Declining wage share and technological change: a panel VAR approach

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Abstract

The decline in the wage share in the last decades has been reported as a worrisome trend for several advanced and emerging economies. Among the many causes of this global phenomenon, there is an empirical literature proposing that technological innovation plays a role in this process. On the other hand, a relatively less explored and still ambiguous causality is how a declining wage share can impact a country's technological progress and catching up process. Thus, this paper studies the theorized two-sided relationship between the wage share of income and a country's relative technological position. To do so, we first construct a simple model to discuss the possible causality paths involved. Then, we proceed to empirically investigate if there is a simultaneous determination in the relationship between the wage share and a measure of the technological gap for a sample of 131 countries that extends over the period 1995-2017. The investigation is carried out with the panel Vector Autoregressive (VAR) methodology, which is suitable because of its robustness to reverse causality. The paper contributes to the evolutionary technology gap as well as the post-Keynesian approach by showing evidence of a two-way causality between the wage share and the technological catching-up process. The results indicate that increases in relative technological capabilities have a negative effect on the wage share, in accordance with the technology-related explanations of its global decline. However, decreases in the wage share are found to impact the country's technological progress negatively. These results support the hypothesis that the catching up process benefits from a less unequal social structure and hint that the current high inequality and low wage share levels could further change the pattern of technological change, a relevant effect that needs to be further assessed.

Keywords: technology-gap, evolutionary theory, wage share, panel VAR.

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1 Introduction

The decline in the wage share in the last decades has been reported as a worrisome trend for several advanced and emerging economies and, as of late, aggravated by the pandemic (Karabarbounis & Neiman, 2014; Dao, Das, Koczan, & Lian, 2017; Piketty, 2014). Among the many causes of this global phenomenon, some studies highlight the direct role of technological advances and their indirect effects through market concentration.

There is an empirical literature proposing that successful technological innovation at the micro level would confer competitive advantages that increase market concentration and, consequently, decrease labor shares. For instance, Autor, Dorn, Katz, Patterson, and Van Reenen (2020) use micro panel data and gather evidence that the fall of the wage share would be related to the rise of "superstar" firms, the most productive ones. They find that technological change increases market concentration, with sales concentrated in a small number of superstar firms in the industry. Moreover, the industries in which concentration has most risen are found to be the ones with the largest wage share declines.

At the same time, the effect of technological advances on the wage share could also be positive, at least at the macro level. From a balance-of-payments constrained growth framework, technological progress and product diversification increase the economic growth rate, consequently increasing the employment rate. Such an increase confers higher bargaining power to workers, resulting in a higher wage share (Dávila-Fernández, 2020; Nishi, 2019).

On the other hand, a relatively less empirically explored and still ambiguous causality is how a declining wage share can impact a country's technological progress. For instance, from an evolutionary point of view, the technological catching-up process depends on social characteristics. Thus, lower inequality and higher wage shares can be conducive to successful innovation and catching up by fostering and reinforcing existing institutions and human capital formation (Abramovitz, 1986; Castellacci, 2007).

Furthermore, there is also a nexus very present in alternative growth theories, like in the classical-Marxian approach to technological change. According to this approach, a higher wage share at the macro level is perceived as higher unit costs by the firms at the micro level, which creates an incentive for labor-saving technological innovation that translates into higher productivity growth (Dávila-Fernández, 2020; Tavani & Zamparelli, 2021).

However, increases in the wage-share, by increasing workers' bargaining power, could reduce ex-ante market power. For firms, market power would ensure barriers to entry, making it easier to prevent imitation and confer internal resources to the technological catching-up process, as claimed by Schumpeter (1942). Less market power could then slow down technological advances. Using markups, either as a measure of market power or market concentration, some empirical works have found a non-monotonical relationship with innovation - with innovation being positively related to markups at lower levels of markup and inversely related at higher levels (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005; Diez, Leigh, & Tambunlertchai, 2018; IMF, 2019). This ambiguity persists as there are only a few studies on how income distribution can affect technical change and even fewer that addressed the two sides of this relationship simultaneously.

Within the evolutionary tradition of studies on technological change, one of the most important macro-oriented approaches is the technology gap one. This approach focuses on technological differences between countries, highlighting the process of catching up to the leader through innovation and international diffusion of technology, and how a country's position and path in the technological race can impact its domestic dynamics in terms of trade and growth (Abramovitz, 1986; Castellacci, 2007). We propose that the relative technological position of a country could also be related to distributional dynamics, as growth and distribution are intrinsically linked (Lavoie, 2014). This focus is also motivated by the empirical trends aforementioned. In particular, considering that diffusion within industries has declined in the last decades (D. Andrews, Criscuolo, & Gal, 2015; Akcigit & Ates, 2019), this may have also harmed technological diffusion between countries.

Therefore, this paper aims to study the theorized two-sided relationship between the wage share of income and a country's relative technological position. To do so, we first construct a simple model to discuss the possible causality paths involved. Then, we proceed to investigate empirically if there is a simultaneous determination in the relationship between the wage share and a measure of the technological gap for a sample of 131 countries that extends over the period 1995-2017. We perform a cross-country empirical analysis with relative technological capabilities being proxied by a productivity ratio between the domestic countries' labor productivity and the one from the technological frontier, following the evolutionary technology-gap approach. The investigation is carried out with the panel Vector Autoregressive (VAR) methodology, which is suitable because of its robustness to reverse causality. (Abramovitz, 1986; Castellacci, 2007; Porcile, Dutra, & Meirelles, 2007).

These aggregate measures have the disadvantage of being less precise than the ones at the firm or industry level, possibly concealing heterogeneities and composition effects. Still, country-level analyses fit into the evolutionary tradition in a useful way, presenting general empirical findings, which may then inspire and motivate micro-level work. Here we aim to contribute to the evolutionary technology-gap literature, which traditionally is concerned with modeling and investigating aggregate macroeconomic phenomena and regularities.

The results indicate that advances in the catching-up process have a negative effect on the wage share, in accordance with the technology-related explanations of the global decline of wage shares. However, decreases in the wage share are found to impact the country's technological progress negatively. These results support the cost-oriented productivity growth approach and also the hypothesis that the process of catching up benefits from a less unequal social structure. They hint that the current high inequality and low wage share levels could further change the pattern of technological change, a relevant effect that needs to be further assessed.

The paper is structured as follows. Section 2 elaborates on the causality paths concerning technological gaps and income distribution through a simple dynamical model. Section 3 describes the empirical strategy adopted in the paper, which includes the data and the estimation method. Section 4 presents and discusses the results. Finally, section 5 concludes.

2 A theoretical model of income distribution and technological progress

In this model, we deal with two economies: the technological laggard and the leader. However, our focus will be on the domestic dynamics of the laggard country, especially how they are affected by its position in relation to the leader. This economy has no government and produces a single good used for consumption and investment. Production is carried out by combining homogeneous capital and labor as the only two factors of production through a fixed-coefficient technology.

In both countries, total income Y is distributed between two classes, workers and capitalists:

$$Y = \frac{w}{P}L + rK\,, \tag{1}$$

where w is the nominal wage, P is the price level, L is employment, K is the capital stock, and r is the profit rate. Thus, from equation (1), the wage share σ of laggard country i is defined as:

$$\sigma_i = \frac{w_i L_i}{P_i Y_i} = \frac{w_i}{P_i a_i} \tag{2}$$

where and $a_i = Y_i/L_i$ is labor productivity.

Taking ω for the real wage $\omega_i = w_i/P_i$, the wage share of country i is simplified as

$$\sigma_i = \frac{\omega_i}{a_i}\,. \tag{3}$$

The relative technological capabilities of country i are defined as the ratio between the productivity of country i and the one from the frontier, being the leader country designated by j:

$$T_i = \frac{a_i}{a_j}\,. \tag{4}$$

The higher the ratio, the closer country i is to the frontier represented by j. In the technological race, country j is the leader to which country i needs to catch up on technological capabilities and innovation activity to reach a competitive place in the global system (Abramovitz, 1986). To do so, the aim of country i is to at least converge to the technological evolution stage of the leader (Fagerberg & Verspagen, 2002).

Following (4), we look into the (long-run) evolution of the technological catching up of country i through its differential equation, which is

$$\hat{T}_i = \hat{a}_i - \hat{a}_j = f_i(\sigma_i, g_i, T_i) - f_j(\sigma_j, g_j)\,, \tag{5}$$

where $g_{i,j}$ is the accumulation rate. According to this definition, the productivity growth of each country has similar, although not identical, determinants. For country i, the level of relative technological capabilities influences how it progresses, as its position in the technological race is relevant to catching up. If this level is too small, meaning that country i is far from the leader, the laggard has, on the one hand, more accumulated global technology to imitate, which could make its catching up easier. On the other hand, this backward position could imply the lack of essential institutional and social aspects that make productivity growth harder (Gerschenkron, 2015). Since country j is the leader, this falling behind narrative does not apply to it.

Productivity growth in both countries is made to depend on the level of each country's wage share. Following the evolutionary approach, a higher wage share could indicate that the institutional and social characteristics of the country are crucial to its ability to imitate and absorb new technologies or innovate (Abramovitz, 1986). Moreover, it could also imply higher unit costs, which the firms at the micro level will take as an incentive for technological innovation, which translates into higher productivity growth. This is the standard classical-Marxian approach, and Dávila-Fernández (2020) has recently presented empirical support to this argument, showing that the causality channel is through labor.

However, as the technological-gap approach brings the Schumpeterian competition mechanism to the macro level, higher wage shares could imply less capitalist power, which would possibly favor successful innovation. Note that in the case of the leader, this causality seems more adequate, as with such power it becomes easier to prevent imitation. Thus, the wage share of each country could affect the technological gap in different directions.

Finally, we add a Kaldor-Verdoorn channel according to which the accumulation rate determines the evolution of productivity by being a mechanism to incorporate new capital and a demand incentive (McCombie, 2002). For the limited purposes of this model, we take the wage share and accumulation rate of the leader j, respectively σ_j and g_j, as exogenous.

Following the technology-gap approach related to the evolutionary tradition, it is worth highlighting that it concerns itself with how a country positions itself in the technological race and how this position can impact its domestic dynamics, usually trade or growth (Castellacci, 2007; Abramovitz, 1986). Moreover, following a post-Keynesian inspired approach, growth and distribution are intrinsically linked, so we should expect that technology and distribution should also have a joint evolution (Lavoie, 2014). For this reason, we look into the wage share dynamics, as it follows from its definition (3):

$$\hat{\sigma}_i = \hat{\omega}_i - \hat{a}_i \,, \tag{6}$$

with $\hat{a}_i = F(\sigma_i, g_i, T_i)$, as previously discussed. Concerning the evolution of the real wage, it depends positively on employment, as a higher employment rate increases the workers' bargaining power to seek further wage hikes. Employment in i, in turn, relates to the technological catch-up of country i negatively. The idea is that the closer laggard economy i approaches the leader j, the more it adopts labor-saving technologies and, therefore, the lower the employment rate (higher structural unemployment). Thus, we have the following composite function h for the evolution of the real wage:

$$\hat{\omega}_i = h(e(T)) \,, \tag{7}$$

where e is the employment rate.

As a result, equations (5) and (6) implicitly form the following dynamical system:

$$\hat{T}_i = F(\sigma_i, T_i) \,, \tag{8}$$

$$\hat{\sigma}_i = G(\sigma_i, T_i) \,. \tag{9}$$

To further analyze this system, we take its four partial derivatives:

$$\frac{\partial \hat{T}_i}{\partial \sigma_i} = \frac{\partial f_i}{\partial \sigma_i} \,, \tag{10}$$

$$\frac{\partial \hat{T}_i}{\partial T_i} = \frac{\partial f_i}{\partial T_i} \,, \tag{11}$$

$$\frac{\partial \hat{\sigma}_i}{\sigma_i} = -\frac{\partial f_i}{\partial \sigma_i} \,, \tag{12}$$

$$\frac{\partial \hat{\sigma}_i}{\partial T_i} = \frac{\partial h}{\partial T_i} - \frac{\partial f_i}{\partial T_i} \,. \tag{13}$$

By doing so, we notice that all four derivatives are ambiguous. As discussed, our main ambiguity of interest is represented by derivative (10), as we seek to explore how the wage share could impact the catching-up process. The wage share could either have a positive or negative impact, depending on how the interplay of social forces works in relation to technology. The level of the productivity ratio, in turn, can impact its growth rate either positively or negatively as well, depending on the resources it acquired to that position in the technological race and how they influence this same position. Moreover, the level of the wage share can impact its growth rate negatively, slowing it down because at a higher level it becomes harder to obtain subsequent increases in wage shares, or it could accelerate its growth, through the exertion of the higher bargaining power. Finally, the effect of technological capabilities on the growth of the wage share depends on whether its depressing effect on the employment rate is reinforced or counterbalanced by its effect on productivity. In the next section, we hope to shed some light on these ambiguities as we move to the empirical investigation.

3 Empirical Investigation

3.1 Data description

To conduct the empirical assessment proposed here, data from the Penn World Table 9.1 was used to measure both relative technological capabilities and wage share.[3] The sample used comprises data for 131 countries, as listed in Table 6 of the Appendix (A), over the period 1995-2017. The period was chosen according to data availability but it also coincides with the decades identified with declining wage shares.

Technological capabilities are proxied by labor productivity, as countries with higher productivity are the ones with higher technological stocks and innovative capacity. Yet, as in this paper we aim to contribute to the evolutionary technology-gap approach, we thus use a relative measure of technological capabilities that looks at the position of each country in relation to the technological frontier in the sample. This relative position is obtained through a "technological capabilities ratio", measured by the ratio of each country's labor productivity to each year's highest labor productivity level, which indicates where the sample frontier is at that year. Therefore, the higher this productivity ratio, the closer the country is to the technological frontier, and the higher the relative technological capabilities of a country. Regarding the wage share, Feenstra et al. (2015) explain the calculations to reach the values of the Penn World Table. Moreover, we estimate two models, the first without controls and in the second we add export growth as a control variable to account for supply-side and exogenous factors that may affect a country's catching up and wage share.

In both models, we employ all variables in levels, not logs, and a further description of their calculations and sources is detailed in Table 7 in Appendix A. Table 1 shows descriptive statistics for relative technological capabilities, wage share, and export growth. All values are within the expected range.

3.2 Estimation strategy

The motivation to apply a Vector Autoregressive (VAR) estimation in this study stems from the theoretical proposition of a two-way causal relationship between wage share and relative technological capabilities, although the direction of these effects remains undetermined. Therefore, we extend the usual single equation panel data investigation moving to a VAR estimation with a system of equations. The VAR deals with the issues

3 See Feenstra, Inklaar, and Timmer (2015) for more information on the Penn World Table database and the specificities of the particular 9.1 version.

Table 1 – Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Relative technological capabilities	786	0.278	0.229	0.00843	1
Wage share	786	0.511	0.126	0.135	0.880
Export growth	655	0.369	0.757	-0.809	14.20

Source: Author's elaboration.

of simultaneity and endogeneity that arise due to ambiguous causality direction, which affects the relationship between the variables.

The VAR methodology was first proposed by Sims (1980) to model the long-run dynamic relationship between two variables. The application of this methodology to panel data was introduced by Holtz-Eakin, Newey, and Rosen (1988). In our case, this regression method conveys that the evolution of relative technological capabilities is explained by its lagged values and the lagged values of the wage share, the same being true for the evolution of the wage share, controlled for changes in export growth in the second model. Taking Y_{it} as the $(1 \times m)$ vector of the m endogenous variables - and here $m = 2$, with our endogenous variables being relative technological capabilities and wage share -, the specification of an autoregressive model of order $p = 1$, that is, with one lag of each variable, is the following:

$$Y_{it} = a_1 Y_{it-1} + a_2 X_{it} + f_i + \varepsilon_{it} \, , \qquad (14)$$

where X_{it} is a $(l \times 1)$ vector of l control variables, a_1 and a_2 are respectively the (2×2) and $(2 \times l)$ matrix of parameters to be estimated, while both f_i, which represents country-specific fixed-effects, and ε_{it}, idiosyncratic errors, are (1×2) matrices.

Regarding the econometric issues involved in estimating the parameters of the system (14), to deal with unobserved fixed country-specific characteristics the estimation could be carried out with a fixed effects estimation or ordinary least squares (after removing the fixed effects by taking the first difference version of the equations). However, these methods would lead to biased estimates since the lagged dependent variables acting as explanatory and the reverse causality involved create endogeneity. Thus, the estimation is carried out with difference GMM (Holtz-Eakin et al., 1988; Arellano & Bond, 1991), which provides consistent estimates in fixed T large N settings. The difference GMM approach estimates the model in first difference using as instruments lagged observations in levels of the explanatory variables (Anderson & Hsiao, 1982).

In using a GMM estimator, the validity of the instruments needs to be verified. This validity depends on instruments being correlated with the endogenous explanatory variables, while exogenous to the error term. Here we assess this property by performing Hansen's J Test of joint validity of instruments in overidentified regressions. Furthermore,

Table 2 – Panel unit root test

	P-value	
	Level	1st diff
Relative technological capabilities	0.0000	0.0000
Wage share	0.5068	0.0000
Export growth	0.0000	0.0000

Notes: The null hypothesis is that all countries' series contain a unit root.
Source: Author's elaboration.

the GMM estimator also requires a panel with a relatively small time dimension to provide consistent estimates. A larger time dimension leads to more moment conditions to be fulfilled and thus demands more instruments. However, too many instruments can, in turn, lead to instrument proliferation, which can overfit the endogenous variables and bias the estimates (Roodman, 2009). We avoid these issues, firstly, with the reduction of the time dimension of the panel by taking four-year averages, which yields a final dimension of six time periods and 131 units. Secondly, we restrict the lag range of the instruments. The results of Hansen's J test and the number of lags used as instruments are reported along with the results.

The model specification is defined following a three-step procedure. First, since for the VAR methodology the variables need to be stationary, we proceed to verify this property in the aforementioned variables with the Harris-Tzavalis unit root test for panel data, which is adequate for fixed/small T large N panels (Harris & Tzavalis, 1999). As Table 2 shows, we can consider in this specification that the technological capabilities variable is stationary, while the wage share is stationary in first difference. We then estimate the models with the level of relative technological capability and the first difference of wage share and export growth. [4].

The second step is to choose the optimal number of lags to be included in the VAR model specification. From D. W. Andrews and Lu (2001)'s moment model selection criteria (MMSC), the Bayesian and quasi-likelihood information criteria suggest that the number of lags that minimizes the statistic is one. Therefore, the model is specified as an autoregressive model of order one, so that one lag of each endogenous variable is included in the estimation. The third and final step is to assure that the specification satisfies the stability condition, which implies the invertibility of the panel VAR so that it can be represented by an infinite-order vector moving average, necessary to correctly interpret the impulse-response functions that will be estimated. We conclude that our panel VAR specification is stable, as will be detailed alongside the presentation of the results, allowing us to present and interpret the impulse-response functions. We also explore in

[4] Yet, we opted for the first difference of export growth because of a non-stationary trend unit root test in levels. Using the first-difference guarantees its stationary property

this study whether any of the variables would precede the other, or even if there is a case of bi-directional causality between them, with the Granger causality test developed by Granger (1969). Nonetheless, we must reinforce that this investigated causality is different from identifying an endogenous causality. The Granger-causality running from w_{it} to z_{it} conveys only that relevant information to predict the variable z_{it} is given by w_{it} so that the prediction of the former variable, after controlling for its past values, is improved when considering lags of the latter.

The empirical investigation is concluded with the estimation of impulse-response functions to assess the impact of shocks to the endogenous variables on one another. The impulse-response functions describe the evolution of our variables along a determined time frame after a shock. To find this response, we start with the infinite vector moving average representation of the panel VAR, assuming away the exogenous vector, which is given by

$$Y_{it} = (I - a)^{-1}\bar{Y}_i + \sum_{j=0}^{\infty} a^j \varepsilon_{it-j} \, , \tag{15}$$

where I is a (2×2) identity matrix and $\bar{Y}_i$ is the stacked average of Y_{it}. The impulses are shocks on the sth component of ε_{it-j} and we look for the reaction of the dependent variable to the shock. Thus, from equation (15), we calculate the following derivative:

$$\frac{\partial Y_{it+j}}{\partial(\epsilon_{it})_s} = a^j e_s \, , \tag{16}$$

where e_s is a (2×1) vector with the number one in the sth column and zero otherwise. Equation (16) provides the response of variable Y_i in the period $t + j$ to a shock in period t. The impulse response function plots equation (16) for all $j = 0, \ldots, h$, with h being the previously defined time frame.

4 Results

Table 3 reports the results of the panel VAR estimation following the specification described in the last section. The results of both models show that, on the one hand, lagged observations of both relative technology capabilities and wage share have significant effects on current wage share, with the former effect being negative and the latter positive. This result indicates that increases in the level of a country's technological capabilities, catching up to the frontier, lead to future decreases in the wage share. Thus, the empirical and theoretical view that successful technological innovation contributes to decreasing wage shares is corroborated (Autor et al., 2020). This could happen through technological-induced gains in firms' market power or a reorientation to labor-saving technologies that diminish worker power, ceteris paribus. Furthermore, higher wage shares would, in turn, increase future wage shares. A higher wage share confers more bargaining power to workers, which allows them to obtain further wage hikes, which in turn increases again the wage share.

Meanwhile, the level of technological capabilities is positively impacted by both its past values and the wage share. This result supports the argument that higher wage shares contribute to creating an adequate environment to innovate and/or that they work as a cost incentive for firms to invest more in technology, following the classical-Marxian argument. Yet, this result does not support that an increase in market power related to lower labor power would affect technology, at least not at the macro level and in this very broad sample of countries, which gives evidence against the hypothesis that only large and profitable firms with high market shares would innovate. The process of investing and succeeding in innovation seems to depend on other factors, for instance, the social and institutional setting that compose the country's National System of Innovations (Nelson, 1993). However, the expectation of future increases in the markup could still affect national firms' innovative behavior, which would corroborate that firms look for profit increases coming from successful innovations (Schumpeter, 1934).

The results presented in Table 3 are corroborated by the verification of the adequacy of the model's specification. First, the result of Hansen's J test suggests that the instruments are valid, which gives evidence in favor of the GMM estimation strategy. Second, the stability of the model is assessed with the system's matrix of eigenvalues reported in Table 4. The moduli are all within the unit circle, that is, smaller than one, indicating that the panel VAR model is stable.

Table 3 – Panel VAR estimates of the relationship between the relative technological capabilities and income distribution

	(1)		(2)	
	Relative technological capabilities	Wage Share	Relative technological capabilities	Wage Share
Relative technological capabilities, lagged	.2646935 ***	-.1247696 ***	.2514449 ***	-.1078499 ***
	(.0811395)	(.0337401)	(.0808582)	(.0326558)
Wage Share, lagged	.176023 **	.2037526 **	.1797146 **	.210635 **
	(.0849603)	(.0828176)	(.0865396)	(.0841564)
Export growth			.0057897 **	-.0061967 ***
			(.002306)	(.0021895)
Observations	393		393	
Lags of instruments	1-3		1-3	
Hansen's J test	0.147		0.128	

Note: Standard errors between parenthesis. The Hansen's J test has the null that the instruments are valid, the value reported is the p-value. Significance: ***=1%; **=5%; *=10%.
Source: Author's elaboration.

Table 4 – Eigenvalue stability condition

(1) - Eigenvalue			(2) - Eigenvalue		
Real	Imaginary	Modulus	Real	Imaginary	Modulus
.234223	-.1450306	.2754892	.2310399	-.1377165	.2689708
.234223	.1450306	.2754892	.2310399	.1377165	.2689708

Source: Author's elaboration.

This empirical investigation using the VAR methodology is complemented with the assessment of precedence or simultaneity relationships between wage share and relative technological capabilities, which is done using the Granger causality test. Table 5 reports the test statistics. According to these results, the test mostly corroborates the relation observed at the estimation with the panel VAR model. The test rejects the null hypothesis that relative technological capabilities do not Granger-causes wage share at 1% significance level and the null that wage share does not Granger-causes relative technological capabilities at 5%. The causality, therefore, seems to run both ways. This once more indicates that drivers of the process of technological change and subsequent increases in productivity need to be further assessed.

Finally, since we ensured that the panel VAR model is stable, we can calculate impulse-response functions. These functions illustrate the response of the variables to shocks in themselves and the other variables. The 95% confidence interval is calculated after 500 Monte Carlo draws. The Cholesky decomposition endogeneity order of the variables is set to relative technological capabilities and wage share, following the Granger-causality test results.

The impulse-response functions are presented in Figure 1. The top right graph shows that a positive shock on the wage share affects relative technological capabilities positively in the first period, as expected, but the catch-up indicator gradually returns to its initial level. Moreover, from the bottom left graph, a positive technological shock reduces the wage share at first, but this reduction does not last long and begins to disappear already in the second period.

In sum, this set of results indicates that, on the one hand, technological advances of an economy in relation to the technological frontier impact income distribution, negatively affecting the wage share of income. On the other hand, increases in wage share have a positive impact on a country's relative technological position. As shown in Figure 1, at first this impact is positive, either due to firms trying to overcome the higher labor costs with labor-saving technologies or due to positive feedback associated with the innovation environment. However, this effect is dissipated as soon as other countries imitate and catch up with the new technology through spillovers and technological diffusion so that this advantage eventually fades away.

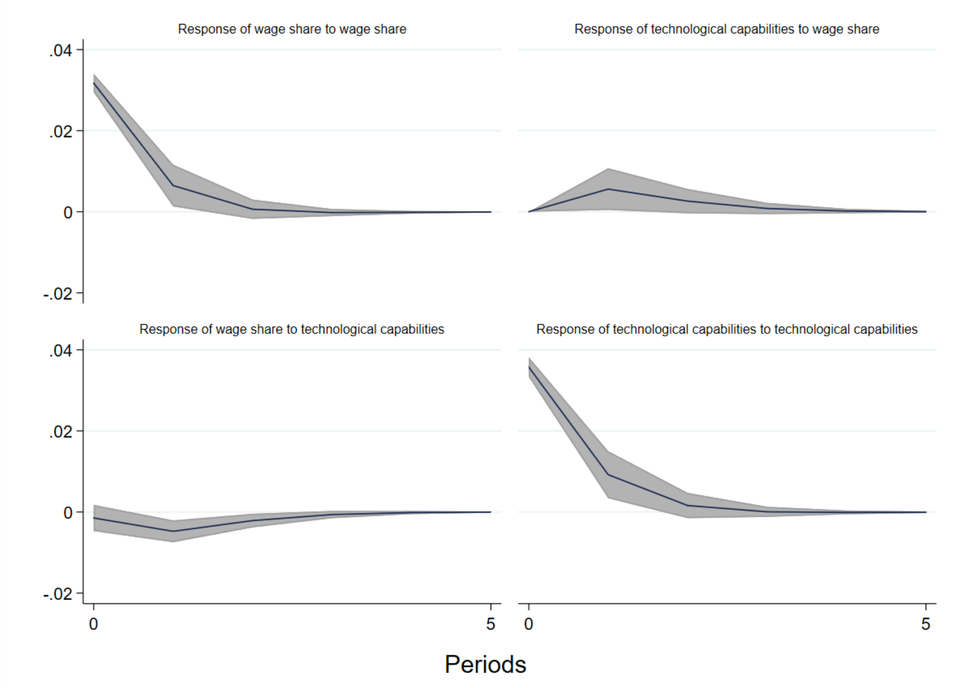
Table 5 – Granger causality test

		(1)			(2)	
Null hypothesis	χ^2	d.f.	p-value	χ^2	d.f.	p-value
Wage share does not Granger-cause Technological capabilities	1.287	1	0.038	4.313	1	0.038
Technological capabilities do not Granger-cause Wage share	13.675	1	0.000	10.907	1	0.001

Note: d.f. denotes degrees of freedom.

Source: Author's elaboration.

Figure 1 – Impulse response function



Note: The 95% confidence interval was estimated with 1000 Monte Carlo simulation draws.
Source: Author's elaboration

5 Concluding Remarks

This paper contributes to the macroeconomic econometric literature concerned with investigating the technological gaps between economies and how recent changes in technology as related to trends such as the declining wage share. In this paper, we explored the relationship between a country's wage shares and relative technological position, given the recent increase in wage share across many countries. Our empirical strategy encompasses the possibility of a simultaneous determination between these variables through a panel VAR estimation. This estimation is carried out with country-level data for 131 countries over the period 1995-2017. We find a two-way causality between our technological catch-up variable and wage share. The results indicate that relative technological capabilities measured by a productivity ratio are positively influenced by wage shares. Moreover, we confirm that technological innovation does lead to lower wage shares, while increases in previous wage shares would increase current ones.

These results suggest, first, that the prospect of either reducing labor costs with new technology or gaining market power to escape competition with successful innovation is reinforced by the evidence indicating that technological capabilities lead to lower wage shares. Second, the reported results imply that the wage share also plays a part in the catching-up process. Thus, the discussion around how to promote technological advances to go ahead in the race to the technological top could also be benefited from incorporating distributional concerns. Even if this is an effect related to firms' cost analysis or if it is positive reinforcement from social and institutional settings related to the National System of Innovation of a country, conducive to national scientific and technological innovation to take place, these distributional effects need to be further assessed. Within the current global context of falling wage shares, this is a worrying effect, and as such should also be included in public policy debates.

The implications for future investigations relate mostly to the measurement imperfections in this paper's analysis. These measurement caveats relate to how the average measures cover heterogeneities between sectors and firms that need to be taken into account. For instance, although some previous analyses have focused on specific sectors, a technologically sensitive division that differentiates levels of technological development, not only productivity levels, between sectors could contribute to describing if technological catching up manifests differently according to the sector. Hence, there are ways to extend the investigation of the relevant issues addressed by this paper, which already provide a guide for future studies.

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A Data specifications

Table 6 – List of Countries

Angola	Côte d'Ivoire	Kyrgyzstan	Romania
Argentina	Denmark	Lao People's DR	Russian Federation
Armenia	Djibouti	Latvia	Rwanda
Australia	Dominican Republic	Lebanon	Sao Tome and Principe
Austria	Ecuador	Lesotho	Saudi Arabia
Azerbaijan	Egypt	Lithuania	Senegal
Bahamas	Estonia	Luxembourg	Serbia
Bahrain	Eswatini	Malaysia	Sierra Leone
Barbados	Fiji	Malta	Singapore
Belarus	Finland	Mauritania	Slovakia
Belgium	France	Mauritius	South Africa
Benin	Gabon	Mexico	Spain
Bolivia	Georgia	Mongolia	Sri Lanka
Bosnia and Herzegovina	Germany	Morocco	Sudan
Botswana	Greece	Mozambique	Suriname
Brazil	Guatemala	Namibia	Sweden
Bulgaria	Guinea	Netherlands	Switzerland
Burkina Faso	Honduras	New Zealand	Taiwan
Burundi	Hungary	Nicaragua	Tajikistan
Cabo Verde	Iceland	Niger	Thailand
Cameroon	India	Nigeria	Togo
Canada	Indonesia	North Macedonia	Trinidad and Tobago
Central African Republic	Iran	Norway	Tunisia
Chad	Iraq	Oman	Turkey
Chile	Ireland	Panama	U.R. of Tanzania
China	Israel	Paraguay	Ukraine
China, Hong Kong SAR	Italy	Peru	United Kingdom
China, Macao SAR	Jamaica	Philippines	United States
Colombia	Japan	Poland	Uruguay
Costa Rica	Jordan	Portugal	Venezuela
Croatia	Kazakhstan	Qatar	Zimbabwe
Cyprus	Kenya	Republic of Korea	
Czech Republic	Kuwait	Republic of Moldova	

Source: Authors' elaboration.

Table 7 – Definitions and sources of variables

Variable	Definition	Source
Wage share (σ)	Share of labor compensation in GDP at current national prices (labsh)	PWT
Output	Expenditure-side real GDP at chained PPPs (in mil. 2011US$) (rgdpe)	PWT
Labor supply	Number of persons engaged (in millions) (emp)	PWT
Labor productivity (Lprod)	Output/labor supply	Authors' calculations
Technological capabilities	$Lprod_{it}/max(Lprod_t)$	Author's calculations
Export share	Share of merchandise exports at current PPPS	PWT
Exports	Output x export share	Authors' calculations
Export growth	Rate of growth of exports	Authors' calculations

Source: Authors' elaboration.