SPRU
Science Policy Research Unit

Working Paper Series

SWPS 2018-01 (January)

Innovation, Structural Change, and Inclusion. A Cross Country PVAR Analysis

Amrita Saha and Tommaso Ciarli

UNIVERSITY OF SUSSEX

SPRU Working Paper Series (ISSN 2057-6668)

The SPRU Working Paper Series aims to accelerate the public availability of the research undertaken by SPRU-associated people, and other research that is of considerable interest within SPRU, providing access to early copies of SPRU research.

Guidelines for authors

Papers should be submitted to swps@sussex.ac.uk as a PDF or Word file. The first page should include: title, abstract, keywords, and authors' names and affiliations. The paper will be considered for publication by an Associate Editor, who may ask two referees to provide a light review. We aim to send referee reports within three weeks from submission. Authors may be requested to submit a revised version of the paper with a reply to the referees' comments to swps@sussex.ac.uk. The Editors make the final decision on the inclusion of the paper in the series. When submitting, the authors should indicate if the paper has already undergone peer-review (in other series, journals, or books), in which case the Editors may decide to skip the review process. Once the paper is included in the SWPS, the authors maintain the copyright.

Websites

UoS: www.sussex.ac.uk/spru/research/swps

SSRN: http://www.ssrn.com/link/SPRU-RES.html

IDEAS: ideas.repec.org/s/sru/ssewps.html

Research Gate: www.researchgate.net/journal/2057-6668_SPRU_Working_Paper_Series

Innovation, Structural Change, and Inclusion. A Cross Country PVAR Analysis*

Amrita Saha[†] Tommaso Ciarli[‡]

This version: February 7, 2018

Abstract

Structural change can be both, a cause or a consequence of innovation, while structural change and innovations are usually accompanied by short-term outcomes of social inclusion or exclusion. Inclusion may in turn have an impact on further innovations. Yet, we find little evidence in the literature on the three-way relations between innovation, structural change and inclusion. This paper advances a first exercise in this direction. Given the multidimensionality of each (innovation, structural change, and inclusion), we extract the underlying unobserved common factor structure from various well-known macro indicators. With a structural vector auto regression (SVAR) model for a short panel of developing countries over 13 years, we find the following main results. First, we confirm the virtuous cycle between innovation and structural change, aligning with existing literature. Second, the strongest result is the positive effect of inclusion on both innovation and structural change, that suggests policy to improve inclusion beyond poverty and inequality. Third, on decomposing the innovation index (formal, firm-level and ICT), we find each related differently to both structural change and inclusion, that suggests specific policy roles in their influence on inclusion and structural change.

Keywords: Innovation; structural change; inclusion
JEL: O3, O11, O15

*A different version of this paper was presented as an Appendix to a report for the International Development Research Centre (IDRC), titled "Measuring the Relation between Innovation, Structural Change and Inclusion: A Cross Country Analysis". This paper has received funding from the IDRC under the project "Pathways to Inclusive Development through Innovation, Technology and Structural Change". The paper has benefited from discussions with project partners Seife Ayele, Maria Savona, and Jodie Thorpe, and from comments in the early stages by David O'Brian and Matthew Wallace and by participants in the workshops "Innovation pathways to inclusive structural change" in London (UK) and Nairobi (Kenya), and in the 10th MEIDE (Uruguay) and seminar at IDS (UK). We have also benefited from constructive comments from the SWPS editors. Ciarli has also received funding from the European Unions Horizon 2020 research and innovation programme under grant agreement No. 649186 - Project ISIGrowth.

[†]Institute of Development Studies, UK; a.saha@ids.ac.uk

[‡]Corresponding author: SPRU, University of Sussex, UK; t.ciarli@sussex.ac.uk

1 Introduction

Structural change and innovation are often characterised by positive feedbacks (e.g. Naude and Nagler, 2015). Where structural change is defined as shifts in the structure of the economy, including from lower to higher productivity sectors, capital deepening, firms' growth, and urbanisation Matsuyama (2008); and innovation is defined as the implementation of new products, made available to users, or the adoption of new production processes, markets, or organisations of production (e.g. Gault, 2016). Different aspects of structural change can be both, a cause, or a consequence of innovation, and vice-versa (Ciarli et al., 2010, 2018)[1]. Also, both structural change and innovation, are usually accompanied by short-term outcomes of inclusion or exclusion; where inclusion is defined as the participation of marginalised or previously excluded groups in the benefits of structural change and innovation and in the decision making processes that shape the directions of structural change and innovation (e.g. Rauniyar and Kanbur, 2010; Heeks et al., 2014).

We find little evidence in the literature on the dynamic relations between innovation, structural change, and inclusion, and none whatsoever for developing countries. To address the dynamic relation between innovation, structural change and inclusion, in this paper we ask two main questions: (i) How are innovation, structural change, and inclusion related through time? (ii) If there is a virtuous cycle between innovation and structural change, how is it influenced by their relation with inclusion?

The literature on the dynamic effect of structural change and innovation on inclusion remains ambiguous. To some extent, the ambiguity of the relation may be ascribed to the ambiguity in the definition of inclusion. For instance, changes in economic structure may create imbalances in the short run (for a discussion see Naude and Nagler, 2015), such as inequality[2] and reduced social cohesion.[3] On the other hand, if we take the view of absolute pro-poor growth, income growth (and the related structural changes) is considered inclusive when the average income increases. The inclusiveness is seen as increasing opportunities available to the poorest individuals, even if inequality has increased (see for instance a discussion in Ianchovichina and Lundström, 2009). In the short run, innovation usually comes to the ad-

[1]See for example Imbs and Wacziarg (2003) on economic diversification, Burgess and Venables (2004) on the creation of new economic activities, Funke and Ruhwedel (2001) and Saviotti and Frenken (2008) on product variety, Hausmann and Hidalgo (2011) on product sophistication and capabilities, Desmet and Parente (2012) on firm size and labour organisation, Kaldor laws (Kaldor, 1981) on capital investment and technological progress, Kuznets (1973) on the capital intensity across sectors and productivity, and so on.

[2]See for example the Kuznets curve.

[3]See for instance Stewart and Langer (2008) on horizontal inequalities, and Esteban and Ray (2011) on polarisation related conflict.

vantage of some and the disadvantage of others.[4] However, in technological regimes in which there is low appropriability of knowledge and technology, low level of accumulation of knowledge, and high opportunities (Malerba and Orsenigo, 1995, 1997), the incumbent may be challenged by the destructive side of innovation, which may favour mobility (e.g. Aghion et al., 2015).

Inclusion, in turn, may influence further innovation and structural change. The literature is even more ambiguous on this direction of causality. Again, this is partly related to the definition of inclusion itself. Looking at inequality, some evidence seems to suggest that less unequal countries are also more innovative[5]. If higher inclusion also implies widespread access to capabilities, it may lead to more innovative outcomes (Planes-Satorra and Paunov, 2017).[6] However, most of the literature has focused on the relation between inequality and growth (which is correlated to innovation and especially structural change, as noted above). A fair amount of literature suggests that income distribution may facilitate economic growth.[7] But what remains unanswered is if this effect goes through innovation and structural change.

In this paper, we address the three-way relation between innovation, structural change and inclusion. We take the virtuous cycle that characterises the relation between structural change and innovation as a starting point. As innovation increases, it will lead to more structural change, which in turn will lead to more innovation in following periods (see Naude and Nagler (2015) for a similar argument). However, the extent of such virtuous cycle depends on how innovation and structural change are related to inclusion (see Fig 1 for a graphical representation). Several scenarios are possible. If inclusion also positively influences innovation (and/or structural change), more innovation (and/or structural change) may serve or set-back the innovation-structural change virtuous cycle. On the one hand, if innovation (and/or structural change) is exclusive, more innovation will reduce inclusion, which in turn will reduce innovation/structural change tomorrow. On the other hand, if innovation (and/or structural change) is inclusive, more innovation/structural change today will lead to even more innovation and structural tomorrow via inclusion, thus completing the virtuous cycle. However, if inclusion reduces innovation (and/or structural change),[8] then exclusive innovation (and/or structural change) would favour more innova-

[4] See for instance skill biased technical change (Card and DiNardo, 2002), property rights and other means to appropriate innovation rents (Guellec and Paunov, 2017)

[5] http://blogs.lse.ac.uk/politicsandpolicy/lower-levels-of-inequality-are-linked-with-greater-innovation-in-economies/

[6] Recent work on US and Finland also find that exclusion in terms of income, gender and race has negative effect on the probability to innovate (Bell et al., 2016; Aghion et al., 2017).

[7] See for example Wilkinson and Pickett (2011), Stiglitz (2012), and Ostry et al. (2014).

[8] For example if innovation requires substantial investments, which require to increase innovation rents, as suggested by Schumpeter.

tion and structural change.

[FIGURE 1 HERE]

We examine the three-way relation for a number of developing countries for which data are available. Our focus is on the dynamic relations, and we attempt to uncover their causal directions. Aiming to spot statistical regularities, we abstract from micro dynamics of innovation, structural change and inclusion, and adopt relatively coarse and aggregate measures for the three dynamics which are by themselves quite complex.[9] We attempt to capture a wider understanding of each of the three dynamics, by building composite indicators that reflect different dimensions of innovation, structural change, and inclusion, subject to data availability.

For innovation, we consider formal activities (such as R&D investment), firm capabilities (in the form of human capital, technology transfer and use of ICTs), and broader adoption of ICT at the societal level. For structural change, we consider both relatively slow changes in the sectoral composition of labour, moving from agriculture to manufacturing and services, as well as a number of changes related to the transformation of production and societies, such as urbanisation, firm size, productivity and capital deepening. For inclusion, we consider aspects of poverty, inequality, labour participation, and gender participation.

The findings are the following. First, we confirm the virtuous cycle between innovation and structural change (left hand side of figure 1). Second, we find no significant effect of innovation or structural change on inclusion; the good news being that we also do not find any negative significant effect on inclusion. Third, inclusion has a positive and significant effect on both innovation and structural change, and the effect seems to be persistent over time (although decreasing); the positive effect of inclusion on structural change manifests only after a few time periods, while the strongest effect on innovation in the long term, comes from a one standard deviation shock in inclusion (stronger than the effect from structural change). Finally, on decomposing the index, we find that different aspects of innovation (formal, firm and ICT) relate differently to both structural change and inclusion.

The remainder of the paper is structured as follows. Section 2 motivates the theoretical framework for the study, outlining various scenarios in terms of outcomes of structural change, innovation and inclusion. We motivate theoretically the dynamic relations between innovation, structural change and inclusion, and the relevance to understand empirically their recursive

[9] In a different paper (Ciarli et al., 2018), we explore different pathways through which innovation may lead to inclusion, structural change, and their relation. And in another related paper (Saha and Jodie, forthcoming 2018) we focus on micro processes, by investigating innovation and inclusion pathways in breeding practices among small dairy farmers in Kenya and in the provision of anti-retro viral treatment in services in Mozambique.

relation. In section 3, we discuss the existing findings from relevant literature that has addressed each of the relations in our framework. We conclude that we know little, especially on how innovation and structural change are related to inclusion. The empirical strategy of the paper is detailed in in section 4, followed by the results in section 5. Finally, Section 6 provides concluding insights and directions towards a future research agenda.

2 Theoretical Framework

How are innovation, structural change, and inclusion related over time? Is there a virtuous cycle between innovation and structural change, with more structural change leading to more innovation, and more innovation produced in sectors that gain more from increasing returns to investment (such as services and manufacturing)? Is such a virtuous cycle inclusive? And does more inclusion nurture this cycle, by leading to more innovation and/or structural change, or does it set it back? In an attempt to illustrate the dynamic relations between innovation, structural change, and inclusion, we begin by theorizing a framework in Figure 2.

[FIGURE 2 HERE]

With respect to Ciarli et al. (2018), we define innovation, structural change, and inclusion using specific measurable variables, to deal with constraints in measuring them across countries.[10] With regard to *innovation* (INN), we refer to both inputs and outputs of the innovation process, which include both Research and Development (R&D) efforts, as well as firm's capabilities (researchers, engineers, foreign technologies, and ICTs) and societal adoption of new technologies, especially Information and Communication Technologies (ICT). With regard to *structural change* (SC) we use two different indexes. The first one captures changes in the composition of employment, particularly towards services and manufacturing. The second one, capture more short term dynamics, which refer to different transformation of societies: urbanisation, firm size, productivity and gross capital formation. *Inclusion* (INC) is perhaps more controversial. Ideally, we would refer to inclusion as "the result of a process to (re)-distribute benefits and losses, as well as power and decision-making, such that those who are currently marginalised have a prominent role in deciding about the pathways to follow and in turn reap net benefits from these changes." (Ciarli et al., 2018, p. 8). However, due to data issues in this paper we refer to measures of poverty, inequality, employment, wages, and gender participation. An increase (decrease) in poverty and/or inequality is considered as a decrease (increase) in inclusion, whereas an increase (decrease) in paid employment,

[10]More details about the data and indices created in Section 4.1.

wages, and gender participation is considered as an increase (decrease) in inclusion.

Among the three dynamics, we assume that structural change is the slowest. It takes time to accumulate the capabilities for firms and workers to move to new industries Rosenstein-Rodan (1943); Hidalgo et al. (2007). But the literature also shows that manufacturing (and most recently services) is the main sources of innovation (Cornwall, 1977; Lall, 2005; Gault and Zhang, 2010; Shen et al., 2007; Cimoli and Porcile, 2011). Structural change also leads to higher accumulation of capital, increased backward and forward linkages (Hirschman, 1958) and productivity (Ciarli and Di Maio, 2014).

On the other hand, innovation is expected to lead to structural change. This is most evident when innovation leads to the creation of new goods (Aoki and Yoshikawa, 2002; Saviotti and Pyka, 2004) and new patterns of consumption (Witt, 2010). But also when innovation generates the conditions for structural change, for instance increasing productivity in agriculture, and setting some of the conditions for the industrial revolution (von Tunzelmann, 1995; Joel Mokyr, 2010).

As a result, as innovation contributes to moving the economy towards the production of more sophisticated goods and services, increased production of such goods may induce more innovation, generating the reinforcing mechanism between structural change and inclusion that is suggested in the left hand side of Figure 2.

The dynamic relations on the right-hand side of the graph seems less clear-cut, and may also affect this virtuous cycle between innovation and structural change just described. Both innovation and structural change may lead to inclusive or to exclusionary outcomes. For instance, an increase in employment and productivity is related to diversification and structural change towards high-tech activities (Cimoli and Porcile, 2009). The employment elasticity in manufacturing and services tends to be higher than in agriculture (Szirmai, 2012; Rowthorn and Ramaswamy, 1997). However, structural change may also lead to exclusion, as workers need to relocate from a shrinking agricultural sector to industries for which they may have no competences.[11] Structural transformation also come with an increased incorporation of firms, and a reduction of self-employment, which may leave many individuals without a job.[12]

Similar conclusions may be reached on the relation between innovation (which is tightly linked to structural change, as we have discussed) and inclusion. Innovation may come in the form of foreign technologies and investments that displace national production and jobs, as foreign technologies

[11] See also the recent discussion by McMillan et al. (2017); Diao et al. (2017) on the increasing gap between available and required skills, which may explain the decline in experiences of catching-up.

[12] See also findings in Blattman and Dercon (2016) on workers negative preferences for low quality employment in large companies in Ethiopia.

that create opportunities for national entrepreneurship and employment, or as local innovations that involve local entrepreneurs and workers. Innovations may reduce inequality by replacing incumbent oligopolies, or increase inequality by allowing incumbents to accumulate even more knowledge and market shares (Malerba and Orsenigo, 1997; Aghion et al., 2015). As suggested in Paunov (2013), there is no clear outcome.

Looking at the opposite direction (whether inclusion may prompt more innovation), including individuals and organisations in the innovation process may exploit more distributed capabilities and talents. As innovation is an uncertain process, an increase in the sources of innovation should also lead to more innovation. However, too much variety and dispersion of capabilities across too many individuals and organisations, may lead to the opposite effect of lower innovation, if there is a threshold in the amount of capabilities required to successfully innovate, and if there are large economies of scale. There seems not to be enough evidence to suggest how inclusive innovation is, under which conditions inclusion leads to an increased diffusion of capabilities in societies, and to which extent increased capabilities lead to more innovation (see next section).

If inclusion has a positive dynamic effect on innovation and structural change (or one of the two, represented by the reinforcing effect in blue in Figure 2) we may fall in one of the following two cases. First, if either innovation or structural change are exclusive (reduce innovation, the red arrows), this will also curb innovation in the following periods. More innovation will lead to less inclusion, which will lead to less innovation. Innovation and inclusion will tend to follow a cyclical pattern. Second, if both innovation and structural change are inclusive (increase inclusion, the blue arrows), this will amplify the virtuous cycle between innovation and structural change. More innovation will lead to more inclusion, which in turn will increase innovation in the following period.

If, instead, inclusion has a negative effect on innovation or structural change (represented by the balancing effect in red) we may fall in none of the following two cases. First, if either innovation or structural change are exclusive, this will induce more innovation in the future. More innovation will lead to less inclusion, which, in turn, favours innovation. Second, if innovation and structural change are inclusive, this will induce less innovation in the future. More innovation will lead to more inclusion, which has a negative effect of future innovation.

As a result we have eight scenarios, which we can represent by allocating a sign to the lagged effect of each of the three variable on the other two (Table 1). In Table 1, a '+' means that the variable in the respective row has a positive effect on the variable in the respective column; otherwise the assigned sign is '−'. In the four scenarios on the left of the table we assume that inclusion favours innovation. In the four scenario on the right, instead, inclusion reduces innovation. Figure 3 represents the same eight scenarios using the system dynamic representation of the relation between innovation, inclusion and structural change introduced in Figure 2.

We start from the left hand side. In scenario 1, innovation in t leads to inclusion in $t + 1$, which increases innovation in $t + 2$. We would then observe a positive recursive mechanism with innovation leading to more innovation via inclusion. In this scenario also structural change leads to more inclusion, and we would observe only reinforcing mechanisms between innovation, structural change and inclusion.

If, instead, structural change is not inclusive (scenario 2), this will have a negative effect on innovation, via reduced inclusion. As innovation pushes structural change, the latter reduces inclusion, which reduces innovation and possibly structural change. The net effect depends on the balance between the different forces, as well as their timing.

[TABLE 1 HERE]

[FIGURE 3 HERE]

In scenario 3, innovation is not inclusive. As a result of more innovation, exclusion leads to lower innovation in the next period. An exogenous structural change may maintain a positive level of innovation, but this is reduced with respect to a scenario in which such innovation is also inclusive. In scenario 4, both innovation and structural change are exclusive, curbing even more the effects of the virtuous cycle between innovation and structural change, due to the exclusion created and the effect that this has on future innovation. The economy still experiences innovation and structural change, but their extent is limited with respect to the first two scenarios in which innovation is also inclusive.

In the four scenarios on the right of the table inclusion may lead to lower innovation, *ceteris paribus*. As a result, if innovation and structural change are inclusive (scenario 1), this will not lead to more innovation in the next period. If, instead, either innovation or structural change are exclusive, the economy would experience a virtuous cycle with more innovation and structural change, especially when both are exclusive.

We next discuss the literature that has addressed these relations, and then test the dynamic relation between innovation, structural change and inclusion, to ascertain which scenario is more commonly observed across countries.

3 What we Know from the Literature

Relatively established: structural change and innovation

Innovation is a key source of structural changes, driving the emergence of new products and industries (product innovation), increases in productivity (process innovation) and firm size (organisational and managerial innovation), capital intensity (investment), entrepreneurship (new opportunities), and changes in consumption patterns (diffusion of new products). In turn, structural changes can induce the introduction of new technologies[13] as firms cope with the opportunities that they generate by introducing innovations (Lundvall, 1992; Antonelli, 2003). The opportunities may originate from changes in relative factor prices, consumption patterns (also as a results of changes in income distribution), urbanisation, organisational innovations, skills and capabilities, and so forth.[14]

In other words, there are aspects of structural change that drive innovation and aspects of innovation that drive structural change, as in the cumulative causation process suggested by Kaldor and the Kaldor-Verdoorn's law (Kaldor, 1966, 1981). This is observed, for example, in the relation between economic growth, variety, and the emergence of new goods (Imbs and Wacziarg, 2003; Burgess and Venables, 2004; Funke and Ruhwedel, 2001; Saviotti and Frenken, 2008; Hausmann and Hidalgo, 2011), and therefore professions, demand, markets, and so on; the increased division of labour (Greif, 2006; Galor, 2010), reorganisation of production (Ciarli et al., 2010; Desmet and Parente, 2012), and trade specialisation Verspagen (1993); Hidalgo et al. (2007); Cimoli et al. (2010); the drastic reduction of self-employment (Carree et al., 2002) and increase in firm size (Ciarli et al., 2010; Desmet and Parente, 2012), along with the development of managerial practices (Cirera and Maloney, 2017).

Overall, we expect to observe a reinforcing mechanisms between innovation and structural change (see Figure 4 panel (a))

[FIGURE 4 HERE]

Relatively ambiguous: the effect of structural change and innovation on inclusion

Less straightforward is the literature on the extent to which innovation and structural change are inclusive (see Figure 4 panel (b)). As suggested before, part of the ambiguity is related to the definitions.

For instance, if we define inclusion as a decrease in inequality, the imbalances that accompany structural change are also related to changes in the

[13] See for instance Dosi G (1997), which suggests an analytical link between relative prices or demand patterns, allocative decisions, and technological possibilities. The work of Ruttan (2002) also emphasizes the differences in relative factor endowments and prices can exert a substantial impact on the direction of technical change; according to Ruttan (2002) expectations about the future dynamic of relative factor prices should be sufficient to induce firms to innovate to save on the increasingly expensive factor.

[14] See for instance a comprehensive definition of structural change in Matsuyama (2008) and Saviotti and Gaffard (2008), and a related model in Ciarli et al. (2017).

accumulation of capital, in the composition of factors, substitution of domestic labour and knowledge for foreign labour, and changes in the demand for skills, which in the short run reduces inclusion – as inequality (Kuznets, 1973; Ravallion, 2004). The recent growing trends of within-country inequality (Atkinson, 2015) and the drop in labour shares in output (Karabarbounis and Neiman, 2013) have called the attention on how factor biases may favour capital with respect to labour, or high with respect to low skilled labour. Although this is now happening in industrialised society, it is not a surprising result when we consider the process of structural change form an agrarian to an industrialised society, along which we tend to observe a replacement of labour for capital.

If we define inclusion in terms of (reduced) poverty, however, structural change may be related to a subsequent increase in inclusion – as poverty (McMillan and Rodrik, 2011; UNU-WIDER, 2012).[15]

If we equate economic growth with structural change, the literature that has made the closest attempt to investigate the relation between structural change and inclusion is that on inclusive growth, defined as "growth that not only creates new economic opportunities, but also ensures equal access to the opportunities created for all segments of society, particularly for the poor" (Ali and Son, 2007, p.12). Results seem to suggest that growth seem to be inclusive most of the time, in the sense that it reduces poverty, but the pace at which poverty is reduced depends on income distribution (Rauniyar and Kanbur, 2010). For instance, in a recent cross country exercise Anand et al. (2013) find that in most cases we observe increase in average income, sometimes with an increase in inequality, sometimes a decrease, and only very few cases in which inclusive growth depends only on improved income distribution. They also find that structural change, measured as product and service sophistication, has a positive effect on inclusive growth. Overall, what counts in the inclusive growth framework, akin to the absolute pro-poor growth paradigm (Ravallion, 2004), is to increase the opportunities of the poor, even if this comes with a higher income increase among the wealthiest (an increase in inequality).

In sum, structural change may be at the same time exclusive in the short run (inequality), and inclusive in the long run (poverty). The final outcome seem to depend on which aspect of structural change and which aspect of inclusion we are considering. As we discuss in Ciarli et al. (2018), innovation and development may follow different pathways, leading to a number of different outcomes with respect to structural change and inclusion.

Similarly, innovation generates winners and losers (Helpman et al., 2010), creating some form of inclusion (winners) and exclusion (losers). Paunov

[15] See also the literature on the relation between economic growth and poverty reduction (Deininger and Squire, 1998; Ravallion and Chen, 2003; Bourguignon, 2003; Dollar et al., 2013).

(2013) suggests that innovation relates to inequality in three ways: first, through direct impacts on income distribution (e.g. innovation favours the highly skilled and risk takers); second, offering solutions for improving the welfare of lower and middle income groups ("frugal innovation"); and, third, as lower-income groups innovate themselves, choosing the direction of welfare improvements (i.e. grass-roots and informal sector activities).

On average, innovation is negatively related to poverty (for the average individual), as suggested by the literature on ICT and more in particular access to mobile finance (Foster and Heeks, 2013; OECD, 2015). For example, Hjort and Poulsen (2017) studies the impact of internet penetration (measured with cabling) on several economic outcomes, among which labour and wealth outcomes. They find that an increase in entry rates, productivity growth, and exports, both the level and quality of employment increased in areas or increased ICT access, with a reduced inequality in employment attainment and increased average income and wealth.

However, we know relatively little about how gains from innovation are distributed across the population, and there fore the relation between innovation and income inequality. As for structural change, recent evidence suggests that the relation between innovation and inequality depends on the level of innovation, and on whether we consider innovation input or innovation outputs (Leoncini, 2017).

Relatively unknown: the effect of inclusion on innovation and struct

We seem to know even less about how inclusion influences innovation in the long run (see Figure 4 panel (c)). Although it is stated that inequality may hamper growth via reduced social cohesion (Rauniyar and Kanbur, 2010) (see the reference on conflict above) the literature on inclusive growth finds an ambiguous effect of inequality on growth (Ianchovichina and Lundström, 2009; Anand et al., 2013). However, it does suggest that increased access to opportunities may have a positive effect on growth (Ali and Son, 2007; Rauniyar and Kanbur, 2010). This is because, as suggested by Planes-Satorra and Paunov (2017), more inclusion also means more widespread access to capabilities, which can be used in entrepreneurship or in fostering productivity. Similarly, Atkinson (2013) suggests that welfare state is essential to allow individuals to participate in productive activity and has been historically essential to allow workers to move from agriculture to industry and guarantee sufficient demand during downturns.

However, the empirical evidence on whether more inclusion induces further successful innovative behaviour is missing.[16] The insights seem to come

[16]Although there are some hints: http://www.theinclusionsolution.me/diversity-does-not-drive-innovation-but-inclusion-can/, https://www.forbes.com/sites/danschawbel/2012/05/13/how-companies-can-benefit-from-inclusion/#6527b482223d, http://symmetra.com.au/symmetra-

mainly from theoretical work.[17] For instance, the discussion about property rights and competition, which suggests that, especially in industries in which innovation is more risky and costly and difficult to appropriate, some degree of oligopoly is required for firms to have the incentive and resources to innovate (Arrow, 1962; Malerba and Orsenigo, 1997).

Recent evidence has emerged on the likelihood that individuals become innovators (patenting), but these are focused on high income countries (US and Finland). Bell et al. (2016) profile inventors along their life-cycle. They find that inventors are substantially more likely to come from a wealthy family, and to be white males. Capabilities, for example measured as maths scores, can fill only part of the gaps generated by income, gender and race. The authors also find that the initial differences are magnified by access to school and early exposure to innovations. And they conclude that social and economic barriers (or exclusion, in this paper language) are detrimental not only for subsequent inequality, but also for the country's potential to innovate and grow. Akcigit et al. (2017) find a similar result in the long run for the US: parents' income is a very important predictor of the probability of becoming an inventor, although education may make the initial income non statistically significant. The authors also find that regions are extremely relevant: inventors tend to move to more innovative regions. Their results seem to indicate that, also in a condition of lower aggregate income (US since end of the nineteenth century) income, education and geographical inclusion matter for innovation, and are relevant explanatory variables for income growth (and related structural chances). Aghion et al. (2017) replicate similar results also for a more equal society such as Finland. They find that parental income is a crucial predictor of the probability of becoming an innovator, even when controlling for IQ and other individual features (although they reduce the income effect).

Our work departs from the literature on inclusive growth and attempts to contribute in several ways. First, following Ciarli et al. (2018) and Naude and Nagler (2015) we look at a three-way relation between innovation, structural change, and inclusion, rather than considering them in pairs. Second, we consider directly structural change and innovation, which are underlying forces of growth, and which in turn may be exclusive. Third, by unpacking innovation and structural change from economic growth, we do not need to rely on an absolute definition of pro-poor growth: inclusive structural change may see periods in which there is no growth and there is only inclusion. This inclusion may favour innovation, which in the next period would

news/diversity-and-inclusion-lead-to-innovation-heres-the-proof.
http://blogs.lse.ac.uk/politicsandpolicy/lower-levels-of-inequality-are-linked-with-greater-innovation-in-economies/.

[17] See for example Caiani et al. (2016) on the relation between workers' wage, innovation and economic growth.

also steer structural change. Fourth a part from poverty and inequality we include in the same index also explicitly labour participation and gender participation. For all indicators we use composite measures, which accounts of different aspects of innovation, structural change,and inclusion. Fifth, we make an attempt to disentangle the temporal and causal relation between these three dynamics. In doing so we try to provide initial indication to fill a gap in the literature, to understand if inclusion leads to further structural change and innovation, not only the other way around.

4 Empirical Strategy

This section outlines the empirical strategy adopted in the paper to examine the dynamic relation between structural change, innovation and inclusion. We begin by explaining our data and sources in detail. Capturing multidimensionality across the three dimensions, we construct indexes for each of them to draw common factor structure from underlying variables that proxy for structural change, innovation and inclusion. Next, a locally weighted smoothing regression (LOWESS) presents the relationships between the three indexes. This is followed by the panel OLS that helps assessing the general results before moving to capture the complete dynamic relations between the three variables in a panel VAR.

4.1 Data & Variables

We use data from 2000-2013 (13 years) for the 33 developing and emerging countries:[18] All data are from the World Development Indicators (WDI) and World Bank Enterprise Survey (WBES), except where explicitly noted.

Given that structural change, innovation, and inclusion are multidimensional and typically measured by highly correlated variables, we employ factor analysis using the principal-component method to draw the common factor structure and combine variables into single composite indexes[19]. Each index is formally computed as:

$$I = \sum W_{ij} x_{ij} \tag{1}$$

[18]Botswana, Brazil, Burkina Faso, Cambodia, Chile, China, Colombia, Congo Dem. Rep., Ethiopia, Gambia, Ghana, India, Kenya, Malaysia, Maldives, Mexico, Morocco, Mozambique, Myanmar, Nepal, Niger, Nigeria, Pakistan, Peru, Philippines, Rwanda, Senegal, South Africa, Sri Lanka, Thailand, Turkey, Uganda, Vietnam, Zambia. The time variation is different across countries and variables that is dictated by data availability.

[19]One general limitation of using composite indexes instead of the individual variable is that it is not possible to unpack which aspect of the index is more relevant in a given relation. However, the index assigns weights based on the relative importance of variables across the data. Given our objective of studying multidimensional variables, indexes are better suited to the purpose of our analysis.

where x_{ij} is the value of the j-th variable forming the composite index and W_{ij} is the relative weight of the j-th variable entering the composite index. We construct the primary indexes for innovation (INN), inclusion (INC), and structural change (SC1). In addition, we construct an alternate index for structural change (SC2) and sub-indexes for innovation (INN1, INN2, INN3). Additional variables in the OLS regressions include GDP Per Capita in PPP (in 1000).

For all indices, we first compute three years rolling averages of underlying variables (e.g. a variable in 2001 is the average of its value in 2000, 2001 and 2002) to deal with business cycle fluctuations. We standardise all variables before computing the principal components. We use the first component explaining the highest variance to construct all index scores. Table 2 provides the summary statistics for all indices. The indices are further outlined by country and year in the Appendix C in Tables 6, 7, 8, and 9.

[TABLE 2 HERE]

The composite index for overall innovation (*INN*) measures the following innovation related aspects: (1) formal innovation,[20] (2) firm level innovation and capabilities,[21] and (3) information and communication technologies (ICT).[22]

The first structural change composite index (*SC1*) is based on changes in sectoral composition measured with employment shares.[23] This represents slow changes that usually accompany a country's economic development. The second structural change index (*SC2*) measures broader and also more rapid socio-economic structural changes.[24]

The three sub-indexes for innovation reflect the distinction discussed above: (1) **R&D Innovation Index (*INN1*)**, (2) **Firm-Level Innovation Index (*INN2*)**, and (3) **ICT Innovation Index (*INN3*)**.

We construct the composite index for inclusion (*INC*) considering poverty[25] and inequality[26] as proxies for exclusion (they enter with a negative sign), the percentage of workers with a full time job,[27] and women participation

[20] Research and development expenditure (% of GDP); Journal Articles (in 1000) per capita in logs; Researchers in R&D.

[21] % of firms with an internationally-recognized quality certification; % of firms using technology licensed from foreign companies; technicians employed in R&D; researchers in R&D

[22] Internet Users (per 100 people); Mobile users per capita; % of firms having their own Web site; % of firms using e-mail to interact with clients or suppliers.

[23] Employment in industry (% of total employment); Employment in services (% of total employment).

[24] Urbanization (Urban Population % of Total); Firm size (Log of the number of permanent full-time workers); Total Factor productivity; Gross capital formation (% of GDP).

[25] Poverty; Poverty Gap; Poverty Head Count Ratio.

[26] Gini Index.

[27] Wage & Salaried Workers.

in the economic activity[28] as proxies of more inclusive societies.

4.2 A Description of the Relations between Innovation, Structural Change, and Inclusion

We use locally weighted smoothing regression (LOWESS) between the indices to examine their association and how it changed between 2000 and 2012. We present the LOWESS using the first structural change index (SC1). The dots indicate the levels of the indexes; the red line is an estimate of the locally weighted relation. The panels on the left exhibit the relation in 2000 and the right panel exhibits the relation in 2012.

Figure 5 plots the relation between innovation (INN) on the vertical axis and structural change (SC1) on the horizontal axis, and the LOWESS between the two indices. The relation between innovation and structural change has witnessed a substantial change between 2000 and 2012.

While innovation and structural change show signs of a positive relationship (linear) in 2000; by 2012, it becomes clear that innovation has a strong, non-linear, correlation with structural change. For example, China, that in 2000 was innovating significantly, but lagging behind in terms of structural change, experiences highest level in both innovation and structural change in 2012. By 2012, the set of developing countries were witnessing more than proportional increases in innovation with increasing structural change. Hence, the returns to innovation were higher with increasing proportions of employment in industry and services.

[FIGURE 5 HERE]

Figure 6 plots the relation between innovation (INN) and inclusion (INC). The relation is positive and non-linear, both in 2000 and 2012. Countries that were innovating with lower inclusion made very limited progress on further innovations, while countries that were more inclusive back in 2000, report higher innovations by 2012. The positive correlation between inclusion and innovation, and a clear improvement in innovations for more inclusive countries suggests inclusive processes for early increases in innovation inputs and outputs, as measured by the composite index.

[FIGURE 6 HERE]

This brings us to the question of how SC and INC are related. Figure 7 plots the relation between structural change (SC) and inclusion (INC). There is a positive relation for both years, but it has changed between the two periods, to a somewhat logistic relationship in 2012. In 2000, inclusion was positively correlated with increasing structural change, but at a

[28] Percent of firms with female participation in ownership; Proportion of permanent full-time workers that are female (%).

decreasing rate – initial changes from agriculture to manufacturing and services seem to be more positively correlated to inclusion, than subsequent changes to higher shares of manufacturing and services. By 2012, lower levels of structural change are associated with an increasing return for improved inclusion. Medium levels of structural change are correlated with a drop in the rate of increase in inclusion. At higher levels of structural change, the positive relation with an increasing rate of response in improved inclusion is restored. This suggests that countries that witnessed increasing structural change, also improved inclusion outcomes. The results are likely to be driven by the poverty dimension of the inclusion index as several countries have achieved reduction in the intensity of poverty (as measured by the poverty gap) and headcount of poor living below the poverty line. Yet the Figure is silent on whether it is more structural change driving inclusion, or the other way round: the trade-offs between structural change and inclusion need further study.

[FIGURE 7 HERE]

4.3 Correlations: Panel OLS

Using the composite indexes of innovation, structural change and inclusion, we examine the key relations between the three dimensions. First, we study the relation between structural change (*SC1*) and innovation (*INN*), controlling for past inclusion (*INC*). Specifying this as Model 1, the estimated equation is:

$$INN_{it} = \alpha_i + \beta_1 SC_{it} + \beta_2 INC_{i,t-1} + \epsilon_{it} \tag{2}$$

For country i, and time t; β_k are the coefficients α_i are the country-specific intercepts to avoid any omitted variable bias arising from omitted factors that vary across countries but are constant over the time-period of analysis; and ϵ_{it} is a country specific error term.

Second, we study the relation between innovation (*INN*) and inclusion (*INC*), controlling for lagged structural change (*SC1*). The estimated equation for Model 2, where γ_k are the coefficients is:

$$INC_{it} = \alpha_i + \gamma_1 INN_{it} + \gamma_2 SC_{i,t-1} + \epsilon_{it} \tag{3}$$

We estimate both equations using panel fixed-effects (within) regression with Driscoll and Kraay standard errors that are heteroscedasticity consistent and robust to general forms of cross-sectional and temporal dependence.

Table 3 reports the results for Model 1 in columns (I) and (II) and for Model 2 in columns (III) and (IV). For Model 1, the results show that innovation is positively and robustly correlated with structural change. Inclusion outcomes in the previous period are also positively correlated with innovation, showing a stronger effect. In Model 2, the strong and positive correlation between innovation and inclusion holds. However lagged structural change has no significant association with inclusion.

[TABLE 3 HERE]

4.4 Dynamic Relations between Structural Change, Innovation, and Inclusion

We employ a panel vector autoregression (PVAR) analysis following Abrigo and Love (2016) to investigate the dynamic relationship between structural change, innovation, & inclusion. Adopting the panel-data vector autoregression methodology, enables us to make use of the traditional VAR approach, while allowing for unobserved individual heterogeneity. The VAR assumes endogeneity of all variables in the system and therefore allows us to study the dynamics of purely exogenous shocks. The cross-sectional heterogeneity is addressed by including country-specific fixed effects, thus reducing the risk of omitted variable bias.

The multivariate panel VAR can be formally described as

$$Y_{it} = \eta_i + \sum_{j=1}^{n} \beta_j Y_{i,t-j} + \epsilon_{it} \tag{4}$$

Where Y_{it} is a 1x3 vector containing the set of endogenous variables (SC_{it}, INN_{it}, $INCL_{it}$) that vary by country i and time t, η_i are the country-specific fixed effects. The $Y_{i,t-j}$ β_j coefficient matrices show, respectively, the contemporaneous and (one year) lag effects of the three variables on one another. ϵ_{it} includes the error terms.

The optimal lag order in PVAR was chosen using the three model selection criteria[29] by Andrews and Lu (2001). Based on Hansen (1982) J-statistic of over-identifying restrictions, this criteria suggested a first-order panel VAR. Any observations with missing data are dropped automatically.

Adopting Cholesky decomposition[30] to ensure identification, the following contemporaneous recursive ordering is specified: (1) structural change, (2) innovation and (3) and inclusion. Structural change is treated as the most exogenous variable in the system since it is expected to be affected by contemporaneous changes in external factors rather than internal factors related to innovation or inclusion. With greater structural change, there is likely to be more innovation contemporaneously, whereas it is unlikely

[29]Three criteria are the Akaike information criteria (AIC), the Bayesian information criteria (BIC) and the Hannan Quinn information criteria (HQIC).

[30]To identify the model, a restriction needs to be imposed to orthogonalize the contemporaneous responses. The Cholesky decomposition achieves this by setting the order of the variables from least to most endogenous. Variables ordered first in the system have a contemporaneous and lag effect on the subsequent variables whereas variables order later in the system have only a lag effect on the preceding variables.

that the innovation would contemporaneously increase structural change.[31] Relatively little is known about the distribution of gains from innovation, and therefore the relation between innovation and inclusion. In light of this unknown, we assume inclusion is the most endogenous variable, since it depends on current values of both structural change and innovation. In contrast, inclusion may not contemporaneously affect either variable. The assumption is that while inclusion can affect innovation and structural change, such changes clearly needs time to materialize. Being the second variable in the system, innovation depends on current values of structural change – whereas structural change is not contemporaneously affected by innovation, and innovation has a contemporaneous impact on inclusion – but not vice-versa.

The system General Method of Moments (GMM) is used to estimate equation (4),[32] by employing lags of regressors as instruments for the endogenous variables. The system is exactly identified as it includes the same amount of instruments as the number of endogenous variables. Moreover, to ensure enough lags to adequately capture the dynamics underlying the link between structural change, innovation, inclusion, we set $j = 5$. Next, to account for country-specific fixed effects (η_i), the variables are transformed using first difference to remove panel-specific fixed effects.

Furthermore, the panel VAR model yields impulse response functions, which show the time path of each variable following a shock to the other variables in the system. We estimated orthogonalized impulse-response functions. Accordingly, we analyse, for example, the response of innovation following a shock to both our structural change indices (SC1/SC2), the magnitude of this shock, and whether this effect is statistically significant over time. One setback of the GMM approach is that it imposes homogeneous dynamics across units. Since our sample consisted only of developing countries, we expect the dynamics for structural change, innovation and inclusion are similar across our set of countries.

[31] However, in the absence of very strong evidence for why inclusion does not affect either variable contemporaneously, we present the results using alternative ordering of variables in the robustness section.

[32] Fixed effects are correlated with the regressors due to lags of the dependent variable, such that we use first differences. The differencing might result in a simultaneity problem due to the correlation between regressors and the differenced error term. Heteroscedasticity may also exist due to maintenance of heterogeneous errors with different countries in the panel. Accordingly, after eliminating fixed effects by differencing, we applied the panel GMM, where lagged regressors were used as instruments to estimate coefficients more consistently

5 Results

5.1 Baseline Results

Table 4 presents the Panel VAR results. The coefficients are average responses of the endogenous variables to an exogenous shock in any one variable after controlling for time-invariant characteristics of individual countries[33]. To operationalize these results, the impulse response functions are presented in figure 8. The solid line denotes the impulse response of the variable following the column (":") to a one standard deviation shock to a the variable preceding the column sign (":"), whereas the grey area denotes the upper and lower bounds of the 95% confidence intervals that were calculated using 200 Monte Carlo simulations.

[TABLE 4 HERE]

First, we notice that three indexes are strongly recursive (panels on the diagonal in Figure 8): countries that experience above average structural change, innovation, or inclusion in t, are expected to experience more structural change, innovation and inclusion in $t+1$. The effect fades away through time. First, structural change: after the first three period earlier structural change does not induce more structural change. Second, innovation: the effect of earlier innovation on future innovation becomes insignificant after 4 periods. Third, inclusion: although the effect of earlier on contemporary inclusion reduced through time, it is still positive and significant after 10 time periods.

[FIGURE 8 HERE]

The impulse response analysis reveals that structural change (SC1) has no significant impact on innovation over the 10-year period under study. Even though the VAR coefficients suggest a positive and significant effect on innovations in time *t+1* from structural change in time t in Table 4, there is no sign of this significant effect when we examine the impulse responses of innovation from the employment based structural change index (panel in the central column of the bottom row in Figure 8). We suspect this is evidence for the fair amount of time for resources to be diverted towards innovation related activities, following an increasing proportion of employment in industry and services.

Structural change (measured as employment shares – bottom panel in the right column, Figure 8) has a tiny positive impact on inclusion for one time period, which quickly becomes non significant. Looking at the VAR results (without estimating the IRF), in Table 4, however we see no sign of

[33] We recognize that the reduced VAR regressions only provide suggestive results, that are then useful to calculate the impulse responses.

this effect, and only a barely significant positive effect of structural change in t on inclusion in $t+1$.

On the other hand, innovation (panels in the middle row, Figure 8) has a positive and significant impact on structural change in the short run (confirmed in Table 4). This takes the form of an inverted U-shape such that there is an initial rise in structural change, with a peak of 0.006% by the third year, before going down to almost no effect by the tenth year. The positive effect is evidence of the initial rise in employment shares for industry and services following an initial shock in innovation. There is then a decline as the initial increases are internalized with more fundamental changes. The inverted U-relation between innovation and structural change is evidence of the initial innovation rents that are in favour of workers in manufacturing and services. Once the system fully accomplishes the transition over time, the increasing returns subside. On the relationship between innovation and inclusion, the coefficients suggest a positive and significant lagged effect of innovation (t) on inclusion ($t+1$) (Table 4). However, the impulse responses shows that a shock to innovation (*INN*) is negative one year later, and fairly uncertain after the first year.

The result of particular interest is the response of innovation to our inclusion index (panels in the first row, Figure 8). Both the estimated coefficients (Table 4) and the impulse responses suggest a strong and positive effect of inclusion on innovation. This is the strongest effect, such that one standard deviation shock to inclusion (*INC*) increases innovation (*INN*) in the following years, and the effect increases through time (the more time passes the stronger is the effect of inclusion on innovation). Innovation reaches a peak of about 0.02% over five years, and remains significantly high. With respect to structural change, although we observe a negative significant lagged impact of inclusion on structural change in the coefficients (Table 4), the response turns positive from the second year on, reaching a peak of 0.005% by the sixth year; with a significant impact until the tenth year. As for innovation, the effect grows through time: as time goes by, the positive effect of inclusive societies increases.

To complement the impulse response functions, we report variance decompositions in Table 11 in the Appendix C.2. While inclusion explains 67% of the variation in the innovation index and 9% of the variation in the structural change index after 10 years, structural change and innovation explain, respectively, only 3.5% and 1.3% of the variation of inclusion after 10 years.

Given that our index of inclusion is multi-dimensional and captures not just poverty and inequality, but also employment, wages, and gender participation, the results suggest importance of inclusive processes that builds capabilities leading to future innovation.

Next, we use an alternative index for structural change based on broader and more dynamic socio-economic changes (*SC2*). Table 5 re-examines the

Panel VAR results for the relation between structural change, innovation, and inclusion.[34] While Figure 9 shows the impulse response functions to one standard deviation shock in the other three indexes – from bottom to top structural change, innovation, inclusion.

[TABLE 5 HERE]

The response of innovation to a shock in structural change (panel in bottom row) is now positive and significant up to the fourth year (although the estimated coefficient for one year lag taken alone is not significant (Table 5). Specifically, a one standard deviation shock to structural change (SC1) increases innovation (*INN*) by about 0.01% by the third year (third panel, central column in Figure 9). Considering a broader measure of structural change, efforts in research and development, firm-level innovations and ICT are likely to go up. In fact, the impact from this type of structural change seems to kick in fairly quickly, but turns insignificant after the fourth year. On the other hand, innovation has a non significant impact on structural change. Structural change also does not have any significant effect on inclusion.

[FIGURE 9 HERE]

As for innovation (second panel in the left column), we confirm that it has no significant effect on inclusion, and in this case also no detectable significant effect on structural change.

Instead, when we look at the effect of a one standard deviation shock in inclusion (first panel in the central column) we find again a positive, significant, and persistent response in innovation. This is again the strongest effect, such that innovation still reaches a peak of about 0.01% over five years, albeit somewhat lower than when using *SC1*. Therefore, our findings strongly suggest that inclusion has a strong dynamic impact, by building capabilities leading to future innovation.

Finally, the lagged impact of inclusion on structural change is positive and significant in the coefficients (Table 5). In the IRFs, the response of structural change is positive, reaching a higher peak of about 0.01%, that turns insignificant after the fourth year (first panel, right column). The findings with a broader measure of structural change provide stronger evidence of how lower poverty and inequality with higher gender participation (higher inclusion), lead to higher structural change for about four years.

[34]For this PVAR system, we set $j = 4$, because the structural change index is based on urbanization, firm size, total Factor productivity, and gross capital formation, which are likely to change at a faster pace than employment shares. The impulse response functions are presented with a similar causal ordering as the first baseline: structural change, innovation, inclusion.

To complement the impulse response functions, we report variance decompositions in Table 11 in the Appendix C.2. The result provide a strong confirmation that when we employ a broader index of structural change, most of its variation after 10 years is explained by inclusion (40%) and innovation (13%); only the remaining 46% is explained by earlier changes in the structure of the economy. Variations in innovation after 10 years are mainly explained by inclusion 10 years before (73% of the variance) and to some extent by structural change (17%). Instead, as with earlier results using $SC1$, neither innovation nor structural change explain a great deal of the variation in inclusion, neither after one period, nor after 10 years: innovation explains 7.5% and structural change 3.4%.

The PVAR results reveal the causal relationship. We also undertook the Granger causality test to examine the direction of causality further. Overall, the results of Granger causality tests suggest a bi-directional relationship between structural change and innovation, and between innovation and inclusion. While, inclusion granger-causes structural change, structural change does not granger-cause inclusion.

The modulus of each eigenvalue of the estimated models were calculated to examine the stability condition of the PVAR models (Lütkepohl (2005)). In our case, the estimated PVAR baseline models satisfy the stability condition, as all eigenvalues lie inside the unit circle. The stability conditions for the baseline with $SC1$ and $SC2$ are outlined in Appendix D.1.

In sum, taking all results together, and with reference to Figure 1 we find that: innovation has a positive effect on structural change in the mid run, when we measure structural change with employment shares in manufacturing and services; structural change has a positive effect on innovation in the mid term, when we measure structural change with broader socio-economic changes; neither innovation nor structural change have any significant effect on inclusion (if we exclude small static effect that do not come up in the impulse response function); and inclusion has positive, significant and long lasting effects on both innovation and structural change. We summarise those results in figure 10, where a grey arrow indicates no significant effect, a black arrow indicate a significant one lag effect, which is not confirmed in the impulse response function, and a red arrow indicates a significant mid or long term effect in the impulse response function.

[FIGURE 10 HERE]

5.2 Types of Innovation

We now examine the PVAR using two sub-indexes for innovation: (1) R& D (Formal) innovation index (INN1) and (2) Firm-level innovation index

(INN2).[35]. We report results using both the structural change indexes SC1 and SC2.

Results with employment-based structural change (*SC1*) suggest a positive impact of lagged structural change on formal innovation in the coefficients in Table 12. The positive impact reduces and turns insignificant (in impulse responses) after the second year (First panel, central column in Figure 12). While, firm-level innovation shows a positive and significant response to a shock in structural change until about the fifth year (First panel, central column in Figure 13). These results suggest that the insignificant result for structural change that we found with the overall innovation index was due to the fact that different aspects of innovation respond differently to structural change.

[FIGURE 12 HERE]

[FIGURE 13 HERE]

When we examine the results for types of innovation with broad structural change (SC2), the effects are closer to the overall baseline result, as we find positive and significant effects on both types of innovation until about the fourth year (First panel, central column in Figures 14 and 15).

[FIGURE 14 HERE]

[FIGURE 15 HERE]

Overall findings here are the following. First, with an increasing proportion of employment in industry and services, the strongest impact appears to be on firm-level innovations, while there is an initial but short-lived positive impact on R&D innovation. Second, using a more broad measure of structural change, we observe the first part of the virtuous cycle such that structural change leads to both R&D and firm-level innovations.

However, the second part of the virtuous cycle from innovation to structural change seems absent over the 10 year period of our analysis. With both types of structural change (SC1 and SC2), the lagged impact of innovation on structural change is insignificant with an impulse in innovation; the only exception being a small positive response of broad structural change (SC2) to firm-level innovation (Second panel, right column in Figure 15).

The impact of structural change on inclusion exhibits a similar pattern where, inclusion shows insignificant effect to shocks in structural change. Again, the only exception is the case of firm-level innovation, where we find a very small positive impact such that inclusion improves in response to

[35] We do not discuss results using our third category of ICT Innovation Index (INN3), owing to instability of PVAR with this sub-index.

broad structural change (SC2) in the initial three years (Third panel, left column in Figure 15).

The positive and significant impact of inclusion on innovation still holds for both formal R&D innovation and firm-level innovation in the case of employment based structural change (SC1). Looking at the impulse responses, the positive response of innovation from inclusion reaches a peak of 0.01% by the fifth year with firm-level innovation, but the effect is merely 0.003% with R&D, that turns uncertain only after two years. However, with broad structural change (SC2), the impact of inclusion on both types of innovation (First panel, central column in Figures 14 and 15), shows a very small positive effect before turning insignificant from the second year. The results for the effect of inclusion on innovation suggest the strongest impact for firm-level innovations, when we consider the case of employment based structural change.

In all cases, the impact of innovation on inclusion is insignificant (Second panel, first column in all Figures of IRFs for innovation types). This confirms our overall baseline where we find no significant impact whatsoever for innovation on inclusion within the ten year period.

Finally, the exceptional results with firm-level innovation and the broad measure of structural change (SC2) above, suggest potential for inclusive structural change as there is evidence of a virtuous cycle between structural change and innovation, inclusion leads to innovation, and structural change in turn also has a small positive impact on structural change.

In what follows, we report some of the robustness analyses that was undertaken to investigate the sensitivity of the baseline results.

5.3 Robustness

This subsection summarizes two types of sensitivity tests to check the robustness of the results. The first considers changing the recursive ordering between the variables in the VAR. The second involves applying the panel regression to allow a number of sensitivity tests.

The baseline specification restricts contemporaneous effects of SC and INN on INCL, while the alternative specification restricts to INN, SC and INCL. Since the variables are contemporaneously correlated, restrictions will tend to limit the positive impact of a variable on the other. As expected, the alternative specification shows a lower peak response (before turning insignificant) of innovation to inclusion (0.015% vs.0.02% in the baseline) and of innovation on structural change (0.004% vs. 0.006% in the baseline). Since differences are small, they do not change the overall interpretation of results.

We also implemented sensitivity tests with the panel OLS. First, we control for GDP per capita that may influence the relation between innovation, inclusion and structural change. Second, we also control for other variables such as trade, education, and financial development. In model 1, the coefficient on structural change becomes significantly smaller, but remains significant; however past inclusion turns insignificant. In model 2, the coefficient for innovation turns negative when we control for additional factors. The results suggest important interaction effects for inclusion with factors such as education. Further checks with the panel OLS remain directions for further research as the main aim of this paper was to examine the dynamic relations.

6 Conclusions

This paper provides evidence on the three-way dynamic relations between innovation, structural change and inclusion. The extant literature suggests a strong positive feedback between innovation and structural change, but is more ambiguous on how either is related to inclusion. As we discuss in the framework, this relation is crucial: if inclusion is a necessary condition for more innovation, for example because talented individuals must have access to the resourced to innovate, a negative effect of innovation and/or structural change on inclusion may reduce future innovation and structural change, thus also reducing the positive feedback between innovation and structural change.

In this paper we add inclusion to the equation and test its relation with innovation and structural change. Accounting for the multidimensionality of innovation, structural change, and inclusion, to measure each of them we extract the underlying unobserved common factor structure from various well-known macro indicators, available for a sufficiently large panel of developing countries. We build a structural vector auto regression (SVAR) model for a short panel of developing countries over 13 years.

The virtuous cycle between innovation and structural change that is well-documented in the literature is also confirmed in our results. However, neither innovation nor structural change have a significant impact on inclusion. At least, experience from the country included do not send a worrying signal that innovation and structural change processes have been largely exclusive, according to the macro indicators used in this paper.

Instead, our strongest result is the positive effect of inclusion on both innovation and structural change. We find that in the medium run the variable that explains most of the variance in innovation is inclusion (more than innovation itself and structural change). This suggests that inclusion nurture innovation, but not the other way round. There is no virtuous cycle between innovation and inclusion.

At the macro level, these results send a strong policy message. If inclusion has a strong positive effect on innovations and structural change (which reinforce each other) over a ten year period, there are two clear policy implications. First, the only way to improve inclusion is direct inclusive policies (fiscal and redistributive policies, access to education, access to credit, etc), as neither innovation nor structural change, alone, improve inclusion – on average in the countries included in our study. Second, there is a space to make innovation and structural change more inclusive (as they do not appear to be so in current evidence). This would create a virtuous cycle between innovation, structural change and inclusion. Currently, innovation and structural change feed themselves, but are hold back by a lack of impact of inclusion – in the countries included in this study. If they were also inclusive, more innovation would also lead to more inclusion, which seem to lead to more innovation and structural change in the future

When we decompose the innovation index (formal, firm-level and ICT), we find each related differently to both structural change and inclusion. Therefore, different types of innovation react differently in their relations with inclusion and structural change. This suggests more nuanced innovation policy.

The paper has a number of limitations. First, in terms of measurement, we use rather coarse indicators of structural change, innovation, and inclusion, which may not do justice to the multiple dimensions of all three dynamics, and the multiple ways in which they intersect. Crucially, we leave out important chunks of innovation which are likely to occur in the countries covered in the paper – but which are not reflected in the variables for which data is collected and available – and multiple aspects of inclusion and exclusion, such as the participation in the innovation process, to name one. Extending the framework to micro-data on innovations, inclusion and structural change, where more detailed information on the three processes can be captured and modelled, remains an important topic of further research. Estimating the dynamic relations with micro-data will enable to overcome the above limits to current research in this paper.

References

Abrigo, M. R. M. and I. Love, "Estimation of panel vector autoregression in Stata," *Stata Journal*, 2016, *16* (3), 778–804(27).

Aghion, Philippe, Ufuk Akcigit, Antonin Bergeaud, Richard Blundell, and David Hémous, "Innovation and Top Income Inequality," jun 2015.

_ , _ , Ari Hyytinen, and Otto Toivanen, "The Social Origins of Inventors," 2017.

Akcigit, Ufuk, John Grigsby, and Tom Nicholas, "The Rise of American Ingenuity: Innovation and Inventors of the Golden Age," jan 2017.

Ali, Ifzal and Hyun Hwa Son, "Measuring Inclusive Growth," *Asian Development Review*, 2007, *24* (1), 11–31.

Anand, Rahul, Mishra Saurabh, and Shanaka J. Peiris, "Inclusive Growth : Measurement and Determinants," 2013.

Andrews, Donald and Biao Lu, "Consistent model and moment selection procedures for GMM estimation with application to dynamic panel data models," *Journal of Econometrics*, 2001, *101* (1), 123–164.

Antonelli, Cristiano., *The Economics of Innovation, New Technologies and Structural Change*, Vol. 20021468, Abingdon: Routledge, 2003.

Aoki, Masanao and Hiroshi Yoshikawa, "Demand saturation–creation and economic growth," *Journal of Economic Behavior & Organization*, 2002, *48* (2), 127–154.

Arrow, Kenneth, "The Economic Implications of Learning by Doing," *Review of Economic Studies*, 1962, *29* (2), 155–173.

Atkinson, A B, "Ensuring social inclusion in changing labour and capital markets," 2013.

Atkinson, Anthony B, *Inequality: What Can Be Done?*, Harvard University Press, 2015.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenen, "The Lifecycle of Inventors," 2016.

Blattman, Christopher and Stefan Dercon, "Occupational Choice in Early Industrializing Societies: Experimental Evidence on the Income and Health Effects of Industrial and Entrepreneurial Work," sep 2016.

Bourguignon, F, "The growth elasticity of poverty reduction: explaining heterogeneity across countries and time periods," in Theo S. Eicher and Stephen J. Turnovsky, eds., *Inequality and growth: Theory and policy . . .*, MIT Press, 2003, chapter 1, pp. 3–26.

Burgess, Robin and Anthony J Venables, "Toward a microeconomics of growth," Policy Research Working Paper Series 3257, The World Bank apr 2004.

Caiani, Alessandro, Alberto Russo, and Mauro Gallegati, "Does Inequality Hamper Innovation and Growth?," 2016.

Card, David E. and John Enrico DiNardo, "Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles," *Journal of Labor Economics*, 2002, *20* (4), 733–783.

Carree, Martin, André van Stel, Roy Thurik, and Sander Wennekers, "Economic Development and Business Ownership: An Analysis Using Data of 23 OECD Countries in the Period 19761996," *Small Business Economics*, 2002, *19* (3), 271–290.

Ciarli, Tommaso and Michele Di Maio, "Theoretical arguments for industrialisation-driven growth and economic development," in Francis A S T Matambalya, ed., *African Industrial Development and European Union Co-operation. Prospects for a reengineered partnership*, Routledge, 2014.

_ , André Lorentz, Marco Valente, and Maria Savona, "Structural Changes and Growth Regimes," 2017.

_ , _ , Maria Savona, and Marco Valente, "The effect of consumption and production structure on growth and distribution. A micro to macro model," *Metroeconomica*, 2010, *61* (1), 180–218.

_ , Maria Savona, Jodie Thorpe, and Seife Ayele, "Innovation Pathways to Inclusive Structural Change. A Framework for a New Research Agenda," 2018.

Cimoli, Mario and Gabriel Porcile, "Sources of learning paths and technological capabilities: an introductory roadmap of development processes," *Economics of Innovation and New Technology*, 2009, *18* (7), 675–694.

_ and _ , "Learning, Technological Capabilities, and Structural Dynamics," in José Antonio Ocampo and Jaime Ros, eds., *The Oxford Handbook of Latin American Economics*, Oxford University Press, 2011.

_ , _ , and Sebastián Rovira, "Structural change and the BOP-constraint: why did Latin America fail to converge?," *Cambridge Journal of Economics*, 2010, *34* (2), 389–411.

Cirera, Xavier and William F. Maloney, "The Innovation Paradox: Developing-Country Capabilities and the Unrealized Promise of Technological Catch-Up," Technical Report, The World Bank, Washington DC 2017.

Cornwall, John, *Modern Capitalism: Its Growth and Transformation*, New York: St. Martin's Press, 1977.

Deininger, Klaus and Lyn Squire, "New ways of looking at old issuesinequality and growth," *Journal of Development Economics*, 1998, *57* (2), 259–287.

Desmet, Klaus and StephenL. Parente, "The evolution of markets and the revolution of industry: a unified theory of growth," *Journal of Economic Growth*, 2012, *17* (3), 205–234.

Diao, Xinshen, Margaret McMillan, and Dani Rodrik, "The Recent Growth Boom in Developing Economies: A Structural Change Perspective," feb 2017.

Dollar, David, Tatjana Kleineberg, and Aart Kraay, "Growth still is good for the poor," *European Economic Review*, 2013, *81* (3), 68–85.

Dosi G, "Opportunities, Incentives and Collective Patterns of Technological Change," *The Economic Journal*, sep 1997, *107* (444), 1530–1547.

Esteban, Joan and Debraj Ray, "Linking Conflict to Inequality and Polarization," *American Economic Review*, jun 2011, *101* (4), 1345–1374.

Foster, Christopher and Richard Heeks, "Conceptualising Inclusive Innovation: Modifying Systems of Innovation Frameworks to Understand Diffusion of New Technology to Low-Income Consumers," *European Journal of Development Research*, apr 2013, *25* (3), 333–355.

Funke, Michael and Ralf Ruhwedel, "Product Variety and Economic Growth: Empirical Evidence for the OECD Countries," *IMF Staff Papers*, 2001, *48* (2), pp. 225–242.

Galor, Oded, "The 2008 Lawrence R. Klein Lecture Comparative Economic Development: Insights from Unified Growth Theory," *International Economic Review*, 2010, *51* (1), 1–44.

Gault, F and G Zhang, "The role of innovation in the area of development," in E Kraemer-Mbula and W Wamae, eds., *Innovation and the Development Agenda*, Paris: OECD/IDRC, 2010.

Gault, Fred, "Defining and Measuring Innovation in all Sectors of the Economy : Policy Relevance," 2016.

Greif, Avner, *Institutions and the path to the modern economy: lessons from medieval trade* Political economy of institutions and decisions, Cambridge University Press, 2006.

Guellec, Dominique and Caroline Paunov, "Digital Innovation and the Distribution of Income," nov 2017.

Hansen, Lars, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, 1982, *50* (4), 1029–54.

Hausmann, Ricardo and César Hidalgo, "The network structure of economic output," *Journal of Economic Growth*, 2011, *16* (4), 309–342.

Heeks, Richard, Christopher Foster, and Yanuar Nugroho, "New models of inclusive innovation for development," *Innovation and Development*, jul 2014, *4* (2), 175–185.

Helpman, Elhanan, Oleg Itskhoki, and Stephen Redding, "Inequality and Unemployment in a Global Economy," *Econometrica*, 2010, *78* (4), 1239–1283.

Hidalgo, Cesar A, B Klinger, A-L Barabasi, and Ricardo Hausmann, "The Product Space Conditions the Development of Nations," *Science*, 2007, *317* (5837), 482–487.

Hirschman, Albert O, *The Strategy of Economic Development*, New Haven: Yale University Press, 1958.

Hjort, Jonas and Jonas Poulsen, "The Arrival of Fast Internet and Skilled Job Creation in Africa," 2017.

Ianchovichina, Elena and Susanna Lundström, "Inclusive Growth Analytics: Framework and Application," mar 2009.

Imbs, Jean and Romain Wacziarg, "Stages of Diversification," *American Economic Review*, 2003, *93* (1), 63–86.

Joel Mokyr, "The Contribution of Economic History to the Study of Innovation and Technical Change: 17501914," in Bronwyn H. Hall and Nathan Rosenberg, eds., *Handbook of the Economics of Innovation*, North-Holland, 2010, chapter 2, pp. 11–50.

Kaldor, Nicholas, *Causes of the Slow rate of Economic Growth in the United Kingdom*, Cambridge: Cambridge University Press, 1966.

— , "The Role of Increasing Returns, Technical Progress and Cumulative Causation in the The Theory of International Trade and Economic Growth," *Economie Appliquée*, 1981, *XXXIV* (4).

Karabarbounis, L. and B. Neiman, "The Global Decline of the Labor Share," *The Quarterly Journal of Economics*, oct 2013, *129* (1), 61–103.

Kuznets, Simon, "Modern Economic Growth: Findings and Reflections," *American Economic Review*, 1973, *63*, 247–258.

Lall, Sanjaya, "Is African Industry Competing?," QEH Working Papers, Queen Elizabeth House, University of Oxford 2005.

Leoncini, Riccardo, "Innovation, inequality and the skill premium," 2017.

Lundvall, Bengt-Åake, *National Systems of Innovation: Toward a Theory of Innovation and Interacting Learning*, London: Pinter Publisher, 1992.

Lütkepohl, Helmut, *New introduction to multiple time series analysis*, Springer Science & Business Media, 2005.

Malerba, Franco and Luigi Orsenigo, "Schumpeterian patterns of innovation," *Cambridge Journal of Economics*, 1995, *19* (1), 47–65.

— and — , "Technological Regimes and Sectoral Patterns of Innovative Activities," *Industrial and Corporate Change*, 1997, *6* (1), 83–118.

Matsuyama, Kiminori, "Structural Change," in Steven N Durlauf and Lawrence E Blume, eds., *The New Palgrave Dictionary of Economics*, second edi ed., Basingstoke: Palgrave Macmillan, 2008.

McMillan, Margaret and Dani Rodrik, "Globalization, structural change and productivity growth," in Marc Bacchetta and Marion Jansen, eds., *Making globalization socially sustainable*, Geneva: International Labour Organization and World Trade Organization, 2011, chapter 2, pp. 49–84.

— , — , and Claudia Sepulveda, "Structural Change, Fundamentals and Growth: A Framework and Case Studies," 2017.

Naude, Wim and Paula Nagler, "Industrialisation, Innovation, Inclusion," 2015.

OECD, "Innovaiton Policies for Inclusive Development. Scaling Up Inclusive Innovations," Technical Report, OECD, Paris 2015.

Ostry, Mr. Jonathan David, Mr. Andrew Berg, and Mr. Charalambos G. Tsangarides, "Redistribution, Inequality, and Growth," 2014.

Paunov, C., "Innovation and Inclusive Development," *OECD Publishing*, 2013, p. 67.

Planes-Satorra, Sandra and Caroline Paunov, "Inclusive innovation policies," apr 2017.

Rauniyar, Ganesh and Ravi Kanbur, "Inclusive growth and inclusive development: A review and synthesis of Asian Development Bank literature," nov 2010.

Ravallion, Martin, "Pro-Poor Growth: A Primer," mar 2004.

_ **and Shaohua Chen**, "Measuring pro-poor growth," 2003.

Rosenstein-Rodan, P N, "Problems of Industrialisation of Eastern and South–Easthern Europe," *The Economic Journal*, 1943, *53* (210/211), 202–211.

Rowthorn, Bob and Ramana Ramaswamy, "Deindustrialization: Causes and Implications," IMF Working Papers 97/42, International Monetary Fund apr 1997.

Ruttan, Vernon W, "Sources of Technical change: Induced Innovation, Ecvolutionary Theory and Path Dependence," in William D Nordhaus Arnulf Grübler Nebojša Nakićenović, ed., *Technological change and the environment*, Resources for the Future, 2002, chapter 2, pp. 9–39.

Saha, Amrita and Thorpe Jodie, "Inclusive Structural Change: Case studies on innovations in breeding practices in Kenya and anti-retro viral therapy service provision in Mozambique," Technical Report, Institute of Development Studies forthcoming 2018.

Saviotti, Pier Paolo and Andreas Pyka, "Economic Development by the Creation of New Sectors," *Journal of Evolutionary Economics*, 2004, *14(1)*, 1–35.

_ **and Jean Luc Gaffard**, "Preface for the special issue of JEE on 'Innovation, structural change and economic development'," *Journal of Evolutionary Economics*, 2008, *18* (2), 115–117.

_ **and Koen Frenken**, "Export variety and the economic performance of countries," *Journal of Evolutionary Economics*, 2008, *18* (2), 201–218.

Shen, J, D Dunn, and Y Shen, "Challenges facing U.S. Manufacturing and Strategies," *Journal of Industrial Technology*, 2007, *23* (2), 2–10.

Stewart, Frances and Arnim Langer, "Horizontal Inequalities: Explaining Persistence and Change," in Frances Stewart, ed., *Horizontal*

Inequalities and Conflict: Understanding Group Violence in Multiethnic Societies, Basingstoke and New York: Palgrave Macmillan, 2008, chapter 4, pp. 54–82.

Stiglitz, Joseph E., *The Price of Inequality: How Today's Divided Society Endangers Our Future*, W. W. Norton, 2012.

Szirmai, Adam, "Industrialisation as an engine of growth in developing countries, 1950-2005," *Structural Change and Economic Dynamics*, 2012, *23* (4), 406–420.

UNU-WIDER, "Structural Change, Poverty Reduction and Industrial Policy in the BRICS," Technical Report, UNU-WIDER, Helsinki 2012.

Verspagen, B, *Uneven Growth Between Interdependent Economies: Evolutionary Views on Technology Gaps, Trade and Growth*, Avenbury, 1993.

von Tunzelmann, G Nick, *Technology and Industrial Progress: The Foundations of Economic Growth*, Aldershot: Edward Elgar, 1995.

Wilkinson, Richard and Kate Pickett, *The Spirit Level: Why Greater Equality Makes Societies Stronger*, Bloomsbury USA, 2011.

Witt, Ulrich, "Product Characteristics, Innovations and the Evolution of Consumption. A Behavioral Approach," mimeo, Paper prepared for the conference on "Technical Change: History, Economics and Policy" in honor of G.N. Tunzelmann, SPRU, March 2010, Max Planck Institute of Economics, Brighton 2010.

A Tables

	INC favours INN				INC reduces INN			
	t	SC	INN	INC	**t**	SC	INN	INC
	t-1				**t-1**			
	SC		+	+	SC		+	+
1	INN	+		+	INN	+		+
	INC	+	+		INC	+	-	
	SC		+	-	SC		+	-
2	INN	+		+	INN	+		+
	INC	+	+		INC	+	-	
	SC		+	+	SC		+	+
3	INN	+		-	INN	+		-
	INC	+	+		INC	+	-	
	SC		+	-	SC		+	-
4	INN	+		-	INN	+		-
	INC	+	+		INC	+	-	

Notes: INN: innovation; SC: structural changes; INC: inclusion; EXC: exclusion. "+/-" indicates a positive/negative relation between the variable in $t-1$ and in t.

Table 1: ***Four scenarios in the dynamic relations between innovation, structural changes, and inclusion.***

Source: own elaboration

Variable	Obs	Mean	Std. Dev.	Min	Max
Employment Based SC					
Structural Change Index-SC1	386	0.470	0.263	0	1
Broad Structural Change Index					
Structural Change Index-SC2	350	0.450	0.267	0	1
Inclusion Index (INC)	422	0.621	0.256	0	1
Innovation Index (INN)	299	0.251	0.221	0	1
Innovation Sub-Indexes					
R&D Innovation Index (INN1)	396	0.443	0.196	0	1
Firm-Level Innovation Index (INN2)	325	0.258	0.202	0	1
ICT Innovation Index (INN3)	396	0.368	0.235	0	1

Table 2: Summary Statistics for Indexes

Figure 2 presents the summary statistics of the indexes.

MODEL 1 Dependent Variable-Innovation			**MODEL 2** Dependent Variable-Inclusion		
Variables	I	II	Variables	III	IV
Structural Change Index	0.325***	0.213***	Innovation Index	0.262***	0.251***
	(0.081)	(0.046)		(0.010)	(0.013)
Inclusion Index (t-1)		1.183***	Structural Change Index (t-1)		0.033
		(0.099)			(0.019)
Constant	0.116***	-0.572***	Constant	0.557***	0.551***
	(0.024)	(0.068)		(0.006)	(0.005)
Observations	286	264	Observations	299	264
Countries	22	22	Countries	23	22

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Panel OLS regression results-Model 1 & Model 2

Figure 3 presents the results for panel OLS with structural change index-SC1. In model 1 (columns I and II), the dependent variable is innovation regressed on structural change and lagged inclusion. The dependent variable in model 2 (columns III and IV) is inclusion regressed on innovation and lagged structural change.

VARIABLES	(1) Structural Change SC1	(2) Innovation	(3) Inclusion
Structural Change(t-1)	0.523***	0.030*	-0.019
	(0.075)	(0.018)	(0.013)
Innovation(t-1)	0.197***	0.686***	0.038***
	(0.037)	(0.049)	(0.012)
Inclusion(t-1)	-0.180**	1.021***	0.872***
	(0.081)	(0.126)	(0.033)
Observations	176	176	176

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: PVAR(1) regression results for Structural Change (SC1), Innovation, Inclusion

Using panel data from 2000-2013 (13 years) for the 33 developing and emerging countries, Table 4 presents the Panel VAR results for structural change index-SC1 with Innovation and Inclusion. The coefficients are average responses of the endogenous variables to an exogenous shock in any one variable after controlling for time-invariant characteristics of individual countries.

VARIABLES	(1) Structural Change SC2	(2) Innovation	(3) Inclusion
Structural Change(t-1)	0.931***	0.002	0.022
	(0.067)	(0.042)	(0.021)
Innovation(t-1)	-0.075	0.871***	0.005
	(0.055)	(0.051)	(0.018)
Inclusion(t-1)	0.593***	0.784***	0.892***
	(0.133)	(0.139)	(0.050)
Observations	189	189	189

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: PVAR(1) regression results for Structural Change (SC2), Innovation, Inclusion

Using panel data from 2000-2013 (13 years) for the 33 developing and emerging countries, Table 5 presents the Panel VAR results for structural change index-SC2 with Innovation and Inclusion. The coefficients are average responses of the endogenous variables to an exogenous shock in any one variable after controlling for time-invariant characteristics of individual countries.

B Figures

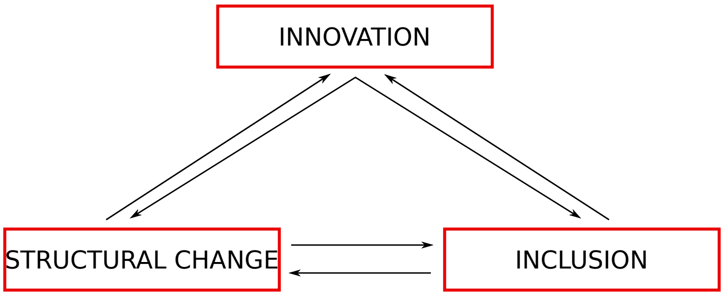


Figure 1: **A three-way virtuous cycle?**.

Source: own elaboration based on (Ciarli et al., 2018)

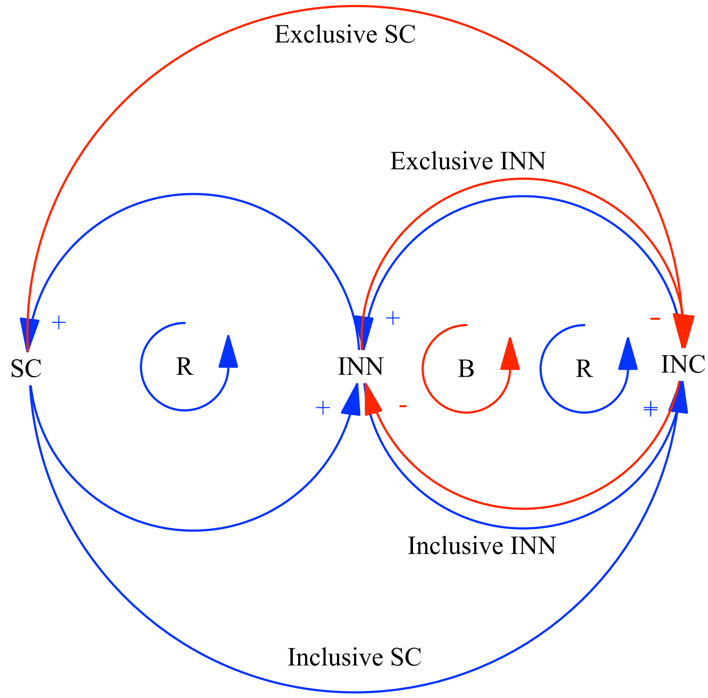


Figure 2: **Dynamic relations between innovation, structural changes, and inclusion**. *Notes: INN: innovation; SC: structural changes; INC: inclusion; R: reinforcing mechanisms – a positive shock in one variable induces a positive effect in the other variable; B: balancing mechanisms – a positive shock in one variable induces a negative effect on the other variable. Blue indicates a positive impact; red indicates a negative impact. Example, starting from SC. As SC increases in* t*, INN will increase in* $t+1$*; in turn, SC will increase in* $t+2$ *because of the reinforcing mechanism between SC and INN, and so on; INN (*$t+1$*) can increase (blue) or decrease (red) INC in* $t+2$*; also SC (*t*) can increase (blue) or decrease (red) INC in* $t+1$*; INC in* $t+1(t+2)$ *can increase (reinforcing mechanism) or decrease (balancing mechanism) INN in* $t+2(t+3)$*; and so on.*

Source: own elaboration based on (Ciarli et al., 2018)

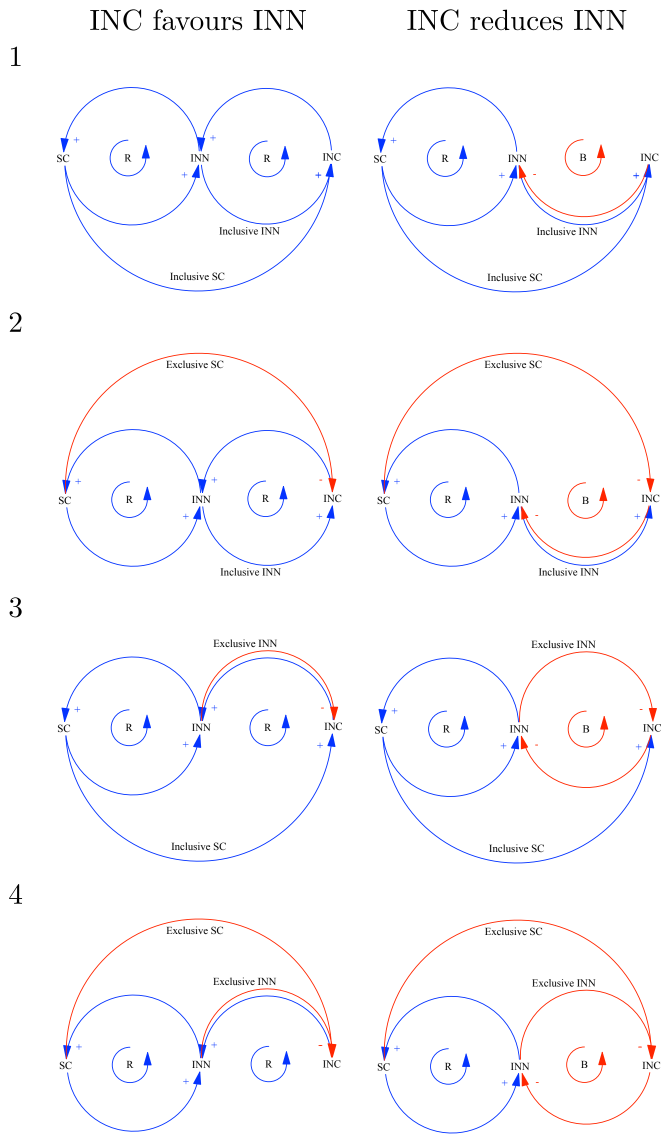
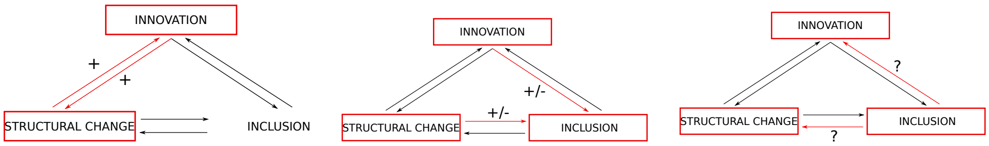


Figure 3: **Four scenarios in the dynamic relations between innovation, structural changes, and inclusion.**.

Source: own elaboration based on (Ciarli et al., 2018)



(a): INN ⇔ SC (b): INN & SC ⇒ INC (c): INC ⇒ INN & SC

Figure 4: **What we seem to know about the three way relation between INN, SC & INC from the literature**.

Source: own elaboration based on (Ciarli et al., 2018)

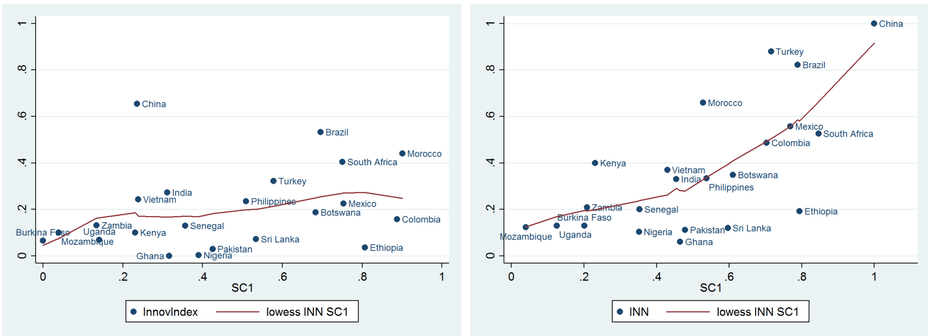


Figure 5: Structural Change & Innovation-2000 & 2012

Figure 5 presents the locally weighted smoothing regression (LOWESS) between the indices of Innovtion (INN) and structural change (SC1) to examine their association and how it changed between 2000 and 2012. The dots indicate the levels of the indexes; the red line is an estimate of the locally weighted relation. The panels on the left exhibit the relation in 2000 and the right panel exhibits the relation in 2012.

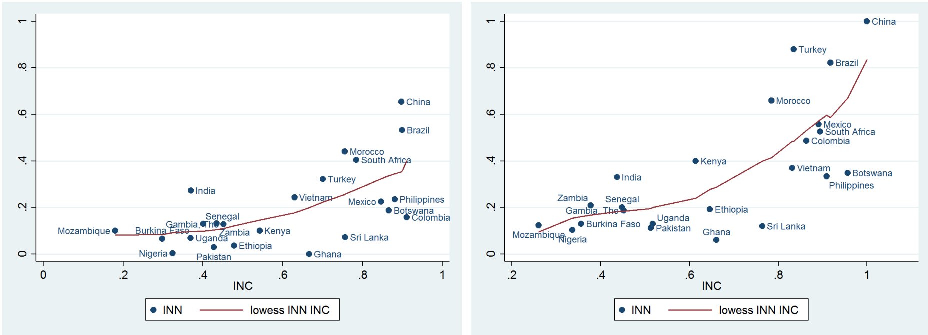


Figure 6: Inclusion & Innovation-2000 & 2012

Figure 6 presents the locally weighted smoothing regression (LOWESS) between the indices of Innovation (INN) and inclusion (INC) to examine their association and how it changed between 2000 and 2012. The dots indicate the levels of the indexes; the red line is an estimate of the locally weighted relation. The panels on the left exhibit the relation in 2000 and the right panel exhibits the relation in 2012.

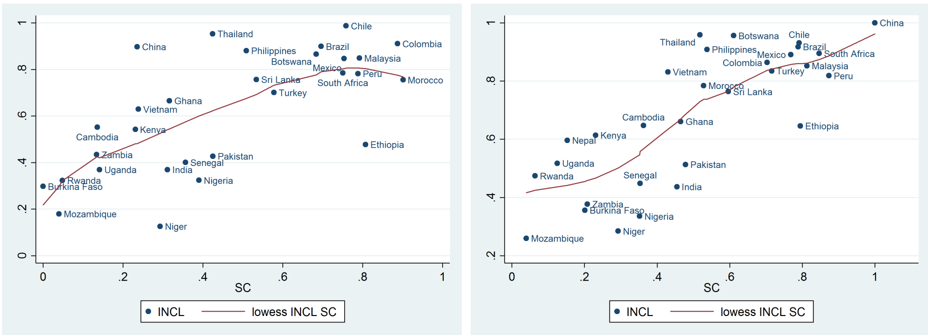


Figure 7: Structural Change & Inclusion-2000 & 2012

Figure 7 presents the locally weighted smoothing regression (LOWESS) between the indices of Inclusion (INC) and Structural change (SC1) to examine their association and how it changed between 2000 and 2012. The dots indicate the levels of the indexes; the red line is an estimate of the locally weighted relation. The panels on the left exhibit the relation in 2000 and the right panel exhibits the relation in 2012.

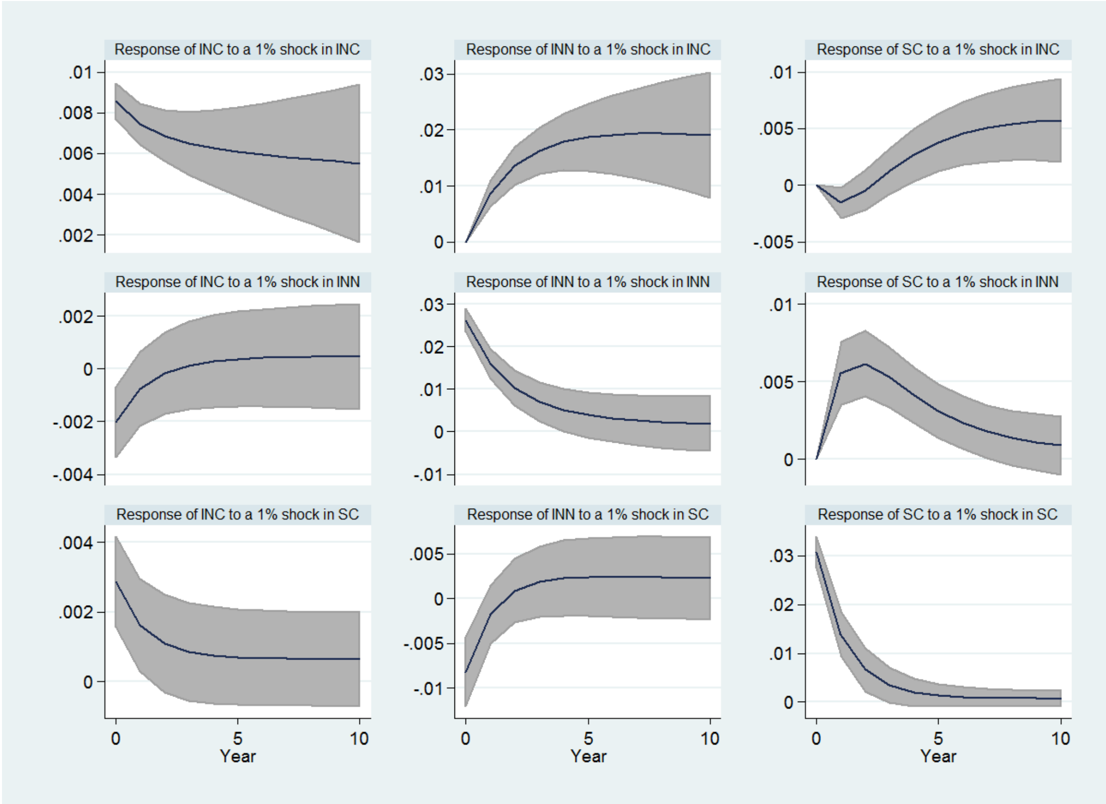


Figure 8: Impulse response functions. Variables: SCI1, INN, INCL.

Figure 8 reports the coefficients from the baseline estimation with employment based structural change index-SC1, innovation index-INN and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN and SC1. The column in the center contains the plots of the responses of INN to a shock of one standard deviation (impulse) in INC, INN and SC1. The column on the right are responses of SC to a shock of one standard deviation (impulse) in INC, INN and SC1. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

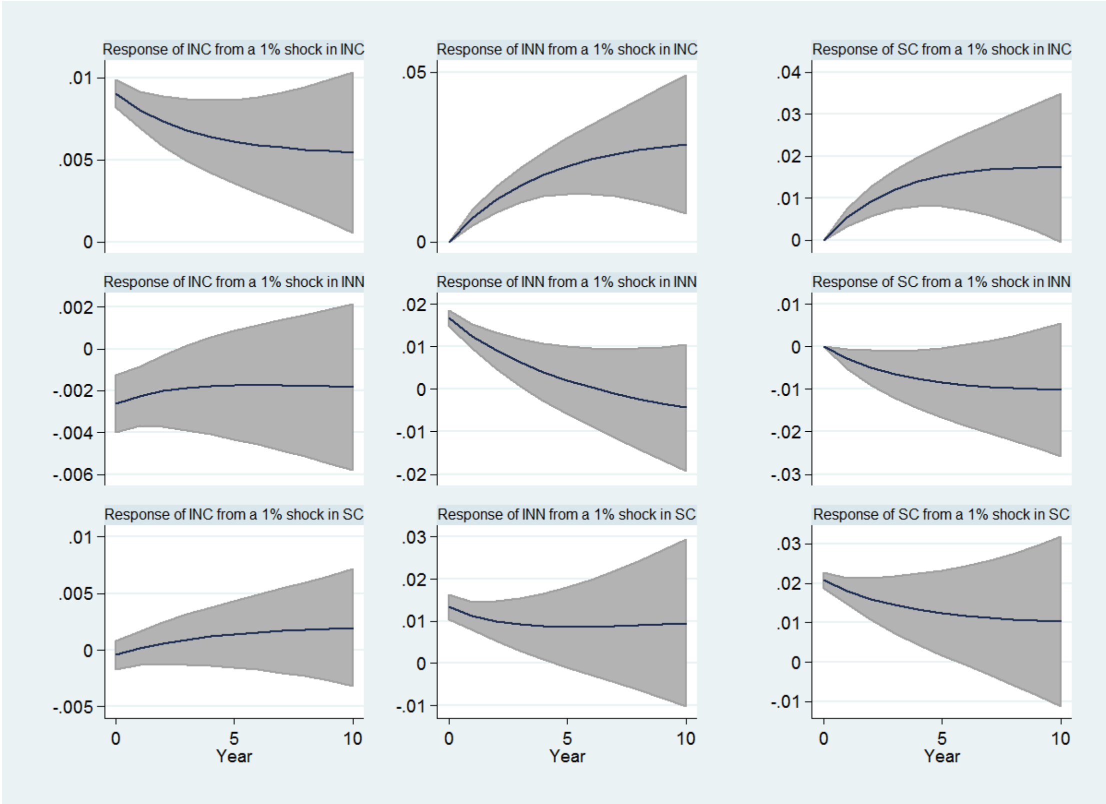


Figure 9: Impulse response functions. Variables: SC2, INN, INCL.

Figure 9 reports the coefficients from the baseline estimation with employment based structural change index-SC2, innovation index-INN and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN and SC2. The column in the center contains the plots of the responses of INN to a shock of one standard deviation (impulse) in INC, INN and SC2. The column on the right are responses of SC to a shock of one standard deviation (impulse) in INC, INN and SC2. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

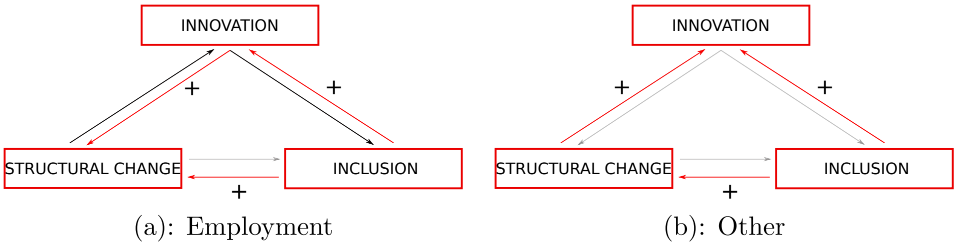


Figure 10: ***Summary of the relations at work*** *With different measures of structural change (a) employment shares in services and manufacturing; (b) broader socio-economic transformations.*

C Tables for Appendix

C.1 Indexes by country year

Country Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Botswana	0.187	0.187	0.187	0.187	0.187	0.186	0.187	0.188	0.189	0.188	0.244	0.301	0.349
Brazil	0.533	0.538	0.544	0.562	0.590	0.624	0.656	0.686	0.715	0.746	0.777	0.804	0.822
Burkina Faso	0.066	0.066	0.073	0.077	0.080	0.072	0.068	0.063	0.065	0.084	0.107	0.127	0.130
China	0.655	0.663	0.677	0.701	0.729	0.762	0.798	0.841	0.888	0.918	0.943	0.961	1.000
Colombia	0.158	0.161	0.165	0.177	0.187	0.196	0.205	0.225	0.248	0.270	0.343	0.414	0.487
Ethiopia	0.036	0.036	0.036	0.037	0.037	0.037	0.037	0.038	0.038	0.038	0.044	0.117	0.193
Gambia, The	0.128	0.128	0.128	0.129	0.130	0.132	0.135	0.136	0.136	0.136	0.138	0.162	0.188
Ghana	0.000	0.000	0.001	0.002	0.004	0.005	0.007	0.010	0.013	0.016	0.030	0.045	0.060
India	0.272	0.271	0.271	0.271	0.274	0.282	0.290	0.297	0.301	0.305	0.312	0.320	0.331
Kenya	0.100	0.101	0.102	0.105	0.108	0.110	0.115	0.121	0.127	0.130	0.209	0.302	0.399
Mexico	0.225	0.231	0.246	0.269	0.298	0.321	0.331	0.334	0.332	0.350	0.420	0.492	0.557
Morocco	0.440	0.441	0.439	0.443	0.456	0.475	0.493	0.502	0.524	0.550	0.595	0.627	0.660
Mozambique	0.100	0.101	0.101	0.102	0.102	0.103	0.106	0.108	0.096	0.082	0.087	0.105	0.124
Nigeria	0.003	0.003	0.003	0.004	0.006	0.010	0.016	0.023	0.038	0.055	0.075	0.090	0.104
Pakistan	0.029	0.032	0.036	0.045	0.053	0.068	0.080	0.108	0.125	0.135	0.128	0.116	0.112
Philippines	0.235	0.236	0.238	0.241	0.244	0.245	0.245	0.246	0.247	0.251	0.274	0.302	0.333
Senegal	0.129	0.130	0.130	0.132	0.136	0.140	0.144	0.148	0.158	0.167	0.181	0.190	0.200
South Africa	0.404	0.405	0.407	0.412	0.426	0.439	0.453	0.458	0.463	0.462	0.471	0.493	0.526
Sri Lanka	0.072	0.072	0.072	0.074	0.076	0.080	0.079	0.078	0.077	0.083	0.093	0.106	0.120
Turkey	0.323	0.329	0.338	0.359	0.414	0.473	0.530	0.576	0.653	0.737	0.805	0.842	0.880
Uganda	0.069	0.069	0.069	0.064	0.060	0.055	0.060	0.069	0.081	0.092	0.106	0.119	0.130
Vietnam	0.243	0.245	0.246	0.251	0.258	0.272	0.287	0.303	0.316	0.328	0.340	0.354	0.370
Zambia	0.131	0.132	0.132	0.134	0.136	0.140	0.144	0.148	0.163	0.176	0.194	0.200	0.208

Table 6: Innovation Index-INN, by country and year

Figure 6 presents the innovation indexes by country and year.

Country Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Botswana	0.684	0.735	0.752	0.755	0.724	0.693	0.650	0.606	0.563	0.563	0.579	0.595	0.611
Brazil	0.696	0.688	0.688	0.684	0.685	0.685	0.690	0.700	0.712	0.720	0.777	0.780	0.789
Burkina Faso	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.083	0.150	0.201	0.201	0.201	0.201
Cambodia	0.136	0.159	0.167	0.182	0.236	0.290	0.344	0.344	0.279	0.215	0.221	0.292	0.362
Chile	0.758	0.764	0.766	0.768	0.810	0.852	0.897	0.902	0.908	0.912	0.872	0.830	0.791
China	0.235	0.235	0.247	0.488	0.731	0.965	0.973	0.980	0.982	0.981	0.981	0.990	1.000
Colombia	0.888	0.704	0.698	0.626	0.681	0.674	0.674	0.680	0.694	0.701	0.698	0.698	0.703
Ethiopia	0.807	0.807	0.807	0.807	0.807	0.560	0.556	0.553	0.797	0.797	0.797	0.795	0.794
Ghana	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.366	0.415	0.465
India	0.311	0.311	0.311	0.311	0.311	0.331	0.350	0.370	0.370	0.370	0.392	0.415	0.454
Kenya	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
Malaysia	0.792	0.809	0.813	0.824	0.817	0.812	0.807	0.802	0.802	0.797	0.799	0.807	0.813
Mexico	0.754	0.750	0.746	0.745	0.746	0.755	0.762	0.771	0.775	0.778	0.778	0.775	0.768
Morocco	0.901	0.900	0.759	0.619	0.472	0.468	0.469	0.484	0.502	0.513	0.521	0.525	0.528
Mozambique	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
Nepal		0.241		0.241		0.241		0.241	0.197	0.182	0.152	0.152	0.152
Niger	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293	0.293
Nigeria	0.390	0.390	0.390	0.390	0.390	0.390	0.390	0.377	0.364	0.352	0.352	0.352	0.352
Pakistan	0.425	0.425	0.450	0.476	0.497	0.493	0.489	0.489	0.484	0.479	0.475	0.477	0.478
Peru	0.788	0.776	0.771	0.755	0.753	0.751	0.758	0.767	0.781	0.814	0.843	0.870	0.873
Philippines	0.509	0.509	0.507	0.508	0.510	0.513	0.514	0.516	0.515	0.516	0.520	0.527	0.537
Rwanda	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.064
Senegal	0.357	0.357	0.357	0.357	0.357	0.357	0.370	0.382	0.395	0.395	0.395	0.374	0.353
South Africa	0.750	0.740	0.728	0.715	0.720	0.739	0.754	0.764	0.768	0.775	0.801	0.825	0.846
Sri Lanka	0.534	0.534	0.534	0.536	0.542	0.561	0.583	0.602	0.606	0.601	0.593	0.585	0.596
Thailand	0.424	0.438	0.445	0.459	0.474	0.485	0.495	0.497	0.496	0.506	0.516	0.519	0.518
Turkey	0.578	0.566	0.571	0.574	0.585	0.605	0.649	0.694	0.722	0.721	0.718	0.716	0.715
Uganda	0.141	0.141	0.141	0.152	0.163	0.155	0.137	0.118	0.118	0.120	0.123	0.125	0.125
Vietnam	0.238	0.250	0.261	0.287	0.314	0.333	0.366	0.390	0.415	0.415	0.415	0.415	0.430
Zambia	0.134	0.134	0.134	0.134	0.134	0.135	0.137	0.138	0.141	0.145	0.148	0.148	0.208

Table 7: Employment Based Structural Change Index-SC1, by Year

Figure 7 presents the employment based structural change indexes-SC1 by country and year.

Country Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Botswana	0.522	0.525	0.530	0.537	0.547	0.543	0.534	0.534	0.559	0.594	0.655	0.692	0.724
Brazil	0.694	0.690	0.687	0.682	0.685	0.691	0.699	0.710	0.726	0.731	0.738	0.739	0.747
Burkina Faso	0.083	0.060	0.065	0.074	0.102	0.126	0.130	0.135	0.143	0.183	0.224	0.259	0.285
China	0.592	0.598	0.604	0.627	0.657	0.685	0.703	0.716	0.736	0.762	0.788	0.808	0.819
Colombia	0.503	0.508	0.513	0.525	0.536	0.547	0.561	0.575	0.588	0.591	0.627	0.667	0.710
Ethiopia	0.234	0.225	0.223	0.222	0.230	0.240	0.249	0.256	0.259	0.259	0.258	0.309	0.376
Gambia, The	0.183	0.213	0.218	0.245	0.318	0.388	0.450	0.443	0.436	0.425	0.396	0.395	0.391
Ghana	0.352	0.351	0.333	0.328	0.342	0.381	0.392	0.384	0.376	0.382	0.404	0.421	0.455
India	0.324	0.334	0.337	0.348	0.369	0.396	0.423	0.451	0.463	0.477	0.474	0.480	0.476
Kenya	0.256	0.264	0.257	0.257	0.254	0.264	0.273	0.287	0.296	0.301	0.304	0.312	0.321
Malaysia	0.947	0.937	0.936	0.930	0.936	0.941	0.953	0.964	0.969	0.962	0.965	0.974	1.000
Mexico	0.613	0.602	0.597	0.596	0.607	0.621	0.633	0.641	0.651	0.650	0.721	0.790	0.867
Morocco	0.812	0.823	0.827	0.841	0.852	0.863	0.870	0.880	0.906	0.919	0.922	0.916	0.919
Mozambique	0.374	0.341	0.352	0.335	0.329	0.294	0.275	0.258	0.254	0.246	0.255	0.279	0.369
Nepal		0.002		0.000		0.021		0.055	0.074	0.081	0.110	0.133	0.143
Niger	0.015	0.014	0.020	0.031	0.039	0.067	0.093	0.121	0.149	0.166	0.196	0.198	0.203
Nigeria	0.078	0.118	0.130	0.158	0.147	0.125	0.101	0.092	0.094	0.109	0.145	0.182	0.201
Pakistan	0.273	0.272	0.270	0.270	0.271	0.280	0.291	0.300	0.305	0.304	0.300	0.290	0.287
Peru	0.808	0.802	0.801	0.798	0.799	0.802	0.813	0.831	0.858	0.861	0.854	0.838	0.840
Philippines	0.542	0.557	0.569	0.581	0.580	0.571	0.555	0.540	0.530	0.522	0.528	0.530	0.532
Rwanda	0.087	0.094	0.099	0.110	0.123	0.136	0.149	0.164	0.190	0.213	0.229	0.246	0.272
Senegal	0.197	0.188	0.183	0.190	0.202	0.225	0.234	0.256	0.275	0.268	0.249	0.234	0.255
South Africa	0.554	0.553	0.556	0.563	0.575	0.586	0.599	0.610	0.627	0.632	0.631	0.626	0.627
Sri Lanka	0.295	0.268	0.263	0.246	0.256	0.268	0.287	0.296	0.299	0.289	0.294	0.308	0.347
Thailand	0.736	0.736	0.737	0.746	0.764	0.800	0.825	0.840	0.849	0.844	0.853	0.858	0.887
Turkey	0.771	0.748	0.749	0.744	0.750	0.716	0.687	0.662	0.699	0.711	0.737	0.745	0.762
Uganda	0.068	0.074	0.078	0.088	0.090	0.096	0.096	0.101	0.102	0.113	0.123	0.136	0.143
Zambia											0.501	0.519	0.522

Table 8: Broad Structural Change Index-SC2, by Year

Figure 8 presents the broad structural change indexes-SC2 by country and year.

Country Name	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Botswana	0.866	0.866	0.866	0.866	0.866	0.866	0.866	0.866	0.866	0.881	0.911	0.942	0.956
Brazil	0.899	0.893	0.892	0.888	0.891	0.893	0.900	0.904	0.909	0.912	0.914	0.915	0.918
Burkina Faso	0.298	0.298	0.298	0.298	0.298	0.298	0.299	0.300	0.302	0.320	0.338	0.356	0.356
Cambodia	0.552	0.553	0.554	0.555	0.552	0.549	0.546	0.555	0.570	0.600	0.623	0.641	0.648
Chile	0.987	0.987	0.986	0.984	0.983	0.983	0.983	0.984	0.986	0.987	0.972	0.951	0.931
China	0.897	0.897	0.897	0.897	0.897	0.919	0.941	0.963	0.969	0.974	0.983	0.991	1.000
Colombia	0.911	0.897	0.907	0.913	0.931	0.936	0.942	0.947	0.946	0.945	0.915	0.891	0.864
Congo, Dem. Rep.	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.005	0.005		0.044		
Ethiopia	0.478	0.478	0.478	0.478	0.478	0.478	0.513	0.549	0.585	0.590	0.600	0.625	0.646
Gambia, The	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452
Ghana	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.666	0.664	0.662	0.661
India	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.380	0.393	0.420	0.437
Kenya	0.542	0.542	0.542	0.542	0.542	0.544	0.564	0.583	0.601	0.606	0.611	0.615	0.614
Malaysia	0.848	0.850	0.852	0.853	0.853	0.852	0.850	0.849	0.848	0.849	0.850	0.852	0.852
Mexico	0.846	0.846	0.846	0.847	0.848	0.849	0.857	0.866	0.873	0.873	0.878	0.884	0.891
Morocco	0.755	0.755	0.755	0.755	0.755	0.754	0.763	0.775	0.785	0.786	0.785	0.785	0.784
Mozambique	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.206	0.233	0.260	0.260	0.260
Myanmar	0.683	0.683	0.683	0.683	0.683	0.683	0.685	0.686	0.688	0.691	0.712	0.734	0.753
Nepal		0.489		0.489		0.489		0.489	0.489	0.489	0.525	0.561	0.597
Niger	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.131	0.136	0.163	0.185	0.246	0.284
Nigeria	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.328	0.332	0.336	0.336
Pakistan	0.427	0.427	0.431	0.435	0.454	0.473	0.490	0.496	0.497	0.499	0.502	0.508	0.513
Peru	0.782	0.782	0.806	0.833	0.840	0.822	0.804	0.811	0.820	0.827	0.825	0.822	0.818
Philippines	0.881	0.879	0.878	0.877	0.878	0.880	0.882	0.883	0.886	0.893	0.900	0.907	0.909
Rwanda	0.324	0.324	0.324	0.324	0.324	0.348	0.373	0.398	0.398	0.398	0.417	0.441	0.474
Senegal	0.400	0.400	0.400	0.400	0.400	0.415	0.429	0.444	0.444	0.444	0.444	0.446	0.448
South Africa	0.784	0.784	0.784	0.784	0.784	0.783	0.804	0.827	0.864	0.880	0.893	0.894	0.895
Sri Lanka	0.757	0.760	0.760	0.762	0.763	0.764	0.767	0.769	0.771	0.770	0.766	0.761	0.764
Thailand	0.953	0.954	0.955	0.956	0.961	0.966	0.969	0.966	0.964	0.962	0.963	0.960	0.959
Turkey	0.701	0.699	0.700	0.700	0.706	0.715	0.724	0.729	0.761	0.794	0.827	0.830	0.835
Uganda	0.369	0.369	0.369	0.369	0.370	0.388	0.406	0.424	0.424	0.453	0.481	0.510	0.517
Vietnam	0.629	0.633	0.633	0.637	0.658	0.680	0.708	0.716	0.733	0.742	0.773	0.804	0.832
Zambia	0.434	0.434	0.434	0.435	0.427	0.418	0.400	0.390	0.383	0.384	0.382	0.380	0.377

Table 9: Inclusion Index INC, by Year

C.2 Baseline-Variance decomposition

Years		SC1			INN			INC	
0	0	0	0	0	0	0	0	0	0
1	1	0	0	0.089	0.911	0	0.096	0.048	0.856
2	0.972	0.026	0.002	0.064	0.866	0.070	0.075	0.032	0.893
3	0.943	0.055	0.002	0.051	0.760	0.188	0.062	0.024	0.913
4	0.922	0.075	0.003	0.044	0.647	0.309	0.054	0.020	0.926
5	0.905	0.087	0.008	0.039	0.550	0.411	0.048	0.017	0.934
6	0.889	0.092	0.019	0.035	0.472	0.493	0.044	0.016	0.940
7	0.872	0.094	0.034	0.033	0.411	0.556	0.041	0.015	0.944
8	0.854	0.095	0.052	0.030	0.364	0.606	0.038	0.014	0.948
9	0.835	0.094	0.071	0.029	0.326	0.645	0.036	0.013	0.950
10	0.817	0.093	0.091	0.027	0.296	0.677	0.035	0.013	0.953

Table 10: Cholesky forecast-error variance decomposition-SC1

The baseline variance decomposition shows the percent of variation in the row variable that is explained by the column variable for 10 periods ahead

Years		SC2			INN			INC	
0	0	0	0	0	0	0	0	0	0
1	1	0	0	0.390	0.610	0	0.002	0.078	0.920
2	0.954	0.010	0.036	0.387	0.550	0.063	0.001	0.076	0.923
3	0.875	0.027	0.098	0.360	0.459	0.181	0.003	0.075	0.923
4	0.788	0.047	0.165	0.321	0.365	0.314	0.005	0.074	0.921
5	0.707	0.066	0.227	0.282	0.286	0.432	0.009	0.073	0.918
6	0.638	0.082	0.280	0.248	0.224	0.528	0.014	0.073	0.914
7	0.580	0.096	0.323	0.220	0.179	0.601	0.018	0.073	0.909
8	0.533	0.109	0.358	0.199	0.146	0.656	0.024	0.073	0.903
9	0.495	0.119	0.386	0.182	0.122	0.696	0.029	0.074	0.897
10	0.464	0.128	0.409	0.169	0.105	0.726	0.034	0.075	0.891

Table 11: Cholesky forecast-error variance decomposition-SC2

Source: The baseline variance decomposition shows the percent of variation in the row variable that is explained by the column variable for 10 periods ahead

C.3 PVAR Results-Types of Innovation

	R&D Innovation			**Firm-Level Innovation**		
VARIABLES	Structural Change	R&D	Inclusion	Structural Change	Firm-Level	Inclusion Index
	(1)	(2)	(3)	(4)	(5)	(6)
Structural Change(t-1)	0.824***	0.037***	-0.001	0.648***	-0.023	-0.041**
	(0.116)	(0.010)	(0.017)	(0.127)	(0.015)	(0.020)
R&D Innovation(t-1)	-0.084	0.964***	0.016			
	(0.071)	(0.048)	(0.021)			
Inclusion(t-1)	0.537***	0.042	0.907***	0.599***	0.581***	0.937***
	(0.167)	(0.058)	(0.047)	(0.120)	(0.082)	(0.047)
Firm-Level Innovation(t-1)				-0.225***	0.652***	0.050**
				(0.068)	(0.069)	(0.020)
Observations	245	245	245	216	216	216

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Innovation Adoption, R&D & Firm-level Innovation-SC1

Source: Table 12 presents the PVAR results with structural change index-SC1, using the R&D Innovation index in columns (1)-(3), and using the Firm-level innovation in columns (4)-(6).

	R&D Innovation			Firm-Level Innovation		
VARIABLES	Structural Change	R&D	Inclusion	Structural Change	Firm-Level	Inclusion Index
	(1)	(2)	(3)	(4)	(5)	(6)
Structural Change(t-1)	0.835***	0.145***	0.054*	0.957***	-0.001	0.011
	(0.074)	(0.046)	(0.028)	(0.053)	(0.031)	(0.021)
R&D Innovation(t-1)	0.076**	1.012***	-0.001			
	(0.038)	(0.046)	(0.023)			
Inclusion(t-1)	0.105	-0.050	0.794***	-0.072	-0.034	0.993***
	(0.073)	(0.083)	(0.063)	(0.047)	(0.068)	(0.057)
Firm-Level Innovation(t-1)	0.071	0.892***	0.010			
	(0.059)	(0.055)	(0.031)			
Observations	254	254	254	218	218	218

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13: Innovation Adoption, R&D & Firm-level Innovation-SC2

Source: 12 presents the PVAR results with structural change index-SC2, using the R&D Innovation index in columns (1)-(3), and using the Firm-level innovation in columns (4)-(6).

D Figures for Appendix

D.1 PVAR-Stability Conditions

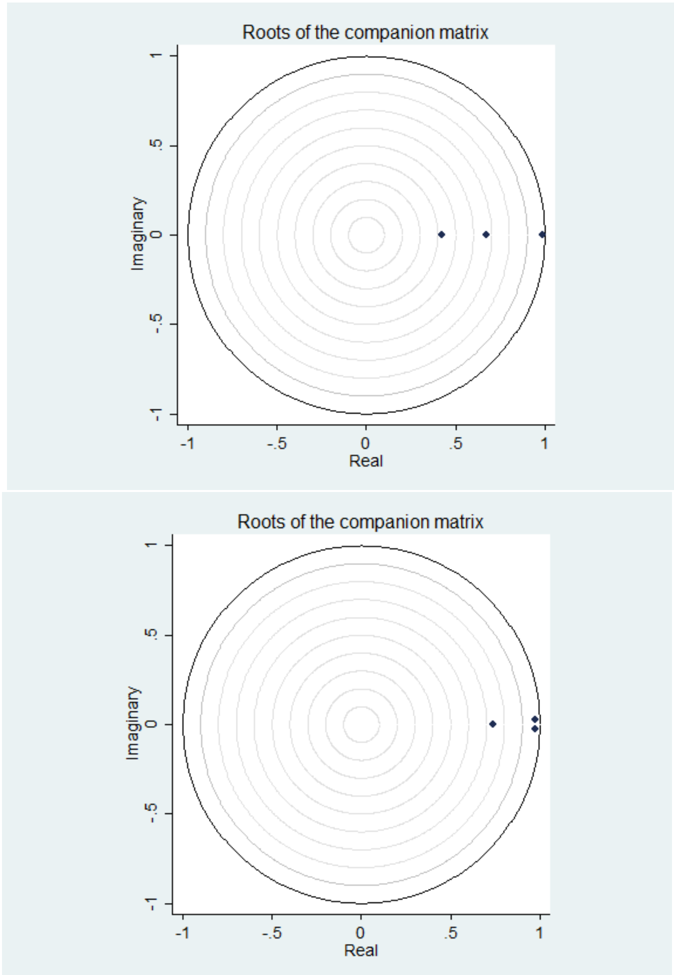


Figure 11: Impulse response functions. Variables: SC, INN, INCL.

Checking stability conditions for the baseline results, we draw graphs of the eigenvalues of the companion matrix. The top panel presents the stability results for the first baseline with the structural change index-SC1, the bottom panel presents the same for the second baseline with the structural change index-SC2. In both cases, we observe that the eigenvalues of the matrix of estimated coefficients are strictly less than one (within the circle).

D.2 Types of Innovation

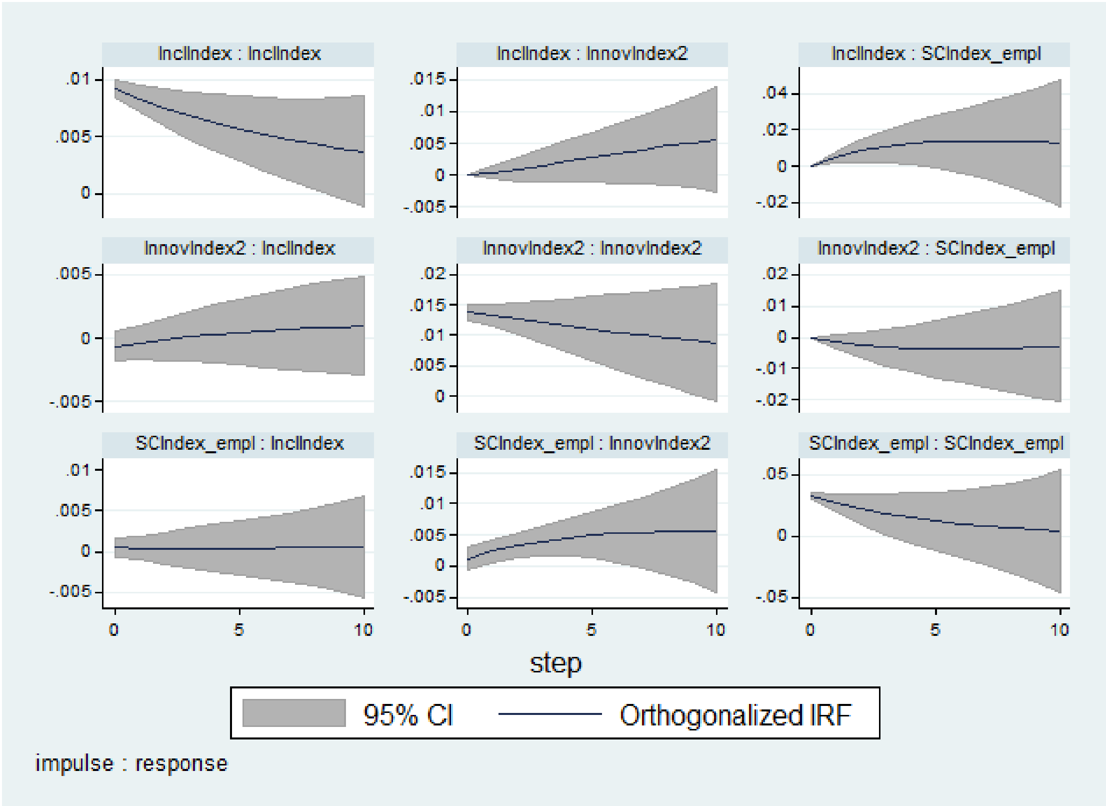


Figure 12: Impulse response functions. Formal R& D Innovation & SC1

Figure 12 reports the coefficients from the baseline estimation with employment based structural change index-SC1, innovation index-INN1 and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN1 and SC1. The column in the center contains the plots of the responses of INN1 to a shock of one standard deviation (impulse) in INC, INN1 and SC1. The column on the right are responses of SC1 to a shock of one standard deviation (impulse) in INC, INN1 and SC1. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

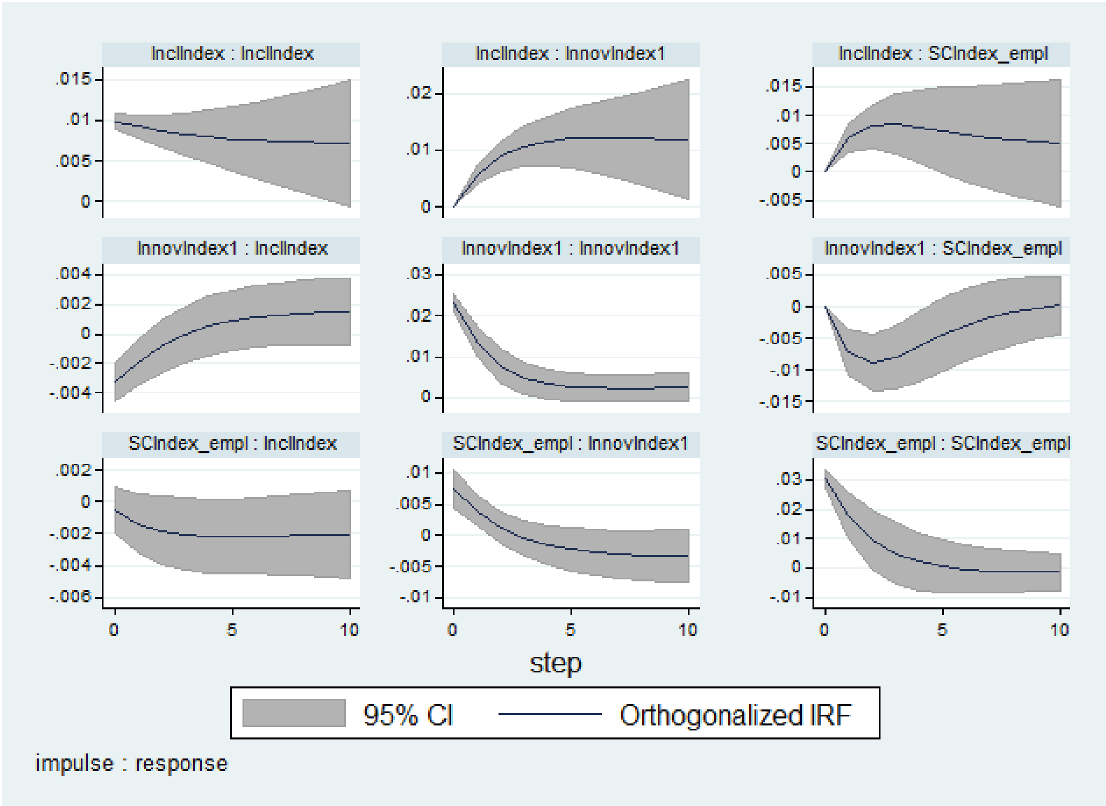


Figure 13: Impulse response functions. Firm Innovation & SC1

Figure 13 reports the coefficients from the baseline estimation with employment based structural change index-SC1, innovation index-INN2 and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN2 and SC1. The column in the center contains the plots of the responses of INN1 to a shock of one standard deviation (impulse) in INC, INN2 and SC1. The column on the right are responses of SC1 to a shock of one standard deviation (impulse) in INC, INN2 and SC1. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

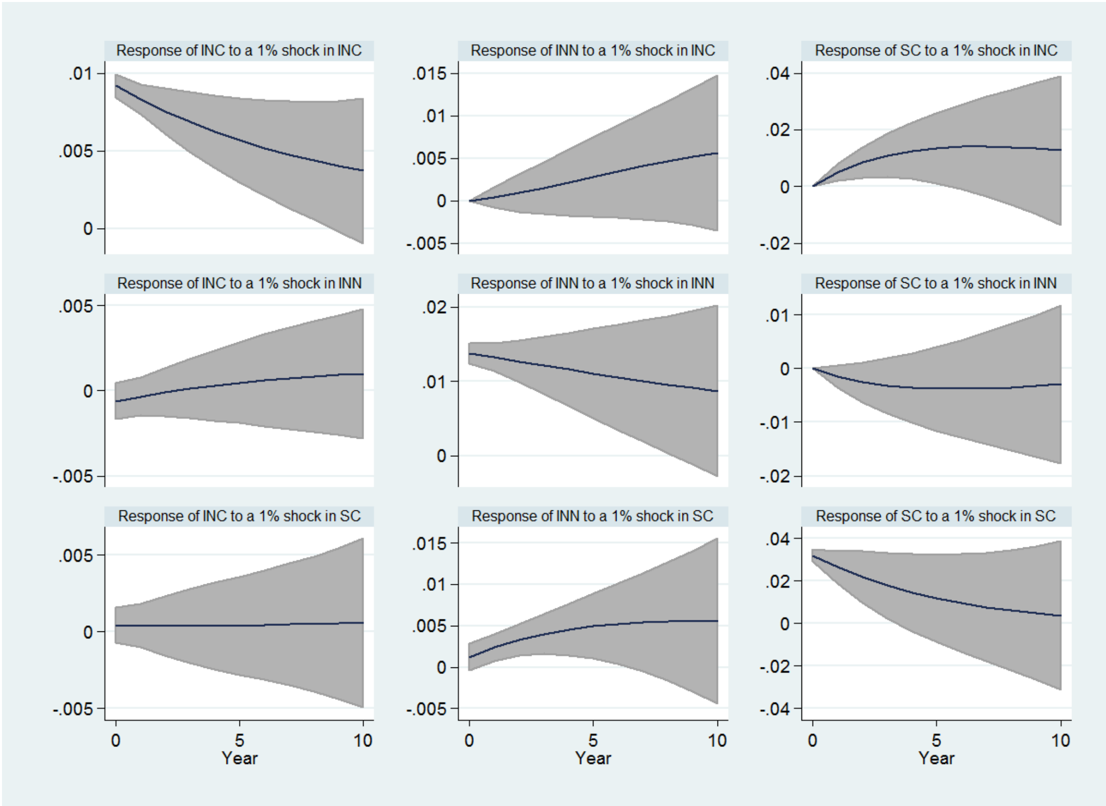


Figure 14: Impulse response functions. Formal R& D Innovation & SC2

Figure 14 reports the coefficients from the baseline estimation with broad structural change index-SC2, innovation index-INN1 and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN1 and SC1. The column in the center contains the plots of the responses of INN1 to a shock of one standard deviation (impulse) in INC, INN1 and SC2. The column on the right are responses of SC2 to a shock of one standard deviation (impulse) in INC, INN1 and SC2. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

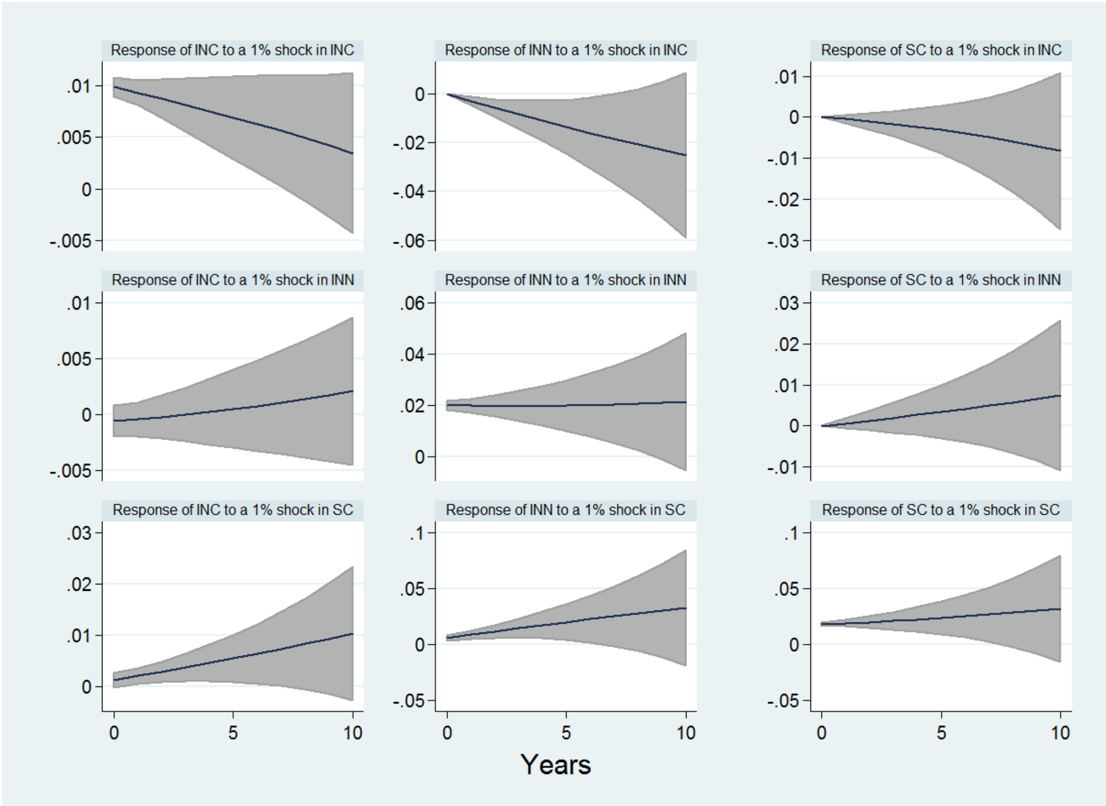


Figure 15: Impulse response functions. Firm-Level Innovation & SC2

Figure 15 reports the coefficients from the baseline estimation with broad structural change index-SC2, innovation index-INN2 and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN2 and SC1. The column in the center contains the plots of the responses of INN2 to a shock of one standard deviation (impulse) in INC, INN2 and SC2. The column on the right are responses of SC2 to a shock of one standard deviation (impulse) in INC, INN2 and SC2. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

D.3 Alternate Ordering-IRF

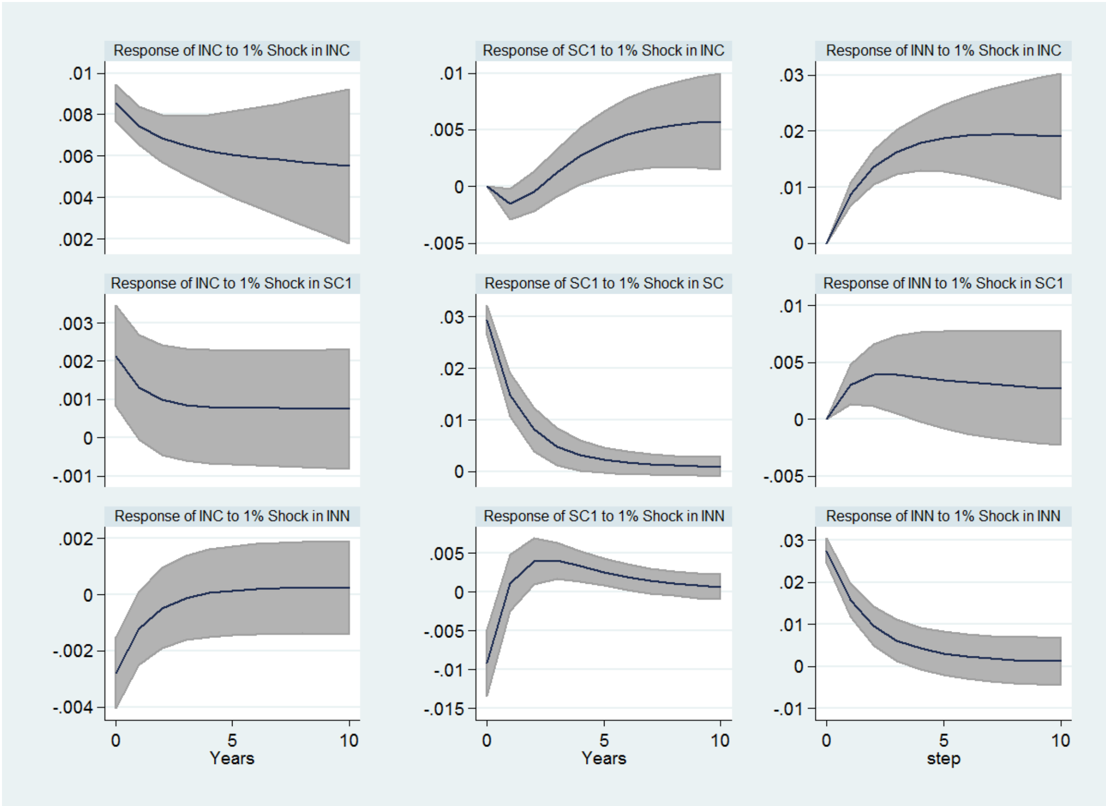


Figure 16: Impulse response functions. Variables: INN, SCI1, INCL.

Figure 16 reports the coefficients from the baseline estimation with employment based structural change index-SC1, innovation index-INN and the inclusion index-INC. The column on the left contains plots of the responses of INC to a shock of one standard deviation (impulse) in INC, INN and SC1. The column in the center contains the plots of the responses of INN2 to a shock of one standard deviation (impulse) in INC, INN and SC1. The column on the right are responses of SC1 to a shock of one standard deviation (impulse) in INC, INN and SC1. The IRF confidence intervals are computed using 200 Monte Carlo draws based on the estimated model.

Recent papers in the SPRU Working Paper Series:

November

A New 'Cut' on Technological Innovation Aiming for Sustainability in a Globalized World. Adela Conchado and Pedro Linares

Resource Efficiency, Environmental Policy and Eco-Innovations for a Circular Economy: Evidence from EU Firms. Giulio Cainelli, Alessio D'Amato and Massimiliano Mazzanti

Exploring Perceptions of the Credibility of Policy Mixes: The Case of German Manufacturers of Renewable Power Generation Technologies. Karoline S. Rogge and Elisabeth Dütschke

Kalecki on Technology and Military Keynesianism. Jan Toporowski

October

Hate at First Sight? Dynamic Aspects of the Electoral Impact of Migrations: The Case of the UK and Brexit. Eugenio Levi, Rama Dasi Mariani and Fabrizio Patriarca

School Infrastructure Spending and Educational Outcomes in Northern Italy. Alessandro Belmonte, Vincenzo Bove, Giovanna D'Inverno and Marco Modica

September

Do Policy Mix Characteristics Matter for Low-Carbon Innovation? A Survey-Based Exploration for Renewable Power Generation Technologies in Germany. Karoline S. Rogge and Joachim Schleich

Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. Ana de Jesus and Sandro Mendonça

Towards a Typology of Intermediaries in Transitions: A Systematic Review. Paula Kivimaa, Wouter Boon, Sampsa Hyysalo and Laurens Klerkx

August

Innovation, Inequality and the Skill Premium. Riccardo Leoncini

User-Intermediaries and the Local Embedding of Low Carbon Technologies. Jake Barnes

Suggested citation:
Amrita Saha and Tommaso Ciarli (2018). *Innovation, Structural Change, and Inclusion. A Cross Country PVAR Analysis.* SPRU Working Paper Series (SWPS), 2018-01: 1-61. ISSN 2057-6668. Available at: www.sussex.ac.uk/spru/swps2018-01

SPRU – Science Policy Research Unit
University of Sussex
Falmer, Brighton, BN1 9SL,United Kingdom
SWPS Website: www.sussex.ac.uk/spru/research/swps
SPRU Website: www.sussex.ac.uk/spru
SPRU Twitter: @SPRU