Statistic	p-value
China	None	50.3733	0.0035	30.9574	0.0051
	At most 1	19.4159	0.1817	11.9124	0.3064
	At most 2	7.5036	0.2778	5.1248	0.4599
	At most 3	2.3788	0.1452	2.3788	0.1452
India	None	52.8911	0.0017	33.6821	0.0019
	At most 1	19.2090	0.1908	10.7912	0.4054
	At most 2	8.4178	0.2061	7.1631	0.2357
	At most 3	1.2547	0.3066	1.2547	0.3066

Notes: The test allows no deterministic trend, and no intercept or trend in the cointegrating equation. Lag interval (in first differences): 1 to 1. "No. of C.E." refers to the hypothesized number of cointegrating equations.

C.12 VECM with u, ϕ, e, and ω as endogenous variables for China

		Dependent variable						
		u		ϕ		e		ω
LR								
	ϕ	0.2150 (0.1778)	u	4.6515*** (0.9186)	u	-1.4393*** (0.2982)	u	-1.6758*** (0.3407)
	e	-0.6948 (0.5785)	e	-3.2318 (2.6788)	ϕ	-0.3094 (0.2672)	ϕ	-0.3603 (0.2444)
	ω	-0.5967*** (0.1886)	ω	-2.7757*** (0.6989)	ω	0.8589*** (0.2583)	e	1.1643 (0.9053)
	trend	-0.3190*** (0.1077)	*trend*	1.4837*** (0.5146)	*trend*	-0.4591*** (0.1872)	*trend*	-0.5345*** (0.1297)
	ECT	-0.3383*** (0.1317)	ECT	-0.0072 (0.0477)	ECT	-0.0243*** (0.0049)	ECT	-0.0837*** (0.1170)
SR								
	Δu_{t-1}	0.2846 (0.1954)	Δu_{t-1}	0.0417 (0.3294)	Δu_{t-1}	-0.0130 (0.0105)	Δu_{t-1}	-0.0091 (0.2911)
	Δu_{t-2}	0.1298 (0.1860)	Δu_{t-2}	0.2729 (0.3134)	Δu_{t-2}	-0.0114 (0.0100)	Δu_{t-2}	0.0326 (0.2770)
	$\Delta \phi_{t-1}$	0.0466 (0.1463)	$\Delta \phi_{t-1}$	0.4334** (0.2465)	$\Delta \phi_{t-1}$	-0.0109 (0.0079)	$\Delta \phi_{t-1}$	-0.2883 (0.2179)
	$\Delta \phi_{t-2}$	-0.0824 (0.1639)	$\Delta \phi_{t-2}$	0.0085 (0.2782)	$\Delta \phi_{t-2}$	-0.0213*** (0.0088)	$\Delta \phi_{t-2}$	-0.1958 (0.2441)
	Δe_{t-1}	-0.1517 (1.7280)	Δe_{t-1}	2.1161 (2.9292)	Δe_{t-1}	1.0222*** (0.0933)	Δe_{t-1}	5.0792** (2.5889)
	Δe_{t-2}	-0.8653 (1.4577)	Δe_{t-2}	-0.2751 (2.4567)	Δe_{t-2}	0.0650 (0.0782)	Δe_{t-2}	-5.4871*** (2.1713)
	$\Delta \omega_{t-1}$	-0.0999 (0.1245)	$\Delta \omega_{t-1}$	0.0337 (0.2098)	$\Delta \omega_{t-1}$	0.0090 (0.0067)	$\Delta \omega_{t-1}$	0.1950 (0.1854)
	$\Delta \omega_{t-2}$	-0.1404 (0.1317)	$\Delta \omega_{t-2}$	-0.0453 (0.2218)	$\Delta \omega_{t-2}$	0.0023*** (0.0071)	$\Delta \omega_{t-2}$	-0.1828 (0.1960)

Notes: LR stands for long run, and SR for short run. Standard error in parenthesis, ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

C.13 VECM with u, ϕ, e, and ω as endogenous variables for India

	Dependent variable							
		u		ϕ		e		ω
LR								
	ϕ	2.8742*** (0.4336)	u	0.3479*** (0.0986)	u	-0.2521*** (0.0910)	u	0.9109*** (0.3877)
	e	-3.9667*** (0.6430)	e	-1.3801*** (0.1137)	ϕ	-0.7246*** (0.0708)	ϕ	2.6180*** (0.6163)
	ω	1.0979*** (0.2969)	ω	0.3820*** (0.1073)	ω	-0.2768*** (0.0672)	e	-3.6131*** (0.6196)
	ECT	-0.0934*** (0.0396)	ECT	-0.3036*** (0.0806)	ECT	-0.0576 (0.0393)	ECT	-0.0221 (0.0350)
SR								
	Δu_{t-1}	0.0919 (0.1823)	Δu_{t-1}	0.1660 (0.1290)	Δu_{t-1}	-0.0151 (0.0455)	Δu_{t-1}	-0.2502* (0.1468)
	Δu_{t-2}	0.4428*** (0.1671)	Δu_{t-2}	0.0338 (0.1183)	Δu_{t-2}	-0.0399 (0.0418)	Δu_{t-2}	0.4683*** (0.1346)
	Δu_{t-3}	-0.0733 (0.1810)	Δu_{t-3}	0.2494*** (0.1281)	Δu_{t-3}	0.0321 (0.0452)	Δu_{t-3}	0.0361 (0.1457)
	$\Delta \phi_{t-1}$	0.0226 (0.2194)	$\Delta \phi_{t-1}$	-0.1511 (0.1553)	$\Delta \phi_{t-1}$	-0.0337 (0.0548)	$\Delta \phi_{t-1}$	-0.0698 (0.1766)
	$\Delta \phi_{t-2}$	-0.2667 (0.2063)	$\Delta \phi_{t-2}$	0.2016 (0.1460)	$\Delta \phi_{t-2}$	-0.0421 (0.0515)	$\Delta \phi_{t-2}$	-0.4917*** (0.1661)
	$\Delta \phi_{t-3}$	-0.0449 (0.2218)	$\Delta \phi_{t-3}$	0.0553 (0.1570)	$\Delta \phi_{t-3}$	-0.0280 (0.0554)	$\Delta \phi_{t-3}$	-0.2970* (0.1786)
	Δe_{t-1}	-0.0300 (0.7164)	Δe_{t-1}	0.4615 (0.5071)	Δe_{t-1}	0.0350* (0.1790)	Δe_{t-1}	-1.3930*** (0.5768)
	Δe_{t-2}	1.2361* (0.7393)	Δe_{t-2}	-0.3630 (0.5233)	Δe_{t-2}	0.2212 (0.1847)	Δe_{t-2}	-1.2244*** (0.5953)
	Δe_{t-3}	0.9218 (0.8759)	Δe_{t-3}	-0.5456 (0.6199)	Δe_{t-3}	-0.0325 (0.2188)	Δe_{t-3}	0.0618 (0.7052)
	$\Delta \omega_{t-1}$	0.3947** (0.2039)	$\Delta \omega_{t-1}$	-0.1217 (0.1443)	$\Delta \omega_{t-1}$	-0.0342 (0.0509)	$\Delta \omega_{t-1}$	-0.0348 (0.1641)
	$\Delta \omega_{t-2}$	0.1210 (0.1725)	$\Delta \omega_{t-2}$	-0.0432 (0.1221)	$\Delta \omega_{t-2}$	-0.0015 (0.0431)	$\Delta \omega_{t-2}$	-0.1108 (0.1389)
	$\Delta \omega_{t-3}$	0.3951*** (0.1497)	$\Delta \omega_{t-3}$	0.1509 (0.1060)	$\Delta \omega_{t-3}$	-0.0144 (0.0374)	$\Delta \omega_{t-3}$	0.3775*** (0.1205)

Notes: LR stands for long run, and SR for short run. Standard error in parenthesis, ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

C.14 VECM residual serial correlation LM tests

Country	Test	Lag	LRE stat.	Prob.	Rao F-stat.	Prob.
China	at lag h	1	12.59	0.7027	0.76	0.7137
		2	11.98	0.7451	0.72	0.7550
	at lags 1 to h	1	12.59	0.7027	0.76	0.7137
		2	32.30	0.4518	0.97	0.5433
India	at lag h	1	9.31	0.9000	0.56	0.9009
		2	6.59	0.9803	0.39	0.9805
		3	23.21	0.1082	1.53	0.1101
	at lags 1 to h	1	9.31	0.9000	0.56	0.9009
		2	23.59	0.8590	0.71	0.8650
		3	44.38	0.6219	0.89	0.6586

Note: Null hypotheses: "No serial correlation at lag h" and "No serial correlation at lags 1 to h."

C.15 VECM residual serial correlation Portmanteau tests

Country	Lags	Q-stat.	Prob.	Adj. Q-stat.	Prob.
China	1	5.73	-	5.95	-
	2	14.43	-	15.35	-
	3	30.19	0.4046	33.08	0.2747
	4	42.39	0.5831	47.40	0.3751
	5	55.71	0.6675	63.74	0.3803
	6	75.03	0.5423	88.58	0.1727
India	1	2.73	-	2.79	-
	2	5.90	-	6.10	-
	3	17.37	-	18.38	-
	4	25.14	0.6201	26.89	0.5244
	5	38.91	0.6890	42.33	0.5432
	6	44.84	0.9277	49.15	0.8402

Note: Null hypotheses: "No serial correlation at lag h" and "No serial correlation at lags 1 to h."

C.16 VECM White heteroskedasticity test (no cross terms)

Country	Chi-square	Degrees of freedom	Prob.
China	191.17	180	0.2708
India	289.40	260	0.1006

Note: Null hypotheses: "No heteroskedasticity."

C.17 VECM residual normality tests

Country	Orthogonalization	Jarque-Bera	Prob.
	Cholesky of covariance	2.25	0.9725
China	Square root of covariance	46.31	0.7918
	Square root of correlation	2.51	0.9613
	Cholesky of covariance	18.55	0.0175
China	Square root of covariance	78.53	0.0203
	Square root of correlation	26.25	0.0010

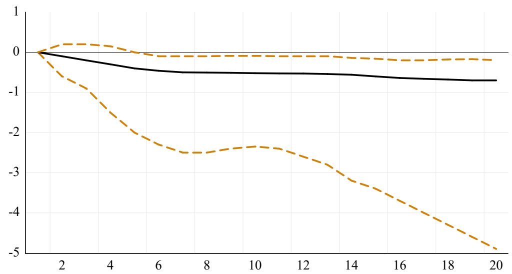
Note: Null hypothesis: "Residuals are multivariate normal."

C.18 Roots of the characteristic polynomial of the VECM

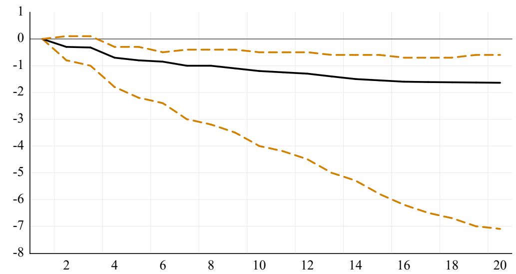
China		India	
Root	Modulus	Root	Modulus
1.0000	1.0000	1.0000	1.0000
1.0000 - 2.01e-15 *i*	1.0000	1.0000	1.0000
1.0000 + 2.01e-15 *i*	1.0000	1.0000	1.0000
0.9592	0.9582	0.7324 - 0.4644 *i*	0.8672
0.7058 - 0.4348 *i*	0.8290	0.7324 + 0.4644 *i*	0.8672
0.7058 + 0.4348 *i*	0.8290	0.8437 - 0.1051 *i*	0.8503
0.4199 - 0.3408 *i*	0.5408	0.8437 + 0.1051 *i*	0.8503
0.4199 + 0.3408 *i*	0.5408	-0.3963 - 0.6970 *i*	0.8017
-0.1127 - 0.4756 *i*	0.4888	-0.3963 + 0.6970 *i*	0.8017
-0.1127 + 0.4756 *i*	0.4888	-0.7056	0.7056
-0.2440 - 0.2165 *i*	0.3262	-0.4886 - 0.4033 *i*	0.6183
-0.2440 + 0.2165 *i*	0.3262	-0.4886 + 0.4033 *i*	0.6183
		0.3188 - 0.5213 *i*	0.6111
		0.3188 + 0.5213 *i*	0.6111
		-0.3100 - 0.2088 *i*	0.3738
		-0.3100 + 0.2088 *i*	0.3738

Note: VECM specification imposes three unit roots.

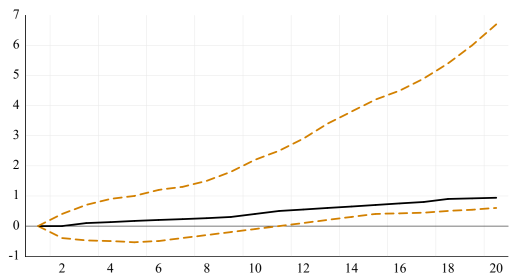
C.19 Responses of u, ϕ, and e to non-factorized negative one-standard deviation innovation in ω using Hall's studentized bootstrap.



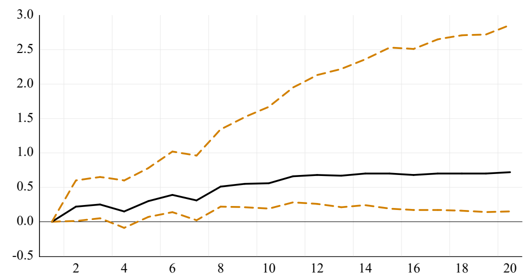
(a) China: response of u



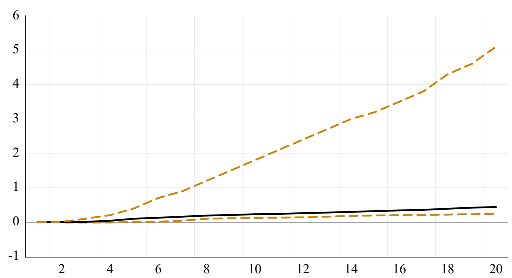
(b) India: response of u



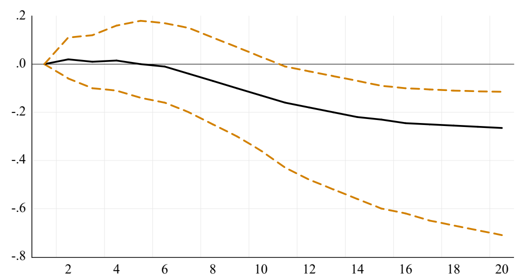
(c) China: response of ϕ



(d) India: response of ϕ



(e) China: response of e



(f) India: response of e

Note: The 95% confidence intervals are calculated using Hall's studentized bootstrap with 1000 bootstrap repetitions and 500 double bootstrap repetitions.