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Insights from South Africa

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Inclusive agro-industrial development and sectoral systems of innovation: insights from South Africa

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ABSTRACT

The agro-industries are widely viewed as important to inclusive industrial development due to their relatively low entry barriers and acessibility to small firms. However, the agro-industries are more technologically complex than commonly assumed. Small and young firms face challenges acquiring capabilities to compete effectively. The paper explores how differing sectoral systems of innovation (SSI) shape patterns of inclusion and exclusion in the agro-industries, and the factors shaping this. It analyses two contrasting South African agro-industrial sectors, maize processing and fresh citrus. It proposes a partial conceptualization of 'inclusive' SSIs (ISSIs) as sectoral configurations of actors and institutions that lower entry barriers and narrow capability gaps between small firms and dominant incumbents at the technological frontier. It argues that ISSIs rely on institutions that coordinate innovation-related activities in a manner benefitting small firms and new entrants, by aiding the broad diffusion of relevant technology and capabilities. Alongside state agencies, business associations can play an important role in this regard. It identifies the characteristics of state-business relations and inter-firm dynamics of competition and collective action as important underlying determinants of ISSIs. Thus, the paper highlights the need for attention to sector-level political economy in understanding the diverse outcomes of SSIs.

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1. Introduction

The promotion of high-value agro-industrial activity is important to structural change in Africa (Ahmad 2022). Development agencies also highlight its importance to 'inclusive growth' that reduces poverty and widens economic participation, in particular through small and medium sized enterprises (SMEs) providing employment and business ownership opportunities for rural communities (e.g. AGRA 2019). However, the agro-industries are more technologically complex than commonly assumed (Cramer, Di John, and Sender 2022). Agri-food global value chains (GVCs) involve increasingly demanding

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quality standards (Lee, Gereffi, and Beauvais 2012), and domestic markets are transforming amid urbanization, supermarketization, and the expansion of multinational firms (das Nair, Chisoro, and Ziba 2018). This entails higher entry barriers, intensifying competition, and increasingly advanced capability requirements in food value chains. Consequently, small and young agro-processing firms and producers face challenges (Ahmad 2022; Jenane, Ulimwengu, and Tadesse 2022; Osei-Amponsah 2022).

More inclusive agro-industrial development trajectories require innovation systems supporting learning and capability acquisition among small and young firms. With this motivation, the paper explores how differing sectoral systems of innovation (SSI) (Malerba and Nelson 2011) shape patterns of inclusion and exclusion of small and young firms in the agro-industries, and the factors underlying these differences. It does so through qualitative analysis of two contrasting South African agro-industrial sectors, maize processing and fresh citrus. These issues are particularly pertinent in South Africa given high levels of inequality, rural poverty, and industrial concentration. Drawing on scholarship on SSIs and inclusive innovation, the paper provides a partial conceptualization of inclusive SSIs (ISSIs) as sector-specific combinations of actors and institutions that narrow capability gaps between small and young firms and incumbents at the technological frontier, and which enhance their agency within the SSI.

The cases show contrasting outcomes, with the citrus SSI characterized by more inclusive systems and processes than maize. From this contrast, the paper argues ISSIs rely on the extent that key innovation challenges are addressed through effective, broadly-accessible 'intermediate institutions' (Chang and Andreoni 2019).[1] The characteristics of state-business relations and inter-firm collective action are potentially important proximate determinants of these ISSI outcomes, in turn influenced by underlying sector-specific differences in the 'market regime' (Lee, Gao, and Li 2016) and positioning within the wider political economy. The paper highlights the significant but often overlooked role of industry associations in innovation systems (see also Papaioannou et al. 2016; Watkins et al. 2015), and the importance of engaging with the political economy of innovation systems to understand variation in sectoral evolution trajectories.

1.1. Conceptualizing inclusive sectoral systems of innovation

Innovation and new technologies play a major role in structural change through total factor productivity growth, that is the continual growth of output and efficiency (Dachs et al. 2016; Antonelli 2003; Kuznets 1959). Much of this innovation takes place in firms, comprising not only new-to-the-world 'frontier' innovation but, broadly defined, 'all types of search and improvement effort' (Lall 1992, 166). Most commonly, it involves 'incremental' innovations for simple imitation and adaptation of existing technology and organizational systems, and the corresponding acquisition of new capabilities (Bell and Pavitt 1993; Malerba and Lee 2021). This is founded on learning, the 'costly and deliberate processes by which additional technical skills and knowledge are acquired' (Bell and Figueiredo 2012, 18). Learning is relational and context-specific, with firm-level innovation varying widely by sector (Lundvall 2016; Pavitt 1984).

SSI approaches help explain this variety. SSIs are evolving configurations of actors, institutions, and a 'technological regime' (Malerba 2002). Firms are the key actors, with varying inter-firm relations generating innovation inducements and knowledge/

technology flows (Malerba and Nelson 2011). Accordingly, SSIs can also differ according to 'market regimes' (Lee, Gao, and Li 2016) – forms of demand, competition, concentration, segmentation, etc. – and value chain governance (Pietrobelli and Rabellotti 2011). Technological regimes are the sector-specific characteristics of dominant technology, including its accessibility, appropriability, and knowledge-base (Malerba and Lee 2021). Institutions may include formal laws and regulations, alongside informal norms, and the range of organizational systems and structures through which productive activities are coordinated. Chang and Andreoni (2019) highlight the importance of 'intermediate institutions' to the augmentation of productive capabilities. With innovation being a 'collective endeavour that goes beyond the boundaries of the firm' (Chang and Andreoni 2019, 427), intermediate institutions serve to support, connect, and coordinate different actors involved in innovation processes, for example through processes of diffusion of technology and knowledge. Such institutions, they argue, 'play a critical intermediary role between R&D, education, markets and in-farm agricultural production. They also bridge and transfer knowledge, technical solutions and innovations across different sectors and, thus, facilitate various forms of intersectoral learning' (Andreoni and Chang 2014, 2).

The relative importance of particular categories of actors and institutions within the SSI can vary considerably across sectors, and can change over time given that different elements of the innovation system are in a relationship of mutually constitutive interaction. As such, cross-sectoral differences or changes over time in the technological regime alters the relative prominence of specific organizations in the SSI according to the changing characteristics of the dominant technology and corresponding innovation imperatives. For example, university laboratories capable of conducting basic research play a more prominent role in more 'science-based' sectors such as agricultural biotechnology, while specialist equipment suppliers (in interaction with the major customers they serve) typically play a more prominent role in mature manufacturing sectors (Pavitt 1984; Malerba and Nelson 2012).

While effective innovation systems create 'dynamic complementarities' – virtuous cycles of interaction between system components that accelerate innovation – 'system failures' due to the absence or dysfunctionality of key elements of the system can create 'vicious cycles of low interaction and low learning' (Lee and Malerba 2018, 178). Though the focus of innovation systems research has typically been on processes of benign interactive learning involving mutually beneficial collaboration, it is important to recognize that in many instances innovation processes involve power struggles, and conflicts and between actors over the distribution of costs and benefits of innovation processes (Lundvall 2007, 112). Such conflicts may impede innovation altogether, or channel innovation processes toward less socially beneficial outcomes, for example those which exacerbate inequality or environmental degradation.

Innovation research in the evolutionary tradition has most commonly focused on 'catch-up' industrialization, with less attention to the broader social consequences of innovation. Much recent scholarship has integrated broader development concerns, in particular the growing literature on inclusive innovation (e.g. Pansera and Owen 2018; Levidow and Papaioannou 2018; Lundvall et al. 2009). Innovation processes and outcomes are frequently 'exclusionary' (Chataway, Hanlin, and Kaplinsky 2014). Inclusive Innovation involves innovation systems contributing to *outcomes* of reduced poverty

and/or inequality, while enhancing agency of marginalized actors within innovation *processes* (Johnson and Andersen 2012; Heeks, Foster, and Nugroho 2014). Much inclusive innovation research has focused on 'bottom of the pyramid' products and services for low-income consumers. There is an additional need to better understand how innovation systems can address poverty and widen economic participation through firm-level learning and capability acquisition (Andersen and Johnson 2015; Joseph 2014). Specifically, this paper seeks to explore how differing SSIs shape innovation processes and outcomes for small and/or young firms. Participation of small and/or young firms is important to inclusive development through enabling economic participation among marginalized groups and challenging concentrations of economic power, particularly in the agro-industries given their significance to employment and asset ownership among low-income, rural populations.

Smaller firms and new entrants commonly face a range of challenges attaining 'minimum threshold' capabilities (Sutton 2012) required in higher-value supply chains and market segments. Though more innovative than commonly assumed, they often require support for learning and capability acquisition in low-income contexts (Kraemer-Mbula 2019). Learning mechanisms and challenges can differ by firm-size (Osei-Amponsah 2022). While potentially less constrained by path-dependencies, small and young firms commonly lack important innovation resources and capabilities, meaning greater reliance on external sources of knowledge, technology, and skills (Romijn 2001; Kaplinsky and Morris 2019). Financial constraints may hamper these being accessed through commercial relationships, meaning greater reliance on public or collective intermediate institutions, social networks, or clusters (Kaplinsky and Morris 2019). Inclusive innovation processes for small and young firms are therefore particularly dependent on SSI attributes.

The state can be anticipated to play a particularly important role in this regard (Habiyaremye, Kruss, and Booyens 2020), both through agencies directly supporting non-commercial knowledge and technology development and dissemination, and through institutions such as industrial policy and product standards. The state's inclination towards doing so depends on the political economy context and state-business relations. Large firms commonly wield political as well as economic power, particularly in lower-income contexts where the industrial structure comprises large numbers of unorganized micro-enterprises and a small number of large-firms with outsize fiscal or balance of payments importance (Moore and Schmitz 2008). Large incumbent firms may be able to distort policy to serve their interests at the expense of smaller firms, particularly given political and symbolic capital often attached to large and highly prominent state-backed industrial projects (Boamah and Sumberg 2019). However, small firms may be more politically salient when well-organized or in contexts of high foreign ownership, inequality or unemployment (Amsden 2001; Whitfield et al. 2015), where state support to small firms may perform a quasi social policy function (Tendler 2002). An understanding of how and when sectoral systems tend towards serving more inclusive ends is therefore contingent on an understanding of how particular sectors fit within the wider political settlement of a given context.

With these considerations, we suggest a partial conceptualization of inclusive SSIs (ISSIs). The first key dimension of this conceptualization defines ISSIs as sector-specific configurations of actors and institutions that, firstly, support learning and

innovation that narrows within-sector capability gaps between small and/or young firms and larger incumbents at the technological frontier, with the outcome of widening economic participation and improving the competitiveness and resilience of the former. This draws from Lema, Fu, and Rabellotti's (2020) definition of catch-up as a 'shifting in the balance of power' between dominant, incumbent firms at the technological frontier and 'latecomers', manifesting in narrowing gaps in technological capabilities. While drawing from this conceptualization of catch-up as gap-narrowing and a shifting balance of power within a sector, the concept of 'latecomers' is not employed in this paper given that not all small firms are 'late' arrivals. Indeed, small firms in many instances may have been operating for a considerable length of time but without achieving growth, either due to various obstacles or the preferences of owners (Penrose 2009 [1959]; Coad 2009).

Gap-narrowing in ISSIs may be relative rather than absolute, preventing small and young firms falling further behind, rather than achieving parity or leadership. ISSIs therefore crucially involve innovation processes enabling such firms to adapt to 'transformation pressures' (Lundvall and Lema 2014) in evolving markets, and 'gap-widening' shifts in the technological regime. This is particularly relevant for inclusivity in African agro-industries, as rapid technological change, stricter private standards, the growth of large processing and retail firms, and lengthening value chains increase the competitive pressures faced by small firms, raises entry barriers, and shrinks sheltered market 'interstices' (Penrose 2009 [1959]) where small firms survive.

As discussed above, established conceptualizaions of inclusive innovation systems – and indeed inclusive development more broadly – encompass not simply inclusive outcomes, but also inclusive processes: the extent to which marginalized actors are able to exert agency within the innovation system. As such, in a second key dimension of our conceptualization, ISSIs also augment the agency of small and young firms within innovation processes. That is, the sectoral system involves institutions and/or organizaions that play a meaningful role in innovation processes, in which small and young firms are able to participate and exert influence. This second dimension can be anticipated to have an important bearing on the first: SSIs that enable participation and agency of small and young firms in innovation processes may be more likely to generate inclusive outcomes in terms of gap-narrowing. Though the main focus of the empirical material in this paper is the first dimension, the second remains critical to further research on this subject.

There are important caveats to this conceptualization. Firstly, it is only partial, requiring elaboration in future research – there are other critical dimensions of inclusion/exclusion in SSIs, particularly concerning labour and 'extra-firm' actors. For example, the transformation pressures and gap-widening shifts in the technological regime discussed above may have severe negative impacts on particular classes of labour lacking requisite skills and/or bargaining power to adapt. Secondly, though commonly important to widening economic participation, small firms are not *a priori* developmentally benign, nor concentrated market structures or large firms automatically malign. This is highly context dependent. Thirdly, depending on sectoral life-cycles and technological regimes, small and young firms may be innovation leaders rather than laggards, and processes of technological change may disadvantage incumbents (Malerba 2002). Finally, the nature of the SSI may only provide partial explanations for the outcomes of interest.

Nonetheless, the conceptualizaion seeks to provide a potentially useful framework for exploring inclusivity in sectoral systems for relatively mature, 'low-tech' industries, such as the agro-industries, in low-and middle income contexts where there is strong interest in supporting new entrants and improving the position of small firms.

2. Materials and methods

To investigate how differing SSIs shape inclusion/exclusion in the agro-industries, we analyze the evolution of South African maize milling and fresh citrus. These are important agro-industrial sub-sectors – maize meal is the staple carbohydrate, citrus the largest agri-export – with key differences in product characteristics and markets. In the maize meal case, we examine a highly-processed product oriented toward the domestic market, and focus on the middle stage in the value chain of milling. In the citrus case, we examine a fresh product oriented toward export markets, and focus on the upstream end of the chain in citrus production. Though conventionally the latter might be considered 'simply' farming rather than an agro-industrial activity, as recent research demonstrates 'fresh' horticultural production for export markets is an increasingly technologically complex, capital intensive activity – referred to as the 'industrialisation of freshness' (discussed further in Section 5) (Cramer, Di John, and Sender 2022). Though not a strictly structured comparison, we use cross-case contrasts to generate insights about how differing antecedent conditions generate differing outcomes, potentially obscured if viewing cases in isolation (Ragin 2014). Studying catch-up in sectoral systems requires a dynamic approach, seeking context-sensitive understanding of long-term co-evolutionary processes in markets, technologies, and institutions (Malerba and Nelson 2011). Using qualitative methods and several data sources, we examine co-evolutionary processes over a quarter-century from the critical juncture of mid-1990s liberalization to the 2019–2020 period, when empirical material was collected in a larger project on agro-industrializaion.

The paper draws on 83 semi-structured key-informant interviews (KIIs) across the two sectors, summarized in appendices 1 and 2. Informed consent was obtained through consent forms and information sheets, or a commensurate oral consent process. Interviews include firm-level interviews (FLIs) with 28 maize milling firms and 13 citrus growers. FLIs were chosen through purposive sampling using business registers and expert consultations, aiming to achieve a heterogeneous sample covering a variety of firms in the sector, with a particular focus on SMEs and new-entrants. Firms were interviewed in-person or via videoconferencing, using a semi-structured questionnaire covering business histories, value chain relations, market conditions, innovation activities, and the business environment. Data was analyzed to identify emergent common themes among interviewees relating to firms' challenges with value chain participation, key markets, competition with major rivals, access to industry and government support, and acquisition of new technological capabilities. FLIs are de-identified to preserve commercial confidentiality, and KIIs are de-identified at the interviewees request. KIIs targeted industry experts and important actors, including government officials, business associations, firms from other value chain segments such as suppliers of inputs and equipment, and specialist innovation actors such as research organizaions and technology suppliers.

We used these KIIs to inform 'qualitative assessments of the 'distance' to the knowledge frontier' (Lema, Fu, and Rabellotti 2020, 1198): that is the extent to which firms' technological capabilities lagged that of frontier firms with which they must compete, reflected for example in differing production systems, and differing levels of productivity and quality. Quantitative data from official statistics and business associations helped triangulate interview data on key trends, with grey literature from key government agencies relating to the agro-industries used to map policy and institutional change (Department of Agriculture, Land Reform and Rural Development 2020, 2022; DTI 2010, 2017; DAFF 2014; National Planning Commission 2013; Presidential Advisory Panel on Land Reform and Agriculture 2019). In combination, these sources enabled an abductive, or iterative, process-tracing analysis (Beach and Pedersen 2019) exploring links between outcomes and key antecedent conditions and processes within the SSI.

3. Context: agro-industries, inclusive development and innovation systems in South Africa

This section outlines key contextual issues pertaining to inclusive agro-industrial development in South Africa. South Africa has unusually low levels of small-business participation relative to comparable economies (Makgetla 2023). Concentration in food manufacturing is particularly high (Table 1). Agriculture is dualistic, with around 2,600 large-scale farms accounting for 67% of farm income (StatsSA 2020), and a large periphery of quasi-commercialized small-scale farmers. This both reflects and reproduces wider racialized inequalities. A concentrated, capital-intensive agro-industrial structure and predominantly white ownership is a legacy of exclusionary regulatory systems and dispossession during colonialism and apartheid (Vink 2012; Marcus 1989; Andreoni et al. 2021). These systems effectively eliminated African commercial agriculture, with small-scale, low-productivity subsistence farming persisting in the crowded 'homelands'. Licencing arrangements and marketing board controls limited the opportunities for small-business participation downstream of farming. Concentration and racialized inequality have proven persistent in the post-apartheid period, with black farmers' share of output low across most major commodities and low levels of black ownership in agro-processing (National Agricultural Marketing Council 2019; B-BBEE Commission 2020).

Agriculture and the agro-industries have been repeatedly identified in high level economic strategy documents as critically important to mitigating South Africa's racialized

Table 1. Large firm by manufacturing sub-sector, 2017 (StatsSA 2020).

	Income share: 5 largest firms	Income share: 20 largest firms
Food products and beverages	29%	50%
… of which, *Production, processing and preserving of meat / meat products*	26%	54%
… of which, *Processing and preserving of fruit and vegetables*	51%	77%
… of which, *Manufacture of dairy products*	60%	85%
… of which, *Manufacture of grain mill products, starches / starch products*	66%	88%
Textiles, clothing, leather and footwear	14%	29%
Metals, metal products, machinery and equipment	23%	37%

inequalities (e.g. National Planning Commission 2013; DTI 2010; DALRRD 2022). In particular, small farming and agro-processing enterprises are commonly identified as means to widen black asset ownership and generate employment in marginalized rural areas, where poverty levels are typically most severe. Alongside land redistribution and restitution where formerly white-owned or state-owned land and/or farming assets are transferred to black beneficiaries, the South African government has implemented several policy measures aimed at addressing racial inequalities both at an industry and national level. These include Broad Based Black Economic Empowerment policy, requiring larger white enterprises to diversify equity ownership and support black employees and black-owned suppliers, alongside various support measures for small, black-owned farms and agro-processing firms. In practice, however, there have been major challenges for inclusive growth in most agri-food value chains.

Following the liberalizaion process which culminated with the Marketing of Agricultural Products Act 1996 that disbanded state marketing boards, extensive state regulation of agri-food markets was replaced by 'private governance' by large firms, their power augmented in some instances by anti-competitive behaviour (Makhaya and Roberts 2013). Retail became highly 'supermarketised', with major challenges entering centralized, consolidated supply chains with higher private standards for hygiene, packaging, appearance, etc. (das Nair, Chisoro, and Ziba 2018). There has been increased technological complexity accompanying digitalization and automation, reflected in capital expenditure trends (Table 2). Export opportunities have increased, particularly for horticultural products, but so too quality, safety, and sustainability standards, and thus barriers to entry.

Small firms face major innovation challenges within the South African NSI (Ndabeni 2014). Strong public-sector STI capacity was historically centralized and orientated toward large-scale, capital-intensive industries, and there have been strong path dependencies (Scerri 2013). Reorientation from the mid-2000s accompanied wider shifts towards more interventionist industrial policy (Ibid). However, general R&D spending has been low, and the South African NSI 'is failing to unlock innovation-driven growth processes' (Marire 2022). Perhaps more than capacity, a key problem has been coordination and implementation (Scerri 2013). This is reflected in the agro-industries. As with small-business innovation generally (Ndabeni 2014), responsibility for agro-industrial development is shared across multiple government departments that often struggle to coordinate, and may operate in 'silos' due to constraints with funding, capacity, or legal demarcation of responsibilities. State agricultural development finance and research institutions have ostensibly increasingly prioritized inclusive agro-industrial development, with support reorientated toward the needs of small black-owned enterprises. However, these are either highly-centralized, devote limited

Table 2. Computer equipment and computer software as a percentage of total Gross Fixed Capital Formation (Source: Quantec).

	Manufacturing (total)	Food manufacturing	… of which, grain milling	… of which, dairy processing
1994	2.7%	0.5%	1.2%	2.7%
1999	3.1%	2.7%	1.4%	3.1%
2004	7.4%	7.1%	5.2%	9.5%
2009	5.6%	5.5%	3.5%	7.2%
2014	12%	11.7%	7.9%	15.1%
2019	12.4%	13.4%	6.9%	21.3%

resources in practice, or have often been dysfunctional – the Agricultural Research Council and Land Bank are key examples. Coordination challenges have extended to state-business relations. After an uneasy coalescence of interests and accommodation between big-business and elite figures in the ruling African National Congress (ANC) around liberalizaion in the early post-apartheid period (Taylor 2007), mistrust and ideological contestation over redistribution generated increasing tension between big-business and the state (Seekings and Nattrass 2011). Small-business has tended to be much more severely marginalized (Seekings and Nattrass 2015). This tension between business and the state is heightened in the agro-industries given the sustained political prominence of land. Such tensions, combined with the state's aforementioned dysfunctionality and reorientation, increased business associations' importance to large-scale agribusiness (Liebenberg, Pardey, and Kahn 2010), and associations have become key innovation system actors, providing sophisticated services for members, including extension, R&D, and standards.

4. Maize processing

4.1. Overview

Maize meal is South Africa's staple carbohydrate (Kirsten 2014), with milled grain products accounting for a fifth of food manufacturing output value.[2] Milling has been an often contentious sector due to high concentration levels and past anti-competitive behaviour (Mncube 2014; Ncube et al. 2016). It has been the target of interventions supporting small millers (Department of Trade and Industry 2017; Mandiriza, Sithebe, and Viljoen 2016). However, SSI outcomes have been relatively exclusionary. As will be discussed below, innovation processes driven by changing consumer demand and competition advanced threshold capability requirements. Small and young firms faced significant resulting challenges, with limited or ineffective support from key public/collective SSI actors and institutions. Some firms able to invest in technology and develop relations with capital goods suppliers successfully adapted, but many small firms exited.

4.2. The shifting technological regime

Apartheid-era institutions created a concentrated industrial structure in milling, with four ultra-large firms accounting for 80% of output by the mid-1990s, and limited small firm participation (Vink 2012).[3] Fixed prices limited incentives to innovate.[4] The grain industry was liberalized in the mid-1990s, with reformers hoping new entrants would subject incumbent big-business to heightened competition, and widen black participation (Bayley 2000). Formally-registered milling firms increased by almost 50% in the first five years following liberalizaion, alongside increased informal milling. As well as increased horizontal competition, the new institutional environment heightened vertical competitive pressures on incumbents with increasing retailer power in food value chains (Makhaya and Roberts 2013). Supermarket and wholesale chains grew rapidly and consolidated, becoming the main route-to-market for maize meal, including for low income consumers (Competition Commission 2019). They dominate value chain governance, using bargaining power to extract value from suppliers. Prices are

determined at retail level (Louw, Meyer, and Kirsten 2017), and because maize meal is a footfall-driver for supermarkets, purchased in bulk by price-sensitive low-income consumers, downward price pressure on millers is intense. Over 90% of output is for domestic consumption, which has grown relatively slowly (Figure 1). This gives competition a zero-sum character.

One response to this changing market regime was product innovation among large-scale incumbent firms (another was a cartel, discussed in 5.4). Product innovation involved refinement and marketing of more highly-processed, finely-granulated 'super' maize-meal offerings. These were orientated to the growing urban consumer market: calorie-dense, faster cooking, and longer-lasting, with a consistent texture and white appearance.[5] Product differentiation was supported by branding investments to augment pricing power and bargaining power with supermarkets – leading maize-meal brands sell at a premium (Pioneer Foods 2019).[6] *Super* output grew to dominate the market (Table 3), as smaller firms pursued catch-up innovation.

Super requires more advanced technological and organizaional capabilities to manufacture, with challenges achieving consistent, refined outputs from a highly variable input.[7] Frontier firms pursued automation and digitalization process innovations to improve precision control, integrating new technologies including advanced de-germinators, optical sorters, packaging robots, and programmable logic control systems enabling remote, real-time adjustments according to key parameters.[8] One experienced head miller put it that '[t]here has been more technological change in last 30 years than the previous 100 years'.[9] Real fixed investment increased 80% in the decade to 2009,[10] with a five-fold proportional increase in GFCF on computers and software (Table 2). This could significantly reduce labour requirements,[11] with highly-automated medium-scale mills interviewed producing around 10 times the per-employee output

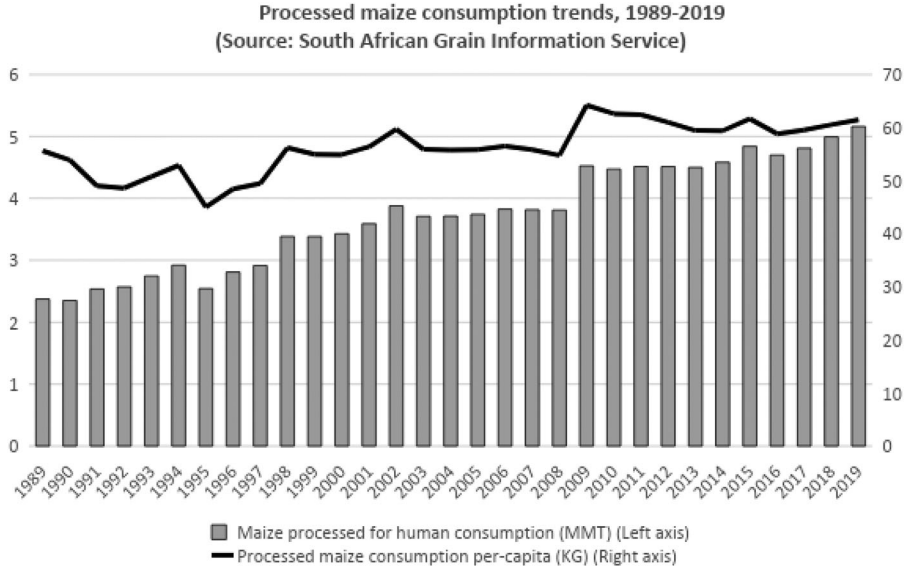

Figure 1. Processed maize consumption trends, 1989-2019. (Source: South African Grain Information Service).

Table 3. Changes in maize-meal output, 1996/97-2018/19 (Source: SAGIS).

	Maize rice, grits and samp		Sifted maize meal		Special maize meal		Super maize meal		Total
	T000	%	T000	%	T000	%	T000	%	T000
1996/97	226	10%	461	20%	968	42%	623	27%	2,278
2018/19	190	6%	28	1%	371	12%	2,495	81%	3,084
Change	−16%		−94%		−62%		300%		35%

of conventional labour-intensive operations.[12] Frontier firms thus transitioned from manual-mechanical manufacturing processes, heavily reliant on tacit knowledge, to precision-automated processes reliant on advanced formal skills. Conventionally, 'putting your hand in' to check tactile qualities was a key skill for head millers, whereas advanced mills digitally controlled processes 'in the decimals'.[13] Accompanying this were requirements for organizaional capabilities managing complex integrated systems, such as elevated hygiene standards compliance demanded by retailers.

4.3. Catching-up and falling behind: differentiated outcomes for SMEs

Induced by changing demand and competitive conditions, innovation processes advanced the technological frontier and raised threshold capability requirements. SMEs faced multiple challenges keeping pace, and withstanding intensifying competition from larger rivals (Table 4). Capital goods suppliers (CGS) had developed smaller, modular technology enabling small firms to produce *Super*, but shortages of skills and finance remained major obstacles.[14]

Though the sample size means findings are not strictly representative, interviews highlight differentiated responses to 'transformation pressures' (Lundvall and Lema 2014) among SMEs. Summarized in Table 5, this included: Firstly, a small but significant number of medium-scale millers successfully adopting an innovation-intensive, growth-orientated catch-up strategy with advanced 'frontier'-standard capabilities ('dynamic adaptation'). Secondly, firms pursuing basic innovations in labour-intensive business models, with capabilities orientated towards resilience in economic 'interstices' (Penrose 2009 [1959]), but unable to compete directly in mainstream channels ('defensive adaptation'). Firms in this category noted a range of difficulties following the technological trajectory of frontier firms, including access to skills, finance, challenges with labour or community relations, and the greater flexibility of labour-intensive business models.[15] Thirdly, a final category identified was struggling firms, predominantly micro-scale, with severe difficulties achieving threshold capabilities ('Precarious maladaptation').

Table 4. Perceptions of competition among SME millers ($n = 28$).

	'We need to continually improve to remain competitive'	'Competition is becoming more intense'
Strongly agree	54%	43%
Agree	36%	46%
Neither agree/ disagree	4%	4%
Disagree	7%	4%
Strongly disagree	0%	4%

Table 5. Typology of SME milling firm responses to transformation pressures ($n = 28$).

	'Precarious maladaptation'	'Defensive adaptation'	'Dynamic adaptation'
	Low levels of innovation activity; struggling to meet threshold capabilities necessary for viability; large and widening gap to the technological frontier.	*Basic and improvisatory process innovations; unable/unwilling to pursue frontier innovations; strong organisational capabilities and tacit knowledge; threshold technological capabilities for sheltered/niche markets; strategy based on resilience*	*Advanced process innovations; high levels of automation and formal skills; exceeding threshold capabilities; narrowing gap to technological frontier; strategy of growth and competing with large firms*
Micro-scale firms	7	1	
Small-scale firms	5	7	
Medium-scale firms		3	5
Total	12	11	5

This differentiation manifests in sector-level data: the four largest firms' market share dropped from 80% in the mid-1990s to 40% by 2019, as medium-scale (dynamic adaptation) firms entered the market in the major grain producing districts and grew rapidly.[16] Meanwhile, many small firms exited, with absolute numbers plummeting (Figure 2). Declines were to some extent offset by new entrants, with high estimated 'churn' rates of around 25% in the five years to 2020.[17] Many firms interviewed were on the brink, or vulnerable to expansion of supermarket and wholesale chains closing the interstices. Thus, despite de-concentration at the top of the firm-size distribution, sectoral evolution has taken an increasingly exclusionary trajectory.

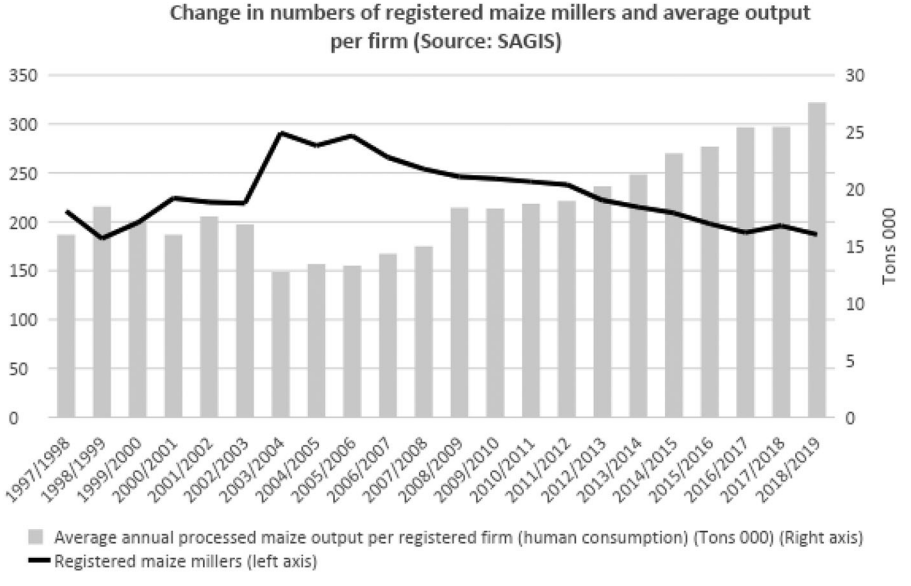

Figure 2. Change in numbers of registered maize millers and average output per firm. (Source: SAGIS).

4.4. Weak collective action, antagonistic state-business relations and exclusionary SSIs

There are many determinants of the outcomes described above, but the configuration of the SSI appears to have been a significant contributor. In a dualistic SSI, firms with significant financial resources could embed in advanced private knowledge networks. Small milling firms, meanwhile, were often 'lonely' in the sense employed by Kaplinsky and Morris (2019), drawing on Schmitz (1995), lacking easy-access to key inputs and services subject to economies of scale. Highly competitive small firms in other industries have commonly been observed to access these through clusters, where co-location generates forms of 'collective efficiency' that support upgrading (Ibid). In this case, however, many small firms interviewed were geographically distant from other firms and key suppliers, partly as a result of servicing markets at the interstices of the food system where competition with large firms is lower, particularly in rural areas.

The voluntary industry association, the National Chamber of Milling (NCM), in 2020 contained less than 10% of registered firms. Membership dropped 60% after the 2010 discovery of a price-fixing cartel within the NCM (Planting 2010).[18] Only two firms interviewed were members, with some medium-scale firms wary of participation risks, and several small/micro-scale firms unaware of its existence or perceiving it as being for large firms. One of the largest millers, Pioneer, eschewed membership, to engage government independently.[19] Combined with the acrimonious cartel fallout, zero-sum competition dynamics produced limited incentives for more benign collaboration. The sector was thus organizationally fragmented, with relatively limited coordination or collective resource mobilization around shared challenges.[20] Nonetheless, the NCM did provide crucial support for capability acquisition through its Grain Milling Academy (GMA), founded in 2016 to address skills shortages and shortcomings in state technical education.[21] However, most enrolments have reportedly been from larger firms, with smaller firms reportedly struggling with costs and staff availability. The state reportedly declined NCM requests to subsidize GMA activities.[22]

This highlights a second key SSI feature: limited and dysfunctional state support, with antagonistic state-business relations. Interviews showed state development finance and research institutions playing a limited role supporting SMEs, and being dysfunctional, highly-centralized, or thinly-spread. Officials interviewed bemoaned limited inter-agency coordination.[23] There had, however, been significant national and local-level state industrial policy support for new small-scale black-owned millers. The cartel harmed state-business relations, and subsequent interventions by-passed the established private sector, seeking to challenge incumbent firms and lower maize-meal prices (DTI 2010).[24] Department of Trade and Industry (DTI) support was instead channelled through a black small-business association, FABCOS (DTI 2017). This included collaboration with leading Swiss equipment manufacturer, Buhler, on the compact *Isigayo* mill. The DTI surmized small millers would be 'viable with moderate assistance from Government' (DTI 2010, 47). This underestimated the challenges involved. State interventions largely failed, bypassing collaboration with the private sector, and financing up-front equipment purchases but not longer-term learning processes.[25] Of the 22 state-funded mills identified since 2010, none appeared competitive. Existing small-scale millers interviewed expressed broadly negative views of the government.

Contrary to this meagre public/collective support, firms with sufficient financial means enjoyed advanced support from domestic and international CGS and consultancies for complex activities concerning automation, hygiene, and regulatory compliance. This supported catch-up among 'dynamic adaptation' firms.[26] Support included design, installation, training, and ongoing aftersales technical support.[27] The extent of knowledge networks available to such firms increased radically with automation and digitalization, since equipment could be remotely monitored/adjusted by overseas engineers. CGS benefited from user-producer interactions, as millers helped product innovation through providing information and suggestions for improvements. For example, one medium-scale firm successfully modified its de-germinators to lower maintenance requirements, resulting in adoption of the innovation as standard by the CGS, a major international manufacturer.[28] Indeed, development of specialized maize de-germinators for *Super* stemmed from user-producer interactions, with CGS modifying rice de-germinators to meet maize millers' articulated needs.[29] Firms outside of such private knowledge networks in the SSI, rely on internal resources, and informal social/family networks for knowledge and finance. Given South Africa's racialized inequalities in asset ownership, this entails not simply major struggles for small-scale enterprise, but also prevalent white ownership among existing small and medium-scale milling firms. The milling industry has thus been defined by a relative exclusionary development trajectory.

5. Fresh citrus exports

5.1. Overview

South Africa's citrus industry has grown significantly to become South Africa's leading agri-food export. Two-thirds of South Africa's citrus production is exported fresh (Department of Agriculture, Land Reform and Rural Development 2022), but higher prices fetched by fresh exports means this generates 95% of total earnings in the industry.[30] Changing export market standards have been key innovation-drivers. Compliance with buyers' escalating quality and sanitary and phytosanitary (SPS) standards has advanced the technological frontier, raised threshold capability requirements, and generated significant transformation pressures.

Crucially, however, key learning and innovation challenges have been collective, requiring collective goods provision alongside broad support for capability acquisition, in particular concerning research, technology development and compliance systems. This is because global competition requires SPS compliance and quality improvements to be industry-wide: compliance failures by a minority negatively impacts producers' collective reputation[31], and may cause export interceptions where importers block consignments following detection of harmful organisms or incomplete documentation (Roberts, Andreoni, and Chisoro 2022). Such pressures compel key SSI actors to pursue collective learning and capability acquisition, through collective intermediate institutions, thus shaping a relatively inclusive innovation trajectory.

A central aspect of inclusive development in citrus is addressing racialized inequalities in asset ownership, investment, and incomes. Commercial citrus has historically been dominated by white-owned farms. However, the industry began diversifying in the democratic era, in particular following farm transfers to black people through land

restitution (Presidential Advisory Panel on Land Reform and Agriculture 2019). Integrating new black growers into high value, fast-growing export markets has been a major challenge, requiring building long-term competitive capabilities.

5.2 The 'industrialisation of freshness' and the shifting technological regime

The citrus industry has been characterized by a rapidly changing technological regime, with significant innovation and widespread capability acquisition underpinning export growth. Given its perishability, the value chain for citrus is highly governed, shaped by complex, ever-changing SPS standards and powerful international buyers' quality demands. Escalating standards create both threats of exclusion, and opportunities for higher margins (Kaplinsky 2010). These challenges are by no means specific to South African citrus, but are common across African countries seeking to export agri-food products (Orr et al. 2022; Whitfield 2017; Amare et al. 2019). Alongside a long shelf-life and the absence of pests and diseases, high-value export citrus must have specific aesthetic and tactile qualities, including colour, absence of blemishes and defects, size, texture, sweetness etc. Achieving this consistently, at scale, requires complex organizaional and technological capabilities, termed the 'industrialisation of freshness' (Cramer, Di John, and Sender 2022; Cramer and Chisoro-Dube 2021). This stretches along the value chain, from improved cultivars, to post-harvest sorting and grading technologies, cold-storage logistics, through to record-keeping systems. Key processes and systems also hinge on research and technology development.

The citrus SSI is a complex ensemble of actors, with innovation-active firms spanning cultivar producers, crop protection inputs suppliers, nurseries, and growers, through to highly-automated packhouses and marketing agents. Beginning upstream in the value chain, export success depends on sourcing and developing new and improved cultivars to respond to changing consumer preferences. This entails significant R&D investments and links to international breeding programmes to track advances and source new genetic material. A few local companies developed these capabilities, with leaders being Citrogold South Africa and Stargrow.[32] After cultivar release, certified nurseries operating under centralized plant material procurement systems ensure disease and pest-free tree propagation for growers (Chisoro and Roberts 2023). Critical to yield, quality and SPS compliance are the effective use of plant protection inputs, supplied by a concentrated industry comprising seven multinational manufacturers alongside around 30 local suppliers.[33] Harvested fruit goes to packhouses, where imperatives for reduced defects and increased quality and speed of grading and sorting have driven technological change, including deployment of optical and digital technologies that are more accurate than hand-grading (Chisoro-Dube, das Nair, and Landani 2019; Cramer and Chisoro-Dube 2021). Fruit is then exported through marketing companies[34], whose long-term relationships with international buyers enable responsiveness to changing export market demands and preferences. Across production stages, the need for improved data capture, storage, and reporting for compliance purposes has driven innovation in the adoption of digital platforms, notably the Phytclean system for issuing export phytosanitary certification. Phytclean digitizes information recording, and ensures consistency in information for different markets (Chisoro and Roberts 2023).

The ever-changing landscape in buyer standards and quality requirements creates strong transformation pressures in a continual ratcheting-up of threshold capabilities for export. Margins for failure are narrow. This poses challenges for all producers, but particularly for smaller-scale black farmers and recent land reform beneficiaries, who commonly have limited experience and capital, but must constantly play catch-up in building capabilities.

5.3 Collective action for innovation

Central to the citrus industry's functioning is coordination by the industry association, the Citrus Growers' Association of Southern Africa (CGA). It performs multiple roles and is funded by a statutory industry levy. CGA membership comprises 1,564 commercial growers of varying sizes, producing primarily for fresh export markets.[35] Members' voting rights are weighted by export volume with decisions requiring two-thirds majorities. The governance structure involves around twenty directors from every citrus producing region.[36] Combined with the grower stage of the value chain being relatively un-concentrated, this means CGA decisions and strategies require broad support (Chisoro-Dube and Roberts 2021).[37]

The CGA has played a particularly important role supporting innovation and widespread capability acquisition. Indeed, these challenges contributed to its formation following mid-1990s market liberalizaion.[38] This far-reaching institutional change created export opportunities but also brought new challenges for producers adjusting to and competing in international markets, resulting in exclusion and bankruptcies (Mather and Greenberg 2003; Sandrey 2008). Shared imperatives for increasing export market participation and upgrading to higher-value products informed the creation of collective services for market access, R&D, and supporting widespread capability acquisition and technology diffusion. These are provided through CGA subsidiaries, including both non-profit companies providing shared services and commercial companies selling products and services.[39]

Among these, Citrus Research International (CRI) plays a key role ensuring production complies with SPS standards across different markets. CRI is a significant actor in the wider agri-innovation system, with three research facilities and a large staff.[40] This in-house research service means the citrus industry does not rely on the state Agricultural Research Council (ARC) and can quickly respond to changing and expanding standards and requirements in export markets. Other industries allocating research funds to the ARC have suffered problems including unfilled posts, poor management, and under-capacity.[41] CRI is supported by levy income, which has increased substantially from around US$5.7million in 2018 to over US$13 million in 2022 (Citrus Growers' Association of Southern Africa 2019, 2022). Members' appreciation for the importance of CRI's R&D for export access provided the CGA with the mandate to apply for a mandatory carton levy.[42] Growers vote on the levy every four years when the CGA presents a case for what is required in terms of R&D and other activities.[43]

To promote market access, CRI operates four divisions: Research, primarily of an applied nature, the Citrus Improvement Scheme, Biosecurity, and Extension.[44] The Research division focuses on citriculture, disease management, and pest management. The Citrus Improvement Scheme and Citrus Foundation Block help diffuse improved

genetic material and safeguard biosecurity.[45] The former is a centralized plant material procurement system,[46] the latter the sole permitted source for nurseries' procurement of certified disease-free plant material. CRI's Extension Division coordinates knowledge transfer to growers and their service agents, again providing a degree of autonomy from the state. Lastly, the CRI's Postharvest Technical Forum coordinates optimizations of cold chain and logistics.[47] Concentrated control of innovation capacity in cultivar and crop protection input supply poses another challenge to producers, giving upstream suppliers potential pricing power.[48] The CGA responded to increase competitive rivalry by establishing its own commercial subsidiaries for cultivars (CGA Cultivar Company) and crop protection inputs (River Bioscience) to develop cheaper products for growers (Chisoro-Dube and Roberts 2021).

There are powerful incentives for the collective innovation activities outlined above, which ensure widespread support for capability acquisition across the industry. Individual producers' shortcomings can jeopardise collective reputations and even market access, thus growers have an interest in other growers' improvements. Meanwhile, the scale and growth of export market demand means, in effect, producers competing collectively 'for the market' (versus other major citrus producing countries) rather than directly against one another. Further, rather than oppositional relations between different stages of the value chain, export performance depends on coordinated improvements across the value chain, from cultivars through to growing, packing, marketing, and leveraging the industry's strong local linkages, capabilities, and coordination roles. While the CGA has developed complex systems affording members relative autonomy from the state in several areas, it also works closely with the government on crucial market access-related issues, including logistics, tariffs, and trade barriers. In particular, it depends on government-to-government negotiations for market access (Chisoro and Roberts 2023). Combined with the large export revenues citrus generates for the fiscus, this contributes to collaborative state-business relations, relative to South Africa's fractious norms.

5.4 The complexities of inclusive development in citrus

As in other parts of the agri-food sector, widening participation of black citrus producers – particularly in commercial citrus production and in higher-value export markets – is a key government imperative.[49] Historical racialized inequalities in land ownership make land reform pivotal to this. Though there have been widely reported challenges with the pace and extent of land restitution and redistribution, a number of large citrus farms have been transferred to trusts, communities, and individuals. There have also been some independent small-scale entrants.[50] Land transfers means farm sizes for black producers are not necessarily substantially smaller than for established white farmers, and as such inclusive development challenges are not equated simply to farm size, but a complex set of intersecting disadvantages faced by these new entrants. Acreage does not necessarily reflect production capacity, much less ability to meet export standards, given the importance of continual investments in cultivars, skills, and the maintenance/improvement of production technologies like irrigation systems, which are frequently outdated on beneficiaries' farms (Chisoro-Dube and Roberts 2021). Beneficiaries frequently lack necessary working and investment capital, with state financial support limited, and a lack of title

deeds often limiting access to commercial finance. Alongside this are the equally critical challenges of skills and know-how for new entrants lacking experience.[51]

In response to the government's imperative for inclusion of black growers into commercial agriculture, the citrus industry established the Citrus Growers Development Company (CGDC) as a platform to organize black citrus growers and to formalize the voice of black growers. The CGDC assists black farmers with production inputs, farm implements, technical advice and facilitating their access into export markets.[52] Beyond targeted CGDC support, black growers benefit significantly from the CGA's broader innovation ecosystem outlined above. Theindustry's 'transformation' activities are funded using 20% of the CGA's export levy income.[53] This is a minimum level set as a conditionality by the state for granting the industry statutory levy – a key source of government leverage over the industry. Of this, 60% should be spent on enterprise development (rather than training, as previously), with activities tracked and enforced by the government (National Agricultural Marketing Council (NAMC 2019)).

The CGDC supports an average of 120 black growers on 7,600 hectares of area planted between 2007 and 2023 although the numbers fluctuate over the years due to entry and exit of new farmers and establishment of new orchards. The black growers account for 10% of the total industry in numbers and 8% of the total area planted in the citrus industry.[54] These are spread across all the seven citrus growing regions in the country although the majority (67%) are located in the major citrus growing regions of Limpopo and Eastern Cape. They consist of different farm sizes ranging from as small as 26 hectares to 184 hectares (Citrus Growers' Association of Southern Africa 2007–2022). It follows that the organization is representative in terms of different regions, sizes of farmers and new entrants. According to CGA figures, of the 120 member-growers, 78 growers were exporting their fresh produce in 2021 up from 51 growers in 2018 and contributing around 5% of total industry exports (Citrus Growers' Association of Southern Africa 2020). Those who are not able to access export markets sell into the lower-value domestic markets. The exporting black growers are therefore also members of the CGA contributing towards the industry's export levies charged on every carton exported. This ensures that black farmers both share in the distribution of benefits and costs of industry investments and shared services. Regarding decision-making at an industry level, the exporting black growers are also able to vote within CGA governance and they occupy two seats on the CGA board of directors. However, given that votes are weighted by export volumes, small growers' influence is limited. Nonetheless, despite progress in various initiatives to build long-term capabilities of black farmers to participate in export markets, they remain in a marginal position and progress needs to accelerate.

6 Discussion

The cases highlight potentially important factors shaping patterns of inclusion and exclusion of small and young firms in agro-industrial SSIs. There are important commonalities, with both citrus and maize milling being sectors where the technological frontier has advanced rapidly, driven by 'demand induced' innovation (Kaplinsky 2011) as firms respond to changing food consumption norms. This generated strong transformation pressures, creating major challenges to small and young firms in attaining threshold capabilities required to participate in markets.

The cases highlight, firstly, that food is not necessarily a 'low-tech' industry, with even seemingly 'basic' products being increasingly innovation-intensive. Secondly, these transformation pressures in the food industry may have important distributional consequences (Lundvall and Lema 2014). In the absence of effective ISSIs, the costs and benefits of these transformation pressures will be unevenly distributed (Ibid). For example, firms lacking the requisite resources and support systems to respond to transformation pressures through productivity-enhancing innovation and capability acquisition, may instead respond through transferring pressures onto labour or – as is apparent through the milling case discussed above – through eventual exit. In the citrus case, transformation pressures risk exclusion of black growers from higher margin export markets due to lack of compliance with standards. In the South African context, the potential for transformation pressures accompanying technological change in agri-food to generate increased concentration and centralization are particularly significant. This is given the policy emphasis placed on fostering the entry of black-owned firms in the agro-industries as a means of addressing severe racial inequalities in asset ownership and the limited employment opportunities in many rural areas, in particular the former 'homeland' regions. It is important therefore to seek a deeper understanding of how differing sectoral systems ameliorate or exacerbate these pressures.

Besides the commonality of intense transformation pressures, there are also important contrasts in outcomes for inclusion/exclusion, resulting partly from differing SSI characteristics in supporting adaptations to transformation pressures. The export-oriented citrus industry has innovation challenges and competitive dynamics quite different from domestically-oriented maize milling. In citrus, there are strong forms of collective action, manifesting in intermediate institutions providing widespread access to technologies, information, and skills otherwise beyond individual firms' reach. This affords new entrants significant support with capability acquisition. Underlying this seems to be a number of factors. Firstly, the collective nature of innovation challenges: market access and reputation requires broad-based upgrading to meet escalating international SPS and quality standards. Therefore, innovation challenges are viewed as shared and necessitating collaboration. Secondly, relatedly, the nature of international competition, with large and growing international demand limiting firm-to-firm rivalry. Thirdly, the industry's relatively un-concentrated structure at grower level means that many growers share similar interests, using similar business models, with more limited concentrations of power in the association. This all seems to have provided a conducive environment for collective action on innovation.

Maize milling differs, with competition zero-sum in a slow-growing domestic market, and innovation challenges largely contained within individual firms rather than shared across them. The sector's firm-size distribution is unbalanced and highly-concentrated. Hence, there are strong disincentives around collaboration on innovation issues, with limited coordination or collective resource mobilizaion around shared challenges. Instead, capability acquisition relies heavily on access to private networks and the firms' internal resources, in particular investments to develop relations with advanced capital goods suppliers. Small firms lack easy-access to suitable intermediate institutions to assist with access to information and knowledge.

The cases highlight the potential significance of industry associations as 'intermediary' innovation system actors, which may play a major role providing collective services,

disseminating knowledge, and solving coordination problems (Papaioannou et al. 2016; Watkins et al. 2015). As the limited role of the NCM and extensive role of the CGA illustrate, institutionalized forms of collective action can be anticipated to play a particularly important role in ISSIs, augmenting firms' innovation resources and amplifying agency, particularly important in contexts such as post-liberalizaion South Africa where the state has retreated from some key innovation system functions. This resonates with earlier scholarship on the importance of joint action and external economies in clusters to upgrading among small firms. The paper argues that a better understanding of the manifestations and drivers of inter-firm collective action is therefore important to inclusive innovation system scholarship. This improved understanding will require a deeper theoretical and empirical understanding of the underlying determinants of differing forms and levels of inter-firm collective action. There is much scholarship on collective action and industry associations in cognate political economy literature, which is beyond the scope of this paper to properly address. It emphasizes the importance of institutional and market environments in shaping levels, manifestations, and goal-orientations of collective action (Battisti and Perry 2015; Bräutigam, Rakner, and Taylor 2002; Doner and Schneider 2000; Whitfield et al. 2015). Within innovation systems scholarship, this points to the importance of differing 'market regimes' and competitive conditions in shaping innovation processes and the institutions which support it (Lundvall 2011). This is apparent in the cases discussed in this paper, where the differing competitive and demand conditions – the market regime – appears particularly influential in shaping the contrasting forms of collective action. This reinforces a broader, often overlooked point, about the extent to which competition shapes innovation processes in the private sector (Lundvall 2011).

A second key contrast between the cases is the nature of state-business relations, shaped by differing sectoral political economies. In citrus, land reform, statutory levy applications, and governments' role in opening export markets provided levers for the state to steer the industry towards greater inclusivity. This, combined with citrus' contribution to foreign exchange earnings and employment, necessitated a degree of collaboration, even as the association sought autonomy in other areas. In milling, the cartel soured state-business relations, evident in antagonism over high concentration levels, suspicion of price gouging on the staple grain, and lack of collaboration around key support measures for small firms and new entrants. Notably, state interventions for small milling firms by-passed key industry actors and sources of private sector expertise, resulting in poor outcomes, while the state did not support the industry association's skills development initiatives. The cases illustrate how wider political economy dynamics may shape innovation trajectories. The extent to which innovation systems are oriented toward benefitting small firms and new entrants over large firms and incumbents, diffuse over concentrated industrial structures, is shaped not simply by ideological preferences towards inclusivity, but by the distribution of power between factions of business, the state, and, depending on the context, other social actors contesting innovation-related institutions and their distributional consequences. Attempting to situate sectoral systems within this broader 'political settlement' (Khan 2018) is therefore essential to understanding the underlying drivers of ISSI outcomes.

7. Conclusions

Summarizing, the cases suggest that ISSIs require the formation of support measures and intermediate associations to assist resource-constrained small and young firms by making key skills, technology, and information etc accessible widely accessible. That is, institutions which diffuse, rather than concentrate, resources needed by firms for capability acquisition. To conclude, we reflect on the broader relevance for development strategy and priorities for further research. As the paper has argued, generating inclusive outcomes in technologically complex and dynamic agro-industries amid severe transformation pressures in part depends on sectoral innovation systems to support learning and capability acquisition among smaller firms and new entrants. In the South African context, this can play an important role in addressing racialized inequalities in asset ownership in the agro-industries, given the severe challenges faced by small firms and new entrants. State research and innovation institutions have an essential role to play in providing key support functions for small firms and new entrants that struggle to access these through the private sector, and in coordinating among differing elements of the sectoral system. However, the selected case studies show that industry associations can play an important role in lowering entry barriers and narrowing the capability gaps through mobilizing and diffusing resources for industry-wide innovation. Furthermore, attention also needs to be paid to making industry associations internally inclusive and responsive to the needs of small firms and producers. This is a subject requiring further research, across a wider range of commodities and contexts.

Enhancing the role of industry associations in inclusive sectoral systems requires a more focused approach to collaboration or cooperation between industry and government through identification of mutually beneficial interests and outcomes. Industry needs the active support and cooperation of the government on a wide range of issues, such as the supply of physical infrastructure, subsidization of the costs of training labour and of research and development, and, in export-orientated agro-industrial sectors, to negotiate preferential trade agreements (Whitfield and Buur 2014). However, there is the risk – highlighted in foundational literature on organized business – of powerful industry associations' rent seeking activities distorting economic policy and generating wider negative economic outcomes (e.g. Olson 1982). Therefore state-business relations must be centred around reciprocal arrangements in which support is contingent and subject to disciplinary mechanisms (Amsden 2001). The government must be able to set conditions and targets as well as enforce rules or conditions attached to policy-created rents for the relevant industry associations to promote inclusion, learning and shared capabilities within the industry. Fundamentally, as Doner and Schneider (2016) assert, the foundation of successful innovation strategy is a process of complex institution building for 'upgrading coalitions' that overcome the fragmentation of social groups. This is all the more complex in initiatives to foster inclusive sectoral systems which incorporate marginalized actors: more proactive measures to address unequal power within markets and key institutions may be a prerequisite. Given the highly-concentrated nature of the South African economy, proactive competition policy combined with industrial policy will continue to be a critical tool to increase participation of small firms and producers through lowering barriers to entry and promoting competitive rivalry.

Considering avenues for further research, though the cases illustrate the manner in which power relations and their intersection with market conditions shape the

possibilities for more inclusive or exclusionary innovation systems, further investigation is required on the political economy underpinnings of ISSIs and the variables and mechanisms that generate differing outcomes. As many other authors have noted, questions of conflict and power struggles within innovation systems remain broadly neglected (Andreoni 2018; Lundvall 2007; Chaminade, Lundvall, and Haneef 2018). Further comparative research is also required on how ISSIs may differ in terms of the range of actors and institutions specific to small firm learning, and the particular 'functions' associated with ISSIs. Finally, given the multi-faceted nature of inclusive development, further research should seek to look beyond the firm to examine how differing sectoral systems generate inclusive/exclusive outcomes for a wider range of stakeholders in the agro-industries, including communities, labour, and consumers.

Notes

1. Institutions composed of intermediate key actors in collective processes of innovation and capability development. See Section 1 for an expanded discussion.
2. Quantec data QSIC 303.
3. Data supplied by SAGIS, personal correspondence.
4. Interviews 7, 13.
5. Interview 6.
6. Interviews 6, 8, 13.
7. Interviews 7, 11, 13.
8. Interviews 7, 13, 17, 18, 20, 35, 39.
9. Interview 7.
10. Interview 6, Quantec, author's calculations.
11. Interview 13.
12. Interviews 17, 35.
13. Interview 8, 13.
14. Interviews 9, 10.
15. Interviews 15, 16, 22, 23, 24, 25, 38, 42.
16. Interview 14. Data supplied by SAGIS, personal correspondence.
17. In this case 'churn' means the combined quantity of new firms entering and existing firms exiting the industry as a proportion of total firms. The high churn rate means that while many firms are exiting the industry, at the same time new firms are entering. The figure was calculated using SAGIS registers' of milling firms, for the five years to 2020.
18. Interview 8.
19. Interview 13.
20. Interviews 6, 8.
21. Interview 9.
22. Interviews 8, 9.
23. Interviews 1, 2, 3, 4, 5.
24. Interview 8.
25. Interview 10, 11, 12, 31, 34.
26. Interviews 17, 18, 20, 35.
27. Interview 11.
28. Interview 35.
29. Interviews 7, 8, 13.
30. Interview 35.
31. Interview 35.
32. Interviews 26, 27.
33. Interviews 31, 32, 33, 35.

34. Interviews 24, 25.
35. www.cga.co.za
36. Interview 35.
37. Interview 35.
38. Interview 35.
39. www.cga.co.za
40. www.cga.co.za
41. Interview 40.
42. Interview 35.
43. Interview 35.
44. http://www.cri.co.za/
45. http://www.cri.co.za/
46. Interview 41.
47. http://www.cri.co.za/
48. Interview 35.
49. Interviews 30, 39.
50. Interviews 17, 18, 19, 20, 21, 22, 23, 39.
51. Interviews 17, 18, 19, 20, 21, 22, 23, 39.
52. Interview 30.
53. Interview 30.
54. Interview 30.

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Appendices

Appendix 1: Maize processing interviews

Interview reference	Interviewee	Province	Date
1	Dharmarai Naicker, Competency Manager, CSIR	Gauteng	05/09/2019
2	State industrial policy officials (de-identified)	Pretoria	10/09/2019
3	State small-business policy official (de-identified)	Pretoria	02/09/2019
4	State agricultural policy officials (de-identified)	Via email	27/09/2019
5	Dumisani Mngadi, South African Bureau of Standards	Gauteng	17/10/2019
6	Large maize processing firm manager (de-identified)	Gauteng	17/07/2019
7	Large maize processing firm manager (de-identified)	Gauteng	26/06/2019
8	Large maize processing firm manager (de-identified)	Via Zoom	31/08/2020
9	Grain industry trade association representative (de-identified)	Johannesburg	12/08/2019
10	Mariana Purnell, Ishmael Tshiame, Agricultural Business Chamber (Grain)	Pretoria	26/08/2019
11	Maize processing equipment supplier (de-identified)	Free State	04/09/2019
12	Xolani Ndzaba, Golden Dice Food	Gauteng	26/02/2020

(*Continued*)

Continued.

Interview reference	Interviewee	Province	Date
13	Large maize processing firm manager (de-identified)	Via Zoom	01/09/2020
14	Nico Hawkins, South African Grain Information Service	Pretoria	09/04/2019
15	Small-scale maize processing firm	Free State	26/08/2019
16	Micro-scale maize processing firm	Free State	27/08/2019
17	Medium-scale maize processing firm	Free State	28/08/2019
18	Medium-scale maize processing firm	Free State	29/08/2019
19	Micro-scale maize processing firm	Free State	30/08/2019
20	Medium-scale maize processing firm	Free State	03/09/2019
21	Medium-scale maize processing firm	Free State	05/09/2019
22	Medium-scale maize processing firm	Gauteng	13/09/2019
23	Small-scale maize processing firm	Gauteng	17/09/2019
24	Micro-scale maize processing firm	Free State	20/09/2019
25	Small-scale maize processing firm	Kwa-Zulu Natal	26/09/2019
26	Small-scale maize processing firm	Kwa-Zulu Natal	26/09/2019
27	Micro-scale maize processing firm	Kwa-Zulu Natal	27/09/2019
28	Medium-scale maize processing firm	Eastern Cape	30/09/2019
29	Small-scale maize processing firm	Eastern Cape	01/10/2019
30	Small-scale maize processing firm	Eastern Cape	02/10/2019
31	Small-scale maize processing firm	Eastern Cape	03/10/2019
32	Micro-scale maize processing firm	Eastern Cape	04/10/2019
33	Micro-scale maize processing firm	Gauteng	08/10/2019
34	Micro-scale maize processing firm	Gauteng	10/10/2019
35	Medium-scale maize processing firm	Free State	14/10/2019
36	Micro-scale maize processing firm	Gauteng	17/10/2019
37	Small-scale maize processing firm	Mpumalanga	18/10/2019
38	Small-scale maize processing firm	Limpopo	21/10/2019
39	Medium-scale maize processing firm	Gauteng	08/11/2019
40	Small-scale maize processing firm	Kwa-Zulu Natal	11/11/2019
41	Small-scale maize processing firm	Gauteng	05/02/2020
42	Small-scale maize processing firm	North West	19/02/2019

Appendix 2: citrus interviews

Interview reference	Classification	Location	Date
1	Canning	Gauteng	21/02/2020
2	Concentrate manufacturer	Northern Cape	17/02/2020
3	Juice-mixing	Gauteng	17/02/2020
4	Fruit preparations	Gauteng	03/03/2020
5	Juice-mixing	Gauteng	10/03/2020
6	Fruit juicing	Gauteng	28/05/2020
7	Concentrate manufacturer	Mpumalanga	27/05/2020
8	Concentrate manufacturer	Limpopo	30/05/2020
9	Fruit juice industry association	Western Cape	14/10/2020
10	Traceability expert	Gauteng	10/02/2020
11	Grower	Limpopo	23/03/2020
12	Grower-packhouse	Limpopo	23/03/2020
13	Grower	Limpopo	23/03/2020
14	Grower-packhouse	Limpopo	23/03/2020
15	Grower	Limpopo	29/06/2020
16	Grower-packhouse	Mpumalanga	20/07/2020
17	Grower	Gauteng	30/07/2020
18	Grower	Eastern Cape	31/08/2020
19	Grower	Eastern Cape	09/09/2020
20	Grower	Eastern Cape	04/09/2020
21	Grower	Eastern Cape	16/09/2020
22	Grower	Limpopo	15/09/2020
23	Grower	Eastern Cape	18/09/2020
24	Fruit Marketing Company	Western Cape	04/09/2020
25	Fruit marketing company	Eastern Cape	14/10/2020
26	Cultivar development & management	Western Cape	14/10/2020
27	Cultivar development & management	Western Cape	02/12/2020
28	Tree nursery	Limpopo	19/08/2020
29	Tree nursery	North West	10/09/2020
30	Industry transformation unit	Gauteng	30/10/2020
31	Co-operative – input supplier	Eastern Cape	07/08/2020
32	Crop protection chemicals	Gauteng	20/08/2020
33	Crop protection solutions industry association	Gauteng	14/05/2021
34	Irrigation water board	Eastern Cape	21/08/2020
35	Industry association	Kwa-Zulu Natal	17/03/2021
36	Provincial Agriculture Department	Limpopo	18/02/2020
37	District Agriculture Department	Limpopo	23/03/2020
38	Provincial Agriculture Department	Mpumalanga	26/05/2020
39	Government finance institution	Gauteng	20/11/2020
40	Government marketing institution	Gauteng	29/11/2021
41	Cultivar inputs supplier	Eastern Cape	10/05/2022