Competition and the Sraffa-Keynes synthesis: intersecting research themes inspired by the work of Sraffa

Graham White
School of Economics
University of Sydney*

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Abstract

The paper explores the intersection of three lines of enquiry all inspired by the work of Sraffa, although not explored by Sraffa himself. The first relates to the dynamic processes which may be supposed to limit profit rate differentials and hence render stable equilibria characterised by a uniform profit rate. The second concerns itself with the explanation of the quantities taken as given in the Sraffa system and the related issue of fusing together a classical-Sraffian inspired explanation of relative prices and distribution and a long-run demand-led explanation of aggregate activity. The third and relatively unexplored line of enquiry relates to the broad field of competition and the relevance for a Sraffian approach of traditional concepts such as 'firm', 'industry' or of firm/market structures in the explanation of the rate of profit and relative prices. As a means of exploring the interconnections between these three areas of research, the paper embodies them in a simple simulation model and considers the significance of these interconnections for the system's dynamics.

* *Address for correspondence*: School of Economics, University of Sydney, NSW, 2006, Australia.
Email: g.white@sydney.edu.au

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1. **Introduction**

The purpose of the present paper is to explore the intersection of three lines of enquiry all inspired by the work of Sraffa, although not explored by Sraffa himself. The first, and perhaps most explored by later writers is the subject of gravitation, specifically, the dynamics processes which may be supposed to limit profit rate differentials and render stable equilibria characterised by a uniform profit rate. The second and less explored line of enquiry and which might loosely be referred to as the Sraffa-Keynes synthesis concerns itself with the explanation of the quantities taken as given in the Sraffa system. More generally it deals with the issue of fusing together a classical-Sraffian inspired explanation of relative prices and distribution and a long-run demand-led explanation of aggregate activity.

A third and relatively unexplored line of enquiry, like the first, also relates to the broad field of competition – though it's connection with Sraffa and the resurrection of classical political economy starts not with gravitation but instead with the question of the relevance for a Sraffian approach of concepts such as 'firm', 'industry' or of firm/market structures in the explanation of the rate of profit and thus relative prices. Perhaps the most intriguing attempt to shed light on this issue was the work of James Clifton (1977, 1983) which suggests that the rise to dominance of the multi-product, multi-divisional corporation of the twentieth century provides the main real world conduit by which the tendencies implicit in Sraffa's assumption of a uniform rate of profit are expressed in modern capitalism.

The key intersecting theme between the latter line of enquiry and the first line of enquiry is about the best way of representing the cross-dual dynamics explored extensively in the gravitation literature. The work of Clifton and Semmler (1984) together with insights on corporate pricing from heterodox writers such as Eichner, suggests a somewhat different representation of these dynamics. In particular, the ultimate goal suggested by these works is the maximisation of growth of the profit flow for the corporate entity; and that this is achieved via changes in the structure of corporate entity's overall production across different industries much more directly than is implied by models of cross-dual dynamics.

This discussion in turns carries with it an interesting implication in relation to the second of the above-mentioned lines of enquiry – the Sraffa-Keynes synthesis. The first relates to the debate between Sraffians and post-Keynesians/Kaleckians over the influence of the rate of growth on the rate of profit of the Sraffa system. The present paper suggests that expectations of faster growth could only influence rates of profit to the extent that the multi-divisional corporate entities are not adjusting their composition to structural changes in the economy. In other words the contention that the rate of growth determines the rate of profit seems to be a disequilibrium phenomena and not necessarily applicable to the general rate of profit of the Sraffa system.

The paper attempts to facilitate discussion of these themes in part through a relatively simplified simulation model which incorporates a version of cross-dual dynamics, bearing in mind insights from each of these three lines of inquiry. The model is a multi-commodity one; where growth and expectations about future growth are driven by growth in autonomous demand for at least one of the commodities. This assumption reflects a key feature of literature on synthesising the Sraffian model and a long-run version of Keynes's principle of effective demand. The "firm" is assumed to be a multi-divisional corporation expanding and contracting divisions in line with changes in expected sectoral growth rates. The paper considers the adaptation of industry structure and relative sectoral

rates of return – including gravitation around a uniform rate - to changes in the rate of growth of autonomous demand.

2. Three intersecting research themes inspired by Sraffa's *Production of Commodities*

(i) Gravitation and the stability of the Sraffian price system

As noted above, out of the three areas of interest in this paper, probably the most explored is the issue of gravitation and associated questions about the stability of the Sraffian price system. Within the research in this area, one of the least explored question concerns the relation between so-called classical and Keynesian dynamics. In particular, the former has been primarily represented in the form of cross-dual dynamics (i.e. prices responding to quantities, in turn influencing profit rates, the latter feeding back on quantities). The latter (Keynesian) set of dynamics, to the extent it features in the gravitation models, has been cast as a form of "dual dynamics" (i.e. quantities such as outputs, investment responding to quantity imbalances). A number of models of "composite dynamics" bringing together both cross-dual and dual sets of dynamics have also been developed within the literature (*cf*. Caminati and Petri, 1990).

Our interest in this paper is particularly with the representation the Keynesian perspective within the literature on gravitation in Sraffian inspired models. This perspective is seen as being captured by quantities responding to quantities, e.g. outputs responding to a demand signals, either directly or in the form of undesired falls in inventories and or in terms of investment demand responding to variations in capacity utilization, or a combination of both kinds of adjustments.

From a Keynesian perspective – particularly, the literature on the Sraffa-Keynes synthesis - The problem is that these models for the most part have tended to treat Keynesian adjustment as an exclusively short-term equilibration by quantities; this being rationalised by reference to short-run price/wage sluggishness (White, 1996b)[1]. As such, this literature has in places cultivated (or at least not disputed) a view not unlike the one of marginalism since Keynes regarding the essence of the Keynesian insight.

Whatever the merits of assuming such a response in order to characterise disequilibrium in the short-run, this is arguably unsatisfactory as a characterisation of Keynes's insights, particularly for those who maintain that those insights, specifically the independence of investment in relation to saving, are no less applicable to the long-run as they are to the short-run (Garegnani, 1977). If one accepts this latter view the challenge for integrating Keynesian insights into gravitation models is one of having both a "classical" and "Keynesian" long-run: classical in the sense of relative prices being anchored by the tendency of competition to eliminate profit rate differentials; Keynesian in the adjustment of capacity along a demand-driven growth path. This task is discussed further below.

One other feature of the gravitation literature of particular interest for the present paper concerns the determination of prices at any point in time; specifically, whether prices respond directly to excess demands in each period, or are set so as to achieve a target rate of return, where the latter may be influenced itself in some measure by excess demands. In models of cross-dual dynamics, if profit rate differentials lead to intersectoral capital mobility, in terms of differential rates of growth of capacity relative to demand between sectors, this mobility feeds back on those profit rate differentials. The question here is the precise nature of this feedback: for the most part it is via

[1] While investment decisions are arguably not short-run, making them dependent on variations of utilization around normal (e.g. Dumenil and Levy, 1985) does tend to push them into the short-run (*cf*. White, *ibid*., pp. 26-29).

changes in excess demands (brought about by intersectoral capital mobility) affecting relative prices directly.

If, however, prices are set so as to achieve a target rate of return (assuming these target rates represent the "relevant" profit rates), the question is how the intersectoral mobility feeds back on target rates of return. This has been explored to a limited extent within the gravitation literature, most notably by Boggio (1985), which allows for a long-run influence of excess demands on target rates of return. This avenue is explored further in the current paper, in the simulation model outlined in section 3 below, reflecting in part some of the insights associated with the third area of Sraffian-inspired research on competition, discussed below.

(ii) The Sraffa-Keynes "synthesis"

The term "Sraffa-Keynes" synthesis refers here to a body of work emerging out of the 1980's and focused at one level on the explanation of the quantities taken as given in Sraffa's *Production of Commodities* and the role that Keynes's principle of effective demand might play in such an explanation (e.g. Vianello, 1985, Ciccone, 1986, Committeri, 1986, Kurz, 1986, White, 1989). Perhaps a more accurate way of describing the research agenda at the heart of this literature is that it has been directed at constructing a long-run version of the principle of effective demand, which may be fused with a Sraffian approach to relative prices and distribution.

One of the questions which emerged early on in this literature was whether the Sraffian price system implied a particular degree of capacity utilization; a degree which could be taken to represent the "full-adjustment' of productive capacity to expected demand conditions within each sector. Related to this were three further questions. The first related to the precise determinants of a "normal" rate of capacity utilization, this being the rate implied by the rate of profit of relevance in the Sraffa system. The second question concerned the relation between movements of actual in relation to normal utilization and the extent to which these movements were indicative of a lack of "full-adjustment" of capacity to demand. The third question concerned the relation between the aggregate adaptation of capacity to demand (and its implications for the movement of actual relative to normal utilization) and the gravitation process "behind the scenes" as it were, in the Sraffian model; whereby capacity adjusted between sectors so as to generate a uniform rate of profit.

The first of these questions was relatively uncontroversial, while the second question was less so. In particular, debate has continued sporadically on the issue of whether the full-adjustment of capacity to demand is inconsistent with a divergence between long-run realised utilization rates and the normal rate (Cesaratto et. al. 2003, Palumbo and Trezzini, 2003, Serrano 1996, Trezzini, 1996, 1998,).

It is the third question which is of most relevance for the present paper. From early on in this literature, the position has been put that gravitation of actual in relation to normal utilization – even as an expression of the full-adjustment of capacity to demand – is not analogous to the process by which relative prices gravitate in relation to normal prices. Indeed that position would suggest that these two processes, while not unrelated, are distinct and will take place with different timing (Ciccone, 1996).[2]

[2] There is an analogy it seems between the position in question and the separability of the explanations of relative prices and distribution on the one hand and the explanation of output on the other hand to be found in the work of the classical economists; a separability emphasised by Garegnani (*cf*. 1984).

Yet the question remains as to the precise connection between the two processes of adjustment. Specifically, the dynamic processes highlighted in the gravitation literature entail adjustment in the relative size of (outputs, and by implication) sectoral capacities in relation to the sectoral pattern of demand in response to profit rate differentials. The long-run version of Keynes's principle of effective demand at the heart of literature on the Sraffa-Keynes synthesis entails adjustment in the aggregate level of capacity in relation to demand, as an expression of the long-run adaptation of saving to investment. Clearly, the former involves adjustment in the composition of aggregate productive capacity while the latter involves adjustment in its level or rate of growth.

It is useful at this point to note an early remark by Garegnani in relation to the two processes in question: "The meaning of "long-run" cannot but be partly different when used in connection with a theory of aggregate output than when it is used for the theory of relative output. … what is relevant for Marshall is the lack of congruence between relative demand and relative capacity in the several industries. What is relevant for the theory of aggregate output like that of Keynes is the lack of congruence between aggregate capacity and aggregate demand …. a long-period analysis of aggregate output … is one and the same thing as a theory of accumulation"(Note 2, Preface to Eatwell and Milgate, 1983).

In this quotation, Garegnani seems to be suggesting that one could in principle consider the issue of adjustment of relative capacities and relative demands in a situation of full-employment and thus independently (at least from a non-marginalist standpoint) of the issue the adjustment of aggregate demand and aggregate capacity. Hence it appears that the question of how the two processes relate to one another is a legitimate one.

The significance of this last point for the present paper lies in the implication that the study of the adjustment of aggregate capacity in line with aggregate output is a study of accumulation as well as the contours of the ensuing discussion about a "Keynesian" view of accumulation and one which would be consistent with a classical-Sraffian approach to prices and distribution. That view of accumulation has distinguished itself from the traditional post-Keynesian approach in emphasising the independence of the rate of profit from the rate of growth; while also emphasising the role of the autonomous components of demand.

In this view of accumulation, adjustment's in the economy's long-run growth rate to changes in the rate of growth of autonomous demand will occur via changes (in the opposite direction) in the ratio of autonomous demand to income (Trezzini, 1996, White, 2006).

How this view of accumulation at the aggregate level might intersect with the cross-dual dynamics associated with studies of gravitation suggests some interesting possibilities. Since the gravitation process involves the adjustment of capacity to demand in response to differential profit rates, the most obvious possibility is that the associated cross-dual dynamics are represented as a process which regulates the extent to which full-adjustment of capacity to demand is achieved within given sector. Alternatively put, full-adjustment is arguably not easily defined independently of assumptions about profit rates. It is conceivably possible that capacity could expand beyond or fall short of the full-adjusted level (defined by the aggregate investment decisions appropriate to expected demand conditions for existing producers within a sector) depending on how profit rates compare across sectors. In other words, a sector with a higher than average rate of profit may experience a growth of capacity faster than expected demand and conversely for a sector with a lower than average rate of profit.

This way of looking at gravitation does provide a means of putting in a setting which allows for not only a "classical" long-run, but also a Keynesian long-run analysis of the long-run Keynesian

adjustment of capacity to demand. It does however also suggest that gravitation in some sense will act as a perturbation in the long-run Keynesian adjustment. The interesting question in this regard is whether the gravitation process facilitates or impedes the process of full-adjustment of capacity to demand.

Part of the answer to this last question and hence precisely how the cross-dual process relates to the long-run adjustment of capacity to demand at the aggregate level is the nature of intersectoral competition and its role in adjusting the composition of capacity to the composition of demand. It is here that the third area of Sraffian-inspired research may provide some insight.

(iii) Competition and a classical-Sraffian approach

As mentioned in the Introduction, this third area of research is relatively unexplored compared with the first two. It is concerned with the precise meaning of competition in a classical-Sraffian approach and with the place for concepts such as the firm and industry within such an approach. In the view of the author, the most intriguing work in this regard has been that of Clifton (1977, 1983), Semmler (1984) and, working within the traditional post-Keynesian framework, Eichner (1983, 1991).

As suggested in White (2014), the insights of these writers taken together lead one to the proposition that if the concept of the firm has any relevance to a classical-Sraffian approach it is arguably in the form of the multi-division corporation dominating the twentieth century. Drawing on the arguments of Clifton and Eichner in particular[3] one is lead to the view that "the multi-product, multi-divisional corporation as a decision making body reinforces the tendencies which are implied in the assumption of a uniform rate of profit in the Sraffa system. Put another way, the multi-product, multi-divisional corporation provides the main conduit by which the tendencies implicit in Sraffa's assumption of a uniform rate of profit are expressed in modern capitalism" (*ibid*., p. 6).[4]

Yet, if one is prepared to accept that the multi-divisional corporation represents the appropriate version of the "firm" in a classical-Sraffian view of competition, this in turn raises some interesting questions about the nature of intersectoral capital mobility; particularly in view of the literature about corporate strategies. That literature suggests that the goal of the corporation is one of maximising the growth in the flow of profit over time. Critical to this is the ability of the corporation to allocate the corporate surplus for investments in a manner which allows where possible the corporation to restructure its production activities in line with the anticipated growth rates of the fastest growing sectors of the economy. In turn this means either increasing market share in industries which are expected to decline relative to the rest of the economy or shunting resources (profit) away from investment in these sectors towards investment in faster growth sectors.

In this view, intersectoral capital mobility might just as well be represented as an allocation based on anticipated long-run growth rates as it is on profit rates. In fact, as is argued in White, 2014, the corporate entity, if indeed its goal is to maximise the rate of growth in its profit flow, would be guided by both relative growth rates and the pattern of anticipated profit rates. Accordingly, for the purposes of the simulation exercises discussed below, both the pattern of growth rates and the pattern of profit rates are considered separately and in combination as the relevant signal guiding decisions about intersectoral capital mobility.

[3] But also writers such as Shapiro (1981), Glick and Ochoa (1988).

[4] In fact, the notion that a corporate head office may be an mechanism responsible for the allocation of capital across sectors, though not made explicit, seems very close to the representation of capital mobility in Dumenil and Levy (1985).

3. Demand-led growth and competition: a simulation model

We consider a relatively simplified model which can be simulated and which incorporates the two key ideas highlighted in the discussion of the previous section, viz., that long-run growth is governed by the growth rate of autonomous demand; and that competition manifests itself in terms of the growth of capacity relative to demand differing between sectors according to perceptions of future growth and future profitability.

The model is in the spirit of that used by Dumenil and Levy (1985). It models a three commodity economy producing a fixed capital good, circulating capital good and pure consumption good. Production of all three commodities requires labour, circulating capital and fixed capital. We also treat time similarly to Dumenil and Levy in their model, by assumed production takes time and occurs during the period, while demand is expressed on markets in the junction between two periods. Output in each period for each sector is assumed to be a simple function of expected demand and thus based on the most recently observed level of demand and the expected growth rate of demand. Inventories of finished goods are ignored for simplicity as are possible shortages of labour. With regard to consumption it is assumed that all wages are spent on the consumption good, but only part of profit flow, so that saving arises entirely out of profit.

Apart from consumption and investment (discussed below) demand, the only other component of demand is autonomous. The paper does not speculate on the origin of this autonomous demand, whether it arises from households, government or the foreign sector, other than to make the assumption that the only autonomous component of demand is for the consumption good.

(i) *Investment and intersectoral capital mobility*

The critical feature of the model is of course investment and its modelling in such a way as to combine the above two key ideas. It is assumed that in the absence of considerations about profitability of production between individual sectors, investment in each sector at the end of each production period would be that required to bring capacity up to a level sufficient to generate an output equal to anticipated demand at the end of the next production period, assuming that capacity is operated at a normal rate of capacity utilization. One could refer to this as the “full-adjusted’ level of investment. Over time of course, investment equal to the fully-adjusted level would imply that capacity grows at the same rate as demand is expected to grow.

When one brings into play considerations of differential profitability between sectors, the actual investment undertaken in any sector may be more or less than the fully-adjusted investment. It is assumed that where profitability is deemed to be above-average, investment will be greater than the fully-adjusted amount and conversely where the profitability is deemed to be below-average.

Two aspects of this formulation need to be clarified further. The first concerns precisely how much investment varies in relation to the fully-adjusted level where profitability is seen to be above or below-average. The second concerns precisely how “profitability” is assessed. With regard to the first aspect, it is necessary to begin with to explain how the expected growth rate of demand is determined. At the end of each period for each sector the expected rate of growth of demand (and hence, given the most recently observed demand level, the expected demand level at the end of the next period) is determined by reference to both realised growth rates for the sector in question over a number of past periods and the expected growth rate of autonomous demand. More precisely the expected growth rate is a weighted average of a long-run moving average growth rate for the sector

and the expected autonomous rate of growth of autonomous demand.[5] Since the growth rate of autonomous demand is assumed constant, the reference to autonomous demand growth in the calculation of expected growth rates acts as a stabilizing force on expected growth rates.

The effect of differential profitability on sectoral investments makes use of the difference between the expected growth rate of demand described above and the long-run average for a sector, without any reference to the rate of growth of autonomous demand. In particular, for the sector deemed to be most profitable, investment demand at the end of the relevant period is based on whichever is the maximum of these two growth rates. For the most part, since consideration of autonomous demand acts as a stabilizing force on expected growth rates, the "maximum" growth rate will be equal to the long-run average growth rate for the sector without any reference to autonomous demand. Hence, for the most part, investment in the most profitable sector will expand capacity beyond the level it would have achieved without any consideration of differential profitabilities.

So what of the least profitable sector? It is assumed that the additional investment – beyond the fully-adjusted level – in the most profitable sector is funded at least in part via the depreciation allowances of the least profitable sector. More precisely, it is assumed that the investment in the least profitable sector is equal to the fully-adjusted investment less an amount transferred to the most profitable sector. The latter amount is the minimum of the value of the excess over the fully-adjusted investment in the most profitable sector and the value of the depreciation allowances in the least profitable sector. Hence in a growing economy, the least profitable sector will see a growth rate of capacity lower than the expected rate of growth of demand, since at least part of worn out capacity in each period will not be replaced.[6]

As to the second aspect referred to above - how "profitability" is assessed – two alternative approaches are considered for the purposes of simulation. Bearing in mind the discussion in part (iii) of the previous section, if the relevant "firm" in one's view of competition is the multi-divisional corporation, the objective is the maximisation of the corporate profit flow. In this case, relative "profitablility" is as much about the anticipated growth rate in different sectors as it is about attainable rates of profit. Hence, for the purposes of simulation, one possibility is to assume that funds are "allocated" in the manner described in the preceding paragraph based on anticipated rates of growth of demand across the three sectors. In other words, this first possibility amounts to assuming that financial resources are allocated between sectors such that in the sector with the highest anticipated long-run growth rate, capacity expands faster than the expected growth rate of demand; hence capacity expands beyond the fully-adjusted level. Conversely, in what is perceived to be the slowest growing sector – in terms of expected long-run demand growth – some of its depreciation allowances are diverted towards investment in the fastest growing sector, so that capacity grows at a slower rate than anticipated demand.

A second possibility regarding the assessment of profitability is to use profit rates for this purpose. In this case, capacity grows faster than expected demand in the sector with the highest profit rate and conversely in the sector with the lowest profit rate. Of course, a third possibility is that "profitability" is assessed for the purpose of the allocation of financial resources for investment on the basis of

[5] This way of determining expectations about demand growth has been explored in White, 2006 and 2008.

[6] This approach of depreciation allowances of least profitable sectors effectively being channelled into investment in the most profitable sectors has been used by Dumenil and Levy (1985). It also seems to be particularly appropriate to a world where the dominant production unit belongs is one division in a multi-divisional corporation competing for shares in the corporate surplus.

both anticipated growth rates of demand and profit rates. Simulations were undertaken for all three possibilities.

(ii) *Prices and rates of profit*

As with the treatment of intersectoral capital mobility, the explanation of relative prices and rates of profit offers up different possibilities. Following on from the discussion of the previous section, the preferred approach in this paper is to assume that prices are set so as to generate a target rate of return at a normal rate of capacity utilization. In particular, it is assumed that the target rate of return in each sector is equal to a long-term interest rate (which are assumed given throughout the simulation exercises) and plus a margin. While the relevant long-term rate of interest is taken as given for the purposes of simulation, the margin between the rate of interest and the target rate of return is assumed to be influenced by long-term demand and supply conditions within the relevant sector. In particular, it is assumed that this margin waxes and wanes to an extent with views about the long-run growth of demand relative to capacity.

It is worth reflecting on how this compares with more standard model of cross-dual dynamics; where, as noted above, prices are influenced by excess demands in each period and in turn this feeds back on profit rates. In the present model the role for excess demand in the determination of relative prices is as a long-run influence in the form of anticipated long-run demand growth and the long-run rate of accumulation in the sector. But in the present model the impact of excess demands on prices is less direct than for most of the cross-dual dynamic literature; in that the direct impact of long-run excess demands is on the target rate of return thus indirectly impacting on relative prices.[7]

The role for excess demand as a short-run influence on prices is watered down even further in the present model in so far as it is assumed that prices are set so as to generate the target rate of return at normal utilization. Short-run differences in demand and supply generate short-run impacts on output in terms of variations in utilization around its normal rate, without impacting on prices. Hence prices respond only in so far as the target rate is adjusted and this is only to the degree that short-run demand and supply imbalances reflect long-run imbalances between expected demand and the scale of productive capacity. In the language of the literature on gravitation, the impact of excess demands in the short-run is primarily on quantities and thus the “dual” mechanism dominates.

(iii) *Cross-dual dynamics*

The nature of the cross-dual mechanism considered in this paper is thus somewhat different from the conception in most of the gravitation literature. Profit rates, considered as target rates of return respond to long-run movements of capacity relative to expected demand across sectors; while financial resources are allocated for investment on the basis of anticipated long-run growth rates of demand, at least in one of the variants of capital mobility considered here.

The process by which differentials in profit rates may be gradually eliminated is accordingly somewhat different from that of the standard cross-dual process. In the present case, a faster anticipated growth rate of demand stimulates a speeding up of capital accumulation relative to other sectors and relative to anticipated demand, without this being triggered by prior increases in the rate of profit relative to other profit rates, as is the case in most studies of gravitation. This

[7] In fact, this way of allowing excess demands to influence relative prices follows Boggio (1985), which is the exception within the gravitation literature.

speeding up of accumulation relative demand will nonetheless impact on that sector's rate of profit; uniformity of profit rates will require that capacity and anticipated demand grow at the same rate across sectors. In a sense, the process of profit rate equalization becomes less complex than that envisaged in models of cross-dual dynamics: that equalization is achieved gradually as misalignments between capacity and demand are resolved over time.

The other key difference between the present analysis and the gravitation literature relates to the assumption of target return pricing. As noted, changes in the growth of capacity relative to demand in sectors impact directly on target rates and in turn on prices rather than the reverse, as is the case in most models of cross-dual dynamics, viz., by influencing prices and in turn profit rates. This means in turn that the present analysis provides some way around the possibility that quantity imbalances affecting relative prices lead to perverse effects on profit rate differentials.[8]

In order to shed light on the differences between the present model and the standard view of cross-dual dynamics, the simulation exercises discussed below include cases where profit rate differentials rather than growth rate differentials are the key signal behind intersectoral capital mobility. The simulations also include cases corresponding to the standard version of cross-dual dynamics. In particular, where prices in each sector for each period are influenced by short-run excess demands, these relative price changes leading to changes in sectoral rates of profit. In this latter case, profit rate differentials guide decisions about intersectoral capital mobility.

4. Simulation results

(i) *Simulations without cross-dual dynamics*:

Graphical representation of the simulation results for the model outlined above is provided in the Appendix. As a control for simulations with intersectoral capital mobility, the model was initially simulated without such mobility. In particular, initial simulations assume that investment is in each sector is governed only by the expected growth rate of demand in that sector, without any reference to growth rates in other sectors, or without reference to profit rates between sectors. These initial simulations consider the system initially on or very close to its steady state growth path and impose a shock in the form a permanent increase in the rate of growth of autonomous demand.

The intention behind these initial simulations is to provide a clearer basis for determining the precise impact that the classical-Sraffian type cross-dual dynamics has, particularly on the aggregate behaviour of the system. These initial simulations also provide a check on the stability of the "multiplier-accelerator" interaction which effectively underpins the behaviour of the aggregate side of the model.

In the cases depicted in the Appendix, for each sector the average growth in the sector over a number of periods in the past and the rate of growth of autonomous demand are weighted equally in the calculation of the expected growth rate of demand on which investment decisions are based (see footnote 5 above).

[8] An example would be an increase (instead of a decrease) in the rate of profit relative to the average for the higher profit rate sector as it expands and pushes down the relative price of its output. This may arise because of the nature of the use of the commodity in question relative to its use in other sectors, being such that as its relative price falls this impacts sufficiently on its costs of production so that it does not adversely affect it profit rate relative to the average.

Figure 1 and Figures 2-4 show sectoral growth rates (of demand), sectoral profit rates, sectoral capital accumulation rates and relative price movements for the cases without and with intersectoral capital mobility respectively.

The most obvious feature of the non-mobility case is the stability of the growth path. Following the shock to the rate of growth of autonomous demand, sectoral rates of growth of demand and capacity converge on the new higher rate of growth of autonomous demand via a damped cycle. Since profit rates are assumed to be governed by expectations of demand growth *vis a vis* growth rates of capacity (section 3 above), there is movement in the aggregate level of profit rates as capacity growth rates vary in relation to demand across all sectors.

One also observes in this case changes in relative profit rates in the convergence to uniformity, though changes in the relative position of profit rates here do not reflect intersectoral capital mobility and thus the existence of a cross-dual dynamics common to the gravitation literature.[9] In fact the changing relative position of profit rates is between that of sectors 1 and 2 on the one hand and sector 3 on the other. Sector 3 produces fixed capital and for this reason tends to lead activity relative to the other two sectors. This explains the changing relative pattern of profit rates.

(ii) Simulations with intersectoral capital mobility

For the case of capital mobility, three different approaches are considered in the simulations. The first two assume that profit rates are governed directly by expectations about demand growth relative to the past growth in capacity in the relevant sector. These first two approaches differ however in relation to what drives the allocation of finance for investment: the first case considered assumes that this allocation is driven by relative expected growth rates of demand; while the second case assumes that this allocation is driven by relative sectoral rates of profit. Results for these two cases are depicted respectively in Figures 2 and 3.

(a) Capital mobility driven by expected growth rates

As discussed in section 3, capital mobility in this first case entails resources being shifted in such a way that capacity grows faster than expected demand in what is expected to be the fastest growth sector and less than expected demand in what is expected to be the slowest growing sector. Figure 2 actually depicts two sub-cases, which differ only in the degree to which the allocation of resources responds (to a lesser extent in panel (a), to a greater extent in panel (b)) to perceptions about differences between sectoral growth rates.

Most noticeable about the results for both sub-cases compared with the no-mobility case is the presence of the aggregate adjustment of capacity to demand; as the aggregate system adapts to the faster growth of autonomous demand. The gravitation process acts as a perturbation on this aggregate adjustment; with the impact on capacity growth and the profit rate clearly more

[9] It is perhaps useful to clarify at this point that the case without intersectoral capital mobility does not strictly entail its complete absence, in the sense of changes in relative size of sectoral capacities. By assumption, capacity is built up in each sector in response to expected growth in demand so that perceived differential growth rates of demand will automatically entail differential growth rates of capacity so that the relative size of sectoral capacities will change. What *is* absent in this case however is any reallocation of resources towards investment on the basis either of relative expected growth rates or relative rates of profit, *over and above* the above-mentioned adjustment of capacity in line with expected growth in demand. To use the terminology of section 3 above, the present case considers the investment in each sector and each period to be equal to the fully-adjusted investment, no more, no less.

pronounced, not surprisingly in the sector producing fixed capital (sector 3). A comparison of the two sub-cases does however suggest that where mobility is more responsive to growth rate differentials, the perturbation of the aggregate adjustment process is more pronounced.

(b) Capital mobility driven by profit rate differentials

Figure 3 provides analogous results to those of Figure 2 but for the case where the allocation of resources for investment is driven by profit rate differentials: capacity expands faster than demand is expected to grow in the highest profit rate sector and conversely in the lowest profit rate sector.

It is evident from a comparison of those results with those depicted in Figure 2 that having profit rates driving intersectoral mobility appears not to substantially alter the system's dynamics compared with the case where growth rates drive that mobility. This is perhaps not so surprising. As already noted, for both cases depicted in Figures 2 and 3, the profit rate moves in response to differences between expected demand growth and the realised trend in capacity; and the fastest growing sector experiences even faster growth in capacity. In the former case the faster growth will react back on the relevant profit rate as capacity expands relative to demand but this change in the profit rate does not directly feedback on the rate of growth of capacity in that sector.

In other words, in the former case, intersectoral capital mobility effectively means that where there are differential growth rates expected for demand, the process of fully-adjusting capacity is overshot and undershot in the fastest and slowest growing sectors respectively. The impact on relative profit rates is a "by-product" of that over and under-shooting as capacity moves relative to demand in different proportions between sectors.

The case examined in Figure 3 is closer to the typical cross-dual mechanism, where the overshooting or undershooting of sectoral capacity relative to demand is regulated via profit rate differentials. Hence a faster expected demand growth for a particular sector relative to other sectors need not elicit an expansion of capacity at a faster rate than demand is expected to grow; whether it does or not depends also on how fast capacity has been growing in that sector relative to demand, compared with other sectors; this being reflected in the pattern of profit rate differentials.

In a sense, the case depicted in Figure 3 differs from that of Figure 2, by bringing into to play much more directly a role for excess capacity in moderating the response of capacity growth to a faster growth of demand; and this role works through the pattern of profit rates being the key driver behind the allocation of resources for investment between sectors.

Worth noting also in respect of Figure 3, is that, just as in the case where growth rates of expected demand drive intersectoral mobility, the greater the responsiveness of mobility to sectoral differences (i.e. profit rate differentials for the case in Figure 3) the more pronounced are the perturbations to the process of aggregate capacity adapting to demand.

(iii) *Simulations with "traditional" cross-dual dynamics*

By way of comparison a further set of simulations were conducted with a version of the cross-dual mechanism much closer (than the cases discussed so far) to that of the gravitation literature. In this last case, intersectoral mobility is driven by profit rate differentials: in particular, for the sector with the highest rate of profit capacity expands at a faster rate than demand is expected to grow and conversely for the sector with the lowest profit rate.

The critical difference with the preceding case is that rates of profit are not interpreted in this last case as target rates of return, responding to differences in the growth of demand relative to capacity. Instead, prices are assumed to respond directly to excess demands and changes in relative prices then impact on the rate of profit (calculated at a normal rate of capacity utilization). Excess demands in this case are ex post and are calculated as the difference between realised demand and the expected demand levels on which production in each period is based.

The results of this final simulation exercise are depicted in Figure 4: the first panel showing the case without intersectoral capital mobility but with excess demand determined prices; while the subsequent two panels show results for cases where intersectoral mobility in response to profit rate differentials is allowed for. It is noteworthy first of all how the non-mobility cases compare i.e. the case depicted in Figure 1 - with profit rates governed by growth in demand relative of capacity and prices determined indirectly via changes in the target rate of return – with the present case. Both cases demonstrate stability in the steady state growth path defined by the rate of growth of autonomous demand; while the present case shows slightly lower amplitude in fluctuations and faster "convergence" to the new higher steady state growth rate.

This slightly greater stability is interesting since the only difference in the cases of Figure 1 and Figure 4(a) is the way in which the rate of profit and prices are determined. This suggests that determining prices directly by excess-demand and this indirectly affecting profit rates rather than allowing for long-run demand and supply imbalances to impact directly on target rates of return has a small stabilizing effect on the system's dynamics.

This may go some way towards explaining one other interesting feature of this last simulation exercise, viz., the lack of convergence in profit rates. In principle, this convergence should occur because of a faster capital accumulation relative to demand reducing excess demands and price in the higher profit rate sector and a slower capital accumulation relative to demand increasing excess demand and price in the low profit rate sector. However, at least for the model simulated here, the stability of the steady state growth rate and the gradual elimination of excess demands and supplies across all sectors appears to proceed sufficiently fast relative to the process by which profit rate differentials are eliminated. As such, the simulations suggest the possibility of growth rates of both capacity and demand converging on the new higher growth rate of autonomous demand before profit rate differentials are eliminated.

5. Concluding notes

The foregoing discussion has been intended to bring together themes arising out of three distinctly different (though not unrelated) areas of Sraffian-based research; and to reflect on the intersection of these themes by means of some relatively simplified simulation exercises. This model in particular has been constructed so as to highlight the interaction between the adaptation of aggregate capacity to an independently determined rate of growth of aggregate demand on the one hand and the adaptation of sectoral capacities to the sectoral pattern of demand emphasised in the literature on gravitation. It has also incorporated some of the implications about the nature of intersectoral capital mobility arising from the literature on corporate pricing and competition, viewed from a classical-Sraffian standpoint; most importantly, that this mobility might be driven as much by expected growth rates as it is by profit rate differentials.

Results from the simulation exercises at the very least suggest that the aggregate adjustment of capacity to demand and the sectoral adjustment might conceptually be thought of as distinct processes. These results however also suggest some caution in this regard; the usefulness of this distinction is obviously in question to the extent that the gravitation process in particular can

significantly impact of the aggregate adjustment of capacity to demand. The simulation results discussed in this paper, though preliminary, are at least suggestive of this possibility at least where the sectoral allocation of resources reacts strongly to either differentials in growth rates or differentials in profit rates.

The simulation results also suggest that, at least where the sectoral allocation of resources is thought of in terms of capacity expanding faster or slower than expected demand, whether that allocation responds directly to differentials in expected growth rates of demand or differentials in profit rates does not appear to significantly alter the system's dynamics.

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Appendix

Figure 1:

Once-over increase in the rate of growth of autonomous demand:
<u>without</u> intersectoral capital mobility

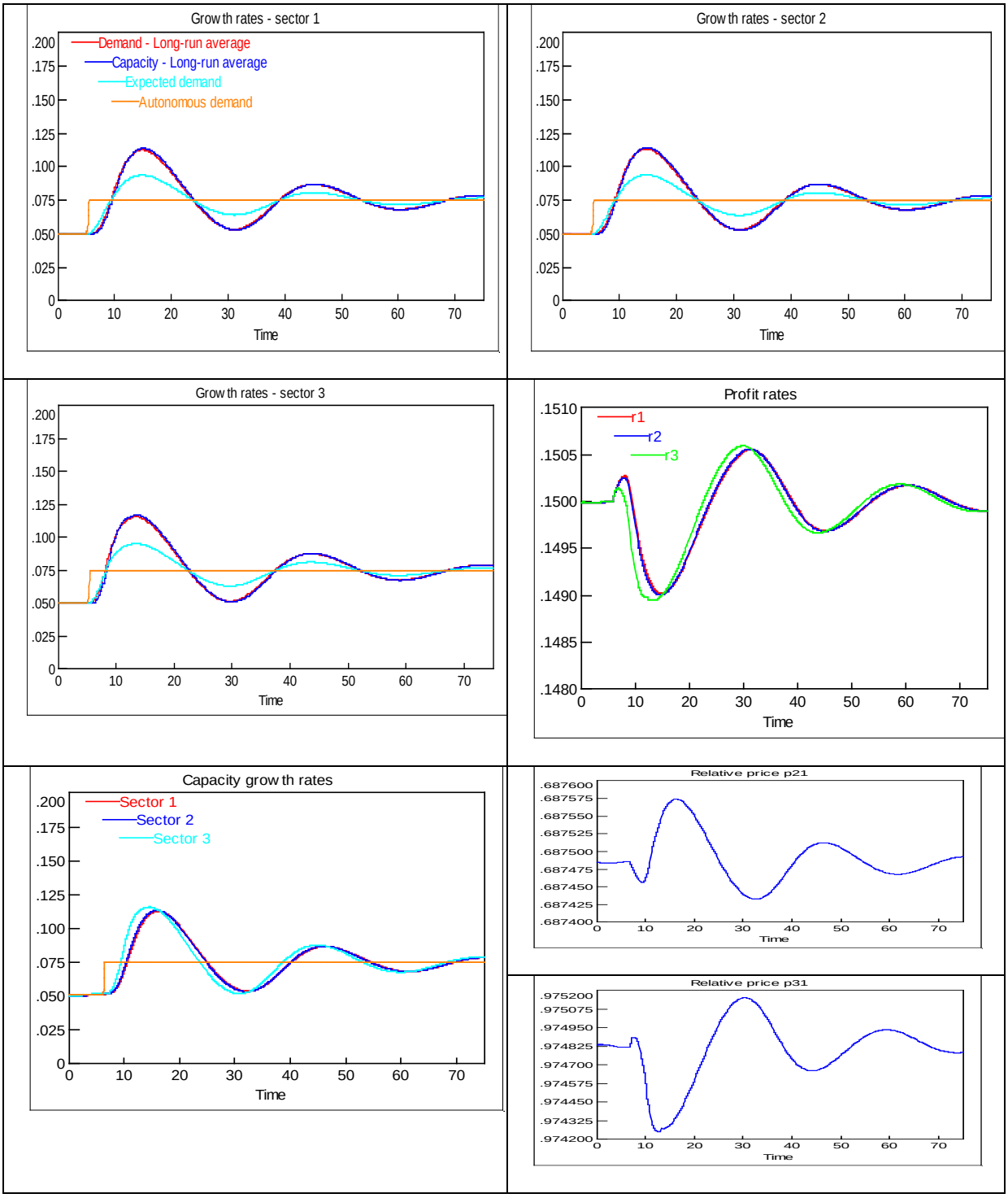

Figure 2: (a)

Once-over increase in the rate of growth of autonomous demand: intersectoral capital mobility triggered by growth rate differentials

(a) lower response (ζ= 1)

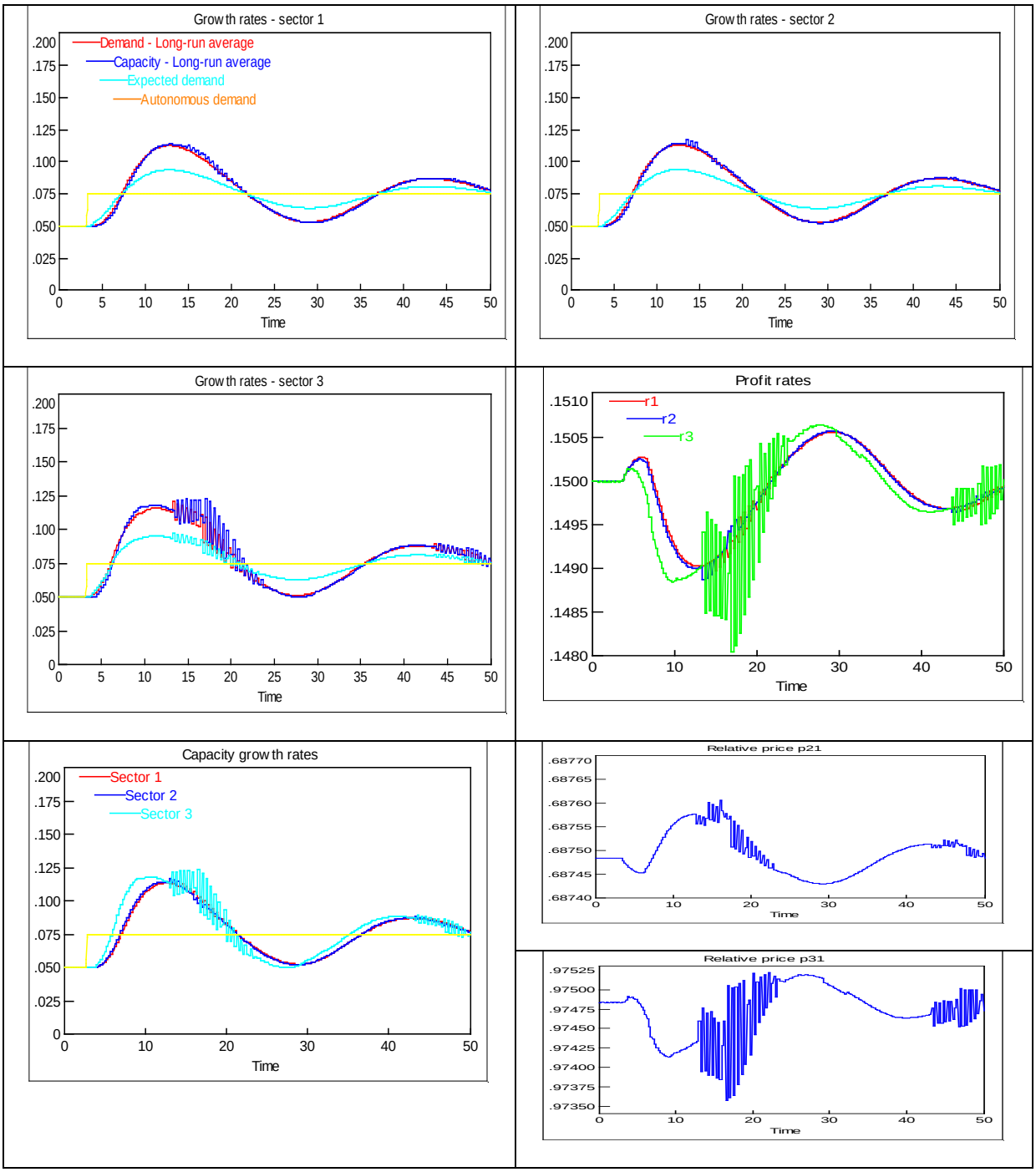

Figure 2: (b)

Once-over increase in the rate of growth of autonomous demand:
intersectoral capital mobility triggered by growth rate differentials (b) higher response (ζ = 1.5)

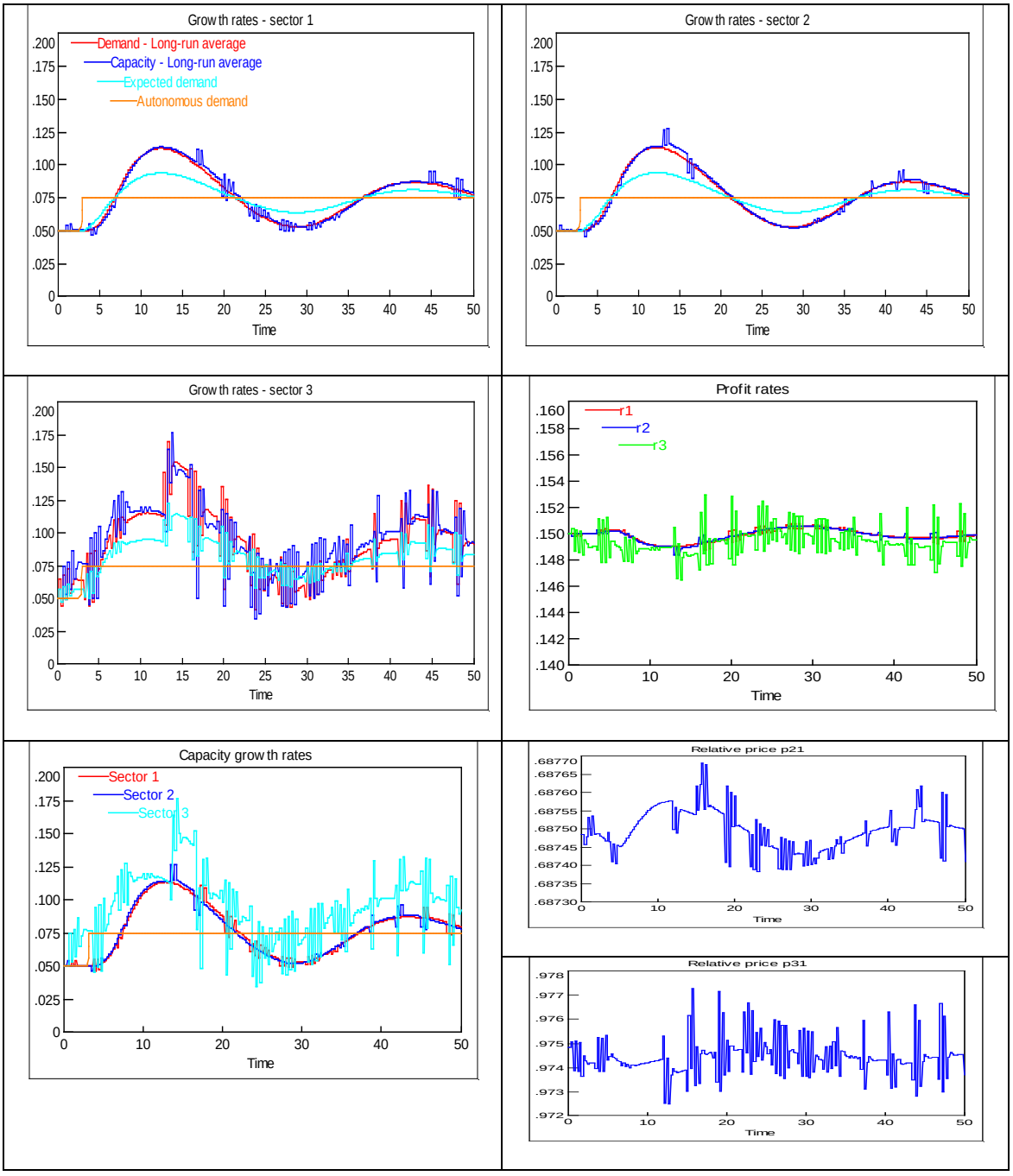

Figure 3 (a)

Once-over increase in the rate of growth of autonomous demand:
intersectoral capital mobility triggered by profit rate differentials (a) lower response (ζ_5= 1)

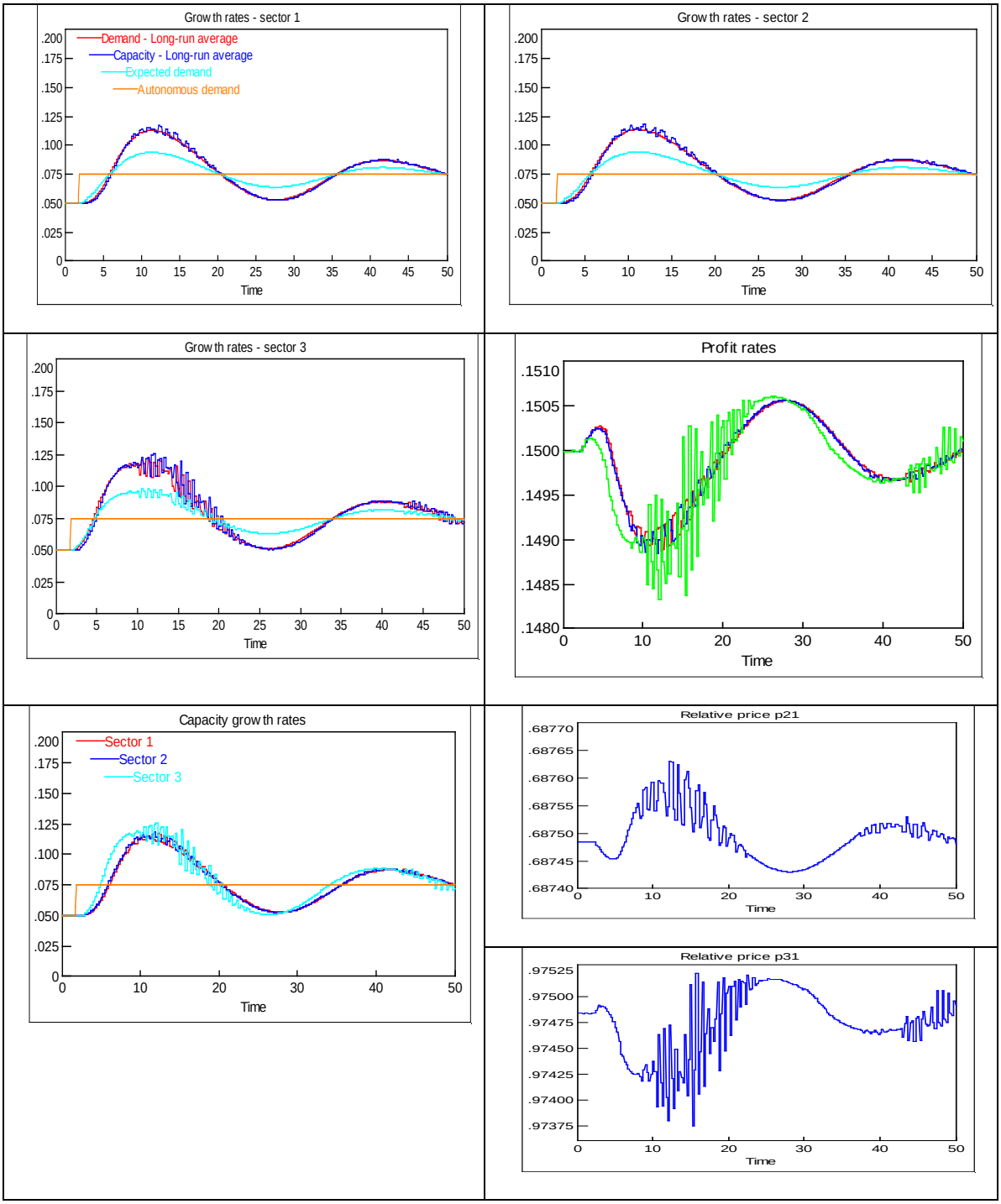

Figure 3: (b)

Once-over increase in the rate of growth of autonomous demand:
intersectoral capital mobility triggered by profit rate differentials (b) higher response (ζ= 1.5)

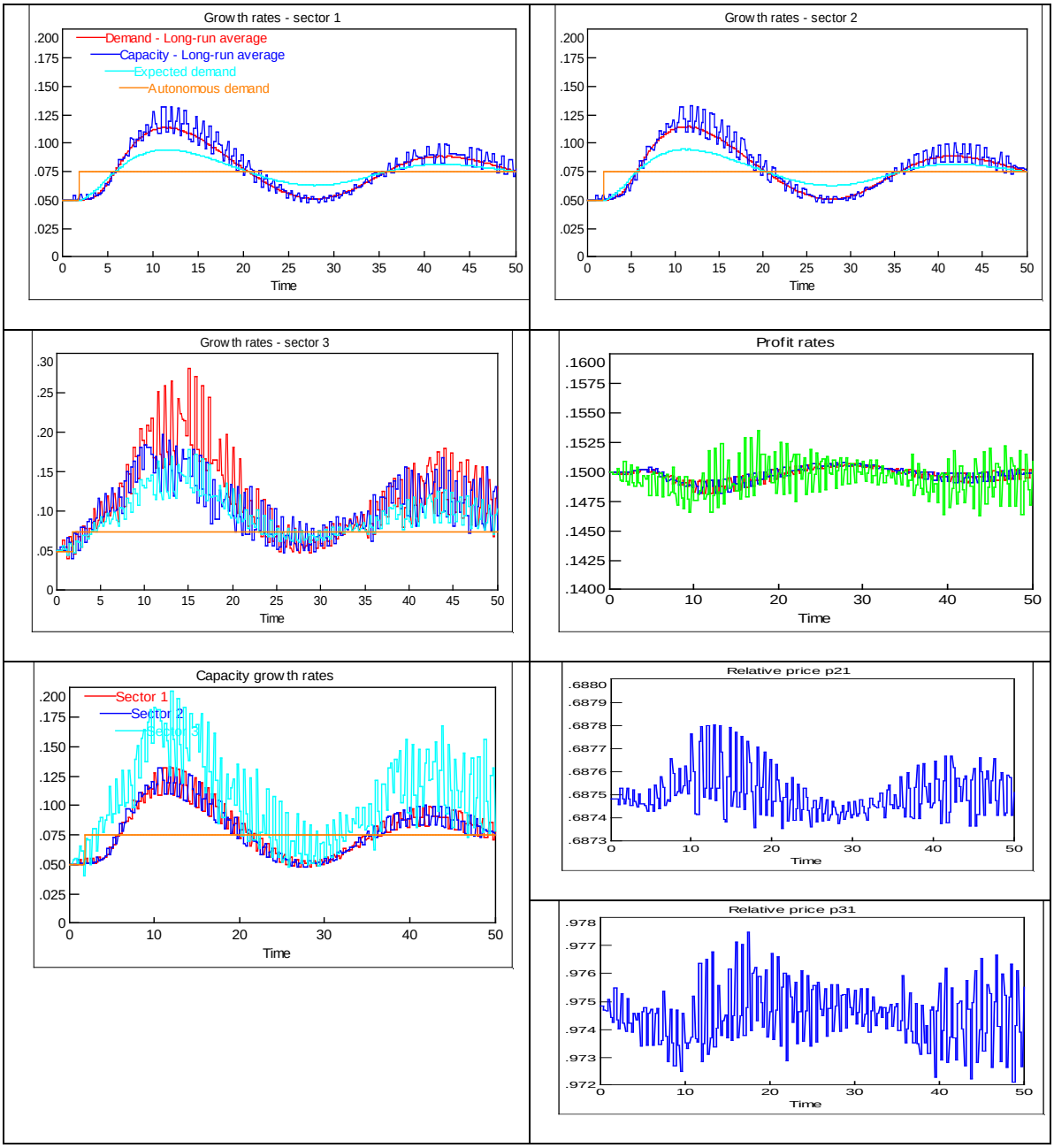

Figure 4 (a)

Once-over increase in the rate of growth of autonomous demand: <u>without</u> intersectoral capital mobility; but <u>excess demand determined prices</u>

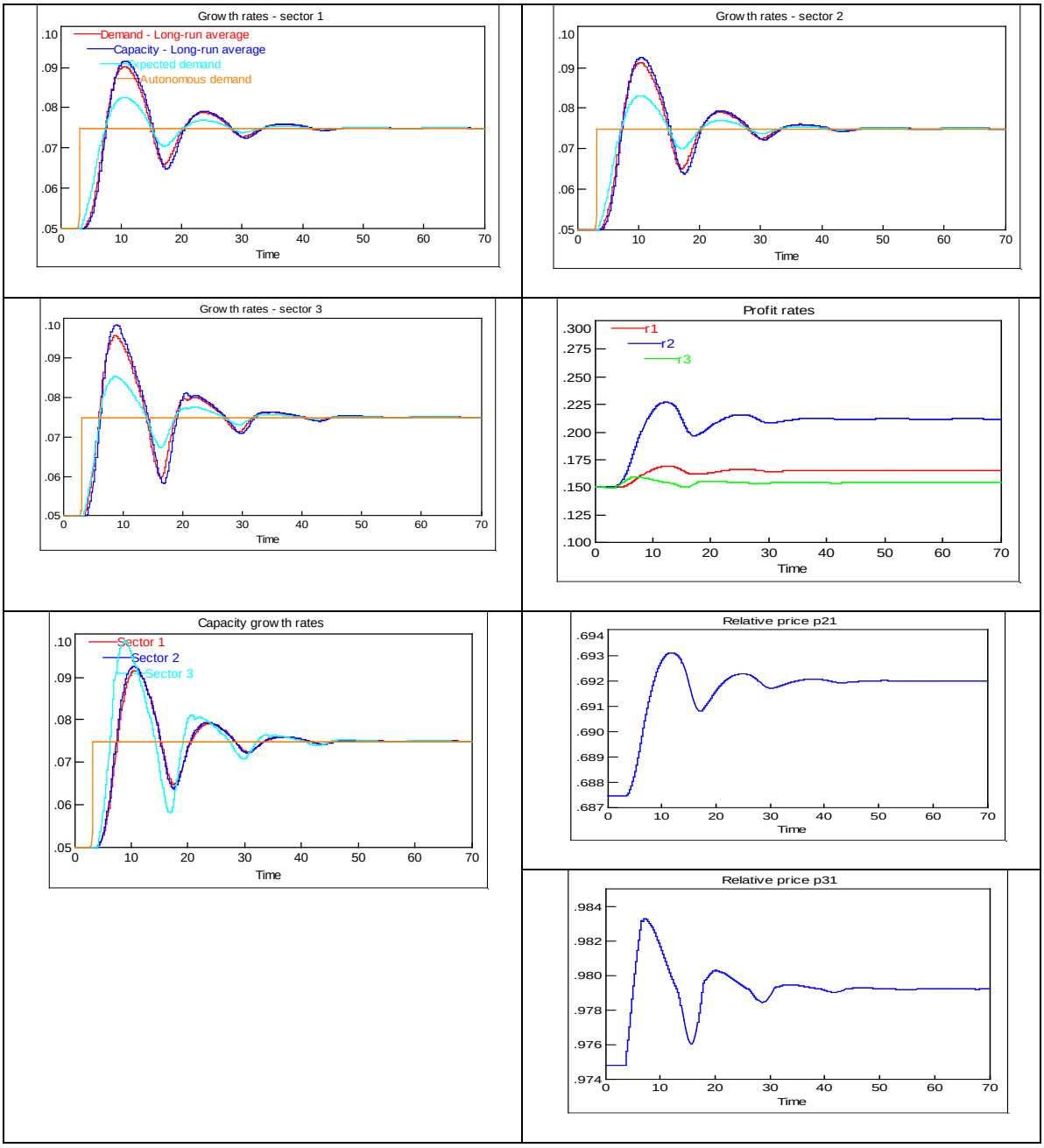

Figure 4 (b)

Once-over increase in the rate of growth of autonomous demand: "traditional" cross-dual dynamics intersectoral capital mobility triggered by profit rate differentials (a) lower response ($\zeta_5 = 1$)

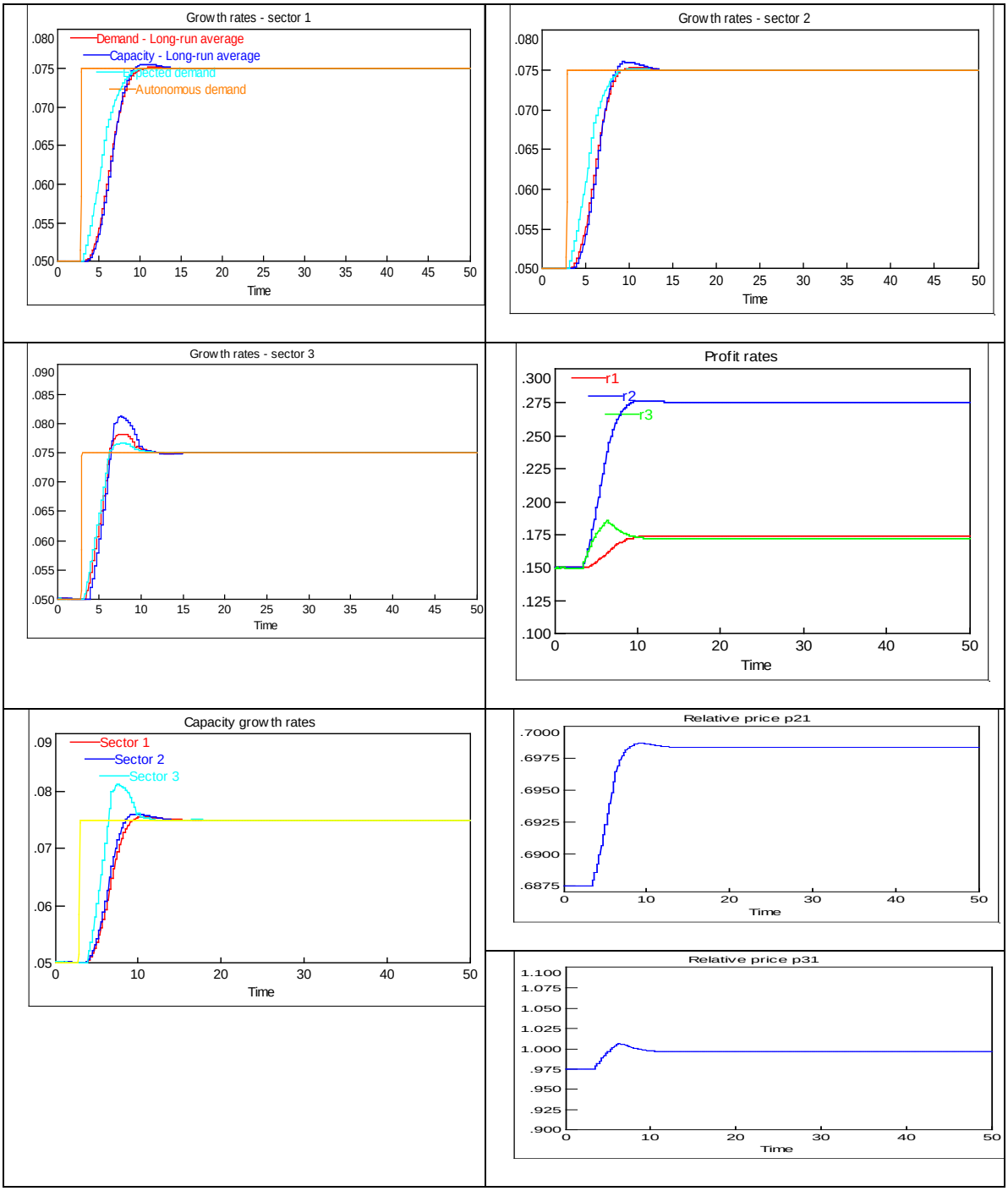

Figure 4: (c)

Once-over increase in the rate of growth of autonomous demand: "traditional" cross-dual dynamics intersectoral capital mobility triggered by profit rate differentials (b) higher response (ζ= 1.5)