

FIVE ESSAYS ON STRUCTURAL CHANGE AND ECONOMIC DYNAMICS

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Preface and Introduction

In my view economies are so impossible complex as to defy any completely satisfactory analysis: rather the best that can be hoped for is a number of different approaches, each of which yields valuable but incomplete insights into the various aspects of the system. Richard M. Goodwin, 1983, p. vi.

I “discovered” R. Goodwin during my first year of Master studies back in 2014. If I am not mistaken, I was in São Paulo participating in the Annual Conference of the Brazilian Keynesian Association. The first key speaker was Nelson Barbosa, who gave a lecture on “Growth and Income Distribution” and at some point mentioned his paper co-authored with Lance Taylor on “Goodwin cycles”. That was also the first time I saw professor Lionello Punzo, who attended the event as special guest. Personally, Goodwin became the main reason behind my decision of applying to the PhD program in Economics of the Tuscan Universities. Foremost, his life-work also motivates the structure of this thesis.

How to obtain growth and fluctuations in a framework where structural change is endogenous and a natural dynamic property of the system was Goodwin’s life-long research program (Punzo, 2006). This led him very early on to his profound insight that the trend and cycle are indissolubly fused (Harcourt, 2015). However, to represent a changing structure requires to present a change in the very mathematical model that generates the expected dynamics. The bridge between structure and dynamics was built investigating stable multi-sectoral production systems in which Input-Output (IO) tables provided an approximate description of the very property defining complex economic systems interdependence between its component parts (Velupillai, 1998; Punzo, 2006).

Despite the fact that both his aggregate non-linear and multi-sectoral linear contributions were developed in parallel, they belong to a unique theoretical project in which equilibrium is irrelevant from a predictive point of view and there are multiple paths or trajectories depending upon the values of the involved parameters. Likewise, this dissertation is divided in two parts.

In Part I, we investigate, from a multi-sectoral perspective, one of the most important processes of structural change of the last fifty years, namely, the increase in relative importance of the financial sector, or *financialisation*. The term financialisation remains an unclear concept in social science. It has been interpreted in varying ways over the years, resulting in different research strands across a range of academic disciplines. From a multi-sectoral perspective, the financial sector is particularly important because it connects the entire productive structure

through financial intermediation. Therefore, understanding how those interdependencies differ across sectors and time is important to a better comprehension of the financialisation process itself.

Following the recent contributions of [Krippner \(2005\)](#) and [van der Zwan \(2014\)](#), one can differentiate between four main approaches to financialisation. On the one hand, there is a traditional perspective on long-term economic change concerned with what is produced in the economy. On the other hand, financialisation can be treated as a regime of accumulation of its own in which profits accrue primarily through financial channels. A third approach examines the role of shareholder value orientation as a guiding principle of corporate behaviour. Finally, a last group of scholars has adopted a cultural perspective, emphasising the encroachment of finance into the realms of everyday life.

To the extent that we investigate financialisation through the lens of IO tables and interpret the latter as reflecting the technology available and used at a certain moment by a certain economy, our contribution could be situated among the first group. We do not claim that our approach is more fundamental or superior to the existing ones. I think it is quite clear that how we conceptualise structural change in the economy depends on one's theoretical purpose. While there are still many questions left unanswered, we aim to provide a fresh starting point to an intensively studied topic.

Hence, we open chapter 1 with a multi-sectoral assessment of financialisation based on IO analysis. Although methods focusing on the disaggregation of IO tables have been largely explored, they have received limited attention in the literature on financialisation. Our main innovation consists in conceptualising financialisation as *an increase in the financial content in monetary terms of each unit of output produced*. This way, we are able to investigate changes in relative importance of financial activities considering interactions among sectors. Using a 15 and 14-sector level of aggregation, we study the United States (US)' and Brazilian's experiences for the period 1947-2015 and 1995-2011, respectively. We aim to refocus on multi-sectoral issues by offering a simple structure of analysis and providing integrated financial information at the sectoral level in order to assess the interconnections between real and financial sides of the economy.

One of the potential implications of understanding financialisation in terms of financial content per unit of output is investigated in chapter 2. In recent decades, advanced countries have undertaken a process of industrial transformation and structural change characterised by an increasing importance of service sectors and a declining weight of manufacturing activities. Furthermore, several studies have reported a reduction in manufacture technical coefficients for developed economies. The US, in particular, has experienced after WWII a process of structural change that combines financialisation with a reduction in manufacture content of production.

We argue that the two phenomenon are related. It is our purpose to identify the nature of such correspondence. Using a 15-sector level of aggregation, we study the evolution of manufacture technical coefficients in the US between 1947 and 2015. We proceed applying cointegration techniques to the relation between a single aggregate measure of manufacture and financial content. Finally, building on Autoregressive Distributed Lag (ARDL) modelling,

Pooled Mean-Group (PMG) estimation methods are used to confront disaggregate series in a heterogeneous panel. Overall results indicate that there is a long-run relationship between both series and that causality goes from financialisation to manufacture content.

Economics and related fields also often distinguish between quantities that are stocks and those that are flows. Chapter 3 closes the first part of the thesis looking to financialisation in terms of this dichotomy and its relationship with the recent increase of income inequality. For the purposes of this chapter, financialisation is understood as a two-fold process characterised by (i) an increase in the contribution of the financial sector in terms of the composition of production, and (ii) an increase in importance of finance in terms of the composition of wealth.

Taking again the United States as referential point and applying cointegrating techniques, the essay brings some news insights to the correspondence between income distribution and financialisation between 1947 and 2013. We identify a positive long-run relationship between the variables. At least in what concerns the traditional Gini index, causality goes from the flow dimension of financialisation to inequality and from inequality to the stock dimension. However, when directly confronting both sides of the financialisation process the latter causes the former.

Part II corresponds to a return to Goodwin himself, and more specifically, to the growth cycle approach put forward in his well known 1967 paper. Last year, [Goodwin's \(1967\)](#) distributive cycle model reached its fiftieth anniversary. In spite of its vintage, the model continues to be a fruitful and powerful “system for doing macrodynamics”. Over the past decades, more than one hundred contributions have tried to generalise its formulation in all possible directions. It must be noted, however, that with the exception of the high-dimensional Keynes-Metzler-Goodwin (KMG) system developed by Chiarella and collaborators most existing efforts have been based on a closed economy set up.

When studying distributive dynamics in open economies, a particularly important problem arises that has not been discussed in the KGM literature and that we consider deserves a careful analysis. The reason for this is that one of the most influential empirical regularities in the Kaldorian growth literature – namely, Thirlwall's law – states that, in the long-run, growth is subject to the balance-of-payments constraint (BoPC). Given that countries cannot systematically finance increasing balance-of-payments imbalances it implies that there is an adjustment in aggregate demand that constrains growth ([Thirlwall, 1979](#)).

Hence, in collaboration with Professor Serena Sordi, chapter 4 expands [Goodwin's \(1967\)](#) model to an open economy framework in a way that incorporates the balance-of-payments constraint on growth. We do so by allowing technical change to be endogenous to the cyclical dynamics of the system and by adopting an independent investment function. We show that a Hopf-Bifurcation analysis establishes the possibility of persistent and bounded cyclical paths both for a 3D and a 4D extension of the model. Some numerical simulations are performed based on the analytical models developed. Motivational empirical evidence is also provided for Thirlwall's law using a sample of 16 OECD countries between 1950 and 2014.

Our results strongly relied on a learning-by-doing mechanism where changes in labour productivity were taken as a function of the level of effective capacity utilisation. Still, the impli-

cations of adopting different specifications of technical change were not discussed. Therefore, in chapter 5, I examine the implications of adopting alternative formulations to the main results of the model developed in the previous chapter.

The analysis of the role of technical change in growth processes has been for a long time of central importance in economic theory. Different approaches have been proposed over the years to study distinct aspects of the phenomenon. Among alternative theories of growth and distribution, two particular viewpoints on the evolution of technology deserve special attention given their influence to Marxian and post-Keynesian macrodynamic modelling, namely: (i) Kaldor-Verdoorn's law, where labour productivity grows in line with output's growth rate or capital accumulation; and (ii) a classical-Marxian technical progress function, where factor productivity growth rates respond positively to factor cost shares.

It is demonstrated in this last essay that the Kaldorian specification leaves the system with no internal equilibrium solution while the Marxian one makes it stable. A Hopf bifurcation analysis shows that the combination of both formulations might give rise to persistent and bounded cyclical fluctuations. Given the lack in the literature of reliable estimates for the classical-Marxian case, we provide a panel-Vector Autoregressive (pVAR) estimation for a sample of 16 OECD countries between 1980-2012 that give some support to its main argument. Our estimates were used to calibrate the models developed in the first part of the chapter showing that persistent bounded fluctuations are robust to different specifications of technical change.

In a beautiful essay on R. Goodwin's contributions to economic theory, [Punzo \(2006\)](#) described a journey that started at Harvard with the limit cycle of the 1950s until finally get to the chaotic attractors that marked the last part of his production in Siena. At this point, my own journey is about to start. These essays indicate, in a way, the direction I am about to follow. The years to come must be judged by their results.

Part I

Financialisation as a Process of Structural Change

Chapter 1

A Multi-sectoral Approach to Financialisation

1.1 Introduction

The term *financialisation* remains an unclear concept in social science. Over the years, it has been interpreted in varying ways, resulting in different research strands across a range of academic disciplines. Even though a precise concept varies considerably across analysis, the shared premise is that the relative size of the financial sector has grown significantly in the last three decades. Broader speaking, financialisation can be understood as an increase in prominence of finance in the economy, or the “increasing role of financial motives, financial markets, financial actors and financial institutions in the operations of the domestic and international economies” (Epstein, 2005, p. 3).

The recent financial crisis has reminded us that financial markets and intermediaries have crucial effects on the real economy. From a multi-sectoral perspective, the financial sector matters precisely because it connects the entire productive structure through financial intermediation. The interconnection between financial and non-financial structures is one of the mechanisms through which the strengths and vulnerabilities of economic activity are transmitted. Hence, understanding how those interdependencies differ across sectors and time is important to a better comprehension of the financialisation process itself.

Early discussions on the relation between finance and the productive structure go back to classical economists such as Adam Smith and Karl Marx. Key subsequent contributions include Hilferding’s (1910) view of an emerging fusion of financial and industrial motives, further extended by Hymer (1960) to an international set up. More recently, several studies have addressed their correspondence with the macroeconomic environment (Keen, 1995; Skott and Ryo, 2008; Sordi and Vercelli, 2014), investment (Stockhammer, 2004; Orhangazi, 2008; Davis, 2017), income distribution (Lin and Tomaskovic-Devey, 2013; Jaumotte et al, 2013; Dünhaupt, 2017), and innovation (Mazzucato, 2003; Mazzucato and Tancioni, 2012).

This chapter presents a multi-sectoral assessment of financialisation based on Input-Output (IO) analysis. Our contribution joins other efforts to provide integrated financial information at

the sectoral level in order to assess the interconnections between real and financial sides of the economy. IO models have been used for many decades to measure sectoral interdependencies, compare structure of economies, quantify structural and productivity changes, etc. Our main innovation consists in conceptualise financialisation as *an increase in the financial content in monetary terms of each unit of output produced*. In this way, we are able to investigate changes in relative importance of financial activities taking into account interactions among sectors.

Using a 15 and 14-sector level of aggregation, we apply our methodology to the United States (US) and Brazil for the period 1947-2015 and 1995-2011, respectively. There is a certain consensus in the literature that the US has experienced a financialisation process after the 1980s. Nevertheless, our results show that once we move on to a more disaggregated set up two different dynamics emerge. First, traditional activities such as agriculture, mining or manufacture show an inverted-U relationship with a reduction in their financial content in recent decades. This contrasts with service industries for which there is a positive trend that increased its slope after the 1980s. Furthermore, once we aggregate all sectors, we are able to partially reproduce well know results indicating an increase in importance of the financial sector in the last thirty five years.

On the other hand, the literature on financialisation in developing countries is relatively new and has pointed out to a more complex phenomenon. While there is no consensus about Brazil going or not through a financialisation process, our analysis shows that the Brazilian economy did not exhibit an increase in the financial content of its production. On the contrary, for most sectors, there is a reduction in financial coefficients specially between 1995 and 1997. This could be explained by the control of inflation that followed the macroeconomic stabilisation plan “Plano Real” which diminished the need of financial instruments for protection against inflation. Still, there is some degree of heterogeneity among sectors that emphasises the importance of analysis at a more disaggregated level.

Although methods focusing on the disaggregation of IO tables have been largely explored, they have received limited attention in the literature on financialisation. This chapter aims to refocus on multi-sectoral issues by offering a simple structure of analysis, and calling for a new wave of developments in this direction. The chapter is organised as follows. In the next section we present a briefly review of the original IO model and the indicators we are going to use in our analysis. Section 3 brings our conceptualisation of financialisation. In the next section we study the cases of the United States and Brazil. Some final considerations follow.

1.2 IO analysis

IO models (Leontief, 1936; 1941) have been used for many decades to measure from sectoral interdependencies and structural change to energy content of commodities, estimation of CO₂ emissions, etc.¹ In this section, we revisit some of the main elements of this framework giving

¹A comprehensive review of the fundamental structure of the Input-Output model and its main applications can be found in Miller and Blair (2009). IO models have been extended to a Social Account Matrix (SAM)

particular emphasis to the indicators we are going to further use in our analysis.

The mathematical structure of an Input-Output system consists of a set of n linear equations with n unknowns. Denote by x_i total output of sector i , z_{ij} sector j 's demand for inputs from sector i , and f_i total final demand of sector i , all of which in monetary terms. Therefore, for each given period, we have:

$$x_i = \sum_{j=1}^n z_{ij} + f_i \quad (1.1)$$

where equation (1.1) represents the way in which sector i distributes its product through sales to other sectors and to final demand.

There will be a similar equation for each of the n sectors so that the information on the distribution of each sector's sales can be summarised in matrix notation as:

$$\mathbf{x} = \mathbf{Z}\mathbf{i}_1 + \mathbf{f} \quad (1.2)$$

where $\mathbf{x} = \{x_i\}$ is a $n \times 1$ vector that stands for total production, $\mathbf{Z} = \{z_{ij}\}$ is a $n \times n$ matrix that captures the direct magnitudes of the inter-industry flows, \mathbf{i}_1 corresponds to a $n \times 1$ vector of 1's, and $\mathbf{f} = \{f_i\}$ is a $n \times 1$ vector of final demands.

A fundamental assumption in IO analysis is that inter-industry flows from i to j for a given period depend entirely on total output of sector j for that same time period. Making use of z_{ij} and x_j , we define the respective technical coefficient as:

$$a_{ij} = \frac{z_{ij}}{x_j} \quad (1.3)$$

so that the sectoral use of inputs occurs in fixed proportions.² Each technical coefficient a_{ij} can be interpreted as the direct content of any particular sector i for each dollar produced of j . Suppose, as an example, that sector j used \$250 of goods from sector i to produce \$1000 of sector j 's output. Hence, the direct content of i in j is $250/1000 = 0.25$.

However, this does not tell us much about the total content of each productive activity because pure technical coefficients do not take into account the interaction between sectors, i.e. direct and indirect effects. Define $\mathbf{A} = \{a_{ij}\}$ the $n \times n$ matrix of technical coefficients as in (1.3). Therefore, we can rewrite equation (1.2) as $\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}$. As long as $\det(\mathbf{I} - \mathbf{A}) \neq 0$, it immediately follows that:

$$\mathbf{x} = \mathbf{L}\mathbf{f} \quad (1.4)$$

framework in order to incorporate households, financial and non-financial corporations, government, and the rest of the world. However, the main disadvantage of SAM tables is that only a few statistical offices actually provide them. Moreover, the use of fixed coefficients beyond the production sphere is also questionable (Polo and Valle, 2012). For this reason our analysis is restricted to the IO set up in its simplest form. Chen et al (2005) provide a discussion about the inclusion of financial assets in the original IO model. A review of countries for which SAMs including financial institutions have been constructed can be found in Aray et al (2017).

²The underlying production function is given by $x_j = \min \left\{ \frac{z_{1j}}{a_{1j}}; \dots; \frac{z_{ij}}{a_{ij}}; \dots; \frac{z_{nj}}{a_{nj}}; v_j \right\}$, where v_j corresponds to value-added payments. For $a_{ij} \neq 0$ these ratios will all be the same and equal to x_j . On the other hand, $a_{ij} = 0$ imply that $\frac{z_{ij}}{a_{ij}}$ will be infinitely large and, hence, will be overlooked in the process of searching for the smallest among the ratios.

where $\mathbf{L} = \{l_{ij}\} = (\mathbf{I} - \mathbf{A})^{-1}$ is known as the Leontief inverse or total requirements matrix. Contrasting with \mathbf{A} , the Leontief inverse captures both direct and indirect magnitudes of inter-industry flows. Each element of \mathbf{L} corresponds to total input by industry required (directly and indirectly) in order to deliver one dollar of industry output to final users.

There are many useful applications in which the IO table is divided into two or more strategic industry groups and the interactions among them are traced through. In the present study we are interested in the relation of the financial sector with the remaining sectors of the productive structure. Using Miyazawa (1976, p. 59-65) partition method, matrix \mathbf{A} can be decomposed as follows:³

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}_{RR} & \mathbf{A}_{RF} \\ \mathbf{A}_{FR} & \mathbf{A}_{FF} \end{bmatrix} \quad (1.5)$$

where \mathbf{A}_{RR} is a $(n - 1) \times (n - 1)$ matrix of direct coefficients showing non-financial inputs used by non-financial industries; \mathbf{A}_{RF} is a $(n - 1) \times 1$ vector that captures non-financial inputs used by the financial sector; \mathbf{A}_{FR} corresponds to a $1 \times (n - 1)$ vector showing direct financial content in the remaining industries, and \mathbf{A}_{FF} gives financial requirements of the financial sector. It can be showed that the matrix of direct and indirect contents becomes:

$$\mathbf{L} = \begin{bmatrix} \mathbf{L}_1 & \mathbf{L}_2 \\ \mathbf{L}_3 & \mathbf{L}_4 \end{bmatrix} \quad (1.6)$$

with

$$\begin{aligned} \mathbf{L}_h &= \mathbf{L}_h([\mathbf{I} - \mathbf{A}_{RR}]^{-1}, \mathbf{A}_{RF}, \mathbf{A}_{FR}, [\mathbf{I} - \mathbf{A}_{FF}]^{-1}) \\ \frac{\partial \mathbf{L}_h}{\partial (\mathbf{I} - \mathbf{A}_{RR})^{-1}} &> 0; \quad \frac{\partial \mathbf{L}_h}{\partial \mathbf{A}_{RF}} > 0; \quad \frac{\partial \mathbf{L}_h}{\partial \mathbf{A}_{FR}} > 0; \quad \frac{\partial \mathbf{L}_h}{\partial (\mathbf{I} - \mathbf{A}_{FF})^{-1}} > 0 \\ h &= \{1, 2, 3, 4\} \end{aligned}$$

The last two sub-matrices, \mathbf{L}_3 and \mathbf{L}_4 , correspond to total (direct and indirect) financial requirements to produce one unit of output of each productive sector and the financial sector, respectively. Even though the disaggregation itself is quite tedious from the algebraic point of view, it comes with an important economic intuition. First, we have that total financial content is a positive function of total requirements of the financial sector itself, $(\mathbf{I} - \mathbf{A}_{FF})^{-1}$. Secondly, the interaction between finance and the remaining industries matters (see \mathbf{A}_{FR} and \mathbf{A}_{RF}). Third, the interactions among industries net of finance, $(\mathbf{I} - \mathbf{A}_{RR})^{-1}$, also have a positive relationship with total financial content. Finally, the correspondence between each of those components has also to be taken into account. This means that total financial content might increase even if direct content remains constant (or decreasing!) as long as there is an increase in the interaction between the other sectors.

Pure indirect requirements can be obtained multiplying direct by total content:

$$\mathbf{B} = \mathbf{A}(\mathbf{L} - \mathbf{I}) \quad (1.7)$$

³A similar application of Miyazawa partition method to a SAM framework that includes the financial sector is provided by Leung and Secrieru (2012).

with $\mathbf{B} = \{b_{ij}\}$ as the respective matrix of indirect requirements.

When a certain sector increases its production, there is an increase in demand for inputs from other sectors. This demand is referred to as backward linkages. A sector with comparatively higher backward linkages indicates that an expansion of its production induces a higher increase in other productive activities. This is easy to see looking to the columns of the Leontief inverse matrix. Formally, for a given sector j the magnitude of its backward linkages can be computed as:

$$backward_j = \sum_{i=1}^n l_{ij} \quad (1.8)$$

that is, the sum of rows of column j from the total requirement matrix, also referred as “output multiplier”.⁴

On the other hand, an increase in production by other industries leads to additional output required from each individual sector. We refer to it as a forward linkages. A relative higher index of forward linkages indicates that production in that sector is more sensitive to changes in other sector’s output. Formally, for a given sector i the magnitude of its forward linkages can be represented by:

$$forward_i = \sum_{j=1}^n l_{ij} \quad (1.9)$$

that is, the sum of columns for row i from the Leontief inverse matrix.

A slight modification of equation (1.4) allows us to identify how activities of each sector i are distributed among industries j . Define $\mathbf{C} = \{c_{ij}\}$ as a $n \times n$ operator matrix that rearranges the right side of (1.4) so that each element of \mathbf{C} corresponds to the interaction of the respective element of the technical coefficient matrix with final demand. That is:

$$\mathbf{C} = \mathbf{L}\hat{\mathbf{f}} \quad (1.10)$$

where $\hat{\mathbf{f}}$ is the diagonal matrix of final demands. Dividing c_{ij} by the sum of columns of its respective row i , we have:

$$d_{ij} = \frac{c_{ij}}{\sum_{j=1}^n c_{ij}} \quad (1.11)$$

The $n \times n$ matrix $\mathbf{D} = \{d_{ij}\}$ indicates how activities of each sector i are distributed among industries j . Suppose, as an example, that $d_{ij} = 0.3$ or 30%. This means that 30% of the activities of i are concentrated in j . It follows that the diagonal of \mathbf{D} indicates the level of vertical integration of the branch. The production process takes place entirely within the branch itself the closer the value of d_{ii} is to 1. Needless to say, each row of the matrix adds to one. The

⁴One should mention that this is not the only way to estimate backward and forward linkages and different indicators have been proposed in the literature. A comprehensive discussion is provided by Miller and Blair (2009, p. 555-565). For a recent application see Borghi (2017).

interpretation is similar to the subsystem approach put forward by [Momigliano and Siniscalco \(1982\)](#) and recently rescued by [Montresor and Marzetti \(2010; 2011\)](#).⁵

In the next section we use the indicators revisit here to understand financialisation from a multi-sectoral perspective. Such structure of analysis can be employed to study different varieties and financialisation paths.

1.3 From financial content to financialisation and structural change

As in the case of globalisation, industrialisation, and many other words terminating with the suffix “-isation”, financialisation designates a particular type of structural change characterised by an increasing weight and importance of the thing or quality preceding the suffix, in this case the financial sector ([Vercelli, 2013](#)). Such transformation is frequently attributed to a process that involves the liberalisation of financial markets, the increasing complexity of financial intermediation, the rise of shareholder value orientation, changes in policy orientation, etc. (see, for example, [Epstein, 2005; Palley, 2013](#)).

One should notice, however, that methods focusing on sectoral disaggregation have received limited attention in the financialisation literature. This is quite surprising given that the interconnection between financial and non-financial structures is a noteworthy mechanism through which strengths and vulnerabilities of economic activity are transmitted. Understanding how those interdependencies differ across sectors and time might prove relevant to a better comprehension of the financialisation process itself. Moreover, data on IO tables is available for a large number of countries which allows valuable comparisons between different economic systems.

In this section, we provide a simple structure of analysis that aims to capture the aforementioned rise of financial activities taking into account the interactions between sectors embedded in the IO tables. Our evaluations are based on a new conceptualisation of the phenomenon that does not intend to exclude the usual interpretations. Still, it emphasises two main elements (i) changes in relative importance, and (ii) interactions among sectors.

Variations in the financial side of economic decisions could be addressed using the methodology currently applied in the deindustrialisation/tertiarisation literature that focuses on the effects of inter-sectoral linkages on employment and output shares (e.g [Peneder et al, 2003; Mon-](#)

⁵Notice that \mathbf{D} does not depend on relative prices. Denoting with $\bar{\mathbf{x}}$, $\bar{\mathbf{A}}$, and $\bar{\mathbf{f}}$ values expressed in physical quantities while $\hat{\mathbf{p}}$ is a diagonal matrix of prices, we can rewrite it as:

$$\begin{aligned} \mathbf{D} &= \hat{\mathbf{x}}^{-1}(\mathbf{I} - \mathbf{A})^{-1}\hat{\mathbf{f}}^{-1} \\ &= (\hat{\mathbf{x}}^{-1}\hat{\mathbf{p}}^{-1})(\mathbf{I} - \hat{\mathbf{p}}\bar{\mathbf{A}}\hat{\mathbf{p}}^{-1})^{-1}(\hat{\mathbf{p}}\hat{\mathbf{f}}) \\ &= (\hat{\mathbf{x}}^{-1}\hat{\mathbf{p}}^{-1})\hat{\mathbf{p}}(\mathbf{I} - \bar{\mathbf{A}})^{-1}\hat{\mathbf{p}}^{-1}(\hat{\mathbf{p}}\hat{\mathbf{f}}) \\ &= \hat{\mathbf{x}}^{-1}(\mathbf{I} - \bar{\mathbf{A}})^{-1}\hat{\mathbf{f}} \end{aligned}$$

Therefore, \mathbf{D} is invariant to relative prices.

tresor and Marzetti, 2011; Ciriaci and Palma, 2016; Peneder and Streicher, 2017). However, we make the case that the two of them actually reflect deeper changes in the composition of production itself since, from the IO model, they are the result of changes in technical coefficients and final demand. Therefore, even though recognising the importance of those contributions, we take a different route.

We conceptualise financialisation as *an increase in the financial content in monetary terms of each unit of output produced*. Our motivation is quite simple. If we are to capture the relative importance of the financial sector looking at the productive structure of the economy, one should investigate the interrelations among firms and industries about possible trends towards certain combinations. Every dollar generated on each particular sector reflects a combination of inputs from other sectors. Assessing these combinations permit us to investigate their relative importance in production.

Let us consider, for example, an agricultural society. The respective IO table displays the low degree of complexity of its productivity structure, with few interactions among industries and mostly concentrated in primary activities. In a traditional set up, as this society moves on to an industrial arrangement, the interconnections among sectors are expected to increase and production starts to rely more on manufacture activities. This, of course, is followed by an increase in importance of manufacture inputs per unit of output produced. Agriculture input flows might continue to rise but its relative importance is reduced over time.

Analogously, it is quite reasonable to expect the rise of services to re-shape the economic system in such a way that each dollar produced reflects those changes. Still, services are a very broad category that aggregates very different activities. There is no reason to believe *a priori* that the relative importance of different service industries should change in similar ways, and probably there are also different implications in terms of growth, employment, productivity, etc. Given the importance of the financial sector in interconnecting different productive activities through financial intermediation, assessing how much this economy relies on financial inputs might tell us something about the relative importance of the financial sector to this economy. In this respect, the IO framework is extremely useful because it provides the tools to investigate those relations.

Different sectors use financial services in different proportions and their content might vary differently over time. Hence, we are particularly interested in the dynamics behind matrices **A** and **B** introduced in the previous section. While from the former it is possible to obtain the direct content of financial services in each productive sector, the latter allows us to measure indirect requirements to deliver one dollar of industry output to final users. In this respect, our exercise shares many similarities with the so called Structural Decomposition Analysis (SDA) defined in the nineties as “the analysis of economic change by means of a set of comparative static changes in key parameters in an input-output table” (Rose and Chen, 1991, p. 3).⁶

⁶In most of SDA formulations, changes in the Leontief matrix are described as some sort of “technological change”, which is often interpreted to include any factor that causes a change in a technical coefficient (Rose and Casler, 1996). This includes true technological change, technical substitution in response to input price changes, scale effects, etc.

Direct and indirect content measures are technical coefficients, and as such, reflect the technology available and used at a certain moment by a certain economy. An increase in financial content means that the respective production technique has become more financial dependent using more intensively financial inputs. Such increase in how much production depends on finance is what we address as financialisation.

From equations (1.3) and (1.7) there is no particular reason for direct and indirect content to move in the same direction. It is true that *ceteris paribus* an increase in direct coefficients implies an increase in indirect ones. However, the *ceteris paribus* assumption is questionable here since coefficients of different sectors can go in different directions over time.

Four different combinations are possible. The most intense case corresponds to the one in which there is an increase of direct and a non-decrease of indirect financial content per unit of output. An increase in direct content with a non-increase of indirect coefficients follows as a softer experience, where increases in direct content are not able to generate a similar response from indirect coefficients. On the other hand, one could actually observe a reduction in direct content such that indirect content actually non-decreases. Given our conceptualisation of the phenomenon, it is debatable to which extend this situation could be included as a case of financialisation. However, the importance of this case relies on the fact that the increase in interactions among all productive sectors more than compensates the reduction of financial direct content. That is, changes in the productive structure occur in such a way that the sign of variations in direct content is reversed so that indirect financial content actually increases.

Furthermore, if there is a reduction in direct and indirect content, it is not possible to refer to financialisation in a particular industry or economy. Still, this does not mean that the importance of the financial sector has been necessary reduced. Suppose that a reduction in direct content is greater than in indirect content. This means that, as time goes by, less direct content is actually generating higher indirect content. Such particular change in the nature of the relationship between the financial sector and the rest of the economy cannot go unnoticed.

Define the coefficient of financial penetration, p_{ij} , as the ratio between indirect and direct content in monetary terms of financial services per unit of output produced:

$$p_{ij} = \frac{b_{ij}}{a_{ij}} \quad (1.12)$$

An increase in p_{ij} indicates an increase in financial penetration regardless the presence or not of financialisation itself. Recall that indirect content in one particular sector is a function of its own direct content, its interactions with the remaining sectors, and the interactions of those sectors among them. Increments in the interactions of the remaining sectors can dilute the effect of a reduction in direct content. If they are strong enough, there might be an increase in the penetration coefficient even if direct contents are falling.

Finally, looking to matrix \mathbf{D} and making use of the backward and forward indices, we can study the direction of eventual financialisation processes. Therefore, while (1.8) and (1.9) allow us to say if financialisation is backward or forward oriented, the financial sector row in \mathbf{D} shows towards which sector financial activities have been directed.

In the next section we apply the structure of analysis developed here to the United States and Brazilian economies. There is some consensus that the US has gone through a financialisation process in the second half of the twentieth century. Applying our methodology to this case enables us to show how it reproduces well known results as well as the novelties that come with it. In what concerns the Brazilian economy, our outcomes are completely new.

1.4 An application to the US and Brazil

Financialisation research has originally focused on the United States experience, but the concept has been increasingly applied to emerging economies. There is a rich literature stressing the particularities of individual country experiences and some recent attempts to compare trajectories also with developed economies (e.g. [Bonizzi, 2013](#); [Karwowsky and Stockhammer, 2017](#)). Throughout this essay, by financial sector we mean finance, insurance, and real estate activities that form the FIRE acronym. We chose to work with the entire FIRE industries because a substantial part of the financialisation literature uses it as main reference.

The widespread availability of digital computers has made the use of the IO framework a widely applied tool for economic analysis. Our database takes 15-sector level of aggregation for the US and comprehends the period 1947-2015. For the Brazilian economy we use a 14-sector level of aggregation for the period 1995-2011. We consider that this level of aggregation allows us to address sectoral heterogeneity keeping the analysis as simple as possible. Differences in the number of sectors between the US and Brazil correspond to “Wholesale and Retail trade” that in the former constitute two different sectors while in the later they are a single one.

Data was provided by the Bureau of Economic Analysis (BEA) and the Organisation for Economic Co-operation and Development (OECD). We use Input-Output tables that rely on matrices of inter-industrial flows of goods and services produced domestically and imported. Time span was chosen given data availability. Because changes in technical coefficients take long periods of time, one should expect a more clear picture of the main trends for the United States. This was indeed the case though we were still able to capture major changes for Brazil during the 17 years for which data was available.

OECD and BEA Input-Output tables are not directly comparable for at least two reasons. First, they use a different structure of aggregation. Secondly, they also have a different price structure. OECD uses basic prices while BEA makes use of production prices. In order to overcome the first problem, we adjust OECD data to approximate the BEA format. The correspondence criteria between both sources is provided in the appendix. Unfortunately, we do not address the second issue here.⁷ Hence, comparisons between both countries require some caution.

⁷An alternative would be to use exclusively OECD tables for Brazil and US. However, this implies a massive loss of data since OECD series are available only after 1995. Still, we should mention that even though not straightforward comparable in levels, cautious comparisons of trends might be useful. This is particularly true in the case of financial concentration (matrix \mathbf{D}) which is independent of relative prices, as showed in section 2.

We begin establishing the main trends and trajectories observed at a sectoral level for the United States and Brazil. The lowess non-parametric procedure with a bandwidth of 0.25 was adopted in order to emphasise the main trends. Aggregate results are also provided weighting each industry accordingly to its share in total output. We proceed investigating the behaviour of the financial penetration coefficient both at a sectoral and aggregate level. Last but not least, we investigate how financial activities are distributed among the productive structure.

1.4.1 Some comments on data distortions

How to measure the participation of finance in production is an interesting topic considering that modern economies produce less measurable outputs than the traditional manufacturing, mining, and agriculture (Nakamura, 2010; Pagano, 2014). For instance, Mazzucato and Shipman (2014) have recently showed that the increased size and influence of financial institutions has widened the scope of divergence between value-creation and value-added. Distortions are mainly due to overstating the financial sector's value-added or counting some purely rent-seeking activity as productive.

In the United States and Brazil, the official System of National Accounts (SNA) includes as financial activities: financial intermediation, insurance, pension funds, and other activities such as administration of financial markets. Assa (2016) provides a comprehensive narrative on the treatment of financial services in national accounting and the distortions created by financialisation in the US. Specifically in what concerns financial services, three types of activities are performed by the financial industry, namely (i) services for which banks explicitly charge a fee; (ii) financial intermediation resulting in net interest income; and (iii) capital gains or dealing profits from spot trading.

These three major types of financial services also received different treatments in national accounts. The first of them is considered productive and is included as value-added. The second one is treated as an input to other industries while the last one is excluded *a priori* from the production accounts. There seems to be a consensus regarding the exclusion of capital gains from value-added accounting since there is no productive activity associated with them. The other two groups are more controversial. In his book, Assa argues that the inclusion of services for which banks charge fees as value-added is responsible for inflating Gross Domestic Product (GDP) by the same amount.

Total output of a sector j is given by the sum of its value-added and inputs used in production. As briefly discussed in the previous paragraphs, distortions in national accounts seem to be related to how we measure financial value-added. But this brings some interesting implications. Divide the IO table between financial and non-financial sector. From equation

(1.5), and making use of (1.3), technical coefficients are such that:

$$\mathbf{A}_{RR} = \mathbf{Z}_{RR}\hat{\mathbf{x}}_R^{-1} \quad (1.13)$$

$$\mathbf{A}_{RF} = \mathbf{Z}_{RF}\mathbf{x}_F^{-1} \quad (1.14)$$

$$\mathbf{A}_{FR} = \mathbf{Z}_{FR}\hat{\mathbf{x}}_R^{-1} \quad (1.15)$$

$$\mathbf{A}_{FF} = \mathbf{Z}_{FF}\mathbf{x}_F^{-1} \quad (1.16)$$

where \mathbf{Z}_{RR} is a $(n-1) \times (n-1)$ matrix that captures direct magnitudes of inter-industry flows outside the financial sector; \mathbf{Z}_{RF} corresponds to a $(n-1) \times 1$ vector for non-financial inputs used by the financial sector; \mathbf{Z}_{FR} is a $1 \times (n-1)$ vector that stands for inter-industry flows going from the financial sector to the remaining sectors of the economy; \mathbf{Z}_{FF} gives financial inputs used by the financial sector itself; \mathbf{x}_R is a $1 \times (n-1)$ vector of non-financial total output such that $\hat{\mathbf{x}}_R$ stands as the respective $(n-1) \times (n-1)$ diagonal matrix; and finally, \mathbf{x}_F corresponds to financial total output. Furthermore:

$$\mathbf{x}_R = \mathbf{i}_2^T \mathbf{Z}_{RR} + \mathbf{Z}_{FR} + \mathbf{V}_R \quad (1.17)$$

$$\mathbf{x}_F = \mathbf{Z}_{RF}^T \mathbf{i}_2 + \mathbf{Z}_{FF} + \mathbf{V}_F \quad (1.18)$$

such that \mathbf{V}_R is a $1 \times (n-1)$ vector that captures value-added of non-financial activities and \mathbf{V}_F corresponds to financial value added. Finally, \mathbf{i}_2 corresponds to a $(n-1) \times 1$ vector of 1's.

Suppose the aforementioned critique is correct and \mathbf{V}_F has been overvalued in the SNA. This means that the true \mathbf{V}_F and \mathbf{x}_F are lower. Hence, technical coefficients \mathbf{A}_{RF} and \mathbf{A}_{FF} are potentially biased downwards. This is clear if we substitute (1.18) in (1.14) and (1.16), and compute the partial derivative on \mathbf{V}_F :

$$\frac{\partial \mathbf{A}_{RF}}{\partial \mathbf{V}_F} = -\mathbf{Z}_{RF} [(\mathbf{Z}_{RF}^T \mathbf{i}_2 + \mathbf{Z}_{FF} + \mathbf{V}_F)^{-1}]^2 < 0 \quad (1.19)$$

$$\frac{\partial \mathbf{A}_{FF}}{\partial \mathbf{V}_F} = -\mathbf{Z}_F [(\mathbf{Z}_{RF}^T \mathbf{i}_2 + \mathbf{Z}_{FF} + \mathbf{V}_F)^{-1}]^2 < 0 \quad (1.20)$$

If distortions are increasing in time, financial value-added is expected to exhibit a positive trend bias which in turn implies that direct and indirect financial content would have a negative trend bias. This means our exercise comes with a disadvantage and an advantage. First, it is important to keep in mind that if we do not find an increase in financial content, this does not necessary mean that there is no financialisation. Nevertheless, whenever we are able to find an increase in financial content, we can ascertain that something really important is going on deep in the structure of the economy that requires a careful analysis. That is, for those cases in which we do find an increase in financial content, we can say more confidently that there is an increase in importance of the financial sector *vis a vis* the rest of the economy.

Equation (1.19) shows that non-financial contents are also affected by these potential biases. We will discuss some of those implications in the next chapter when we address the relationship between financial and manufacture activities. Naturally, the existence of such distortions is also debatable and one might disagree about the relevance of the critique. In that case, if there is no distortion in \mathbf{V}_F , our coefficients are strictly correct.

Still, one might speculate how different financial content trajectories would be if we give a different treatment to financial value added. Hence, in order to provide a more robust analysis, we investigate some implications of manipulating \mathbf{V}_F . Motivated by the discussion provided by Assa (2016), we repeat our exercise making all FIRE incomes as intermediate inputs to the rest of the economy. Our strategy consists in redistributing financial value-added - as reported in the SNA - so that it enters the IO table exclusively as inputs. In this way, we are artificially setting financial value-added to zero while we are able to maintain the consistence of IO tables. The three crucial variables to change are \mathbf{Z}_{FR} , \mathbf{Z}_{FF} , and \mathbf{V}_F , that are now given by:

$$\begin{aligned}\tilde{\mathbf{Z}}_{FR} &= \mathbf{Z}_{FR} + \mathbf{Z}_{FR}\hat{\mathbf{s}} \\ \tilde{\mathbf{Z}}_{FF} &= \mathbf{Z}_{FF} + \mathbf{Z}_{FF}s_{ii} \\ \tilde{\mathbf{V}}_F &= 0\end{aligned}$$

where $\hat{\mathbf{s}} = \{s_{ij}\}$ is a $(n - 1) \times (n - 1)$ diagonal matrix with $s_{ii} = \mathbf{V}_F / \sum_{j=1}^n z_{Fj}$, i.e. the ratio between FIRE's value-added and the sum of all financial inputs before redistribution. We expect this second modified set up to deliver greater financial content coefficients. It corresponds to an extreme scenario that has a complementary role in our analysis basically showing if, in the limit, distortions in \mathbf{V}_F have more influence in levels or in trends. Finally, notice that independently of the treatment given to financial value-added, our concentration and vertical integration indicators remain the same (see matrix \mathbf{D}). This is quite obvious from equation (1.11) where we can see that this manipulation basically multiplies numerator and denominator by the same value.

1.4.2 United States

Different sectors present different trajectories for the evolution of financial content per unit of output. We are able to identify two main trends and divide accordingly the productive structure in two groups. The first of them - formed by traditional activities such as “Agriculture, forestry, fishing and hunting” (from now on just Agriculture), “Mining”, “Utilities”, “Construction”, and “Manufacture” - seems to follow an inverted-U path. On the other hand, the remaining sectors form a second group of mainly service industries with an almost permanent increase in financial content. Accordingly, we divide our analysis in two parts. After covering the trajectories of both groups, we aggregate the economy and further investigate the degree of vertical integration of the financial sector.

Traditional activities

Direct content Let us start with the first of them. In what concerns direct content, “Agriculture” experienced an increase from the 1960s to late 1980s that has been completely reversed afterwards. A similar trajectory can be observed for “Mining” but with a peak in the early 1960s. “Construction” showed its higher financial content around 1983 while “Utilities” and “Manufacture” presented an increase in direct content until the beginning of the twenty-first

century. In this last two cases, such positive trend was dramatically reversed after 2001. After the global financial crisis of 2007, direct content basically returned to its 1950s levels.

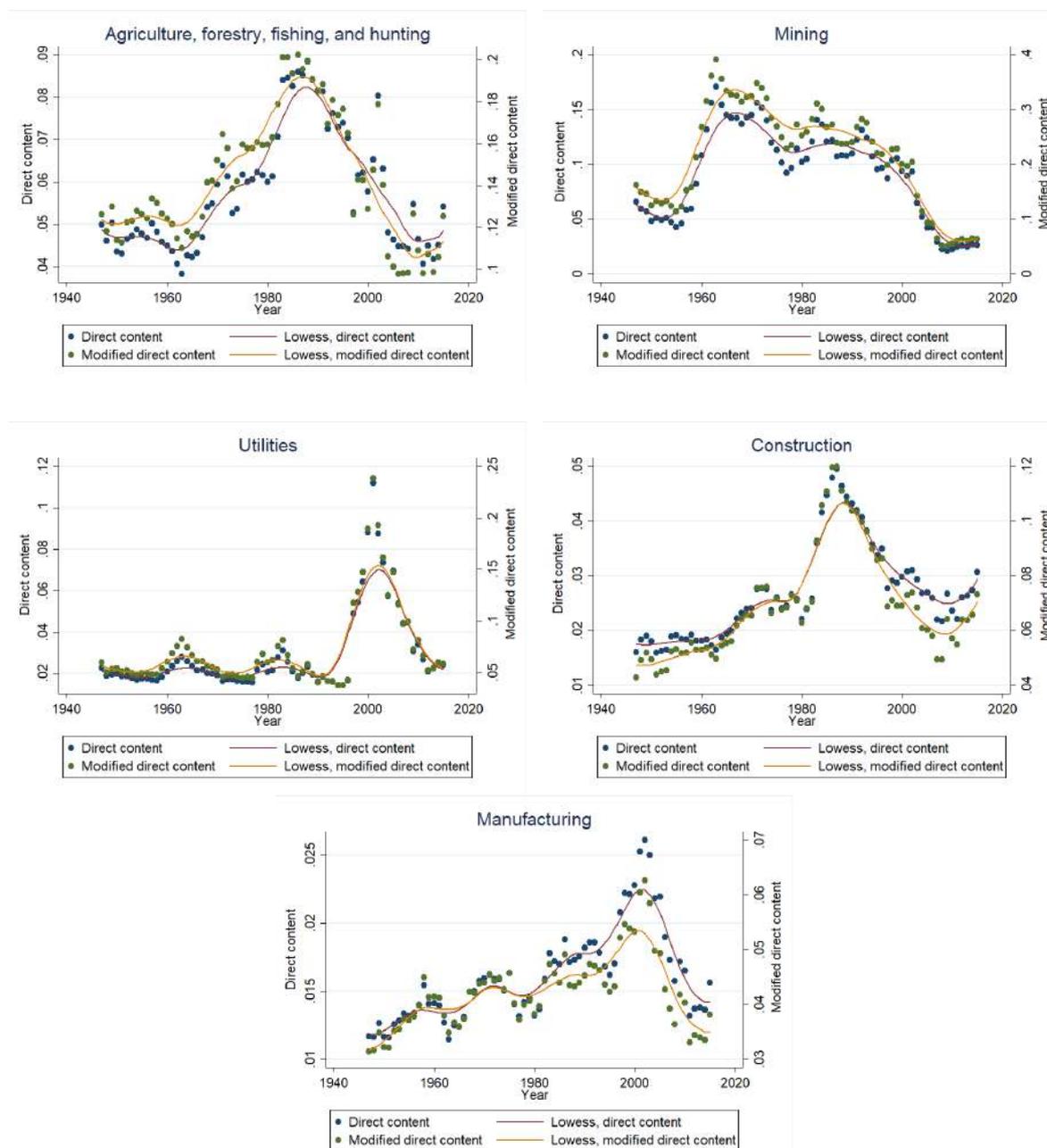


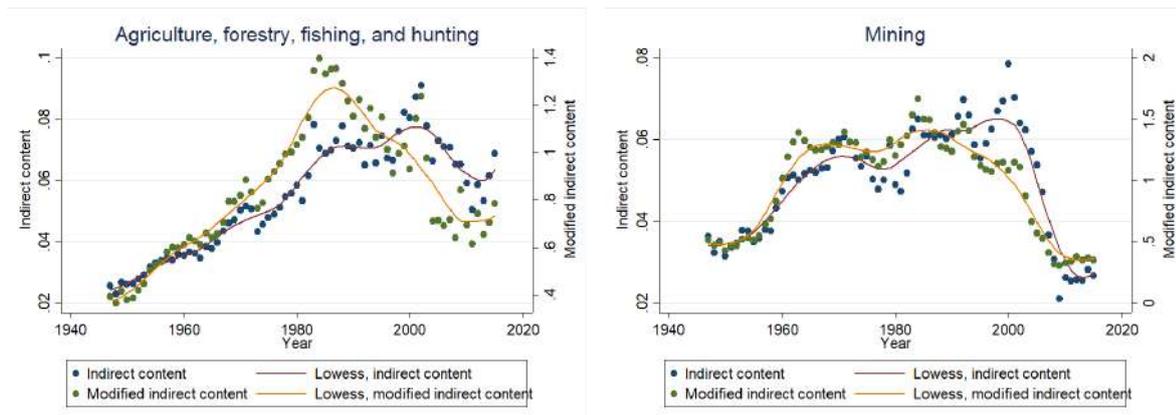
Figure 1: Direct financial content in traditional activities, US

One should also pay attention to the magnitudes involved. Looking at our preferred measure of financial direct content, coefficients for “Agriculture” were close to 0.05 until 1962. In the next twenty years, there was an increase to 0.08. Such trajectory was reversed with a similar speed so that by 2000 direct content had returned to its initial levels. “Mining” started from a similar

position with its coefficient increasing up to 0.15, the highest of the group. From the 1970s onwards, its technical coefficient has been shrinking to even lower magnitudes than in 1950. Continuing, “Utilities” direct content only started to grow in the 1990s jumping from 0.02 to 0.07 and returning to its initial value by 2010. Finally, “Construction” and “Manufacture” present the lowest coefficients for the whole sample. Still, the former one rose from 0.02 to 0.05 and then fell to 0.03. The later exhibited very small variations starting around 0.01, peaking in 0.025 and falling back to its previous levels.

The story does not change significantly for our modified indicator of financial direct content. There is an evident increase in levels but the trajectories are pretty much the same. Coefficients are 2 to 3 times greater in comparison to our preferred indicator. We can still visualise the previously reported inverted-U relationship. “Agriculture” doubles its technical coefficients from 0.1 in 1950 to 0.2 in 1980 when it reached its peak. “Mining” jumped from 0.15 to 0.4 in the sixties going back to 0.1 afterwards. “Utilities”, “Construction”, and “Manufacture” continue to achieve their maximum values in the 2000s – when they reached 0.25, 0.12, and 0.06, respectively – falling afterwards.

Indirect content Indirect content magnitudes, on the other hand, are much more similar across sectors though there are some differences between our two treatments to financial value-added. Figure 2 plots the main trends. For our preferred indicator, there is a shared starting initial value close to 0.03 which increased until the dot-com crisis of 2001 when it reached the 0.06-0.08 interval. Nevertheless, there is significant heterogeneity after that, with “Agriculture” going back to 0.06, “Manufacture” and “Construction” to 0.05, and the remaining sectors falling to 0.02. These remarkable similarities, also in terms of the year of the peak, are the result of the interaction between sectors from the Leontief inverse. Indirect requirements in all of those cases peaked in the early 2000s coinciding with the dot-com bubble.



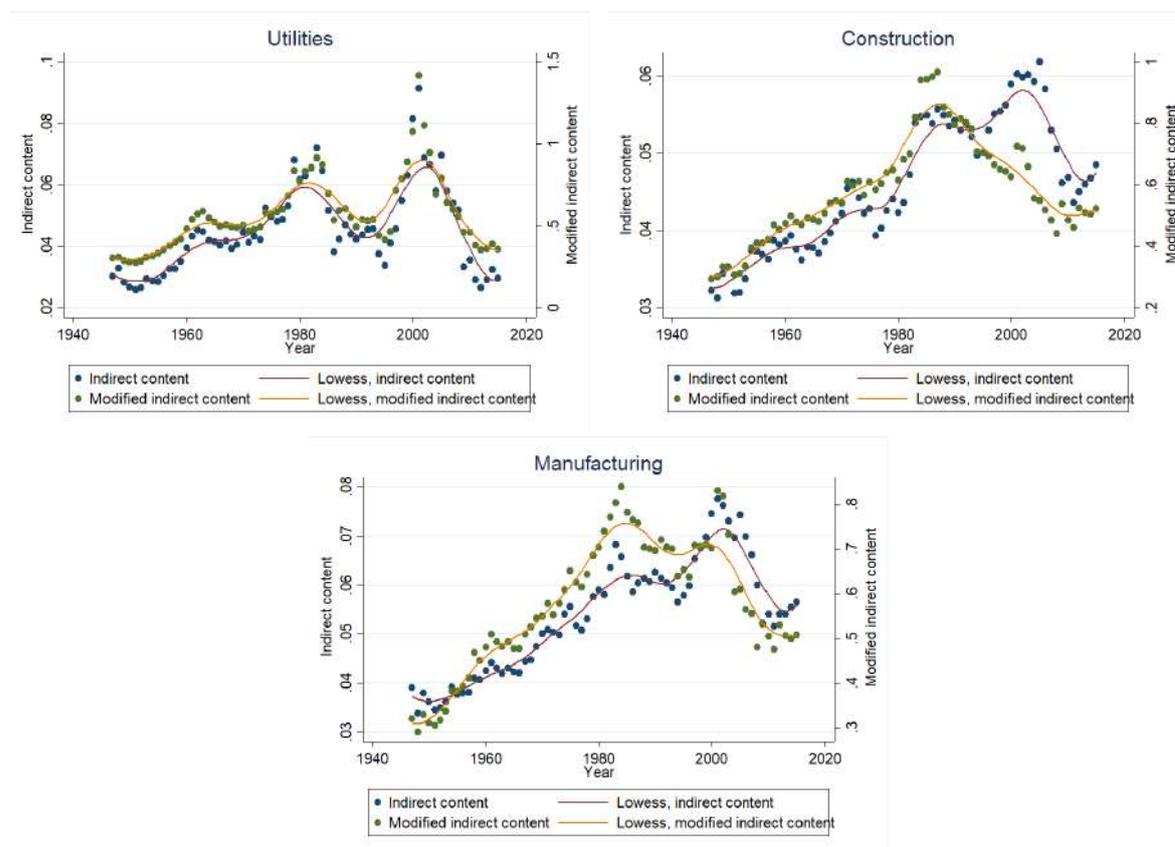


Figure 2: Indirect financial content in traditional activities, US

Moving to our modified indicator of financial content, there are some differences worth to discuss. Shortly, the main trajectories are the same but coefficients are significantly greater. This is particularly true for “Agriculture”, “Mining”, and “Utilities” which presented values in some moments 20 times higher than our preferred indicator. One should also notice that “Manufacture” peaks twice, first in the 1980s and again in the 2000s. Finally, “Agriculture” peaks in the 1980s instead of the 2000s as in our previous case.

Despite those differences, an inverted-U relationship for direct and indirect content indicates that those sectors experienced an intensive financialisation process that is no longer in progress. In other words, it is not possible anymore to refer to financialisation in those activities in the terms put forward in this essay. One should notice that for some sectors such as “Mining”, coefficients not only returned to their 1950 values but actually went below that. Even though there are some deviations among trajectories for different treatments to financial value-added, the main trends do not change. Furthermore, as result of the interactions among sectors, indirect content seems to fall slightly less than direct content.

Penetration coefficient The ratio between indirect and direct content, named as financial penetration, is plotted in figure 3. “Agriculture”, “Mining”, and “Manufacturing” presented an

increase in the penetration coefficient for almost the whole period, indicating that before the peak indirect content was growing faster than direct content while after the peak direct content was falling faster than the indirect coefficient. This contrasts with the other three sectors for which patterns are not very clear. For instance, “Utilities” depicts an inverted-U shape curve with indirect content growing and declining faster than direct content while the “Construction” ratio is to some extent stable.

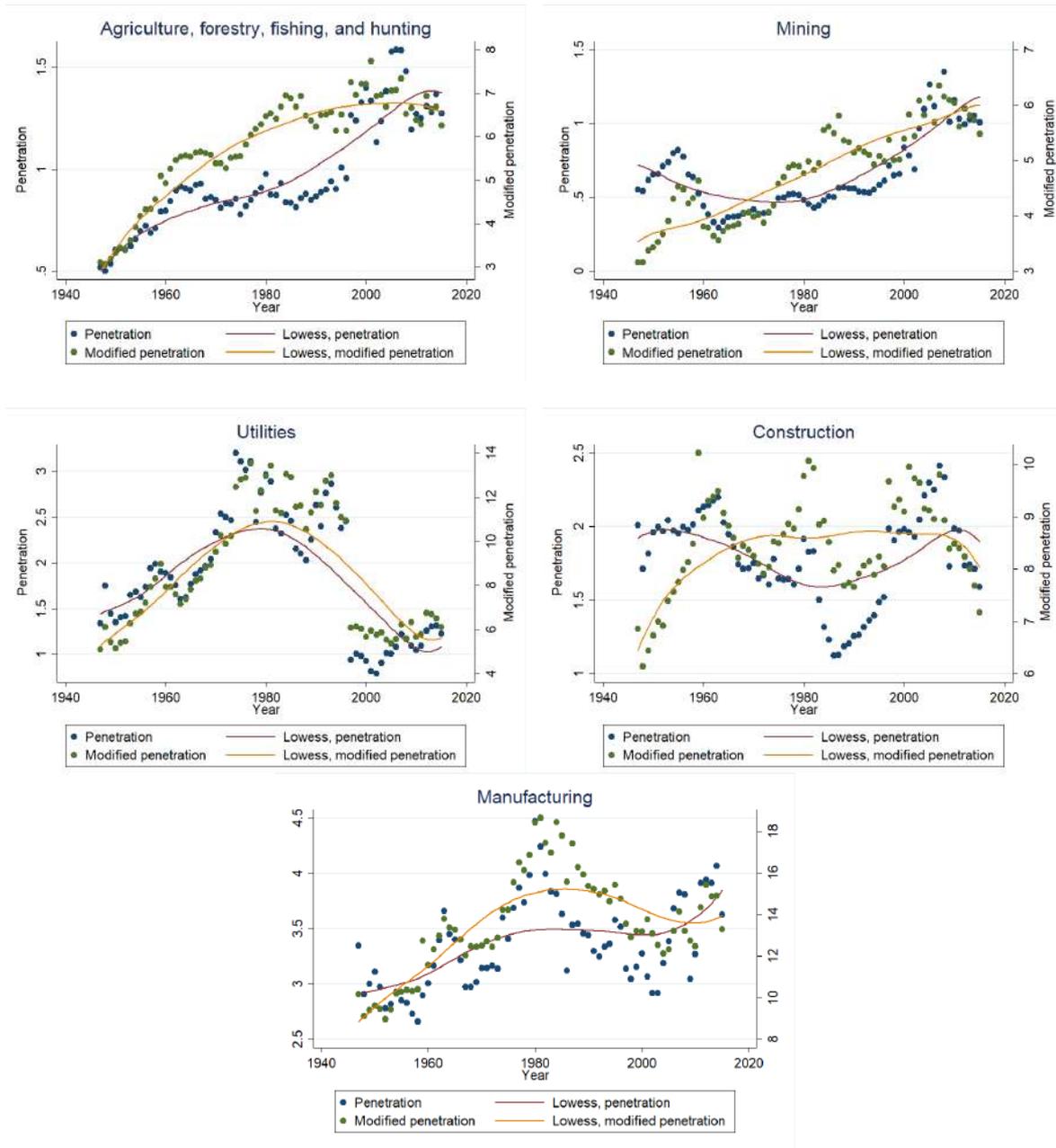


Figure 3: Penetration coefficient in traditional activities, US

In terms of magnitudes, we begin with our first measure of financial content. “Manufacture” has by far the highest values, increasing from 3 in the 1950s to 4 by the end of the period.

This means that indirect effects induced by the interactions between sectors increased financial content 4 times. More modest values are found in other activities. “Agriculture” and “Mining”, that had penetration coefficients around 0.5, experimented an increase to 1.4 and 1, respectively. On the other extreme, there is “Construction” with a slight cyclical reduction of the penetration coefficient from 2 to 1.7. Finally, “Utilities” also presented significant fluctuations. Its ratio between indirect and direct content increased from 1.5 to 3 in 1980 and went back to 1 by 2010.

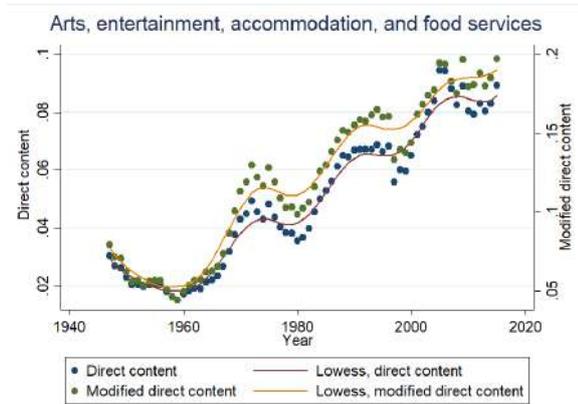
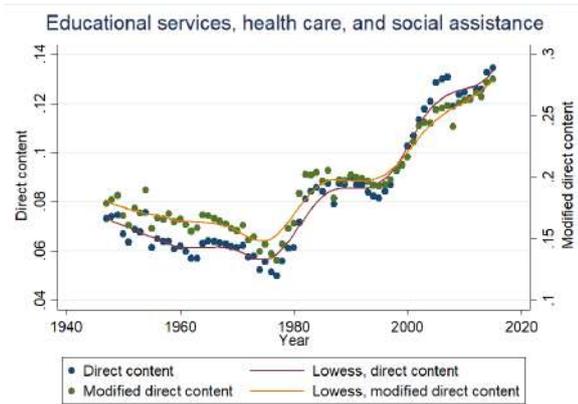
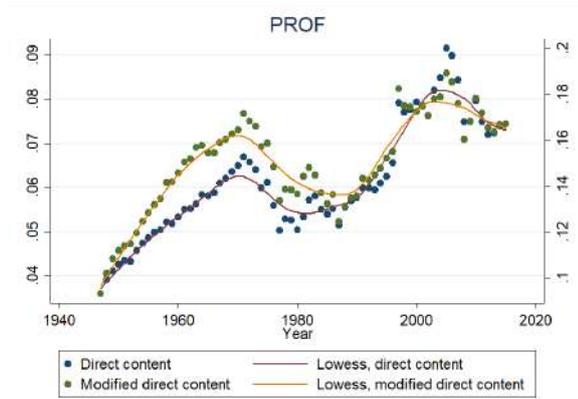
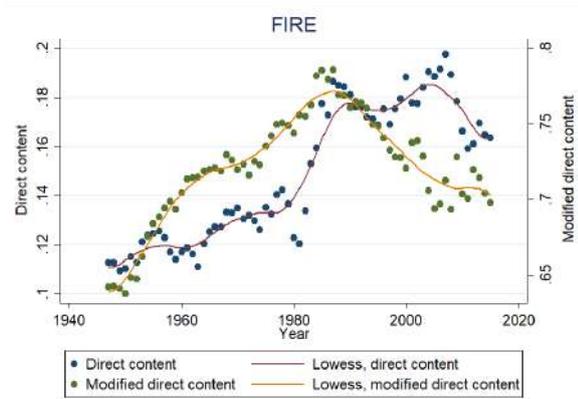
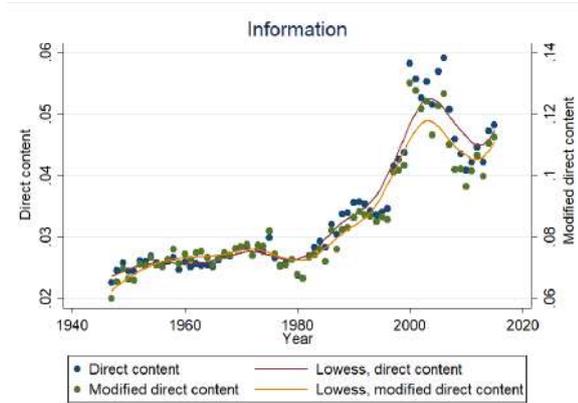
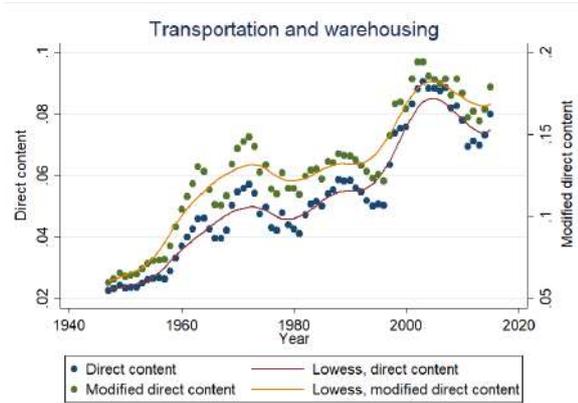
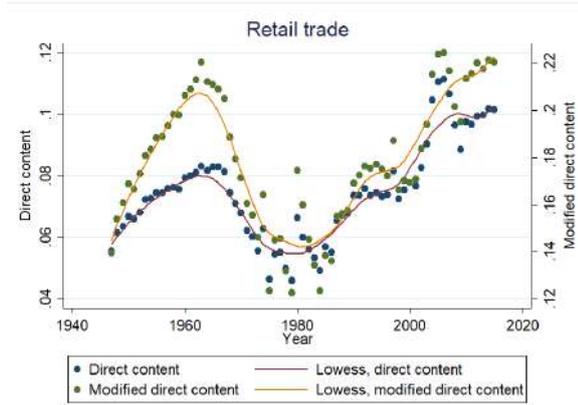
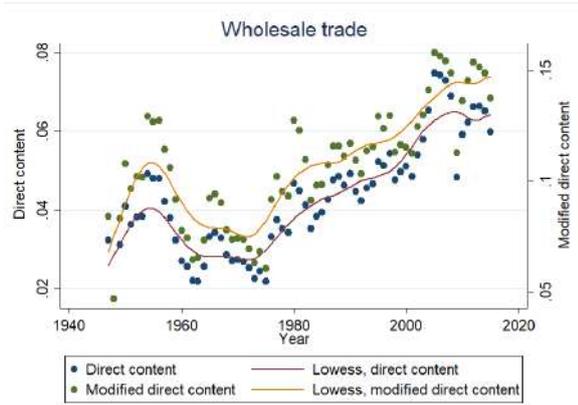
There are some minor differences in comparison to our modified indicators of financial content. As already reported, setting financial value-added to zero increases coefficients in levels. In this case, penetration coefficients are on average 5 times greater than in the previous one. One can also notice that lowess curves are more concave, specially in the first thirty years of the sample. The main example of this is “Agriculture” that had its indirect content peak anticipated from 2000 to 1980.

Services activities

Direct content We proceed reporting the trajectories of the remaining 10 industries. Looking first to our preferred set up, they can be further divided in two subgroups. A first one - formed by “Wholesale trade”, “Retail trade”, “Information”, “Educational services, health care, and social assistance” (from now on just Education and Health), and “Other services” - did not experiment an increase in direct content until 1980s. All other sectors basically show a positive trend for direct content the whole period. Trajectories are plotted in figure 4. Furthermore, after 2007 some sectors seem to have experienced a reduction or stabilisation of their financial content. Nevertheless, the magnitude of those reductions is quite small in comparison to what was observed in figure 1.

As it will become clear, for this group of industries it is possible to refer to an ongoing financialisation process, or at least this was the case until the 2001 dot-com and 2007 financial crisis. Contrasting it with the previous group, the 1980s configured a transitional period in which financial content in traditional industries was already (or about to) losing space while services were (or about to) rising. This means that in the last twenty to thirty years the burden has fallen basically on service activities. That is, our analysis suggests that recent financialisation has been to a great extend of a service-led type.

This last finding is particularly interesting if we consider that such increases in financial content have happened in a context marked by a rise in the use of personal computers and the internet. These last two elements have introduced an obvious revolution in the “Information” sector but not only there. The Internet altogether with more recent tools such as machine learning are dramatically changing the logistics in business and in all cases are deeply related to the development of financial markets.



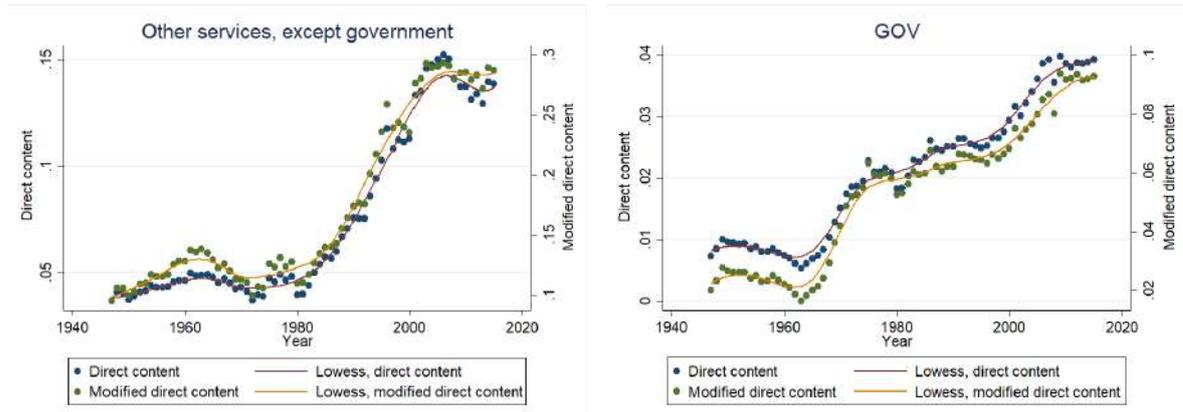


Figure 4: Direct financial content in services, US

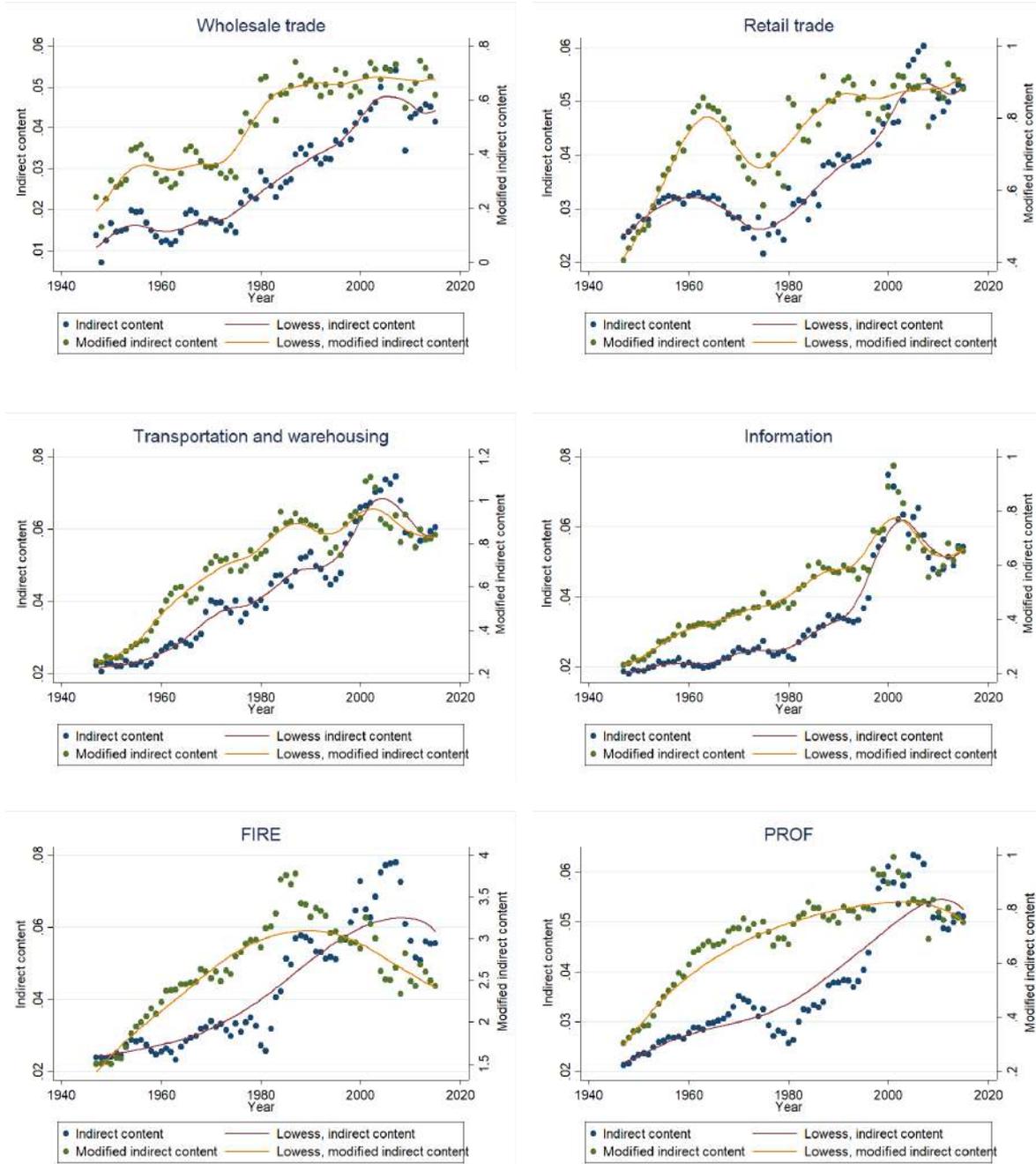
Some comments on the magnitudes of direct financial content follow. There is significant heterogeneity across sectors that, as we will show, contrasts with more homogeneous coefficients for indirect content. In terms of our preferred financial content measure, sectors such as “FIRE”, “Education and Health”, and “Other services” started from different initial values - 0.11, 0.07, and 0.04, respectively - but converged to a 0.13-0.16 interval. Those correspond to the higher magnitudes of the group and are comparable to “Mining” when it reached its peak. On the other extreme, “Wholesale trade”, “Transportation and Warehousing”, “Information”, “PROF”, “Arts and Entertainment”, and “GOV” departed from smaller technical coefficients - between 0.01 and 0.04 - and did not go further than 0.04-0.08. In that sense, “Retail trade” is some sort of intermediate case since its financial direct content grew from 0.06 to 0.1.

Moving to our second set up, there are three important features. First, coefficients are on average between 2 and 3 times greater than in the previous case. However, “FIRE” differentiates itself from the rest with coefficients 4-6 times higher. Even though this might not seem to be a very important distinction, it is worth to mention because reflects the fact that we set financial value-added to zero, thus, especially increasing this coefficient.

The other two differences are more interesting. For instance, “FIRE” now depicts an inverted-U path with a peak in 1980. Our preferred indicator does point out to a small reduction in direct financial content of the financial sector after 2000. Here, however, such reduction happened 20 years before and is much stronger. Finally, “Wholesale trade”, “Retail trade”, and “PROF” experienced a small episode of financialisation of their own with a peak in the 1960s. This was particularly strong for “Retail trade” where the peak was similar in magnitude to current values of financial content. Still, the main trends are preserved and indicate a generalised increase in financial content of service activities, specially between 1980 and 2007.

Indirect content Indirect financial content for this second group of sectors has basically a positive trend for the whole sample with an increase in its slope around 1980. Similarly to

the first group, initial values for our preferred measure were around 0.01-0.03 and converged to something between 0.04-0.06. Our results indicate that the maximum values for financial content in traditional and service activities are very similar, though they happened in different moments on time. The main trends are reported in figure 5.



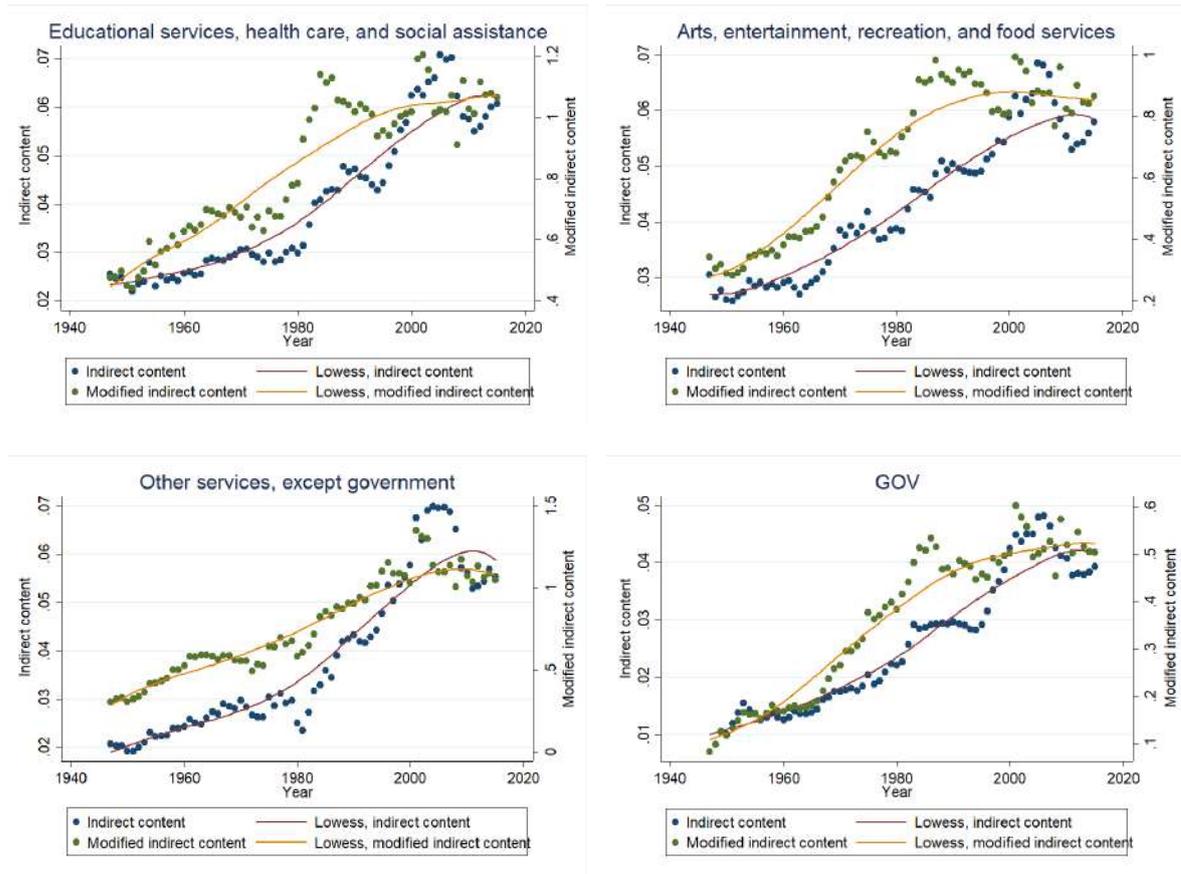


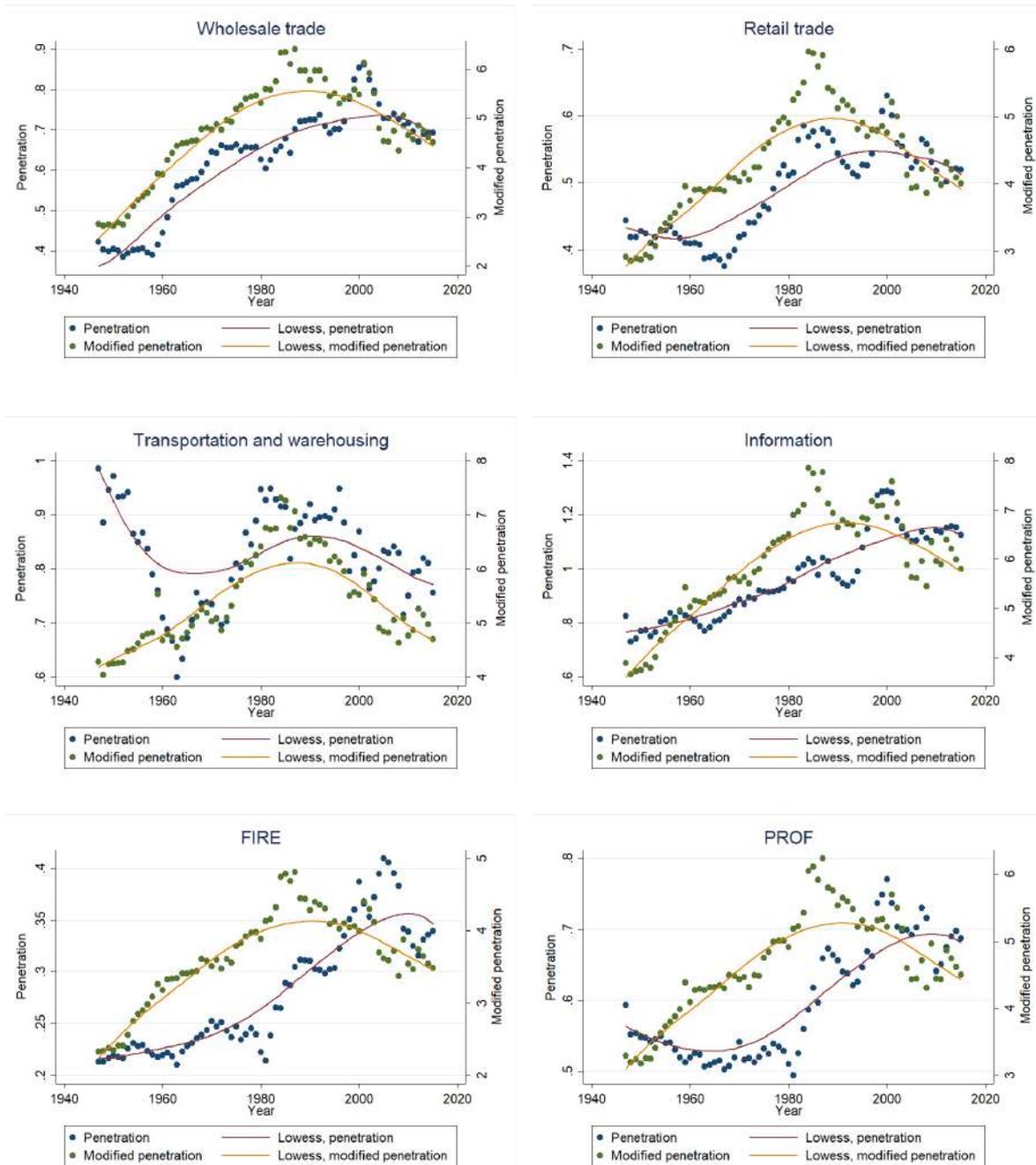
Figure 5: Indirect financial content in services, US

On the other hand, our modified indicators of indirect financial content presented a similar story with some crucial differences. The main trends are maintained which gives some robustness to our analysis. However, “Retail trade” once more exhibited a peak in the 1960s similar in magnitude to current values of financial content. Moreover, “Wholesale trade”, “Retail trade”, and “PROF” showed relatively stable coefficients after the 1980s. Finally, “FIRE” repeats the inverted-U shape reported in direct content. These results contrast with trajectories in our preferred measure of financial content that exhibited a more consistent positive trend with an increase in slope after the 1980s until the dot-com and 2007 financial crisis.

Penetration coefficient When it comes to the penetration coefficient, we find some sort of mixed behavior. From figure 6 we have that “Wholesale trade”, “Retail trade”, “Information”, “FIRE” and “PROF” lowess curves have an upward slope indicating not only that their financial content has increased but that the induced indirect effects have grown faster than direct coefficients.⁸ Still, after 2000, coefficients stabilise and in some industries we observe small decreases.

⁸PROF includes Legal services, Computer system design, Scientific activities, Management, Administrative services, and Waste management services.

On the other hand, our preferred measure of financial content shows that for “Education and Health”, “Other services” and “Government” the penetration ratio seems to follow an inverted-U relationship with their respective peaks in the 2000s, 1960s and 1970s, respectively. One should notice, however, that the ratio between indirect and direct content for traditional activities is significantly higher than in services. In the former, all coefficients were above 1 with “Manufacturing” reaching 4. In the second group, with the exception of “GOV”, penetration is in general below 1. This indicates that traditional activities have more interconnections with the rest of the economy, amplifying financial content more strongly.



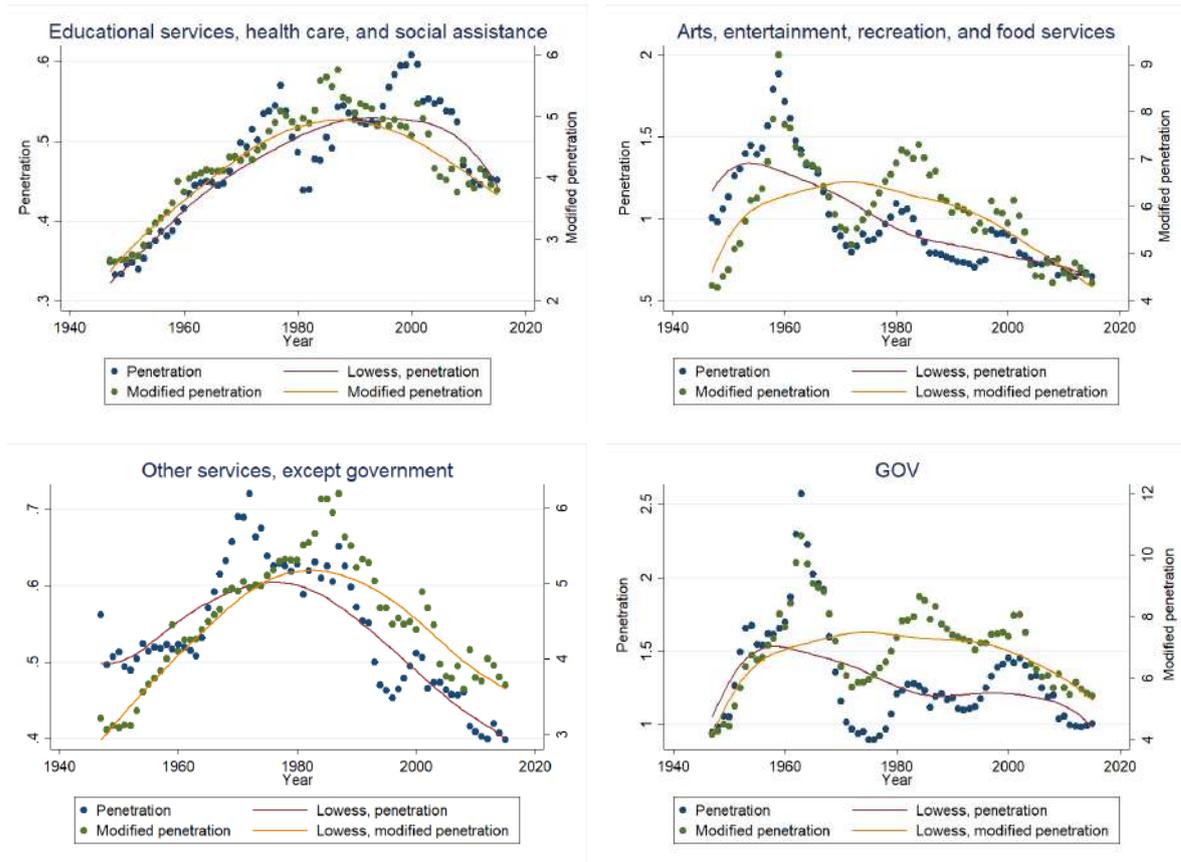


Figure 6: Penetration coefficient in services, US

Moving on to our modified indicators, lowess curves are more concave depicting more pronounced inverted-U paths. Most of them peaked between 1980 and 2000. Since services have shown a more consistent increase in financial direct and indirect content, this reinforces the idea that direct coefficients have lately grew faster than indirect ones. Still, traditional activities also have greater financial penetration than services while magnitudes involved are higher in comparison with our preferred financialisation measure. For the first group of industries, indirect content reached values up to 20 times greater than direct content while in the second group it did not go above 10.

Aggregate results

Aggregating the economy using the shares of each sector in total output gives us a positive trend for both direct and indirect financial content, as depicted in figure 7. In what concerns direct content, our preferred indicator shows an increase in the slope of the curve in 1980 as suggested by the literature on financialisation. If we instead look to indirect content, a similar increase happened in the mid 1990s and is interrupted a couple of years before the financial crisis in 2007. In the last fifty years, financial coefficients have doubled their value which basically corresponds to an increase of 100% of financial content.

However, when we redistribute FIRE’s value-added so that it enters the IO table exclusively as inputs, things change. Despite differences in magnitudes, we actually observe a continuous increase of direct content the whole sample with some stability after 2000. A similar positive trend follows when we look to indirect content though trajectories become stable after 1980. In order to understand such differences in trends it might be useful to assess what this coefficients are in fact measuring.

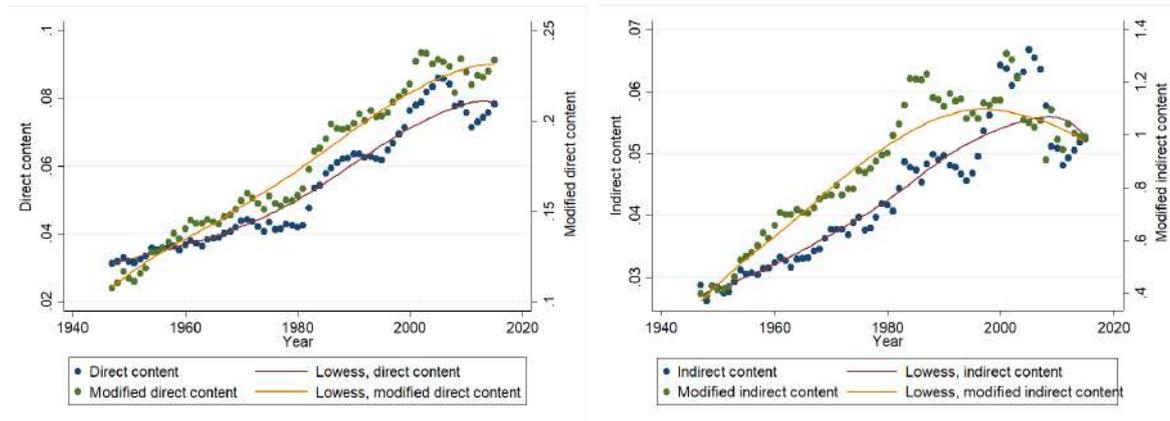


Figure 7: Aggregate direct (left) and indirect (right) financial content, US

As previously discussed in the last subsection, the SNA considers services for which banks explicitly charge a fee as financial value-added, while financial intermediation resulting in net interests income is included as intermediate inputs. However, since in our modified scenario we redistribute all FIRE’s value-added so that it enters the IO table exclusively as inputs, we expect our preferred indicators of financial content to rely more on the dynamics behind interest rates and the stock of debt than our modified measures.

According to [Palley \(2013\)](#), the defining feature of financialisation in the US has been an increase in the volume of debt. He reports that between 1973 and 1989 interest rate payments rose from 25% to 60% of profits, as result of the high interest rates that prevailed in the 1980s. This is in line with our preferred results that point out to a sharp increase in the slope of financial direct content in that period. He continues showing that by 2007 corporate interest payments as a share of profits had fallen back to 1973 levels, reflecting the low interest rates that prevailed in the 2000s. Our coefficients also capture this last change though the magnitude of the reduction in financial content is relatively small. This could be the result of the high volume of debt accumulated in the period. A disaggregate analysis indicates that in the last thirty years this trend was lead mainly by service industries.

Modified financial content points out to a more continuous phenomenon. The increase in relative importance of the financial sector in the US has been gradual and goes back at least to 1950. Initially, it was lead by traditional industries while in the last years this role has been played mainly by services. Modified direct content seems to get stable by the end of the

1970s though it jumps afterwards returning to its main previous trend. For indirect content, things changed in 1980 with coefficients stabilising and fluctuating slightly above one.

Figure 8 shows that the eighties are a watershed for the penetration coefficient but in a different way. Using our main indicators of financial content, direct and indirect coefficients seem to have varied similarly until 1980 when direct requirements started to grow faster. In the last five to ten years of the sample such tendency is not reverted because the indirect coefficient dropped faster than the direct one. This explains a constant ratio between 1950 and 1980 with a negative trend afterwards.

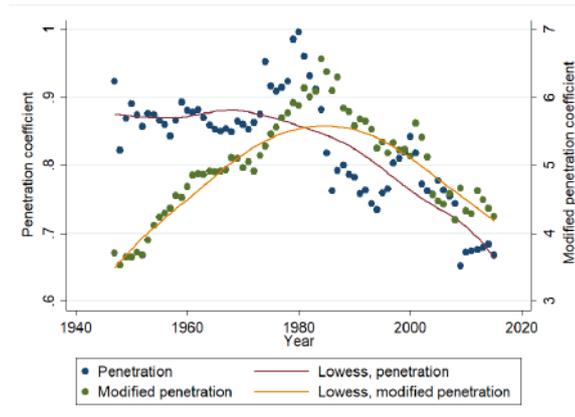


Figure 8: Aggregate penetration coefficient, US

On the other hand, our modified indicators depict an inverted-U relationship. Financial penetration increased until 1980 because indirect content was growing faster than direct one. When services started to lead the process, changes in direct content overcame indirect coefficients explaining the negative trend. In both cases, financial penetration has been falling since 1980. This indicates that interactions among sectors have not changed as fast as increases in direct financial content. Furthermore, it also reflects changes in the composition of output. Traditional activities such as “Manufacturing” were reported to have higher financial penetration in comparison to other sectors. Since its share in total output has been declining over time this also leads to a reduction in aggregate figures.

With this results in mind we move on to the evolution of backward and forward linkages. Figure 9 brings some new insights on some characteristics of the aforementioned change in importance of the financial sector. The main element is the marked increase in forward linkages that contrasts with relatively stable backward linkages. In our prefer scenario, the former rose sharply from 2 in the 1950s to 3.3 in the beginning of the 2000s falling to 2.8 afterwards. Setting financial value added to zero increased indirect content levels which explains the higher magnitudes in our second scenario. Forward linkages went from 10 to 20 in the first forty years of the sample, stabilising with a small negative trend until 2015 when they reached 15. Despite differences in the time of the peak, both suggest a significant net increase in forward linkages.

Backward linkages, on the other hand, are much more stable. Figure 9 on the left shows that until 1980 there was actually a reduction in this coefficient from 1.5 to 1.4, going to 1.68 in the 2000s and decreasing to 1.58 in 2015. Magnitudes involved in the second case are greater but variations are still comparatively small. There is a positive trend from 1950 to 1980 with a marked decrease afterwards. This reflects a characteristic of the financial sector: a follower more than an inducer. Furthermore, the expressive increase in forward linkages indicates that the financial sector has become increasingly more sensible to changes in production of other sectors.

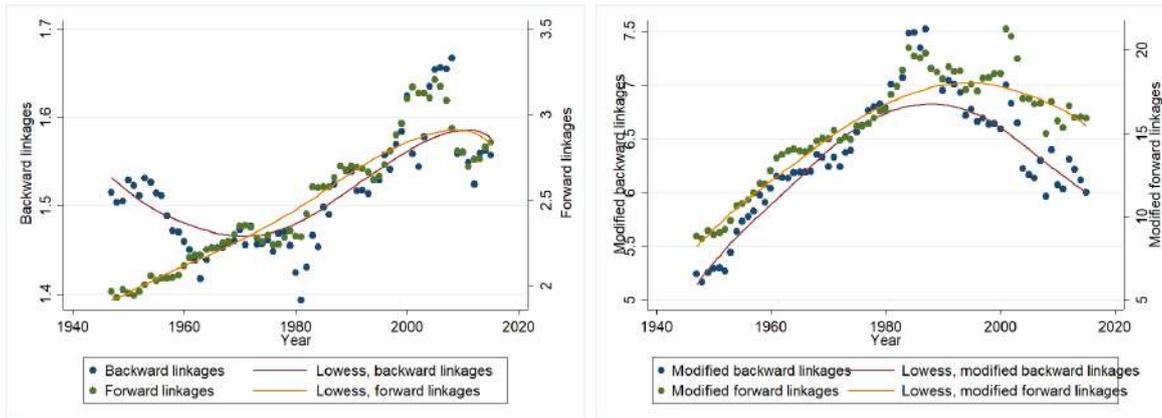


Figure 9: Backward/forward linkages (left) and index (right), US

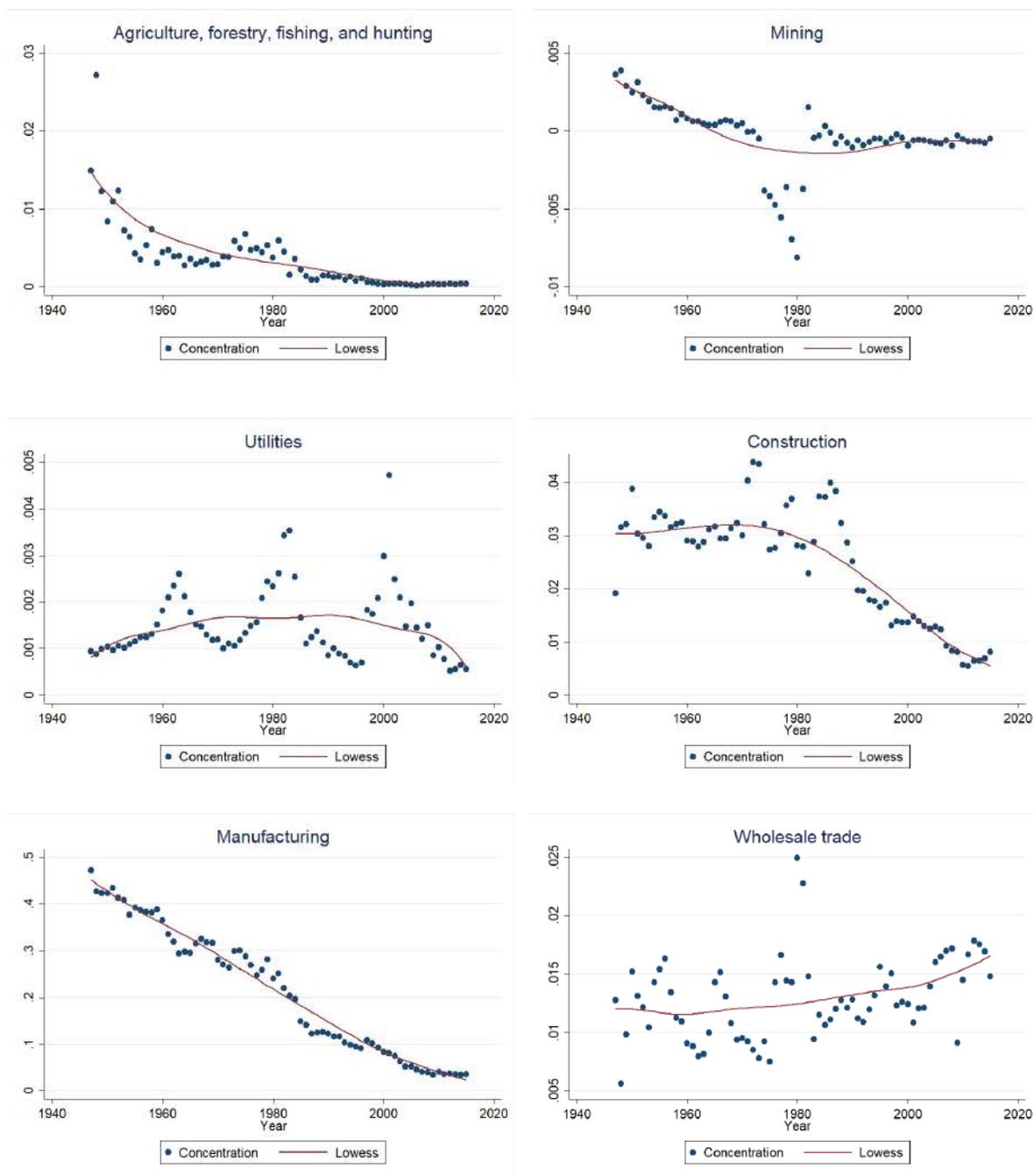
As important as the rise of finance in the aftermath of 1980s, our indicators seem to point out to a second structural break after the dot-com and 2007 financial crisis. From figures 3 and 4, we were able to identify a reduction of direct and indirect financial content in service activities after 2001. Because financialisation seems to be in a sense service-led, this was reflected in our aggregate indicators including the backward and forward linkages. However, it is not clear if coefficients will continue to rise or if they have reached some sort of new steady-state.

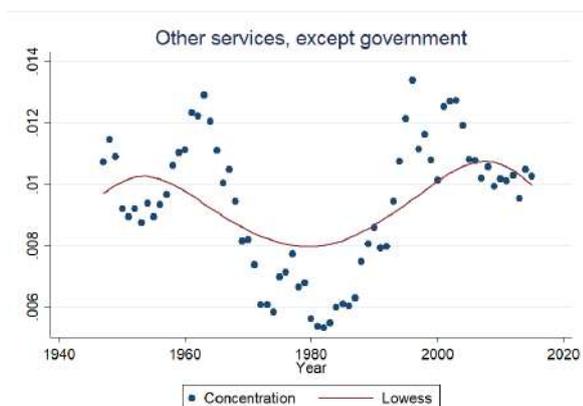
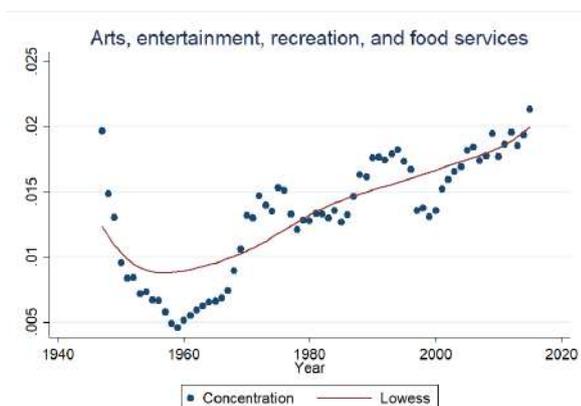
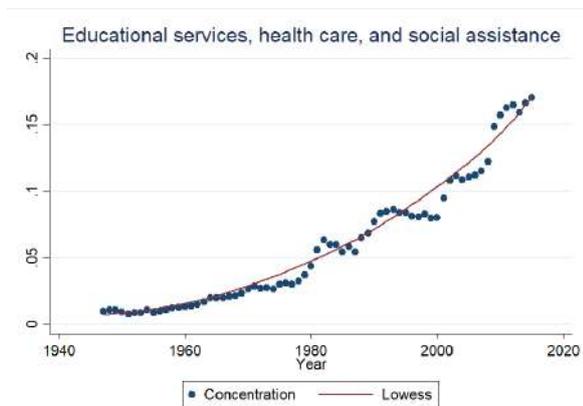
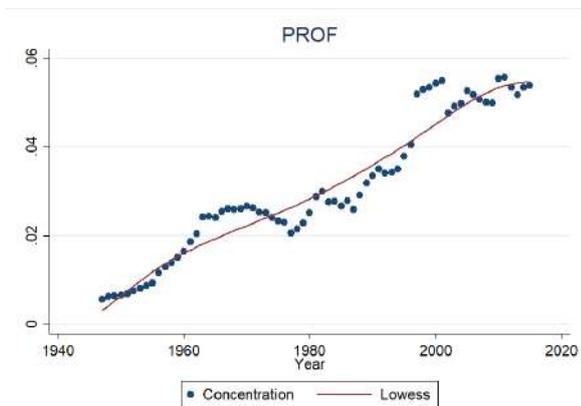
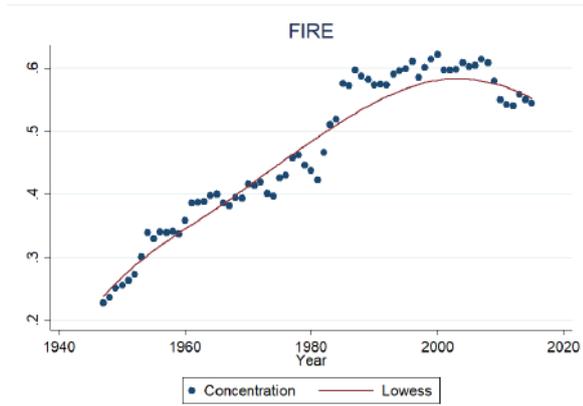
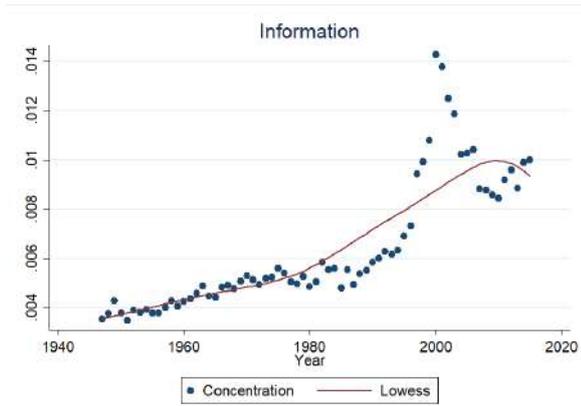
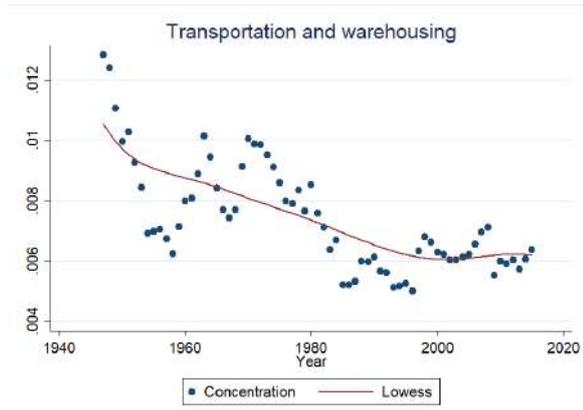
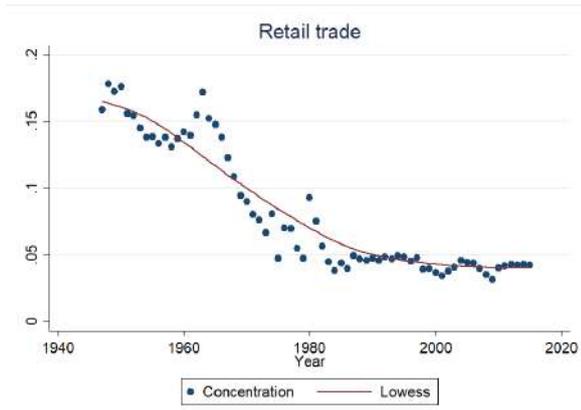
Vertical integration

Finally, we can see how financial industries have been distributed among productive activities. Figure 10 depicts that finance has engaged a clear process of vertical integration. In fact, the share of FIRE activities that takes place entirely within itself has grown from 20% to 55% in the last fifty years. “Education and Health”, and “PROF” follow as sectors that experienced a strong increase in this indicator. In the beginning of the period “Education and Health” received only 1% of all financial activities, which increased to 17% in 2015. Similarly, “PROF” increased from 0.5% to 5.5%. This movement contrasts with the dramatic reduction experienced by “Manufacture”. In the 1950s, “Manufacture” concentrated almost half of financial activities and was reduced to less than 5% by 2015. Negative value shares in “Mining” are the result of negative values of final demand in this sector given the high trade deficit in particular after the

oil crisis.

Vertical integration of financial activities could be interpreted as an increasing separation of the financial from the real sides of the economy. If financial activities are suppose to only intermediate the allocation of resources between investors and those who save, why almost 60% of the “FIRE” sector is concentrated on itself? This does not mean that the productive structure relies less on the financial sector but might indicate finance is increasingly relying less in the rest of the productive structure. FIRE has become more sensible to changes in output of other sectors, and at the same time increasingly vertical integrated.





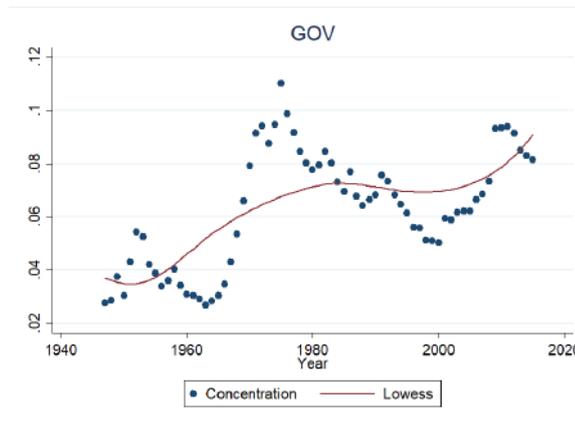


Figure 10: Concentration and sectoral distribution of FIRE, US

Such interpretation finds some echo in the literature on financial crises *a la* Minsky. As discussed by several scholars, Minsky’s theory rests on the bifurcation of an economy’s price system. On the one hand, there is the price system for goods and services. On the other hand, there is a wholly separate price system for assets. It is here where stability leads to asset price inflation, then a build up in debt, and eventually a crisis (see, for example, [Wray, 2015](#)). Though it is not the goal of this essay, one could conjecture to which extend an increasing separation of the financial from the real sides of the economy could precisely lead to an increase of financial fragility in Minskyan terms.

Overall, it is possible to observe a positive trend in service activities that suggests that the financial sector is leaving traditional sectors and moving towards the tertiary sector. For instance, “Agriculture ” and “Construction ” had a reduction from 3% to 1% that is still significant, though not comparable to the dramatic reduction in “Manufacture”. On the other hand, “Mining” and “Utilities ” basically fluctuated around zero. These results are in line with the tertiarisation process experienced by the US economy during the second half of the twenty century. Still, notice that the concentration of finance in our second group of “service industries” is not unanimous. “Retail trade” did experienced a reduction from 15% to 5% during the first thirty years of the sample and maintained that level after 1980.

As we will see in the next subsection, tertiarisation by itself does not necessary is followed by a concentration of FIRE in services. The Brazilian case corresponds to an example of a country that is also going through a deindustrialisation (tertiarisation) process but with a reduction in FIRE’s vertical integration. We conclude this subsection emphasising our main results:

- Inverted-U trajectories of financial content in traditional activities;
- Increasing financial content in service activities, especially after 1980s;
- Increase in vertical integration of the financial sector;
- No clear trend for financial penetration;

- Financial penetration is higher in traditional activities;
- Stable backward linkages with a marked increase in forward linkages;
- The dot-com crisis of 2001 and the financial crash of 2007 are two important structural breaks for financial content;

1.4.3 Brazil

The literature on financialisation in developing countries is relatively new and has pointed out to a more varied and complex phenomenon than in developed ones. [Karwowski and Stockhammer \(2017\)](#), for instance, have outlined at least six different interpretations that include financial deregulation and integration to global markets, shifts from bank-based to market-based financial systems, increased involvement of households in finance, etc. Ironically, a concept that remains unclear to developed countries seems to be even more dispersed for developing economies.

Among those authors who claim that there is an ongoing financialisation process in the Brazilian economy, two explanations stand out. On the one hand, [Kaltenbrunner \(2010, p. 296\)](#) argued that Brazil has experienced rising “international financialisation”, defined as an increased participation of foreign investors in short-term domestic assets. More recently, [Kaltenbrunner \(2017\)](#) has shown important structural changes in Brazil’s financial integration in the form of currency internationalisation and financialisation, mediated through a hierarchic international monetary system.

A second group of scholars has brought to attention the growing ratio between financial assets and productive capital indicating that Brazilian financialisation is centered in high interest rates rents associated to public debt (e.g. [Bruno et al, 2011](#); [Araújo et al, 2012](#)). In both cases, results contrast with those presented by [Karwowski and Stockhammer \(2017\)](#) who concluded that Latin American economies - including Brazil - have seen a relatively weak (if any) financialisation.

It is our purpose in this subsection to verify if is possible to refer to financialisation in Brazil from a multi-sectoral perspective. Our exercise is not in conflict with those previous interpretations. On the contrary, it explores a different side of the phenomenon that emphasises sectoral interactions and might be preferable in some cases for the reasons already explained. Furthermore, providing that financialisation in developing countries is a more varied and complex phenomenon, we consider is important to apply the conceptualisation put forward in this chapter also to a developing economy. If financialisation is to be understood as an increase in relative importance of the financial sector, we do not see why this should not be the case also for an economy like Brazil.

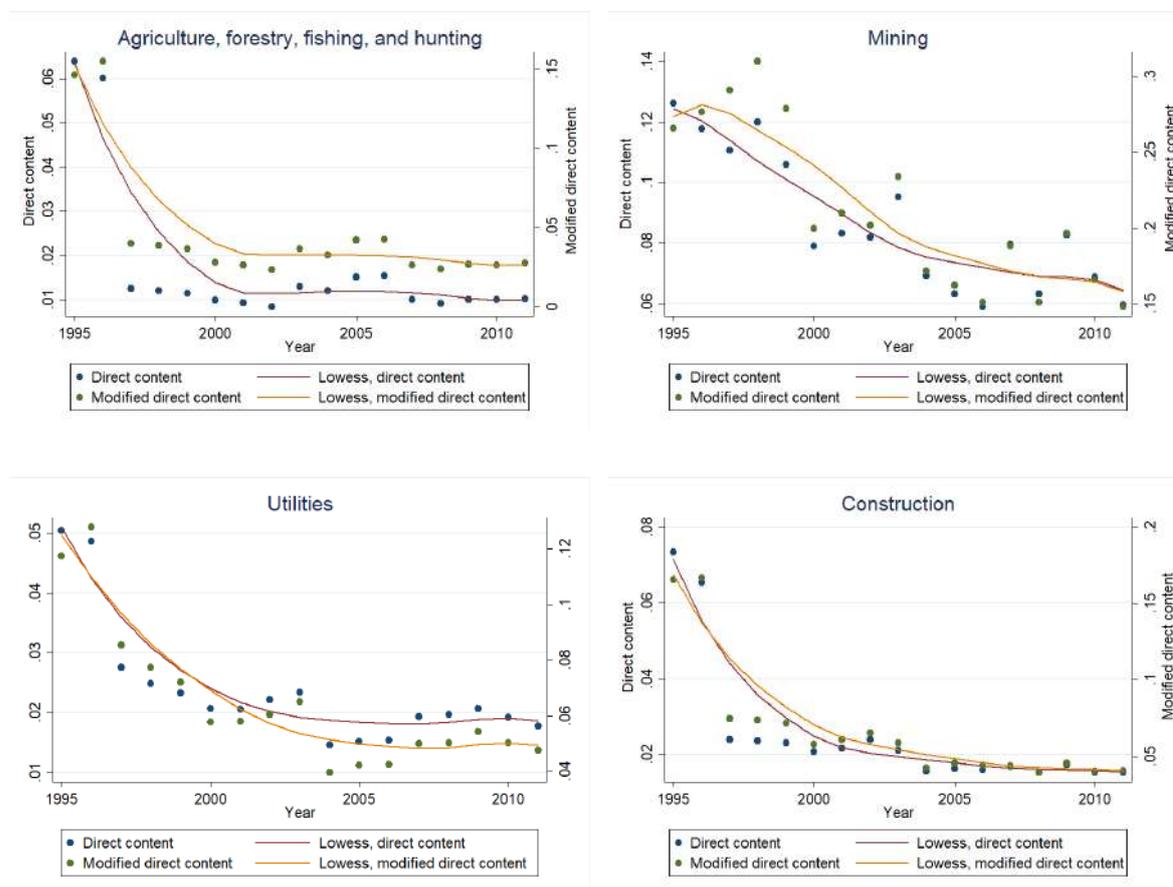
The period for which data is available is considerably shorter but coincides with what Bruno and collaborators refer to as “financeirização pela renda de juros” ([2011, p. 740](#)). Since changes in technical coefficients take several years, we are not able to capture great movements like in the US case. Nevertheless, some patterns still appear. Following a similar structure to the previous subsection, we divided sectors between traditional activities and mainly services. In

the previous subsection such division was motivated by different trends between groups. In this subsection, we chose to maintain the separation for expositional purposes.

Traditional activities

Direct content Figure 11 plots the sectoral evolution of financial direct content for “Agriculture”, “Mining”, “Utilities”, “Construction” and “Manufacture”. At first, one can grasp that for most sectors there is a strong reduction in technical coefficients between 1995 and 1997. Over the whole period, direct financial content fell in at least 50%. Comparing our preferred and modified indicators, we have very small differences in terms of data trends. Nevertheless, the magnitudes involved are significantly higher in the later, being around 2 to 3 times greater.

For instance, “Agriculture” experienced a strong reduction of direct content between 1995 and 1997, going from 0.06 to 0.01 in our preferred scenario and from 0.15 to 0.04 in the modified set up. “Utilities” and “Construction” followed a similar trajectory with technical coefficients shrinking from 0.05 (0.13) and 0.08 (0.16), respectively, to 0.02 (0.05). The story is slightly different for “Mining” and “Manufacture” because those sectors presented a more continuous path. Our preferred measure indicates that, in the former, there is a steady reduction from 0.12 to 0.06 between 1995 and 2006, while in “Manufacture” coefficients fell from 0.06 to 0.03 during the same period. On the other hand, modified direct financial content points out to a reduction from 0.3 to 0.15 for “Mining”, and from 0.14 to 0.1 for “Manufacturing”.



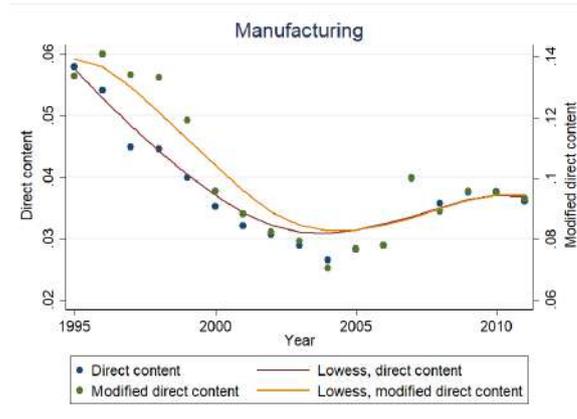
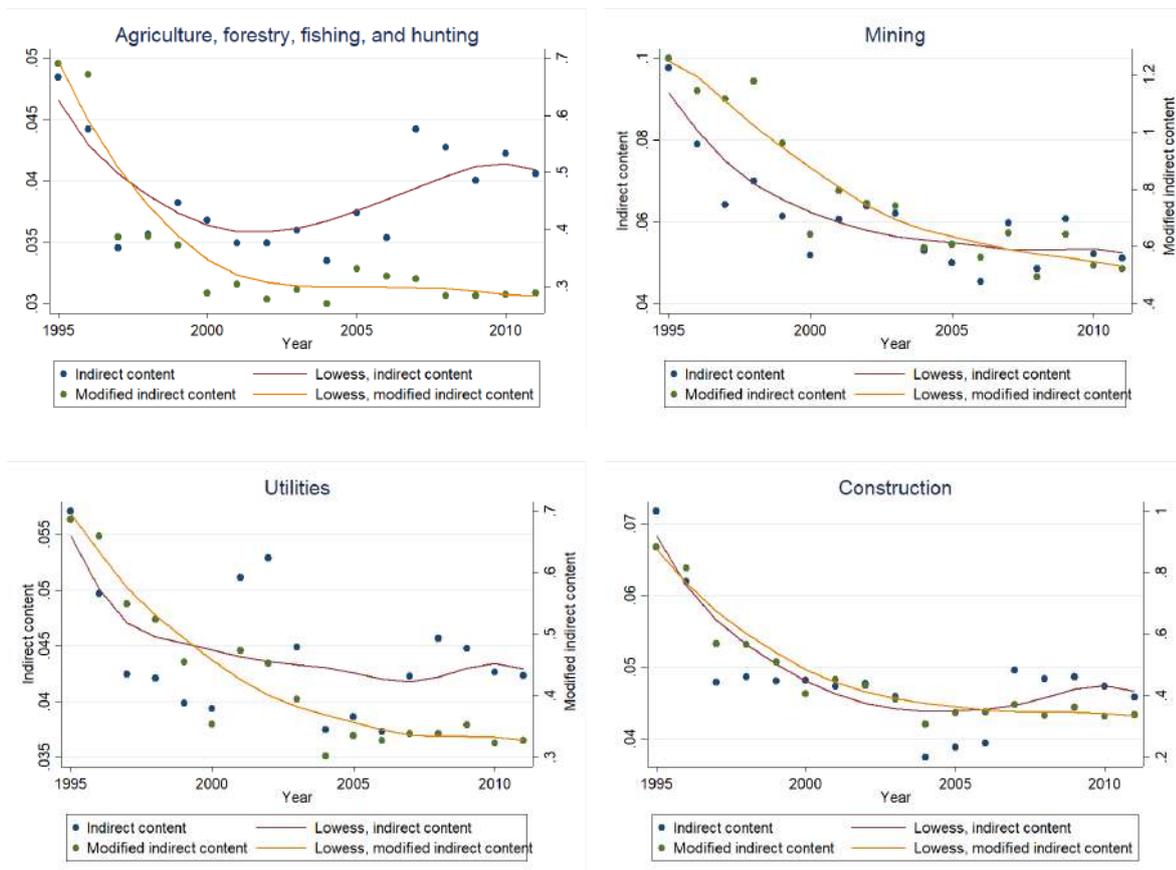


Figure 11: Direct financial content in traditional activities, Brazil

Indirect content Indirect content also depicted a negative trajectory for this group of industries. Once more, our two measures of indirect content deliver similar results in terms of trends though this is not the case for levels. Because of the interactions among sectors from the Leontief matrix, redistributing financial value-added as intermediate inputs significantly increases coefficients. In “Mining” and “Manufacturing” they are up to 10 times greater while in “Construction” this difference is even higher.



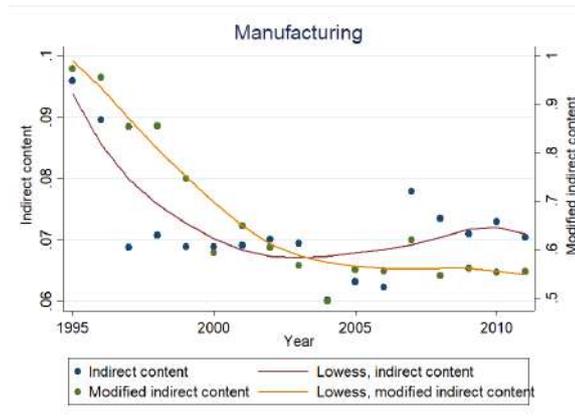


Figure 12: Indirect financial content in traditional activities, Brazil

Our preferred indicator fluctuates very little for “Agriculture” and “Utilities” with modest reductions from 0.05 to 0.04 and 0.055 to 0.045, respectively. Reductions are more substantial for “Mining”, “Construction”, and “Manufacture”. The first one went from 0.1 to 0.055, the second from 0.07 to 0.045 and the later from 0.1 to 0.07. Notice that there seems to be a convergence to values closer to the ones reported for the US, specially at the moment those sectors peaked. In terms of our second measure of financial content, reductions are more pronounced. “Agriculture” fell from 0.7 to 0.3; “Mining” went from 1.2 to 0.5; “Utilities” started close to 0.7 and by 2010 almost reached 0.3; “Construction” fell from 1 to 0.4; and “Manufacturing” experienced an almost linear reduction from 1 to 0.6 in the first ten years of the sample.

Penetration coefficient The ratio between indirect and direct content, here referred as the penetration coefficient, is reported in figure 13. This is the indicator where our two measures of financial content disagree the most. Despite the expected difference in levels, there is also trend divergence in some sectors. Lowess curves for our preferred measure show that in all sectors there is a increase in financial penetration. This is in odds with our modified indicator where such positive trend is observed in three out of five industries. The exceptions are “Mining” and “Manufacturing” that registered net decreases over the period of analysis.

Magnitudes are to some extent similar to those observed for the United States. In terms of our preferred financial content indicator, with the exception of “Mining” that presented only a small positive trend and values always bellow 1, all other industries showed a marked positive trend and values above 1. In “Agriculture” this coefficient jumped from 1 to 4, in “Utilities” it went from 1 to 2.5, in “Construction” it increased from 1 to 3, and finally for “Manufacturing” it rose from 1.6 in 1995 to 2.4 in 2004 and then fell back to 2. Recall that in these activities we reported a reduction in financial contents. Hence, the explanation for the increase in financial penetration lies in a stronger reduction of direct than of indirect content. That is, despite the reduction in financial technical coefficients, there was an increase in the interactions between sectors that attenuated this effect, making indirect content to fall less.

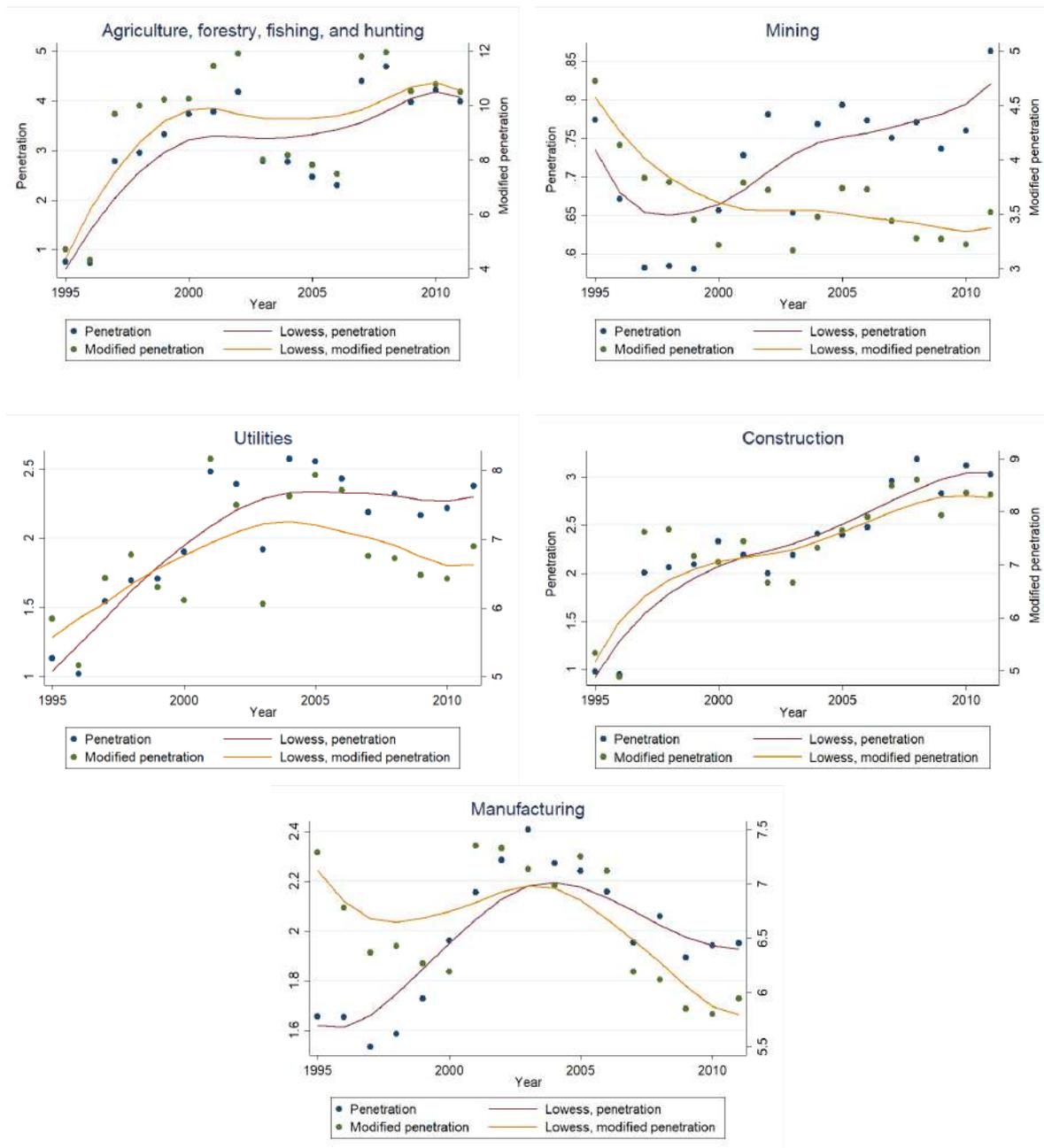


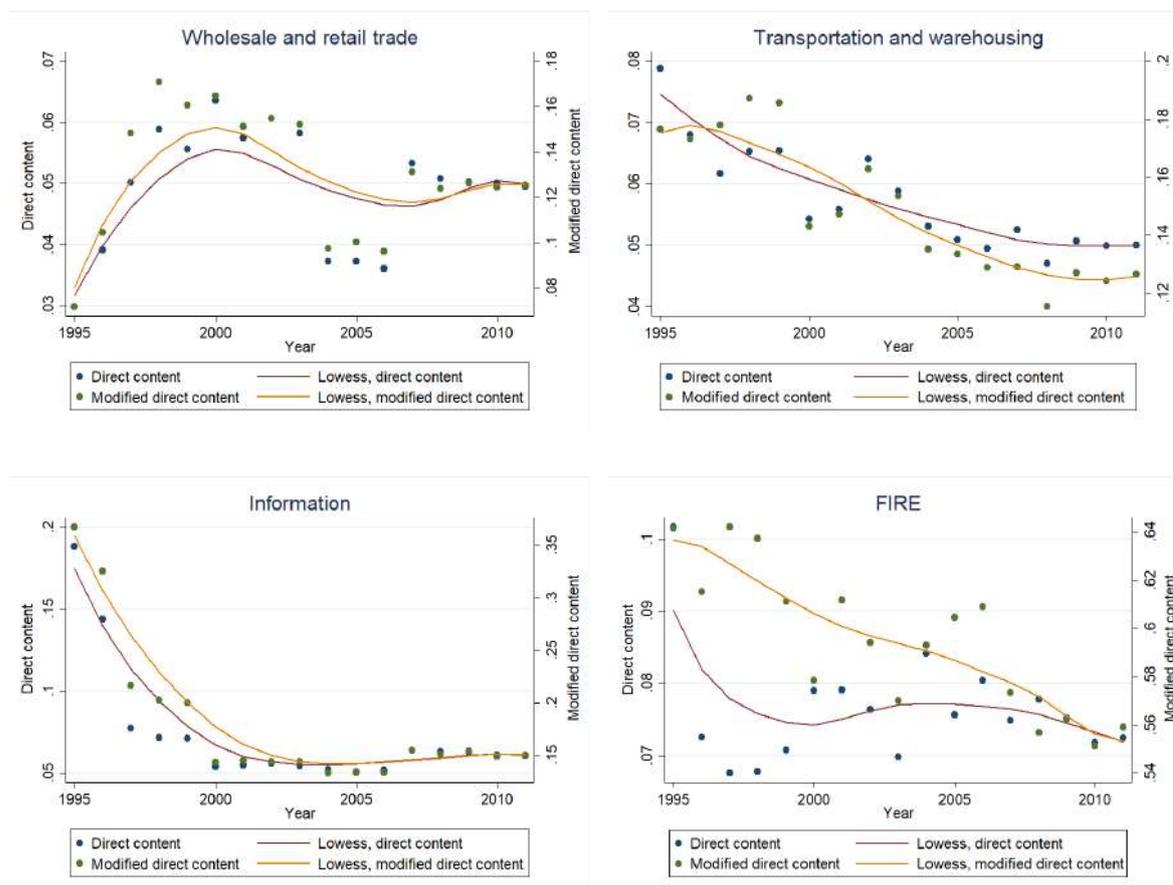
Figure 13: Penetration coefficient in traditional activities, Brazil

In terms of our modified measure, figure 12 showed that reductions of indirect content were more pronounced in comparison with our preferred scenario. A stronger reduction in indirect content explains why increases in financial penetration are not so intense in this case, as well why “Mining” and “Manufacturing” actually had a net reduction in penetration. The sector with the highest increase in financial penetration was “Agriculture”, with a coefficient that jumped from 4 to 10 in fifteen years. Less pronounced increases are registered for “Utilities”

and “Construction” with coefficients that went from around 5-6 to close to 7-8. On the other hand, “Mining” and “Manufacture” went in the opposite direction, dropping from 4.5 and 7 to 3.5 and 6, respectively.

Service activities

Direct content We proceed reporting financial content trajectories of the remaining nine industries. In general, we are able to observe strong reductions in direct and indirect content in the first two years of the sample. Six out of nine sectors presented such behavior. The three exceptions are “Wholesale and retail trade”, “Arts and entertainment”, and “GOV”. The first of them actually displayed an increase in direct content that went from 0.03 to 0.05 in our main set up. That corresponds to a net increase of more than 65%. We will come to this point later. The other two seem to follow an inverted-U path but considering the magnitudes involved one could make the case that they have been basically stable.



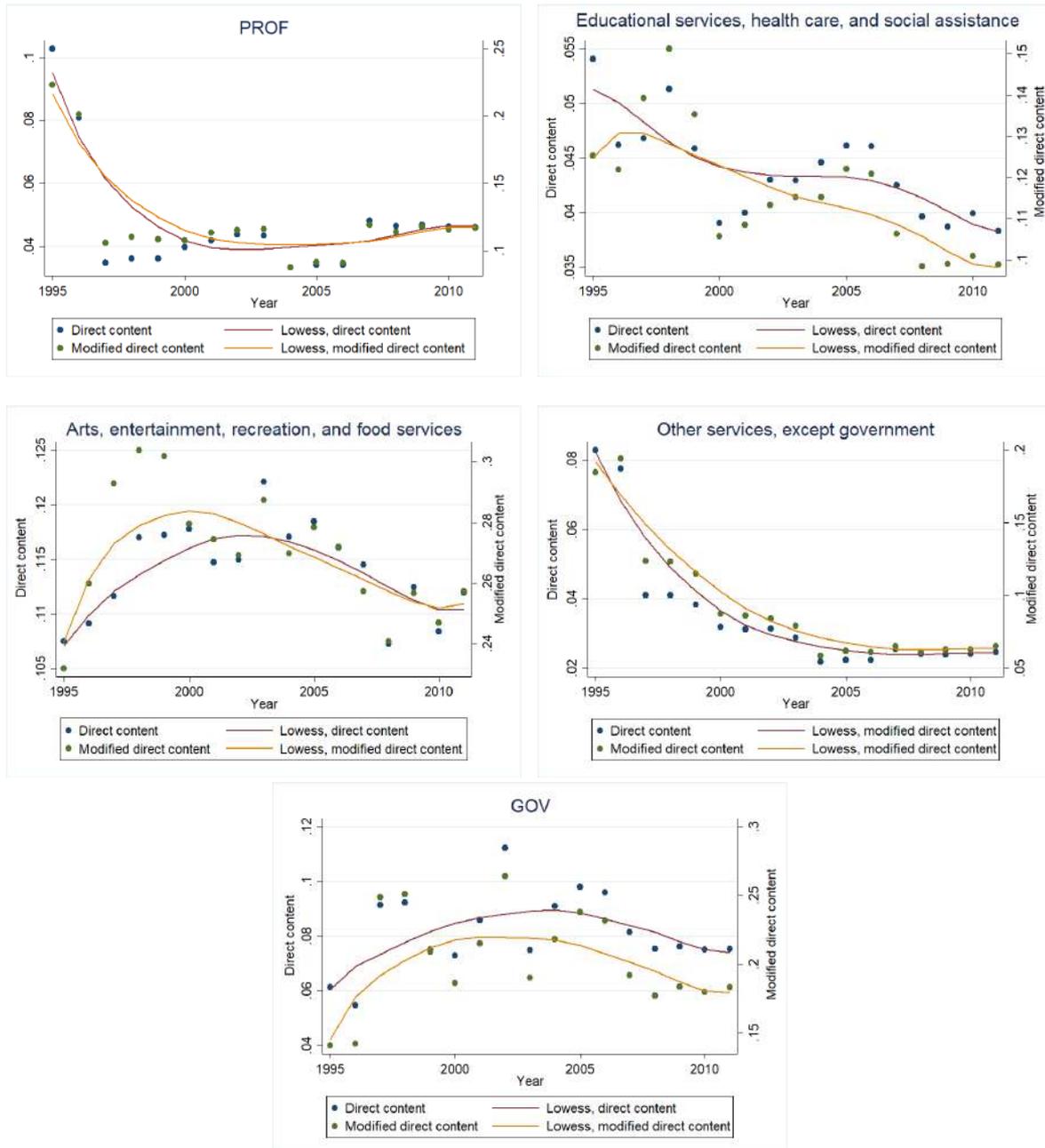


Figure 14: Direct financial content in service activities, Brazil

Focusing first on our preferred scenario, industries such as “Information”, “FIRE”, “PROF”, and “Other services” exhibited the strongest reductions of the group, with coefficients falling from 0.2 to 0.05, 0.1 to 0.07, 0.1 to 0.04, and 0.08 to 0.02, respectively. This does not mean that drops in other sectors were less significant. “Transportation and Warehousing”, for instance, started with values close to 0.08 that by the end of the sample were in the neighbourhood of 0.05. Finally, “Education” presented small variations. Still, a reduction from 0.05 to 0.04, for example, corresponds to a decrease of 20%.

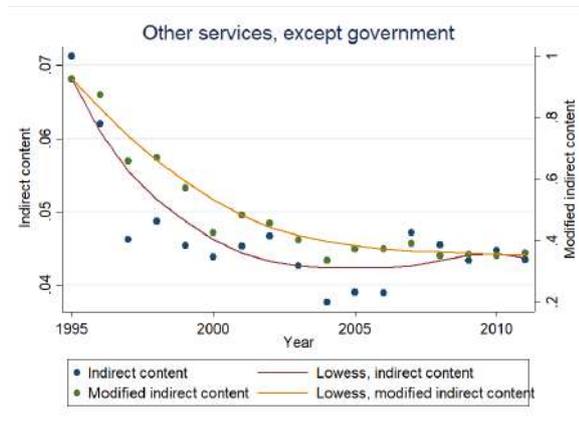
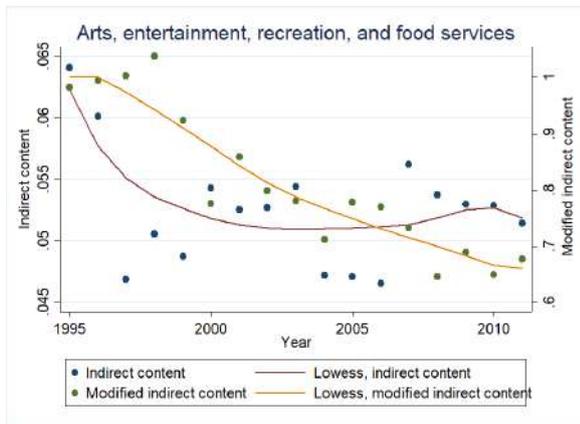
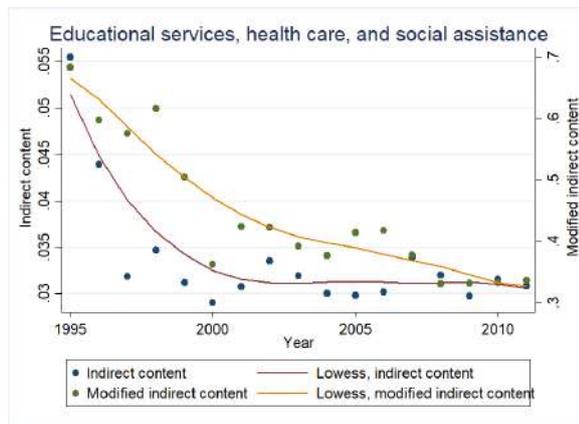
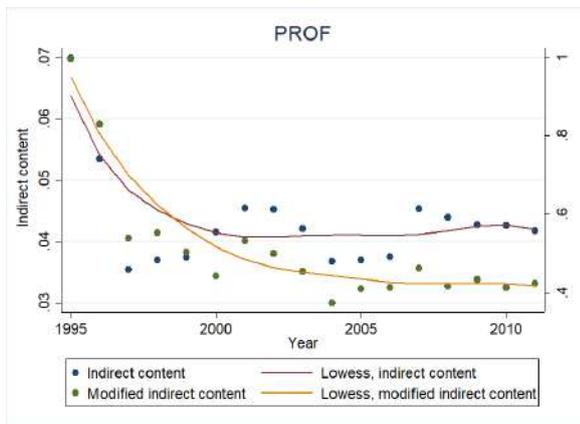
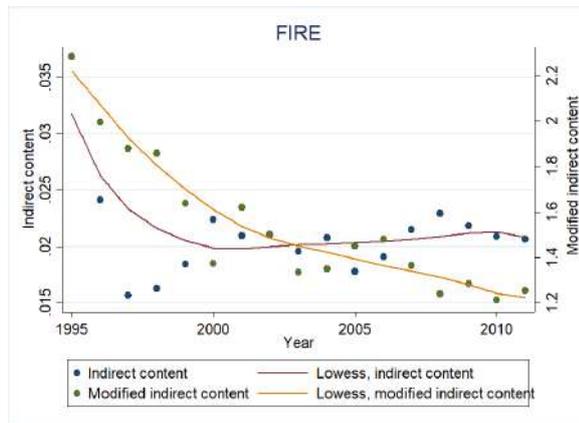
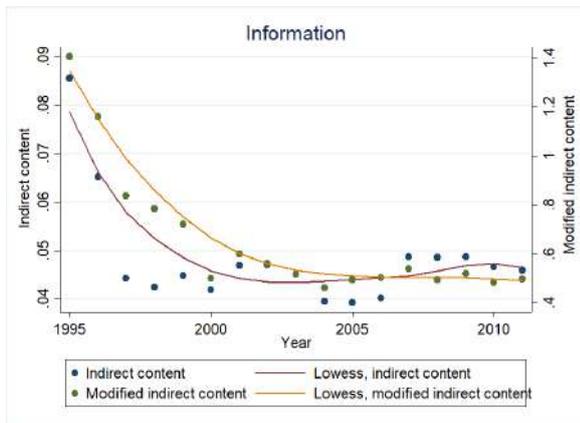
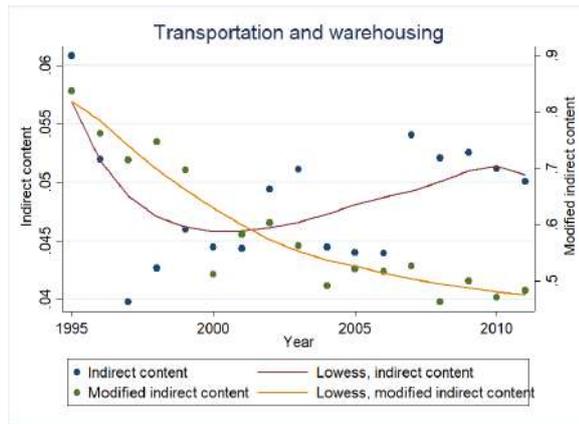
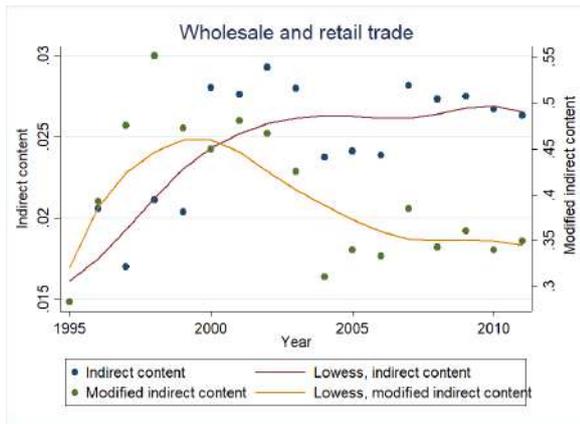
Magnitudes involved in our second scenario are greater though the main trends are preserved. For this indicator the strongest reductions were observed in “Information”, “PROF”, and “Other services”. In 1995, coefficients were 0.35 in the former, 0.25 in the second, and 0.2 in the later. By 2011 they were 0.15, 0.1, and 0.05, respectively. “Transportation and warehousing” follows with an important reduction in coefficients from 0.18 to 0.12. “FIRE” and “Education” close the list with smaller decreases. The former started in 0.65 in 1995 and continuously decreased to 0.55 in 2011. The later went from 0.13 to 0.1.

Indirect content It is possible to observe a marked decrease in indirect financial content in the first years of the sample. The two exceptions are “Wholesale and retail trade” and “Transportation and warehousing”. When we assessed direct content trajectories, the first of them was already reported to follow very particular dynamics. “Transportation and warehousing”, on the other hand, displayed divergence between our preferred and modified indicators. In the former there is initially a decrease in financial content that was partially compensated after 2000. However, the modified scenario indicates a continuous negative trend for the whole period.

Focusing first in our main measure of indirect content, no sector showed an initial value lower than 0.035, see “FIRE”, and most of them were close to 0.06 and 0.07. The financial sector also presented the lowest indirect content by 2011, equal to 0.02. Leaving aside “Wholesale and retail trade” and “Transportation and warehousing” - that actually experienced an increase or little change in indirect content - the remaining seven sectors have shown a reduction of indirect content on average of almost 40%.

Our second scenario depicts negative trends for all sectors but “Wholesale and retail trade”. In fact, this last industry also presented a small reduction after 2000 with its coefficient going from 0.45 to 0.35. However, from 1995 to 1999 there was actually an increase in financial content from 0.35 to 0.45 so that, over the whole sample, one could argue that its coefficient was quite stable. There seems to be some convergence in six out of eight of the remaining industries. “Transportation”, “Information”, “PROF”, “Art and entertainment”, “Other services”, and “Government” had very different starting points but by 2011 reached values close to 0.5. Finally, “FIRE” and “Education” also presented strong reductions going from 2.2 and 0.7 to 1.2 and 0.3, respectively.

Because magnitudes involved in our preferred set up are much lower, coefficients are more homogeneous across sectors, and it is not clear if they are indeed converging to a certain value. Still, it is worth noting that “Information”, “Arts and entertainment”, and “Other services” went from 0.08, 0.06, and 0.07, respectively, to a common value close to 0.05. Indirect content in “FIRE” was 0.03 in 1995 and went to 0.02 by the end of the sample. Continuing, “PROF” experienced a reduction from 0.065 to 0.04 while “Education” and “GOV” went from 0.05 to 0.03. In any case, both direct and indirect financial content coefficients seem to suggest that the Brazilian economy has actually experienced a reduction in financial content since 1995.



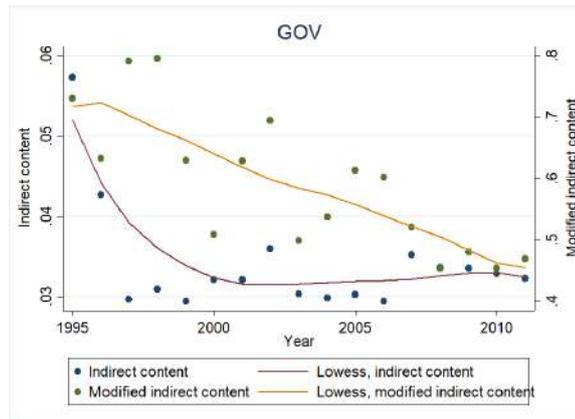
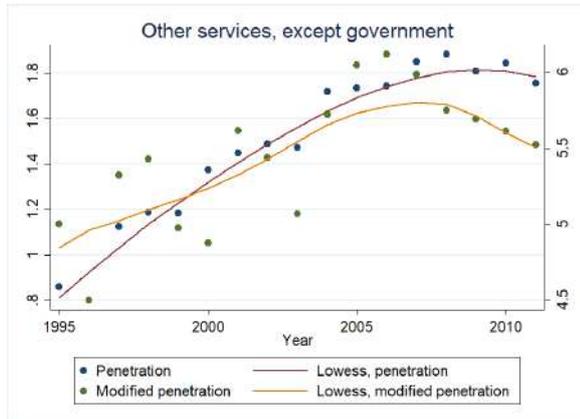
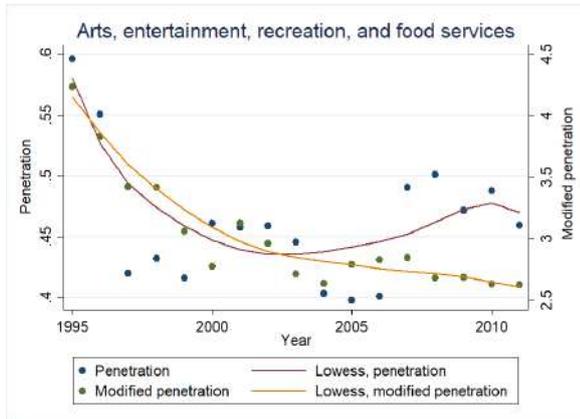
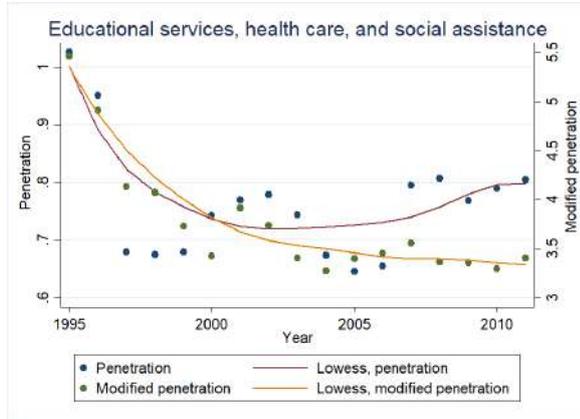
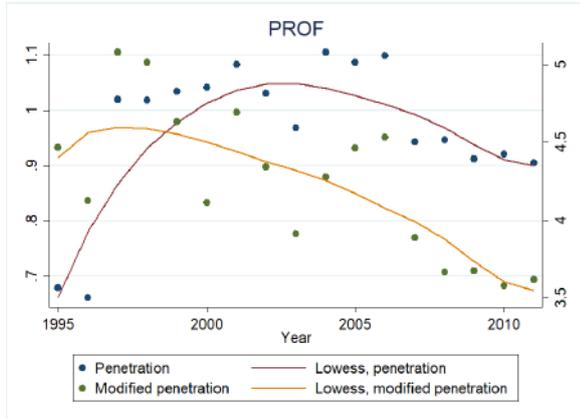
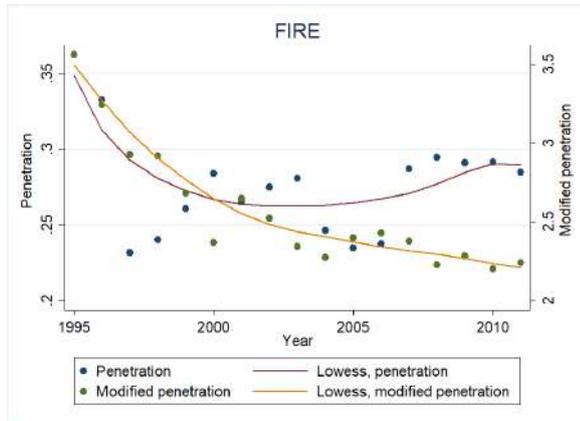
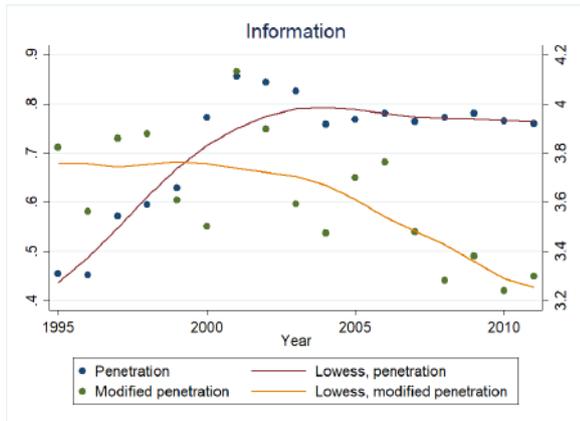
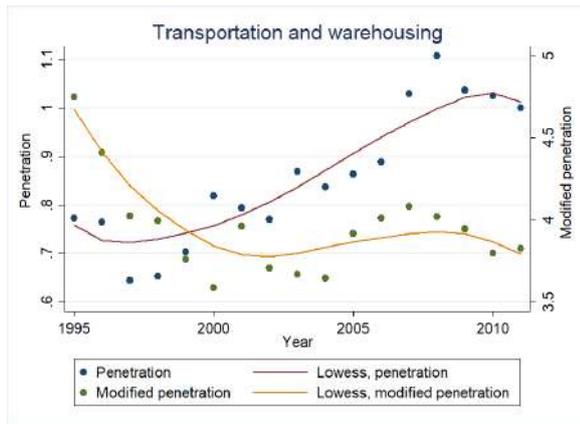
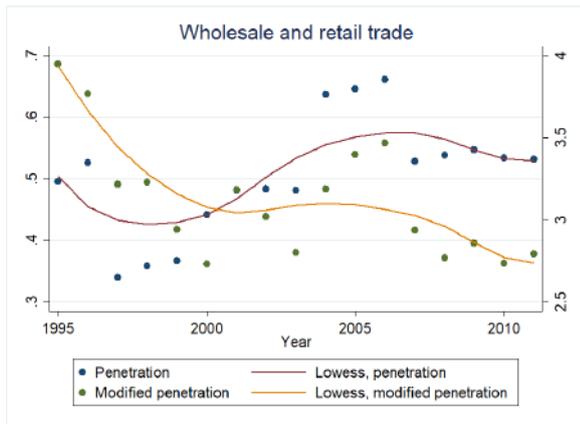


Figure 15: Indirect financial content in service activities, Brazil

Penetration coefficient Looking now to the penetration coefficient, figure 16 indicates some sort of mix behaviour. On the one hand, there is a mix of sectors that experimented an increase or reduction in financial penetration. On the other hand, in some industries, our preferred and modified scenario also deliver different trends. This last situation has already appeared when investigating traditional activities. It seems to be related to the fact that, in the modified set up, we have strong continuous negative trends for indirect content. In fact, with the exception of “Other services”, all industries exhibited a reduction in financial penetration. The smallest decrease is reported in “Information” with its coefficient going from 3.8 to 3.2. The greatest reduction corresponds to “Transportation” and “GOV”, where financial penetration fell by 50%.

If instead we use our main indicators of financial content, sectors can be divided in two sets. A first subgroup formed by “Transportation and Warehousing”, “Information”, “PROF”, and “Other services” have shown an increase in financial penetration that in most cases was concentrated in the first years of the sample. This follows direct content going through a stronger reduction than indirect content between 1995 and 1997. The remaining sectors show smaller increases with coefficients often below 1.

“Wholesale and Retail”, “FIRE”, “Arts and Entertainment”, and “GOV” close the list with opposite trajectories. “Arts and entertainment” coefficient fell from 0.6 to 0.45 between 1995 and 1997 fluctuating around that last value afterwards. “GOV” shows a more dramatic reduction going from values close to 1 to something around 0.4. Furthermore, “Wholesale and Retail” and “FIRE” basically do not move, fluctuating around 0.5 and 0.3, respectively. Comparing the first group of traditional with the second of service activities, once more we have that the former exhibited in general higher financial penetration.



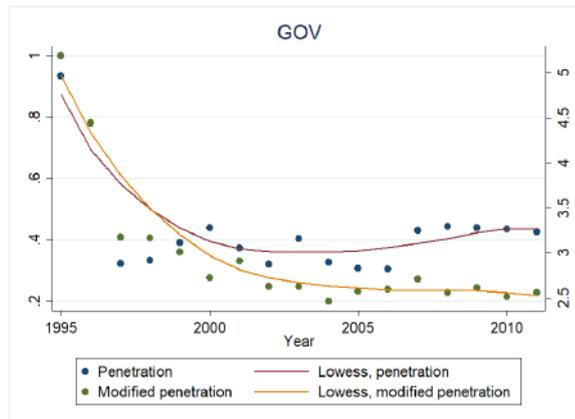


Figure 16: Indirect financial content in service activities, Brazil

Traditional sectors display higher financial penetration also in our modified set up. In the previous subsection we showed this to be the case for the United States. Brazil has smaller financial penetration in levels but the ratio between indirect and direct content in traditional industries is still 2 to 3 times greater than in services. Notice that, by the end of the sample, no service industry had a coefficient above 5 while in traditional industries, with the exception of “Mining”, financial penetration was always above that threshold.

Aggregate results

At an aggregate level, figure 17 presents a significant negative trend for financial content from 1995 until 2000-05 with stability afterwards. Trajectories are pretty much the same between our preferred and modified measures which gives some robustness to our analysis. The main difference is the continuous decline of indirect content in the modified set up that also seems to be determinant to the observed divergence between scenarios in terms of financial penetration. This is more clear when we directly compare lowess curves.

In our basic framework, direct content fell from 0.07 in 1995 to 0.045 in 2004, becoming relatively stable afterwards. On the other hand, indirect content followed closely direct technical coefficients going from 0.065 to 0.045. Such changes indicate a reduction of near 35% in financial content. Continuing, in the first three years of the sample, decreases of direct content were slightly weaker than of indirect content, explaining the initial reduction in the penetration coefficient, as we can see in figure 18. From 2000 onwards, both have varied at similar speed though there is a small positive trend. By the end of the sample, financial content in Brazil was 1.1 indicating that Brazilian production structure basically amplifies direct content in a proportion of one to one.

As previously discussed, our second scenario delivers similar trends though magnitudes involved are different. In fact, financial direct content in Brazil shrank from 0.22 to 0.16 between 1995 and 2011. Basically all this reduction happened before 2005 with coefficients

remaining basically constant afterwards. Moreover, indirect content went from 1 to 0.5. In this case, reductions were more continuous over time though still concentrated in the period before 2005. Overall, we have a reduction in financial content of 30% and 50%, respectively.

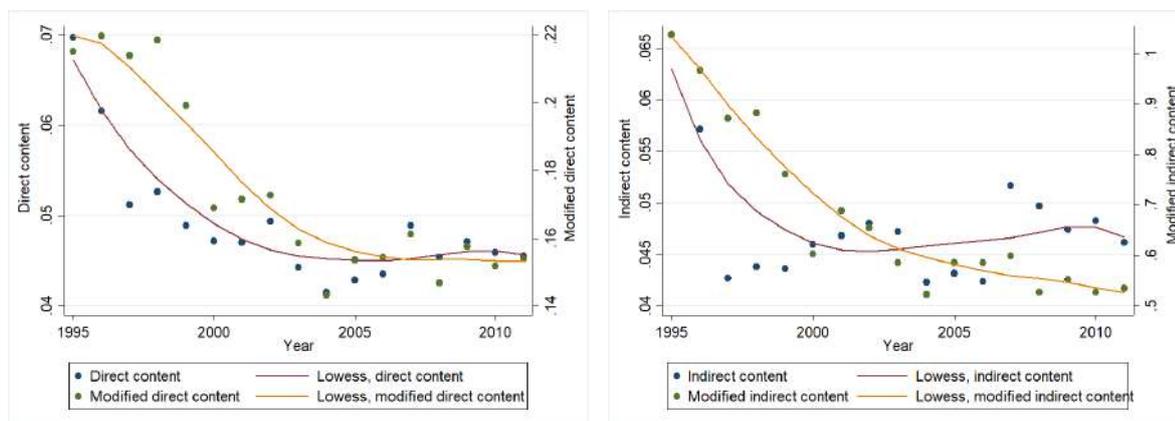


Figure 17: Aggregate direct (left) and indirect (right) financial content, Brazil

Given that no industry actually shows a continuous positive trend in financial content, it is not possible to refer to a financialisation process in Brazil in the terms put forward in this essay. Furthermore, one still have to find an explanation for these reductions. While in the United States an increase in financial content could be related to the dynamics of interest payments, we do not think this to be the case for Brazil because firm indebtedness has been historically relatively low in this country. A decrease in financial content, specially in the first two years of the sample, could actually be explained by the control of inflation that followed “Plano Real”.

Bruno et al (2011) argued that during the years of high inflation, Brazil developed an inflationary financial-monetary regime in which an increase in inflation rates was associated with a greater share of the financial sector in GDP. Under high or explosive increases in prices, firms and consequently productive activities needed specific financial services to protect themselves against inflation. After 1994, these were not necessary any longer, explaining the observed reduction in financial content of production.

In fact, in 1995 the government released the “Programa de Estímulo à Reestruturação e ao Fortalecimento do Sistema Financeiro Nacional”(PROER) in order to avoid a collapse of Brazilian financial system as a result of the control of inflation. At the time, several banks were specialised in using the institutional mechanism of monetary correction and price indexation to make profits. Hyperinflation was also used to cover illegal operations and balance sheet issues. Once prices were under control, some of them faced severe problems and were about to break. PROER divided those institutions between “good” and “bad” allowing the former to be purchased by another bank while the later were liquidated by the Central Bank.

There are not many surprises in terms of financial penetration in Brazil. In our preferred scenario, coefficients have been quite stable though there is a small reduction until 1997 followed

by a slight increase afterwards. Using our modified indicators of financial content, we obtained a negative trend during the whole sample that was driven mainly by a reduction in indirect content. Financial penetration in this last case decreased by approximately 25% going from 4.5 to 3.5 between 1995 and 2011.

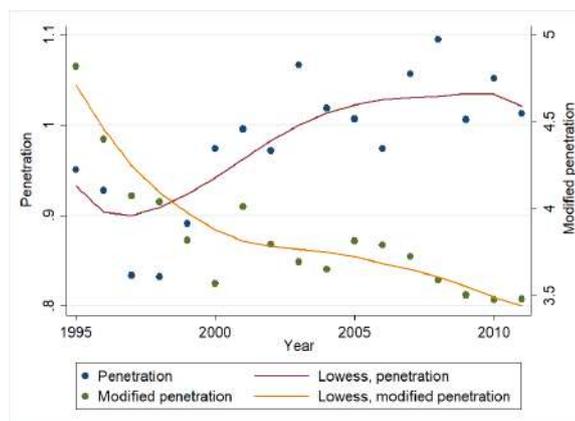


Figure 18: Aggregate penetration coefficient, Brazil

At this point, we can also make some caution comparisons between Brazil and the United States. One should keep in mind that we are dealing with very different economic systems and also the time span of our analysis is different between the two of them. Still, some patterns appear. For example, Brazil's direct financial content in 2010 was very similar to the US in 1950 while the US in 2010 approximates Brazil in 1995. A similar situation occurs in terms of indirect content, regardless if we are in the preferred or modified scenario. In the light of the concepts developed in this chapter, Brazil is not going through a financialisation process, but the financial sector used to be as important as it is to the US nowadays after at least 35 years of financialisation.

Backward and forward linkages reinforce the main conclusions described so far. Let's begin with our preferred measures of financial content. On the one hand, backward linkages show some stability for the whole sample, fluctuating around 1.4 as depicted in figure 19 (left). On the other hand, forward linkages exhibited a decline trend between 1995 and 2001 followed by a period of relative stability. Still, forward linkages were reduced almost 50% between 1995 and 2011.

Figure 19 on the right reveals trajectories when we set financial value added to zero so that financial total output equals the sum of inputs used by the financial sector. In this case we obtain a negative trend for both backward and forward linkages, basically for the whole sample. Still, notice that decreases in forward linkages are much stronger with coefficients going from 18 to 10. This contrasts with reductions in backward linkages that went from 6 to 5 in fifteen years. The same figure also reports the respective lowess curves. The financial sector in Brazil has proved to be a follower more than an inducer. Furthermore, its response to an stimulus

from other sectors has been reduced over time. That is, the financial sector has become less sensible to changes in output from other sectors.

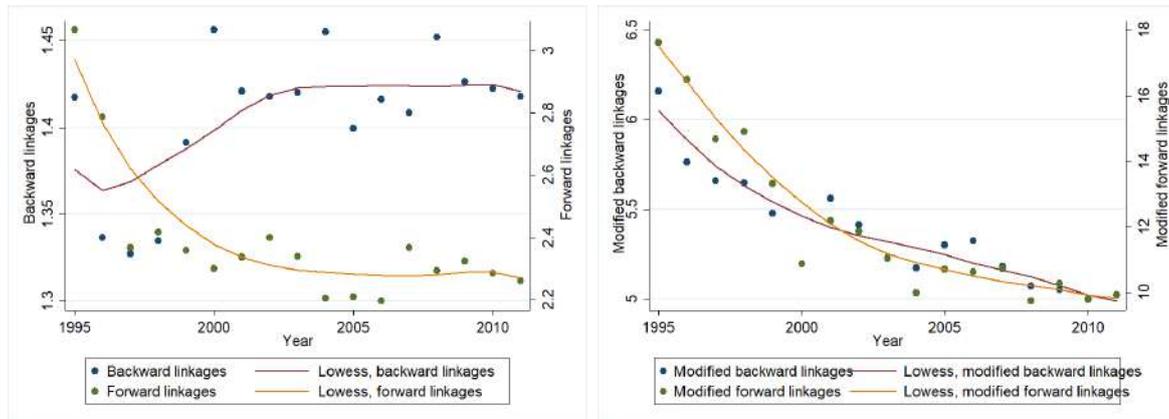


Figure 19: Backward/forward linkages (left) and index (right), Brazil

Vertical integration

We proceed investigating if there have been important modifications in how financial activities are distributed among sectors. For instance, an increase in financial vertical integration could also suggest an increasing separation with the real side of the economy. As we will see, this is not the case. Three interesting features can be extracted from figure 20.

First, “Manufacture” heavily concentrates financial intermediation with a share of 50% of “FIRE”, similar in magnitude to the United States in the 1950s. Financial content in manufacture activities remained constant the whole period despite the ongoing and well known deindustrialisation process visible both in employment and GDP statistics. Secondly, “Wholesale and retail trade” have experienced an important increase in a two-waves process, going from 1% to almost 10% of financial intermediation. The first wave can be attributed to the increase in consumption that followed the control of inflation while the second wave coincides with the expansion in consumption during the Labour Party governments.

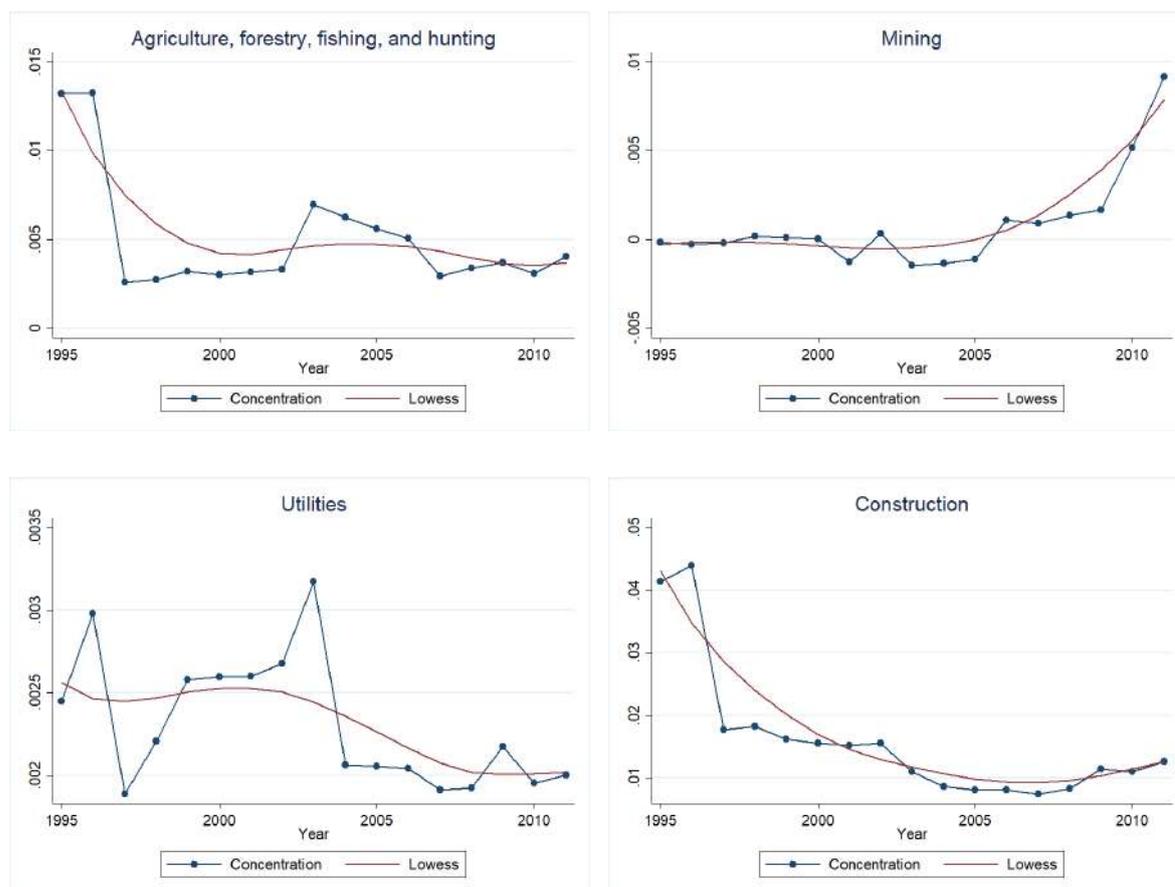
A reduction in inflation and the expansion of credit and consumption during the Labour Party administration help to explain the increase in financial content reported for “Wholesale and retail trade”. In fact, while direct and indirect coefficients fell for all other industries, “Wholesale and retail trade” increased in two waves. The first started in 1995 and lasted until 2000 with financial content basically doubling its figures. From 2003 to 2006 those coefficients dropped in our main set up from 0.06 to 0.04 for direct content, and from 0.03 to 0.025 for indirect content. A second wave started in that moment with a recover of financial content per unit of output.

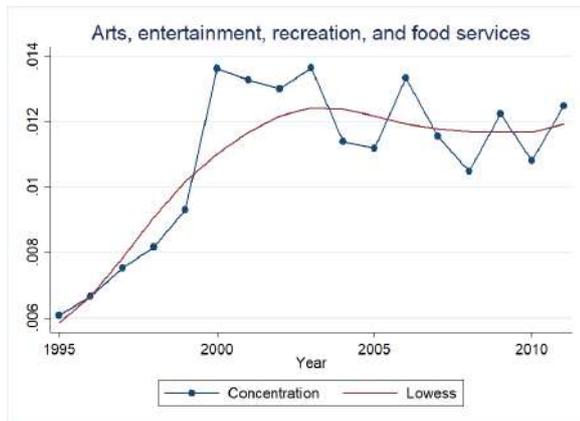
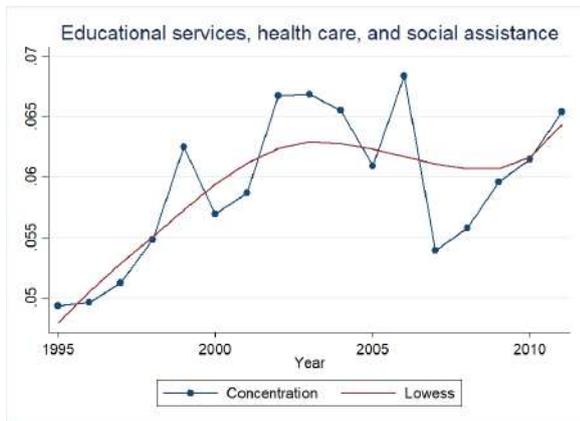
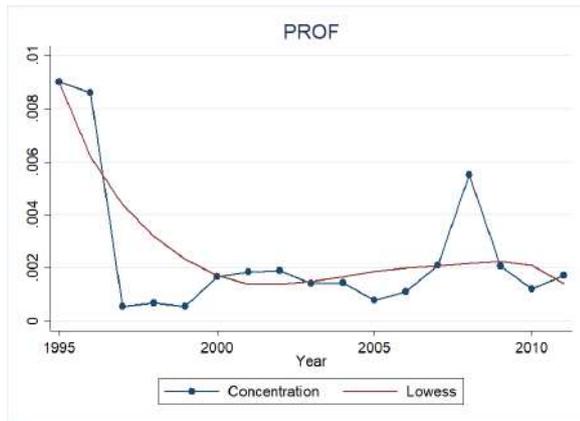
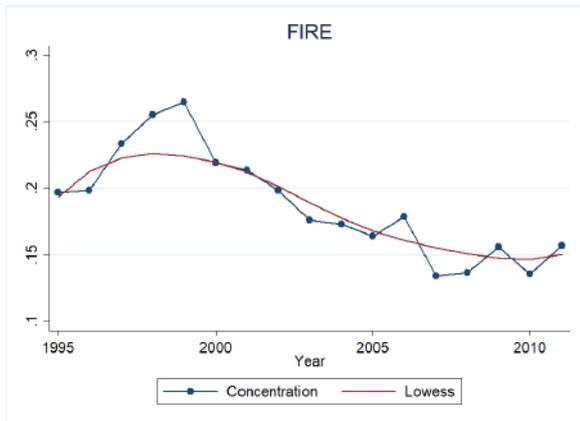
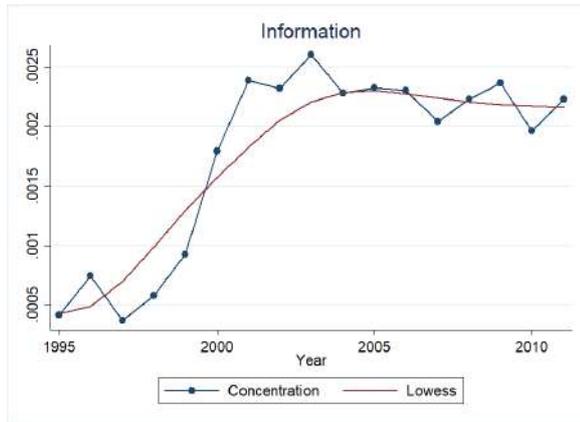
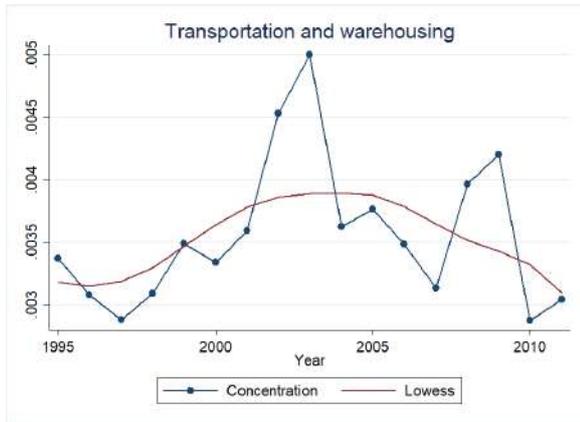
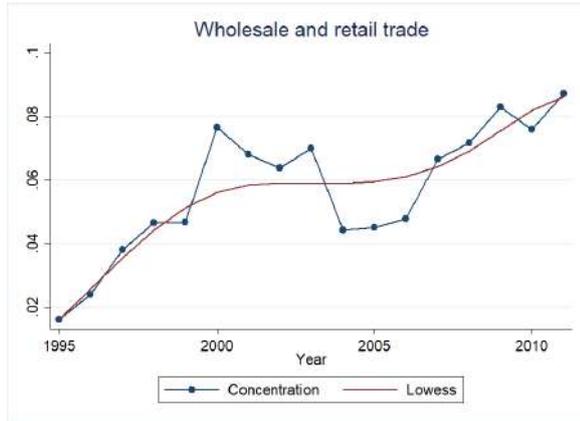
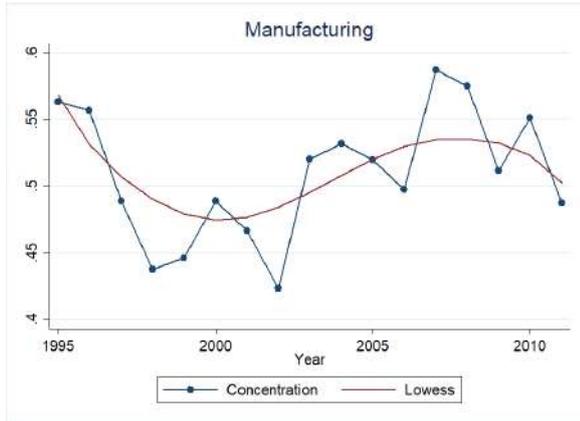
We would like to emphasise a third characteristic that deserves special attention and corresponds to the “Mining” sector. Until 2005, its share was negative or close to zero basically because final demand in this sector was negative. The reason for this is that sectoral imports

where higher than the sum of consumption, investment and exports. The situation changed after 2006 with the boom of commodities and the autonomy in oil production gained in the same period. As a result, there has been an important increase in the share of financial activities going to “Mining” even though it continues to be relatively small.

These last results indicate the financial sector still heavily relies on traditional activities such as manufacture and has responded positively to consumption and natural resources booms. Surprisingly, after a brief increase in the first years of the sample, “FIRE” showed a reduction in the level of vertical integration of the branch from 25% to 15% that contrasts with the inverse trend in the United States.

Straightforward comparisons between Brazil and the US are possible in this case because, as demonstrated in section 2, our concentration indicator does not depend on the price index. Hence, two observations follow. First, notice that in the two countries there is an increase in the share of financial activities that go to government services. However, the magnitudes involved in Brazil are much higher. By 2011, around 15% of “FIRE” went to “GOV” in Brazil contrasting with less than 10% in the US. Secondly, financial intermediation on “Education and health” did not change significantly in Brazil after 1995. This also contrasts with the US that exhibited a continuous increase. By 2011 it was almost three times greater than in Brazil.





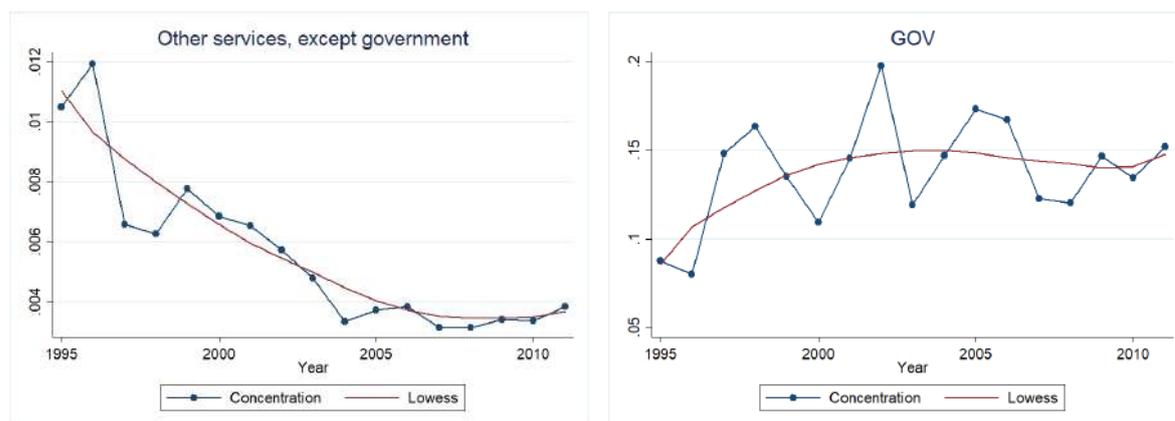


Figure 20: Concentration and sectoral distribution of FIRE

We conclude this subsection emphasising our main results:

- Decrease in financial content or “De-financialisation” associated with Plano real and the control of inflation;
- In terms of financial content, Brazil in 2010 was very similar to the US in 1950 while the US in 2010 shares features with Brazil in 1995;
- Financial vertical de-integration;
- No clear patterns in terms of financial penetration;
- Higher financial penetration in traditional activities relative to services;
- Stable backward linkages that contrast with decreasing forward linkages;
- The financial sector heavily relies on traditional activities such as manufacture and has responded positively to consumption and natural resources booms;

1.5 Final Considerations

The recent financial crisis has reminded us that financial markets and intermediaries have crucial effects on the real economy. From a multi-sectoral perspective, the financial sector matters precisely because it connects the entire productive structure through financial intermediation. The interconnection between financial and non-financial industries is one of the mechanisms through which the strengths and vulnerabilities of economic activity are transmitted. Hence, understanding how those interdependencies vary across sectors and time is important to a better comprehension of the financialisation process itself.

This chapter presented a multi-sectoral assessment of financialisation based on Input-Output analysis. Our contribution joins other efforts to provide integrated financial information at the sectoral level in order to assess the relationship between real and financial sides of the economy. We conceptualised financialisation as *an increase in the financial content in monetary terms of each unit of output produced*. Such definition allowed us to introduce a structure that can be employed to study different varieties and financialisation paths.

Using a 15 and 14-sector level of aggregation, our conceptualisation was applied to the United States and Brazil for the period 1947-2015 and 1995-2011, respectively. In the US, our results show that once we move on to a more disaggregated set up two different dynamics emerge. First, traditional activities such as agriculture, mining or manufacture presented an inverted-U relationship with a reduction in their financial content in recent decades. This contrasts with service industries in which there is basically a positive trend for the whole sample that increased its slope after the 1980s. Therefore, current financialisation has been a phenomenon mainly of the non-tradable sector or service-led.

This last finding is particularly interesting if we consider that a service-led type of financialisation fits in a context marked by the rise of internet and the use of personal computers. More recent developments such as machine learning are introducing deep changes in the logistics of business. Overall, the information revolution is deeply related to the development of financial markets and our indicators seem to capture this transformation, at least in the United States.

Moreover, the financial sector has increased the vertical integration of the branch. The production process that takes place entirely within itself has grown from 20% to almost 60% in the last fifty years. The evidence provided gives some support to the idea of an increasing separation of the financial from the real sides of the economy in the US. In the light of Minskyan theories of the financial cycle, this could be related to an increase of financial fragility. We consider that further research in that direction is required.

Aggregating the economy, we are able to reproduce well know results. For instance, it is evident that the 1980s stand as a major structural break with an increase in the slope of the financialisation process. It is also clear that the dot-com bubble and the financial crisis of 2007 have left an important mark in the US productive structure. Overall, direct and indirect coefficients have double in the last fifty years indicating that financial content per unit of output has increase by 100%.

On the other hand, Brazil did not exhibit an increase in the financial content of its production. On the contrary, most sectors showed a reduction in their financial content especially between 1995 and 1997. This can be explained by the control of inflation that followed the macroeconomic stabilisation plan “Plano Real” which diminished the need of financial instruments for protection against inflation. Furthermore, the financial sector still heavily relies on traditional activities such as manufacture and has responded positively to consumption and natural resources booms. Still, there is some degree of heterogeneity among sectors that emphasises the importance of the analysis at a more disaggregated level.

Our results also contrast differences in terms of backward and forward linkages for both countries. In terms of levels, forward linkages are greater than backward ones reinforcing the

intuition that this sector is a follower more than an inducer. Furthermore, forward links also exhibited opposite trends for Brazil and United States. In terms of our preferred scenario, the former experienced an important reduction from 3 to 2.2. The later shows an increase of the indicator from 2 to 3. Backward linkages were much more stable fluctuating around 1.4 and 1.5.

While there are still many questions left unanswered, we have aimed in this chapter to provide a different starting point to an intensively studied topic. For instance, it will be interesting to understand the implications of changes in financial content per unit of output in terms of economic growth, income distribution, and other sectors of the economy. A further step in that direction is given in the next chapter, where we investigate the relationship of finance and manufacture activities.

Appendix

The following correspondence is established between OECD and BEA IO tables:

OECD	BEA
Agriculture, hunting, forestry and fishing	Agriculture, forestry, fishing, etc
Mining and quarrying	Mining
Food products, beverages and tobacco	Manufacturing
Textiles, textile products, leather and footwear	Manufacturing
Wood and products of wood and cork	Manufacturing
Pulp, paper, paper products, etc	Manufacturing
Coke, refined petroleum products, etc	Manufacturing
Chemicals and chemical products	Manufacturing
Rubber and plastics products	Manufacturing
Other non-metallic mineral products	Manufacturing
Basic metals	Manufacturing
Fabricated metal products	Manufacturing
Machinery and equipment, nec	Manufacturing
Computer, Electronic and optical equipment	Manufacturing
Electrical machinery and apparatus, nec	Manufacturing
Motor vehicles, trailers and semi-trailers	Manufacturing
Other transport equipment	Manufacturing
Manufacturing nec; recycling	Manufacturing
Electricity, gas and water supply	Utilities
Construction	Construction
Wholesale and retail trade; repairs	-
Hotels and restaurants	Arts, accommodation, food etc
Transport and storage	Transportation and warehousing
Post and telecommunications	Information
Financial intermediation	FIRE
Real estate activities	FIRE
Renting of machinery and equipment	FIRE
Computer and related activities	PROF
R&D and other business activities	PROF
Public admin. and defence	GOV
Education	Educational services, health care, etc
Health and social work	Educational services, health care, etc
Other community, social and personal services	Other services, except government

Chapter 2

Manufacture Content and Financialisation: An Empirical Assessment

2.1 Introduction

Structural change is a term that has also been used loosely in the economic literature depending on the issue being studied. Even though a precise concept varies across analysis, the shared premise is of a shift or change in the basic ways the economic system functions or operates. It involves the study of the effects of the incorporation of new technologies and infrastructures, aspects of international economic integration and development, changes in the sectoral configuration of the economy and income distribution, instability and crisis, etc.

In recent decades, advanced countries have undertaken a process of industrial transformation and structural change characterised by an increasing importance of service sectors and a declining weight of manufacturing activities (Castellacci, 2010). The rise of services may be considered one of the main characteristics of the establishment of the so called “knowledge economy” (Ciriaci and Palma, 2016, p. 55). Although it dates back to early 1940s, the hypothesis that economic development passes through a binomial deindustrialisation-tertiarisation has reemerged in recent debate. It does not take much to see this relationship. If the relative importance of primary activities such as agriculture or mining remains constant over time, an eventual rise of services must be followed by a decline in manufacture. In any case, services are re-shaping economic fundamentals, from the demand and supply sides (Peneder et al, 2003; Montresor and Marzetti, 2010).

As previously discussed in chapter 1, a popular and effective way of investigating structural change over time is making use of the Input-Output (IO) framework because it is a unique and rich representation of the economic structure (Ciobanu et al, 2004). The use of IO techniques in the analysis of structural change is as old as the discipline itself and goes back to Leontief (1941) and Chenery (1960). In this respect, Structural Decomposition Analysis (SDA) - understood as “the analysis of economic change by means of a set of comparative static changes in key

parameters in an input-output table” (Rose and Chen, 1991, p. 3) - has consolidated itself as a way of distinguishing major sources of change in an economy.

Among service activities, one in particular has received perhaps limited attention in the IO/SDA literature despite its importance for the functioning of the entire economic system, namely, the financial sector.¹ We started this dissertation proposing to conceptualise financialisation as “*an increase in the financial content in monetary terms of each unit of output produced*”. Following the SDA literature, our analysis was based on the identification of changes in technical coefficients across sectors in the IO tables. An application of this conceptualisation to the United States (US) between 1947 and 2015 points out to significant increases of financial content per unit of output, specially in the service sector.

On the other hand, when it comes to manufacture activities, several studies have reported a reduction in the respective technical coefficients indicating that, for developed countries, manufacture content has been declining over time (e.g. Feldman et al, 1987; Driver, 1994; Peneder et al, 2003; Franke and Kalmbach, 2005; Savona and Lorentz, 2006). This reduction is at the core of recent contributions that study deindustrialisation and tertiarisation processes using the IO framework (e.g. Montresor and Marzetti, 2011; Ciriaci and Palma, 2016; Peneder and Streicher, 2017). Extending to the manufacture sector our conceptualisation of financialisation, a reduction in manufacture content per unit of output could be seen as a footprint of deindustrialisation itself.

The United States has experienced after WWII a process of structural change characterised by an increase in financial content and a reduction in manufacture content per unit of output produced. In this essay we argue that both phenomenon are related. It is our purpose to identify the nature of this relation. Our analysis is limited to the US because the Brazilian economy does not exhibit a significant variation neither in financial nor manufacture content.

Using a 15-sector level of aggregation, we begin studying the evolution of manufacture technical coefficients between 1947 and 2015. We proceed applying cointegration techniques to the relation between a single aggregate measure of manufacture and financial content. Three models are estimated, namely, a Vector Error Correction (VEC), a Fully Modified Ordinary Least Squares (FMOLS), and a Dynamic Ordinary Least Squares (DOLS). There is a negative long-run relationship between both series such that, in our preferred scenario, an increase of one unit of the financial sector’s technical coefficient is associated with a reduction of two units in manufacture’s coefficient. Moreover, Granger causality test indicates that causality goes from financialisation to manufacture content. Given that we are referring to predictive causality our estimates indicate that the increase in financial content happens first and predicts the reduction in manufacture content that follows.

Finally, building on Autoregressive Distributed Lag (ARDL) modeling, Pooled Mean-Group (PMG) estimation methods are used to confront disaggregated series in a heterogeneous panel. Estimates support the hypothesis that there is a long-run relationship between both series. Our panel regressions show that an increase of one unit of direct financial content decreases

¹Two remarkable exceptions are Leung and Secieru (2012) and Aray et al (2017). For recent applications of SDA see Toh and Thangavelu (2013) and Incera (2017).

direct manufacture content in 0.4 – 0.6 units. To the best of our knowledge, we are the first to perform an exercise of this type. Furthermore, panel Granger causality tests confirm our previous findings, suggesting that financialisation predicts the decline in manufacture content.

The chapter is organised as follows. In the next section we present the sectoral evolution of manufacture content for the US economy providing some motivation to the relationship we are about to study. Section 3 brings our cointegration exercise using a single aggregate measure for manufacture and financial technical coefficients. In the next section, we present results of the heterogeneous panel ARDL based analysis. Overall results are discussed in section 5. Some final considerations follow.

2.2 Assessing manufacture content

If the relative importance in production of primary activities such as agriculture or mining remains constant over time, an eventual rise of services must be followed by a decline in manufacture. In that sense, deindustrialisation and tertiarisation processes can be understood as different sides of the same phenomenon. Different explanations are found in the literature for the dynamics behind this relationship that in general point out to the role of outsourcing, changes in relative prices, Bell’s Law, productivity gains, etc (e.g. [Rowthorn and Coutts, 2004](#); [Palma, 2008](#)). Still, those explanations do not refer specifically to how the financial sector enters the story.

A possible way to do it and that will be further discuss here and in the next chapter is the following. In an increasingly integrated world economy, international competition between firms has increased as global markets expanded and integrated after World War II. Competition has forced firms to operate in a state of constant innovation and flexibility.² To keep profit margins, they have pursued either product differentiation – with the creation of new goods, branches and markets – and/or cost reductions – moving production abroad to low-wage countries. In the first case, there has been a systematic reallocation of jobs and value-added towards high-skill intensive service sectors. This movement has been labelled by some authors as “Skill Biased Structural Change” ([Buera and Kaboski, 2012](#); [Buera et al, 2015](#)).

The other alternative has resulted in moving production abroad to low-wage countries. Firms in the search of lower labour costs and/or more lenient tax systems have invested abroad. There is a mix of integration in trade with disintegration of production that has been well documented in the growing global value chain literature ([Gereffi et al, 2005](#); [Seabrooke and Wigan, 2017](#)). In the United States, they are reflected in the increase of the non-manufacture share on employment.

Furthermore, globalisation has favored the development of new financial instruments encouraging a restructuring of production, with firms narrowing their scope to core competence. In this context, the liberalisation of international markets has provided incentives to fusions

²While the literature on innovation provides some evidence of an inverted-U relationship between competition and innovation, turning points only occur for elevated levels of the former ([Aghion et al, 2005](#); [Aghion et al 2014](#)). This means that most of the time competition is positive correlated with innovation.

and acquisitions while shareholder value orientation has contributed to increase the pressure for profitability (Milberg, 2008; Milberg and Winkler, 2010; Brennan, 2016). Those last elements can be seen as catalysts for deindustrialisation and provide a preliminary insight of the link between increases in relative importance of the financial sector and the fall of manufacture activities.

We opened this dissertation presenting an innovative conceptualisation of financialisation as “*an increase in financial content in monetary terms of each unit of output produced*”.³ By financial sector we mean financial intermediation activities, insurance, real estate, rental, and leasing, forming the FIRE acronym. Financial content is measured through the matrix of technical coefficients and the well known Leontief inverse matrix. While the first one provides an indicator of direct content, the second one allows to take into account indirect effects through the interaction among sectors.

In a recent survey of the main contributions in the field, van der Zwan (2014) emphasises the existence of three main approaches to financialisation. The first of them considers financialisation as a regime of accumulation in which “profits accrue primarily through financial channels rather than through trade and commodity production” (Krippner, 2005, p. 174). As result, corporations have increasingly derived profits from financial activities and the financial industry has increased its share on GDP. A second approach examines the role of shareholder value orientation as a guiding principle of corporate behaviour. Finally, a third group of scholars have adopted a cultural perspective on financialisation, particularly with regard to the encroachment of finance into the realms of everyday life.

To the extent that we see the rise of the FIRE sector as a change in the production technique that brings an increase of financial content in production, our contribution could be situated among the first group. Direct content measures are technical coefficients, and as such, reflect the technology available and used at a certain moment by a certain economy. An increase in financial content means that the respective production technique uses more intensively financial inputs. Such increase in how much production depends on finance is what we refer to as financialisation. Furthermore, the explanation we provide for the negative relationship between manufacture and finance also finds some echo in the second group described by van der Zwan (2014).

For the purposes of this chapter it might be useful to emphasise the meaning of direct technical coefficients. Suppose, as an example, that sector j used \$350 of goods from sector i to produce \$1000 of sector j 's output. Hence, direct content (or the technical coefficient) of i in j is $350/1000 = 0.35$. In terms of financial content, if sector j uses \$50 of financial inputs to deliver \$1000 of its output, we say financial direct content in that sector is $50/1000 = 0.05$. Extending the approach to the manufacture sector, one could think of deindustrialisation not only as a reduction of the share of manufacture in employment and Gross Domestic Product (GDP) but

³The concept of financialisation is particularly controversial, as it has been defined in many ways that often look mutually inconsistent. A more comprehensive discussion of those issues can be found in Vercelli (2013), van der Zwan (2014), and Karwowski et al (2016). We will come back to the last one in the next chapter when we investigate the interaction between flow and stock dimensions of financialisation.

also as a particular type of structural change that involves a reduction in manufacture content of each unit of output produced.⁴

It is not our intention in this chapter to put forward a new conceptualisation of deindustrialisation. Nevertheless, it is important to keep in mind that several studies have reported a reduction in manufacture technical coefficients for developed economies (e.g. [Feldman et al, 1987](#); [Driver, 1994](#); [Peneder et al, 2003](#); [Franke and Kalmbach, 2005](#); [Savona and Lorentz, 2006](#)). Such reductions are also at the core of recent contributions that study deindustrialisation and tertiarisation processes using the IO framework (e.g. [Montresor and Marzetti, 2011](#); [Ciriaci and Palma, 2016](#); [Peneder and Streicher, 2017](#)).

The OECD, for instance, has recently published a decomposition of the main determinants behind manufacturing sectoral decline for a sample of developed countries between 1995 and 2011 ([OECD Economic Outlook, 2017](#)). They distinguished between (i) a technology channel through input-output linkages, (ii) a taste channel, and (iii) changes in trade. Their results indicate that changes in input-output linkages explain a sizable share of the manufacture relative decline in all countries. The question we ask ourselves concerns what is behind this decrease in manufacture technical coefficients?

This chapter argues that the observed increase in financial content and the respective reduction in manufacture content are two related phenomenon. In order to assess the nature of this relationship we make reference specifically to direct content. The reason for this is that we want to focus on changes in technical coefficients without having to deal with the interactions that come when we compute the Leontief inverse. This does not mean that indirect effects cannot be studied. However, to evaluate econometrically the relationship between financial and manufacture indirect coefficients is of little use. By construction, indirect coefficients are a function of the interactions of direct coefficients between all industries. Therefore, we already know a priori that financial and manufacture indirect content are related. On the other hand, if we find a causal long-run correspondence between direct technical coefficients this indicates that both processes of structural change are interconnected.

2.2.1 A note on data distortions

At this point we must make some important clarifications. In the beginning of this section, we mentioned that deindustrialisation implies tertiarisation and vice versa. At first, a similar situation could appear here since, for a given sector, the sum of technical coefficients plus the share of its value added on total output must be equal to one. Nonetheless, we consider that there are important differences when it comes to financial and manufacture content because: (i) technical coefficients of different sectors move in different directions over time, and (ii) the share of value added on total output is also not necessary constant over time. Therefore, it is

⁴Deindustrialisation is traditionally defined as a decline in manufacturing as a share of total employment. However, some authors have advocate for the use of other measures such as manufacturing as a share of total output. Others have brought to attention the possibility of some sort of premature deindustrialisation. For a broader discussion on those issues, see for example, [Palma \(2008\)](#), [Treggena \(2009\)](#) and [Rodrik \(2016\)](#).

not obvious to us that an increase in one coefficient must be related to a decline in another. We will come to this point later.

Furthermore, as discussed in chapter 1, several authors have shown that there might be important distortions in the way financial value added is measured in national accounts. Such distortions could potentially biased our analysis and invalidate our exercise. We have already addressed this issue specifically in what concerns our measure of financial content. We showed that, indeed, an eventual overestimation of financial value-added would introduce a negative bias on financial content. However, this did not invalidate our exercise. On the contrary, whenever there is an increase in financial content (as it is the case for the United States), we can say more confidently that there is an increase in relative importance of the financial sector.

In what concerns manufacture content, the potential existence of a positive trend bias in how we measure financial GDP also has major implications. For expositional purposes, let's divide the IO table between manufacture and non-manufacture sectors. The respective technical coefficients are given by:

$$\mathbf{A}_{RR} = \mathbf{Z}_{RR}\hat{\mathbf{x}}_R^{-1} \quad (2.1)$$

$$\mathbf{A}_{RM} = \mathbf{Z}_{RM}\mathbf{x}_M^{-1} \quad (2.2)$$

$$\mathbf{A}_{MR} = \mathbf{Z}_{MR}\hat{\mathbf{x}}_R^{-1} \quad (2.3)$$

$$\mathbf{A}_{MM} = \mathbf{Z}_{MM}\mathbf{x}_M^{-1} \quad (2.4)$$

where \mathbf{Z}_{RR} is a $(n-1) \times (n-1)$ matrix that captures the direct magnitudes of the inter-industry flows outside the manufacture sector; \mathbf{Z}_{RM} corresponds to a $(n-1) \times 1$ vector of non-manufacture inputs used by manufacture; \mathbf{Z}_{MR} is a $1 \times (n-1)$ vector that stands for inter-industry flows going from manufacture industries to the remaining sectors of the economy; \mathbf{Z}_{MM} gives manufacture inputs used by the manufacture sector itself; \mathbf{x}_R is a $1 \times (n-1)$ vector of non-manufacture total output such that $\hat{\mathbf{x}}_R$ stands as the respective $(n-1) \times (n-1)$ diagonal matrix; and finally, $\hat{\mathbf{x}}_M$ corresponds to manufacture's total output.

Furthermore:

$$\mathbf{x}_R = \mathbf{i}^T\mathbf{Z}_{RR} + \mathbf{Z}_{MR} + \mathbf{V}_R \quad (2.5)$$

$$\mathbf{x}_M = \mathbf{Z}_{RM}^T\mathbf{i} + \mathbf{Z}_{MM} + \mathbf{V}_M \quad (2.6)$$

such that \mathbf{V}_R is a $1 \times (n-1)$ vector that captures value-added of non-manufacture activities and \mathbf{V}_M corresponds to manufacturing value added. Finally, \mathbf{i} corresponds to a $(n-1) \times 1$ vector of 1's.

If financial's value-added has been overestimated in the System of National Accounts (SNA), this means the true \mathbf{V}_R is actually lower. From equation (2.5) this implies that the true \mathbf{x}_R is also smaller. Moreover, if distortions are increasing over time, there is a negative trend bias in manufacture content. In fact, substituting (2.5) in (2.3) and computing the partial derivative on \mathbf{V}_R we have:

$$\frac{\partial \mathbf{A}_{MR}}{\partial \mathbf{V}_R} = -\mathbf{Z}_{MR}[(\mathbf{i}^T\mathbf{Z}_{RR} + \mathbf{Z}_{MR} + \mathbf{V}_R)^{-1}]^2 < 0 \quad (2.7)$$

In other words, our results could be driven by distortions in the financial sector. Obviously, one could debate if the existence of such distortions is relevant and disagree about the relevance of this critique to national accounts. In that case, if there is no distortion in \mathbf{V}_R , our coefficients are strictly correct.

Still, we could further speculate how different manufacture content trajectories would be if we give a different treatment to financial value-added. Motivated by the discussion provided in the last chapter, we also perform our analysis making all FIRE incomes as intermediate inputs to the rest of the economy. Such manipulation of \mathbf{V}_R allows us to provide a more robust analysis, especially in terms of data trends. We redistribute financial value-added – as reported in the SNA – so that it enters the IO table exclusively as inputs. This is exactly the same procedure adopted in chapter 1 that permitted us to artificially set financial value-added to zero while maintaining the consistency of IO tables.

The two crucial variables to change are \mathbf{Z}_{RR} and \mathbf{Z}_{RM} , i.e. the non-manufacture content of all productive sectors. One can partition those matrices so that:

$$\mathbf{Z}_{RR} = \begin{bmatrix} \mathbf{Z}_{\bar{R}\bar{R}} & \mathbf{Z}_{\bar{R}F} \\ \mathbf{Z}_{F\bar{R}} & \mathbf{Z}_{FF} \end{bmatrix} \quad (2.8)$$

and

$$\mathbf{Z}_{RM} = \begin{bmatrix} \mathbf{Z}_{\bar{R}M} \\ \mathbf{Z}_{FM} \end{bmatrix} \quad (2.9)$$

where $\mathbf{Z}_{\bar{R}\bar{R}}$ is a $(n-2) \times (n-2)$ matrix of inter-industry flows outside the manufacture and financial sectors; $\mathbf{Z}_{\bar{R}F}$ is a $(n-2) \times 1$ vector of non-manufacture non-financial inputs used by the financial sector; $\mathbf{Z}_{F\bar{R}}$ corresponds to a $1 \times (n-2)$ vector of financial inputs used by non-manufacture non-financial industries; \mathbf{Z}_{FF} gives financial inputs used by the financial sector itself; $\mathbf{Z}_{\bar{R}M}$ is a $(n-2) \times 1$ vector of non-manufacture non-financial inputs used by manufacture industries; and finally, \mathbf{Z}_{FM} stands for financial inter-industry flows going to the manufacture sector.

Furthermore, non-manufacture value-added can be decomposed as:

$$\mathbf{V}_R = \begin{bmatrix} \mathbf{V}_{\bar{R}} & \mathbf{V}_F \end{bmatrix} \quad (2.10)$$

such that $\mathbf{V}_{\bar{R}}$ is a $1 \times (n-2)$ vector of non-manufacture non-financial value-added and \mathbf{V}_F stands for financial value-added. This decomposition is very similar to the one performed in chapter 1.

Hence, from equations (2.8)-(2.10), the four variables to change are actually $\mathbf{Z}_{F\bar{R}}$, \mathbf{Z}_{FF} , \mathbf{Z}_{FM} , and \mathbf{V}_F , that are now redefined as:

$$\begin{aligned} \tilde{\mathbf{Z}}_{F\bar{R}} &= \mathbf{Z}_{F\bar{R}} + \mathbf{Z}_{F\bar{R}}\hat{\mathbf{s}} \\ \tilde{\mathbf{Z}}_{FF} &= \mathbf{Z}_{FF} + \mathbf{Z}_{FF}\mathbf{s}_{ii} \\ \tilde{\mathbf{Z}}_{FM} &= \mathbf{Z}_{FM} + \mathbf{Z}_{FM}\mathbf{s}_{ii} \\ \tilde{\mathbf{V}}_F &= 0 \end{aligned}$$

where, this time, $\hat{\mathbf{s}} = \{s_{ij}\}$ is a $(n - 2) \times (n - 2)$ diagonal matrix with $s_{ii} = \mathbf{V}_F / \sum_{j=1}^n z_{Fj}$, i.e. the ratio between FIRE's value-added and the sum of all financial inputs before redistribution. This second modified set up corresponds to an extreme scenario that complements our analysis in two ways. From a descriptive point of view it basically shows if, in the limit, distortions in \mathbf{V}_F change our main trends of interest. Moreover, it also provides a second measure of manufacture content that can be use to test the robustness of our econometric estimations.

Continuing, given that our analysis is performed using IO in current prices, one could also argue that we might be just capturing price dynamics. For example, the trends for manufacture value-added as a share of GDP are very different at current and constant prices. In the first case there is a marked negative trajectory, meanwhile, at constant prices there is no trend at all (see, for example, [Rodrik, 2016](#)).

The problem is that the Bueau of Economic Analysis (BEA) publishes IO tables at current Production Prices (PPI) while the Buerau of Labor Statistics (BLS), responsible for producing price indexes, does not report deflators for all IO sectors. Still, we have reasons to believe this does not compromises our analysis. This is because the BLS does publishes a PPI indicator for total manufacture and one for all commodities. There does not seem to be much difference between the two indicators as we can see in figure 1.

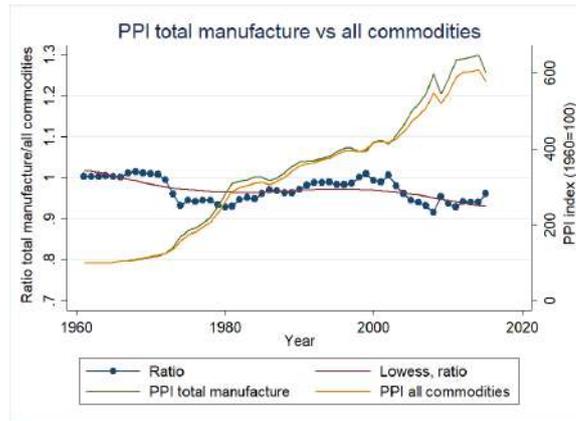


Figure 1: PPI total manufacture and all commodities

On the left we read the ratio between manufacture and all goods index while on the right we have actual PPIs. There is no particular trend indicating that prices in manufacture have behaved very differently that in other sectors. Therefore, we proceed describing our database and some main trends before performing our main econometric exercise.

2.2.2 Data and descriptive statistics

Our database takes a 15-sector level of aggregation for the US and comprehends the period 1947-2015. Data is in monetary terms and was provided by the Bureau of Economic Analysis

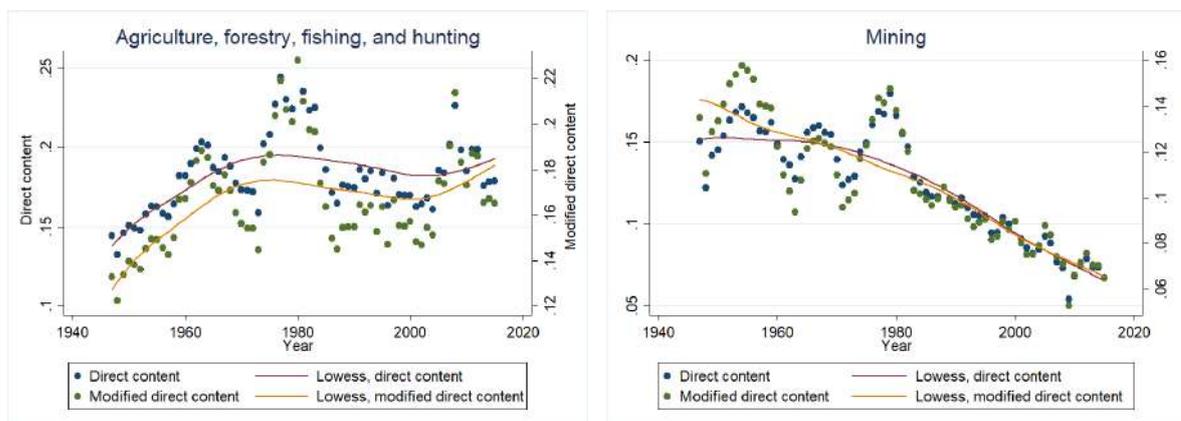
(BEA). The Industry Economic Accounts (IEA) of the BEA are available at three levels of detail: sector (15 industry groups), summary (71 industry groups), and detail (389 industry groups). We chose to use a 15-sector level of aggregation because it allows us to address sectoral differences keeping the analysis as simple as possible. Time span was chosen given data availability.

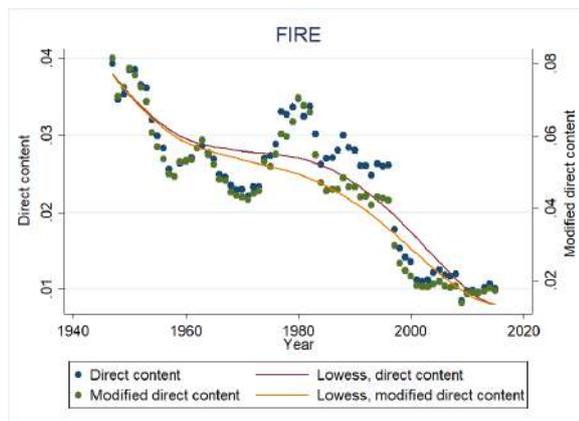
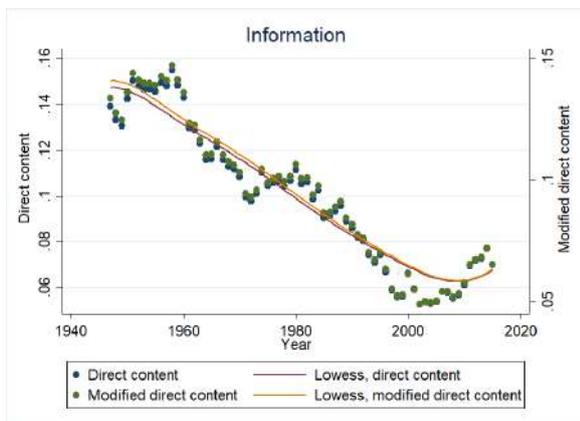
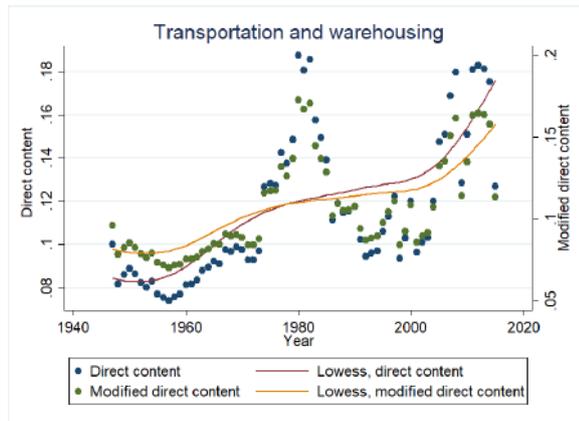
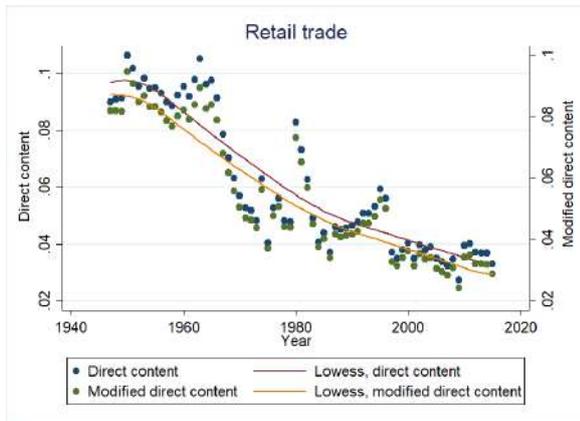
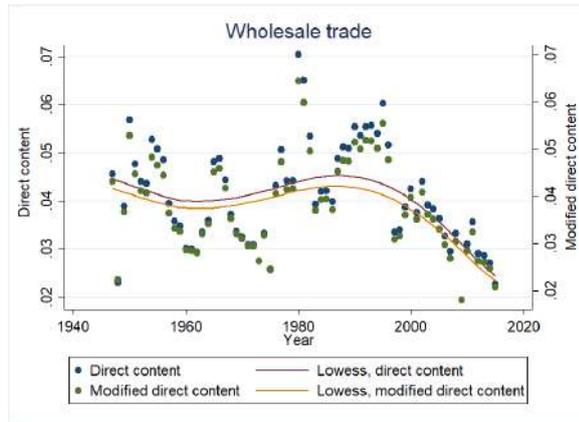
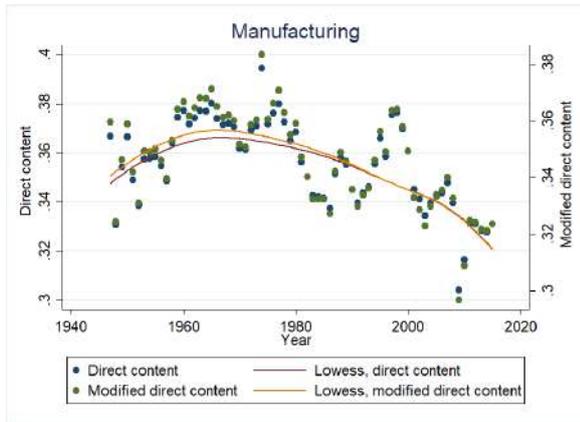
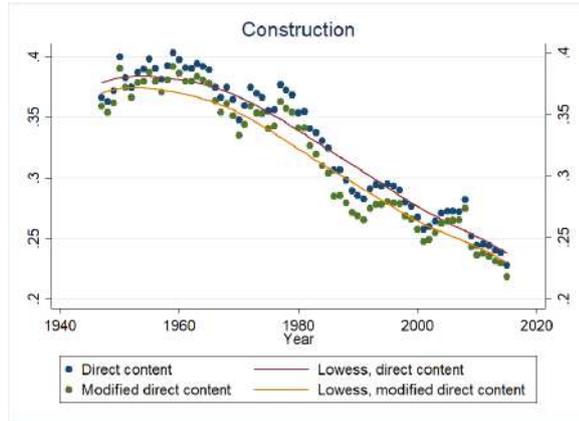
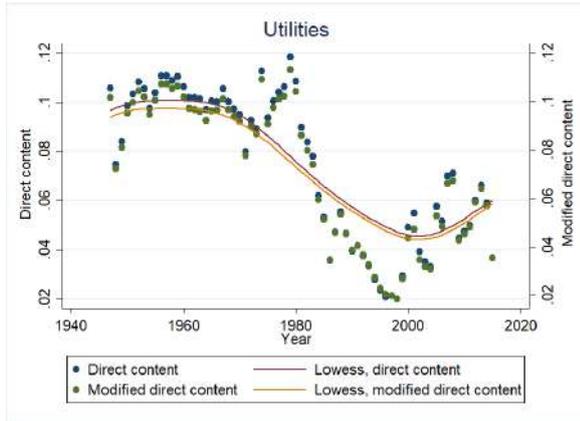
Figure 2 reports the evolution of manufacture direct content per sector of the US economy. We are able to identify four different dynamics. The most important of them is the clear general tendency of a reduction in manufacture technical coefficients. Nine out of fifteen sectors presented an almost continuous contraction in direct content for the whole sample. Secondly, “Agriculture”, “Manufacture”, “Wholesale”, and “Education and Health” experienced inverted-U trajectories with the peak of the series around 1970 and 1980.

In terms of the magnitudes involved, we can make a useful separation between traditional activities and service industries. Notice that there is no much difference between our preferred and modified measures of manufacture content, both in terms of levels and trends. This contrasts with results previously reported for financial content where there were no changes in trends but significant differences in levels. The only exception now is “FIRE”, where our modified measure of manufacture content is twice the one obtained from the preferred scenario.

Starting with traditional industries, “Agriculture” experienced an increase in manufacture content from 0.15 to 0.25 in 1980 followed by a reduction basically to 1960 levels. The coefficient of “Mining” fell from 0.15 to 0.07. “Utilities” and “Construction” also presented a sharp decrease in manufacture content from 0.1 and 0.4 to 0.04 and 0.25, respectively. In “Manufacture” itself there are some small oscillations, with coefficients going from 0.35 to 0.4 in 1980 and falling to 0.33 by the end of the period.

For service industries we can also observe a pronounced decline in manufacture content that is stronger after 1980. Sectors such as “Wholesale trade” and “Education and Health” exhibited an inverted-U trajectory increasing from 0.05 and 0.1 to 0.07 and 0.14 in the eighties. A strong reduction followed and content fell to 0.02 and 0.07 afterwards, respectively. Continuing, “Retail trade” dropped from 0.1 to 0.04, and manufacture coefficients in “Information” were reduced from 0.15 to 0.06.





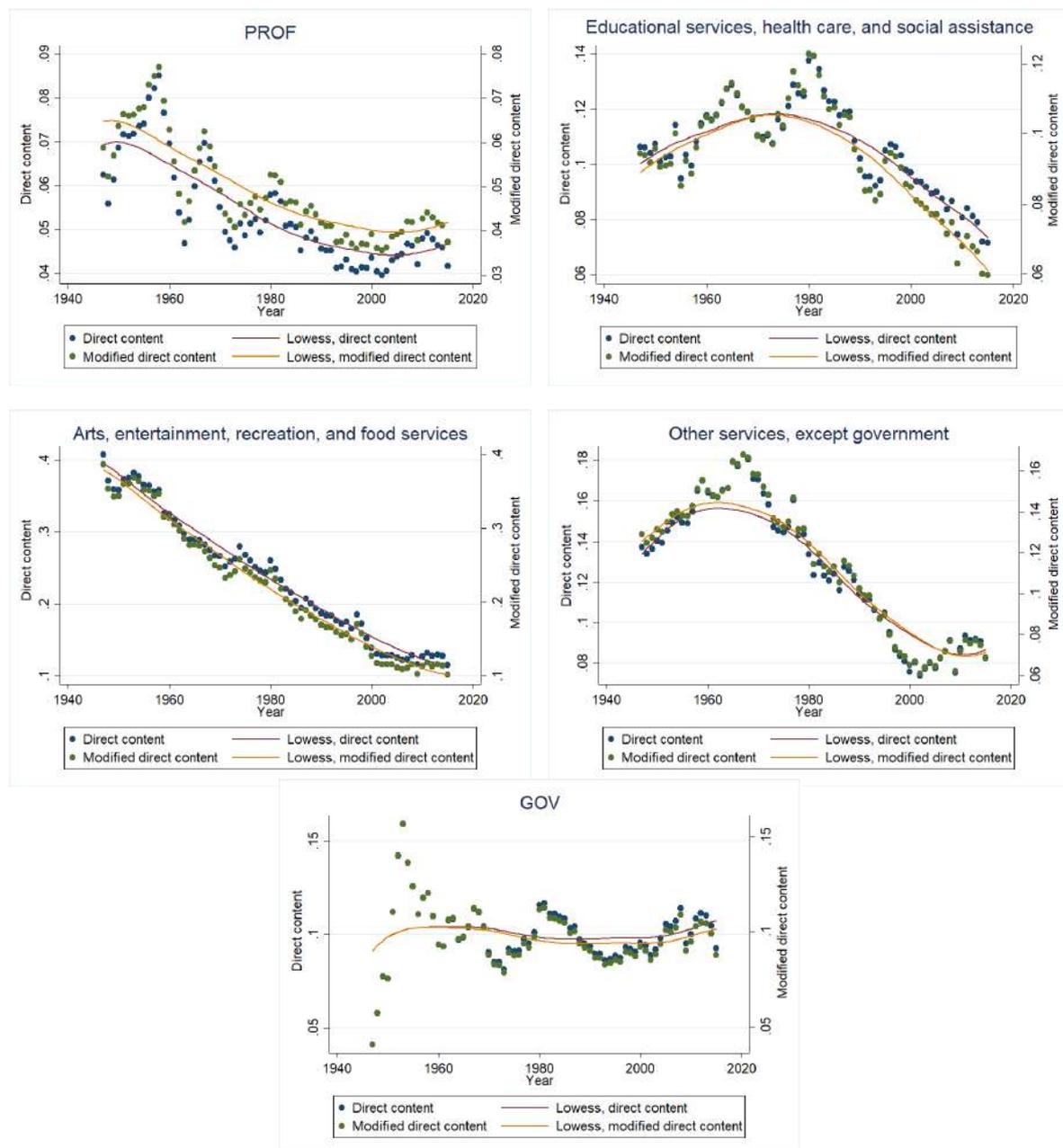


Figure 2: Manufacture direct content

As already pointed out, financial activities are a particular industry because our preferred and modified measures are different in levels. In the first case, there is a reduction in content from 0.04 to 0.01. In the second, coefficients fell from 0.08 to 0.02. “PROF” went from 0.07 to 0.04 while “Arts and Entertainment” started at 0.4 in the 1950s and fell to 0.1 by 2015. Finally, “Other services” followed this negative trend and experienced a contraction of manufacture direct content from 0.15 to 0.1

Such trends are in line with the financialisation literature and also the results of chapter 1 that indicate the eighties as a decade with important changes in the way the economic

system operates. Thirteen out of fifteen sectors experienced a reduction in manufacture direct content in the last thirty years. In eight of those - “Mining”, “Utilities”, “Construction”, “Retail trade”, “Information”, “FIRE”, “PROF”, and “Arts and Entertainment” - there were expressive reductions with coefficients diminishing in a range from 40 – 75%.⁵

The two exceptions for this decreasing pattern are “Government”, and “Transportation and warehousing”. The first one presented a stable trajectory with no trend and content fluctuating around 0.1. On the other hand, the last one follows a unique increasing path briefly reverted in the 1980s but resumed in the next decade until the end of the series. Its technical coefficient that was smaller than 0.1 in 1950 grew to 0.15 by the end of the sample.

A similar negative trend is clear if we aggregate data using the shares of each sector in total output. In fact, it follows closely the share of manufacture in total output. Figure 3 on the left depicts aggregate manufacture direct content per unit of output while on the right we have financial direct content. On an aggregate set up, one could debate if the manufacture technical coefficient presented a negative trend at all between 1950 and 1970. There is a small reduction from 0.23 to 0.2 in twenty years. Still, after 1970, manufacture content was strongly reduced to around 0.12 in 2015. Moreover, notice that our preferred indicator and our modified measure of manufacture content display similar trajectories both in terms of trends and levels.

Financial content, on the other hand, depicts a positive trajectory for the sample. As previously reported, in our preferred scenario there is a small increase in financial content until 1980 where there is an upswing in the slope of the curve. Redistributing FIRE’s value-added as intermediary inputs brings a continuous increase in financial content from 1950 to the financial crisis in 2007. That is, trends are similar though there are important differences when it comes to levels of financial direct content.

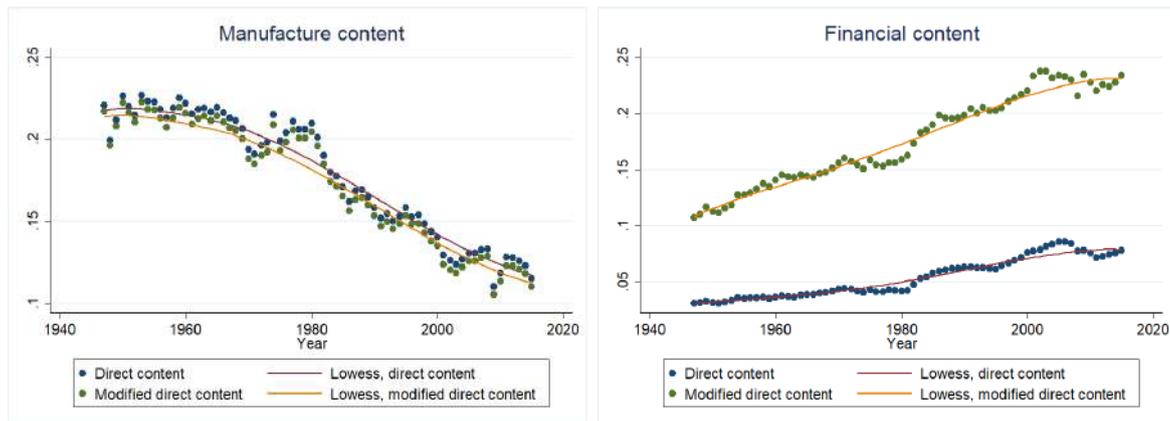


Figure 3: Aggregate manufacture and FIRE direct content

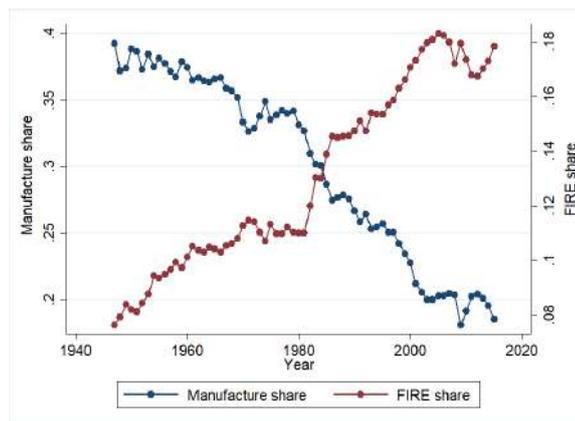
Aggregate measures embody two different movements in data. The first one concerns changes in coefficients. As explained in the previous subsection, given that we are dealing

⁵Recall that FIRE is given by financial intermediation, insurance, real estate, rental, and leasing activities. PROF corresponds to Professional and business services while GOV is given by government activities.

with a 15-sector level of aggregation, it is not obvious that increases in financial content must be related to a decrease in manufacture content. Nonetheless, one could still make the case that, *ceteris paribus*, an increase (decrease) of one variable implies a reduction (increase) in the other. We refer to this as a composition problem. Even in that case, the importance of the exercise is two-fold. First, to estimate the magnitudes involved. Secondly, to indicate who is moving first, addressing in that way predictive causality.

If there is a long-run negative relationship driven mainly by the composition effect, two outcomes are expected: (i) estimated coefficients close to 1, and (ii) bi-directional causality. Both results come from the fact that, in the long-run and *ceteris paribus*, changes in financial and manufacture content are considered to be a mirror one to the other. Anticipating our main results, in the next sections we show this is not the case.

Moreover, there is a second type of change in the aggregate data that refers to the share of manufacture and financial industries in total output. In fact, manufacturing share in total output depicts a negative trend for the whole sample going from 40% to less than 20%. This, of course, contrasts with changes observed in the financial sector. Financial share in total output went to the opposite direction, increasing from 8% to 18%, as we can see in figure 4.



(a)

Figure 4: Manufacture and FIRE output shares

With these results in mind we perform in the next section a cointegration exercise to assess the long-run relationship between financialisation and the reduction of manufacture content. In the last section we move on to a disaggregate framework.

2.3 A cointegration exercise

To ascertain the existence of a long-run relationship between financialisation and changes in manufacture content, we make use of cointegration techniques. At this stage, our exercise is constrained to an aggregate set up. In the next section we proceed extending it to a heterogeneous panel set up. Our strategy consists in estimating two basic models, testing the robustness

of our results to different estimators. In model 1 we confront our preferred measures of financial and manufacture direct content while, in model 2, we repeat the exercise for the case in which financial value added was redistributed as intermediary inputs.

In order to test if variables are stationary, we performed the standard Augmented Dickey-Fuller (ADF) test, the Dickey-Fuller test with GLS detrending (DF-GLS), and the DF unit root test with a break point. Results are reported in the appendix and indicate that series are integrated of order one (see tables A1 to A4).

Once we identify that our data is $I(1)$, we proceed applying the Johansen cointegration test. We follow closely the methodology proposed by [Risso et al \(2013\)](#), which requires estimating a VEC model. From visual inspection, we identified a structural break around the 1980s. Multiple break point Bai-Perron test identifies several breaks for direct financial content (1957, 1967, 1983, 1996, 2006 in our preferred set up; 1958, 1969, 1983, 1998 in our modified case) and direct manufacture content (1957, 1969, 1982, 1992, 2002 in our main scenario; 1969, 1985, 2000 in the second case). Therefore, all tests performed and estimated models in this section included dummy variables to capture the structural break effects. One dummy variable was assigned for each indicator. They assume value 1 for years with breaks and zero for years with no break.

Schwarz's Bayesian Information Criteria (SBIC) was used for choosing lag selection. We allow for automatic lag selection imposing a maximum of 4 lags. SBIC criterion was preferred over the popular Akaike (AIC) insofar it is strongly consistent while AIC is generally more efficient though not consistent. In other words, while the former will asymptotically deliver the correct model order, the latter will deliver on average a too large model ([Brooks, 2014](#)). Still, whenever serial correlation was potentially harmful, we opted for using AIC since it assigns a higher number of lags, thus, controlling for serial correlation problems.

Table 1 reports results of the Johansen cointegration test identifying at least one cointegration relation between financial and manufacturing coefficients. This result is robust to the inclusion of data trends for both trace statistics and maximum eigenvalue statistics.

Table 1: Number of cointegrating relations by model

Model 1: VEC(1,1)				
Data trend	None	Linear	Linear	Quadratic
Test type	Intercept/No trend	Intercept/No trend	Intercept/Trend	Intercept/Trend
Trace	1	1	1	2
Max-Eig.	1	1	1	2
Model 2: VEC(1,1)				
Data trend	None	Linear	Linear	Quadratic
Test type	Intercept/No trend	Intercept/No trend	Intercept/Trend	Intercept/Trend
Trace	2	1	1	2
Max-Eig.	2	1	1	2

In table 2 we present the long-run cointegration equation while in table 3 we report coefficients of the VEC estimated models. Notice that all error correction terms are negative so that there is convergence to the long-run solution. Moreover, the cointegration equation term of financial content is statistically not significant which implies that this variable is weakly exogenous. Under weak exogeneity, we are allowed to carry out optimal inference with respect to the set of parameters of the long run equation (see [Johansen, 1995](#)). This means that we can take the parameters of the long-run equation without the necessity of modeling the endogenous dynamics of financial content.

Financial content was found to be weakly exogenous in both set ups. However, the error correction term of manufacture content was negative and statistically significant. It indicates that between 25 – 35% of any movements into disequilibrium are corrected for within one period. Over the long run, technical coefficients are negatively related. An increase of one unit of direct financial content is associated with a reduction of 2.2 units of manufacture content in the first model and 1 unit in the second case.

Table 2: VEC estimates, long-run coefficients

Long-run equation	Model 1: VEC(1,1)	Model 2: VEC(1,1)
Manuf. content	1.000000	1.000000
Finan. content	2.201808***	1.020812***
C	-0.297452	-0.353996

*, **, and *** stand by 10%, 5% and 1% of significance

Short-run coefficients, on the other hand, are not significant suggesting that in the short run there is no relationship at all. The exception is the short-run impact of financial content on itself. In fact, an increase of one unit in the financial sector direct content is related to an increase between 0.3 and 0.4 units of this technical coefficient.

Table 3: VEC estimates, short-run coefficients

Short-run equation	Model 1: VEC(1,1)		Model 2: VEC(1,1)	
	D(Manuf. content)	D(Finan. content)	D(Manuf. content)	D(Finan. content)
Error correction	-0.344128***	-0.028802	-0.269091***	-0.003270
D(Manuf. content[-1])	0.039075	0.042233	0.109782	-0.170661
D(Finan. content[-1])	0.301695	0.395495***	0.355861	-0.335847**
C	-0.000999	0.000350	-0.001515*	0.001901***
Dummy Manuf.	-0.003083	0.000854	-0.001468	0.000998
Dummy Finan.	-0.002350	0.001060	-0.002883	0.004107
Adj. R ²	0.124848	0.089415	0.129373	0.022220

*, **, and *** stand by 10%, 5% and 1% of significance

In order to assess the robustness of this result, we estimate FMOLS and DOLS models. Both are single equation methods that deal with endogeneity problems and are asymptotically equivalent and efficient. The robustness of the cointegration relation is also verified using the Hansen Cointegration Instability test. In what concerns model 1, AIC criteria selected a prewhitening with two lags for FMOLS, and zero lead and length for the DOLS estimator. In model 2, we have a prewhitening with one lag for FMOLS, while four lead and five length for DOLS. In all cases, we allowed for automatic lag selection imposing a maximum of 4 lags and 10 leads/lags for FMOLS and DOLS, respectively. The Akaike criteria was preferred over the SBIC because it allowed additional lags avoiding in this case serial correlation problems. Results are reported in table 4.

Table 4: FMOLS and DOLS estimations

Dependent variable: Manuf. content				
Regressors	Model 1		Model 2	
	FMOLS(2)	DOLS(0,0)	FMOLS(1)	DOLS(4,5)
Finan. content	-2.135376***	-2.091596***	-0.907003***	-0.964934***
C	0.292828***	0.291094***	0.332351***	0.342516***
Dummy Manuf.	-0.003531	-0.002527	0.009759	0.000679
Dummy Finan.	0.005788	0.003740	-0.003140	-0.000723
Adj. R ²	0.949240	0.949676	0.934570	0.976590
Hansen (Lc statistic)	0.262471	0.023661	0.832700	0.015705
Cointegration	Yes	Yes	No	Yes

*, **, and *** stand by 10%, 5% and 1% of significance

An increase of one unit in direct financial content is associated with a decrease of around 2.1 units of manufacture content in the first scenario and a reduction of 0.9 units in the second model. We cannot reject the null of cointegration in three out of four models. The magnitude

of coefficients of the FMOLS and DOLS regressions is similar to the one obtained from the VEC model. Our estimates give support to the thesis of a negative long-run relationship between the technical coefficients of the financial sector and manufacture. Moving from our preferred set up to the modified one reduces the strength of the relationship but it continues to be statistically significant at 1% and of relevant size.

After establishing that series cointegrate, we proceed to determine the existence of causality. A first attempt to get an insight about the direction of causality is given by the weakly exogeneity test. However, exogeneity does not mean causality. This can be investigated through Granger causality tests. When variables are I(1), [Toda and Yamamoto \(1995\)](#) one extra lag modification of the test is advisable. Nevertheless, this method could be inefficient with small samples and there might be a loss of power due to an overspecification of the lag length. Moreover, when there is cointegration, the standard Wald test yields better results than a modified test estimating extra coefficients (see [Dolado and Lütkepohl, 1996](#); [Lütkepohl, 2005](#)). Thus, the Toda and Yamamoto procedure is not always needed. In table 5 we present results of the VAR Granger causality based on the Wald test.

Table 5: VAR Granger Causality, Block exogeneity test

Dependent variable: Manuf. content				
	Model 1		Model 2	
Excluded	df	Prob.	df	Prob.
Finan. content	1	0.0048	1	0.0373
Dependent variable: Finan. content				
	Model 1		Model 2	
Excluded	df	Prob.	df	Prob.
Manuf. content	1	0.7814	1	0.9654

*, **, and *** stand by 10%, 5% and 1% of significance

Causality tests indicate that there is unilateral causality going from financial to manufacture technical coefficients in both scenarios. This allows us to claim that an increase of one unit of direct financial content – in monetary terms per unit of output produced – causes a decrease between one and two units in manufacture content. We find this result extremely important since, even if in the long-run an increase in financial content must be related to a decrease in manufacture content because of the compositional effect, we actually have that financial content is weakly exogenous, precedes and has predictive power on manufacture content. That is, changes go from the financial to the manufacture sector.

To assess a valid inference and not spurious regressions, residuals of all six regressions were checked for serial correlation. If residuals are correlated the estimated coefficients would be biased and inconsistent. We conclude that our estimates are consistent, thus the cointegrating regressions are not spurious. Results are reported in the appendix (see table A5 and A6).

2.4 A panel PMG/ARDL approach

It is quite common now to have panels in which both T - the number of time series observations - and N - the number of groups - are quite large. In the previous section, we were able to identify a negative long-run relationship between financial and manufacture technical coefficients with causality going from the financial sector to manufacture activities. However, we were confronting aggregate measures. In this section we relax this assumption and build a panel in which for each one of the 15 sectors we have one technical coefficient for manufacturing and one for FIRE.

One may argue that the use of a panel set up might not be appropriate for our task given the intrinsic specificities across productive sectors. Such specificities were quite clear, for example, when we investigated the evolution of manufacture technical coefficients. While there was a general tendency for a reduction in those coefficients, some activities presented an inverted-U trajectory and “Transportation and warehousing” actually experienced an increase in manufacture content. There are also important differences in financial content trajectories among sectors, as reported in chapter 1. In order to avoid this critique, we adopt heterogeneous panel techniques which allow us to take into account some of those issues.

Ascertaining the order of integration of the variables under analysis is an essential precondition to establish whether the use of panel cointegration tests is warranted. In this respect, we performed the Levin, Lin and Chu test that assumes a common unit root process, and the Im, Pesaran and Shin test, the ADF and Phillips-Perron (PP) tests that assume individual unit root processes. Results are reported in the appendix (tables A7 and A8). While we are able to establish that direct financial content is integrated of order one, we cannot determine if manufacture content is stationary in levels or if it is also $I(1)$.

In this case, the use of MG and PMG estimators within an ARDL approach is useful since both provide consistent estimates in a dynamic panel context, even in the presence of potentially non-stationary regressors (Pesaran et al, 1999; Blackburne and Frank, 2007; Lanzafame, 2014).⁶ The MG procedure consists in estimating N separate regressions and calculate the coefficient mean. On the other hand, the PMG estimator constrains long-run coefficients to be identical but allows short-run coefficients and error variances to differ across groups.

Given that PMG constrains long-run coefficients to be equal across all panels, it yields efficient and consistent estimates only when the restrictions are true. However, if the true model is heterogeneous, estimates are inconsistent while the MG estimator is consistent in either case. The choice between MG and PMG estimators depends on the trade-off between consistency and efficiency. Thus, a modified Hausman test on the long-run parameter homogeneity restriction can be used to choose the most appropriate model.

⁶The asymptotics of large T dynamic panels are different from small T panels. The latter usually rely on fixed or random effects estimators or a combination of fixed effects and instrumental variable estimators such as the Generalised Method of Moments (GMM). However, these methods require the assumption of homogeneity of slope parameters that is often inappropriate when T is large (Blackburne and Frank, 2007). This point has been made by Pesaran and Smith (1995), and Im et al (2003), among others. Moreover, for large T panels, nonstationarity is also a concern. MG and PMG estimators address both issues.

SBIC criteria chose an optimal ARDL(1,1). We allow for automatic lag selection imposing a maximum of 4 lags for dependent and independent variables. The calculated Hausman statistic is 1.1 for model 1 and 1.11 for model 2. Hence, we cannot reject the null hypothesis that differences in coefficients are not systematic, which means the PMG model is preferred. Results of the MG estimates and the Hausman test are reported in the appendix (table A9). Table 6 brings the estimates of the PMG model.

Table 6: PMG/ARDL estimates

Long-run equation	Model 1: ARDL(1,1)	Model 2: ARDL(1,1)
Variable	Coefficient	Coefficient
Finan. content	-0.6672051***	-0.4145752***
<hr/>		
Short-run equation	Model 1	Model 2
Variable	Coefficient	Coefficient
Coint. Equation	-.0869481***	-0.0798147***
D(Finan. content)	-0.216749	-0.1685292
C	0.0138741***	0.013748***

*, **, and *** stand by 10%, 5% and 1% of significance

An increase in one unit of direct financial content is related in the long-run to a decrease of 0.4 – 0.65 units of manufacture content. One should notice that the magnitude of the effect is quite lower than previous estimates using aggregate data. An explanation for this is the following. Changes in aggregate data actually embody two movements. On the one hand, we have variations in technical coefficients. On the other hand, there are also changes in the share of each sector in total output. In the last fifty years there has been a reduction in manufacture’s share on output and an increase in service activities shares increasing the apparent effect of financialisation.

A negative and significant error-correction term provides strong support for the hypothesis that the variables share a significant long-run relationship. Furthermore, 8% of any movements into disequilibrium are corrected for within one period. However, when it comes to the short-run, financialisation seems to have no significant effect over manufacture content. A first insight of this appeared for the first time when we estimated our VEC model. In the short-run, an increase of one unit in financial direct content reduces manufacture technical coefficient in 0.15 – 0.2 units though this magnitude is not statistically different from zero.

Since the PMG estimator allows short-run coefficients and error variances to differ across sectors, we proceed presenting them for model 1 in table 7. This permits us to explain why in the previous table the financial short-run coefficient was not statistically significant and to evaluate specific effects on each sector in the short-term.

Table 7: Model 1 sectoral short-run coefficients

Variable	Agriculture	Mining	Utilities
Coint. Equation	-0.1530733***	-0.0055911***	-0.0318887***
D(Finan. content)	-0.00196	-0.1625479***	0.4946509***
C	0.0344727***	-0.000268***	0.0019612***
Variable	Construction	Manufacturing	Retail trade
Coint. Equation	0.0088718***	-0.1664912***	-0.1414795***
D(Finan. content)	-0.5936278*	-1.895517	1.061522***
C	-0.0050037***	0.0606283***	0.0091342***
Variable	Wholesale trade	Transportation	Information
Coint. Equation	-0.0426033***	-0.0672731***	-0.022184***
D(Finan. content)	0.9339003***	-1.601407***	0.3202724***
C	0.0032862***	0.0119117***	0.0015708***
Variable	FIRE	PROF	Education and Health
Coint. Equation	-0.02097***	-0.0990279***	-0.2415257***
D(Finan. content)	0.026413***	-0.0659128*	0.3028954***
C	0.0021523***	0.0091326***	0.0384111***
Variable	Arts and Entertainment	Other services	GOV
Coint. Equation	-0.0362269***	-0.0212848***	-0.263474***
D(Finan. content)	-0.9271824***	0.1074204**	-0.1250154
C	0.0063219***	0.0028187***	0.0315809***

*, **, and *** stand by 10%, 5% and 1% of significance

In the short-run different sectors present very particular dynamics and it is not possible to identify a clear pattern among them. In seven sectors - “Utilities”, “Retail trade”, “Wholesale trade”, “Information”, “FIRE”, “Education and Health”, and “Other services” - an increase in financial direct content is actually associated with an increase in manufacture technical coefficient. This contrasts with the remaining eight sectors - “Agriculture”, “Mining”, “Construction”, “Manufacturing”, “Transportation”, “PROF”, “Arts and Entertainment”, and “Government” - that present a negative relation among variables than in some cases is not statistically significant. Heterogeneity among sectors emphasises the importance of analysis at a more disaggregated level and our econometric choice.

These results do not change much if we look to short-run estimates of model 2. As we can see in table 8, all coefficients become statistically significant at 5% but there is still sizable heterogeneity among sectors. Main differences can be divided in two groups. First, “Agriculture”, “Construction”, “Manufacturing”, “PROF”, and “GOV” maintained their negative signal while became statistically significant. Secondly, it is worth noting that the only sector for which there

is a change in sign was “Other services”. In model 1 its coefficient was positive but became negative in model 2.

Table 8: Model 2 sectoral short-run coefficients

Variable	Agriculture	Mining	Utilities
Coint. Equation	-0.149685***	-0.001465**	-0.028840***
D(Finan. content)	-0.069760***	-0.143610***	0.183763***
C	0.034269***	-0.000951***	0.001944***
Variable	Construction	Manufacturing	Retail trade
Coint. Equation	0.009310***	-0.165062***	-0.100648***
D(Finan. content)	-0.432521***	-1.004632***	0.435135***
C	-0.005059***	0.059647***	0.007674***
Variable	Wholesale trade	Transportation	Information
Coint. Equation	-0.033396***	-0.065522***	-0.024942***
D(Finan. content)	0.396660***	-0.773743***	0.107242***
C	0.003048***	0.012073***	0.002147***
Variable	FIRE	PROF	Education and Health
Coint. Equation	-0.008391***	-0.095425***	-0.215136***
D(Finan. content)	-0.121504***	-0.083872***	0.068455***
C	0.002045***	0.010391***	0.036954***
Variable	Arts and Entertainment	Other services	GOV
Coint. Equation	-0.035323***	-0.021801***	-0.260895***
D(Finan. content)	-0.502262***	-0.018888**	-0.568401***
C	0.006286***	0.003238***	0.032509***

*, **, and *** stand by 10%, 5% and 1% of significance

One should also pay particular attention to “Transportation and warehousing”. In chapter 1, we reported an increase in financial direct content from 0.02-0.05 to 0.08-0.15, depending on which indicator we use. On the other hand, in the previous section we also showed that there has been an increase in its manufacture content during the same period from 0.08 to 0.2. A superficial analysis would suggest that in this case financial and manufacture content are positively related. However, a more careful analysis shows this is not true. An increase in financial content is actually associated with a reduction in manufacture content both in the short and long-run.

As a final step, we investigate the existence of predictive causality using panel Granger tests. We perform two different tests. The first one treats the panel data as one large stacked set and assumes all coefficients are the same across all cross-sections. A second approach is to follow [Dumitrescu-Hurlin \(2012\)](#) and allow coefficients to be different across cross-sections.

Because we are not able to determine precisely the order of integration of our series, we prefer to deal with them in first differences. Providing that SBIC lag criteria chose an ARDL(1,1), our causality tests also allow for one lag. Table 9 brings our results.

For both tests we cannot reject the null of non-Granger causality going from manufacture to financial content. On the other hand, we do find causality from financial to manufacture technical coefficients. These outcomes are in line with what we discussed in the previous subsection showing that changes in financial direct content precede and have predictive power over what happens in the manufacture sector.

Table 9: Panel VAR Granger Causality

	Model 1				Model 2			
	Common coef.		Individual coef.		Common coef.		Individual coef.	
Dependent variable: Manuf. content	df	Prob.	df	Prob.	df	Prob.	df	Prob.
Excluded variable: Finan. content	1	0.0198	1	0.0101	1	0.0471	1	0.0212
Dependent variable: Finan. content	df	Prob.	df	Prob.	df	Prob.	df	Prob.
Excluded variable: Manuf. content	1	0.1380	1	0.1965	1	0.2386	1	0.1018

Once again, residuals were checked for serial correlation in order to assess valid inference and not spurious regressions. We concluded that our estimates are consistent. Results are reported in the appendix (see table A10).

2.5 Discussion

Overall, the outcomes of our panel and time-series empirical analysis bring qualified support to the hypothesis that financialisation, in the terms define in chapter 1, is behind the reduction in manufacture technical coefficients. This evidence is in line with the exercise we are to perform in the next section, where we explore the possible interactions between financialisation, deindustrialisation and income inequality in the United States.

From an IO perspective, what does it mean that an increase in financial content causes a reduction in manufacture content? We started section 2 telling a story that can be further examined now. globalisation, understood as an increase in the level of integration of the world economy, might be behind the explanatory mechanism. A more integrated world economy increases competition between firms at an international level. In response to these pressures, corporations need to operate in a state of constant innovation and flexibility. To keep profit margins, they have been pushed to increase efficiency which can be seen, for instance, in the reduction of manufacture inputs used per unit of output produced, i.e. a reduction in manufacture technical coefficients.

Changes in the structural matrix have been described over the years as “technological change”, often broadly interpreted to include any factor that causes a change in technical coefficients, such as true technological change, technical substitution as response to input price changes, and scale effects (Rose and Casler, 1996). We consider that understanding these changes as “efficiency gains” instead of technical change has some advantages specially when it comes to manufacture activities. The reason for this is that the literature on deindustrialisation has also documented an important process of service outsourcing that entails the so called tertiarisation effect (e.g. Montresor and Marzetti, 2010).

Outsourcing is usually conceived as a process that is symmetrical to vertical integration, reducing the vertical scope of the firm. In terms of structural change, it entails two movements. On the one hand, there is an artificial reduction in the economic contribution of manufacturing because the same activities once performed inside manufacture are now record as services. On the other hand, it constitutes a particular kind of structural change amounting to an extension of the manufacturing into the non-manufacturing sectors. It involves the transfer of tacit and codified knowledge to the external organisation (McCarthy and Anagnostou, 2004). In any case, it is an adaptation driven by transaction cost rewards.

The development of new financial instruments and shareholder value orientation have contributed to the maintenance of profitability increasing the pressure for cost reductions and efficiency gains. If the increase in relative importance of the financial sector can effectively be captured by our measure of financial content, then it might help to explain why the increase in financial content is associated with a reduction of manufacture content. Such association is further in line with the idea of financialisation as a catalyst for deindustrialisation.

This of course does not say much about other implications of that relationship on growth or inequality, for example, which will motivate chapter 3. Moreover, while we could interpret the reduction in manufacture technical coefficients as an increase in efficiency in the use of those inputs, there are respective inefficiencies associated with a continuous increase in the need of financial inputs to produce one unit of output. Such observation reflects, in a sense, the fact that manufacture goods are tradable and therefore subject to international competition while FIRE is mainly a non-tradable.

The problem with the aforementioned explanation is that it relies on the assumption that financial technical coefficients reflect an increase in relative importance of the financial sector without going deeper on what is behind these coefficients. To a great extend, financial inputs are a function of financial intermediation resulting in net interests income. Thus, changes in financial technical coefficients are deeply related to the dynamics of interest rates and debt. This is in line with several interpretations of financialisation that put the increase in the volume of debt at the center of stage (see, for example, Palley, 2013).

If this is so, an alternative causal mechanism is be the following. The strong increase of interest rates during the 1980s and of indebtedness afterwards increased financial content. Such increase provoked a reduction in the use of other inputs because highly indebted firms could not use freely inputs as before. The reduction of manufacture coefficients followed as natural consequence. Such explanation avoids relying on globalisation as a channel through which

competition has increased.

The idea that globalisation has brought an increase in competition is debatable. For instance, several scholars have pointed out a remarkably consistent upward trend in market concentration in the United States (e.g. [Autor et al, 2017](#); [Galston and Hendrickson, 2018](#)). On the other hand, the reduction in multilateral and regional trade barriers, the fall in cost of international transport and communications, and the greater integration of capital markets have led to higher levels of international competition (see, for example, [Wiersema and Bowen, 2008](#); [Mion and Zhu, 2013](#); [Liu and Rosell, 2013](#); [Bloom et al, 2016](#)).

This apparent contradiction, however, might be just that, apparent. The key element is the complementarity between trade and technology. An increase in foreign trade exposure may alter the return of different technologies. Data for a sample of European countries, for example, indicates that firms facing higher levels of Chinese import competition create more patents, raise their IT intensity, and increase their overall level of productivity ([Bloom et al, 2016](#)). [Liu and Rosell \(2013\)](#) also find for the United States that innovation is not neutral to the degree of international competition.

But then, why has industry sales concentration increased? [Autor et al \(2017\)](#) hypothesise that industries are increasingly characterised by a “winner take most” feature so that superstar firms with higher productivity increasingly capture a larger slice of the market. If firms now are more likely to innovate and the persistence of firms’ innovative advantage has risen, the innovator advantage would increase and so would his market share. Possible explanations include the diffusion of new competitive on-line platforms with high fixed or low-marginal costs and rising international integration of product markets. In that sense, one could speculate that the globalisation of markets and industries has fundamentally changed the competitive conditions facing firms. Low-tech firms have been negatively impacted while high-tech activities have flourished in a “winner take most” structure that has raised US market concentration.

In any case, in the light of results presented here, there has been a pressure for efficiency gains that is captured by a reduction in manufacture technical coefficients. Financialisation continues to enter as a catalyst of this process. Our story has several similarities with the aforementioned literature, though we emphasise the role of financial activities in an IO framework.

One should also keep in mind that we can refer to such a negative relationship only in the long-run. In the short-term different sectors present different dynamics for both financial and manufacture content. That is, it is perfectly possible that for a certain sector an increase in the financial technical coefficient is associated with an increase in the manufacture coefficient, depending on sectoral specificities. This does not put into question our main argument, though it emphasises the importance of analysis also at a more disaggregated level.

In recent decades, advanced countries like the US have undertaken a process of structural transformation characterised by an increase in importance of service sectors and a declining weight of manufacture. At least in what concerns the US, this phenomenon does not seem to be constrained to the labour market or GDP shares. A multi-sectoral approach to the recent rise in relative importance of the financial sector in the economy indicates that there is a negative long-run relationship between financialisation and the decline of manufacture content. Services

and in particular the financial sector seem to be re-shaping economic fundamentals.

2.6 Final considerations

The United States has experienced after WWII and specially in the last thirty five years a process of structural change characterised by an increase in financial content and a reduction in manufacture content per unit of output produced. In this chapter we argued that both processes are related and we investigated the nature of this relation.

Using a 15-sector level of aggregation we studied the evolution of manufacture technical coefficients in the US between 1947 and 2015. Nine sectors experienced a reduction in manufacture direct content for the whole sample while thirteen exhibited a similar negative trend in the last thirty years. Those results can be reproduced if we aggregate the economy using the shares of each sector in total output.

We proceed applying cointegration techniques to the relation between a single aggregate measure of manufacture and financial content. Finally, building on ARDL modeling, Pooled Mean-Group estimation methods were used to confront disaggregated series in a heterogeneous panel. Overall results indicate that there is a negative long-run relationship between both series and that causality goes from financialisation to manufacture content. An increase of one unit in the financial sector technical coefficients is related to a decrease between 0.4 and 2 units of manufacture coefficients.

Granger tests indicate that there is unilateral causality going from financial to manufacture technical coefficients. This allow us to claim that an increase of one unit of direct financial content causes a decrease between 0.4 and 2 units in manufacture content. We find this result extremely important since it implies that our conclusions are not driven mainly by the composition effect. We actually have that *financial content is weakly exogenous, precedes and has predictive power on manufacture content*. Our outcomes are in line to other recent efforts showing that financialisation and deindustrialisation processes might be intrinsically related.

A reduction in technical coefficients can be interpreted as an increase in productive efficiency since it is possible to produce more with the same amount of inputs. Paradoxically, a reduction in efficiency in how financial inputs are treated seems to be associated with an increase in efficiency in the use of manufacture inputs.

We made the case that financial liberalisation and shareholder value orientation have contributed to profitability increasing the pressure for efficiency gains. Since both are part of a broader process referred to as financialisation, it could be part of the explanation of the aforementioned negative relationship. Still, there are respective inefficiencies associated with a continuous increase in the need of financial inputs to produce a unit of output. This, in a sense, reflects the fact that manufacture goods are tradable and therefore subject to international competition while FIRE is mainly a non-tradable.

At least in what concerns the US, the observed phenomenon does not seem to be constrained to the labour market or GDP shares. To the best of our knowledge, we are the first ones to

address finance and manufacture links looking directly to the evolution of sectoral technical coefficients. Our approach indicates that services and in particular the financial sector are indeed re-shaping economic fundamentals.

Appendix

Table A1 reports results of the unit root tests in levels for our main indicators of financial and manufacture direct content. Outcomes indicate that we cannot reject the null hypothesis that series are non-stationary in levels.

Table A1: Unit root tests (levels)

Finan. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-0.448705	-	-3.257610*	-
DF-GLS	0.557049	-	-2.085017	-
Breakpoint test	-3.822634	1981	-4.274469	1995
Manuf. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-0.271243	-	-2.897041	-
DF-GLS	0.492570	-	-2.447081	-
Breakpoint test	-3.002058	1980	-3.819164	1980

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

In table A2, we repeat the same set of tests now for our modified financial and manufacture technical coefficients. Once more we have that it is not possible to reject the null of non-stationarity. Also notice that most Breakpoint tests indicate 1980 as break year.

Table A2: Unit root tests (levels)

Mod. Finan. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-0.936608	-	-2.403723	-
DF-GLS	1.121193	-	-2.463967	-
Breakpoint test	-3.134885	1981	-3.730143	1981
Mod. Manuf. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-0.312832	-	-2.936354	-
DF-GLS	0.498042	-	-2.535202	-
Breakpoint test	-3.014521	1980	-3.849367	1980

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

Table A3 presents results of unit root tests in first differences for our preferred scenario. We conclude series are integrated of order one.

Table A3: Unit root tests (first differences)

Finan. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-5.680146***	-	-5.639946***	-
DF-GLS	-5.723793***	-	-5.708018***	-
Breakpoint test	-6.467647***	2008	-6.664748***	2008
Manuf. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-9.265483***	-	-9.387315***	-
DF-GLS	-1.701034*	-	-5.848057***	-
Breakpoint test	-10.00592***	1974	-9.936536***	2009

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

We proceed performing the same set of tests for our modified indicators now in first differences. The null of non-stationarity is rejected in all cases, as we can see in table A4.

Table A4: Unit root tests (first differences)

Mod. Finan. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-9.231278***	-	-9.189571***	-
DF-GLS	-8.996576***	-	-9.231684***	-
Breakpoint test	-10.19717***	2008	-10.11312***	2008
Mod. Manuf. content (t-statistic)				
Method	Intercept	Break year	Trend and intercept	Break year
ADF	-9.242496***	-	-9.340825***	-
DF-GLS	-1.699982*	-	-5.860066***	-
Breakpoint test	-9.950256	1974	-9.885815***	2009

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

Table A5 bring the results of the result of the VEC Residual Serial Correlation LM Tests. We cannot reject the null hypothesis of no serial correlation, which indicates our VEC estimates are consistent.

Table A5: VEC residual serial correlation

H_0 : No serial correlation at lag h		
	Model 1	Model 2
Lag	Prob.	Prob.
1	0.3567	0.8697
2	0.5217	0.6307

H_0 : No serial correlation at lags 1 to h		
	Model 1	Model 2
Lag	Prob.	Prob.
1	0.3567	0.8697
2	0.3838	0.8165

Stationarity of residuals of FMOLS and DOLS models are tested due to standar ADF unit root test. Results are reported in table A6. We concluded errors are stationary and, therefore, the cointegrating relations estimated are not spurious.

Table A6: Unit root tests (levels)

FMOLS, residuals (t-statistic)				
	Model 1		Model 2	
Method	Intercept	Trend and intercept	Intercept	Trend and intercept
ADF	-4.598494***	-4.559805***	-4.647814***	-4.767692***

DOLS, residuals (t-statistic)				
	Model 1		Model 2	
Method	Intercept	Trend and intercept	Intercept	Trend and intercept
ADF	-4.391662***	-4.521170***	-3.877776***	-3.813678**

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

Table A7 reports results of the unit root tests in levels. The optimal number of lags was determined using the SBIC. In terms of our preferred indicators, financial content is non-stationary while results are not conclusive for manufacture content. Moving on to our modified set up the situation is inverted. Manufacture content is clearly non-stationary but we cannot state precisely if this is also the case for financial content.

Table A7: Panel Unit root tests (levels)

Method	Manuf. content		Mod. Manuf. content	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
	Prob.	Prob.	Prob.	Prob.
Levin, Lin & Chu	0.2613	0.0109	0.8179	0.6321
Im, Pesaran and Shin	0.3844	0.0005	0.8470	0.5963
ADF	0.0993	0.0007	0.8419	0.7815
PP	0.1367	0.0159	0.6575	0.7719

Method	Finan. content		Mod. Finan. content	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
	Prob.	Prob.	Prob.	Prob.
Levin, Lin & Chu	0.9519	0.7424	0.7006	0.3342
Im, Pesaran and Shin	0.9894	0.6109	0.7494	0.0024
ADF	0.9910	0.6006	0.5928	0.0086
PP	0.9767	0.8331	0.1279	0.0108

Still, one can say for sure series are not integrated of order two. Table A8 brings the results of the unit root tests in first differences. Once more, the number of lags was chosen using the SBIC. Outcomes indicate that series are stationary in first differences, hence, they are at most I(1). This justifies our choice for the ARDL estimator.

Table 8: Panel Unit root tests (First difference)

Method	Manuf. content		Mod. Manuf. content	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
	Prob.	Prob.	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000	0.0000	0.0000
Im, Pesaran and Shin	0.0000	0.0000	0.0000	0.0000
ADF	0.0000	0.0000	0.0000	0.0000
PP	0.0000	0.0000	0.0000	0.0000

Method	Finan. content		Mod. Finan. content	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
	Prob.	Prob.	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000	0.0000	0.0156
Im, Pesaran and Shin	0.0000	0.0000	0.0000	0.0000
ADF	0.0000	0.0000	0.0000	0.0000
PP	0.0000	0.0000	0.0000	0.0000

MG estimates are presented in table A9. Notice that the long-run coefficient of financial

content is not statistically significant neither in the basic or modified cases. Error correction terms are negative and significant as expected, showing that there is convergence to the long-run solution. However, Hausman test results give an statistic of 1.1 and 1.11 which justifies our choice of PMG as preferred model.

Table A9: MG/ARDL estimates

Long-run equation		
	Model 1	Model 2
Variable	Coefficient	Coefficient
Finan. content	-3.455824	1.686722
Short-run equation		
	Model 1	Model 2
Variable	Coefficient	Coefficient
Coint. Equation	-0.1015606***	-.0932464***
D(Finan. content)	-0.2129981	-0.1707817
C	0.0160907***	0.0147733***
Hausman statistic	1.1	1.11

*, **, and *** stand by 10%, 5% and 1% of significance

Stationarity of residuals of the PMG/ARDL model is tested due to panel unit root test. Results are reported in table A10. We concluded errors are stationary and, therefore, the relations estimated are not spurious.

Table A10: Panel Unit Root tests, residuals PMG/ARDL

PMG/ARDL	Intercept	Trend and Intercept
Method	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000
Im, Pesaran and Shin	0.0000	0.0000
ADF	0.0000	0.0000
PP	0.0000	0.0000

Chapter 3

Some New Insights on Financialisation and Income Inequality

3.1 Introduction

The United States and many countries in Europe have experienced growing income inequality over the past decades that has not gone unnoticed. As consequence, there has been a marked revival of interest in the study of income distribution.

Much research has focused on the question of the role of globalisation in this phenomenon (e.g. [Alderson and Nielson, 2002](#); [Krugman, 2008](#); [Ezcurra and Rodríguez-Pose, 2013](#); [Jaumotte et al, 2013](#); [Cabral et al, 2016](#)). The debate has often concentrated on the impact of an increasingly integrated world economy on distribution. Indeed, empirical evidence does give some support to the hypothesis of a positive association between trade/financial integration, production relocation and income inequality.

Even though it is very difficult to disentangle technological change from globalisation patterns, some authors have directly explored the impact of technology on inequality. A prominent argument is the Skill Biased Technological Change (SBTC) according to which technical change has favor skilled groups replacing tasks previously performed by the unskilled and specially by the medium-skilled, exacerbating income inequality and job polarisation ([Acemoglu, 2002](#); [Autor et al, 2008](#); [Acemoglu and Autor, 2011](#)).

If skills are provided by education, rising inequality becomes the result of the pace of new technology exceeding the ability of schools to supply the necessary skills, that is, technology is “winning the race” against education ([Goldin and Katz, 2008](#)). Furthermore, authors in this strand of the literature have also pointed out to the impact of international trade and the role of services through similar channels ([Autor et al, 2013](#); [Autor and Dorn, 2013](#); [Acemoglu et al, 2016](#)).

A third explanation emphasises the role of changes in institutions and social norms. It is hard to parse out cleanly and precisely a separation between globalisation, technology and institutional issues. Keeping this in mind, it has been claimed, for example, that the rise and fall of unionisation and a declining minimum wage explain much of the recent increase in

inequality (Card and DiNardo, 2002; Western and Rosenfeld, 2011; Volscho and Kelly, 2012). The same follows the increased ability of “superstars” and top executives to set their own pay (Dew-Becker and Gordon, 2005; Gordon and Dew-Becker, 2007).

In a similar vein, other scholars have argued that a deregulated financial environment has led to the rise of shareholder value orientation with implications in terms of both personal and functional income distribution (Epstein, 2005; Lin and Tomaskovic-Devey, 2013; Dünhaupt, 2017). Stiglitz (2013) for instance has sustained that growing inequality is largely the result of how we have structured the market economy in the last thirty years. Not by chance, the explosion of top managerial compensation and its link with large cuts in top tax rates have been investigated when constructing top income shares time series over the long-run (Atkinson et al, 2011; Piketty and Saez, 2013).

Finally, departing from Kuznets’ principle that changes in inequality are largely guided by the structure composition and the stage of development of the economy, a fourth group of contributions have decomposed variations on income distribution following wage variations across economic sectors (Conceição and Galbraith, 2001; Galbraith, 2012; Galbraith and Hale, 2014). Such disaggregations have enlightened the roles played by the financial sector, the technology boom and by wartime public spending in driving the evolution of income distribution in the United States.

Our contribution combines elements of these last two groups in the sense that we are interested in the implications of the rise in relative importance of the financial sector to income inequality. The literature on financialisation has extensively documented over the past decades an “increasing role of financial motives, financial markets, financial actors and financial institutions in the operations of the domestic and international economies” (Epstein, 2005, p. 3).¹ In general terms, financialisation is a process of structural change that involves an increase in relative importance of the financial sector and its interactions with the rest of the productive structure.

We proposed in chapters 1 and 2 a novel way to conceptualise financialisation based on a multi-sectoral approach and the use of IO tables. In this way, we showed how financialisation and the fall of manufacture activities might be related as a complex process of structural change. This chapter, on the other hand, explores the implications of studying financialisation as a stock and flow phenomenon.

In Economics we often distinguish between quantities that are stocks and those that are flows. For the purposes of this chapter, financialisation is introduced as a two-fold process. On the one hand, it can be understood as an increase in the contribution of the financial sector in terms of the composition of production, or a flow dimension. On the other hand, it can be seen as an increase in importance of finance in terms of the composition of wealth, or a stock dimension.

Applied research on the topic has consistently differentiated between flow and stock measures.

¹Once more we would like to emphasise that the concept of financialisation is particularly controversial and has been defined in many ways that often look mutually inconsistent. A more comprehensive discussion of those issues can be found in Vercelli (2013) and Karwowski et al (2016).

In general, activity or flow indicators refer to financial incomes or payments relative to total income, while vulnerability or stock indicators are basically debt over Gross Domestic Product (GDP). However, those indicators are misleading for several reasons. For instance, it has been argued that modern economies produce less measurable goods/services which potentially creates distortions in how we treat financial and R&D outputs (e.g. [Nakamura, 2010](#); [Mazzucato and Shipman, 2014](#); [Pagano, 2014](#)). Moreover, it is important to notice that the ratio of a stock over a flow is in fact a time measure. Hence, the debt to GDP ratio fails to capture the stock dimension of the financialisation process.

In order to overcome the main limitations of current metrics, we propose two different measures of financialisation, one for each dimension. Accordingly, we make use of the share of financial employment on total employment as a proxy of the first dimension. By not relying on value-added shares or the share of financial income on GDP, the use of employment shares has the advantage of avoiding the accounting problems above mentioned.

Notwithstanding, the main contribution of this essay relies in looking at the structure of the economy also in terms of stocks. This is done in our empirical exercise by measuring wealth composition as the share of financial assets on corporates' total assets. Such simplification does not come without a cost since we are deliberating leaving aside households and we do not differentiate financial and non-financial companies. However, while still a good proxy for the size of finance on wealth, it allows us to focus our analysis on corporations that after all are the economic units responsible for production activities. We consider that the financialisation measures proposed in this essay overcome the main limitations of previous indicators used in the literature. In this way, we provide a better treatment of the process under analysis in its flow and stock dimensions.

Therefore, this chapter studies the relation between income distribution and financialisation in the United States between 1947 and 2013. Applying cointegration techniques we identify a positive long run relationship between the share of financial employment and income inequality as well as between the share of financial assets and income inequality. At least in what concerns the traditional Gini index, causality goes from the flow dimension of financialisation to inequality and from inequality to the stock dimension. However, when directly confronting both sides of the financialisation process the latter causes the former.

We begin elaborating further our main argument and giving a preliminary look at the US experience in terms of data descriptive analysis. Section 3 presents our empirical exercise of the relation between financialisation and income inequality. Section 4 concludes with a discussion of our main results.

3.2 A brief descriptive narrative

The suffix “-isation” has been intensively used in Economics to designate a changing weight and importance of the thing or quality preceding it. Broader speaking financialisation corresponds to an increase in importance of finance in the economy, or the “increasing role of financial

motives, financial markets, financial actors and financial institutions in the operations of the domestic and international economies” (Epstein, 2005, p. 3).

Economics and related fields also often distinguish between quantities that are stocks and those that are flows. Such differentiation is particularly useful to this case as it will become clearer in the rest of the chapter. Thereby, financialisation is understood as a two-fold process characterised by (i) an increase in the contribution of the financial sector in terms of the composition of production, or flow dimension; and (ii) an increase in importance of finance in terms of the composition of wealth, or stock dimension. In other words, we are interested to capture the increase in relative importance of the financial sector in terms of its flow and stock dimensions.

Karwowski et al (2016) have recently presented an extensive review of the empirical literature on financialisation distinguishing between flow and stock measures. In their classification, activity or flow indicators refer to financial incomes or payments relative to total income. On the other hand, vulnerability or stock indicators are basically debt relative to income. However, those measures are misleading for several reasons.

It has been documented that modern economies produce less measurable outputs than the traditional manufacturing, mining, and agriculture (see, for example, Nakamura, 2010; Pagano, 2014). Authors such as Mazzucato and Shipman (2014) have shown lately an increase in divergence between value-creation and value-added measures. They attribute such phenomenon to the rise in size and influence of financial institutions and markets. The financial sector value-added has been overstated while pure rent seeking activities have been counted as productive. This has put into question natural candidates to capture the importance of financial activity vis-a-vis real activity such as gross financial income or the financial sector value added as a share of GDP.

In what concerns the stock indicators of financialisation used in the literature, it is important to notice that the ratio of a stock over a flow is in fact a time measure, $units/(units/time) = time$. Hence, the debt to GDP ratio is a useful indicator of financial fragility, but we consider it does not capture properly the stock dimension of the financialisation process.

Given the distortions that an inadequate treatment of financial outputs might have in the analysis of income inequality, we propose the share of financial employment on total employment as a proxy for the flow dimension of financialisation. The use of employment shares allows us to establish a direct link between financialisation and deindustrialisation. In a sense, deindustrialisation is an integral part of the globalisation, technological and institutional arguments while an enlargement in the share of financial employment is part of a broader upswing in the share of non-manufacture employment. To the extent that deindustrialisation is defined as a decrease in manufacture employment, financialisation becomes a different side of the same phenomenon.

In a detailed and relatively recent assessment of financialisation in the United States, Krippner (2005) has contrasted a traditional perspective on long-term economic change concerned with what is produced in the economy *vs* one engaged in understanding where profits are generated. Indicators such as the share of financial employment or financial GDP would be part

of the first group. The relative importance of financial to non-financial profits, on the other hand, would capture the second view.

As she did at the time, we do not claim that ours or hers separation is more fundamental or more “true” given that “how one conceptualises structural change in the economy depends very much on one’s theoretical purpose” (Krippner, 2005, p. 176). Our motivation is much simpler. Following a long tradition in Economics, we aim to provide a more accurate treatment of financialisation from a stock and flow composition perspective, and its relation with income inequality.

At this point, the reader may also ask himself why not to use the indicators developed in the previous chapters. Our reasons are twofold. First, we understand that a significant amount of research has already be done differentiating between stocks and flows. Considering the limitations of current indicators, our exercise intends to bring some new insights to this relationship. Secondly, the main principle that has guided our analysis throughout this dissertation has been to see financialisation as a process of structural change that involves changes in relative importance of the financial sector. Hence, we aim to emphasise this perspective also in terms of the composition of employment and wealth.

Furthermore, while a correspondence between employment or wealth composition and income inequality is easier to explain, eventual links between technical coefficients and distribution are not so straightforward. It is our purpose in future research to investigate if there is a link also in terms of financial content. For now, we will focus on the labour market and how corporations distribute their wealth between financial and non-financial assets.

Figure 1 on the left shows the evolution of the share of employment in financial activities between 1950-2010, and the respective lowess curves. A detailed description of the data used in this study is provided in the next section. It is possible to identify a positive trend for the whole period. We can also divide the sample before and after the eighties. While between 1950 and 1980 financial employment increased from 7% to 10% of total employment, in the next thirty years it gets closer to 20%.

Even though we do not report here the evolution of overall non-manufacture employment, it is important to notice that it increased from 75% in 1947 to 91.3% by 2014, an expansion of 16.3%. During the same period, the share of financial employment increased 11.3%, from 6.7% to 18%. This means that, looking to the labour markets, the flow dimension of financialisation is responsible for something around 70% of the deindustrialisation process, $11.3/16.3 = 0.69$. One must say, it is a significant part of the transformation of the productive structure of the US economy.

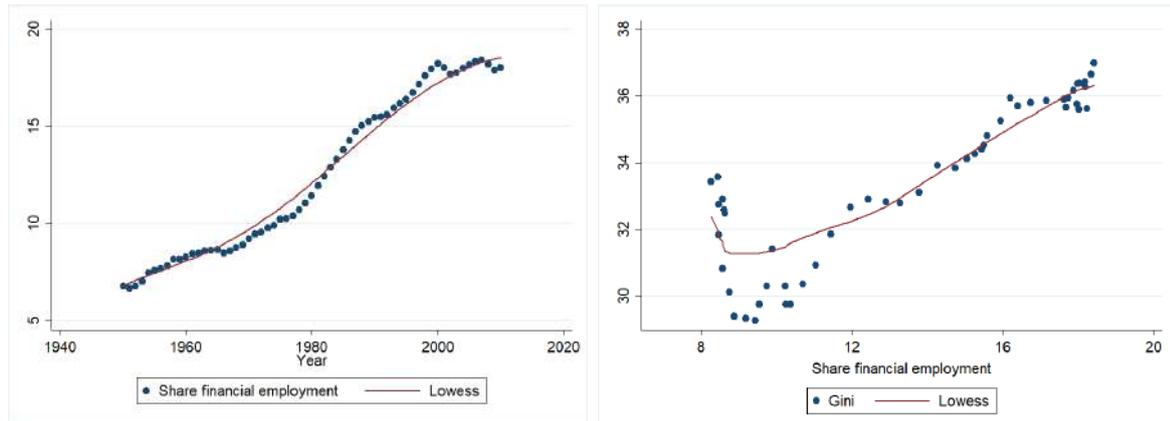


Figure 1: Share of financial employment and income inequality

This process seems to be correlated with the recent upswing in income inequality. It is well known that the service sector, which includes financial activities, has a greater income gap between high paying and low paying jobs than does manufacturing.² If workers displaced from manufacture activities used to be in the middle-income percentiles of the population and are not able to be reallocated in non-manufacture activities with higher or equal earnings, we shall expect income distribution to worst off. labour saving technological change has reduced the demand for many blue-collar jobs while globalisation is creating a global market place putting workers of tradable sectors in competition with comparable workers from abroad. Deindustrialisation has weakened the bargain power of workers producing higher inequality.

As a matter of fact, [Dew-Becker and Gordon \(2005\)](#) documented that in the United States between 1966 and 2001 no quantile bellow the 90th percentile experienced growth in wages commensurate with the average rate of productivity growth. [Yellen \(2006\)](#) points out that when displaced workers do find new jobs, they take a pay cut of about 17% on average. In the early 2000, the size of this wage loss was the highest in at least twenty years. These considerations might also have impact in terms of the functional distribution of income. A reduction in the wage-share in the past decades has been reported for several countries including the United States by [Karabarounis and Neiman \(2014\)](#), [Dünhaupt \(2017\)](#) and [Hein et al \(2017\)](#), among others.

In addition, the increase in importance of finance is deeply related to the remuneration of corporate officers. The financial sector has developed expertise in a variety of rent-seeking forms that go from taking advantage of asymmetries of information to lending and abusive credit card practices ([Stiglitz, 2013](#)). If workers in the financial sector are in the top-income

²This does not mean we do not acknowledge that manufacture activities are also heterogeneous. The literature on complexity, for example, has stressed the relation between technology and manufacture as well as possible bridges with income inequality ([Hausmann et al, 2014](#); [Hartmann et al, 2017](#)). Moreover, services also exhibit different patterns of growth that vary according to each country development level ([Eichengreen and Gupta, 2013](#)).

percentils of the population and manage to increase their wages above productivity gains, we shall also expect a deterioration of income distribution.

Figure 1 on the right depicts the positive relation between income inequality and the share of financial employment. Higher levels of income inequality seem to be associated with higher levels of employment in that sector. For a share of financial employment between 8 and 10% there is no clear association between these two variables and if something it looks negative. However, an increase in the share of financial employment from 10% to almost 20% is associated with an increase of 7 points in the Gini index. Lowess non-parametric procedure confirms the main positive trends described so far.

Considering that indicators that resemble debt to income or GDP ratios are inappropriate to capture the stock dimension of financialisation, we use instead the share of financial assets on corporates' total assets. Corporate's wealth is traditionally defined as net (or residual) wealth of the corporate's sector, i.e. the sum of non-financial and financial assets owned by corporate sector minus their debt liabilities. In practice, the corporate sector is owned in part by the two domestic sectors (private and government) and in part by the rest of the world. Hence, the value of corporations is already included in the financial assets and therefore in the net wealth of these other sectors. If Tobin's Q ratio is equal to one, then by construction net corporate wealth is equal to zero: the full value of corporations is already included in private and public wealth so there is nothing to add (Alvaredo et al, 2016).

However, in this essay we are not looking to corporates' net wealth but instead to the composition of corporations gross wealth, i.e. the sum of non-financial and financial assets owned by corporate sector. An increase in the share of financial assets on corporates' gross wealth does not imply that wealth has been created but does mean that there are ongoing changes in the economy. Moreover, those changes might indicate an increase in intermediation and securitisation activities with possible implications in terms of income distribution.

Two more advantages justify our use of the composition of corporates' gross wealth to account for the second dimension of the financialisation process. First, it does capture the composition of a proper stock. This feature is important if we are to understand financialisation as an increase in relative importance of the financial sector. Secondly, though it leaves aside households and does not differentiate between financial and non-financial companies, it permits us to concentrate on the basic units of production, that is, on corporations.

Figure 2 on the left presents the evolution of the share of financial assets on corporates' total assets in the last sixty years, and on the right, the positive relation between this proxy of wealth composition and inequality. The 1980s divide the sample in two periods. There is a clear structural break in that year that contrasts with a more continuous trajectory in financial employment. Between 1950 and 1980 the share of financial assets increased from 60% to 65%. However, in the next thirty years we observe an increase to around 85% by the end of the period.

From an uneven distribution of financial assets favoring those in the top income percentiles of the population, we expect an increase of income inequality if returns on the financial sector

are higher than in the real sector.³ A change in corporate governance towards shareholder value also benefits asset holders through an increase in the dividend payout ratio and rising stock prices (Dünhaupt, 2017; Hein et al, 2017). The magnitude of this effect further depends on the size of finance on wealth composition. This hypothesis is quite plausible considering, for example, that the rate of return on fortunes increases with their size (Wade, 2014).

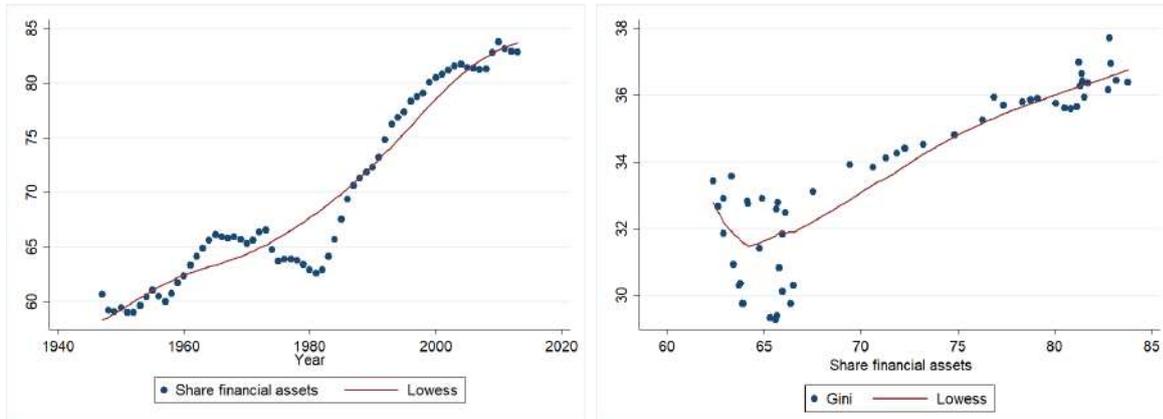


Figure 2: Share of financial assets on corporates total assets and income inequality

An increase in the share of financial assets from 70 to 85% seems to be associated with an increase of 4 points in the Gini index. Still, for values below 70% there is no clear correspondence, a pattern already identified in terms of employment. Lowess curves confirm the main trends as we can see in figure 2.

Those considerations bring us to the last relation explored in this chapter, that is, the possible channels that exist between the two dimensions of financialisation. It is reasonable to suppose that there is a relation between flow and stock measures of the economy's structure. The basic structure of a differential equation depicts, for instance, such correspondence. On the one hand, stocks are the result of the cumulative behavior of flows. If a greater share of the pie is generated in the financial side of the economy, one could expect a preference in accumulation also in the form of financial assets. Still, the other way around is also possible. For a given composition of the stock, a certain flow is determined. That is, the way wealth is distributed between financial and non-financial assets conditions how the productive structure will be organised.

³For a preliminary discussion of these issues from a functional income distribution theoretical perspective see Dávila-Fernández et al (2017). Recently, Piketty (2014, 2015) has suggested that the size of the gap between the rate of return on capital, r , and the economy's growth rate, g , is one of the important forces that can account for the historical magnitude and variations of wealth inequality. It is interesting to notice that if we divide Piketty's broad definition of capital between financial and non-financial assets, $r > g$ becomes $\theta i + (1 - \theta)r > g$ where i is the rate of return of financial assets, θ is the share of financial assets over total assets and r is strictly the rate of return on capital.

There is a striking positive association between them, as we can see in figure 3. A higher share of financial assets seems to be related to a higher share of financial employment. In what follows, we proceed investigating the nature of the trends presented in this section.

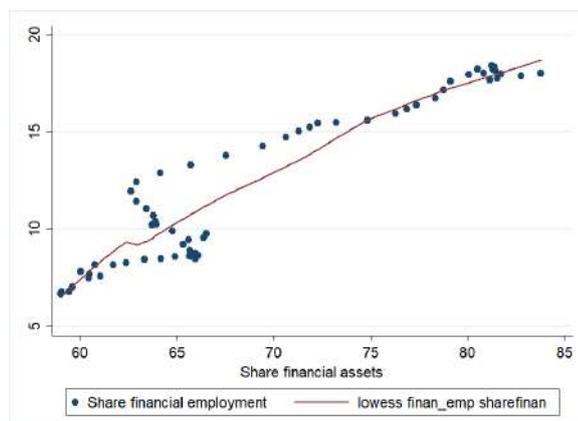


Figure 3: Flow and stock dimensions of financialisation

3.3 A cointegration exercise

Our dataset is annual and comprehend the period between 1947 and 2013. We use the Gini net index provided by the Standardised World Income Inequality Database (SWIID) available from 1960-2014. The share of financial assets over total corporations' assets was computed using data provided by the World Wealth and Income Database (WW&ID) from 1947 to 2013. Corporate financial assets correspond to the sum between corporate equity, fund shares, off-shore wealth, corporate currency, deposit banks, loans, corporate pension funds and life insurance. Corporate non-financial assets are given by the sum of business, housing and other non-financial assets. Finally, the share of financial employment was provided by the Groningen Growth and Development Centre from 1950 to 2010. Data was converted to logarithmic form.

To ascertain the existence of a long-run relationship between financialisation and income inequality, we use country-specific cointegrating techniques. While still constrained by parametric assumptions, this approach overcomes two of the main shortcomings of the usual cross-country regressions. First, by focusing exclusively on the time dimension of the data it avoids some heterogeneity problems. Second, the omitted variable issue does not affect the reliability of our estimates. This is because an omitted variable will either be stationary - in which case the estimated coefficients are invariant to its inclusion - or it will be non-stationary - in which case we will not be able to obtain a stable cointegrating relationship if we leave it out.⁴

⁴Only if an omitted variable is strongly correlated with one of the variables in the cointegration analysis we can end up with spurious estimates. For a further discussion and references on the econometric properties of the time-series approach and its advantages/disadvantages in comparison to cross-country analysis, see Gobbin and Rayp (2008).

Considerable attention has been paid over the past decades to testing the existence of relationships in levels between variables. Different approaches have been adopted, for example: (i) the Engle-Granger two-step residual-based procedure; (ii) the Johansen system-based reduced rank regressions, or (iii) the Hansen instability test. Those tests, however, require series to be unequivocally non-stationary and integrated of the same order. This might be a problem when it is not known with certainty whether the underlying regressors are trend or first-difference stationary.

Ascertaining the order of integration of the variables under analysis becomes an essential precondition to establish whether the use of traditional cointegration techniques is warranted. In this respect we performed the traditional Augmented Dickey-Fuller (ADF) and the Dickey-Fuller test with GLS detrending (DF-GLS). The share of financial employment and Gini index were found to be integrated of order one while the share of financial assets is at least integrated of order two (see tables A1 and A2 in the appendix). This posits a problem since under such conditions we cannot proceed with our exercise.

Notice, however, that from visual inspection we identified a structural break around the 1980s for the share of financial assets. Multiple breakpoint Bai-Perron test identifies several repartition breaks for Gini (1986, 1994, 2004), Share of financial employment (1959, 1970, 1981, 1993, 2002), Share of financial assets (1961, 1988, 1998). As Perron (1989) points out, structural change and unit roots are closely related, and might invalidate conventional unit root tests. A large literature has followed outlining unit root tests that remain valid in the presence of a break. Hence, we also performed the Dickey-Fuller test allowing for a structural break as reported in the appendix (see tables A3 and A4). Results indicate that series are at most integrated of order one though the share of financial employment and assets might be $I(0)$.

Hence, we make use of the Auto-Regressive Distributed Lag (ARDL) bounds testing procedure developed by Pesaran and Shin (1998) and latter extended by Pesaran et al (2001). This methodology has several advantages over other cointegration methods as it allows the undertaking of analysis regardless of whether the variables are a mixture of stationary, $I(0)$, and integrated of order one, $I(1)$, which is our case. All models estimated are bivariate. Unless explicitly said otherwise, all tests performed and estimated models included dummy variables to capture the structural break effects. One dummy variable was assigned for each indicator. They assume value 1 for years with breaks and 0 for years with no break.

In what follows, we adopt a two-step estimation strategy. First, the relation between financialisation and inequality is addressed in separate models. The analysis also includes the investigation of Granger causality and the estimation of long-run coefficients. After that, we directly confront our two dimensions of financialisation using a similar route map.

3.3.1 Assessing income inequality

A series of four ARDL models were estimated, all of them including income distribution either as dependent or explanatory variable. In order to avoid potential serial correlation issues, the order of lags was obtained using the Akaike (AIC) informational criteria. We allow for automatic lag

selection imposing a maximum of 4 lags for dependent and independent variables. Some models were found to have serial correlation, in which cases we maintained the automatic lag selection criteria but increased the maximum number of lags until serial correlation was removed.

If two series are cointegrated, this means that they have a long-term relationship, which prevents them from wandering apart without bound. Pesaran et al (2001) and Narayan (2005) provided supply bounds on the critical values for the asymptotic distribution of the F-statistic. Table 1 reports our estimates of the ARDL/Bounds cointegration test:

Table 1: Bounds cointegration test

Dependent	Explanatory	Model	F-statistic
Gini	Share finan. emp.	ARDL(2,0)	5.015386**
Share finan. emp.	Gini	ARDL(2,2)	3.637056*
Gini	Share finan. assets	ARDL(3,3)	2.288055
Share finan. assets	Gini	ARDL(5,2)	4.315043**

*, **, and *** stand by 10%, 5% and 1% of significance

The calculated F-statistic is higher than the 5% of significance critical value for two out of four models. When Gini is used as dependent variable a cointegration relationship was found with the share of financial employment. For the cases where income distribution appeared as explanatory variable, a cointegrating relationship was obtained only with the share of financial assets. That is, we are able to identify the existence of a long-run relationship between the variables under analysis. financialisation and income distribution are related.

As a next step, we test for causality by incorporating the lagged error-correction term that represents the long-run causal relationship (Narayan and Smyth, 2006; Odhiambo, 2009). This is done only for those cases where we found cointegration. Results are provided in table 2:

Table 2: Granger non-causality test

Causal flow	ECM coefficient	R ²
Share finan. emp. \implies Gini	-0.175581***	0.426188
Gini \implies Share finan. assets	-0.062804***	0.704534

*, **, and *** stand by 10%, 5% and 1% of significance

The significance of the coefficient of the lagged error-correction term indicates that there is a distinct unidirectional causal flow going from the flow measure of financialisation to inequality and from inequality to the stock measure of financialisation. For both cases the ECM coefficient is negative implying that there is convergence to the long-run equilibrium solution. In the first case, 17% of any movements into disequilibrium are corrected for within one period. In the second case, we have 6% of correction within one period.

It is also worth to notice that convergence to equilibrium is much faster for employment shares than for wealth composition. This result is expected considering that changes in stocks are suppose to happen slower than adjustments in flows. As a final step, long-run coefficients are reported in table 3:

Table 3: Long-run coefficients, ARDL models

Dependent variable: Gini				
Variable	Coefficient	Std. Error	t-statistic	Prob.
Share finan. emp.	0.261200	0.038488	6.786467	0.0000
C	2.832504	0.099155	28.56629	0.0000
Dependent variable: Share financial assets				
Variable	Coefficient	Std. Error	t-statistic	Prob.
Gini	1.607426	0.228275	7.041621	0.0000
C	-1.325467	0.792512	-1.672489	0.1020

Our estimates support the proposition that there is a positive relation between financialisation and income inequality. Recall that all variables were converted to logarithmic form. An increase of 1% in the share of financial employment is related to an increase of 0.26% in Gini net. Moreover, an increase of 1% in income inequality is followed by an increase of 1.6% in the share of financial assets. Results are in line with previous studies that have also documented an association between financialisation and inequality (e.g. [Sjöberg, 2009](#); [Dünhaupt, 2014](#)). Still, it is interesting to notice the sequence of events, with income distribution as an intermediary between the two dimensions of financialisation. Changes in the importance of the financial sector in terms of the composition of production impact income distribution that amplifies this effect on the composition of wealth.

Although the idea that deindustrialisation is behind the rise of inequality in the U.S. finds echo in the literature, our exercise also brings some insights in this respect.⁵ For instance, deindustrialisation has been originally interpreted as a reduction in the share of manufacture employment. As previously reported in this chapter, around 70% of this reduction corresponds to a rise in the share of financial employment. To the extent that, in this particular case, financialisation can be seen as a mirror to deindustrialisation, we have here also a correspondence between deindustrialisation and the rise of income inequality in the United States.

3.3.2 Assessing stocks *vs* flows

A natural question that arises is how both dimensions of financialisation are related one with the other. On the one hand, it is reasonable to suppose that the flow indicator determines the stock one since the latter is the result of the cumulative behaviour of the former. As discussed in the previous section, if a greater share of the pie is generated in the financial side of the economy, one could expect a preference in accumulation also in the form of financial assets. However,

⁵For example, Moller, Alderson and Nielsen (2009) do include a “deindustrialisation” variable when addressing income inequality in the United States. However, they use a within-county panel approach. On the other hand, studies like Alderson and Nielsen (2002) or Jaumotte et al (2013) rely on traditional cross-country regressions.

the other way around is also possible. For a given composition of the stock, a certain flow is determined. That is, the way wealth is distributed between financial and non-financial assets conditions how the productive structure will be organised. To assess the order of relevance between both dimensions of financialisation we now confront those variables.

Table 4 reports our estimates of the ARDL/Bounds cointegration test. The order of lags was once more obtained using the Akaike (AIC) informational criteria. We allow for automatic lag selection imposing a maximum of 4 lags for dependent and independent variables. However, in this case, our dummy variables were not able to fully account for structural break issues as the ECM term of the estimated model was found to be positive. Therefore, we introduced another dummy variable that assumes value zero for years before 1975 and 1 afterwards. We take 1975 as a reference year since much of the financialisation literature points the 1970s and 1980s as a watershed for the rise of finance.

Table 4: Bounds cointegration test

Dependent	Explanatory	Model	F-statistic
Share finan. emp.	Share finan. assets	ARDL(2,0)	7.442222***
Share finan. assets	Share finan. emp.	ARDL(4,0)	2.144839

*, **, and *** stand by 10%, 5% and 1% of significance

As expected, both dimensions of financialisation are related in the long-run. When the share of financial employment is used as dependent variable, the estimated F-statistic is much higher than the critical value at 1% of significance. This means that the share of financial employment is strongly related to the share of financial assets. However, when we include the composition of wealth as dependent, we do not find a cointegrating relationship. This gives us a preeliminary idea of the direction of causality.

In fact, long-run causality is assessed through the significance of the lagged error-correction term in the ECM regression. Results are presented in table 5.

Table 5: Granger non-causality test

Causal flow	ECM coefficient	R ²
Share finan. assets \implies Share finan. emp.	-0.009093***	0.386451

*, **, and *** stand by 10%, 5% and 1% of significance

The significance of the lagged error-correction coefficient indicates that there is unidirectional causality going from the share of financial assets to the share of financial employment. That is, the stock dimension of financialisation precedes and has predictive power over the flow dimension. Putting together this result with our estimates in the previous subsection, we have what seems to be a cycle going from the labour market to income distribution, from inequality to wealth composition, and finally from the share of financial assets on the labour markets.

In addition, it is worth noting that the ECM coefficient is negative and significant but small. This means that there is a very slow convergence to the long-run equilibrium solution. Only 1% of any movements into disequilibrium are corrected for within one period. As a final step, long-run cointegration coefficients were estimated and are reported in table 6.

Table 6: Long-run coefficients, ARDL model

Dependent variable: Share finan. emp.				
Variable	Coefficient	Std. Error	t-statistic	Prob.
Share finan. assets	-7.640408	42.56125	-0.179516	0.8582
C	35.26265	183.0375	0.192653	0.8480

An increase of 1% in the share of financial assets on corporates' total assets has no significant effect on the share of financial employment. This outcome is quite surprising because we did find that there is a long-run relationship between both financialisation dimensions. Still is not possible to assert precisely if the stock dimension of financialisation leads to an increase or reduction in the share of financial employment.

Taking as departure point Kuznet's principle that changes in income inequality largely depend on the sectoral composition of the economy, the results presented allow us to go further and propose that the composition of production (flow) is to some extent guided by the composition of the stock behind it, that is, wealth. Stocks represent accumulation and capture the "state of the system". Of course they start with some initial value and thereafter change by flows into or out of them. Nevertheless, they provide the basis for making choices. It follows that the composition of the stock provides the basis for making the choices that are going to determine the composition of the flow.

Even though the increase in the share of financial assets on corporates' gross wealth does not imply that wealth has been created, it does suggest that the structure of the economy is changing. In particular, it indicates an increase in financial intermediation and securitisation. This process has strong ties with changes with financial employment though we are not able to determine the sign of such relationship. Still, the observed increase in the share of financial employment has exacerbated income inequality leading to a further movement towards financial assets. At the end of the day the recent rise in income inequality is strongly linked with the increase in importance of finance in terms of wealth composition. The relevance of this result is increased if we acknowledge the fact that current measures used in the literature fail to properly capture the stock dimension of the financialisation process.

The reader may ask how sustainable this process is in the very long-run. It is true that the share of financial employment or financial assets cannot grow forever since, in the limit, all employment or assets would become financial. Even then, financialisation, as described in this dissertation, will come to an end because there will not be anymore an increase in relative importance of the financial sector. Still, we showed that this once and for all change in the sectoral composition of the economy has important implications for income distribution.

To assess a valid inference and not spurious regressions, residuals of all ARDL regressions were checked for serial correlation using Breusch-Godfrey LM test. If residuals are correlated the estimated coefficients would be biased and inconsistent. We conclude that our estimates are consistent. Results are reported in the appendix (see table A5 and A6).

3.4 Final considerations

The United States and many countries in Europe have experienced growing income inequality over the past decades that has not gone unnoticed. There is a wide agreement among economists that technological change, international trade and social norms are playing a role in this process. Departing from Kuznets' principle that changes in inequality are largely guided by the structure composition and the stage of development of the economy, we introduced financialisation as a two-fold process characterised by (i) an increase in the contribution of the financial sector in terms of the composition of production and (ii) an increase in importance of finance in terms of the composition of wealth.

Given the distortions that an inadequate treatment of financial outputs might have in the analysis of income inequality, we proposed the share of financial employment on total employment as a proxy of our first dimension of financialisation. The use of employment shares allowed us to avoid accounting problems and to establish a link between financialisation and deindustrialisation as different sides of the same process. Wealth composition was brought into the analysis through the share of financial assets on corporates' total assets. We consider that this stock measure of financialisation overcomes the main problems of the misleading debt to GDP ratio.

Using cointegration techniques we identified a positive long-run relationship between the share of financial employment and income inequality as well as between the share of financial assets and income inequality. An increase of 1% in the flow measure of financialisation increases Gini net in 0.26% while a 1% increase in inequality is associated with an increase of 1.6% of the stock indicator. At least in what concerns the traditional Gini index, causality goes from the flow dimension to income distribution and from distribution to the stock dimension. However, when directly confronting both sides of the financialisation process the latter causes the former.

Deindustrialisation has been originally interpreted as a reduction in the share of manufacture employment. As previously reported in this chapter, around 70% of this reduction corresponds to a rise in the share of financial employment. To the extent that, in this particular case, financialisation can be seen as a mirror to deindustrialisation, we have here also a correspondence between deindustrialisation and the rise of income inequality in the United States. Our main findings can be summarised in a simple diagram:

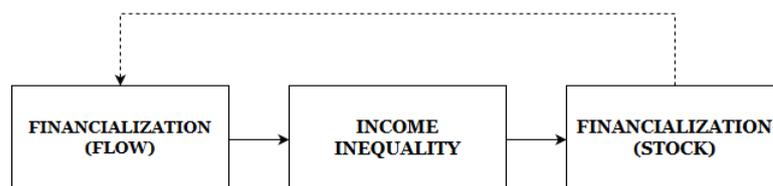


Figure 4: A summarising diagram

Though simple the figure above suggests the presence of cyclical dynamics between financialisation and income inequality. There is a cycle involving both dimensions of financialisation

and income inequality. An increase in the share of financial employment increases income inequality which in turn is reflected in increases in the share of financial assets on wealth (maybe) due to an expansion of financial intermediation and securitisation.

Results presented allow us to propose that the composition of production (flow) is to great extend guided by the composition of the stock behind it, that is, wealth. This means that overall the recent rise in income inequality is strongly linked in a cumulative fashion with the increase in importance of finance in terms of wealth composition. Though the two of them have received significant attention of scholars in the last years, we hope this essay has brought some new insights, specially in what concerns the role of wealth composition in the economy.

Appendix

Table A1 reports a summary of ADF and DF-GLS unit root tests in levels for two dimensions of financialisation and income inequality. Outcomes indicate that we cannot reject the null hypothesis that series are non-stationary in levels.

Table A1: Unit root tests (levels)		
Share financial employment (t-statistic)		
Method	Intercept	Trend and intercept
ADF	-1.845990	-0.784212
DF-GLS	0.390764	-1.390072
Share financial assets (t-statistic)		
Method	Intercept	Trend and intercept
ADF	-1.081258	-2.412301
DF-GLS	-0.583155	-2.374531
Gini (t-statistic)		
Method	Intercept	Trend and intercept
ADF	-0.298750	-2.551861
DF-GLS	-0.345902	-1.445929

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

We proceed reporting in table A2 a summary of unit-root tests for variables in first differences. Employment shares and Gini are found to be stationary while the share of financial assets it is not.

Table A2: Unit root tests (first differences)

Share financial employment (t-statistic)		
Method	Intercept	Trend and intercept
ADF	-4.802604***	-5.144403***
DF-GLS	-2.894712***	-3.814785***
Share financial assets (t-statistic)		
Method	Intercept	Trend and intercept
ADF	-2.784285*	-2.663430
DF-GLS	-0.866853	-1.784651
Gini (t-statistic)		
Method	Intercept	Trend and intercept
ADF	-4.798761***	-4.824245***
DF-GLS	-4.854743***	-4.749295

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

In other words, the share of financial employment and income distribution seem to be integrated of order 1 while the share of financial assets is at least integrated of order two. However, these tests do not take into account the possibility of structural breaks. Table A3 brings our results of the DF unit-root tests with a structural break for the variables in levels.

Table A3: Structural Break unit root tests (levels)

DF - Structural Break (t-statistic)				
Variable	Intercept	Break year	Trend and intercept	Break year
Share financial employment	-4.432819*	1977	-2.778716	1980
Share financial assets	-4.420055*	1982	-4.324244	1965
Gini	-3.455419	1977	-3.629620	1984

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

The share of financial employment and financial assets are stationary at 10% when we do not include a trend. Still, we cannot reject the null of non-stationarity once we introduce a trend. Furthermore, income distribution is also found to be non-stationary. Table A4 reports a first differences unit root tests allowing for structural break. We can now state that once we control for a structural break series are at most integrated of order one.

Table A4: Structural Break unit root tests (first differences)

Variable	DF - Structural Break (t-statistic)			
	Intercept	Break year	Trend and intercept	Break year
Share financial employment	-5.832861***	2000	-6.270547***	1977
Share financial assets	-4.449756**	1957	-6.026640***	1982
Gini	-6.082168***	1969	-6.195527***	1971

*, **, and *** stand by 10%, 5% and 1% of significance. SBIC automatic lag-length selection

Table A5 provides Breusch-Godfrey serial correlation test for the errors of the ARDL models of subsection 3.1. We cannot reject the null of no-serial correlation. Hence, our estimates are consistent.

Table A5: Breusch-Godfrey serial correlation test

Breusch-Godfrey Serial Correlation LM test (2 lags included)				
ARDL	F-statistic	0.152497	Prob. F(2,41)	0.8590
(2,0)	Obs*R-squared	0.361813	Prob. Chi-Squared(2)	0.8345
ARDL	F-statistic	0.510063	Prob. F(2,38)	0.6045
(2,2)	Obs*R-squared	1.281036	Prob. Chi-Squared(2)	0.5270
ARDL	F-statistic	1.788349	Prob. F(2,39)	0.1807
(3,3)	Obs*R-squared	4.284306	Prob. Chi-Squared(2)	0.1174
ARDL	F-statistic	1.020224	Prob. F(2,39)	0.3699
(5,2)	Obs*R-squared	2.585334	Prob. Chi-Squared(2)	0.2745

Prob. indicates asymptotic one-side p-values

Finally, table A6 provides Breusch-Godfrey serial correlation test for the errors of the ARDL models of subsection 3.2:

Table A6: Breusch-Godfrey serial correlation test

Breusch-Godfrey Serial Correlation LM test (2 lags included)				
ARDL	F-statistic	0.279968	Prob. F(2,50)	0.7570
(2,0)	Obs*R-squared	0.653406	Prob. Chi-Squared(2)	0.7213
ARDL	F-statistic	1.532871	Prob. F(2,49)	0.2261
(4,0)	Obs*R-squared	3.532927	Prob. Chi-Squared(2)	0.1709

Prob. indicates asymptotic one-side p-values

We cannot reject the null hypothesis of no serial correlation. Therefore, once more, we conclude our estimates are consistent.

Part II

Income Distribution and Growth in Open Economies

Chapter 4

Distributive Cycles in a BoPC Growth Model

Co-authored with Serena Sordi (University of Siena)

4.1 Introduction

Goodwin's (1967) distributive cycle model has reached its fiftieth anniversary. In spite of its vintage, the model continues to be a fruitful and powerful “system for doing macro-dynamics”. In the last fifty years, more than one hundred contributions have tried to generalise its formulation in all possible directions and the mathematical structure of the model has been used as a basic framework to study different dimensions of capitalism's structural instability.

It must be noted, however, that with the exception of the high-dimensional Keynes-Metzler-Goodwin (KGM) system put forward by Asada, Chiarella, Flaschel and Franke (e.g. [Asada et al, 2003](#)) or the Kaldor-Goodwin type of models by Pugno (1996; 1998), most existing efforts have been based on a closed economy set up. Needless to say, in the real world, economies are open to international trade and there are complications in applying analytical results based on the assumption of a closed economy.

When studying distributive dynamics in open economies, a particularly important problem arises that has not been discussed in the KGM literature and that we consider deserves a careful analysis. The reason for this is that one of the most influential empirical regularities in the Kaldorian growth literature – namely, Thirlwall's rule (or law) – states that, in the long-run, growth is subject to the balance-of-payments constraint (BoPC). Given that countries cannot systematically finance increasing balance-of-payments imbalances it implies that there is an adjustment in aggregate demand that constrains growth ([Thirlwall, 1979, 2011](#)).

[Pugno \(1998\)](#) seems to have been the first to explicitly put Goodwin and Thirlwall altogether. His main concern was to understand the stability properties of the BoPC model by incorporating price dynamics and a labour market *a la* Goodwin. Still, there is a significant departure from the growth cycle approach given that the model is unable to generate permanent cyclical fluctuations and capital accumulation is not properly treated. Hence, is our purpose to

investigate the aforementioned aggregate demand adjustment mechanism and its distributive implications over the cycle while preserving crucial features of the original framework such as Goodwin's profound insight that the trend and cycle are indissolubly fused. In order to do so, we expand the growth cycle set up to an open economy environment in a way that incorporates the external constraint. Furthermore, is our aim to do this by allowing technical change to be endogenous to the cyclical dynamics of the system.

The importance of our contribution lies in providing a base-line model to study distributive dynamics in open economies. In this sense, our exercise has some similarities with the pioneering work of [Blecker \(1989\)](#) and more recently [Sasaki et al \(2013\)](#), among others. Still, these contributions start from a Kaleckian framework which is different from the perspective adopted here. We consider our approach preferable for at least three reasons. First, cycles are rooted in the functioning of labour markets. This contrasts with traditional Kaleckian models that give marginal attention to the labour market. Second, even though the growth cycle set up does not explicitly differentiate between long and short run, its dynamics recall Kalecki statement "the long run trend is but a slowly changing component of a chain of short run situations; it has no independent entity" ([Kalecki, 1968, p.5](#)) – a statement frequently ignored in latter formalisations of the Polish economist. Finally, we do not rely in the controversial Keynesian stability condition.

Introducing demand constraints means that any assumption of a constant or full rate of capacity utilisation cannot hold anymore. Hence, the basic motion of the system includes, besides the employment rate and the wage-share, also the rate of capacity utilisation. We show that without having to impose any special condition on the values of the parameters, a Hopf-Bifurcation analysis establishes the possibility of persistent and bounded cyclical paths for the resulting 3-dimensional non-linear dynamic system providing insights to enable better understanding of the nature of real-world fluctuations.

While the hypothesis of equilibrium in the balance-of-payments is plausible for the long-run, in the short-term growth might deviate from the external constraint. Therefore, we also allow for such deviations by developing a 4-dimensional dynamic system that is fully embedded in Goodwin's fundamental insight that trend and cycle are indissolubly fused. In this second case, disequilibrium in the goods market is further explored introducing an independent investment function. Some numerical simulations are performed based on the analytical models.

The chapter is organised as follows. In the next section we briefly review the original formulation of Goodwin's distributive cycle model. Section 3 presents our first extension of the model in which we no longer have full capacity utilisation and the rate of growth of output always follows the BoPC. In section 4 we allow growth to deviate from the external constraint and, therefore, we are also able to introduce an independent investment function. Some final considerations follow.

4.2 The original formulation

In his growth cycle paper, [Goodwin \(1967\)](#) aimed at building a model capable of generating cycles in the growth rate of output rooted in the functioning of the labour market and the dynamics of distributive conflict. To concentrate on this point, he assumed full capacity utilisation so that the Keynesian principle of effective demand plays no role. The model was originally conceived for a closed economy without government. For expositional purposes we can divide it into two blocks of equations: (i) supply conditions, and (ii) distributive conditions.

4.2.1 Supply conditions

Consider the following production function:

$$Y = \min\{Ku; qNe\}$$

where Y is output, K stands for capital, u in the absence of better nomenclature stands for effective capacity utilisation, q is labour productivity, N is total labour force, and e is the employment rate. Effective capacity utilisation is given by $(Y/Y^*)(Y^*/K)$ with Y^* as production at full capacity. That is, effective capacity utilisation equals actual capacity utilisation multiplied by capital productivity when all machines and equipment are employed. This is the same as saying that u is given by actual capital productivity, Y/K , or the inverse of the actual capital-output ratio, $(K/Y)^{-1}$. Notice that in [Goodwin \(1967\)](#), Y/Y^* was supposed to be equal to one so that effective and actual capacity are the same and u becomes simply the inverse of the capital-output ratio. Moreover, the employment rate is given by L/N , where L is the level of employment.

The Leontieff dynamic efficiency condition states that:¹

$$\frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} + \frac{\dot{u}}{u} = \frac{\dot{q}}{q} + \frac{\dot{N}}{N} + \frac{\dot{e}}{e} \quad (4.1)$$

For a constant effective capacity utilisation, such that $\dot{u}/u = 0$, and an exogenous labour force growth rate, equal to n , from (4.1) it follows that the rate of growth of output equals the rate of capital accumulation:

$$\frac{\dot{Y}}{Y} = \frac{\dot{K}}{K} \quad (4.2)$$

and

$$\frac{\dot{e}}{e} = \frac{\dot{Y}}{Y} - \frac{\dot{q}}{q} - n \quad (4.3)$$

i.e., variations in the employment rate are set by the difference between the economy's growth rate and the sum of labour productivity and labour force growth rates. This is equivalent to saying that the employment rate adjusts to the difference between actual and (Harrod's) natural rate of growth.

¹For any variable x , \dot{x} indicates its time derivative (dx/dt), while \hat{x} indicates its growth rate (\dot{x}/x). Notice that the Leontieff production function is in a sense an accounting identity because $Y = K \left(\frac{Y}{Y^*}\right) \left(\frac{Y^*}{K}\right) = \left(\frac{Y}{L}\right) N \left(\frac{L}{N}\right)$.

4.2.2 Distributive conditions

In an economy with two factors of production and no government, the income identity is:

$$Y = wL + rK$$

where w and r are respectively real wages and the rate of return on capital.

Assuming that all savings come from profits and that all profits are reinvested we have that:

$$\frac{\dot{K}}{K} = (1 - \varpi)u \quad (4.4)$$

where $\varpi = wL/Y = 1 - rK/Y = w/q$ is the wage share. Given this assumption, there is no room in the model for an independent investment function.

Variations of real wages are given by a generic Phillips curve of the type:

$$\frac{\dot{w}}{w} = F(e), F'(\cdot) > 0, F''(\cdot) \geq 0 \quad (4.5)$$

indicating that the bargaining power of workers increases at an increasing pace as employment expands.

Finally, from the definition of wage-share we have that:

$$\frac{\dot{\varpi}}{\varpi} = \frac{\dot{w}}{w} - \frac{\dot{q}}{q} \quad (4.6)$$

In other words, a constant functional income distribution is only possible if variations in real wages follow variations in labour productivity. As a result, distribution depends on the interaction between technology and distributive conflict.

4.2.3 The dynamic system

Substituting (4.4) into (4.2) and then the result into (4.3), we have:

$$\frac{\dot{e}}{e} = (1 - \varpi)u - \frac{\dot{q}}{q} - n \quad (4.7)$$

Then, substituting (4.5) into (4.6) we obtain:

$$\frac{\dot{\varpi}}{\varpi} = F(e) - \frac{\dot{q}}{q} \quad (4.8)$$

For an exogenous growth rate of labour productivity and constant effective capacity utilisation, equations (4.7) and (4.8) form the original growth cycle model. They contain the basic elements of a theory of economic fluctuations with the cycle emerging endogenously from the dynamic interaction of deterministic variables and not as the outcome of exogenous aleatory shocks.

The distributive cycle works as follows: an increase in the employment rate leads to an increase in the wage share, which decreases the profit share and thus capital accumulation.

A reduction in capital accumulation decreases the rate of growth of output and consequently the rate of employment, leading to a decrease in the wage share and an increase in the profit share. The outcome of a higher profit share is faster capital accumulation because all profits are reinvested, increasing the rate of growth of output and employment. At this point the cycle restarts.

$$\begin{aligned}
 e \uparrow \Rightarrow \varpi \uparrow \Rightarrow \frac{\dot{K}}{K} \downarrow \Rightarrow \frac{\dot{Y}}{Y} \downarrow \Rightarrow e \downarrow \\
 e \downarrow \Rightarrow \varpi \downarrow \Rightarrow \frac{\dot{K}}{K} \uparrow \Rightarrow \frac{\dot{Y}}{Y} \uparrow \Rightarrow e \uparrow
 \end{aligned}$$

4.3 A first extension of the model

The original growth cycle representation we have just described has been extended in a number of directions in the last fifty years.² However, little attention has been given to possible applications to the case of an open economy. Furthermore, Post Keynesian models have emphasised over the years the importance of demand constraints on growth. One of the most successful empirical regularities among them is Thirlwall's rule. It proposes that since countries cannot systematically sustain increasing balance-of-payments imbalances, there is an adjustment in aggregate demand that constrains growth.³

The introduction of aggregate demand issues in an open-economy set up leaves at least four questions to be answered. First, it is not possible to assume full capacity utilisation. Second, it is not clear how the rate of employment and income distribution interact with the external constraint. Third, while the hypothesis of equilibrium in the balance-of-payments is plausible for the long-run, in the short-term growth might deviate from the external constraint and it is necessary to understand the mechanism behind this adjustment process. Finally, once we allow the rate of growth of output to deviate from the BoPC we can go further and explore the implications of using an independent investment function.

In the remainder of the chapter we modify the original model in order to address these issues. This section deals with the first two problems. We allow for variations in effective capacity utilisation while the rate of growth of output follows Thirlwall's rule. However, we assume that the economy never deviates from the balance-of-payments equilibrium condition and investment is still determined by savings. These two last assumptions are to be relaxed in the next section. From now on the model can be divided into three blocks of equations.

²For a very recent review of the literature on some of the main theoretical and empirical contributions in this field, see Araújo et al (2017). In particular emphasis must be given to the importance of recent extensions of the model in explaining financial fluctuations and the great financial crisis based on Minsky's financial instability hypothesis (Keen, 2013; Sordi and Vercelli, 2012, 2014).

³The idea that growth is BoPC has been a crucial component of much demand-led growth theory since at least Prebisch (1959). However, it is the role of demand in defining the nature of the constraint that distinguishes the approach from other growth models (Razmi, 2016). For a literature review on some of the main theoretical and empirical contributions, see Thirlwall (2011).

Besides the original (i) supply conditions, and (ii) distributive conditions, we now have (iii) the external constraint.

4.3.1 Supply conditions

Once effective capacity utilisation is allowed to vary, from the Leontieff efficiency condition (4.1) it follows that:

$$\frac{\dot{u}}{u} = \frac{\dot{Y}}{Y} - \frac{\dot{K}}{K} \quad (4.9)$$

i.e., the rate of change in capacity utilisation now depends on the difference between the rate of growth of output and capital accumulation.

Following the Kaldorian literature, labour productivity gains are endogenous to the performance of the economy. Although the growth rate of labour supply is exogenous in our model, the growth rate of labour productivity is endogenously determined through a learning-by-doing mechanism. This modification is necessary in order to change the nature of the model from one that is supply-side determined to a more Keynesian demand-led model. Therefore, productivity gains are supposed to be a function of effective capacity utilisation:⁴

$$\frac{\dot{q}}{q} = G(u), \quad G'(\cdot) > 0 \quad (4.10)$$

Kaldor in particular developed different ways to endogenise technological change (Kaldor, 1957, 1961, 1966). For instance, in his technical progress function he anticipated some of the basic insights behind Arrow's learning-by-doing model. Traditional specifications assume $G(\cdot)$ to be a linear function of the actual growth rate of the economy. We avoid this road for at least two reasons. First, a linear specification is extremely arbitrary at this point in the analysis. Second, the traditional interpretation of the linear coefficients has been convincingly questioned by McCombie and Spreafico (2016) because it can be derived from a neoclassical production function.⁵

⁴In his inaugural lecture at the University of Cambridge, Kaldor (1966, p. 10) considered the relation between productivity and output to be "a dynamic rather than a static relationship – between the rates of change of productivity and of output, rather than between the level of productivity and the scale of output". In this sense equation (4.10) is somehow an hybrid since we are establishing a link between the rate of change of productivity and the level of output.

⁵Needless to say that the problems of such production functions are well known. For a comprehensive discussion see Petri (2004) and Felipe and McCombie (2013). Moreover, it is easy to see that using G as a linear function of output's growth rate makes the model completely supply side again. Suppose $\dot{q}/q = \alpha_0 + \alpha_1 \dot{Y}/Y$, where α_0 and $0 < \alpha_1 < 1$ are parameters that capture a combination of increasing returns to scale, induced and exogenous technical change, greater efficiency in the use of resources, and the inter-sectoral reallocation of resources. From the Leontieff efficiency condition (4.1) we have $\dot{e}/e = (1 - \alpha_1)\dot{Y}/Y - \alpha_0 - n$. In steady-state $\dot{e}/e = 0$, hence, $\dot{Y}/Y = (\alpha_0 + n)/(1 - \alpha_1)$ and growth becomes supply-side. Setterfield (2006) and Gabriel et al (2016) among others have argued that the so called Verdoorn coefficient (α_1) could be endogenised. But then we go back to the traditional interpretation of G which has been shown to be invalid by McCombie and Spreafico (2016).

On the other hand, our specification still captures the concept of a learning-by-doing process associated with the presence of economies of scale in the use of capital. The basic idea is that to a great extent technical progress is labour saving and capital embodied. Nevertheless, machines must be operating in order for productivity gains to be effectively incorporated. Notice that since $u = \left(\frac{Y}{Y^*}\right) \left(\frac{Y^*}{K}\right)$ there are two possible channels for effective capacity utilisation to influence labour productivity. The first one is through an increase in the degree of utilisation of machines. Higher rates of idle capacity indicate that machinery has not been properly used leaving little room for learning-by-doing. The second one is through an increase in the productivity of machines. That is, the adoption of modern production techniques comes with spillover effects on workers' productivity.

Sasaki (2013) has recently argued that making G a function of e would capture the view that technological change is driven by inter-class conflict. An increase in the employment rate is supposed to increase the bargaining power of workers and generate upward pressure on wages, leading capitalists to adopt labour saving technical changes. Different versions of the argument have been put forward by several authors (e.g. Naastepad, 2006; Dutt, 2006; Flaschel, 2015; for a review of endogenous technical change in alternative growth theories see Tavani and Zamparelli, 2017). Even though we do not deny the plausibility of such a mechanism, we are, in particular, more interested in incorporating endogenous technical progress as a learning process than as a result of inter-class conflict. Hein and Tarassow (2010) and Rezai (2012) are examples of contributions suggesting that the two formulations might not be incompatible.⁶

4.3.2 Distributive conditions

Keeping the income identity, once we allow the level of capacity utilisation to change, if all savings come from profits and a constant share s of those profits is reinvested we have that:

$$\frac{\dot{K}}{K} = s(1 - \varpi)u \quad (4.11)$$

Furthermore, we keep the same Phillips curve (4.5) for the real wage dynamics, and variations of the wage-share continue to be given by the difference between the rate of growth of wages and the rate of growth of labour productivity (4.10).

4.3.3 The external constraint

Suppose the following traditional functions for exports and imports:

$$X = X(Z), X'(\cdot) > 0 \quad (4.12)$$

$$M = M(Y), M'(\cdot) > 0 \quad (4.13)$$

⁶One should note that Sasaki et al (2013) in an open economy Kaleckian model uses $G(u)$ but maintains the inter-class conflict interpretation making reference to Okun's law.

where X are exports, M corresponds to imports, and Z is the rest of the world's output. Since we are abstracting from any price considerations, the real exchange rate is supposed to be constant and does not influence trade. For simplicity, it is also assumed that all trade consists in the exchanges of final goods. Equilibrium in trade, which in this framework approximates equilibrium in the balance-of-payments, implies:

$$X(Z) = M(Y)$$

Thus, we can easily show that:

$$\frac{\dot{Y}}{Y} = \rho \frac{\dot{Z}}{Z} = y_{BP} \quad (4.14)$$

where $\rho = \frac{dX}{dZ} \frac{Z}{X} / \frac{dM}{dY} \frac{Y}{M}$ is the ratio between foreign income elasticities of exports and imports, and y_{BP} is the BoPC growth rate. Notice that (4.14) is nothing other than Thirlwall's law.⁷

Foreign trade income elasticities are dependent upon the level of diversification of the economy's productive structure. A low level of diversification is associated with a high propensity to import which in turn implies a high income elasticity of imports. It is also associated with a low elasticity of exports because the economy will have few different types of goods to export in the face of increasing demand.

An extensive literature on complexity has stressed the positive relation between economic complexity and productive diversification (Hidalgo et al, 2007; Hausmann et al, 2014). Therefore, ρ can also be understood as a structural variable that captures the non-price competitiveness of an economy. Gouvea and Lima (2010, 2013), Romero and McCombie (2016a) and Martins Neto and Porcile (2017) provide empirical evidence of such an interpretation.

Several methodologies have been used over the years to estimate Thirlwall's rule – which range from Ordinary Least Squares (OLS) in first differences to Vector Error Correction (VEC) models, Fixed Effects (FE) models, panel Autoregressive Distributive Lag (pARDL) and Generalised Method of Moments (GMM) (for a review see Romero and McCombie, 2016a). Here we provide some empirical evidence of our own using the ARDL cointegration technique from a sample of 16 OECD countries between 1950 and 2014. Details of the estimation procedure and the innovative aspects of our exercise are presented in the Empirical Appendix at the end of the chapter. Table 1 shows that actual and estimated growth rates are indeed very close.

⁷From the equilibrium in trade condition we have $X(Z) = M(Y)$. Taking time derivatives this means $(dX/dZ)\dot{Z} = (dM/dY)\dot{Y}$. This last expression is equivalent to $(\frac{dX}{dZ} \frac{Z}{X})(X/Z)\dot{Z} = (\frac{dM}{dY} \frac{Y}{M})(M/Y)\dot{Y}$. Rearranging we have $(\frac{dX}{dZ} \frac{Z}{X}) \frac{\dot{Z}}{Z} X = (\frac{dM}{dY} \frac{Y}{M}) \frac{\dot{Y}}{Y} M$. But if trade is in equilibrium and is different from zero it follows $(\frac{dX}{dZ} \frac{Z}{X}) \frac{\dot{Z}}{Z} = (\frac{dM}{dY} \frac{Y}{M}) \frac{\dot{Y}}{Y}$ or $\frac{\dot{Y}}{Y} = \rho \frac{\dot{Z}}{Z}$. Moreover, it is straightforward from Euler's homogeneity theorem that if X and M are homogeneous functions, then ρ is constant.

Table 1: Actual vs estimated growth rates

Country	Actual growth	BoPC	Country	Actual growth	BoPC growth
Australia	0.037	0.04	Belgium	0.03	0.033
Canada	0.036	0.037	Denmark	0.029	0.032
Finland	0.035	0.036	France	0.035	0.031
Germany	0.039	0.041	Italy	0.038	0.055
Japan	0.05	0.077	Netherlands	0.038	0.056
New Zealand	0.032	0.031	Norway	0.044	0.085
South Korea	0.075	0.109	Sweden	0.03	0.035
UK	0.027	0.024	US	0.032	0.03

The Kaldorian roots of the rule derive not only from the fact that Thirlwall himself is the biographer and literary executor of the Cambridge economist but also because in his last writings Kaldor gave special attention to the role of exports in economic development. In his own words, “the rate of economic development of a region is fundamentally governed by the rate of its exports” (Kaldor, 1970, p. 342). Assuming for simplicity that $X(\cdot)$ and $M(\cdot)$ in (4.12) and (4.13) are homogenous functions, we have from Euler’s theorem that ρ is constant. In the absence of the ability to attract a permanent net inflow of capital from abroad, the rate of growth of the economy is constrained by the requirement that it achieves current account balance.

4.3.4 The dynamic system

Substituting (4.10) and (4.14) into (4.3) we have:

$$\frac{\dot{e}}{e} = y_{BP} - G(u) - n$$

or

$$\dot{e} = [y_{BP} - G(u) - n] e = f_1(e, \varpi, u) \tag{4.15}$$

Variations in the rate of employment are entirely determined by aggregate demand dynamics. On the one hand, the external constraint rules the rate of growth of output. Thus, a relaxation of the BoPC increases employment. On the other hand, labour productivity follows our learning-by-doing mechanism. Therefore, an increase in the rate of effective capacity utilisation actually reduces employment through an increase in productivity. This of course is a partial effect since u itself is an endogenous variable.

Making use of (4.5), (4.6) and (4.10), distributive dynamics become:

$$\frac{\dot{\varpi}}{\varpi} = F(e) - G(u)$$

or

$$\dot{\varpi} = [F(e) - G(u)] \varpi = f_2(e, \varpi, u) \tag{4.16}$$

Equation (4.16) is basically the same as (4.8) and states that variations in functional income distribution follow the difference between the rate of growth of real wages and labour productivity. A stable wage-share can only be obtained if real wages grow at the same pace as productivity gains. Moreover, employment and effective capacity utilisation have opposite effects on the wage-share. An increase in the employment rate increases worker's bargaining power allowing a rise in wages which in turn has a positive impact on the wage-share. On the other hand, an increase in the rate of capacity utilisation increases labour productivity through the learning-by-doing mechanism reducing the share of wages in income.

Finally, substituting (4.11) and (4.14) into (4.9) we obtain the equation for the dynamics of capacity utilisation:

$$\frac{\dot{u}}{u} = y_{BP} - s(1 - \varpi)u$$

or

$$\dot{u} = [y_{BP} - s(1 - \varpi)u]u = f_3(e, \varpi, u) \quad (4.17)$$

The effect of the rate of growth of output on effective capacity utilisation is straightforward. Higher demand increases capacity utilisation. Nevertheless, an increase in capacity utilisation or a reduction in the wage-share decrease u . This is because both have a positive impact on capital accumulation through savings.

The dynamic system of the modified model is formed by equations (4.15)-(4.17).

4.3.5 Equilibrium points, local stability analysis and Hopf bifurcation

In steady state $\dot{e}/e = \dot{\varpi}/\varpi = \dot{u}/u = 0$. This gives us the following equilibrium conditions:

$$y_{BP} = G(u) + n \quad (4.18)$$

$$F(e) = G(u) \quad (4.19)$$

$$y_{BP} = s(1 - \varpi)u \quad (4.20)$$

Equation (4.18) shows that in equilibrium the sum of labour productivity and labour force growth rates must equal the BoPC growth rate. Nevertheless, the so called "natural rate of growth" is endogenous, pro-cyclical and determined by the external constraint as several empirical studies have shown to be the case (León-Ledesma and Thirlwall, 2002; Libânio, 2009; León-Ledesma and Lanzafame, 2010; Lanzafame, 2014). The equilibrium condition (4.19) simply states that real wages and labour productivity must grow at the same rate in order for the wage share to be constant. Finally, condition (4.20) implies that the rate of growth of output must equal the rate of growth of the capital stock so as not to generate permanently increasing or decreasing idle capacity.

This last result is particularly compelling because it represents a simple and elegant formulation of "Say's Law in reverse". Still, we further improve it in the next section when an independent investment function is introduced. A broader discussion of the relation between

y_{BP} and capital accumulation as well as a solution with similar characteristics can be found in [Dávila-Fernández et al \(2018\)](#).

Given the equilibrium conditions (4.18)-(4.20) we can state and prove the following Proposition regarding the existence and uniqueness of an internal equilibrium.

Proposition 4.1 *The dynamic system (4.15)-(4.17) has a unique internal equilibrium point given by:*

$$e^* = F^{-1}(y_{BP} - n) \quad (4.21)$$

$$\varpi^* = 1 - \frac{y_{BP}}{sG^{-1}(y_{BP} - n)} \quad (4.22)$$

$$u^* = G^{-1}(y_{BP} - n) \quad (4.23)$$

Proof. See Mathematical Appendix 4.5. ■

Looking at equations (4.21) and (4.23) it is interesting to note that an increase in the rate of growth of output (which is determined by the external constraint) increases both the rate of employment and the rate of effective utilisation. This relation resembles Okun's rule. The result is also in line with recent developments of the so called "utilisation controversy" where [Nikiforos \(2013, 2016\)](#) in particular has demonstrated that firms tend to utilise their capital more as output grows, conditional on the behaviour of increasing returns to scale. Moreover, a higher growth rate of the labour force is also associated with a lower rate of employment and effective capacity.

Lastly, the relation between the BoPC growth rate and the wage-share is not univocal. Notice that (4.22) can be written as $\varpi^* = 1 - y_{BP}/su^*$ and therefore $d\varpi^*/dy_{BP} = [(du^*/dy_{BP})(y_{BP}/s) - u^*]/u^{*2}$. If $\frac{\partial u^*}{\partial y_{BP}} \frac{y_{BP}}{u^*} > s$, an increase in y_{BP} increases the wage share. This is because income distribution is the adjustment variable that guarantees a constant rate of capacity utilisation. Higher growth increases u^* and if this effect is too strong (above s) the wage share must be reduced in order to keep capital accumulation equal to the rate of growth of output. On the contrary, for $\frac{\partial u^*}{\partial y_{BP}} \frac{y_{BP}}{u^*} < s$ a relaxation of the external constraint harms the wage share. In other words, for a propensity to save larger than the sensibility of u^* to the rate of growth of output, the wage share required to keep capacity utilisation constant will be lower.

Next, we turn to the investigation of the local stability properties of the equilibrium points defined by equations (4.21)-(4.23).

Proposition 4.2 *If the sensitivity of real wages to changes in the employment rate is sufficiently low and such that*

$$F'(e^*) < \frac{s(1 - \varpi^*)u^*}{e^*} = \frac{y_{BP}}{F^{-1}(y_{BP} - n)}$$

the internal equilibrium (e^, ϖ^*, u^*) of the dynamic system (4.15)-(4.17) is locally asymptotically stable.*

Proof. See Mathematical Appendix 4.5. ■

However, for higher values of $F'(e^*)$, it may happen that $F'(e^*) > s(1 - \varpi^*)u^*/e^*$. Thus, the dynamic behaviour of the model may drastically change, from the qualitative point of view, as the sensitivity of real wages to changes in e increases, with all the other parameters remaining constant. Using $F'(e^*)$ as a bifurcation parameter, our purpose is now to apply the Hopf Bifurcation Theorem (HBT) for 3D systems (see Gandolfo, 2009) to show that persistent cyclical behaviour of the variables can emerge as $F'(e^*)$ is increased.

Proposition 4.3 *For values of $F'(e^*)$ in the neighbourhood of the critical value*

$$F'(e^*)_{HB} = \frac{s(1 - \varpi^*)u^*}{e^*} \quad (4.24)$$

the dynamic system (4.15)-(4.17) has a family of periodic solutions.

Proof. See Mathematical Appendix 4.5. ■

This result is in line with Goodwin's (1967) aim of generating cycles rooted in the functioning of the labour market and the dynamics of distributive conflict. Periodic solutions emerge as a result of an increase in the sensitivity of workers' wage demands to the employment rate.

4.3.6 Numerical Simulations

In this section, we present numerical simulations to show that the Hopf bifurcation occurring for values in the neighbourhood of $F'(e^*)$ defined in (4.24) is supercritical so that the emerging limit cycle is stable. The exercise also illustrates that, under plausible settings, the internal equilibrium and oscillations have economic meaning. To this end, we must first of all choose functional forms for the two behavioural equations of the model, namely, $F(\cdot)$ and $G(\cdot)$. We specify these functions as follows:

$$F(e) = a(e - \bar{e}) \quad (4.25)$$

$$G(u) = bu^\beta \quad (4.26)$$

where \bar{e} is the rate of employment above which workers are able to obtain real wage increases. The functional form we have chosen in (4.25) captures the Marxian reserve army effect and should not be confused with some sort of non accelerating inflation rate of unemployment (NAIRU).⁸ On the other hand, the parameter β in equation (4.26) captures the presence of increasing returns to scale for the labour productivity growth function. Finally, a and b are adjustment parameters.

⁸Notice that (4.25) can be obtained from Goodwin's (1967) original formulation of the Phillips curve. Suppose $F(e) = -a_1 + ae$. Name $a_1 = a\bar{e}$. Therefore, $F(e) = -a\bar{e} + ae = a(e - \bar{e})$. We use the last expression for convenience.

Recalling the expressions given in equations (4.21)-(4.23), equilibrium values become:

$$e^* = \bar{e} + \frac{y_{BP} - n}{a} \quad (4.27)$$

$$\varpi^* = 1 - \frac{y_{BP}}{s \left(\frac{y_{BP} - n}{b} \right)^{1/\beta}} \quad (4.28)$$

$$u^* = \left(\frac{y_{BP} - n}{b} \right)^{1/\beta} \quad (4.29)$$

In order to choose plausible parameter values we have considered the evidence given in a number of empirical studies. They are presented below:

$$\begin{aligned} y_{BP} &= 0.03105, \quad n = 0.01, \quad s = 0.3, \quad \beta = 1.17 \\ a &= 0.0372, \quad \bar{e} = 0.28986, \quad b = 0.091522 \end{aligned} \quad (4.30)$$

Taking $F'(e^*) = a$ as the bifurcation parameter, these values imply that $a_{HB} \approx 0.0345$. Consequently, in our simulation, we used a value of a slightly higher than this.

Figure 1 on the left displays the solution path for two different initial values (e_0, ϖ_0, u_0) equal to $(0.92, 0.6, 0.35)$ and $(0.77, 0.65, 0.24)$, both converging to the limit cycle around $(e^*, \varpi^*, u^*) = (0.85572, 0.63653, 0.28475)$. Figure 1 on the right plots the time series of our simulations.

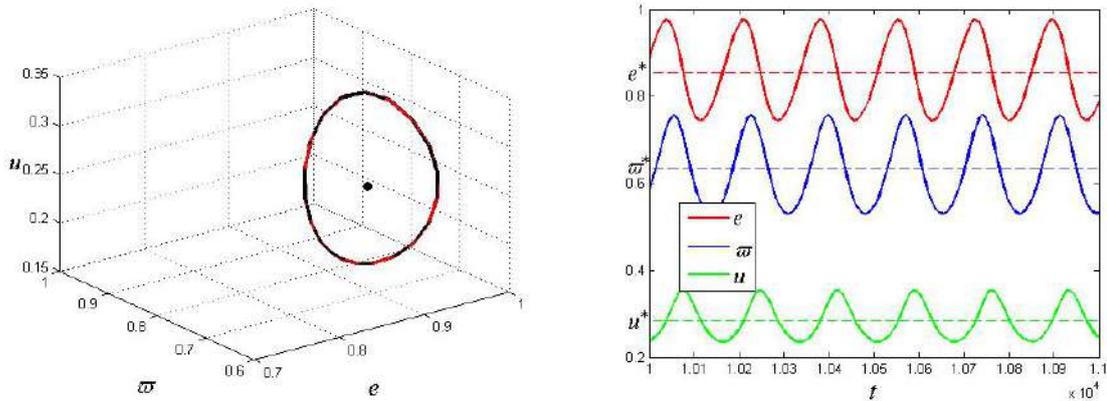


Figure 1: Limit cycle and time series 3D

Taking a closer look at the figures above, we can attempt to sketch a description of the dynamic interactions among the three variables along any given cycle. An increase in the employment rate leads to an increase in the wage share, which decreases the profit share and thus capital accumulation. A reduction in capital accumulation increases the effective rate of capacity utilisation because the rate of growth of output is given and determined by Thirlwall's rule. The increase in capacity utilisation increases the rate of growth of labour productivity through our learning-by-doing mechanism reducing the rate of employment and the wage share,

leading to an increase in the profit share. The outcome of a higher profit share is faster capital accumulation, reducing capacity utilisation and increasing the rate of employment. At this point the cycle restarts:

$$\begin{aligned} e \uparrow \Rightarrow \varpi \uparrow \Rightarrow \frac{\dot{K}}{K} \downarrow \Rightarrow \frac{\dot{u}}{u} \uparrow \Rightarrow e \downarrow \\ e \downarrow \Rightarrow \varpi \downarrow \Rightarrow \frac{\dot{K}}{K} \uparrow \Rightarrow \frac{\dot{u}}{u} \downarrow \Rightarrow e \uparrow \end{aligned}$$

4.4 A second extension of the model

As briefly discussed at the beginning of the previous section, while the hypothesis of equilibrium in the balance-of-payments is plausible in the long-run, for the short-run the story is different. Moreover, if we are to fully embed Goodwin's fundamental insight that trend and cycle are indissolubly fused in our model, it is perfectly possible, as indeed is the case, that over the business cycle growth deviates from the external constraint. How actual growth adjusts to the BoPC and interacts with the rest of the dynamic system is the question we address in this section.

In an open economy without government the expenditure identity is given by:

$$Y = C + I + X - M$$

where C stands for consumption, I is investment, X corresponds to exports, and M stands for imports. It immediately follows that:

$$S - I = X - M \tag{4.31}$$

with savings, S , equal to total output minus consumption.

Hence, equilibrium in the current account, $X = M$, implies that $S = I$ and we have $\frac{S}{K} = \frac{I}{K}$. However, as already shown, from $X = M$ we obtain y_{BP} , while $\frac{S}{K} = s(1 - \varpi)u$ with ϖ and u determined in steady state by (4.22) and (4.23), respectively. This means that an independent investment function would actually make the model overdetermined since S and I would be equal only by chance.

Once we allow actual growth rates to deviate from the external constraint, i.e. outside equilibrium $X = M$ does not necessarily hold, we are able to introduce an independent investment function. Accordingly, the model developed must go through two important changes, one in the distributive conditions block and one in the external constraint block.

4.4.1 Supply conditions

There are no changes in the supply conditions of the economy. Starting from the initial Leontief production function we have that variations in effective capacity utilisation adjust the difference between the rate of growth of output and capital accumulation. Analogously, variations in the

employment rate adjust to the growth rate of the economy and variations in labour productivity. Last but not least, labour productivity continues to be modelled as a function of effective capacity utilisation.

4.4.2 Distributive conditions

The determination of investment is central to Keynesian theories of effective demand. Equations (4.4) and (4.11) resulted from the assumption that all profits or a share of them were reinvested. Dropping this hypothesis opens the door to the use of an independent investment function. In this respect, the accumulation function is critical for the properties and implications of the model. Unfortunately, there is considerable disagreement over the specification of this function (see Skott, 2012 for a discussion of the topic).

For the purposes of this essay, we adopt the following general specification:

$$\frac{I}{K} = H(\varpi, u), \quad H_{\varpi} < 0 \text{ and } H_u > 0 \quad (4.32)$$

The intuition of the expression above is similar to the one discussed by Bhaduri and Marglin (1990) and is recurrent in the Kaleckian literature. The basic idea is that profitability and capacity utilisation are used by investors as predictors of marginal profitability on new investment and the future state of demand, respectively. According to Bhaduri and Marglin (p. 380), this investment function has the analytical advantage of separating the “demand side” impact on investment operating through the acceleration effect of higher capacity utilisation from the “supply side” impact operating through the cost-reducing effect of a lower real wage and higher profit share.

A possible alternative would be to make investment a function only of the accelerator effect.⁹ This route is also pursued by Skott (1989, 2012) in a Harroddian set up. His contribution is particularly important because he presents a strong critique of the Kaleckian formulation. However, even though he makes an appealing defence of the Harroddian case, we chose to stick to equation (4.32). Our reasons are threefold.

First, empirical evidence does give some support to the hypothesis that investment depends to some degree on the functional income distribution (Stockhammer et al, 2009; Onaran and Galanis, 2014, 2016). Second, the model developed in this section does not rely on the extension of the standard short-run Keynesian stability condition to the long-run. That is, we do not assume that investment is less sensitive than savings to variations in the utilisation rates of capital. To the best of our knowledge, this was the main objection against the Kaleckian investment function. Finally, having H as a function of ϖ is required in order to generate distributive cycles in our model. A different alternative would be to assume that $\frac{\dot{Y}}{Y}$ is a negative function of the wage-share (as does Skott). Even though we do not deny the plausibility of such a mechanism, we present an alternative one that has some virtues of its own.

⁹Different specifications of a flexible accelerator can be found in the literature and of course in Goodwin himself (e.g. Goodwin, 1948, 1951; Asada et al, 2003; Chiarella et al, 2005).

4.4.3 The external constraint

Although the BoPC growth model is addressed to the investigation of the long-run, it also has profound implications for short-run dynamics. Few studies are devoted to the analysis of how deviations from long-run paths are generated and corrected.¹⁰ What happens in an open economy if the actual growth rate causes balance-of-payments disequilibrium, which is not automatically corrected by relative prices, so that the growth of income has to adjust to bring the growth of imports and exports into line?

If the economy is growing faster than the BoPC it means imports are growing faster than exports and therefore from (4.31) that investment is growing faster than savings. Leaving aside any considerations about the level of international reserves of a country, if investment is growing faster than savings, then the economy is (or will be) accumulating debt. An increase in debt on the other hand is related to an increase in risk perception which indicates that at some point lenders might limit access to credit. The simple increase in risk leads to an increase in the interest rate which also contributes to a reduction of expenditure (both in terms of consumption and investment). The intensity of this adjustment depends on how creditors perceive the behaviour of the borrower. This corresponds to the traditional BoPC adjustment and in the extreme case one should expect a balance-of-payments crisis.

On the other hand, if the rate of growth of output is below what is determined by Thirlwall's rule, exports are growing faster than imports which in turn implies that savings are growing faster than investment. In other words, the rest of the world is accumulating debt with this country. At first such a process could continue without limits as long as the domestic economy is willing to be a global creditor. However, two constraints might sooner or later appear. First, at some point the country might fear not being paid and force borrowers to meet their obligations. But then, imports of the debtor country will be reduced, which is equivalent to saying that exports of the surplus country will be lower, adjusting the balance of payments.

Another alternative is that the rest of the world, understanding that being in extreme debt is damaging to their interests (even politically speaking), might try to force the lender country to reduce its surplus. In this case, the economy will have to increase its expenditures increasing as a consequence its imports and restoring equilibrium in the balance of payments. This last situation resembles current negotiations led by the United States in demanding a reduction of current account surpluses by China and Germany.

Taking logarithms and time derivatives of equation (4.31), we obtain a dynamic version of the external constraint:

$$\theta \frac{\dot{M}}{M} + (1 - \theta) \frac{\dot{S}}{S} = \Omega \frac{\dot{X}}{X} + (1 - \Omega) \frac{\dot{I}}{I} \quad (4.33)$$

where $\theta = M/(M + S)$, $\Omega = X/(X + I) \in [0; 1]$.

Recall from our import function, $\dot{M}/M = \pi \dot{Y}/Y$, where $\pi = \frac{dM}{dY} \frac{Y}{M}$ is the income elasticity of imports. Substituting this last expression in the dynamic external constraint given by (4.33),

¹⁰Soukiazis (2012, 2014) and Garcimartin et al (2016) are recent remarkable exceptions, ones that formally address the issue although from a different perspective.

and rearranging, we obtain:

$$y = \frac{1}{\theta\pi} \left[(1 - \Omega) \frac{\dot{I}}{I} - (1 - \theta) \frac{\dot{S}}{S} + \Omega \frac{\dot{X}}{X} \right] \quad (4.34)$$

where we have set $y = \dot{Y}/Y$ in order to simplify the notation. Equation (4.34) separates the growth rate of output in two components. On the one hand there is disequilibrium between investment and savings. That is, higher growth rate of investment relative to savings implies in higher output's growth rate. The second component corresponds to the growth rate of exports than in this case is the only "autonomous" component of aggregate demand.

In our economy, savings come from profits, $S/K = s(1 - \varpi)u$. Investment, on the other hand, is given by (4.32), so that $\dot{K}/K = I/K = H(\varpi; u)$. From these last two behavioral relations, we have that:

$$\frac{\dot{S}}{S} = H(\varpi; u) - \left(\frac{\dot{\varpi}}{1 - \varpi} \right) + \frac{\dot{u}}{u} \quad (4.35)$$

$$\frac{\dot{I}}{I} = H(\varpi; u) + \frac{H_{\varpi}\dot{\varpi} + H_u\dot{u}}{H(\varpi; u)} \quad (4.36)$$

Substituting (4.35) and (4.36) in (4.34):

$$y = \frac{1}{\pi\theta} \left\{ (1 - \Omega) \left[\frac{H_{\varpi}\dot{\varpi} + H_u\dot{u}}{H(\varpi; u)} \right] + (1 - \theta) \left[\left(\frac{\dot{\varpi}}{1 - \varpi} \right) + \frac{\dot{u}}{u} \right] + \Omega \frac{\dot{X}}{X} \right\} \quad (4.37)$$

Looking at the expression above, $(1 - \Omega)(H_{\varpi}\dot{\varpi} + H_u\dot{u})/H(\varpi; u)$ captures the "investment effect" on growth, $(1 - \theta)[\dot{\varpi}/(1 - \varpi) + \dot{u}/u]$ is the "consumption effect" and $\Omega\dot{X}/X$ stands for the "foreign demand effect". Notice that exports are the only true autonomous demand component following the Kaldorian tradition. Furthermore, in steady state, $\dot{\varpi} = \dot{u} = 0$ so that $\dot{I}/I = \dot{S}/S$. Once equilibrium in the current account is re-established, $\theta = \Omega$, and is easy to see that $y = (\dot{X}/X)/\pi = y_{BP}$. In reasoning with some similarities to the one presented here, [Garcimartin et al \(2016\)](#) called an expression that resembles (4.37) as the short-run BoPC rate of growth.

Equation (4.37) shows that the impact of all cyclical variables on the rate of growth of output is difficult to determine. Suppose for a moment that θ and Ω are constant. Then, if an increase (decrease) in the wage-share increases (decreases) consumption more than it decreases (increases) investment, the rate of growth of output will be higher (lower). In contrast, an increase in capacity utilisation only increases growth if it causes an increase in investment that overcomes the reduction in consumption. This is because an increase in u increases the rate of growth of labour productivity which in turn reduces the wage-share. Finally, variations in the rate of employment have an effect similar to variations in the wage-share because they operate through the latter. Nevertheless, allowing θ and Ω to vary results in signals becoming almost completely undetermined. This indeterminacy resembles the profit-led vs wage-led controversy in the Kaleckian literature (see [Blecker, 2016](#) for a discussion of the topic).

It is outside the scope of this essay to take a position in the debate or propose a particular solution for that discussion. Still, it is not possible to ignore the effects of cyclical variables in the adjustment process of y . Therefore we propose a simple adjustment rule in order to take into account these cyclical motions:

$$\begin{aligned} \dot{y} &= D(y_{BP} - y, e - e^*, \varpi - \varpi^*, u - u^*), \text{ with } D(y_{BP}, e^*, \varpi^*, u^*) = 0 \\ D_y &< 0, \quad D_e \geq 0, \quad D_{\varpi} \geq 0, \quad D_u \geq 0, \\ D_e|_{e=e^*} &= 0, \quad D_{\varpi}|_{\varpi=\varpi^*} = 0, \quad D_u|_{u=u^*} = 0 \end{aligned}$$

where the only additional conditions we impose are that the partial derivatives of $D(\cdot)$ with respect to employment, wage-share and effective capacity are equal to zero at their respective equilibrium values. In other words, variations in the growth rate occur only when the system is outside equilibrium while, in steady state, we recover $y = y_{BP}$.

4.4.4 The dynamic system

Substituting (4.10) into (4.3) we have:

$$\frac{\dot{e}}{e} = y - G(u) - n$$

or

$$\dot{e} = [y - G(u) - n]e = g_1(e, \varpi, u, y) \quad (4.38)$$

The interpretation of the first dynamic equation remains the same with the only difference that now the actual growth rate of output is also an endogenous variable.

Distributive dynamics continue to be given by:

$$\frac{\dot{\varpi}}{\varpi} = F(e) - G(u)$$

or

$$\dot{\varpi} = [F(e) - G(u)]\varpi = g_2(e, \varpi, u, y) \quad (4.39)$$

Taking account of (4.9), (4.10) and (4.32), variations in effective capacity utilisation are such that:

$$\frac{\dot{u}}{u} = y - H(\varpi, u)$$

or

$$\dot{u} = [y - H(\varpi, u)]u = g_3(e, \varpi, u, y) \quad (4.40)$$

An increase in demand above capital accumulation increases effective capacity utilisation. The reason for this is easy to explain: production is increasing faster than the expansion of productive capacity. Notice that capital accumulation is now given by the independent investment function.

Finally, we simply restate the adjustment mechanism between the rate of growth of output and the external constraint:

$$\dot{y} = D(y_{BP} - y, e - e^*, \varpi - \varpi^*, u - u^*) = g_3(e, \varpi, u, y) \quad (4.41)$$

Equations (4.38)-(4.41) form the dynamic system of our second modified model.

4.4.5 Local stability analysis and Hopf bifurcation

In steady-state $\dot{e}/e = \dot{\varpi}/\varpi = \dot{u}/u = \dot{y} = 0$. This gives us the following conditions:

$$y = G(u) + n \tag{4.42}$$

$$F(e) = G(u) \tag{4.43}$$

$$y = H(\varpi; u) \tag{4.44}$$

$$0 = D(y_{BP} - y, e - e^*, \varpi - \varpi^*, u - u^*) \tag{4.45}$$

The interpretation of equations (4.42)-(4.45) is very similar to the interpretation we have given for the previous model. From (4.43), it follows that real wages and labour productivity must grow at the same rate in order to obtain a constant wage-share. Furthermore, the rate of growth of output is such that the natural rate of growth, capital accumulation and Thirlwall's law are equal to the former three adjusting to the last one.

In analogy with what was done with regard to the previous version of the model, we now turn to the investigation of the local stability properties of the equilibrium points. As a first step, we state and prove the following Proposition, regarding the conditions for a unique economically meaningful internal equilibrium.

Proposition 4.4 *The dynamic system (4.38)-(4.41) has a unique internal equilibrium point that satisfies:*

$$e^* = F^{-1}(y_{BP} - n) \tag{4.46}$$

$$H[\varpi^*, G^{-1}(y_{BP} - n)] = y_{BP} \tag{4.47}$$

$$u^* = G^{-1}(y_{BP} - n) \tag{4.48}$$

$$y^* = y_{BP} \tag{4.49}$$

Proof. See Mathematical Appendix 4.5. ■

Comparing equations (4.46) and (4.48) with (4.21) and (4.23) we see that they are exactly the same. Equation (4.47) on the other hand comes with some novelty because of the investment function. Moreover, the net effect of growth on the wage-share continues to be undetermined but now depends on the shape of the investment function. Furthermore, for a given rate of growth of output (determined by Thirlwall's law) we obtain a rate of employment and of capacity utilisation that depends on the bargaining power of workers and on the learning-by-doing mechanism, respectively. After that, the income distribution will adjust in order to

ensure that capital accumulation is such as to maintain the equilibrium rate of effective capacity utilisation.¹¹

Notice also that there are two ways to permanently increase the rate of employment of the economy. The first involves a deep transformation of the economic structure in favour of productive diversification and technological complexity in order to ensure a higher y_{BP} . The second is related to a reduction in the bargaining power of workers. However, this second mechanism does not rely on the problematic neoclassical factor demand curves but works as follows. In order to obtain a constant wage-share, real wages and labour productivity must grow at the same rate. Highly combative workers translate small increases in employment into large increases in real wages. This means that, for a given rate of growth of labour productivity, the employment rate that ensures that real wages and productivity grow at the same rate will be lower the higher the capacity of workers to increase their wages. Therefore, a reduction in bargaining power of workers can increase equilibrium employment.

With regard to this unique internal equilibrium point, we can now state and prove the following Proposition regarding its local stability.

Proposition 4.5 *If the sensitivity of real wages to changes in the employment rate is sufficiently low and such that*

$$F'(e^*) < \frac{H_u(\varpi^*, u^*)u^*}{e^*} = \frac{H_u(\varpi^*, u^*)G^{-1}(y_{BP} - n)}{F^{-1}(y_{BP} - n)}$$

the internal equilibrium $(e^, \varpi^*, u^*, y^*)$ of the dynamic system (4.38)-(4.41) is locally asymptotically stable.*

Proof. See Mathematical Appendix 4.5. ■

Still, for higher values of $F'(e^*)$, it may happen that $F'(e^*) > H_u(\varpi^*, u^*)u^*/e^*$. Thus, the dynamic behaviour of the model may drastically change, from the qualitative point of view, as the sensitivity of real wages to changes in e increases, with all the other parameters remaining constant. We pursue a route similar to the one we have followed in the section and use $F'(e^*)$ as a bifurcation parameter in order to study the possibility of persistent cyclical behaviour.

Proposition 4.6 *For values of $F'(e^*)$ in the neighbourhood of the critical value such that*

$$F'(e^*) = \frac{H_u(\varpi^*; u^*)u^*}{e^*}$$

the dynamic system (4.38)-(4.41) admits a family of periodic solutions.

Proof. See Mathematical Appendix 4.5. ■

Once more cyclical behavior is rooted on the labour market and distributive conflict.

¹¹This last conclusion resembles Kaldor's (1957) contribution to the "Capital Controversies" because capital accumulation was supposed to adjust to the natural growth rate through a redistribution between wages and profits. At that time, however, the discussion concerned closed economies, a very different scenario from the one discussed here. Still, we would say that the similarity is not negligible.

4.4.6 Numerical Simulations

We proceed by presenting a numerical simulation exercise to illustrate the existence and economic interpretation of the limit cycle whose existence was proved in the last subsection. Following what was done in section 3.6, we first determine functional forms for the behavioural equations. We maintain equations (4.25) and (4.26) for $F(\cdot)$ and $G(\cdot)$. Therefore, there are only two behavioural equations missing, namely, $H(\cdot)$ and $D(\cdot)$ for which we choose the following specifications:

$$H(\varpi, u) = c_1 - c_2\varpi + c_3u \quad (4.50)$$

$$D(y_{BP} - y, e - e^*, \varpi - \varpi^*, u - u^*) = d(y_{BP} - y) + f_1(e - e^*)^3 + f_2(\varpi - \varpi^*)^3 + f_3(u - u^*)^3 \quad (4.51)$$

where d is the adjustment parameter of the growth rate of output to the BoPC and f_i with $i = \{1, 2, 3\}$ stand for the influence of the other cyclical variables on growth. A cubic form for the deviations of employment, wage share and effective capacity utilisation was preferred over a quadratic formulation because it allows for changes in the signal of the effect if deviations occur upwards or downwards.

Recalling (4.46)-(4.49), equilibrium values become:

$$e^* = \bar{e} + \frac{y_{BP} - n}{a} \quad (4.52)$$

$$\varpi^* = \frac{c_3}{c_2} \left(\frac{y_{BP} - n}{b} \right)^{1/\beta} + \frac{c_1 - y_{BP}}{c_2} \quad (4.53)$$

$$u^* = \left(\frac{y_{BP} - n}{b} \right)^{1/\beta} \quad (4.54)$$

$$y^* = y_{BP} \quad (4.55)$$

Parameter values were chosen in accordance with the magnitude of the ones found in several empirical studies. Accordingly, for the numerical simulations, we use the following parameter values:

$$\begin{aligned} y_{BP} &= 0.03105, \quad n = 0.01, \quad a = 0.0422 \\ \bar{e} &= 0.28986, \quad b = 0.091522, \quad \beta = 1.17 \\ c_1 &= 0.03061, \quad c_2 = 0.05, \quad c_3 = 0.11407 \\ d &= 0.6, \quad f_1 = 0, \quad f_2 = \pm 0.75, \quad f_3 = 0 \end{aligned}$$

There are eight possible combinations of f_i that can provide different cyclical dynamics. We chose to set f_1 and f_3 equal to zero in order to focus on income distribution. This of course does not have necessarily to be the case. Nevertheless, it allows the model to provide some specific insights into the relation between the income distribution and growth. A positive f_2 comes near to the so called wage-led case because over the cycle an increase in the wage share

increases consumption more than it decreases investment and therefore increases the rate of growth of output. Analogously, a negative f_2 approaches the profit-led case.

Taking $F'(e^*) = a$ as the bifurcation parameter it turns out that $a_{HB} \approx 0.0394$ and for the simulation we used a value slightly higher than this. Figure 3a displays the solution path for two different initial values $(e_0, \varpi_0, u_0, y_0)$ equal to $(0.9, 0.6, 0.4, 0.04)$ and $(0.77, 0.65, 0.24, 0.2)$ when $f_2 = 0.75$. Both trajectories converge to the limit cycle around $(e^*, \varpi^*, u^*, y^*) = (0.78868, 0.64083, 0.28475, 0.03105)$. Figure 3b plots the time series for the first trajectory. This confirms that the Hopf bifurcation is supercritical and that, as consequence, the emerging persistent periodic solution is stable.

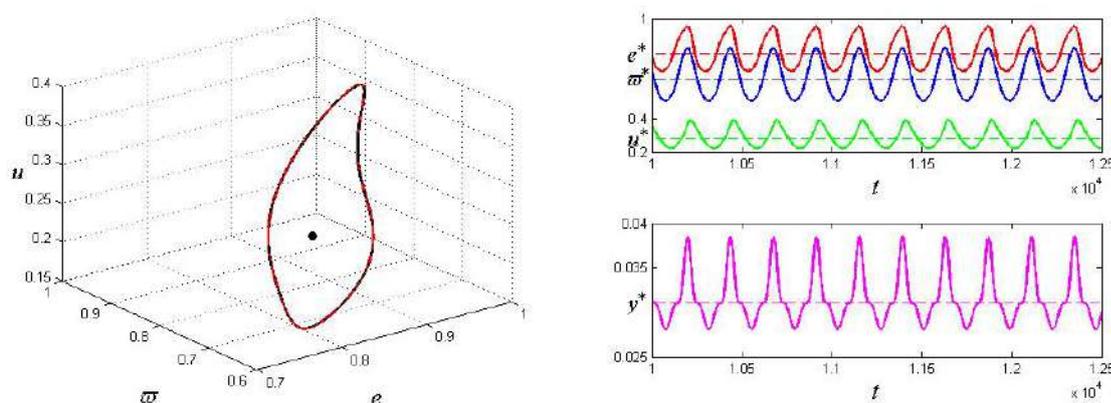


Figure 2: Limit cycle and time series 4D, “wage-led” economy

From the figures above we can sketch a description of the dynamic interactions of the four variables over the cycle. These effects can now be divided in two groups with different characteristics, which are not easy to separate. An increase in the employment rate leads to an increase in the wage share. On the one hand this reduces capital accumulation, creating pressure for an increase in capacity utilisation. On the other hand, given that an increase in the wage-share increases consumption more than it decreases investment, there is going to be an increase in the rate of growth of output which in turn creates pressure for an increase in employment and the rate of capacity utilisation. The increase in the employment rate repeats the narrative while the increase in utilisation brings downward pressure on employment and the wage share through the learning-by-doing mechanism.

A reduction in the rate of employment reduces the wage share. This increases capital accumulation and *ceteris paribus* reduces the rate of effective utilisation. Nevertheless, a reduction in the wage share reduces the rate of growth of output, bringing downward pressure on employment and capacity utilisation. The reduction in employment has the same effects we have just described while a reduction in utilisation has as outcome an increase in employment and wage share because of learning-by-doing.

When $f_2 = -0.75$ we were also able to find a supercritical Hopf bifurcation with a periodic stable solution around the same equilibrium as before. However, the limit cycle lies outside values with an economic interpretation. Figure 4 plots the time series of our simulation for initial values (e_0, ϖ_0, u_0) equal to $(0.9, 0.6, 0.4, 0.04)$.

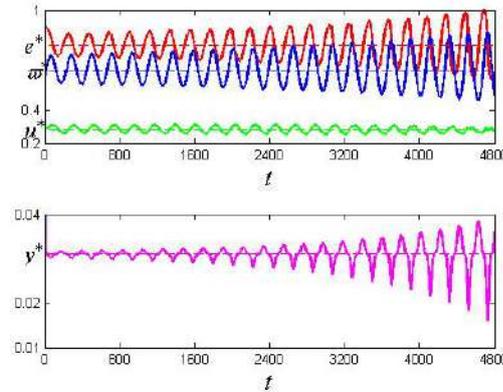


Figure 3: Time series 4D, “profit-led” case

As we can see, the periodic solution increases in magnitude while slowly converging to the limit cycle outside values with economic meaning. While this result has to be taken parsimoniously, it throws a question, at least for the set of parameters and functional forms used in numerical simulations, over the sustainability of the so called profit-led regime that is usually claimed for open economies.

Still, two observations have to be made. First, in general profit-led regimes are considered to be more likely in open economies because of price-competitiveness effects, while here we abstracted from any price considerations. Second, recall from the local stability analysis that for values of $F'(e^*) < a_{HB}$ the system actually exhibits convergence to equilibrium. Periodic solutions emerge as a result of an increase in the sensitivity of workers’ wage demands to the employment rate. What our numerical exercise indicates is that the profit led regime is unsustainable only once endogenous fluctuations emerge, that is, for highly combative workers.

A description of the dynamics follows. An increase in the employment rate increases the wage share and as consequence reduces capital accumulation and the rate of growth of output because the reduction in investment is higher than the increase in consumption. On the one hand, a reduction in capital accumulation creates upward pressure on the rate of capacity utilisation which is expected to decrease the employment rate through learning-by-doing. On the other hand, a reduction in the rate of growth of output creates downward pressure on capacity utilisation, which in turn is expected to increase employment. It seems that at the beginning, the first effect prevails and we have periodic fluctuations within an economically meaningful range. However, the second effect increases in magnitude as time goes by and the model converges to a limit cycle outside a range of values with economic meaning.

4.5 Conclusions

In the last fifty years Goodwin's distributive cycle model has been and continues to be used as a fruitful "system for doing macro-dynamics". We note, however, that most of the existing contributions have been based on a closed economy framework. In this chapter we have offered a modeling structure that expands the original model to an open economy framework in a way that incorporates the Balance-of-Payments constraint on growth. We have done so allowing technical change to be endogenous to the cyclical dynamics of the system.

We developed a three dimensional dynamic system that includes, besides the employment rate and the wage-share of the original model, also the rate of effective capacity utilisation. We showed that without having to impose any special condition on the values of the parameters, a Hopf-Bifurcation analysis establishes the possibility of persistent and bounded cyclical paths providing insights to enable better understanding of the nature of real-world fluctuations.

Moreover, in order to obtain a model that is fully embedded in Goodwin's fundamental insight that trend and cycle are indissolubly fused, we build a four dimensional dynamic system where the rate of growth of output was allowed to deviate from the external constraint. In this second case, disequilibrium in the goods market was further explored introducing an independent investment function. The importance of our contribution resides in its provision of a base-line model to study distributive dynamics in open economies.

Some numerical simulations were performed based on the analytical models. We showed that indeed under plausible conditions, a stable limit cycle emerges. Furthermore, even though our model is not Kaleckian in nature, it is possible to obtain insights that address the wage-led vs profit-led growth regimes. Our last growth-cycle model questions the sustainability of the so called profit-led regime that is usually claimed for open economy models.

Empirical appendix

Thirlwall's law states that $y_{BP} = \rho \frac{\dot{Z}}{Z}$ where $\rho = \frac{dX}{dZ} \frac{Z}{X} / \frac{dM}{dY} \frac{Y}{M}$. Notice, however, that $(\frac{dX}{dZ} \frac{Z}{X}) \frac{\dot{Z}}{Z}$ is nothing other than the growth rate of exports, \dot{X}/X . Therefore, we can rewrite the rule as $y_{BP} = (\dot{X}/X) / \frac{dM}{dY} \frac{Y}{M}$, that is, as the ratio between the growth rate of exports and the income elasticity of imports. Assuming that $M(\cdot)$ is an homogenous function of degree π , we have:

$$y_{BP} = \frac{\dot{X}/X}{\pi}$$

where π stands for the income elasticity of imports.

The empirical relevance of the BoPC model is usually investigated by relying on this last simple expression. This crucially depends on the estimate of the income elasticity of imports which can be obtained from a standard aggregate import function. To this end, in this essay we use country-specific cointegrating techniques. This approach has two main advantages over usual cross-country regressions. First, it avoids a number of heterogeneity problems by focusing on the time dimension of data. Secondly, omitted variable issues are less likely to compromise the reliability of our estimates. On the one hand, if the omitted variable is stationary, estimated coefficients are invariant to its inclusion. On the other hand, if non-stationary, leaving it out we will not be able to find a stable cointegrating relationship.¹²

We make use of the Auto-Regressive Distributed Lag (ARDL) bounds, testing the cointegration procedure developed by Pesaran and Shin (1998) and latter extended by Pesaran, Shin and Smith (2001) to estimate Thirlwall's law for each individual country. This methodology has several advantages over other cointegration methods as it allows the analysis to be undertaken regardless of whether the variables are a mixture of stationar, $I(0)$, and integrated of order one, $I(1)$, which is potentially our case.

To the best of our knowledge Lanzafame (2014) is the only other author to have used a similar technique when estimating the law. However, he imposes a common lag structure to all countries and does not apply the Bounds cointegration test. Actually, he considers that the significant negative error-correction coefficients provide enough support for the hypothesis that the variables share a long-run relation. The novelty of our exercise is in (i) allowing different lags for each country and (ii) applying the Bounds/ARDL cointegration test.

Our dataset is annual and covers the period between 1950 and 2014 for 16 OECD countries (Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zeland, Norway, South Korea, Sweden, United Kingdom, and United States). Output is measured as real Gross Domestic Product (GDP) at current PPPs (in millions of 2011 US dollars). Finally, exports and imports are obtained multiplying the respective shares in output by total output. Data was converted to logarithmic form.

In order to confirm that all series are at most integrated of order one we perform for each country two different group unit root tests. The first one is the Levin, Lin and Chu (LLC) that

¹²For a further discussion and references on the econometric properties of the time-series approach see Gobbin and Rayp (2008).

assumes a common unit root process. The second one is the Im, Pesaran and Shin (IPS that assumes an individual unit root process. Given the large number of tables, results are available on request.

Table A1 reports each ARDL estimation and the Bounds test for cointegration between imports and GDP. We can see that in all cases the null hypothesis of no cointegration is rejected, i.e. series are cointegrated. Moreover, the significance and negative signal of the coefficient of the lagged error-correction term indicates that the system is stable and there is Granger causality running from the explanatory variables to imports.¹³

Table A1: ARDL and Bounds test

Country	Model	Bounds/Coint.	EC
Australia	ARDL(1,2)	13.62090***	-0.402002***
Belgium	ARDL(3,0)	17.35839***	-0.233623***
Canada	ARDL(1,0)	10.23942***	-0.265771***
Denmark	ARDL(1,0)	12.73576***	-0.233573***
Finland	ARDL(1,1)	5.438476**	-0.436487***
France	ARDL(3,1)	6.177276***	-0.261651***
Germany	ARDL(1,0)	35.06542***	-0.364196***
Italy	ARDL(1,0)	14.87707***	-0.263317***
Japan	ARDL(1,0)	15.25011***	-0.233760***
Netherlands	ARDL(1,0)	5.883139**	-0.216290***
New Zealand	ARDL(1,0)	10.79018***	-0.487103***
Norway (add dummies)	ARDL(3,0)	7.558276***	-0.691814***
South Korea	ARDL(1,0)	14.01765***	-0.314425***
Sweden	ARDL(1,0)	13.11425***	-0.436441***
UK	ARDL(1,0)	13.87858***	-0.349302***
US	ARDL(1,0)	18.74725***	-0.329578***

*, **, and *** stand by 10%, 5% and 1% of significance

Long-run coefficients correspond to the income elasticity of imports and are reported in table A2:

¹³In the case of Norway, the error correction term was found to be particularly low, rising suspects of structural breaks. Hence, we add a sequence of five dummy variables that assume value one for the 1960s, 1970s, 1980s, 1990s, and 2000s, respectively.

Table A2: ARDL Long-run coefficients

Country	C	ln GDP	Country	C	ln GDP
Australia	-8.879893***	1.535388***	Belgium	-9.941208***	1.806132***
Canada	-5.976610***	1.357813***	Denmark	-8.594565***	1.662484***
Finland	-7.816791***	1.583907***	France	-12.32235***	1.777486***
Germany	-12.59660***	1.796033***	Italy	-6.203675***	1.341538***
Japan	-2.185159***	1.022031***	Netherlands	-4.974679***	1.355067***
New Zealand	-6.204707***	1.437409***	Norway	-0.328503***	0.925507***
South Korea	-5.699657***	1.346022***	Sweden	-5.943632***	1.413814***
UK	-11.24704***	1.704916***	US	-15.75352***	1.848028***

*, **, and *** stand by 10%, 5% and 1% of significance

As expected from theory, the income elasticity of imports is positive and significant in all cases. An increase of 1% in GDP is associated with an increase of between 0.9% – 1.85% of imports. To assess a valid inference and no spurious regressions, residuals of all ARDL estimations were checked for serial correlation using the Bresch-Godfrey LM test. We concluded that our estimates were consistent. Results are available on request.

As previously discussed, the coefficient of $\ln GDP$ corresponds to the estimated income elasticity of imports ($\hat{\pi}$) of each country. Taking the average growth rate of exports and dividing by $\hat{\pi}$ we obtain the long-run BoPC growth rate. Our estimates of Thirlwall's law provide a fair approximation of actual average long-run growth rates for countries of the sample, as reported in table 1.

Mathematical appendix

Proof of Proposition 4.1

To prove Proposition 4.1 we proceed in four steps. First, from equation (4.18) we have that $G(u) = y_{BP} - n$, where $G : \mathfrak{R} \rightarrow \mathfrak{R}$ is a function monotonically increasing in u . The inverse of $G(\cdot)$ is also monotonically increasing so that $u^* = G^{-1}(y_{BP} - n)$ is the unique equilibrium value of effective capacity utilisation.

Making use of equations (4.18) and (4.19) we obtain the rate of growth of real wages in terms of the external constrain, i.e. $F(e) = y_{BP} - n$, where $F : \mathfrak{R} \rightarrow \mathfrak{R}$ is monotonically increasing in e . Therefore, its inverse is also an increasing function and we obtain $e^* = F^{-1}(y_{BP} - n)$ as the unique equilibrium value of the rate of employment.

The equilibrium wage-share is defined as the value of the wage-share that brings effective capacity utilisation and the external constraint to equilibrium. Rearranging (4.20) it is easy to see that $\varpi = 1 - y_{BP}/su$. Substituting the equilibrium value of capacity utilisation in this last expression we arrive at $\varpi^* = 1 - y_{BP}/[sG^{-1}(y_{BP} - n)]$.

Finally, in order for equilibrium values to have an economic meaning, we have to impose $0 < G^{-1}(y_{BP} - n) < 1$, $0 < F^{-1}(y_{BP} - n) < 1$, and $y_{BP} < sG^{-1}(y_{BP} - n)$.

Proof of Proposition 4.2

In this Appendix we first derive the characteristic equation of the dynamics system (4.15)-(4.17) and prove Proposition 4.2. To do this, we linearise the dynamic system around the internal equilibrium point so as to obtain:

$$\begin{bmatrix} \dot{e} \\ \dot{\varpi} \\ \dot{u} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 0 & J_{13} \\ J_{21} & 0 & J_{23} \\ 0 & J_{32} & J_{33} \end{bmatrix}}_{J^*} \begin{bmatrix} e - e^* \\ \varpi - \varpi^* \\ u - u^* \end{bmatrix}$$

where the elements of the Jacobian matrix J^* are given by:

$$\begin{aligned} J_{11} &= \left. \frac{\partial f_1(e, \varpi, u)}{\partial e} \right|_{(e^*, \varpi^*, u^*)} = 0 \\ J_{12} &= \left. \frac{\partial f_1(e, \varpi, u)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*)} = 0 \\ J_{13} &= \left. \frac{\partial f_1(e, \varpi, u)}{\partial u} \right|_{(e^*, \varpi^*, u^*)} = -G'(u^*)e^* < 0 \\ \\ J_{21} &= \left. \frac{\partial f_2(e, \varpi, u)}{\partial e} \right|_{(e^*, \varpi^*, u^*)} = F'(e^*)\varpi^* > 0 \\ J_{22} &= \left. \frac{\partial f_2(e, \varpi, u)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*)} = 0 \\ J_{23} &= \left. \frac{\partial f_2(e, \varpi, u)}{\partial u} \right|_{(e^*, \varpi^*, u^*)} = -G'(u^*)\varpi^* < 0 \\ \\ J_{31} &= \left. \frac{\partial f_3(e, \varpi, u)}{\partial e} \right|_{(e^*, \varpi^*, u^*)} = 0 \\ J_{32} &= \left. \frac{\partial f_3(e, \varpi, u)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*)} = su^{*2} > 0 \\ J_{33} &= \left. \frac{\partial f_3(e, \varpi, u)}{\partial u} \right|_{(e^*, \varpi^*, u^*)} = -s(1 - \varpi^*)u^* < 0 \end{aligned}$$

so that the characteristic equation can be written as

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

where the coefficients are given by:

$$b_1 = -\text{tr } J^* = -J_{33} > 0 \quad (4.56)$$

$$b_2 = \begin{vmatrix} 0 & J_{23} \\ J_{32} & J_{33} \end{vmatrix} + \begin{vmatrix} 0 & J_{13} \\ 0 & J_{33} \end{vmatrix} + \begin{vmatrix} 0 & 0 \\ J_{21} & 0 \end{vmatrix} = -J_{23}J_{32} > 0 \quad (4.57)$$

$$b_3 = -\det J = -J_{13}J_{21}J_{32} > 0 \quad (4.58)$$

The necessary and sufficient condition for the local stability of (e^*, ϖ^*, u^*) is that all roots of the characteristic equation have negative real parts, which, from Routh–Hurwitz conditions, requires:

$$b_1 > 0, \quad b_2 > 0, \quad b_3 > 0 \quad \text{and} \quad b_1 b_2 - b_3 > 0.$$

Given (4.56)-(4.58), the crucial condition for local stability becomes the last one. Through direct computation we find that:

$$\begin{aligned} b_1 b_2 - b_3 &= J_{33} J_{23} J_{32} + J_{13} J_{21} J_{32} \\ &= J_{32} (J_{33} J_{23} + J_{13} J_{21}) \\ &= J_{32} [s(1 - \varpi^*) u^* G'(u^*) \varpi^* - G'(u^*) e^* F'(e^*) \varpi^*] \\ &= J_{32} \varpi^* G'(u^*) [s(1 - \varpi^*) u^* - e^* F'(e^*)] > 0 \end{aligned} \tag{4.59}$$

a condition that is satisfied when:

$$F'(e^*) < \frac{s(1 - \varpi^*) u^*}{e^*} = \frac{y_{BP}}{F^{-1}(y_{BP} - n)}$$

Proof of Proposition 4.3

To prove Proposition 4.3 using the (existence part of) the Hopf Bifurcation Theorem and using $F'(e^*)$ as bifurcation parameter, we must first of all (HB1) show that the characteristic equation possesses a pair of complex conjugate eigenvalues $\theta [F'(e^*)] \pm i\omega [F'(e^*)]$ that become purely imaginary at the critical value $F'(e^*)_{HB}$ of the parameter – i.e., $\theta [F'(e^*)_{HB}] = 0$ – and no other eigenvalues with zero real part exists at $F'(e^*)_{HB}$ and then (HB2) check that the derivative of the real part of the complex eigenvalues with respect to the bifurcation parameter is different from zero at the critical value.

(HB1) Given that the conditions $b_1 > 0$, $b_2 > 0$ and b_3 are all satisfied, in order that the characteristic equation has one negative real root and a pair of complex roots with zero real part we must have:

$$b_1 b_2 - b_3 = 0$$

a condition which, given the expression for $b_1 b_2 - b_3$ derived in (4.59), is satisfied for

$$F'(e^*)_{HB} = \frac{s(1 - \varpi^*) u^*}{e^*}$$

(HB2) By using the so-called sensitivity analysis, it is then possible to show that the second requirement of the Hopf Bifurcation Theorem is also met. Substituting the elements of the Jacobian matrix into the respective coefficients of the characteristic equation:

$$\begin{aligned} b_1 &= s(1 - \varpi^*) u^* \\ b_2 &= sG'(u^*) \varpi^* u^{*2} \\ b_3 &= sG'(u^*) F'(e^*) e^* \varpi^* u^{*2} \end{aligned}$$

so that

$$\begin{aligned}\frac{\partial b_1}{\partial F'(e^*)} &= 0 \\ \frac{\partial b_2}{\partial F'(e^*)} &= 0 \\ \frac{\partial b_3}{\partial F'(e^*)} &= sG'(u^*)e^*\varpi^*u^{*2} > 0\end{aligned}$$

When $F'(e^*)_{HB} = s(1 - \varpi^*)u^*/e^*$, apart from $b_1 > 0$, $b_2 > 0$ and $b_3 > 0$ which is always true, one also has $b_1b_2 - b_3 = 0$. In this case, one root of the characteristic equation is real negative (λ_1), whereas the other two are a pair of complex roots with zero real part ($\lambda_{2,3} = \theta \pm i\omega$, with $\theta = 0$). We thus have:

$$\begin{aligned}b_1 &= -(\lambda_1 + \lambda_2 + \lambda_3) \\ &= -(\lambda_1 + 2\theta) \\ b_2 &= \lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3 \\ &= 2\lambda_1\theta + \theta^2 + \omega^2 \\ b_3 &= -\lambda_1\lambda_2\lambda_3 \\ &= -\lambda_1(\theta^2 + \omega^2)\end{aligned}$$

such that:

$$\begin{aligned}\frac{\partial b_1}{\partial F'(e^*)} &= -\frac{\partial \lambda_1}{\partial F'(e^*)} - 2\frac{\partial \theta}{\partial F'(e^*)} = 0 \\ \frac{\partial b_2}{\partial F'(e^*)} &= 2\theta\frac{\partial \lambda_1}{\partial F'(e^*)} + 2(\lambda_1 + \theta)\frac{\partial \theta}{\partial F'(e^*)} + 2\omega\frac{\partial \omega}{\partial F'(e^*)} = 0 \\ \frac{\partial b_3}{\partial F'(e^*)} &= -(\theta^2 + \omega^2)\frac{\partial \lambda_1}{\partial F'(e^*)} - 2\lambda_1\theta\frac{\partial \theta}{\partial F'(e^*)} - 2\lambda_1\omega\frac{\partial \omega}{\partial F'(e^*)} \\ &= sG'(u^*)e^*\varpi^*u^{*2}\end{aligned}$$

For $\theta = 0$, the system to be solved becomes:

$$\begin{aligned}-\frac{\partial \lambda_1}{\partial F'(e^*)} - 2\frac{\partial \theta}{\partial F'(e^*)} &= 0 \\ 2\lambda_1\frac{\partial \theta}{\partial F'(e^*)} + 2\omega\frac{\partial \omega}{\partial F'(e^*)} &= 0 \\ -\omega^2\frac{\partial \lambda_1}{\partial F'(e^*)} - 2\lambda_1\omega\frac{\partial \omega}{\partial F'(e^*)} &= G'(u^*)e^*\varpi^*u^{*2}\end{aligned}$$

or

$$\begin{bmatrix} -1 & -2 & 0 \\ 0 & 2\lambda_1 & 2\omega \\ -\omega^2 & 0 & -2\lambda_1\omega \end{bmatrix} \begin{bmatrix} \frac{\partial \lambda_1}{\partial F'(e^*)} \\ \frac{\partial \theta}{\partial F'(e^*)} \\ \frac{\partial \omega}{\partial F'(e^*)} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ sG'(u^*)e^*\varpi^*u^{*2} \end{bmatrix}$$

Thus:

$$\begin{aligned} \frac{\partial \theta}{\partial F'(e^*)} \Big|_{F'(e^*)=F'(e^*)_{HB}} &= \frac{\begin{vmatrix} -1 & 0 & 0 \\ 0 & 0 & 2\omega \\ -\omega^2 & sG'(u^*)e^*\varpi^*u^{*2} & -2\lambda_1\omega \end{vmatrix}}{\begin{vmatrix} -1 & -2 & 0 \\ 0 & 2\lambda_1 & 2\omega \\ -\omega^2 & 0 & -2\lambda_1\omega \end{vmatrix}} \\ &= \frac{2\omega sG'(u^*)e^*\varpi^*u^{*2}}{4\omega(\lambda_1^2 + \omega^2)} > 0 \end{aligned}$$

Proof of Proposition 4.4

The demonstration of Proposition 4.4 follows very closely the steps of Proposition 1. Nevertheless, the first variable to adjust is output. In equilibrium, equation (4.45) states that $D(y_{BP}, e^*, \varpi^*, u^*) = 0$, where $D(\cdot)$ is monotonically decreasing in y . It follows by construction that $y = y_{BP}$, $e = e^*$, $\varpi = \varpi^*$ and $u = u^*$ with the employment rate, the wage share and capacity utilization still to be determined. Once output converges to the BoPC growth rate we have from (4.42) that $G(u) = y_{BP} - n$, where $G: \mathfrak{R} \rightarrow \mathfrak{R}$ is a function monotonically increasing in u . The inverse of $G(\cdot)$ is also monotonically increasing so that $u^* = G^{-1}(y_{BP} - n)$ is the unique equilibrium value of effective capacity utilisation.

Making use of equations (4.42) and (4.43) we obtain the rate of growth of real wages in terms of Thirlwall's law, i.e. $F(e) = y_{BP} - n$, where $F: \mathfrak{R} \rightarrow \mathfrak{R}$ is monotonically increasing in e . Therefore, its inverse is also an increasing function and we obtain $e^* = F^{-1}(y_{BP} - n)$ as the unique equilibrium value of the rate of employment.

The equilibrium wage-share is defined as the value of the wage-share that brings effective capacity utilisation and the balance-of-payments to equilibrium. The novelty here is the independent investment function $H: \mathfrak{R} \rightarrow \mathfrak{R}$, monotonically increasing in u and decreasing in ϖ . Making use of the equilibrium value of capacity utilisation and equation (4.45) we have that $H[\varpi; G^{-1}(y_{BP} - n)] = y_{BP}$. It follows that the unique equilibrium for the wage-share is determined and defined by ϖ^* that satisfies that expression.

Finally, in order to obtain equilibrium values with economic meaning we have to impose $0 < G^{-1}(y_{BP} - n) < 1$, $0 < F^{-1}(y_{BP} - n) < 1$ and $0 < H^{-1}[y_{BP}; \varpi; G^{-1}(y_{BP} - n)] < 1$.

Proof of Proposition 4.5

In this Appendix we first derive the characteristic equation of the dynamic system (4.38)-(4.41) and prove Proposition 4.5. To do this, we first linearise the dynamic system around the internal

equilibrium point so as to obtain:

$$\begin{bmatrix} \dot{e} \\ \dot{\varpi} \\ \dot{u} \\ \dot{y} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 0 & J_{13} & J_{14} \\ J_{21} & 0 & J_{23} & 0 \\ 0 & J_{32} & J_{33} & J_{34} \\ 0 & 0 & 0 & J_{44} \end{bmatrix}}_{J^*} \begin{bmatrix} e - e^* \\ \varpi - \varpi^* \\ u - u^* \\ y - y^* \end{bmatrix}$$

where the elements of the Jacobian matrix J^* are given by:

$$\begin{aligned} J_{11} &= \left. \frac{\partial g_1(e, \varpi, u, y)}{\partial e} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\ J_{12} &= \left. \frac{\partial g_1(e, \varpi, u, y)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\ J_{13} &= \left. \frac{\partial g_1(e, \varpi, u, y)}{\partial u} \right|_{(e^*, \varpi^*, u^*, y^*)} = -G'(u^*)e^* < 0 \\ J_{14} &= \left. \frac{\partial g_1(e, \varpi, u, y)}{\partial y} \right|_{(e^*, \varpi^*, u^*, y^*)} = e^* \end{aligned}$$

$$\begin{aligned} J_{21} &= \left. \frac{\partial g_2(e, \varpi, u, y)}{\partial e} \right|_{(e^*, \varpi^*, u^*, y^*)} = F'(e^*)\varpi^* > 0 \\ J_{22} &= \left. \frac{\partial g_2(e, \varpi, u, y)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\ J_{23} &= \left. \frac{\partial g_2(e, \varpi, u, y)}{\partial u} \right|_{(e^*, \varpi^*, u^*, y^*)} = -G'(u^*)\varpi^* < 0 \\ J_{24} &= \left. \frac{\partial g_2(e, \varpi, u, y)}{\partial y} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \end{aligned}$$

$$\begin{aligned} J_{31} &= \left. \frac{\partial g_3(e, \varpi, u, y)}{\partial e} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\ J_{32} &= \left. \frac{\partial g_3(e, \varpi, u, y)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*, y^*)} = -H_{\varpi}(\varpi^*; u^*)u^* > 0 \\ J_{33} &= \left. \frac{\partial g_3(e, \varpi, u, y)}{\partial u} \right|_{(e^*, \varpi^*, u^*, y^*)} = -H_u(\varpi^*; u^*)u^* < 0 \\ J_{34} &= \left. \frac{\partial g_3(e, \varpi, u, y)}{\partial y} \right|_{(e^*, \varpi^*, u^*, y^*)} = u^* > 0 \end{aligned}$$

$$\begin{aligned}
 J_{41} &= \left. \frac{\partial g_4(e, \varpi, u, y)}{\partial e} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\
 J_{42} &= \left. \frac{\partial g_4(e, \varpi, u, y)}{\partial \varpi} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\
 J_{43} &= \left. \frac{\partial g_4(e, \varpi, u, y)}{\partial u} \right|_{(e^*, \varpi^*, u^*, y^*)} = 0 \\
 J_{44} &= \left. \frac{\partial g_4(e, \varpi, u, y)}{\partial y} \right|_{(e^*, \varpi^*, u^*, y^*)} = -D_y < 0
 \end{aligned}$$

Thus, the characteristic equation for the linearised system is:

$$\lambda^4 + b_1\lambda^3 + b_2\lambda^2 + b_3\lambda + b_4 = 0$$

where the coefficients are given by:

$$b_1 = -\text{tr } J^* = -J_{33} - J_{44} > 0 \quad (4.60)$$

$$\begin{aligned}
 b_2 &= \begin{vmatrix} J_{33} & J_{34} \\ 0 & J_{44} \end{vmatrix} + \begin{vmatrix} 0 & 0 \\ 0 & J_{44} \end{vmatrix} + \begin{vmatrix} 0 & J_{23} \\ J_{32} & J_{33} \end{vmatrix} \\
 &+ \begin{vmatrix} 0 & J_{14} \\ 0 & J_{44} \end{vmatrix} + \begin{vmatrix} 0 & J_{13} \\ 0 & J_{33} \end{vmatrix} + \begin{vmatrix} 0 & 0 \\ J_{21} & 0 \end{vmatrix} \\
 &= J_{33}J_{44} - J_{23}J_{32} > 0
 \end{aligned} \quad (4.61)$$

$$\begin{aligned}
 b_3 &= - \begin{vmatrix} 0 & J_{23} & 0 \\ J_{32} & J_{33} & J_{34} \\ 0 & 0 & J_{44} \end{vmatrix} - \begin{vmatrix} 0 & J_{13} & J_{14} \\ 0 & J_{33} & J_{34} \\ 0 & 0 & J_{44} \end{vmatrix} \\
 &- \begin{vmatrix} 0 & 0 & J_{14} \\ J_{21} & 0 & 0 \\ 0 & 0 & J_{44} \end{vmatrix} - \begin{vmatrix} 0 & 0 & J_{13} \\ J_{21} & 0 & J_{23} \\ 0 & J_{32} & J_{33} \end{vmatrix} \\
 &= J_{23}J_{32}J_{44} - J_{13}J_{21}J_{32} > 0 \\
 b_4 &= \det J = -J_{21}J_{13}J_{32}J_{44} > 0
 \end{aligned} \quad (4.63)$$

The necessary and sufficient condition for the local stability of (e^*, ϖ^*, u^*) is that all roots of the characteristic equation have negative real parts, which, from Routh–Hurwitz conditions, requires:

$$b_1 > 0, b_2 > 0, b_3 > 0, b_4 > 0 \text{ and } b_1b_2b_3 - b_1^2b_4 - b_3^2 > 0.$$

Given (4.60)-(4.63), the crucial requirement for local stability becomes the last one. Through direct computation we find that:

$$\begin{aligned}
 b_1b_2b_3 - b_1^2b_4 - b_3^2 &= -(J_{33} + J_{44})(J_{33}J_{44} - J_{23}J_{32})(J_{23}J_{32}J_{44} - J_{13}J_{21}J_{32}) \\
 &- (J_{33} + J_{44})^2 J_{21}J_{13}J_{32}J_{44} - (J_{23}J_{32}J_{44} - J_{13}J_{21}J_{32})^2 \\
 &= \underbrace{-J_{32}}_{<0} (J_{13}J_{21} + J_{23}J_{33}) \underbrace{(J_{33}J_{44}^2 + J_{44}^3 + J_{13}J_{32}J_{21} - J_{23}J_{32}J_{44})}_{<0}
 \end{aligned}$$

Therefore, the last Routh–Hurwitz condition is satisfied when:

$$J_{13}J_{21} + J_{23}J_{33} > 0$$

Substituting the respective values of the Jacobian matrix:

$$\begin{aligned} &= -G'(u^*)e^*F'(e^*)\varpi^* + G'(u^*)\varpi^*H_u(\varpi^*; u^*)u^* \\ &= -G'(u^*)\varpi^*[e^*F'(e^*) - H_u(\varpi^*; u^*)u^*] > 0 \end{aligned}$$

a condition which is satisfied when:

$$F'(e^*) < \frac{H_u(\varpi^*; u^*)u^*}{e^*} = \frac{H_u(\varpi^*; u^*)G^{-1}(y_{BP} - n)}{F^{-1}(y_{BP} - n)}$$

Proof of Proposition 4.6

To prove this proposition (see [Asada and Yoshida, 2003](#)), we must show that there exists a value of $F'(e^*) = F'(e^*)_{HB}$ such that we have (HB1) $b_1[F'(e^*)_{HB}]$, $b_2[F'(e^*)_{HB}]$, $b_3[F'(e^*)_{HB}]$, $b_4[F'(e^*)_{HB}] > 0$ and (HB2) $\Phi[F'(e^*)_{HB}] = b_1b_2b_3 - b_1^2b_4 - b_3^2 = 0$ with $\left. \frac{d\Phi}{dF'(e^*)} \right|_{F'(e^*)=F'(e^*)_{HB}} \neq 0$.

(HB1) Given the expressions for b_1, b_2, b_3 and b_4 in (4.60)-(4.63) the first part of the demonstration is immediately satisfied.

(HB2) Through direct computation we obtain:

$$\begin{aligned} b_1b_2b_3 - b_1^2b_4 - b_3^2 &= -(J_{33} + J_{44})(J_{33}J_{44} - J_{23}J_{32})(J_{23}J_{32}J_{44} - J_{13}J_{21}J_{32}) \\ &\quad - (J_{33} + J_{44})^2J_{21}J_{13}J_{32}J_{44} - (J_{23}J_{32}J_{44} - J_{13}J_{21}J_{32})^2 \\ &= \underbrace{-J_{32}(J_{31}J_{12} + J_{23}J_{33})}_{<0} \underbrace{(J_{33}J_{44}^2 + J_{44}^3 + J_{13}J_{32}J_{21} - J_{23}J_{32}J_{44})}_{<0} \end{aligned}$$

Taking $J_{31}J_{12} + J_{23}J_{33}$ and substituting the respective values of the Jacobian matrix, it is certainly possible to find a $F'(e^*)$ sufficiently greater than $\frac{H_u(\varpi^*; u^*)u^*}{e^*}$ such that:

$$\begin{aligned} &J_{31}J_{12} + J_{23}J_{33} \\ &= -G'(u^*)e^*F'(e^*)\varpi^* + G'(u^*)\varpi^*H_u(\varpi^*; u^*)u^* \\ &= -G'(u^*)\varpi^*[e^*F'(e^*) - H_u(\varpi^*; u^*)u^*] < 0 \end{aligned}$$

and therefore $b_1b_2b_3 - b_1^2b_4 - b_3^2 < 0$. By continuity, this means that there exists at least one value of the parameter $F'(e^*) = \frac{H_u(\varpi^*; u^*)u^*}{e^*}$ such that $\Phi = 0$ with $\left. \frac{d\Phi}{dF'(e^*)} \right|_{F'(e^*)=F'(e^*)_{HB}} \neq 0$.

Chapter 5

Alternative Approaches to Technological Change when Growth is BoPC

5.1 Introduction

The analysis of the role of technical change in growth processes has been for a long time of central importance in economic theory. Different approaches have been proposed over the years to study distinct aspects of the phenomenon. Among alternative theories of growth and distribution, two particular viewpoints on the evolution of technology deserve special attention given their influence to Marxian and post-Keynesian macrodynamic modeling, namely: (i) Kaldor-Verdoorn's law, where labour productivity grows in line with output's growth rate or capital accumulation; and (ii) a classical-Marxian technical progress function, where factor productivity growth rates respond positively to factor cost shares.

On the other hand, the seminal paper on the growth cycle by [Goodwin \(1967\)](#) has consolidated itself throughout the past decades as a powerful "system for doing macrodynamics". In the last fifty years, a great number of contributions have tried to generalise its formulation in all possible directions. The introduction of technical change considerations has not been an exception, especially in what concerns the dependence of labour productivity growth on the share of labour in production, as initially discussed by [Shah and Desai \(1981\)](#), and further elaborated by [van der Ploeg \(1987\)](#), [Foley \(2003\)](#), [Julius \(2006\)](#) or [Tavani and Zamparelli \(2015; 2018\)](#), among others.

Recognising that the relationship between growth and income distribution has been a central issue for non-neoclassical theories of social conflict, in chapter 4 (hereafter DF&S), we have extended [Goodwin's \(1967\)](#) model to study the interaction between distributive cycles and international trade for economies in which growth is Balance-of-Payments Constrained (BoPC), i.e. follows [Thirlwall's \(1979\)](#) law. We have demonstrated that under very general conditions and without relying in price-adjustment mechanisms, output's growth rate fluctuates around the external constraint while preserving the persistent endogenous oscillations that characterise

the original growth cycle model.

However, our results strongly relied on a learning-by-doing mechanism where changes in labour productivity are a function of the level of effective capacity utilisation. In DF&S we made the case that technical progress is to a great extent capital embodied but machines must be operating in order to productivity gains to be effectively incorporated. Still, the implications of adopting different specifications of technical change have not been discussed. It is our purpose in this chapter to address some of those issues, especially in terms of the local stability properties of the system.

We proceed in three steps. First, and following the Kaldorian literature, we introduce labour productivity gains as a function of capital accumulation or output's growth rate. In a second step, we adopt a classical-Marxian technical change approach and make both labour and capital productivity growth rates to depend positively on factor cost shares. Finally, a combination of these two specifications is studied. The Kaldorian case basically leaves the system with no internal equilibrium solution while the Marxian one makes the system stable. Furthermore, a Hopf bifurcation analysis shows that the combination of both formulations might give rise to persistent and bounded cyclical paths.

When it comes to the empirics of technical change, there is robust literature on Kaldor-Verdoorn's law that gives support to its formulation (e.g. [McCombie and De Ridder, 1983; 1984; Angeriz et al, 2008; 2009; Romero and McCombie, 2016a; Magacho and McCombie, 2017; Romero and Britto, 2017](#)). The same cannot be said about the classical-Marxian construction. Therefore, it is also our purpose to address empirically the relation between functional income distribution and the evolution of technology.

We applied panel Vector Autoregression (pVAR) techniques to a sample of 16 OECD countries between 1980 and 2012. Orthogonalised Impulse Response Functions (OIRFs) indicate that one standard deviation impulse on the profit-share /wage-share ratio decreases labour productivity growth rates by 2% though it has a neglectable effect on capital productivity. Moreover, changes in income distribution are responsible for up to 40% of changes in labour productivity growth rates. To the best of our knowledge, we are the first to provide more consistent estimations that give some support to the classical-Marxian technical change argument.

Our estimates are used to calibrate the models developed in the first part of this essay. Numerical simulations show that the main dynamics of DF&S are robust to alternative specifications of technological change. Furthermore, the introduction of a forcing term motivated by Goodwin's discussion of "Schumpeter clock" gives rise to irregular fluctuations similar to those observed in real data.

This chapter is organised as follows. In the next section we revisit DF&S main dynamic equations discussing the implications of adopting different specifications for technical change. Section 3 brings our econometric exercise that provides some empirical support to the Marxian argument. Readers not interested in the theoretical discussion can go directly to this part. In section 4 we use those estimates to calibrate our theoretical model. Some final considerations follow.

5.2 Kaldorian and classical-Marxian technical change

Suppose an economy in which output is produced with capital and labour inputs. The production technology can be characterised by the pair (ρ, q) where ρ and q represent capital and labour productivities, respectively. For the purposes of this essay, technical progress is expressed as a combination of changes in both variables. In this section we briefly revisit the main structure of DF&S model and study the implications of adopting the Kaldorian and classical-Marxian formulations.¹

Goodwin's (1967) paper aimed at building a model capable of generating growth cycles rooted in the functioning of the labour market and the dynamics of distributive conflict. The model was originally conceived for a closed economy without government. DF&S extension introduced international trade to take into account the BoPC on growth. Define e as the rate of employment, Y as the level of output, N represents total labour force, ϖ is the wage share, w corresponds to real wages, u is the level of capacity utilisation, and K is the capital stock. The employment rate is defined as $e = L/N$ where L stands for labour employed in production. Capacity utilisation is given by $u = Y/Y^*$ with Y^* as production at full capacity. labour and capital productivity are defined as $q = Y/L$ and $\rho = Y^*/K$, respectively. The main structure of the dynamic system is given by:²

$$\frac{\dot{e}}{e} = \frac{\dot{Y}}{Y} - \frac{\dot{q}}{q} - \frac{\dot{N}}{N} \quad (5.1)$$

$$\frac{\dot{\varpi}}{\varpi} = \frac{\dot{w}}{w} - \frac{\dot{q}}{q} \quad (5.2)$$

$$\frac{\dot{u}}{u} = \frac{\dot{Y}}{Y} - \frac{\dot{K}}{K} - \frac{\dot{\rho}}{\rho} \quad (5.3)$$

Assumption 5.1 The balance-of-payments is always in equilibrium so that output's growth rate is demand-side determined and given by Thirlwall's law, i.e.

$$\frac{\dot{Y}}{Y} = y_{bp}$$

Though it is true that there are short-run deviations from such lon-run trend, this assumption allows us to isolate and focus on the implications of adopting different specifications of technical change.³ Another way of thinking of it is to implicitly assume there is a government that applies a fixed tax rate on wage and capital income, and adjusts its expenditures in order to guarantee that output follows the external constraint. In fact, from the expenditures

¹See Tavani and Zamparelli (2017) for a comprehensive and recent survey on endogenous technical change in alternative theories of growth and distribution.

²For any variable x , \dot{x} indicates its time derivative (dx/dt) .

³Although the BoPC growth model is addressed to the investigation of the long-run, it also has profound implications for short-run dynamics. For a formal analysis of how deviations from long-run paths are generated and corrected, see Soukiazis et al (2012; 2014), Garcimartin et al (2016), and DF&S. The last one shows that as long as savings and investment growth at the same rate, output's growth rate follows Thirlwall's law.

identity, we have that the difference between savings and investment is always equal to the difference between exports and imports. Hence, a balance-of-payments that is always in equilibrium requires that domestic savings must be equal to firm's investment plans. Since in what follows we are going to introduce an independent investment function, we need savings to be the adjustment variable.

Equations (5.1)-(5.3) are direct manipulations of accounting identities.⁴ In steady state, $\dot{e}/e = \dot{\varpi}/\varpi = \dot{u}/u = 0$. For positive values of employment, wage share and utilisation, we obtain the following equilibrium conditions:

$$y_{bp} = \frac{\dot{q}}{q} + \frac{\dot{N}}{N} \quad (5.4)$$

$$\frac{\dot{w}}{w} = \frac{\dot{q}}{q} \quad (5.5)$$

$$y_{bp} = \frac{\dot{K}}{K} + \frac{\dot{\rho}}{\rho} \quad (5.6)$$

From (5.4) we have that output's growth rate must equal the natural growth rate in order to deliver a constant employment rate. It establishes a correspondence between the capacity of the economy to expand production and how this interacts with changes in the supply of labour. Equation (5.5) consists of the equilibrium condition to distributive conflict. A stable income distribution requires real wages to grow at the same pace as labour productivity. Finally, and analogously to the first expression, a constant level of capacity utilisation is the result of output growing at the same rate of the sum between capital accumulation and productivity. It shows how the capacity of the economy to expand production interacts with changes capital accumulation. We are now ready to study how this structure responds to different behavioral assumptions.

5.2.1 Labour productivity and Kaldor-Verdoorn's law

It has been observed that changes in factor productivity do not occur symmetrically through time. For a large group of capitalist countries and over long periods of time, capital productivity has in fact remained constant or even declined while labour productivity shows a clear positive trend.

The Kaldorian tradition has indeed paid little attention to changes in capital productivity. In a well-known paper, Kaldor (1961, p. 178) himself stated as one of his "stylised facts" a constant capital-output ratio, i.e. constant capital productivity. In what concerns labour, Kaldor-Verdoorn's law states that labour productivity growth rates are directly related either to capital accumulation or to output growth. The basic idea goes back to Adam Smith's pin

⁴Suppose a Leontief production function such that $Y = \min\{\rho Ku; qNe\}$. The efficiency condition states that $Y = \rho Ku = qNe$. Notice that, in a sense, this is an accounting identity because $Y = (Y^*/K) K (Y/Y^*) = (Y/L) N (L/N)$. Taking logarithms and time derivatives of $Y = \rho Ku$ and $Y = qNe$, we obtain equations (5.1) and (5.3). Finally, the wage share is defined as the share of wages in output, $\varpi = wL/Y = w/q$. Taking logarithms and time derivatives we arrive at equation (5.2).

factory and highlights the importance of dynamic returns to scale or macroeconomic increasing returns that are involved in learning-by-doing processes.⁵ Two alternative specifications are:

$$\frac{\dot{q}}{q} = G\left(\frac{\dot{K}}{K}\right), \quad G_{\dot{K}/K} > 0 \quad (5.7)$$

or

$$\frac{\dot{q}}{q} = G\left(\frac{\dot{Y}}{Y}\right), \quad G_{\dot{Y}/Y} > 0 \quad (5.8)$$

where both functions are monotonically increasing in their main arguments.

Five behavioral relations are needed in order to close the model. Set $\dot{q}/q = G\left(\dot{K}/K\right)$ as in equation (5.7) and $\dot{\rho}/\rho = 0$. Furthermore, make the labour force grow at an exogenous rate n . Assuming a real wages Phillips curve $\dot{w}/w = F(e)$, with $F'(\cdot) > 0$, and a conventional capital accumulation function $\dot{K}/K = H(\varpi, u)$, with $H_{\varpi} < 0$ and $H_u > 0$, the dynamical system (5.1)-(5.3) becomes:

$$\dot{e} = e \{y_{bp} - G[H(\varpi, u)] - n\} \quad (5.9)$$

$$\dot{\varpi} = \varpi \{F(e) - G[H(\varpi, u)]\} \quad (5.10)$$

$$\dot{u} = u [y_{bp} - H(\varpi, u)] \quad (5.11)$$

For a given rate of growth of output, an increase in capital accumulation increases labour productivity reducing employment rates and the wage share. Further reductions in ϖ increase profitability of investment. This leads to an increase in the growth rate of the capital stock which in turn implies higher labour productivity. Even though the last equation indicates that u stabilises itself, increases in capacity utilisation seem to trigger instability through an increase in capital accumulation.

In steady state, $\dot{e}/e = \dot{\varpi}/\varpi = \dot{u}/u = 0$. Equilibrium conditions for this first set of behavioral equations are:

$$y_{bp} = G[H(\varpi, u)] + n \quad (5.12)$$

$$F(e) = G[H(\varpi, u)] \quad (5.13)$$

$$y_{bp} = H(\varpi, u) \quad (5.14)$$

Therefore, we can state and prove the following Proposition regarding the existence of a non-trivial equilibrium solution.

Proposition 5.1 *The probability that the dynamic system (5.9)-(5.11) has an internal (non-trivial) equilibrium solution is zero.*

Proof. *Substituting equation (5.14) in (5.12) we obtain $y_{bp} = G(y_{bp}) + n$. Since y_{bp} and n are parameters in the model, only by chance this expression is actually true. In a continuous sample space, the probability of any elementary event, consisting of a single outcome, is zero. ■*

⁵For a comprehensive review of Kaldor-Verdoorn's law see McCombie et al (2002).

At this point, it is quite intuitive to realise that a similar problem arises when adopting the second specification of Kaldor-Verdoorn's law. In fact, substituting (5.8) in the first dynamic equation, and keeping all other behavioral relations, we obtain:

$$\dot{e} = e [y_{bp} - G(y_{bp}) - n] \quad (5.15)$$

In steady-state $\dot{e}/e = 0$ and a non-trivial solution exists only if $y_{bp} = G(y_{bp}) + n$. Given that y_{bp} and n are exogenous parameters, it is easy to understand that the equality is unlikely to be satisfied.

Such result comes from the fact that we are fixing $\dot{Y}/Y = y_{bp}$, i.e. the growth rate of output required to maintain the equilibrium in the balance of payments. However, a simple relaxation of this assumption does not come without problems. Keeping $\dot{\rho}/\rho = 0$, from equations (5.4) and (5.5) it is clear that in order to obtain a constant rate of employment and capacity utilisation we need $\dot{Y}/Y = \dot{q}/q + n$ and $\dot{Y}/Y = \dot{K}/K$. Define $\Phi = \dot{Y}/Y - G(\cdot)$. This means that as long as Φ has an inverse, $\dot{Y}/Y = G(\dot{Y}/Y) + n = \Phi^{-1}(n)$ and growth becomes supply-side determined. Such result goes against recent empirical evidence indicating that the natural rate of growth is not only endogenous but also determined by the external constraint (see, for example, Lanzafame, 2014).

Setterfield (2006) and Gabriel et al (2016) among others have tried to overcome the problem using linear specifications of $G(\cdot)$. Suppose $G(\dot{Y}/Y) = \alpha_0 + \alpha_1 \dot{Y}/Y$ where α_1 is the so called Verdoorn coefficient and is assumed to capture the presence of dynamic economies of scale. Hence, they endogenised α_1 allowing an adjustment towards the external constraint. Nonetheless, this is still quite unsatisfactory. As showed by McCombie and Spreafico (2016) such interpretation of the linear coefficients is wrong because it implies $G(\cdot)$ to be a subproduct of a neoclassical production function instead of a behavioral relation.⁶ They demonstrated that if a linear form is adopted “the intercept *cannot* and *should not* be interpreted as the separate contribution to economic growth of the rate of exogenous technical change” while “the Verdoorn coefficient also *should not* be interpreted as a measure of increasing returns to scale per se” (p. 1131, emphasis added).

Another alternative would be to make the growth rate of the labour force, n , an endogenous variable. For OECD countries, for example, this could be justified by immigration. In developing countries one could make the case that n changes as the excess of labour supply is absorbed by the modern sector. However, we do not deal with such cases here since endogenising n goes beyond the scope of this essay.

5.2.2 Classical-Marxian technical change

Classical-Marxian technological change is based on the assumption that labour-saving or capital-saving innovation depends on the share of labour and capital costs in production. The inspiration for this idea is not purely classical and the first modern reference is Hicks (1932) – with the

⁶Needless to say that the problems of such production functions are well known. For a comprehensive discussion see Petri (2004) and Felipe and McCombie (2013).

induced (or biased) innovation hypothesis – while further contributions include neoclassical (e.g. Kennedy, 1964; Samuelson, 1965; and more recently Funk, 2002; Acemoglu, 2003) and non-neoclassical scholars (see Okishio, 1961; Duménil and Levy, 1995; Foley, 2003; Kemp-Benedict, 2017a).

We continue redefining the labour productivity growth rate, so that we can write:

$$\frac{\dot{q}}{q} = G(\varpi), \quad G_{\varpi} > 0 \quad (5.16)$$

$$\frac{\dot{\rho}}{\rho} = J(\varpi), \quad J_{\varpi} < 0 \quad (5.17)$$

Notice that there is a fundamental difference between this case and the first one discussed in the previous subsection. Back then, an increase in the wage share reduced capital accumulation and as consequence labour productivity growth. Now, changes in income distribution have the opposite effect, at least in what concerns labour. An increase in the wage share indicates that real wages are higher relatively to labour productivity. Hence, firms respond increasing the search for labour saving techniques.

In a similar scenario to the one adopted for the Kaldorian specifications, make the labour force grow at an exogenous rate n , assume a real wages Phillips curve $\dot{w}/w = F(e)$, with $F'(\cdot) > 0$, and a conventional capital accumulation function $\dot{K}/K = H(\varpi, u)$, with $H_{\varpi} < 0$ and $H_u > 0$. Finally, making use of equations (5.16) and (5.17), we can rewrite the dynamic system (5.1)-(5.3) as:

$$\dot{e} = e[y_{bp} - G(\varpi) - n] \quad (5.18)$$

$$\dot{\varpi} = \varpi[F(e) - G(\varpi)] \quad (5.19)$$

$$\dot{u} = u[y_{bp} - H(\varpi, u) - J(\varpi)] \quad (5.20)$$

An increase in the wage share reduces the rate of employment and capital productivity growth through technical change functions. It also brings down investment's profitability resulting in lower capital accumulation. Lower capital accumulation and productivity rates increase the level of capacity utilisation. Such increase may sound counterintuitive but comes from the fact that capacity of production is expanding slower relatively to aggregate demand. On the other hand, higher capacity utilisation increases capital accumulation through the accelerator effect, which reduces u stabilising the system. Furthermore, a reduction in employment rates has a negative impact on real wages because workers are not able to obtain same wage increases as in the past. This leads to a reduction in the wage share and also stabilises the system.

In steady state, $\dot{e}/e = \dot{\varpi}/\varpi = \dot{u}/u = 0$. This gives us the following equilibrium conditions:

$$y_{bp} = G(\varpi) + n \quad (5.21)$$

$$F(e) = G(\varpi) \quad (5.22)$$

$$y_{bp} = H(\varpi, u) + J(\varpi) \quad (5.23)$$

Therefore, we can state and prove the following Proposition regarding the existence and uniqueness of a non-trivial equilibrium solution.

Proposition 5.2 *The dynamic system (5.18)-(5.20) has a unique internal equilibrium point that satisfies*

$$\begin{aligned} e^* &= F^{-1}(y_{bp} - n) \\ \varpi^* &= G^{-1}(y_{bp} - n) \\ y_{bp} &= H[G^{-1}(y_{bp} - n), u^*] + J[G^{-1}(y_{bp} - n)] \end{aligned}$$

Proof. See *Mathematical Appendix B1*. ■

The equilibrium solution values are very similar to those of DF&S with one striking difference. While in the original model the wage share was responsible for adjusting capacity utilisation to the external constraint, now u adjusts itself once e and ϖ are previously determined by the Phillips curve and labour technical change functions. Moreover, notice that in equilibrium the share of wages on income only depends on the shape of $G(\cdot)$. An increase in output's growth rate leads to higher employment and wage share. This is because higher growth requires higher productivity growth in order to keep employment rates constant. The only way to increase \dot{q}/q is through an increase in the wage share. Moreover, in order to keep income distribution stable, wages must grow at the same pace resulting in higher employment.

Intuitively, if the economy is growing faster, firms will hire more workers increasing the employment rate. This strengthens the position of workers in the wage bargain process and ultimately increases the wage share. If the increase in output's growth rate is permanent so will be the changes in e and ϖ . Additionally, this also causes an increase in the level of capacity utilisation because machines are used more intensively.

It is also worth noting the effect of an increase in the sensitivity of labour productivity to income distribution. If small increases of the wage share lead to high jumps in labour productivity, the ϖ require in order to achieve $y_{bp} - n$ will be lower. Therefore, an increase in the slope of $G(\cdot)$ actually causes a reduction in the equilibrium wage share. If it is easier to firms to find new production techniques when facing increases in labour costs, the bargain power of workers is reduced and, therefore, they get a smaller piece of the cake, so to speak.

Such mechanism has some similarities with a concept put forward not long ago and in a different set up as "Power Biased Technical Change" (see [Skott and Guy, 2007](#)). New technologies, in particular the so called ICTs, have allowed firms to monitor workers more closely. Even though one could debate to which extent ICTs have increased labour productivity growth rates, a higher capacity of monitoring allows firms to respond quicker and faster to changes in labour costs and could be interpreted as an increase in the slope of $G(\cdot)$. The final outcome in both cases involves a reduction in the income share that goes to those affected by the increase in surveillance.

Moreover, a lower wage share increases capital profitability and, hence, capital accumulation. This means that, for a given y_{bp} , the level of capacity utilisation required to bring u to equilibrium will be lower. Higher profitability makes corporations to rely less on the accelerator effect which in turn is reflected in a reduction of utilisation levels. Figure 1 on the left shows

the response of income distribution and capacity utilisation to an increase in y_{bp} while on the right we depict their response to an increase in G_{ϖ} .

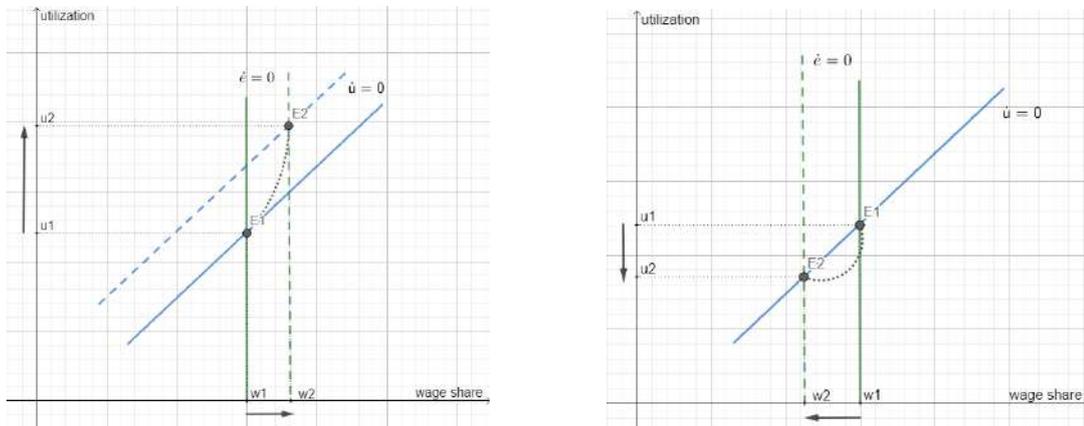


Figure 1: Response of equilibrium to changes in y_{bp} (left) and G_{ϖ} (right)

With regard to the unique internal equilibrium point, we can now state and prove the following Proposition concerning its local stability.

Proposition 5.3 *The unique internal equilibrium point of the dynamic system (5.18)-(5.20) is locally stable.*

Proof. See *Mathematical Appendix B2*. ■

Adopting a classical-Marxian specification for factor productivity growth changes dramatically the capacity of the model of generating cycles rooted in the functioning of the labour market and the dynamics of distributive conflict. That is, it breaks one of the main results of Goodwin (1967) and also of DF&S. It has been known for a while that incorporating the induced innovation hypothesis leads to the disappearance of the growth cycle (see [Tavani and Zamparelli, 2017](#)). The reason for this is that eventual increases in the employment rate are immediately corrected through the effect of income distribution on labour productivity. Still, several exercises have showed that under standard parameterisations, the direction of adjustment is not monotonic being characterise by persistent fluctuations of decreasing amplitude.

5.2.3 Combining both approaches

So far we have showed that incorporating Kaldor-Verdoorn's law to our framework basically leaves the system with no internal equilibrium solution while the Marxian specification makes the system locally stable. However, one may wonder what happens if both approaches were

combined. Since we used in this chapter two different specifications for the Kaldorian argument, the simplest way to combine these approaches is modelling changes in labour productivity as:

$$\frac{\dot{q}}{q} = G\left(\frac{\dot{K}}{K}, \varpi\right), \quad G_{\dot{K}/K} > 0 \text{ and } G_{\varpi} > 0 \quad (5.24)$$

or

$$\frac{\dot{q}}{q} = G\left(\frac{\dot{Y}}{Y}, \varpi\right), \quad G_{\dot{Y}/Y} > 0 \text{ and } G_{\varpi} > 0 \quad (5.25)$$

Given that $\dot{K}/K = H(\varpi, u)$ we have that $G_{\dot{K}/K} = G_H$ from which it follows $G_H H_{\varpi} < 0$ and $G_H H_u > 0$.

Assumption 5.2 The sensitivity of labour productivity growth rates to changes in the wage share is such that:

$$G_{\varpi} > |G_H H_{\varpi}|$$

Increases in the wage share reduce investment profitability and therefore capital accumulation. This would lead to a reduction in the growth rate of labour productivity through the Kaldor-Verdoorn's effect. On the other hand, the Marxian component implies that an increase in real wages relatively to productivity forces capitalists to search for labour saving techniques, increasing the growth rate of labour productivity. Since our econometric exercise reports a positive net impact of cost shares on factor productivity shares, as we will show in the next section, this assumption sounds quite plausible.

Maintaining the previous behavioral relations and making use of (5.24), the dynamic system (5.1)-(5.3) becomes:

$$\dot{e} = e \{y_{bp} - G[H(\varpi, u), \varpi] - n\} \quad (5.26)$$

$$\dot{\varpi} = \varpi \{F(e) - G[H(\varpi, u), \varpi]\} \quad (5.27)$$

$$\dot{u} = u [y_{bp} - H(\varpi, u) - J(\varpi)] \quad (5.28)$$

An increase in the level of capacity utilisation has a positive effect on capital accumulation through the accelerator. This in turns leads to a reduction in employment rates, in the share of wages, and in u itself. The first two effects are the result of an increase in labour productivity due to the Kaldorian part of the $G(\cdot)$ function. The latter comes from the fact that the capital stock is growing faster relatively to aggregate demand. A reduction in the wage share results in a reduction of labour productivity growth rates as well as an increase in the rate of growth of capital stock and productivity. This, in turn, pushes employment, wage share and utilisation up. At this point what seems to be a cycle restarts.

In steady state, $\dot{e}/e = \dot{\varpi}/\varpi = \dot{u}/u = 0$. This gives us the following equilibrium conditions:

$$y_{bp} = G[H(\varpi, u), \varpi] + n \quad (5.29)$$

$$F(e) = G[H(\varpi, u), \varpi] \quad (5.30)$$

$$y_{bp} = H(\varpi, u) + J(\varpi) \quad (5.31)$$

Contrary to the pure Kaldorian case, we can now state and prove the following Proposition regarding the existence and uniqueness of a non-trivial equilibrium solution.

Proposition 5.4 *The dynamic system (5.26)-(5.28) has a unique internal equilibrium point that satisfies*

$$\begin{aligned} e^* &= F^{-1}(y_{bp} - n) \\ G[H(\varpi^*, u^*), \varpi^*] &= y_{bp} - n \\ H(\varpi^*, u^*) + J(\varpi^*) &= y_{bp} \end{aligned}$$

Proof. See Mathematical Appendix B3. ■

The equilibrium value of the employment rate is the same as in the pure Marxian-biased case. This comes from the fact that in both models employment is solely determined in the labour market. Higher output growth rates or less combative workers are capable of increasing steady-state employment. The last two equations simultaneously determine the wage share and capacity utilisation. Still, some interesting implications follow in terms of comparative statics. When proving proposition 4, we showed that equations (5.29) and (5.31) can be rewritten as $u = \Psi(\varpi)$ and $u = \Theta(\varpi)$, respectively, with $\Psi'(\cdot) < 0$ and $\Theta'(\cdot) > 0$. We can now briefly discuss the effects of changes in the BoPC growth rate and in the shape of $G(\cdot)$.

A relaxation of the external constraint, meaning an increase in y_{bp} , moves $\Psi(\cdot)$ to the right and $\Theta(\cdot)$ to the left. This implies in an increase of equilibrium capacity utilisation. The net effect on income distribution, however, is indetermined, contrasting with the classical-Marxian case where the net effect was positive. Figure 2 represents this case.

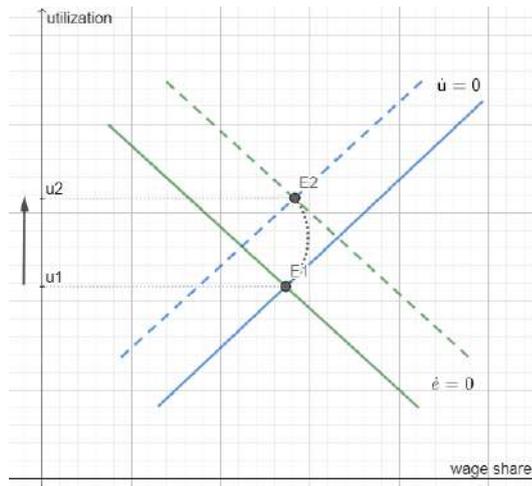


Figure 2: Response of equilibrium to changes in y_{bp}

An extensive literature on complexity has shown that there is a positive relation between economic complexity, productive diversification and growth (e.g. [Hidalgo et al, 2007](#); [Hausmann](#)

et al, 2014). In fact, one of the main findings in this literature is that more-sophisticated products are located in a densely connected core whereas less-sophisticated products occupy a less-connected periphery. Furthermore, recent contributions have also pointed out to a robust negative correspondence between income inequality and economic complexity (Hartmann et al, 2017; Gala et al, 2017). Our model provides an explanatory mechanism for those findings.

On the one hand, we have that the BoPC growth rate reflects non-price competitiveness of an economy (or region) which in turn is determined by the complexity and diversification of its productive structure (see Gouvea and Lima, 2010; 2013; Romero and McCombie, 2016b; Dávila-Fernández et al, 2018). On the other hand, observed trends show that the labour income share has typically fallen alongside an increase in income inequality, while countries that have managed to reduce inequality also show increases in the labour share (ILO, IMF, OECD and World Bank, 2015; ILO and KIEP, 2015).⁷ In the light of the results presented so far, as long as the sensitivity of capital accumulation to profitability is relatively weak, there is a positive relationship between y_{bp} and ϖ that explains the aforementioned relations. It is important to notice that in the pure classical-Marxian case such correspondence exists without any requirements for H_{ϖ} .

Assuming that investment is not very sensible to changes in income distribution, an increase (reduction) in economic complexity increases (reduces) y_{bp} and, therefore, employment rates. Higher (lower) employment leads to an increase (decrease) in the bargain power of workers. In this way they are able to get a bigger (smaller) piece of the pie increasing (decreasing) the wage share. This leads to an increase (decrease) in labour productivity growth rates which in turn guarantees a stable employment rate at equilibrium. In other words, a reduction in economic complexity could explain the reduction in wage shares and the slowdown of labour productivity growth observed in several OECD countries.

In what concerns the Kaldorian component of $G(\cdot)$, an increase in the sensitiveness of \dot{q}/q to capital accumulation might produce a simultaneous increase or decrease in the level of capacity utilisation and wage share. Net effects depend on structural parameters of the economy. That is because a higher Kaldor-Verdoorn effect implies a reduction of the slope and intercept of $\Psi(\cdot)$ while $\Theta(\cdot)$ remains unchanged. If the reduction of the intercept is smaller relative to the change in the slope both variables move upwards as in figure 3 on the left. Otherwise, we fall in the second situation, as in figure 3 on the right.

On the contrary, a higher classical-Marxian effect increases the slope of $\Psi(\cdot)$ with respect to income distribution without changing the intercept. The natural growth rate becomes very sensible to changes in income distribution and because wage share and labour productivity are positively related, a smaller ϖ is required to keep steady state employment. This result follows the intuition described for the pure Marxian case. If firms are able to easily translate increases

⁷In theory, the relationship between the share of wages on income and inequality is not clear-cut, depending largely on how labour and capital incomes are distributed as well as the magnitude of other sources of household incomes and the impact of taxes and social transfers. Yet, recent evidence confirms that declines in the labour income share have a significant relationship with income inequality, especially when the decline in labour shares was concentrated at the lower end of the labour income distribution.

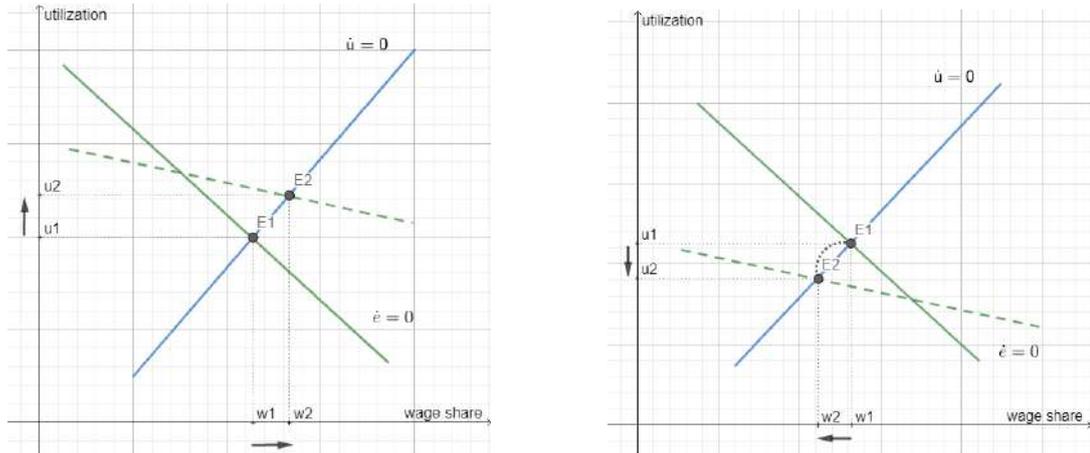


Figure 3: Different responses of equilibrium to changes in Kaldor-Verdoorn effect

in labour costs to a change in production techniques, the bargain power of workers is reduced and consequently the equilibrium wage share. Furthermore, a lower wage share means higher capital accumulation. For a given y_{bp} this implies that a lower u is required to bring utilisation levels to equilibrium. This is because firms now rely less in the accelerator for making their investment plans which allow for a reduction in u . We depict this case in figure 4.

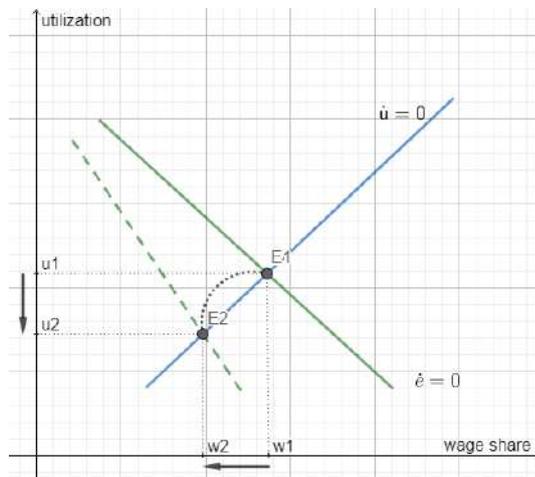


Figure 4: Response of equilibrium to changes in the Marx-biased effect

With respect to the unique internal equilibrium point, we can now state and prove the following Proposition regarding its local stability.

Proposition 5.5 *If the Kaldorian and classical-Marxian effects on factor productivity growth rates are such that*

$$\varpi^* (G_H H_\varpi + G_\varpi)^2 > |u^* G_H H_u [H_\varpi + J'(\varpi^*)]|$$

the internal equilibrium (e^*, ϖ^*, u^*) of the dynamic system (5.29)(5.31) is locally asymptotically stable.

Proof. See Mathematical Appendix B4. ■

This condition basically concerns the response of factor productivity to changes in income distribution. By assumption, an increase in the wage share is always followed by an increase in the growth rate of labour productivity, i.e. $G_H H_\varpi + G_\varpi > 0$. But a higher ϖ also triggers a reduction in capital accumulation and productivity growth rates which in turn causes an increase in capacity utilisation. Through Kaldor-Verdoorn's law, higher utilisation rates will further increase labour productivity leading to a reduction in the wage share. The proposition above guarantees that this second effect is not so strong so that we have a smooth convergence to equilibrium. Such relation, of course, might not necessarily be satisfied in which case two propositions follow.

Proposition 5.6 *If the Kaldorian and classical-Marxian effects on factor productivity growth rates are such that*

$$\varpi^* (G_H H_\varpi + G_\varpi)^2 < |u^* G_H H_u [H_\varpi + J'(\varpi^*)]|$$

and the sensitivity of real wages to changes in the employment rate satisfies

$$F'(e^*) < -\frac{u^* [\varpi^* (G_H H_\varpi + G_\varpi) + u^* H_u] \{(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]\}}{e^* \varpi^* \{\varpi^* (G_H H_\varpi + G_\varpi)^2 + u^* G_H H_u [H_\varpi + J'(\varpi^*)]\}},$$

then, the internal equilibrium (e^*, ϖ^*, u^*) of the dynamic system (5.29)(5.31) is locally asymptotically stable.

Proof. See Mathematical Appendix B5. ■

Even when the inequality in proposition 5 is violated, convergence to equilibrium is ensured if worker's real wages do not strongly increase with small changes on employment rates. However, for higher values of $F'(e^*)$, it may happen that the last part of Proposition 6 also does not hold. Thus, the dynamic behaviour of the model may drastically change from the qualitative point of view, as the sensitivity of real wages to changes in e increases, with all the other parameters remaining constant. Using $F'(e^*)$ as a bifurcation parameter, our purpose is now to apply the Hopf Bifurcation Theorem (HBT) for 3D systems to show that persistent cyclical behaviour of the variables can emerge as $F'(e^*)$ is increased (Gandolfo, 2009).

Proposition 5.7 *If the Kaldorian and classical-Marxian effects on factor productivity growth rates are such that*

$$\varpi^* (G_H H_\varpi + G_\varpi)^2 < |u^* G_H H_u [H_\varpi + J'(\varpi^*)]|,$$

then, for values of $F'(e^*)$ in the neighbourhood of the critical value

$$F'(e^*)|_{HB} = -\frac{u^* [\varpi^* (G_H H_\varpi + G_\varpi) + u^* H_u] \{(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]\}}{e^* \varpi^* \{\varpi^* (G_H H_\varpi + G_\varpi)^2 + u^* G_H H_u [H_\varpi + J'(\varpi^*)]\}} \quad (5.32)$$

and for which the real negative root of the characteristic equation satisfies

$$\lambda_1 \neq u^* \left\{ \frac{G_H H_u [H_\varpi + J'(\varpi^*)]}{G_H H_\varpi + G_\varpi} - H_u \right\}$$

the dynamic system (5.29)(5.31) has a family of periodic solutions.

Proof. See Mathematical Appendix B6. ■

These results seem to be in line with Goodwin's (1967) aim of generating cycles rooted in the functioning of the labour market and the dynamics of distributive conflict. They basically correspond to an adaptation of DF&S four-dimensional model to a three-dimensional set up in which the behavioral equation for labour productivity was adjusted to the Kaldor/Marx story. Permanent periodic solutions might emerge as a result of an increase in the sensitivity of workers' wage demands with respect to the employment rate.

If instead we make labour productivity growth rate to follow equation (5.25), we basically go back to the pure Marxian case. This is because aggregate demand does not deviate from the external constraint, i.e. $\frac{\dot{Y}}{Y} = y_{bp}$. Therefore, the Kaldorian part of $G(\cdot)$ becomes a constant and the wage share turns out to depend only on the shape of the Marxian component and on $y_{bp} - n$.

It is important to notice that in this last case we also recover the negative relationship between economic complexity and income inequality previously discussed. However, as in the pure classical-Marxian set up, the existence of such correspondence and the mechanism behind it do not required a sufficiently low response of capital accumulation to changes in income distribution. Furthermore, the system becomes once again locally stable presenting asymptotically convergence to the internal equilibrium solution.

A natural next step would be to perform numerical simulations in order to investigate the responsiveness of the model to different scenarios. However, at this point of the analysis, any attempt of calibrating the system will be unsatisfactory. The reason for this is that there are not reliable estimates in the literature for the classical-Marxian effect of ϖ on \dot{q}/q and $\dot{\rho}/\rho$. Therefore, we proceed to present some estimates of our own for functions $G(\cdot)$ and $J(\cdot)$.

5.3 Estimating classical-Marxian technical change

There is a robust literature on Kaldor-Verdoorn's law giving support to its formulation (e.g. McCombie and De Ridder, 1983; 1984; Angeriz et al, 2008; 2009; Romero and McCombie, 2016a; Magacho and McCombie, 2017; Romero and Britto, 2017). The same cannot be said about the classical-Marxian specification. It is our purpose in this section to properly estimate the relation between functional income distribution and changes in factor productivities.

Several neoclassical contributions have investigated both theoretically and empirically the existence of induced (or biased) technical change using a CES production function in which each factor is paid accordingly to its marginal productivity. As usually is the case in that literature,

the crucial estimated parameter is the elasticity of substitution between capital and labour, though there seems to be little empirical consensus on its value and nature (see León-Ledesma et al, 2010, for a comprehensive review).

Among non-neoclassical economists, there have been some attempts to address the empirics behind factor productivity dynamics. Before continuing, however, an important clarification is necessary. In this chapter we are interested in study the relationship between factor productivity and factor cost shares also referred to as classical-Marxian technical change. Though somehow related, this concept is different from the also well known Marx-biased technical change (MBTC).

MBTC corresponds to the hypothesis that for a constant wage share, labour productivity historically increases while capital productivity decreases, i.e. technical change is labour-saving and capital-using. It was first proposed by Foley and Michl (1999) and has been observed in specific periods of time for different countries and regions (e.g. Marquetti, 2003; Pichardo, 2007; Marquetti and Porsse, 2017). Moreover, authors such as Michl (2002), Sasaki (2008), and Basu (2010) have assessed empirically the predictions of a standar MBTC and neoclassical models making use of the so called “viability condition”.⁸ Nonetheless, those contributions do not really test the assumption that labour or capital saving technical change increase under higher factor costs.

In this respect, Hein and Tarassow (2010) and Tridico and Pariboni (2017) are maybe the closest references to our exercise. The former applies single equation techniques to a sample of 6 OECD countries between 1960 and 2007 while the latter uses panel data for 26 OECD countries from 1990 to 2013. Still, the evidence provided is limited for at least three reasons. First, their tests are only concerned with labour saving technical change. Secondly, the treatment used to remove cyclical effects is not convincing. Hein and Tarassow (2010), for instance, introduce up to three lags to control for cyclical variations. However, in their procedure, “insignificant variables were excluded and the equations re-estimated” (p. 742). This is quite strange because then, for some countries, no lags at all were included in their regressions (see, for example, the Netherlands or Austria, p. 748). In other cases only lag $t - 2$ or $t - 3$ are estimated. It is difficult to understand the meaning of such results. Tridico and Pariboni (2017), on the other hand, do not provide any treatment for cyclicality. Finally, their regressions are likely to suffer with endogeneity by omitted variable and simultaneity.⁹

5.3.1 Empirical methodology

Our empirical strategy consists in estimating functions $G(\cdot)$ and $J(\cdot)$ as in equations (5.16) and (5.17). Under the hypothesis that firms make a local search relative to their current

⁸Foley and Michl (1999) derived the viability condition from a profit-maximising entrepreneur that choses a new technique only if it can generate a higher expected rate of profit at the ongoing wage rate, compared with the old technique. See Basu (2018) for selective review on quantitative empirical research in marxist political economy.

⁹Still, one should mention that in a related literature, some scholars have found that increases in real wages are positive related to labour productivity growth (see, for example, Hartwig, 2014).

technology and implement discoveries following a profitability criteria, [Kemp-Benedict \(2017a\)](#) demonstrates that changes in labour and capital productivities must satisfy:

$$\frac{\partial (\dot{q}/q)}{\partial \pi} = \frac{\partial (\dot{\rho}/\rho)}{\partial \varpi} = - \left(\frac{\pi}{\varpi} \right) \frac{\partial (\dot{\rho}/\rho)}{\partial \pi} = - \left(\frac{\varpi}{\pi} \right) \frac{\partial (\dot{q}/q)}{\partial \varpi} \quad (5.33)$$

where π is the share of profits on income. [Kemp-Benedict \(2017b\)](#) adopts the functional forms:

$$\frac{\dot{q}}{q} = a - b \left(\frac{\pi}{\varpi} \right) \quad (5.34)$$

$$\frac{\dot{\rho}}{\rho} = c + d \ln \left(\frac{\pi}{\varpi} \right) \quad (5.35)$$

where a , b , c , and d are parameters. Factor productivity respond positively to changes in factor costs, and theory requires $b = d$. Hence, equations (5.34) and (5.35) provide the functional forms we estimate.

We make use of a panel-data Vector Autoregression methodology (pVAR). This technique combines the traditional VAR approach, which treats all variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity. Time-series VAR models originated in the macroeconometrics literature as an alternative to multivariate simultaneous equation models. With the introduction of VAR in panel data settings, pVAR models have been used in multiple applications across fields. In this essay, we follow the procedure put forward by [Love and Zicchino \(2006\)](#) and [Abrigo and Love \(2016\)](#).

Consider the following structure for our bi-variate pVAR with panel-specific fixed effects:

$$X_{i,t} = \sum_{j=1}^p X_{i,t-j} A_j + z_i + \varepsilon_{i,t}$$

where X_t is a two variable vector $\{\dot{q}/q, \pi/\varpi\}$ or $\{\dot{\rho}/\rho, \ln(\pi/\varpi)\}$ of dependent variables, A_j are 2×2 matrices of parameters to be estimated, p is the number of lags, while z and ε are 1×2 vectors of dependent variable-specific panel fixed-effects and indiosyncratic errors, respectively.

In applying the VAR procedure to panel data, we need to impose that the underlying structure is the same for each cross-sectional unit. Such constraint in general does not hold in practice. One way to overcome this problem is introducing fixed effects, which allows for individual heterogeneity in the model. However, since the fixed effects are correlated with the regressors, the mean-differencing procedure commonly used to eliminate fixed effects would create biased coefficients. To avoid this problem [Love and Zicchino \(2006\)](#) use Helmert procedure of forward mean-differencing. Such transformation preserves the orthogonality between transformed variables and lagged regressors, so that lagged regressors are used as instruments and coefficients are estimated by system GMM.

5.3.2 Dataset and general overview

Our dataset fundamentally comes from the Penn World Table 9.0 (PWT), which contains standardised macro series for a large number of economies from the 1950s onwards. Output is

measured both as real GDP at current PPPs and as constant 2011 national prices (in millions of 2011 US\$). Total employment is given by the number of persons engaged in production (in millions). Hence, we obtain two indicators for labour productivity, computed as the ratio of those two measures and employment.

On the other hand, recall that capital productivity is defined as the ratio between potential output and the capital stock. The PWT lacks of estimates for Y^* and, therefore, we adjust Y making use of output gap series available from the World Economic Outlook Database (WEO). However, one should keep in mind that estimates of output gaps are subject to a significant margin of uncertainty. The WEO calculates the output gap as actual GDP less potential GDP as a percentage of potential GDP, i.e. $gap = (Y - Y^*)/Y^*$. This is equivalent to say that $Y^*/Y = 1/(1 + gap)$. Therefore, capital productivity is obtained as $Y^*/K = (Y/K)(Y^*/Y)$, where data for the capital stock comes from the PWT at both current PPPs and constant 2011 national prices (in millions of 2011 US\$).

The reader may ask why not just approximate ρ as simple as Y/K . The reason is the following. Doing that, $\dot{\rho}/\rho$ becomes the difference between output and capital growth rates. The first one follows in the long-run Thirlwall's law. The second depends on investment behavior. But we know that the wage share and investment are negative related through profitability. This means that an increase in the wage share reduces capital accumulation resulting in an apparent increase in the growth rate of ρ , against the Marxian proposal. That is, making $\rho = Y/K$ is very likely to wrongly reject the classical-Marxian specification.

When addressing functional income distribution, aggregate labour share measures are influenced by the methods used to separate labour and capital income earned by entrepreneurs, sole proprietors, and unincorporated business. Thus, we use the novel database put forward by [Karabarbounis and Neiman \(2014\)](#) that focus on the labour share within the corporate sector and, thus, circumvent many of those measurement difficulties. By default, the profit share is equal to $1 - \varpi$. Data for most OECD countries is available after the 1980s.

In order to keep our exercise as close as possible to DF&S, we use the same sample of 16 OECD countries (Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, South Korea, Sweden, United Kingdom, and United States). Our final dataset comprehends the period 1980 to 2012. Time span was determined due to data availability.

Over the past twenty years the Hodrick-Prescott (HP) filter has been used in macroeconomic analysis to separate trend from cycle when using macrodata. Although some of its drawbacks have been known for some time, the method continues to be widely adopted. Recently, [Hamilton \(2018\)](#) has strongly argued against its use showing this to be a serious mistake. He not only demonstrates that the HP filter introduces spurious dynamic relations that have no basis in the underlying data but provides an alternative that does the job without those distortions.

Hamilton's method consists in estimating an OLS regression of the type:

$$x_{t+h} = \beta_0 + \beta_1 x_t + \beta_2 x_{t-1} + \beta_3 x_{t-2} + \beta_4 x_{t-3} + v_{t+h}$$

where x is a generic variable, β 's are the estimated coefficients, and v is the error component.

He proposes a 2-year horizon as a standard benchmark, in which case $h = 2$. Hence, residuals are:

$$\hat{v}_{t+2} = x_{t+2} - \hat{\beta}_0 - \hat{\beta}_1 x_t - \hat{\beta}_2 x_{t-1} - \hat{\beta}_3 x_{t-2} - \hat{\beta}_4 x_{t-3}$$

and correspond to time series cyclical component. Making $x - \hat{v}$ we obtain the trend.

We apply this procedure to detrend our data for q , ρ , and ϖ . Once we got rid of the cyclical component, we compute labour and capital productivity growth rates. In Figure 5 we scatter plot the relation between factor productivity in levels and income distribution. Following equation (5.34), income distribution is measured as the ratio between the share of profits and wages on income. As we can see, it is not possible to distinguish any clear pattern linking the two variables. There does not seem to be a clear association between productivity and factor cost shares in levels.

Outcomes are slightly different in what concerns factor productivity growth rates. We make use of local regression analysis to have a first idea of what does it look like the relationship of the variables under analysis. The lowess nonparametric procedure with bandwidth of 0.8 allows us to obtain a flexible form for $G(\cdot)$ and $J(\cdot)$. The estimated curves are also reported in figure 5 and indicate that an increase in the wage share is associated with a reduction in productivity growth rates. This, of course, goes against the classical-Marxian hypothesis we want to test.¹⁰

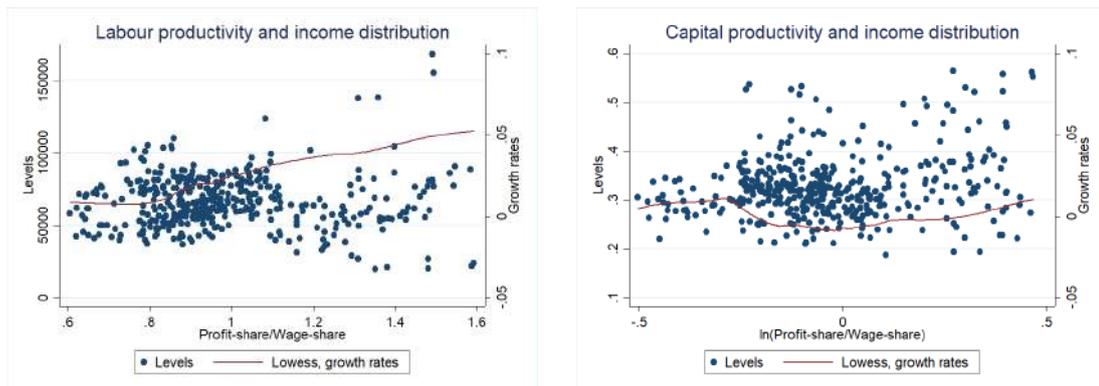


Figure 5: Factor productivities and cost shares

All of this is to say that a superficial look to data might suggest that there is no correspondence between functional income distribution and factor productivity neither in levels nor growth rates. Particularly in what concerns labour productivity growth, descriptive analysis might even find a negative correlation with labour cost. We proceed to estimate a series of pVAR models which control for endogeneity and individual heterogeneity.

¹⁰The picture does not change significantly if we use data at constant national prices, and similar figures are available under request.

5.3.3 Panel-VAR estimates

Ascertaining the order of integration of the variables under analysis is an essential precondition to establish whether the use of panel-VAR tests is warranted. In this respect we performed the Levin, Lin and Chu test that assumes a common unit root process, and the Im, Pesaran and Shin test, the ADF and PP tests that assume individual unit root processes. Results are reported in the Empirical Appendix and indicate that series are stationary. Therefore, we can proceed and investigate the correspondence between factor productivities and cost shares using our pVAR methodology.

Labour productivity

Two pVAR models for labour productivity, \dot{q}/q , and income distribution, π/ϖ , were estimated following Schwarz lag order selection criteria. Schwarz lag selection criteria was preferred over the popular Akaike insofar as usually it assigns a lower number of lags which in this case is desirable given the limited size of our sample.¹¹ Model I uses labour productivity in PPPs while in model II we have constant national prices converted to 2011 US\$ dollars. Table 1 reports our estimates.

Table 1: Income distribution vs Labour productivity growth, pVAR estimates

Model	I		II	
Explanatory	\dot{q}/q	π/ϖ	\dot{q}/q	π/ϖ
$(\dot{q}/q)_{t-1}$	0.107678	0.0683345	0.3916637***	0.3716756***
$(\pi/\varpi)_{t-1}$	-0.3507041***	0.7405059***	-0.2891601***	0.6392449***
No. Lags instruments	5		4	
No. Obs.	378		378	
No. Panels	16		16	
Average t	23.625		23.625	

*, **, and *** stand by 10%, 5% and 1% of significance

Results indicate that the growth rate of labour productivity responds negatively to an increase in the profit/wage share ratio. That is, an increase in the wage share increases \dot{q}/q as expected from theory. Stability conditions of the estimated panels are checked in the Empirical Appendix.

Granger (1969) argued that causality in economics could be tested for by measuring the ability to predict the future values of a time series using prior values of another time series. Though the question of “true causality” is deeply philosophical, Granger causality testes are

¹¹Schwarz criterion is strongly consistent while Akaike is generally more efficient though not consistent. In other words, while the former will asymptotically deliver the correct model order the latter will deliver on average a too large a model (Brooks, 2014). In our case Akaike criteria recommended 2 lags for model I and 3 lags for model II. Still, estimates using 2 or 3 lags do not change significantly and are available under request.

useful because they allow us to investigate if values of income distribution provide statistically significant information about future values of labour productivity growth rates. Table 2 reports our results for the two models estimated. In both cases we have that π/ϖ Granger causes \dot{q}/q . Still, in the first model there is unilateral causality and in the second both variables have equally predictive power over each other.

Table 2: Granger causality

Model		I		II	
Equation	Excluded	chi2	Prob>chi2	chi2	Prob >chi2
\dot{q}/q	π/ϖ	8.073	0.004	29.596	0.000
π/ϖ	\dot{q}/q	0.615	0.433	7.781	0.005

*, **, and *** stand by 10%, 5% and 1% of significance

With our pVAR model in hands, we can also make use of variance decomposition analysis to assess the amount of information income distribution contributes to labour productivity in the autoregression. This allows us to determine how much of the forecast error variance of the latter can be explained by exogenous shocks in the former. As table 3 shows, with a 10-year forecast horizon, something around 20 – 40% of variation in \dot{q}/q can be explained by income distribution. On the other hand, changes in labour productivity explain around 20% of variations in income distribution.

Table 3: Variance decomposition

Response variable	Impulse variable	Model I	Model II
\dot{q}/q	π/ϖ	0.1909791	0.3848296
\dot{q}/q	\dot{q}/q	0.8090209	0.6151704
π/ϖ	π/ϖ	0.7638016	0.7894201
π/ϖ	\dot{q}/q	0.2361984	0.2105799
Forecast horizon t		10	10

*, **, and *** stand by 10%, 5% and 1% of significance

As a final step we plot the response of \dot{q}/q to a shock in π/ϖ as in traditional impulse response analysis. Figure 6 reports OIRFs and only reinforces what we have found so far, that is, an increase in the share of wages on income incentive firms to adopt labour saving techniques increasing labour productivity growth rates. Most of these effects happen between 1 and 5 years after the shock.

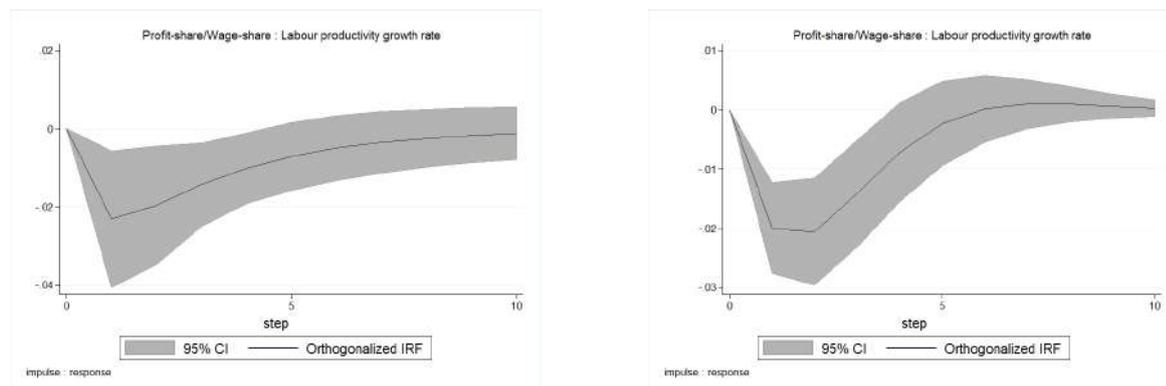


Figure 6: Impulse response functions, Model I (left) and II (right)

Capital productivity

Two pVAR models for capital productivity, $\dot{\rho}/\rho$, and income distribution, $\ln(\pi/\varpi)$, were estimated. Model I uses data for real GDP and capital stock in PPPs while in model II both series are in national prices converted to 2011 US\$ dollars. In the first case, Schwarz and Akaike lag selection criteria chose a two lag model. In the second case, Schwarz selected one lag while Akaike two lags. Following the procedure adopted in the last subsection, we preferred the former. Table 4 reports our estimates.

Table 4: Income distribution and capital productivity growth, pVAR estimates

Model	I		II	
Explanatory	$\dot{\rho}/\rho$	$\ln(\pi/\varpi)$	$\dot{\rho}/\rho$	$\ln(\pi/\varpi)$
$(\dot{\rho}/\rho)_{t-1}$	0.2705985***	-0.0835614	0.2837008***	0.2918696
$(\dot{\rho}/\rho)_{t-2}$	-0.1326931*	-0.0575909	-	-
$\ln(\pi/\varpi)_{t-1}$	-0.2341877**	0.7806212***	0.0146131	0.7800752***
$\ln(\pi/\varpi)_{t-2}$	0.2436164**	-0.3626047***	-	-
No. Lags instruments	4		5	
No. Obs.	329		377	
No. Panels	16		16	
Average t	20.563		23.563	

*, **, and *** stand by 10%, 5% and 1% of significance

For both models, an increase of the profit share relatively to the wage share seems to be positively related to an increase in capital productivity growth rates. However, net effects here are not as clear as in the labour productivity case. In the first of them, for instance, an increase in $\ln(\pi/\varpi)$ has a negative effect in $t - 1$ though a positive and slightly higher in $t - 2$. In

model II, the respective coefficient is positive but statistically not different from zero. Stability conditions of the estimated panels are checked in the Empiric Appendix.

These first insights are confirmed by Granger causality tests. Table 5 reports our results for the two models estimated. In the first case we have that $\ln(\pi/\varpi)$ unilaterally Granger causes $\dot{\rho}/\rho$ though this relationship disappears in the second model. This means that while in the first model past values of income distribution predict changes in capital productivity in the second model such correspondence does not hold anymore.

Table 5: Granger causality

Model		I		II	
Equation	Excluded	chi2	Prob>chi2	chi2	Prob>chi2
$\dot{\rho}/\rho$	$\ln(\pi/\varpi)$	9.853	0.007	0.622	0.430
$\ln(\pi/\varpi)$	$\dot{\rho}/\rho$	4.597	0.100	2.360	0.124

Variance decomposition analysis emphasises the small relationship between income distribution and capital productivity growth rates. As table 8 reports, within a 10-year forecast horizon, only 1 – 5% of variation in $\dot{\rho}/\rho$ can be explained by $\ln(\pi/\varpi)$. Numbers do not change when we look at the response of income distribution to changes in capital productivity growth rates. For such magnitudes it is quite safe to say that there is basically no correspondence at all among the variables. There is a clear contrast with the labour productivity case where changes in income distribution could explain up to 40% of variations in productivity.

Table 6: Variance decomposition

Response variable	Impulse variable	Model I	Model II
$\dot{\rho}/\rho$	$\ln(\pi/\varpi)$	0.0554572	0.0108349
$\dot{\rho}/\rho$	$\dot{\rho}/\rho$	0.9445428	0.9891652
$\ln(\pi/\varpi)$	$\ln(\pi/\varpi)$	0.9451099	0.9648765
$\ln(\pi/\varpi)$	$\dot{\rho}/\rho$	0.0548901	0.0351234
Forecast horizon t		10	10

Figure 7, by means of OIRFs, reinforces what we have found so far, that is, changes in the functional income distribution have little effect in firms' decisions to adopt capital saving techniques. In model I it is possible to visualise the initial negative effect of an increase in the profit share relatively to the wage share. Such negative impact is immediately reversed in the next three to four periods leading to a small positive net effect. On the other hand, model II depicts a non-statistically significant positive effect.

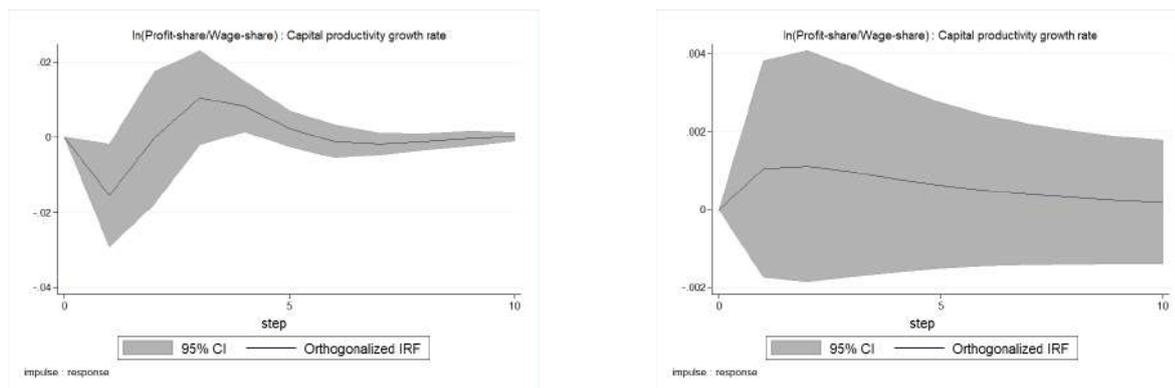


Figure 7: Impulse response functions, Model I (left) and II (right)

5.3.4 Discussion

The intuition behind functions $G(\cdot)$ and $J(\cdot)$ is that changes in functional income distribution reflect variations in factor cost shares. Firms respond to this change in costs adopting different technologies. We make use of functional forms following [Kemp-Benedict's \(2017a\)](#) extension of [Dumenil and Levy \(1995\)](#) results.

An increase in the wage share means that real wages have increased relatively to labour productivity. This implies a reduction in profitability and forces firms to increase their search for labour saving techniques, thus, increasing labour productivity growth rates. Analogously, an increase in profit shares is related to an increase in the cost of capital relatively to capital productivity. Theory considers that firms should respond in a similar way and increase capital productivity growth rates.

Our results lead us to two possible conclusions. The first one comes from a straight reading of the estimates presented in this section. Variations in the wage (or profit) share only impact labour. The channel between the share of wages and labour productivity continues to be the same. Nevertheless, it seems that an increase in the profit share – which is equivalent to a reduction in the wage share – is not interpreted by the firm as an increase in capital costs but only as labour becoming cheaper. Such asymmetric behavior can be justified by asymmetries in the ownership of the firm. If those who own capital also own corporations, the latter will be mainly concern with the factor of production it actually hires, that is labour. Therefore, asymmetries in firm's ownership are reflected in how them respond to changes in factor costs.

“In a perfectly competitive economy, it doesn't really matter who hires whom” ([Samuelson, 1957, p. 894](#)). This statement has been for a long time challenged by non-neoclassical economists and more recently by new-institutional scholars, who have shown that technologies are not neutral in regard to the nature of property rights and corporate governance (see, for example, [Pagano, 2013](#)). The evidence presented in this chapter could be interpreted as reflecting such non-neutrality.

Alternatively, one could just bring to attention that our estimates of capital productivity strongly depend on estimates of potential output. Potential output and the output gap are unobserved variables. Their estimation is deeply linked with the estimation of production functions which involve controversial concepts such as the natural rate of unemployment and total factor productivity.¹² As briefly mentioned in the beginning of this section, potential output and output gap indicators are subject to significant margin of uncertainty and might not be reliable. In this case, coefficients reported for capital productivity are not reliable as well and should be interpreted very carefully.

5.4 Numerical Simulations

In section 2 we studied the analytical implications of adopting (i) Kaldor-Verdoorn's law, and (ii) classical-Marxian technical change to the main results of our model. The Kaldorian specification basically left the system with no internal equilibrium solution while the Marxian formulation one made it stable. Nevertheless, a Hopf bifurcation analysis demonstrated that the combination of both theories might give rise to persistent and bounded cyclical fluctuations when Verdoorn's effects are related to capital accumulation dynamics. Therefore, in this section, we present numerical simulations to investigate if the bifurcation is supercritical so that, under plausible settings, oscillations have economic meaning.

To this end, we must first of all choose functional forms for the main behavioral equations of the model, namely, $F(\cdot)$, $H(\cdot)$, $G(\cdot)$, and $J(\cdot)$. Given that our empirical exercise indicated that the effect of income distribution on the growth rate of capital productivity is neglectable, we set d in equation (5.35) equal to zero and focused only on the first three relationships. Leaving aside for a moment any considerations about changes in labour productivity, the two remaining relations are expressed by:

$$F(e) = \beta(e - \bar{e}) \quad (5.36)$$

$$H(\varpi, u) = \gamma_1 - \gamma_2\varpi + \gamma_3u \quad (5.37)$$

where \bar{e} is the rate of employment above which workers are able to obtain real wage increases. The functional form we have chosen in (5.36) captures the Marxian reserve army effect as previously discussed in chapter 4. On the other hand, parameter β corresponds to the sensitiveness of real wages to changes in employment rates. In (5.37), we adopt a linear specification of investment, where γ_1 captures the growth rate of the capital stock when wage income and capacity utilisation are both set to zero, while γ_2 and γ_3 stand for the sensitiveness of accumulation to income distribution and capacity utilisation, respectively.

We have discussed Kaldor-Verdoorn's effects on labour productivity under two different specifications. The first one makes \dot{q}/q a function of capital accumulation while the second one takes into account output's growth rate. Local stability analysis demonstrated that those different formulations change the nature of the dynamic system from a qualitative point of view.

¹²For a review of the methodology employed by the IMF to estimate those variables see De Masi (1997).

When \dot{q}/q depends on output's growth rate, we basically return to the pure marxian case with simple convergence. Hence, in what follows, we investigate the case when labour productivity relies on \dot{K}/K .

In the empirical section of this essay, we used equation (5.34) to estimate the relationship between income distribution and labour productivity growth. This functional form was used in accordance with Kemp-Benedict's (2017a and 2017b) condition for the existence of biased technical change. For our numerical simulations exercise, however, a linear specification of $G(\cdot)$ was preferred. The reason for this is that we want to make it clear that the dynamics obtained do not depend on ad-hoc induced non-linearities. The system is intrinsically non-linear as a result of the interaction between its basic structure, given by equations (5.26)-(5.28), and the adopted behavioral rules, which are kept linear. Therefore, make:

$$G\left(\frac{\dot{K}}{K}, \varpi\right) = a + b\varpi + \vartheta\left(\frac{\dot{K}}{K}\right) \quad (5.38)$$

For this case, the steady-state internal equilibrium solution is such that satisfies:

$$e^* = \bar{e} + \frac{y_{bp} - n}{\beta} \quad (5.39)$$

$$\varpi^* = \frac{(1 - \vartheta)y_{bp} - n - a}{b} \quad (5.40)$$

$$u^* = \frac{y_{bp} - \gamma_1 + \gamma_2\varpi^*}{\gamma_3} \quad (5.41)$$

In order to choose plausible parameter values, we have considered the evidence given in a number of empirical studies. In particular in what concerns the classical-Marxian effect, we dwell on our estimates of the impulse response functions.

$$\begin{aligned} y_{bp} &= 0.03, n = 0.01, \bar{e} = 0.85, a = -0.0275, b = 0.05 \\ \vartheta &= 0.5, \gamma_1 = -0.0125, \gamma_2 = 0.05, \gamma_3 = 0.1 \end{aligned}$$

For this set of parameters we have that the inequality in proposition 5 is violated and, hence, there might be persistent and bounded fluctuations. Taking $F'(e^*) = \beta$ as bifurcation parameter, it turns out that $\beta_{HB} \approx 0.25055$. Therefore, for the simulations, we used a value slightly higher than this. Figure 8 displays the solution path for initial values (e_0, ϖ_0, u_0) equal to $(0.95, 0.7, 0.75)$ which converge to a limit cycle around $(0.93, 0.65, 0.75)$. It represents the case of an economy that is initially overheated, with employment rates and wage-share above equilibrium.

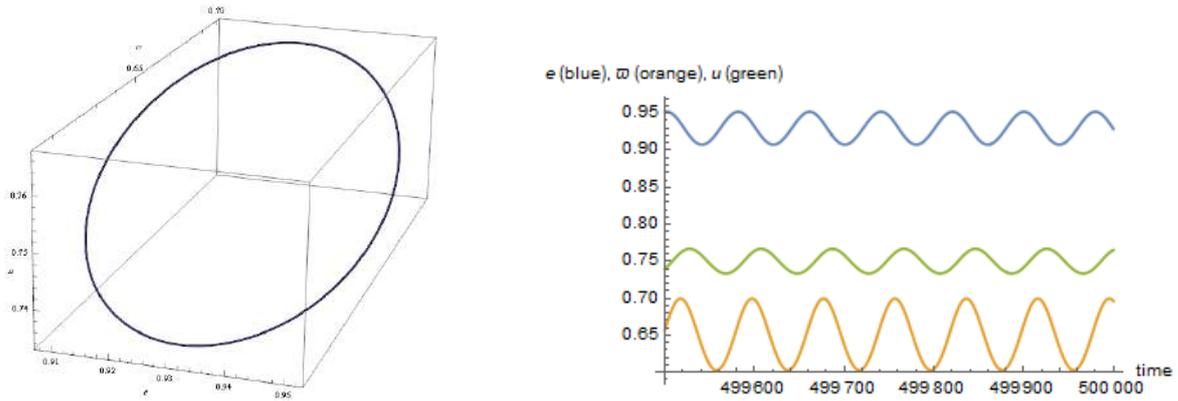


Figure 8: Limit cycle and time series

Still, it is important to understand the mechanism that is generating this outcome. Suppose that, for some exogenous reason, there is an increase in the employment rate. This will increase the bargain power of workers and therefore the wage share. Two effects follow. First, there is an increase in labour productivity which in turns brings down employment and the wage share. Thus, we have a sequence similar to the one obtained by Goodwin, with

$$\begin{aligned}
 e \uparrow &\Rightarrow \frac{\dot{w}}{w} \uparrow \Rightarrow \varpi \uparrow \Rightarrow \frac{\dot{q}}{q} \uparrow \Rightarrow e \downarrow \\
 e \downarrow &\Rightarrow \frac{\dot{w}}{w} \downarrow \Rightarrow \varpi \downarrow \Rightarrow \frac{\dot{q}}{q} \downarrow \Rightarrow e \uparrow
 \end{aligned}$$

On the other hand, the increase in the wage share that follows the increase in employment makes investment profitability to shrink and brings capital accumulation down. This leads to an increase in capacity utilisation. Through the accelerator effect, investment goes up and ultimately there is a reduction of u . Because of Kaldor-Verdoorn’s law, one should expect an increase in labour productivity growth rate. But we know that by assumption this effect is small and does not overcome the Marxian effect. Still, the reintroduction of Kaldor-Verdoorn’s law breaks the pure stability obtained from the marxian mechanism, allowing the model to maintain its basic cyclical feature.

In his paper *On the Nonlinear Accelerator and the Persistence of Business Cycles*, [Goodwin \(1951\)](#) discussed the so called “Schumpeter clock” relating the evolution of ideas to capital accumulation. New ideas require investment to occur regularly, but nonetheless the later goes by spurts. On the one hand, I is limited by the capacity of the investment goods industry. On the other hand, machines once made, cannot be unmade, so that negative investment is constrained to attrition from time and innovations waves.

So far, our model has dealt with an induced component of investment. It is possible to evaluate numerically the implications of introducing a cyclical autonomous component. Making innovations a periodic function of time, as done by [Sordi \(1990\)](#), we can rewrite equation (5.37)

as:

$$H(\varpi, u) = \gamma_1 + \gamma_A \cos(\tau t) - \gamma_2 \varpi + \gamma_3 u \tag{5.42}$$

where γ_A and τ are parameters.

In this way, we obtain a scenario in which a nonlinear system with a “natural” oscillation frequency interacts with an external periodic “force” resulting in a torus. A competition between two or more independent frequencies characterising the dynamics of the system is a well-known route to more complex behaviour. Figure 9 depicts the solution path for the same initial values making $\gamma_A = 0.01$ and $\tau = 0.25$.

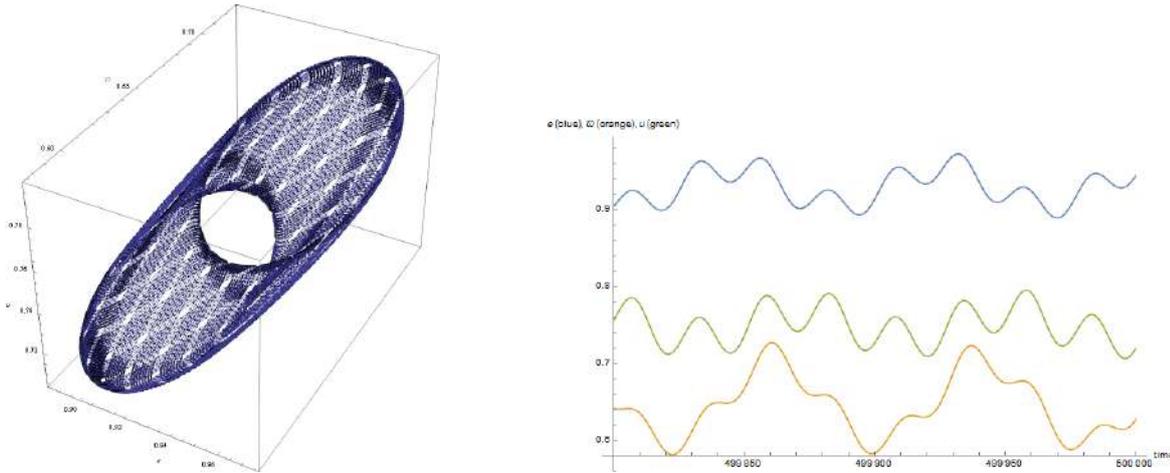


Figure 9: Torus and time series

The Newhouse-Ruelle-Takens theorem requires a three dimensional torus for chaos possibility to arise in this context (Gandolfo, 2009). Providing that obtained quasi-periodic fluctuations result from a two-dimensional torus, there is no sensitive dependence on initial conditions. Still, the term quasi-periodic is used to describe the behaviour of the system given that it never exactly repeats itself (Lorenz, 1993).

One of the motives that lead Goodwin to the study of nonlinear dynamical systems was the advantage this structure offers to represent the interaction between cycle and trend. Hence, before concluding this chapter, we show how the growth cycle can be easily recover by relaxing the assumption that output’s growth rate is fixed and equal to Thirlwall’s law. Recalling the adjustment mechanism for GDP growth described in chapter 4, we can write:

$$\frac{\dot{Y}}{Y} = y_{bp} + D(e - e^*, \varpi - \varpi^*, u - u^*) \tag{5.43}$$

where $D(0, 0, 0) = 0$ and $D_e|_{e=e^*} = D_{\varpi}|_{\varpi=\varpi^*} = D_u|_{u=u^*} = 0$. It is easy to see that this modification does not change our local stability analysis. Since the system never actually reaches equilibrium, we have permanent and irregular fluctuations in the employment rate, wage share, capacity utilisation, and output’s growth rate.

5.5 Final Considerations

The analysis of the role of technical change in growth processes has been for a long time of central importance in economic theory. Different approaches have been proposed over the years to study distinct aspects of the phenomenon. On the other hand, in chapter 4, we have extended Goodwin's (1967) model to study the interaction between distributive cycles and international trade for economies in which growth is BoPC. This chapter examined the implications of adopting (i) Kaldor-Verdoorn's law; and (ii) classical-Marxian technological change to the main results of the model.

We showed that using a Kaldorian approach to technical progress basically leaves the system with no internal equilibrium solution while the classical-Marxian formulation makes it stable. However, a Hopf bifurcation analysis demonstrated that the combination of both formulations might give rise to persistent and bounded cyclical fluctuations. Our numerical simulations confirmed that the Hopf bifurcation is supercritical and the limit cycle lies in a range of values with economic meaning. In other words, the main dynamics of the model developed in the previous chapter are robust to alternative specifications of technological change. Moreover, the introduction of a forcing term motivated by Goodwin's discussion of "Schumpeter clock" gives rise to irregular fluctuations.

Furthermore, the models developed in this essay provide a mechanism that helps to explain the positive correspondence found in the literature between economic complexity and income inequality. An increase in the diversification of the productive structure increases the BoPC growth rate and, therefore, employment rates. Higher employment leads to an increase in the bargain power of workers allowing them to get a bigger piece of the pie, i.e. increasing the wage-share. This results in higher labour productivity which in turn guarantees a stable employment rate at equilibrium. Inversely, a reduction in economic complexity could explain the reduction in wage shares and the slowdown of labour productivity growth observed in several OECD countries. New technologies, in particular the so called ICTs, have allowed firms to monitor workers more closely increasing the slope of $G(\cdot)$ and accentuating the aforementioned effect.

When it comes to the empirics of technological progress, studies testing the classical-Marxian formulation are limited. Several scholars have address the so-called MBTC hypothesis according to which, for a constant wage share, labour productivity historically increases while capital productivity decreases, i.e. technical change is labour-saving and capital-using. Nevertheless, to the best of our knowledge, there are no reliable studies testing the correspondence between factor productivity growth and cost shares. Therefore, we provided estimates of our own that give some support to the Marxian argument.

An increase in the wage share means that real wages are higher relatively to labour productivity. This implies in a reduction in profitability and forces firms to increase their search for labour saving techniques, thus, increasing labour productivity growth rates. Analogously, an increase in profit shares is related to an increase in the cost of capital relatively to capital productivity. Making use of a pVAR model to a sample of 16 OECD countries between 1980 and 2012, we find that one standard deviation impulse on the profit-share/wage-share ratio

decreases labour productivity growth rates by 2% though it has a neglectable effect on capital productivity growth rate.

Our results lead us to two possible conclusions. The first one is that variations of income distribution only impact labour. Such asymmetric behavior could be justified by asymmetries in the ownership of the firm. If those who own capital also own firms, the latter would be mainly concerned with the factor of production it actually hires, that is labour. Therefore, asymmetries in firm's ownership are reflected in how the firm responds to changes in factor costs. Alternatively, one could just bring to attention that our estimates of capital productivity strongly depend on estimates of potential output that are problematic because involve controversial concepts such as the natural rate of unemployment or total factor productivity. Further research on those issues is required and encouraged.

Empirical Appendix

We performed the Levin, Lin and Chu test that assumes a common unit root process, and the Im, Pesaran and Shin test, the ADF and PP tests that assume individual unit root processes. Number of lags was chosen following the Schwarz criteria. Results are reported in table A1. Series are found to be stationary.

Table A1: Panel Unit root tests

π/ϖ	Intercept	Trend and Intercept
Method	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000
Im, Pesaran and Shin	0.0000	0.0000
ADF	0.0000	0.0000
PP	0.0000	0.1003

$\ln(\pi/\varpi)$	Intercept	Trend and Intercept
Method	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000
Im, Pesaran and Shin	0.0000	0.0000
ADF	0.0000	0.0000
PP	0.0000	0.0566

Variable	PPPs, 2011 US\$		cons. nat. prices, 2011 US\$	
\dot{q}/q	Intercept	Trend and Intercept	Intercept	Trend and Intercept
Method	Prob.	Prob.	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000	0.0000	0.0000
Im, Pesaran and Shin	0.0000	0.0000	0.0000	0.0000
ADF	0.0000	0.0000	0.0000	0.0000
PP	0.0000	0.0000	0.0000	0.0000

Variable	PPPs, 2011 US\$		cons. nat. prices, 2011 US\$	
$\dot{\rho}/\rho$	Intercept	Trend and Intercept	Intercept	Trend and Intercept
Method	Prob.	Prob.	Prob.	Prob.
Levin, Lin & Chu	0.0000	0.0000	0.0000	0.0000
Im, Pesaran and Shin	0.0000	0.0000	0.0000	0.0000
ADF	0.0000	0.0000	0.0000	0.0000
PP	0.0000	0.0000	0.0000	0.0000

Finally we check the stability condition of the estimated pVAR. We start plotting the stability diagram for models I and II relating labour productivity growth rates and income distribution as in figure A1. Real and imaginary roots of the companion matrix lie inside the unit circle confirming the model is stable.

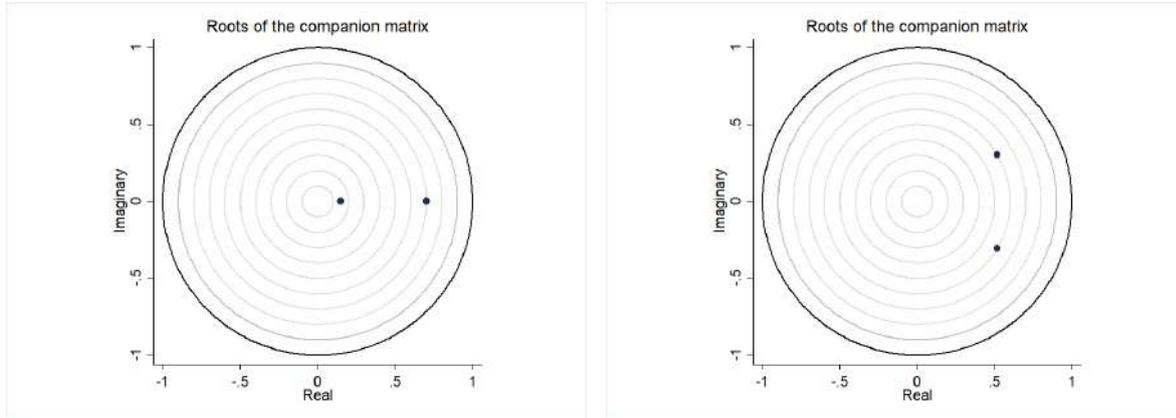


Figure A1: Stability condition, Model I (left) and Model II (right)

Figure A2 plot the unit circle for the relation between capital productivity and functional income distribution. Once more, models are found to be stable.

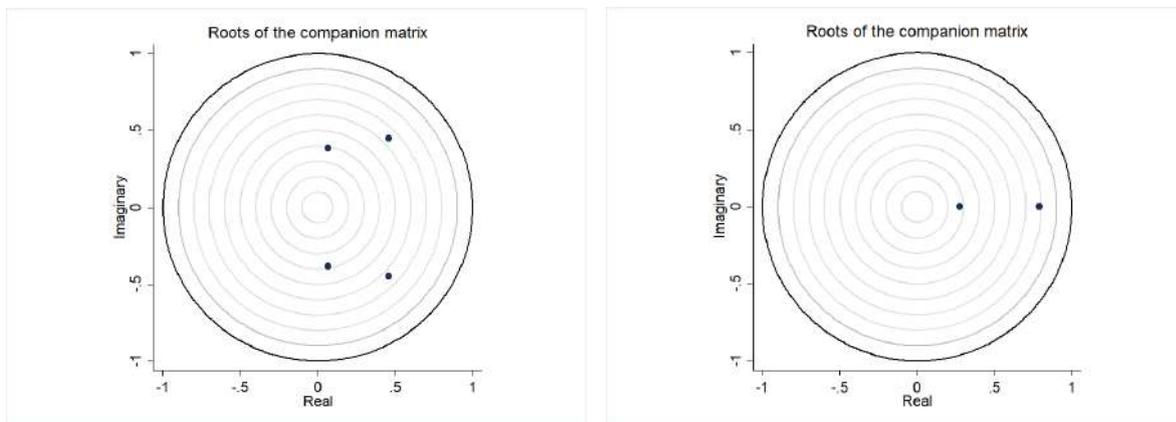


Figure A2: Stability condition, Model I (left) and Model II (right)

Mathematical Appendix

5.5.1 Proof of Proposition 5.2

To demonstrate proposition 5.2 we proceed in three steps. First, from equations (5.21) and (5.22) we obtain the rate of growth of real wages in terms of the external constrain, i.e. $F(e) = y_{bp} - n$, where $F : \mathfrak{R} \rightarrow \mathfrak{R}$ is monotonically increasing in e . Therefore, its inverse is also an increasing function and we obtain $e^* = F^{-1}(y_{bp} - n)$ as the unique equilibrium value of the rate of employment.

Looking at equation (5.21), it is straightforward that $G_{\varpi}(\varpi) = y_{bp} + n$, where, $G_{\varpi} : \mathfrak{R} \rightarrow \mathfrak{R}$ is a function monotonically increasing in ϖ . The inverse of $G_{\varpi}(\cdot)$ is also monotonically increasing so that $\varpi^* = G_{\varpi}^{-1}(y_{bp} - n)$ is the unique equilibrium value of the wage share.

The equilibrium capacity utilisation is defined as the value of u that brings utilisation and the balance-of-payments to equilibrium. Our investment function $H : \mathfrak{R} \rightarrow \mathfrak{R}$ is monotonically increasing in u and decreasing in ϖ . Making use of the equilibrium value of the wage share, we have that $y_{bp} = H[G^{-1}(y_{bp} - n), u] + J[G^{-1}(y_{bp} - n)]$. It follows that the unique equilibrium for capacity utilisation is determined and defined by u^* that satisfies that condition.

Finally, in order to obtain values with economic meaning we have to impose $0 < F^{-1}(y_{bp} - n) < 1$, $0 < G^{-1}(y_{bp} - n) < 1$, and $0 < u^* < 1$.

5.5.2 Proof of Proposition 5.3

In this Appendix we first derive the characteristic equation of the dynamic system (5.18)-(5.20) and prove Proposition 5.3. To do this, we linearise the dynamic system around the internal equilibrium point so as to obtain:

$$\begin{bmatrix} \dot{e} \\ \dot{\varpi} \\ \dot{u} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & j_{12} & 0 \\ j_{21} & j_{22} & 0 \\ 0 & j_{32} & j_{33} \end{bmatrix}}_{J^*} \begin{bmatrix} e - e^* \\ \varpi - \varpi^* \\ u - u^* \end{bmatrix}$$

where the elements of the Jacobian matrix J^* are given by:

$$\begin{aligned} j_{11} &= 0 \\ j_{12} &= -G_{\varpi} e^* < 0 \\ j_{13} &= 0 \end{aligned}$$

$$\begin{aligned} j_{21} &= F'(e^*) \varpi^* > 0 \\ j_{22} &= -G_{\varpi} \varpi^* < 0 \\ j_{23} &= 0 \end{aligned}$$

$$\begin{aligned} j_{31} &= 0 \\ j_{32} &= -H_{\varpi}u^* > 0 \\ j_{33} &= -H_uu^* < 0 \end{aligned}$$

so that the characteristic equation can be written as

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

where the coefficients are given by:

$$b_1 = -\text{tr } J^* = -(j_{22} + j_{33}) > 0 \quad (5.44)$$

$$\begin{aligned} b_2 &= \begin{vmatrix} j_{22} & 0 \\ j_{32} & j_{33} \end{vmatrix} + \begin{vmatrix} 0 & 0 \\ 0 & j_{33} \end{vmatrix} + \begin{vmatrix} 0 & j_{12} \\ j_{21} & j_{21} \end{vmatrix} \\ &= j_{22}j_{33} - j_{12}j_{21} > 0 \end{aligned} \quad (5.45)$$

$$b_3 = -\det J^* = j_{12}j_{21}j_{33} > 0 \quad (5.46)$$

The necessary and sufficient condition for the local stability of (e^*, ϖ^*, u^*) is that all roots of the characteristic equation have negative real parts, which, from Routh-Hurwitz conditions, requires:

$$b_1 > 0, \quad b_2 > 0, \quad b_3 > 0 \quad \text{and} \quad b_1b_2 - b_3 > 0.$$

Given (5.44)-(5.46) the crucial condition for local stability becomes the last one. Through direct computation we find that:

$$\begin{aligned} b_1b_2 - b_3 &= -(j_{22} + j_{33})(j_{22}j_{33} - j_{12}j_{21}) - j_{12}j_{21}j_{33} \\ &= (G_{\varpi}\varpi^* + H_uu^*) [G_{\varpi}\varpi^*H_uu^* + G_{\varpi}e^*F'(e^*)\varpi^*] - G_{\varpi}e^*F'(e^*)\varpi^*H_uu^* \\ &= G_{\varpi}\varpi^* [G_{\varpi}\varpi^*H_uu^* + G_{\varpi}e^*F'(e^*)\varpi^*] + H_uu^*G_{\varpi}\varpi^*H_uu^* > 0 \\ &= \underbrace{(G_{\varpi}\varpi^*)^2}_{>0} \underbrace{(H_uu^* + e^*F'(e^*)e^*)}_{>0} + \underbrace{(H_uu^*)^2}_{>0} \underbrace{G_{\varpi}\varpi^*}_{>0} > 0 \end{aligned}$$

Therefore, the system is locally stable.

5.5.3 Proof of Proposition 5.4

To demonstrate proposition 5.4 we proceed in the following series of steps. First, from equations (5.29) and (5.30) we obtain the rate of growth of real wages in terms of the external constrain, i.e. $F(e) = y_{bp} - n$, where $F : \mathfrak{R} \rightarrow \mathfrak{R}$ is monotonically increasing in e . Therefore, its inverse is also an increasing function and we obtain $e^* = F^{-1}(y_{bp} - n)$ as the unique equilibrium value of the rate of employment.

Looking at equation (5.29), we have that $G[H(\varpi, u), \varpi] = y_{bp} + n$, where, $G : \mathfrak{R} \rightarrow \mathfrak{R}$ is a function monotonically increasing in its two arguments while $H : \mathfrak{R} \rightarrow \mathfrak{R}$ is decreasing in ϖ and increasing in u . However, by assumption, $G_{\varpi} > |G_H H_{\varpi}|$ which implies $G(\cdot)$ is monotonically increasing in ϖ and u . Hence, we can rewrite (5.29) as $u = \Psi(\varpi)$, where, $\Psi : \mathfrak{R} \rightarrow \mathfrak{R}$

is monotonically decreasing in ϖ . Analogously, from equation (5.31) a constant level of capacity utilisation requires $H(\varpi, u) + J(\varpi) = y_{bp}$, with $J : \Re \rightarrow \Re$ is a decreasing function in ϖ . Since H is also monotonically decreasing in the wage share we can rewrite (5.31) as $u = \Theta(\varpi)$, where, $\Theta : \Re \rightarrow \Re$ is monotonically increasing in ϖ .

Given that Ψ is a decreasing function of ϖ in u and Θ is an increasing one, they intercept each other in one unique point that characterise the equilibrium solution of the system for these two variables. That is, though the employment rate is determined alone in the labour market, income distribution and capacity utilisation are simultaneously chosen. Finally, in order to obtain values with economic meaning we have to impose $0 < F^{-1}(y_{bp} - n) < 1$, $0 < \varpi^* < 1$, and $0 < u^* < 1$.

5.5.4 Proof of Proposition 5.5

In this Appendix we first derive the characteristic equation of the dynamic system (5.26)-(5.28) and prove Proposition 5.5. To do this, we linearise the dynamic system around the internal equilibrium point so as to obtain:

$$\begin{bmatrix} \dot{e} \\ \dot{\varpi} \\ \dot{u} \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & j_{12} & j_{13} \\ j_{21} & j_{22} & j_{23} \\ 0 & j_{32} & j_{33} \end{bmatrix}}_{J^*} \begin{bmatrix} e - e^* \\ \varpi - \varpi^* \\ u - u^* \end{bmatrix}$$

where the elements of the Jacobian matrix J^* are given by:

$$\begin{aligned} j_{11} &= 0 \\ j_{12} &= -(G_H H_\varpi + G_\varpi) e^* < 0 \\ j_{13} &= -G_H H_u e^* < 0 \\ \\ j_{21} &= F'(e^*) \varpi^* > 0 \\ j_{22} &= -(G_H H_\varpi + G_\varpi) \varpi^* < 0 \\ j_{23} &= -G_H H_u \varpi^* < 0 \\ \\ j_{31} &= 0 \\ j_{32} &= -[H_\varpi + J'(\varpi^*)] u^* > 0 \\ j_{33} &= -H_u u^* < 0 \end{aligned}$$

so that the characteristic equation can be written as

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

where the coefficients are given by:

$$b_1 = -\text{tr } J^* = -(j_{22} + j_{33}) > 0 \quad (5.47)$$

$$b_2 = \begin{vmatrix} j_{22} & j_{23} \\ j_{32} & j_{33} \end{vmatrix} + \begin{vmatrix} 0 & j_{13} \\ 0 & j_{33} \end{vmatrix} + \begin{vmatrix} 0 & j_{12} \\ j_{21} & j_{21} \end{vmatrix} \\ = j_{22}j_{33} - j_{23}j_{32} - j_{12}j_{21} > 0 \quad (5.48)$$

$$b_3 = -\det J^* = -j_{13}j_{21}j_{32} + j_{12}j_{21}j_{33} > 0 \quad (5.49)$$

The necessary and sufficient condition for the local stability of (e^*, ϖ^*, u^*) is that all roots of the characteristic equation have negative real parts, which, from Routh-Hurwitz conditions, requires:

$$b_1 > 0, \quad b_2 > 0, \quad b_3 > 0 \quad \text{and} \quad b_1b_2 - b_3 > 0.$$

Given (5.44)-(5.46) the crucial condition for local stability becomes the last one. Through direct computation we find that:

$$b_1b_2 - b_3 = [(G_H H_\varpi + G_\varpi) \varpi^* + H_u u^*] [(G_H H_\varpi + G_\varpi) \varpi^* H_u u^* - G_H H_u \varpi^* [H_\varpi + J'(\varpi^*)] u^* \\ + (G_H H_\varpi + G_\varpi) e^* F'(e^*) \varpi^*] + G_H H_u e^* F'(e^*) \varpi^* [H_\varpi + J'(\varpi^*)] u^* \\ - (G_H H_\varpi + G_\varpi) e^* F'(e^*) \varpi^* H_u u^* \\ = (G_H H_\varpi + G_\varpi) \varpi^* [(G_H H_\varpi + G_\varpi) \varpi^* H_u u^* - G_H H_u \varpi^* [H_\varpi + J'(\varpi^*)] u^* \\ + (G_H H_\varpi + G_\varpi) e^* F'(e^*) \varpi^*] + H_u u^* [(G_H H_\varpi + G_\varpi) \varpi^* H_u u^* - G_H H_u \varpi^* [H_\varpi + J'(\varpi^*)] u^*] \\ + G_H H_u e^* F'(e^*) \varpi^* [H_\varpi + J'(\varpi^*)] u^* \\ = \varpi^* u^* \underbrace{[(G_H H_\varpi + G_\varpi) \varpi^* + H_u u^*]}_{>0} \underbrace{[(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]]}_{>0} \\ + \underbrace{e^* \varpi^* F'(e^*)}_{>0} \underbrace{[\varpi^* (G_H H_\varpi + G_\varpi)^2 + G_H H_u u^* [H_\varpi + J'(\varpi^*)]]}_{\geq 0} \quad (5.50)$$

Therefore, $\varpi^* (G_H H_\varpi + G_\varpi)^2 > G_H H_u [H_\varpi + J'(\varpi^*)] u^*$ is a sufficient condition for $b_1b_2 - b_3 > 0$, and hence, guarantees local stability of the dynamical system.

5.5.5 Proof of Proposition 5.6

When demonstrating Proposition 5, we showed that $\varpi^* (G_H H_\varpi + G_\varpi)^2 > G_H H_u [H_\varpi + J'(\varpi^*)] u^*$ is a sufficient condition for local stability. However, even if that inequality is not satisfied, local stability might still hold. Manipulating equation (5.50) we have that this is the case as long as:

$$F'(e^*) < -\frac{u^* [\varpi^* (G_H H_\varpi + G_\varpi) + u^* H_u] \{(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]\}}{e^* \varpi^* \{\varpi^* (G_H H_\varpi + G_\varpi)^2 + u^* G_H H_u [H_\varpi + J'(\varpi^*)]\}}$$

5.5.6 Proof of Proposition 5.7

To prove Proposition 5.7 using the (existence part of) the Hopf Bifurcation Theorem and using $\partial F/\partial e$ as bifurcation parameter, we must: (HB1) show that the characteristic equation

possesses a pair of complex conjugate eigenvalues $\theta [F'(e^*)] \pm i\omega [F'(e^*)]$ that become purely imaginary at the critical value $F'(e^*)_{HB}$ of the parameter – i.e. $\theta [F'(e^*)_{HB}] = 0$ – and no other eigenvalues with zero real part exists at $[F'(e^*)]_{HB}$, and then (HB2) check that the derivative of the real part of the complex eigenvalues with respect to the bifurcation parameter is different from zero at the critical value.

(HB1) Given that the conditions $b_1 > 0$, $b_2 > 0$ and b_3 are all fulfilled, in order that the characteristic equation has one negative real root and a pair of complex roots with zero real part we must have:

$$b_1 b_2 - b_3 = 0$$

a condition which, given the expression for $b_1 b_2 - b_3$ derived in (5.50), is satisfied for

$$F'(e^*)|_{HB} = -\frac{u^* [\varpi^* (G_H H_\varpi + G_\varpi) + u^* H_u] \{(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]\}}{e^* \varpi^* \{\varpi^* (G_H H_\varpi + G_\varpi)^2 + u^* G_H H_u [H_\varpi + J'(\varpi^*)]\}}$$

(HB2) By using the so-called sensitivity analysis, it is then possible to show that the second requirement of the Hopf Bifurcation Theorem is also met. Substituting the elements of the Jacobian matrix into the respective coefficients of the characteristic equation:

$$\begin{aligned} b_1 &= (G_H H_\varpi + G_\varpi) \varpi^* + H_u u^* \\ b_2 &= (G_H H_\varpi + G_\varpi) \varpi^* H_u u^* - G_H H_u \varpi^* [H_\varpi + J'(\varpi^*)] u^* \\ &\quad + (G_H H_\varpi + G_\varpi) e^* F'(e^*) \varpi^* \\ b_3 &= -G_H H_u e^* F'(e^*) \varpi^* [H_\varpi + J'(\varpi^*)] u^* \\ &\quad + (G_H H_\varpi + G_\varpi) e^* F'(e^*) \varpi^* H_u u^* \end{aligned}$$

so that

$$\begin{aligned} \frac{\partial b_1}{\partial F'(e^*)} &= 0 \\ \frac{\partial b_2}{\partial F'(e^*)} &= (G_H H_\varpi + G_\varpi) e^* \varpi^* > 0 \\ \frac{\partial b_3}{\partial F'(e^*)} &= e^* \varpi^* u^* \{(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]\} > 0 \end{aligned}$$

When $F'(e^*) = F'(e^*)_{HB}$ as in (5.32), apart from $b_1 > 0$, $b_2 > 0$ and $b_3 > 0$ one also has $b_1 b_2 - b_3 = 0$. In this case, one root of the characteristic equation is real negative (λ_1), whereas the other two are a pair of complex roots with zero real part ($\lambda_{2,3} = \theta \pm i\omega$, with $\theta = 0$). We thus have:

$$\begin{aligned} b_1 &= -(\lambda_1 + \lambda_2 + \lambda_3) \\ &= -(\lambda_1 + 2\theta) \\ b_2 &= \lambda_1 \lambda_2 + \lambda_1 \lambda_3 + \lambda_2 \lambda_3 \\ &= 2\lambda_1 \theta + \theta^2 + \omega^2 \\ b_3 &= -\lambda_1 \lambda_2 \lambda_3 \\ &= -\lambda_1 (\theta^2 + \omega^2) \end{aligned}$$

such that:

$$\begin{aligned}\frac{\partial b_1}{\partial [F'(e^*)]} &= -\frac{\partial \lambda_1}{\partial [F'(e^*)]} - 2\frac{\partial \theta}{\partial [F'(e^*)]} = 0 \\ \frac{\partial b_2}{\partial [F'(e^*)]} &= 2\theta\frac{\partial \lambda_1}{\partial [F'(e^*)]} + 2(\lambda_1 + \theta)\frac{\partial \theta}{\partial [F'(e^*)]} + 2\omega\frac{\partial \omega}{\partial [F'(e^*)]} = P > 0 \\ \frac{\partial b_3}{\partial [F'(e^*)]} &= -(\theta^2 + \omega^2)\frac{\partial \lambda_1}{\partial [F'(e^*)]} - 2\lambda_1\theta\frac{\partial \theta}{\partial [F'(e^*)]} - 2\lambda_1\omega\frac{\partial \omega}{\partial [F'(e^*)]} = R > 0\end{aligned}$$

where $P = (G_H H_\varpi + G_\varpi) e^* \varpi^*$ and $R = e^* \varpi^* u^* \{(G_H H_\varpi + G_\varpi) H_u - G_H H_u [H_\varpi + J'(\varpi^*)]\}$.

For $\theta = 0$, the system to be solved becomes:

$$\begin{aligned}-\frac{\partial \lambda_1}{\partial [F'(e^*)]} - 2\frac{\partial \theta}{\partial [F'(e^*)]} &= 0 \\ 2\lambda_1\frac{\partial \theta}{\partial [F'(e^*)]} + 2\omega\frac{\partial \omega}{\partial [F'(e^*)]} &= P \\ -\omega^2\frac{\partial \lambda_1}{\partial [F'(e^*)]} - 2\lambda_1\omega\frac{\partial \omega}{\partial [F'(e^*)]} &= R\end{aligned}$$

or

$$\begin{bmatrix} -1 & -2 & 0 \\ 0 & 2\lambda_1 & 2\omega \\ -\omega^2 & 0 & -2\lambda_1\omega \end{bmatrix} \begin{bmatrix} \frac{\partial \lambda_1}{\partial [F'(e^*)]} \\ \frac{\partial \theta}{\partial [F'(e^*)]} \\ \frac{\partial \omega}{\partial [F'(e^*)]} \end{bmatrix} = \begin{bmatrix} 0 \\ P \\ R \end{bmatrix}$$

Thus:

$$\begin{aligned}\frac{\partial \theta}{\partial [F'(e^*)]} \Big|_{F'(e^*)=F'(e^*)_{HB}} &= \frac{\begin{vmatrix} -1 & 0 & 0 \\ 0 & P & 2\omega \\ -\omega^2 & R & -2\lambda_1\omega \end{vmatrix}}{\begin{vmatrix} -1 & -2 & 0 \\ 0 & 2\lambda_1 & 2\omega \\ -\omega^2 & 0 & -2\lambda_1\omega \end{vmatrix}} \\ &= \frac{(P\lambda_1 + R)}{2(\lambda_1^2 + \omega^2)}\end{aligned}$$

and $\frac{\partial \theta}{\partial [F'(e^*)]} \Big|_{F'(e^*)=F'(e^*)_{HB}} \neq 0$ as long as $P\lambda_1 + R \neq 0$. Substituting the respective expressions of P and R , that is equivalent to say that:

$$\lambda_1 \neq u^* \left\{ \frac{G_H H_u [H_\varpi + J'(\varpi^*)]}{G_H H_\varpi + G_\varpi} - H_u \right\}$$

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