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ABSTRACT
Building on the macroeconomic Cambridge capital controversies and issues regarding capital reversal, this article develops a novel microeconomic way of understanding productivity figures and demonstrates that thinking using a two-dimensional model corresponding to scale and pricing. The two-dimensional depiction enables a deeper understanding of the demand and supply forces that lie behind GVA figures, underscores that demand factors are critically important, and stimulates reflection on how the absence of aggregate demand in conventional supply-side productivity models perverts our understanding of the evolution of GDP productivity figures.

KEYWORDS
Productivity; GVA; prices; costs; scale

JEL CLASSIFICATION
D24; L11; O4

Introduction

Measuring the size and change of an economy's Gross Domestic Product (GDP) is a complex and imperfect process. Subtracting taxes from and adding subsidies to GDP figures gives Gross Value Added (GVA) figures; dividing GVA by the number of workers (or the number of worker hours) provides an indication of labor productivity (GVApw). These data are used extensively to measure levels of and changes in productive efficiency and are available across many countries at different levels of aggregation, from the individual firm level to the national aggregate level. Although these measures of output are standard and commonplace, this paper argues that analysts of these data fail to unfold the intricacies involved in this measurement of productivity because conventional productivity models overemphasize the importance of supply-side factors relating to capital, labor, and technological change, and underemphasize demand-side factors; we offer a solution to this problem.[1]

Productivity growth has been declining since the 1980s across many industrialized countries (Jones 2016), and the 2008 global financial crisis (GFC) increased the exposure of many industrialized countries to productivity shocks. In the UK, productivity shocks were the by-product of sudden

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contractions of aggregate demand and cutbacks in public expenditure, which resulted in a flatlining of productivity growth (McCann and Vorley 2020). However, the GFC alone does not explain all productivity-related concerns (e.g., unemployment, living standards, savings, and wealth acquisitions) that affect peoples' expectations of their own personal and professional development. In this paper, we argue that an important part of the productivity problem is related to the way in which conventional macroeconomic productivity analysts understand GVA (or GDP) as a measure of productivity.

Our article provides a novel way of thinking about the GVA productivity measure, and we illustrate our case through the use of firm-level productivity figures. Although this is a simplification of a more complex macroeconomic issue, this simplification is a functional step which illustrates how events that impair aggregate demand diminish firms' revenues and ultimately their capacity to boost productivity. In contrast to the conventional view of firm-level GVA figures–which interprets it as a single (multi-digit) number on a one-dimension continuum–our approach proposes a two-dimensional understanding of the same GVA data. We argue that this additional dimension enables a more rounded appreciation of the issues that affect GVA figures, including pricing procedures and opportunities to exploit scale economies. In addition, our two-dimensional understanding of GVA figures magnifies an explicit recognition of the influence of demand and stresses the importance of contextual and institutional factors that vary across countries, geographies, industries, and firms.

The theoretical framework of our article is closely linked to the central macroeconomic debate between Post Keynesian economists who emphasize that aggregate outcomes depend on the adequacy of aggregate demand, not just on supply factors, and Classical economists who argue that output depends on individual-level savings/consumption decisions and on supply conditions. We start our contribution by providing an overview of this macroeconomic debate and specifically the 'Cambridge capital controversies in the theory of capital' (CCC). The CCC share the same background on which the modern discussion on productivity is built; that is, *what are the causes and consequences of economic growth, and/or the lack of it?*

This article makes four contributions to the literature. First, it emphasizes that the standard one-dimensional understanding of GVA productivity figures is deficient because it ignores the way that GVA figures are constructed, and that sweeps away important information present in each of its constituent parts. For instance, firm-level GVA figures are calculated by subtracting the market *value* of goods and services used up or transformed in the production process, such as raw materials or intermediate inputs, from total revenues, and we know that revenues are strongly affected by demand. We also understand that market value reflects the interaction of both supply and demand forces, though perhaps not in an equilibrium setting. Second, this article presents a novel two-dimensional depiction of GVA-based productivity data. This representation highlights the links between GVA figures, social relationships, and institutional forces, such as implicit contracts. This two-dimensional representation facilitates a deeper understanding of GVA productivity figures while simultaneously emphasizing avenues for future research. Third, this article emphasizes that aggregate demand is at the core of productivity figures, and that GVA data are not only a reflection of supply-side issues, and that policies which affect aggregate demand, such as austerity measures and policies to reduce net immigration, will inevitably reduce the rate of increase of GVA figures, holding all else equal. Fourth, the article offers an explanation of the productivity slowdown problem. Policymakers aiming to enhance GVA productivity figures should be cognizant of the effects of low levels of demand and disadvantageous socioeconomic factors that curtail GVA productivity growth.

The structure of this article is as follows: section "Seven decades of productivity debates" presents the principles underpinning our theoretical framework. Section "The construction and standard interpretation of GVA data" presents a brief summary of interpretations of one-dimensional GVA data. Section "Think 2D: towards a deeper understanding of productivity" provides a two-dimensional reconceptualization of GVA productivity data. Section "GVA growth in a 2D framework" explores how GVA productivity figures change. The final two sections address the productivity puzzle and present conclusions respectively.

Seven decades of productivity debates

The way we think about productivity and how we measure it has been an object of contention for over seventy years. A crucial area of debate has been the Cambridge Capital Controversies (CCC)[2] and the need for a more appropriate approach to measure and analyze productivity. Here we present alternative perspectives on productivity to emphasize the consequences of applying long-run neoclassical models, and this theoretical discussion lays the foundations of our proposed new way of thinking about productivity. In doing so, we voice concerns about why policymakers continue to be guided by the neoclassical framework while formulating their economic plans despite the fact that the critical side of the CCC–Cambridge, England–exited victoriously, with the acknowledgement from prominent neoclassical economists (Champernowne 1953/1954; Levhari and Samuelson 1966; Blaug 2009; Bliss 2005, 2009).[3] Our aim is not to explain why policymakers continue to adopt highly criticized neoclassical frameworks; for this we refer the reader to Harcourt (1995), Cohen and

Harcourt (2003), Petri (2007), and Lazzarini (2011); instead, our aims are to emphasize crucial areas of the CCC debate, to echo worries of recent scholars (Birner 2002; Vorley and Nelles 2020) who call for alternative ways of thinking about productivity and how to measure it, and to use this as a basis for our innovative way of thinking about productivity proposed later in the paper.

Crucial areas of debate in the Cambridge capital Controversies

The CCC, which took place between 1953 and the mid-1970s, began with Joan Robinson's famous article 'The Production Function and the Theory of Capital' (1953–54) and ended, only notionally, with Garegnani (1976), who proved the inconsistency of neoclassical growth models built upon the Walrasian notion of capital.[4] In her 1953–54 article, Robinson made two critical complaints regarding (i) the ambiguity concerning the unit in which capital was measured in the neoclassical aggregate production function (Harcourt 1972, 11) and particularly those of economic growth, and (ii) the use of long-period positions to analyze processes of change. Garegnani (1976) extended the implications of the CCC to methodological grounds; he saw changes to both temporal and intertemporal general equilibrium theory as an historical process for the formation and dissemination of the neoclassical school's ideas, with emphasis resting on capital and consequently on reswitching.

The CCC controversies covered a large spectrum of issues of concern in neoclassical models.[5] Although the aggregate production function[6] is not essential to the foundations of neoclassical theory, is not essential for understanding productivity-related issues either, and any reference to it is misleading when discussing productivity. We base our line of reasoning on the fact that the CCC proved two important issues in this regard. First, the adoption of the traditional notion of capital, which measures capital in *value* terms rather than technical units, creates a circular problem between inputs and outputs. Put simply, capital in value terms depends on distribution, which is the very output that the theory should determine from the input used (i.e., capital). Second, the CCC showed that even when neoclassical theory adopts a Walrasian notion of capital–which moves from considering capital as a value to a measure of its physical form, allowing for heterogeneous capital–these models remain anchored to the notion of capital as a single value,[7] potentially because temporal and intertemporal general equilibrium models do not cast any doubts about the *mechanism of substitution* which endogenously ensure the composition of capital (Petri 2004, 137, 153–56). Making the highly dubious assumption that capital is homogeneous and easily aggregable resolves this mechanism of substitution problem with capital.

The remaining crucial area of debate concerning the reliability of neoclassical models then rests on the *principle of factor substitution.* The neoclassical justification underpinning the adoption of this principle is based on two mechanisms. First, the substitution mechanism, which ensures a univocal relationship between capital intensity and changes in distribution, and which implies an *inverse* monotonic relationship between the rate of interest and the capital/output ratio (Cohen and Harcourt 2003). Second, the free competition mechanism, which ensures the stability of the equilibrium. Thus, assuming constant returns to scale and free competition, the principle of factor substitution ensures (i) the derivation of a downward-sloping marginal productivity curve for all involved factors and (ii) a unique and stable equilibrium position.

Yet, the CCC proved the flaw in this logic. The very possibility of reswitching[8] (where the same technique could be chosen both for low and high interest rates, while another technique is chosen in between) implies the existence of a *positive* relationship between capital demand and the rate of interest (i.e., capital reversing). This means that the demand for capital may be either negative or positive with respect to the rate of interest, with probable multiple equilibria or extreme equilibrium values such as zero wages or zero interest (Garegnani 1970). Hence, the existence of alternative production techniques involving heterogeneous capital goods and the possibility for producers to cost-minimize together make production a function of both distribution and prices (Harcourt 1969; Garegnani 1966, 564) and not a univocal relationship, as is suggested by neoclassical theory.[9]

The existence of a non-monotonic relationship between changes in distribution and capital-intensities undermines the role of capital in neoclassical models from both the supply side and the demand side. The CCC show that the principle of substitution of scarce factors, which is the very foundation of the neoclassical theory, cannot incorporate variations in the means of production as are evident in the real world.

Risks and implications of long-run neoclassical models

Although the above CCC conclusions constitute a rare example of formally proven and undeniable results that should have led to a full reconsideration on the use of the marginal approach to the study of real-world economies, many neoclassical economists chose to ignore these lessons. One side of the neoclassical school (Samuelson 1966, 583; Ferguson 1969; Blaug 1974; among others) chose to diminish its impact on our understanding of productivity by arguing for its empirical irrelevance,[10] while the other side of the neoclassical school (Bliss 1970; Hahn 1972, 1974, 1975, 1982; Stiglitz 1974) chose to dispute the CCC results via the aggregate production function (APF).

The APF assumes that national output is produced *as if* it were a single good, both a consumption and capital good, produced by means of labor and of itself. This simplification for convenience ignores both that the production process requires the adoption of a bewildering variety of machines, software, patterns, and skills, and that one can only provide an inexact estimate of their value given such a variety of inputs (Harcourt 1969, 1972, 2001). Similarly, Garegnani (1966, 564) stated that "*the 'return' of a technique* [reswitching] *shows that any measure of capital intensity, even if it could be found, would lead to contradicting the principle of an inverse relationship between rate of interest and capital intensity*", and ensues that the aggregation of capital not only lacks an intuitive justification but is also mathematically inconsistent (Sraffa 1960; Garegnani 1976).

Despite the evidence brought into light by the CCC, a significant majority of the literature ignores these lessons (Kumbhakar and Lovell 2000). The reason for this continuance rests on the generalization of the APF in neoclassical growth models by Solow (1956, 1957) and Swan (1956), whose studies decompose total output growth into the weighted sum of three inputs: increases in labor quality, increases in the quantity of capital, and increases in the quantity of capital relative to increases in the quantity of labor, plus a component that cannot be explained by changes in inputs over time. This latter component is known either as the 'Solow residual' or 'technical progress' or 'total factor productivity' (TFP). Abramovitz (1956) and Solow (1956) defined the Solow residual as a measure of our ignorance, because it includes all that is left after the contributions of labor and capital are subtracted out, and Lipsey and Carlaw (2001, 39) argue that the residual is "as much a measure of our ignorance as it is a measure of anything positive."[11]

Empirically, the measurement of TFP has been operationalized by estimating a production function with the regression residual being interpreted primarily as a measure of innovation and/or technological change. This approach has been adopted empirically to measure TFP across a variety of sectors in the economy, from agricultural (e.g., Souza and Gomes 2015) to manufacturing (e.g., Jin, Zhao, and Kumbhakar 2019; Cave, Chaudhuri, and Kumbhakar 2023) to finance (e.g., Galán, Veiga, and Wiper 2015; Kai, Andrew, and Valentin 2018; Staub, D'Souza, and Tabak 2010; Zhang et al. 2015; Delis, Iosifidi, and Tsionas 2020). However, increases in TFP also respond to other types of economic change that improve efficiency which go beyond conventional understandings of innovation or technological changes; for instance, increases in productivity result from evolving labor market change from low-productivity rural jobs in mining to high-productivity finance jobs in cities.

Robinson (1953–54) criticized the use of a long-period APF to analyze processes of change, as adopted by Solow. Robinson's criticisms emphasize that the economic theory underpinning neoclassical growth models suffers from the fallacy of composition, i.e., that it is not accurate to construct macroeconomic or growth models that merely magnify the image of the micro universe, and then present that as a model of the macro sphere. The simple aggregation of individual production processes undertaken by a myriad of different producers does not deliver an understanding of the total production by society. Moreover, focus on the Solow residual fails to provide any knowledge or meaningful intuition regarding the relevance and importance of institutional frameworks, social relations, and demand factors, or their respective roles in productivity growth.

Given the issues brought to light by the CCC, it becomes apparent that the APF is not the foundation of neoclassical theory as the main purpose of the APF is to test empirically the marginalist theory. And yet according to Robinson, and echoed by Harcourt (1972, 8, 2001, 189), reswitching and capital reversing are the fundamental principles that highlight the logical flaws of neoclassical theory and all of its versions. Therefore, any discussion about productivity should be focused on the implications of reswitching and capital reversing, and any neoclassical economic model that measures productivity in terms of TFP are logically inconsistent and justifiably flawed. The widespread adoption and estimation of those models can only create a distraction that at best does not help deal with the understanding of real-world productivity issues and most likely poses a serious risk that leads to misleading conclusions and inappropriate policy formations.

The risks and implications of adopting long-run neoclassical models are numerous, with the following being those that arise from the conclusions of the CCC. First, measuring productivity in terms of TFP increases the risk of obtaining spurious conclusions such as that improvements in productivity arise uniquely from technical progress. While this could be a valid assumption for firms that operate on their technical frontier (Kumbhakar and Lovell 2000), in reality most firms operate somewhere below their technical frontier (Hwang, Lee, and Zhu 2016). One of the implications of the misleading conclusion that productivity growth arises uniquely from technical progress is that it makes it difficult to quantify the effects of potential drivers of variation in output among firms and industries other than technical change; these could include the effects of learning by doing, managerial practices, and/or the poor diffusion of technological knowledge (Kumbhakar and Lovell 2000; Hwang, Lee, and Zhu 2016) among others. In short, by focusing exclusively on TFP we neglect all other possible factors that have the potential to improve productivity, but for which data are not readily available.

Second, the measure of TFP as a residual from a regression model neither allows us to consider the nature of competition across product markets (and its impacts on allocative efficiency) nor allows us to consider the possibility that firms can operate on a proportion of the production function that exhibit non-constant returns to scale (Saint-Paul 1997; Kumbhakar, Parmeter, and Zelenyuk 2020). The implications of this conclusion are two-fold: first the approach fails to capture the impact on productivity of any deviation from a perfectly competitive setting, which of course is everywhere, and second it fails to identify which social, cultural, economic, and/or environmental factors may explain differences in productivity, and hence the approach cannot identify the actual sources of productivity differentials between and within industries (Griffell-Tatjé, Lovell, and Sickles 2018) or between countries and economies variously defined.

Third and finally, when considering the measurement of sector productivity, the existing framework fails to identify the component of productivity that drives positive or negative changes in output (Bean 2016). Although, this may ostensibly appear irrelevant when discussing productivity slowdown, it is indispensable because it directly affects the interpretation of the labor productivity ratio (Brynjolfsson, Rock, and Syverson 2018). For instance, after 2008 in the UK, sectors such as information and communications technology (ICT) and financial services recorded the largest fall in productivity (Riley, Rincon-Aznar, and Samek 2018) even though these industries' outputs are notoriously difficult to measure. Consequently, if sector productivity is not measured adequately then labor productivity (as measured by statistical offices) risks severe over- or under-estimation at the industry and/or business levels. The same logic can be extended when measuring productivity at the regional level, where adoption of faulty economic models risks impairing the development of more accurate measures of productivity that better reflect the industrial structure of any region.

The construction and standard interpretation of GVA data

Productivity figures vary across and within countries and industries, with some sub-national areas recording particularly low levels of productivity in the USA (Wu and Gopinath 2008), the UK (HM Treasury 2001), and Spain (Gómez-Antonio and Fingleton 2012). Measurement of the efficiency of production at the firm level is problematic because of the need to make a series of decisions to enable inter-firm comparisons. First, the analyst needs to decide whether to measure productivity in terms of volumes or values. Volume data make a clear link between the number of inputs and the number of outputs in some industries. For instance, for a vineyard, tonnes of grapes can be mapped onto the number of bottles of wine.

In other industries, however, the link between inputs and outputs is more problematic, such as the association between the number of hours of writing and redrafting a journal article and the number of accessed and read copies of that article.

Given these complexities, it has become conventional to conduct GVA productivity analyses using the monetary values of inputs and outputs. It is convention to calculate firm-level GVA figures by subtracting the market value of goods and services used up or transformed in the production process, such as raw materials or intermediate inputs, from total revenues. The compulsory collection of revenue and cost data, either directly through accounting returns for tax collection purposes or through the compulsory completion of Annual Business Surveys (often completed by a firm's accountants), provides analysts with data that enable the construction of firm-level GVA productivity figures. The resulting GVA productivity figure is a single (multi-digit) number on a one-dimension continuum. For instance, if a firm's total revenue is $50,000 and the total value of goods and services used up or transformed in the production process is $20,000, then the GVA figures is $30,000; this gap is not simply profit, as we detail later. If there are three workers within the firm, then the corresponding GVA per worker figure, which is an indication of labor productivity, would be $10,000.

The OECD (2001) advocates that measures of GVA productivity should focus on growth rates rather than levels to remove challenges of unit conversion and comparison. However, growth rates of variables are only useful if there is sufficient understanding of the forces that shape the level and effect the change in the underlying measure, and this is an area of contention covered in the next section of this paper.

In spite of all these complexities, adjustments, and pejorative concerns, it remains extremely common for empiricists and policymakers to rely on one-dimensional GVA productivity data to quantify levels and changes in levels of productive efficiency. Below we argue that GVA data are seriously misunderstood and misinterpreted, and we contend that GVA productivity data could be understood better using a two-dimensional representation.

Think 2D: toward a deeper understanding of productivity

Statistical data services from a range of countries including the US, UK,[12] Australia, New Zealand, Holland, and Germany provide secure data laboratories that facilitate the analysis of firm-level data and permit the creation of evidence-based studies designed to contribute to policy formulation. Firm-level datasets for research purposes are, without doubt, extremely useful and important sources of information, but Ehrlich et al. (2019, 443) voice the need for economists to dig deeper into our GVA productivity data by stating that "*the time is ripe for re-engineering the data collection and measurement of key economic indicators such as real output and inflation*." Although we agree with Ehrlich et al.'s sentiment, a crucial first step is to ensure that we reflect on what existing data actually show, and we respond to their claim by unpacking a GVA productivity figure into its constituent parts. In this section, we contend that GVA productivity data are understood better using a two-dimensional (2D) representation, and the details revealed herewith are consistent with the lessons of the CCC.

Firm-level GVA figures are calculated by subtracting the market value of goods and services used up or transformed in the production process from total revenues. Figure 1 presents our novel 2D representation of firm-level GVA data. Total revenue is the sum of the firm's receipts from its sales at the average sales price, *S*, multiplied by the number of units sold, *Q*, so total revenue is an area represented by *SAQO*, also known as turnover. The market value of goods and services used up or transformed in the production process is depicted by spreading these costs, *C*, across the number of units of sold, *Q*, shown by the rectangle *CBQO*. As firm-level GVA figures are calculated by subtracting area *CBQO* from *SAQO*, so firm-level GVA data reflect the *area* represented by *SABC*.

Measures of labor productivity, such as GVA per worker (GVApw) or GVA per hour worked, which are the focus of much interest and debate, are simply the division of the size of the area *SABC* by the number of full-time equivalent workers or the number of hours worked. The appropriateness of any denominator will depend on the bias that this introduces when comparing firms. Inter-firm differences in GVApw productivity figures will inevitably depend on the manager's preference for a particular choice of production techniques, such as the ratio of capital to labor, are likely to vary hugely across sectors, depending only in part on the state of technology, and are likely to vary over time, as emphasized in the CCC.[13]

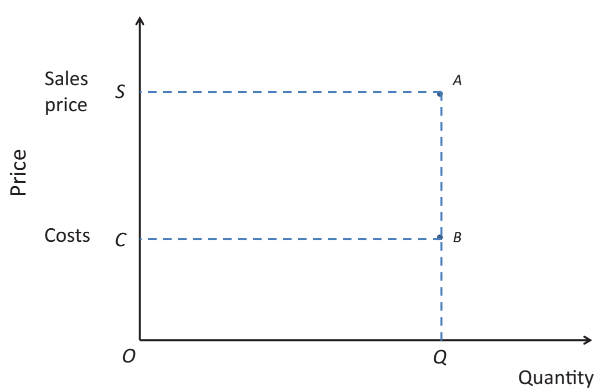

Figure 1. A 2D GVA representation.

Economists recognize that capital and labor are vital for both the creation of output and for driving up economic growth, even when the quality of these resources are endogenous. Capital depreciation, workers' wages, and net profits are all part of the GVA area, *SABC*, as shown in Figure 2, and are not part of the raw cost area, *CBQO*. Note that this Official Statistics measurement approach is entirely consistent with the perspective that good prices are anchored in the monetary-surplus production economy through administered prices (Means 1936), average cost pricing, or markup pricing. Each of these four areas can expand and contract over time due to contrasting power in the market while their respective areas vary enormously between firms. Indeed, the factors that determine good' prices may be distinctly different from the factors that determine output levels and change, or the factors that affect wages and employment levels and their evolution.

For illustration, Figure 3 highlights how the production costs of a pallet of yoghurt can be traced from the consumer back across the supply chain. Assume a dairy farmer has low direct costs relating to cows and their feed. To produce milk, the farmer uses their labor time and capital etc, and makes a net profit by selling their milk to the yoghurt producer for $120. Milk is the main raw input for the yoghurt producer, who adds their labor and capital etc, and makes a net profit by selling their yoghurt to the supermarket for $270. Finally, the supermarket, whose main direct cost is the yoghurt itself, employs labor and capital etc and makes a net profit by selling yoghurt to consumers for a combined total of $570. Note that different parts of the production process require different extra expenses, such as utilities, and these extra expenses are included in the rectangle marked 'Other'. Each of these three companies have different GVA figures with the dairy farmer, yoghurt producer, and supermarket recording GVA figures of $110, $150, and $300, respectively.

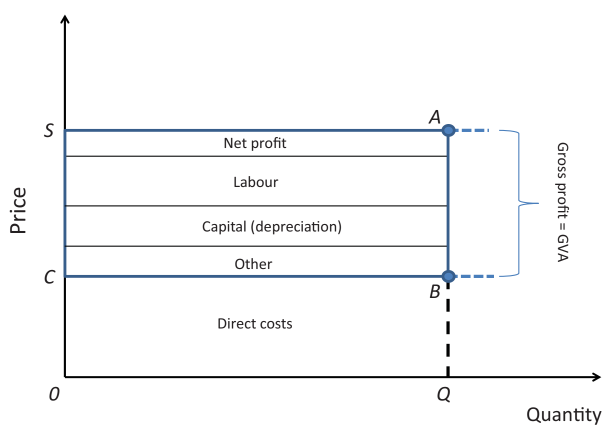

Figure 2. Splitting GVA into its component parts.

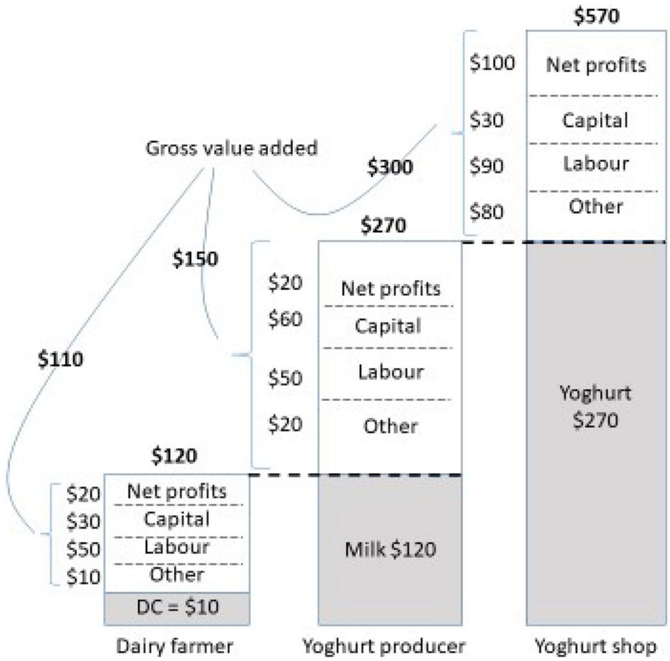

Figure 3. GVA figures across a supply chain.

Each segment in Figure 3 is in competition with other segments for a larger portion of the GVA area; similar forces occur across the whole economic system and reflect market power.[14] The net profit segment is under pressure to expand when firms need to pay dividends to shareholders, and if the GVA area, *SABC*, does not increase then the only way for net profits to increase is if the size of at least one contending area decreases. Labor unions fight to maintain their share of GVA by trying to ensure either stable or increasing employment and/or real wages, depending on the union's dominant strategy. Changes in the shares of GVA distributed to labor or capital often depend on the manager's choice of production techniques and can be shaped by social norms. It should be clear now that it would be wrong to simply aggregate all firms together and assume a long-period aggregate production function, which recall was the approach adopted by Solow, as this suffers from the fallacy of composition (Robinson 1953–54). Our next step is to explore a range of forces that lead to changes in the GVA area.

GVA growth in a 2D framework

When we embrace a 2D interpretation of GVA data then increases in area *SABC* occur due to a change in one, two, or all three of the following: a reduction in the market value of goods and services used up or transformed in the production process costs (*C*), increases in sale prices (*S*), or increases in the scale of production (*Q*). These three parameters change with or against each other, such that the total area of the GVA rectangle may remain unchanged when, for example, *Q* increases but *S* falls.

C could decrease for a wide range of reasons, such as through cost savings associated with offshoring or the exploitation of market power. Consider the managing director of a supermarket who wants to persuade customers that it is strongly price competitive and passes costs savings onto consumers. One way to increase its GVA figure is to pay dairies $0.1 less per liter of milk (as this would reduce *C*) while at the same time reducing the price of milk to its consumers by $0.05 (as this would reduce *S*). The overall effect of these two simultaneous changes is an increase in the GVA area irrespective of whether it is accompanied by a commensurate increase in *Q* that may result from advertisement of the supermarket's lower milk prices. The use of market power tends not to be integrated into empirical productivity regression models, but it is known to be prominent in the real world and this example illustrates one of its potential effect on GVA figures.

Post Keynesian theory, and particularly the Kaleckian perspective, tells us that the degree of concentration in any market is proportional to the level of profit markup and price, with trade associations and cartels regulating the amount of markup. However, firms make strategic decisions on price and profit margins to allow them to grow and expand over time (Melmiès 2015) regardless of the market structure in order to manage competition (Lee 2013). Lee's (1998) perspective that firms use variants of profit markup on costs and associated pricing policies, irrespective of the degree of market competition, is permissible under this framework too, but this reminds us that the *C* to *S* gap will vary from one firm to the next, perhaps also with the spread of profit margins across firms being greater at one part of the business cycle than at another. With the degree of market power (as well as the market structure) varying spatially, such as is the case with local monopolies, use of available national and industry-wide deflators to understand productivity may conceal important local contexts and dynamics. Further research is required to identify with greater clarity the extent that market power effects GVA productivity figures, whether the effect of market power on GVA productivity figures is increasing over time, and whether this change in greater in some countries than in others.

Recalling the yoghurt example above, one important aspect of this type of analysis is that the supply chain will have a clear spatial pattern. A yoghurt shop, located in an urban area to maximize passing trade and demand, could increase its GVA figure by using its market power to reduce the amount that it pays to the yoghurt manufacturer. The yoghurt manufacturer, located in an urban fringe distribution center to minimize logistical costs, could in turn maintain its profit margin by using its market power to reduce the price they pay to the dairy for milk, and that dairy will be located in a rural area. Following this logic, rural areas should have GVA figures that are lower than urban GVA figures even though the ratio of inputs to outputs–which is the traditional way of understanding productivity–may be unchanged.

Another way to increase GVA figures is to participate in shrinkflation, whereby *S* is kept constant while the size of the product, and hence *C*, is reduced. Confectionary companies have followed this strategy for many years: Horton (2017) provides examples that includes Terry's Chocolate Orange (shrunk from 175 g to 157 g), Toblerone (made lighter by increasing the size of the gap between the peaks), Maltesers (now selling in weights of 103 g rather than 121 g), the Quality Street selection box (from 1 kg of chocolates in 2011, to 870 g in 2012, to 780 g in 2014), Twix (reduced from 58 g to 50 g), Snickers (down 17% from 58 g to 48 g), and Dairy Milk (shrunk from 49 g to 45 g). In all these instances, the GVA productivity measure would have increased in spite of the customer receiving less for their money.

S could increase for a variety of reasons. Although an abundance of literature emphasizes that most businesses keep their prices fixed (Blinder 1991; Sheshinski and Weiss 1977; Mankiw 1985; Ball and Romer 1991; Cooper and John 1988; Stiglitz 1984; Azariadis 1975; Gordon 1974; Azariadis and Stiglitz 1983; Okun 1981; Fischer 1977; Taylor 1979; Stigler 1968; Lichtenstein and Burton 1989; Spence 1973; Stiglitz 1975), evidence suggests that some firms only increase their prices once they realize that competing firms charge more for the same product or decrease their prices if the manager does not want to be seen to be greedy (Webber et al. 2018). In some cases *S* depends on other factors, such as when estate agents charge a fee proportional to the price of the property sold, so when such firms service commuter areas of a wealthy city then their *S* will be large (and *C* will be small) and their GVA productivity figures would be very high in a boom when many properties change ownership.

An underappreciated issue in modern productivity analysis is that the level of demand for an individual good will be a function of (i) the level of aggregate demand and (ii) the level of demand specific for a firm's products or services. Kalecki's (1938/40) intuition that the price of a good is dependent on its elasticity of demand which is a function of the ratio of the good's price to the industry's price is significant here, such that changes in a firm's price is positively associated with changes in the industry price. There are collective agreements for increases in industry prices (such as for oil via OPEC and OPEC+) that increase their GVA productivity figures. Note however that demand is especially important here, with industries with inelastic (elastic) demand increasing (decreasing) GVA figures when prices go up.

One ploy used by firms to encourage expenditure is to promote status-related conspicuous consumption to justify higher prices (Veblen 1899), such as functionally equivalent sunglasses only differentiated according to the name appended to a plastic rim. Psychological pricing points (Kahneman and Tversky 1979) whereby firms increase prices until they are marginally under a threshold (e.g., $99.99) convey the impression that the firm is trying hard to keep prices low even when the firm could sell the product at a much lower price. Fractional pricing (e.g., $137.31) is commonplace and used to give consumers the impression that the firm is pricing the good as low as possible even though again it may be able to charge a lower price. These marketing issues question the exactitude of estimates of the price elasticity of demand for psychological reasons. Persuasive marketing and advertising, discussed by Galbraith (1958) as a system of want creation, makes a direct positive link between production and wants. Each of these considerations lead to the conclusions that increases in *value* added can be due to increases in S even though such adjustments do not improve the efficiency of producing a *volume* of outputs given a set of inputs. Although in practice the total volume of inputs used and outputs produced are likely to be loosely positively associated with turnover and value added, assuming that they are functionally equivalent is both naïve and misleading for policy formation. Recognizing the importance of firms' demand-influencing strategies and integrating them into the (supply-sided) analyses of productivity should necessarily change the discourse regarding the dogged focus on productivity as a government policy.[15]

The other way that the $SABC$ area can change is if Q changes. Syverson (2004, 1217) contends that demand density has an identifiable effect on productivity which is distinct from the influence of market size. Indeed the total revenue area, S, is recognized in mainstream market analyses to reflect the position of the demand curve because point A lies on the demand curve. In practice, product demand responds to fashion trends, persuasive advertising, and demand management (Galbraith 1958, 1964), complementarity and substitute goods, increases in the feeling of wealth (the opposite to austerity measures), and/or population growth through hikes in fertility, falls in death rates, and positive net immigration. Q will reduce and GVA productivity growth will be measurable low or even negative when, ceteris paribus, population size and trade reduce. GVA is the sum of potential productivity and demand excess/shortage, and there is always a demand aspect to this apparent supply-side measure, but the importance of the demand side for GVA measurement only becomes diagrammatically obvious when we adopt this 2D perspective.

So what?

The traditional (one-dimensional) and 2D understandings of GVA productivity data are decisively different because they stimulate different ways of thinking about productivity and lead to different, nuanced policy recommendations. Consider Figure 4, which presents depictions of two firms that have identical GVA figures (2D area = 1D figure). In the upper panel, firm A charges a high sales price, incurs low costs and has low sales volume; this could relate to a specialist product that requires highly skilled workers, such as the Morgan automobile company which confers exclusivity and status and has more production stages in-house relative to competing brands. In the lower panel, firm B has a smaller gap between *C* and *S* albeit with high sales volumes, perhaps due to the use of highly efficient automated production lines, and this firm could mass-produce automobiles.[16] Without comprehending the 2D context, it would be understandable to infer the same policy recommendations from one-dimensional GVA figures; this would be erroneous because the responsiveness of demand to price changes would differ between the two goods. The 2D representation of GVA data reveals shortcomings of a blanket policy aimed at improving GVA and provides a nuanced understanding that could explain why some government strategies to enhance GVA productivity figures have had questionable rates of success.

Conceptualizing GVA figures using the 2D approach permits an analysis shown in Figure 5, where the vertical axis captures the ratio of the sales price to the average cost of goods and services used up or transformed in

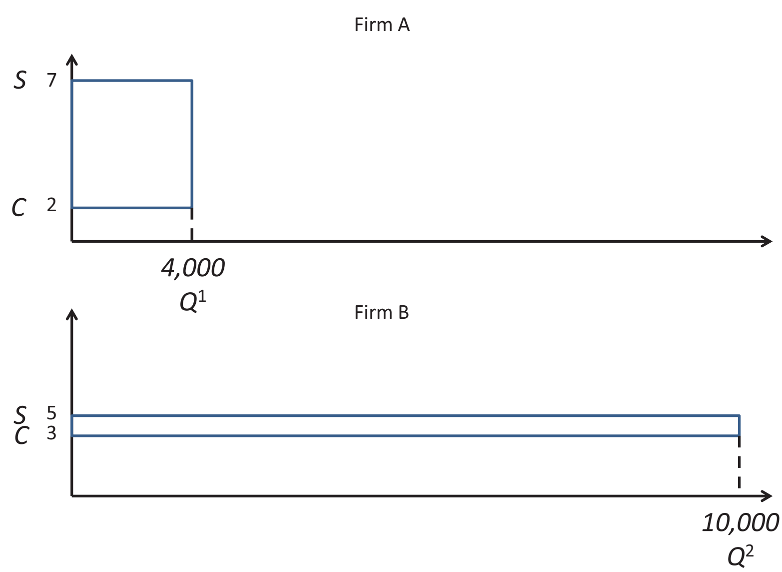

Figure 4. Two very different firms with identical one-dimensional GVA figures.

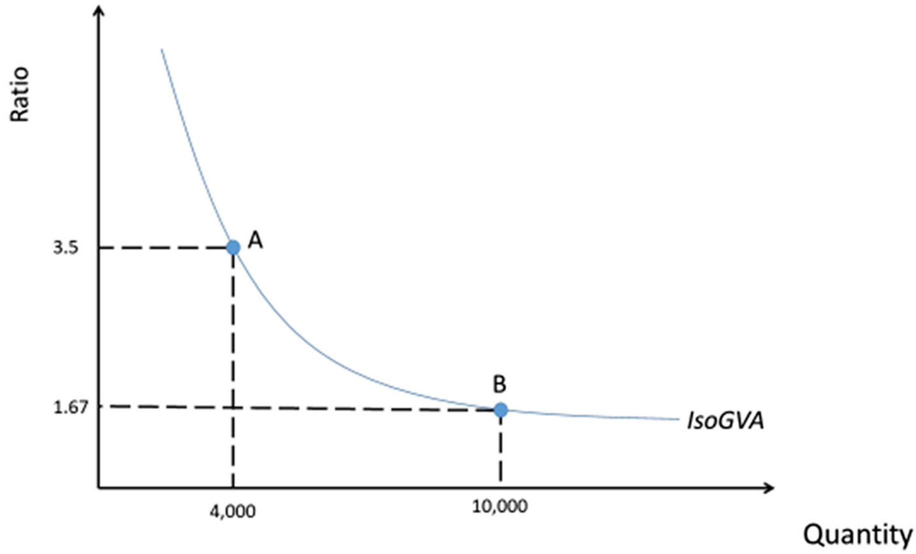

Figure 5. An isoGVA.

the production process, and the horizontal axis corresponds to the quantity of output. Firms with identical GVA figures lie along a single *isoGVA* line. Firm A, which Figure 4 reveals has a quantity of sales equal to 4,000, has a ratio of S to C of 3.5 (= 7/2). Two issues reveal themselves as being crucial for the determination of GVA values, which are the scale of production and the gap between S and C, and this is consistent with Shapiro and Sawyer's analysis (2003). Policy designed to enhance GVA figures need to recognize that different firms along the *isoGVA* curve should receive different external business advice. For instance, firms higher up and to the left on an *isoGVA* curve are more likely to produce items associated with status related conspicuous consumption aspects of demand, since the high price conveys prestige, and the low quantity conveys exclusivity (Veblen 1899). Conversely, firms producing goods down to the right on the *isoGVA* curve are likely to be producing necessities or homogenous products (or even conformity related conspicuous consumption, Veblen 1899), since the high output and low C to S markup would make the product more accessible to consumers.[17] So, although many countries experience 'long tails' in their firm-level GVA productivity distributions (Haldane 2018). Figure 5 illustrates that there is no one-size-fits-all policy to rectify this problem, though these nuances would have been missed using a standard 1D understanding of GVA figures. Instead, firms need to play to their strengths, with some firms increasing their scale of production and others increasing their C to S markup; whether either of these is possible will depend on their own market conditions and their ability of consumers to exercise their demand. Thus a firm's ability to achieve an increase in GVA is not solely a function of supply side issues, since the success of either GVA enhancing policy depends on the demand for the products, as reflected in the total revenue part of GVA and reflected in *Q*.

Much of the neoclassical productivity discussion focuses on factor substitution, human capital, technology, and sometimes deal with endogenous relationships. Although there is a demand side implicit in that narrative, it is conventional for the supply-side to have prominence. It is crucial to recognize that GVA figures have a clear demand side component, especially as the discourse limits how people think and articulate productivity ideas (Trowler 2001) and constrains and regulates what we perceive and how we respond to new knowledge (Wodak 2006), events, and contexts.

Returning to the productivity puzzle

Many national statistical agencies reveal a flattening of the trend in their GVA growth figures since the start of the GFC. The debate surrounding the "productivity problem", which describes a flat-lining of country-level GVA productivity figures since 2007, leads some to conclude that something is amiss and that the rate of conversion of inputs into outputs is now, temporarily at least, following a different pattern. ONS (2017) calculates that if the pre-2008 trend growth rate had continued then output per hour in 2015 would have been 8 percent higher in Germany, 9 percent higher in the US, 14 percent higher in France, and 18 percent higher in the UK. Authors have put the reason for these productivity gaps down to a lack of investment and a lack of proper appreciation of intangibles (Goodridge, Haskel, and Wallis 2018), a lack of willingness by managers to shed workers after a fall in their output (Martin and Rowthorn 2012), the impact of the financial crisis on the willingness of banks to lend to businesses and the persistence of zombie firms (Bloom and van Reenen 2007), and a lack of business investment due to expectations of slow increases in demand (Bloom, Sadun, and Van Reenen 2013), much of which is consistent with the neoclassical understanding of productivity.[18] Others suggest that the flat-lining of productivity figures is embedded in the dispirited narrative of widespread stagnation, depressed demand, and underinvestment (Summers 2018), problems in the highly integrated global financial system (Tooze 2018), or issues of governance (Dymski 2020). An alternative explanation lies in our understandings and interpretations of GVA figures, and just because a string of data is readily available does not necessarily mean that it reflects what we want it to.

Drawing on the above conceptual foundations, we argue that resolving the productivity problem requires a better understanding of the complexity of economies as social systems, and that the productivity problem therein demands dynamic and reflexive government interventions. These interventions need to embrace the multidimensional and interdependent nature of policies affecting productivity, and the variety of causes and contexts in which productivity problems persist. The CCC proved neoclassical models of production and distribution cannot be extended to encompass the multidimensional and interdependent nature of policies and contexts affecting productivity; thus, such an approach cannot be appropriate for understanding and dealing with the influence of sets of conditions or used as the backbone to advice policymakers.

Instead, we need an alternative and innovative approach to understand productivity and growth that is focused on real world conditions. For example, policy measures to address the productivity gap due to poor diffusion of technological innovation must be different from policies needed to address efficiency gaps due to poor managerial practices or the presence of diseconomies of scale (Griffell-Tatjé, Lovell, and Sickles 2018). Productivity policy is therefore more than the coordination of policy areas (silos), it is about the government capacity to respond to dynamic economic challenges (systems) that change over time and vary in relation to the actions of individuals, industries, and social economies. Notwithstanding neoclassical productivity models, our novel way of thinking about productivity allows for such an integrated analysis.

Interpreting GVA figures using a 2D format clarifies that there is always a demand side element to this apparent supply side measure. Many countries have populations experiencing lower levels of confidence, severe austerity measures, and high levels of uncertainty (particularly relating to job insecurity), all of which influence consumers' effective demand and firms' investment decisions. Research needs to recognize whether productivity growth is currently relatively slow because market power is increasing, competition is falling, or if Q has been shifting to the right at a slower rate. If Q has been static since the GFC, then the flatlining of productivity suggests that the markup between C and S also has been relative static on average across firms. This may be a concern to Post Keynesians as we tend to see associations between investment and the profit markup (albeit with profit markups having origins detached from the market; Lee 2011), although that makes assumptions about the change in the other components of the 2D GVA area too.

Falling real wages during and following the GFC reduced aggregate demand (OECD 2016) while underconsumption flattens output growth and causes recessions (Hobson 1910). Another possible reason for the flatlining in productivity, which is consistent with the ideas of Steindl (1945), is that profits may be high enough in oligopolistic industries with strong market power to allow firms to reduce investment, thereby reducing technical progress and stagnating the economy.[19] The 2D approach is a structure that can be used to evaluate Baran and Sweeny's (1966) perspective that economic surplus tends to rise overtime with big businesses setting high prices and maintaining sales through effective advertising while competing by cutting costs. However, as recessions put pressure on consumers to reduce their status related conspicuous spending (Ordabayeva, Goldstein, and Chandon 2010) and foster a sense of solidarity (Putnam 2007), some firms may have both largely abstained from increasing prices, *S*, and refrained from putting downward pressure on their suppliers' prices, *C*, both of which may have been reflected in low inflation rates during the 2010s. Of course, different products experience changes in their prices at different rates, as was observed by Adam Smith (1776), and should be integrated into productivity analyses building on the CCC.

GVA figures reflect the ability of firms within an economy to create added value, and slower increases in GVA figures are likely to reflect three things. First, a reluctance or an inability to increase *S*, which can be due to a range of issues not least implicit contracts (Azariadis 1975; Azariadis and Stiglitz 1983; Gordon 1974; Okun 1981) or monopoly capitalism (Baran and Sweeny 1966). Second, a reluctance or an inability to reduce *C*, such as when nominal contracts are involved between firms and their suppliers (Fischer 1977; Taylor 1979). Third, stagnating levels of sales, *Q*, due to low aggregate demand growth associated with greater job uncertainty throughout the slow economic recovery, perhaps due to austerity measures. Efforts to enhance GVA figures, divided or not by a labor input indicator such as hours of work to generate a labor productivity indicator, should have a clear focus on the roles of effective demand.

Demand-led growth theories suggest that increases in GVA productivity can stem from increases in wages, in which case the labor share of GVA would need to increase initially (Lavoie and Stockhammer 2013) albeit at the expense of other segments of GVA. The 2D approach illustrates that the association between GVA growth and wage growth are impure because increases in workers' wages will increase consumer demand and that will shift *Q* outward. The 2D approach illustrates that the link between higher wages (that are not at a cost to the returns to other factors of production) and higher GVA must be associated with either higher *S* or greater *Q*.[20] Policymakers interested in stimulating GVA productivity growth should pay greater attention to the need to stimulate domestic demand, facilitate and encourage overseas demand for domestically produced products, and be more cognizant of the adverse effects on demand that policies, such as austerity, have on GVA productivity.

Further research using this 2D GVA productivity approach could identify whether austerity measures have been the foremost determinant of the flat-lining of GVA productivity figures. Unfortunately, academic researchers and policymakers tend to have access to firm-level data sets that only include data for the total amount of revenue (S^*Q) and the total value of goods and services used up or transformed in the production process (C^*Q), rather than any of the specific base values of Q, S, or C. It is crucial for academic researchers and policymakers interested in influencing the productivity debate to have access to data containing at least one of these three parameters, Q, S or C, as otherwise evidence-based policy will continue to be grounded on 1D GVA figures and will continue to ignore the lessons of the CCC thereby basing their understanding of the drivers of productivity on guesswork.

Conclusion

This article argued that the standard one-dimensional representation of GVA productivity figures is deficient because it ignores important information dealing with markup and scale of production. Researchers interested in understanding more fully the determinants of GVA productivity figures must have access to data on sale prices, costs, and the scale of production in order to provide useful policy recommendations. This would also enable a deeper understanding of the dynamics of the growth and gain a deeper understanding of errors made due to the fallacy of composition.

Long ago the Cambridge Capital Controversies was won by scholars in Cambridge, England, and yet the neoclassical framework continues to be the basis for growth modeling and the formulation of economic plans. There have been calls for the need to look at alternative ways of thinking about and measuring productivity, and this paper has proposed an innovative approach grounded on information about sale prices, costs, and the scale of production.

The OECD (2001) claims that measures of one-dimensional aggregate productivity change should be the focus of measurement and comparison. However, a two-dimensional representation of firm-level GVA figures illustrates that a one-dimensional focus blurs most of the information on how and why GVA figures evolve. Economic models are there to improve understanding, illustrate a point, and offer guidance to policymakers. Adopting a two-dimensional understanding of GVA productivity figures creates a step-change in our understanding of firm-level productivity.

The simplicity of our 2D GVA productivity model permits deeper analysis while simultaneously emphasizing deficiencies in the existing literature. Demand is at the core of productivity figures, and GVA figures are not merely a reflection of supply-side issues but also a reflection of changes in demand. This argument leads to the conclusion that some policies that inevitably affect demand, such as austerity measures and policies to stem net immigration, will inevitably reduce the rate of increase of GVA figures, and this will stunt the rate of growth of workers' wages.

This article also offered an explanation of the spatial productivity puzzle. Local policies to enhance GVA productivity figures should be cognizant of the local effects of low levels of demand, supply chain effects, and unfavorable socioeconomic and institutional forces that curtail the growth of GVA. Future research into the determinants of productivity and its change needs access to sale price, cost, and the scale of production data in order to progress and gain empirical support for the theoretical ideas presented herein.

Notes

1. Gordon (2016, 537–550) asserts that in the aftermath of War World II households' 'pent-up demand' was the economic miracle that rescued the American economy from the secular stagnation of the late 1930s. Gordon's analysis also shows that the shrinking of real wages after the mid-1970s was consistent with rising inequality over the past three decades. Both cases provide relevant evidence of the crucial role that aggregate demand played in the rise and fall of American growth in the past century and corroborates the need to explicitly recognise the influence of aggregate demand in productivity models.
2. The CCC is also known as the 'reswitching and capital reversing debate'. Due to economies of space, we define as Cambridge, England, protagonists Joan Robinson, Kaldor, and Pasinetti. However, we acknowledge that Sraffa's contributions were also vital to this debate. From the other side of the debate, Cambridge, America, we define Samuelson and Solow of M.I.T. as their protagonists.
3. Champernowne (1953/1954) was the first to discuss reswitching and capital reversing. Champernowne proved that a hidden assumption in the neoclassical analysis of production was the cause of the anomalies that had not been predicted by the model. He also clarified that the anomalies were only present when using a comparative-static model to describe processes over time.
4. See Walras (1926 [1954], 278–312, Lessons 23–28).
5. See Harcourt (1969, 1972, 1976, and 2001) for a detailed review of the CCC's contributions.
6. The neoclassical aggregate production function, constructed by means of labour and capital, assumes that national output is produced as if it were a single good, such that the form of capital is a means of consumption and, simultaneously, a production good.
7. Robinson (1970, 315) critically commented on this feature: "When the neo-neoclassicals reconstituted orthodoxy after the Keynesian revolution, they went to Walras, who does not have a theory of profits at all".
8. Reswitching expresses producers' tendency to switch from one capital-intense technique to another. Specifically, when exposed to alternative techniques and low interest rates, producers are prompted to adopt the more capital-intensive technique to minimise production costs and maximise profits. Any rise in interest rates leads producers to choose (switching) less capital-intensive techniques due to cost-minimisation, leading the economy to a lower quantity of capital per worker. It

follows that any further rise in interest rates leads producers to change technique again (reswitching) and choose the less capital-intensive alternative.

9. Despite Samuleson and Levhari's attempts to show that reswitching can arise only for single industries and not for the whole economy (Levhari 1965), the CCC proved that the very possibility that producers can choose the same technique both for low and high interest rates, while another technique is chosen in between (reswitching), undermines the principle of factor substitution. The preferred technique is thus one that yields the highest wages for any given interest rate over all its plausible values. Switches occur when the costs are equal in both techniques.
10. Ferguson (1969, xvii) stated "[…] its importance is an empirical matter that depends upon the amount of substitutability there is in the system. Until the econometricians have the answer for us, placing reliance upon neo-classical economic theory is a matter of faith".
11. Metcalfe (1987) and Griliches (1995) voice further concerns about the use and measurement of multi-factor productivity.
12. The UK uses a firm-level productivity measure called Approximate Gross Value Added (aGVA). In contrast to GVA, data for aGVA come from the firm-level Annual Business Survey (ABS) rather than the National Accounts. While more detailed at the firm level, this measure includes firms from fewer sectors and collectively captures approximately ¾ of the economy (Ayoubkhani 2014).
13. Differences in the choice of production techniques among firms may be behind Rigby and Essletzbichler's (2006) observation of strong asymmetries in measured productivity levels even within small geographical market areas.
14. For a connected discussion, see Weintraub (1981).
15. The sweeping adjustments for inflation in estimates of productivity models misses the point because it provides a veil of sophistication that price changes have been integrated sufficiently into the modelling process when in fact such an approach misses the importance of industrial power struggles, as emphasised in the literature on conflict inflation (see Summa and Serrano 2018).
16. Of course, although the amount of GVA is the same across these two firms, corresponding GVA per worker figures could be very different depending on the number of full-time equivalent workers that are conditional on managerial preferences for a particular choice of production technique, and which emphasises the importance of the CCC discussed above. For instance, robotised production lines in mass-production car factories would have very different GVA per worker productivity figures than corresponding figures in factories where automobiles are hand-built.
17. Future research should assess whether public sector organisations are located closer to *b*. The nature of public and merit goods could make it not socially acceptable to increase the *C* to *S* mark-up.
18. The OECD produced a "Measuring Productivity Manual" (OECD 2001) that summarises alternative formulations of productivity. The lack of international consistency of productivity measurement rationalizes the work of the World KLEMS Initiative, which promotes and facilitates the analysis of growth and productivity patterns around the world using a growth accounting framework. Macro-type productivity analyses use data in constant prices to factor out inflation in input and output prices, and hence any increase in outputs not attributable to an increase in inputs is thought to reflect productivity growth.
19. Steindl's (1945) work on the mature economy takes account of the effects of oligopolistic firms' actions on its big competitors and vice versa. With price

competition shunned, excess capacity dampens the decision to invest. Sunk costs and market power lead to risk aversion rather than aggressive price competition. Moreover, indebtedness influences the decision to invest profits and savings and creates hesitancy to extend borrowing. To Steindl, these factors lead to a marked tendency for slower growth and for stagnation.

20. This assumes there is inter-temporal redistribution.

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