Technology sharing for economic growth – the case of Australian–Indonesian agricultural engagement.

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Abstract

Much of the geopolitical tension between China and the United States has centred on preventing the sharing of technology between countries. The findings of this paper suggest this is unwise. The paper uses the case study of agricultural cooperation between Australia and Indonesia and shows that technology sharing and the productivity improvements it delivers lifts all boats. Short-term labour with experience in agriculture have a positive impact on the productivity of Australia's agricultural workforce and offers a pathway to facilitate technology transfer between countries. This paper models a policy where Indonesian farmers work in Australian agriculture for up to 12 months to contribute to Australian agricultural production and gain skills and experience in new practices that increase the productivity of Indonesia agriculture on their return. This paper shows that this policy offers direct benefit for both Australian and Indonesian agriculture through increased output and investment. This policy also has broader economic benefits for Indonesia with increased output and investment across all sectors as well as increased GDP, investment, and consumption. This paper finishes with a discussion of the broader implications from this policy and the role of productivity and technology transfer on long-term economic development.

Introduction

The now cliched African proverb says 'if you want to go fast, go alone. If you want to go far, go together.' This sentiment provides an underlying premise for technology sharing between developed and developing nations to support both agricultural and broader economic development. This paper outlines the case for collaboration between agricultural industries as a tool for broader economic growth.

Productivity growth will fundamentally shape what the future looks like. This is especially true for agriculture, where growth is fundamentally built on increasing productivity. In a world with climate change, food insecurity, diminishing resources and increasing natural disasters, producing more from less is essential. But not only will agricultural productivity support greater food security, but it also offers new economic growth and development.

The growing geopolitical competition between China and the United States threatens to change the structure and function of global supply chains through increased domestic manufacturing and "friend-shoring". If realised, this will reduce the spread of new technology that occurs as a result of free trade and foreign investment through global supply chains. In this context, it is important to focus on the positive role of collaboration and cross-country engagement as a key tool to support technology transfer, new practices and productivity enhancing tools.

Long-term productivity growth has underpinned agricultural development across the world (Sheng, 2010; Gray et al., 2011; Suphannachart & Warr, 2011; Mullen & Keogh, 2013; Boult & Chancellor, 2020), providing the surplus labour that underpins the theory of structural adjustment in developing countries (Lewis, 1954). It has also supported significant agricultural output growth in developed countries (Global Harvest Institute, 2017).

The relationship between economic development and productivity, especially within agriculture, is well recognised within the economic literature (Mallawaarachchi et al., 2009; Gray et al., 2011; Mullen & Keogh, 2013). Extending this relationship, there is significant focus on how further increasing productivity within agriculture can improve food security and raise community living

standards around the world (Suphannachart & Warr, 2011). As such, there is a justified focus on productivity in agriculture in both developed and developing nations.

There are consistent long-term trends in the growth of agricultural Total Factor Productivity (TFP), driven by technological and organizational change, trade liberalisation, institutional policies, and infrastructure investment (Mallawaarachchi et al., 2009; Boult & Chancellor, 2020). However, gains through agricultural productivity have not been fairly distributed across the world.

This paper examines the opportunity of cross-country collaboration between Australia and Indonesia. It will look at how a targeted program of labour transfer can increase productivity and facilitate technology transfer from Australia to Indonesia. It will also assess the broader economic growth and development that occurs from this policy.

Agriculture plays a relatively small role in the Australian economy. In 2022, agriculture accounted for 2.4% of GDP and employed 2.5% of the workforce (ABARES, 2023b). As a result of its large agricultural output and small population, Australia is a large exporter of agricultural products, constituting 11.6% of Australia's exports (ABARES, 2023b).

Australian agriculture has a sophisticated research and development ecosystem through rural research and development corporations, agricultural focussed regional universities, and private sector research and development. As a result of this ecosystem, Australian agriculture has a high, long-term productivity growth (ABARES, 2023a).

Australian agriculture has experienced labour shortages which reduces the sector's ability to fulfill its potential growth and development (Capel, 2023). While this has facilitated the uptake of mechanization and labour-saving technology, Australian agriculture can still benefit from new workers and an expanded workforce.

Agriculture plays a large but declining role in the Indonesian economy. In 2022, agriculture accounted for almost 14% of GDP and employed 28% of the total workforce (OECD, 2022). Despite being a large producer of agricultural product, Indonesia is a net-importer of grains, horticulture, and livestock (Quincieu, 2015; Timmer, 2015).

Increasing agricultural productivity in Indonesia offers a pathway to increase food production, increase food security and ultimately contribute to broader economic development. Indonesian agriculture is currently dominated by small family farms with larger commercial farms producing perennial crops such as palm oil (Quincieu, 2015). Due to this industry make up, the Asian Development Bank estimates that a 7% per annum increase in smallholder productivity could result in a $50 billion increase in agricultural revenues by 2030 (Quincieu, 2015).

Between 1976 and 2006, both Australian and Indonesian agricultural TFP grew at consistent rates, as shown in Figure 1 (USDA, 2022). Over this period, Australian agriculture experienced annual average TFP growth of 1.6% (Sheng et. al, 2013; USDA, 2022), while the TFP growth rate in Indonesian agriculture averaged 1.4% (Fugile, 2010). However, since 2006, Indonesian agriculture significantly increased its growth rate to take over Australian agricultural growth (USDA, 2022). At the same time, TFP in Australian agriculture slowed and, in some cases, significantly declined due to increased climate variability and the significant drought across eastern Australian between 2016 and 2020 (Hughes & Gooday, 2021; USDA, 2022).

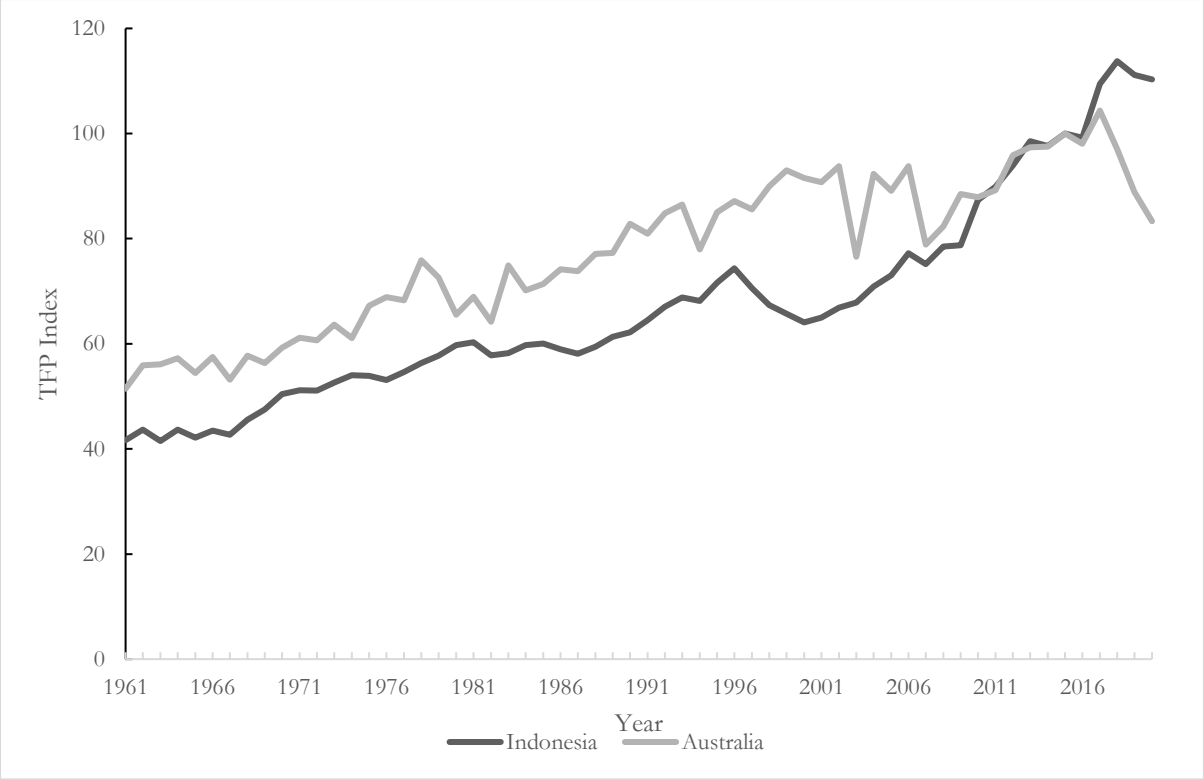

Figure 1. Change in Total Factor Productivity index for in Australia and Indonesia between 1961 and 2020 – 2015 = 100 (USDA, 2022).

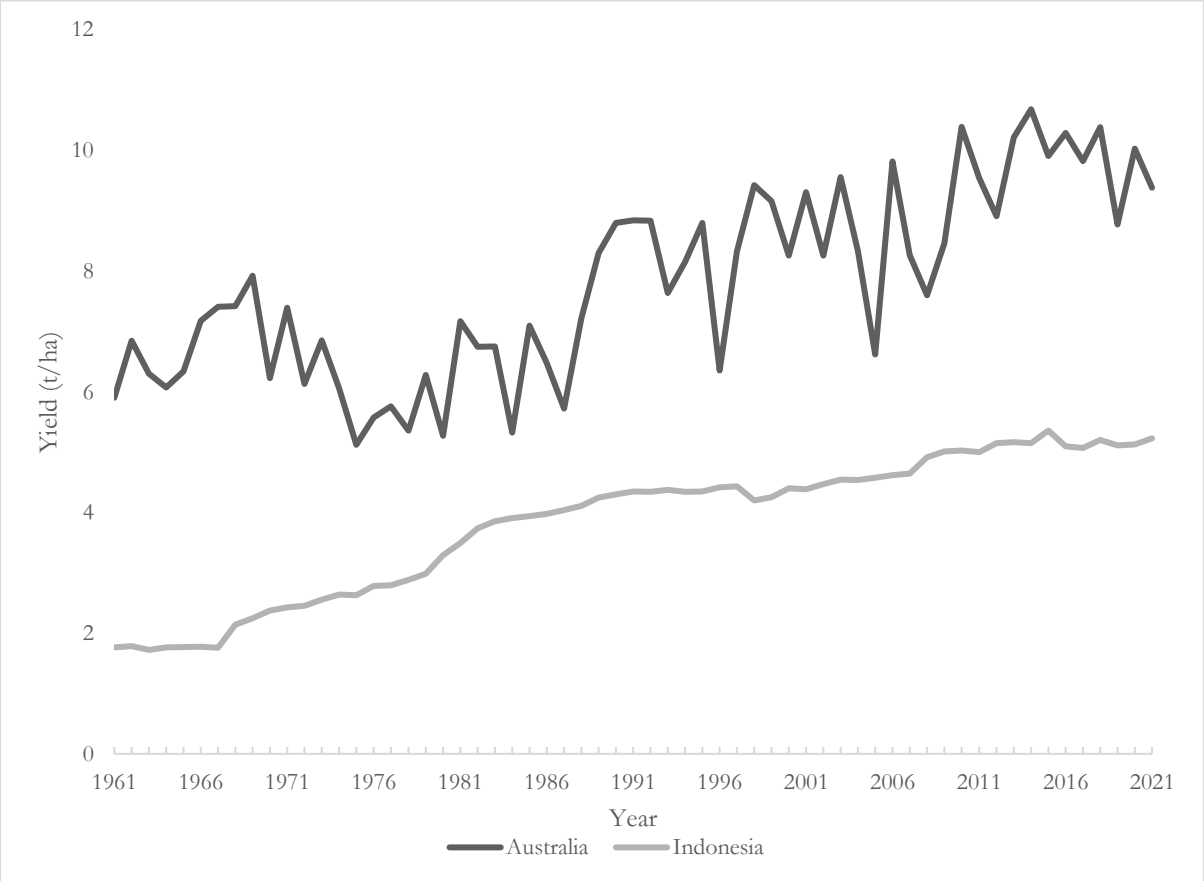

Figure 2. Rice yield in Australia and Indonesia expressed as tonnes per hectare between 1961 and 2021.

It is expected that Indonesian agriculture will experience a rapid increase in productivity growth as it increasingly takes up new technology and practices that have been developed in other parts of the world (ABARES, 2023a). However, these productivity increases are applied to a lower base in Indonesia. Yield is a common indicator of productivity as it provides a clear measure of output per hectare. Therefore, examining existing yield in Australia and Indonesia provides a clear comparison of the output levels between both countries. This is demonstrated in Figure 2 which shows the yield gap between rice production in Australia and Indonesia.

While there has been significant research and development for agriculture around the world, the uptake of new technology and practices are often hampered by applicability to local characteristics (Alston & Pardey, 2014; Warr, 2022). That is, new agricultural technology is developed for specific locations and cannot be readily transferred without alteration (Warr, 2022). This reduces the potential spill over of agricultural research and development in developed countries to developing nations. Increasing the skills, experience, and human capital of the agricultural workforce in developing nations can support local adaption of new technologies.

Labour productivity in Australia has increased significantly through the adoption of technology and machinery through Australian farm businesses (Capel, 2023). Between 1988 and 2006, labour productivity in Australian agriculture grew more than two and a half times (Campbell & Withers, 2017). However, agriculture is now facing slowing productivity and output through the labour shortages that prevent produce being picked (Capel, 2023).

The source and background of short-term labour has a large impact on individual productivity. This has a broader impact on the total productivity of Australia's agricultural workforce. Multiple studies have shown that individuals who migrate to Australia specifically to work in agriculture have significantly higher productivity than other purposes. This is most evident in the comparison of short-term labour under the Seasonal Worker Program and Working Holiday Makers Program.

Zhao et. al (2018) estimates that workers from the Seasonal Worker Program employed as short-term labour are up to 20% more productive than Working Holiday Makers. This increases an additional 15% if the workers return for two or more seasons (Zhao et. al, 2018). These results are supported by Leith & Davidson (2013) who found that the relatively productivity of the Seasonal Worker Program was 22% higher than Working Holiday Makers.

These findings are also supported by examining migration trends to regional Australia. The employment of new migrants in agriculture across all employment types, can significantly boost labour productivity (Collins et. al, 2016). Collins et. al, (2016) found that migration of people with an agricultural background provide a positive contribution to agricultural productivity in rural and regional Australia. These studies demonstrate that even though new labour is sourced from countries with a lower agricultural productivity level, they can increase the productivity of Australia's agricultural workforce.

Given this information, closing the gap in the TFP growth rate between Australia and Indonesia offers significant opportunity to increase agricultural output, increase food security and underpin economic growth and development. This paper models a short-term labour mobility scheme where Indonesian farmers work on Australian farms for up to 12 months. This experience allows the Indonesian farmers to build on their existing agricultural knowledge to develop new skills and experience in the use and application of technology and productivity enhancing practices. The Indonesian farmers then take this knowledge back to Indonesia and apply it on their farms, increasing on-farm productivity within Indonesia.

Many studies also discuss the benefit of increased labour supply as a solution to labour shortages that exist in Australian agriculture. Current estimates suggest that up to $45 million of Australian produce is wasted each year from produce that cannot be harvested and is wasted. While the increased workforce would address this issue, it is not considered in this paper.

Model

Productivity Scenario

Proposed Policy

This paper models the impact of a policy of direct collaboration between Australia and Indonesia that seeks to increase the productivity and development of agriculture in both countries.

The policy will place 2,500 Indonesian farmers and agricultural workers on Australian farms for 12 months. This will provide an opportunity for Indonesian farmers to learn about Australian agricultural production, increase their awareness and understanding of new techniques and practices. This process will upskill the Indonesian farmers and facilitate technology transfer and increased productivity when the Indonesian farmers return to Indonesia. Additionally, this policy will have a positive impact on Australian agriculture. The additional workers will offer a solution to resolve some of the existing labour shortages within Australian agriculture.

Australian Labour Productivity Increase

The addition of 2,500 Indonesian farmers to Australian agriculture will resolve existing labour shortages in Australian agriculture and increase the sector's labour productivity. These workers are also likely to replace some other sources of short-term labour used on Australian farms, such as working holiday makers.

This paper assumes productivity increases in line with Zhao et. al (2018)'s findings. Using this productivity increase, when the 2,500 new Indonesian workers are added to the total agricultural workforce, they increase the effective productivity of the total agricultural workforce by the equivalent of 3,000 workers. Taken as a percentage of the total agricultural workforce, this is equivalent to a total increase of labour productivity of 0.164%. This is outlined in Table 1.

Table 1. Impact of additional workers on the labour productivity of the Australian agricultural workforce.

Size of agricultural workforce before policy[1]	300,900
Number of new employees	2,500
Productivity rate of new employees	120%
Size of agriculture workforce after policy	303,400
Effective size of agricultural workforce after policy	303,900
Percentage change in labour productivity of agricultural workforce	0.164%

[1] ABS data for agricultural workforce, March 2023 seasonally adjusted. https://www.abs.gov.au/statistics/labour/employment-and-unemployment/labour-force-australia-detailed/latest-release

Indonesian Total Factor Productivity Increase

The upskilling of Indonesian farmers also offers a key opportunity for technology transfer from Australia to Indonesia. This technology transfer is a clear pathway to increase the productivity of the Indonesian agriculture sector.

This paper assumes that the increase in farmer productivity and human capital will support an increase in Indonesian agricultural TFP by 0.2% per year. This is in line with Warr (2022), which identified that foreign technology spill overs contribute approximately 0.23% per year to Indonesian agricultural TFP growth.

This assumes that specific training and upskilling of Indonesian farmers will almost double the existing contribution of international spill overs to TFP growth of Indonesian agriculture through the increased ability to tailor new research and development to specific Indonesian requirements.

The G-Cubed (G20) Model

This paper uses the G-Cubed (G20) model, a multi-country, multi-sector, intertemporal general equilibrium model, originally developed by Warwick McKibbin and Peter Wilcoxen.

The G-Cubed model has been constructed to examine changes in the global economy as a result of policy decisions and has contributed to current policy debates on environmental policy and international trade with a focus on global warming policies. G-Cubed offers an opportunity to combine three areas of research – econometric general equilibrium modelling, international trade theory and modern macroeconomics (McKibbin & Triggs, 2019).

There are several versions of G-Cubed which have been built over many years, each with incremental improvements. The version used for this paper is a recent version of the G-Cubed model, designed specifically to study the G20 and the implications of cooperation through a shared multilateral policy agenda (McKibbin & Triggs, 2019). G-Cubed has been shown to be a useful tool in explaining the adjustment processes in many historical periods, including the Asian Financial Crisis, making it a useful tool in examining the changes in economic activity that will result from greater collaboration in agricultural policy (McKibbin & Triggs, 2019).

The G-Cubed (G20) model represents the world as 24 autonomous blocks: one for each G20 economy (including the rest of the euro zone) and four regions which represent the world's non-G20 economies (McKibbin & Triggs, 2019). Each region in G-Cubed is represented by its own multi-sector econometric general equilibrium model with highly disaggregated, multi-sectoral flows of goods and assets between them (McKibbin & Triggs, 2019).

Each country and region has six industries, which correspond to the production of six goods: energy, mining, agriculture (including fishing and hunting), durable manufacturing, non-durable manufacturing and services (McKibbin & Triggs, 2019). Each good in a region is an imperfect substitute for goods from other regions, meaning there are effectively 144 goods (McKibbin & Triggs, 2019).

Each country consists of 6 representative firms, a representative household and a government (). The model also includes markets for goods and services, factors of production, money and financial assets (bonds, equities and foreign exchange) (McKibbin & Triggs, 2019). All countries in the model are linked through the glows of goods and assets (McKibbin & Triggs, 2019). These are summarised in Table 2.

Table 2: Overview of the G-Cubed (G20) model (McKibbin & Triggs, 2019)

Countries:	**Regions:**
Argentina	Rest of the OECD
Australia	Rest of Asia
Brazil	Other oil producing countries
Canada	Rest of the world
China	
Rest of euro zone	**Sectors:**
France	Energy
Germany	Mining
Indonesia	Agriculture (including fishing and hunting)
India	Durable manufacturing
Italy	Non-durable manufacturing
Japan	Services
Korea	
Mexico	**Economic Agents in each Country:**
Russia	A representative household
Saudi Arabia	A representative firm (in each of the 6 production sectors)
South Africa	Government
Turkey	
United Kingdom	
United States	

Results

Characterisation of results

The results provided through each scenario are projections of percentage changes to each variable of interest relative to the baseline. Each result is predicated on the assumed economic behaviour and market structures embodied in the equation structure and database of the model and on the parameters that determine the degree of responsiveness in key relationships (Productivity Commission, 2010). These results are also designed to illustrate the mechanisms and orders of magnitude that result from increased labour productivity in Australia and increased TFP in Indonesia and the resulting changes to sectoral and economic conditions (Productivity Commission, 2010).

In this paper, the changes in labour productivity and TFP are assumed to be induced through a single policy of labour transfer between two agricultural industries. However, the simulation does not account for other productivity enhancing factors such as trade-policy structure, broader policy reform and other technical change. To this end, the results may underestimate the impact of the proposed policy.

To the extent that greater labour collaboration leads to increases in productivity, these projections could underestimate the potential for other economics factors and behaviours between both countries that may facilitate greater uptake of new technologies and higher productivity.

This paper models the impacts of policy with 2,500 Indonesian farmers working in Australia each year. The positive benefits of this policy can be increased through a scaling of the program to include a larger number of farmers working in Australia each year.

Indonesia

This policy has a positive impact on both the agriculture sector and the broader Indonesian economy. Increased productivity sees a significant increase in investment into the agriculture sector (Figure 3) and output from Indonesian agriculture (Figure 4) as the marginal product of capital increases. Agricultural output increases 2.44% over the 10 years to 2032, increasing the food and agricultural products available for Indonesians, increasing domestic food security. Over this same period, investment in Indonesian agriculture increases 1.49%. This demonstrates clear positive benefits for agriculture as a result of the policy.

Interestingly, this policy has a positive impact on other industries. Ordinarily, it would be expected that a change in one sector wouldn't have any real macroeconomic impact. However, in this case it has broad impact across all sectors in Indonesia.

The importance of agriculture to the Indonesian economy means that the growth from this policy positively effects other industries across the economy, particularly those which feed inputs directly into the agricultural sector. The increased agricultural productivity sees increased investment in all sectors over 10 years to 2032 (Figure 3). This investment growth is most evident across mining (1.42%), durable (1.98%) and non-durable manufacturing (1.54%) sectors.

Likewise, output grows in durable manufacturing, non-durable manufacturing, and mining (Figure 4). This shared output growth occurs as the durable and non-durable manufacturing sectors can feed in equipment and other good into the agriculture as result of greater output and activity. Through this expanded output, there is greater demand for investment in these industries, as shown in Figure 4.

The increased productivity also has significant benefits for the broader economy and macroeconomic conditions. Increased agricultural productivity and output contributes to increase in Indonesian GDP (Figure 5), investment (Figure 6), and consumption across the economy. This policy sees a positive contribution to Indonesian GDP, with a 0.4% increase over the 10 years to 2032 (Figure 5).

This policy leads to a reduction in Indonesia's trade balance (Figure 7). The increased productivity of Indonesian agriculture and other sectors increases investment in each industry. The resulting inflow of capital to finance these investment booms sees the real exchange rate increase. The 0.5% increase in the real exchange rate makes Indonesia's exports more expensive in the global marketplace because of a stronger rupiah.

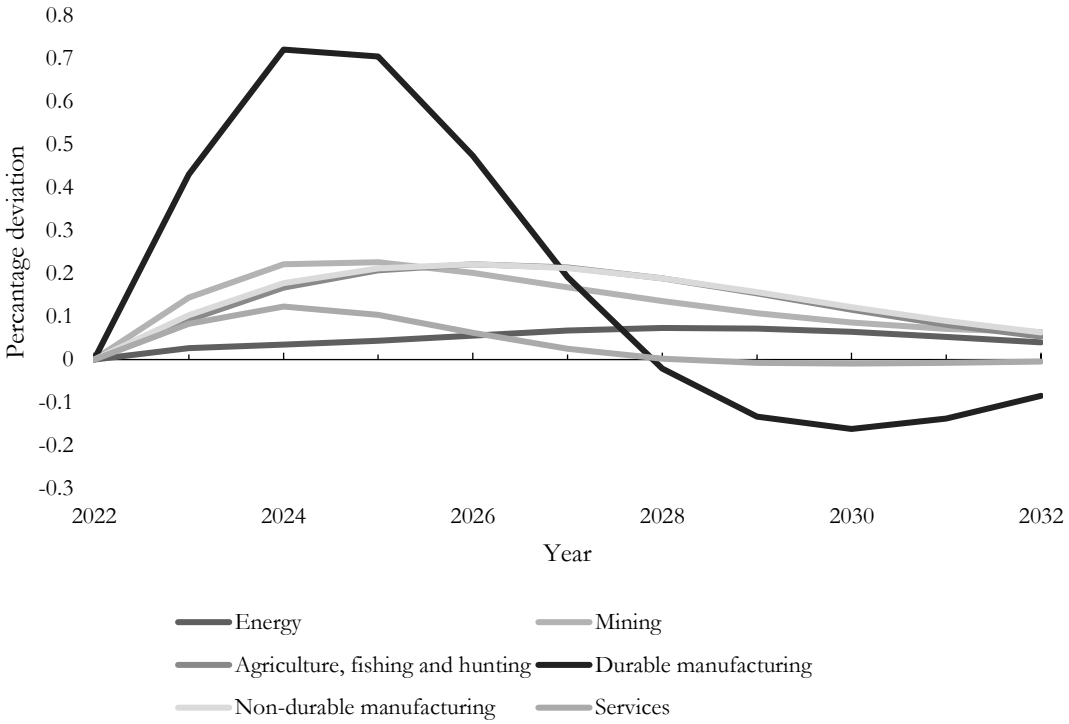

Figure 3. Percentage change in investment into each Indonesian industry as a result of the policy.

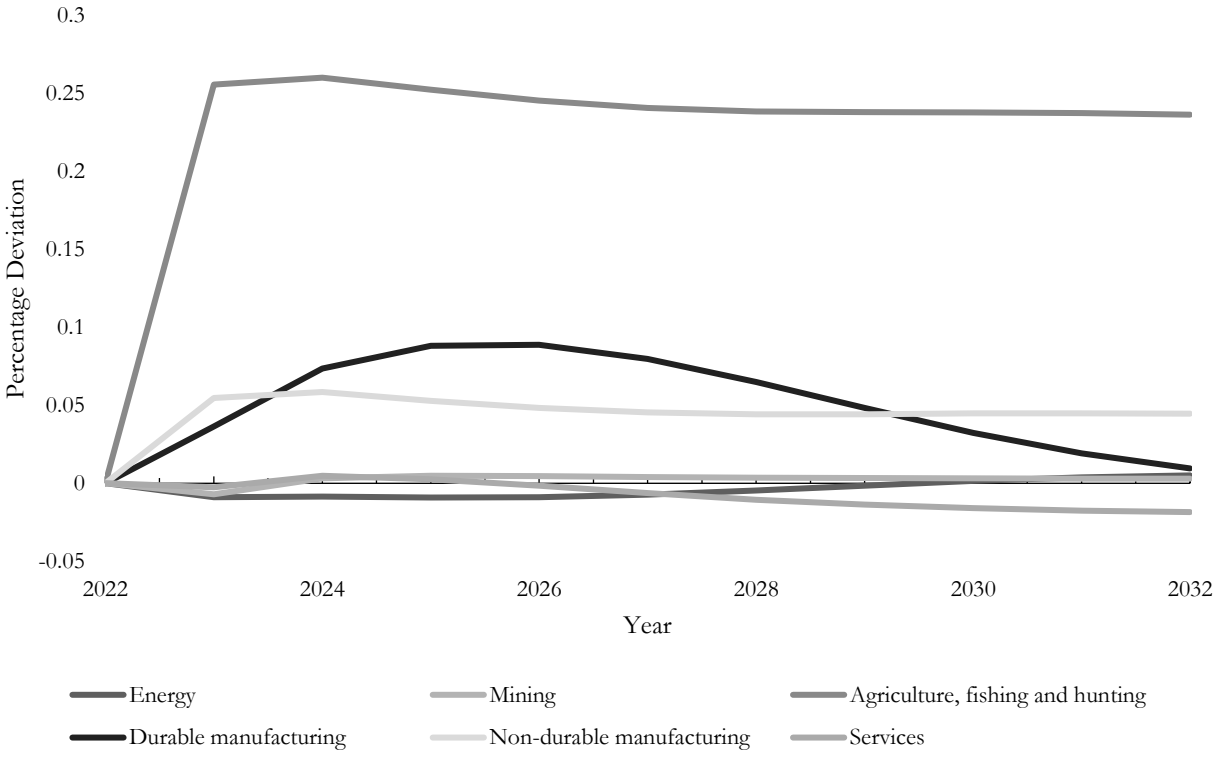

Figure 4. Percentage deviation in output per sector in Indonesia as a result of the policy.

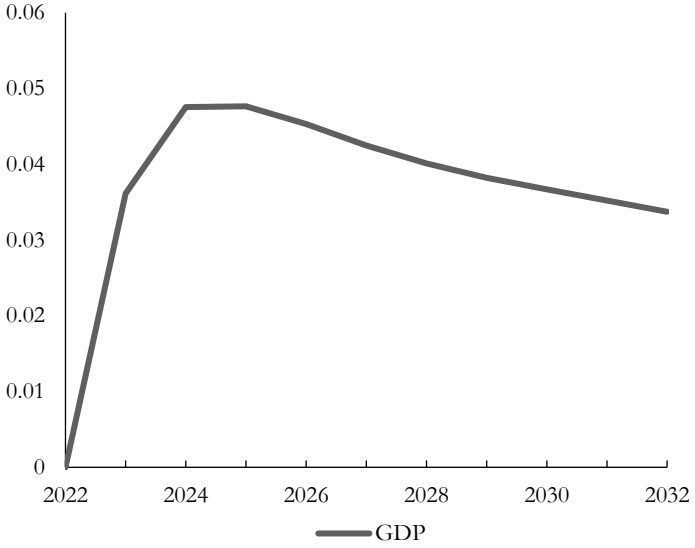

Figure 5. Change in Indonesia's real GDP as a result of the policy.

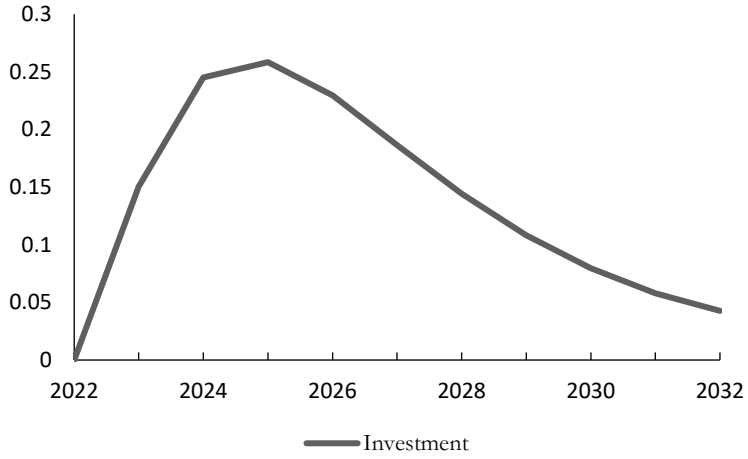

Figure 6. Change in total investment in Indonesia as a result of the policy.

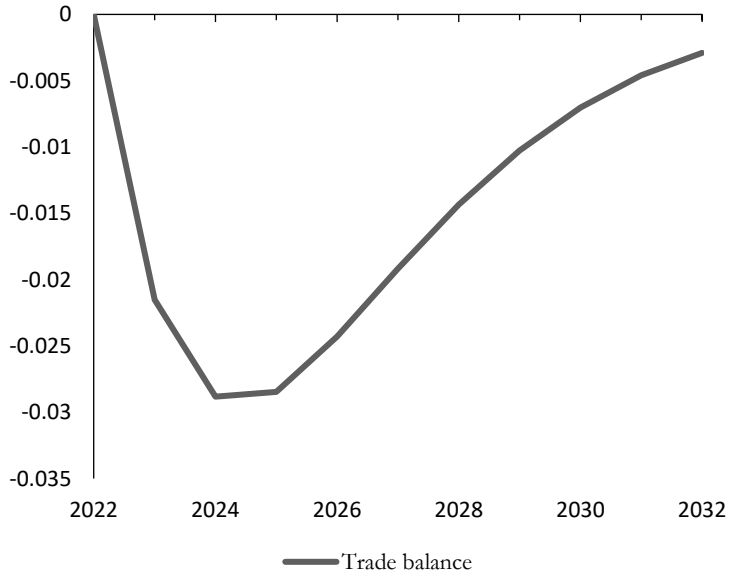

Figure 7. Change in Indonesian trade balance as a result of the policy.

Australia

This policy has a positive impact on the Australian agriculture sector. There is a large increase in agricultural output as a result of this policy. Over the 10 years to 2032, output from Australian agriculture increases by 1.9% (Figure 8). The increased agricultural output from this policy provides a key insight into the potential of Australian agriculture in increasing food security across the world. At the same time, there is a decrease in output from all other sectors in the economy except for non-durable manufacturing. Non-durable manufacturing has a slight increase in the year after the policy is introduced and then declines.

This policy also has a positive impact on investment in the short term (Figure 9). Immediately following the introduction of this policy, investment in agriculture and non-durable manufacturing increase. This increased investment results from the greater productivity and output from the agricultural sector. However, unlike Indonesian, the increased investment wains overtime and eventually becomes negative.

There are very small, almost negligible changes to Australia's macroeconomic conditions. Over 10 years, there is a small contraction in Australian GDP (-0.34%), small reduction in national consumption (-0.24%) and an effectively zero change in the trade balance (-0.004%).

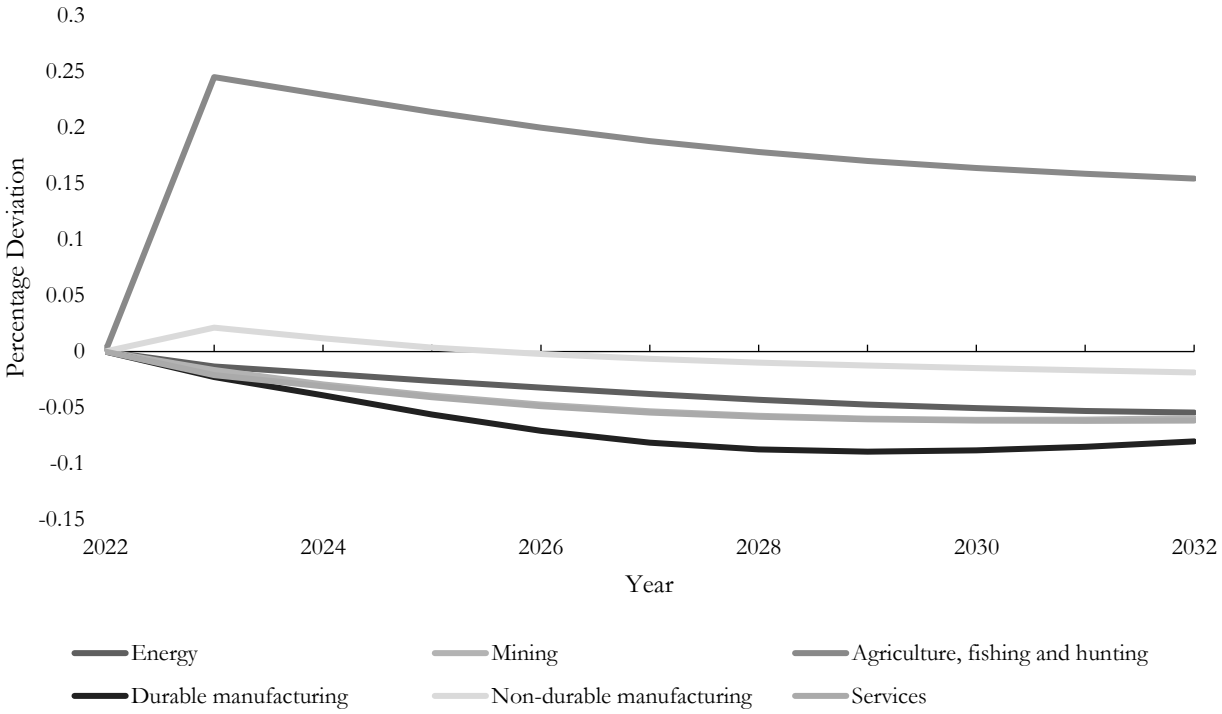

Figure 8. Percentage deviation in output per sector in Australia

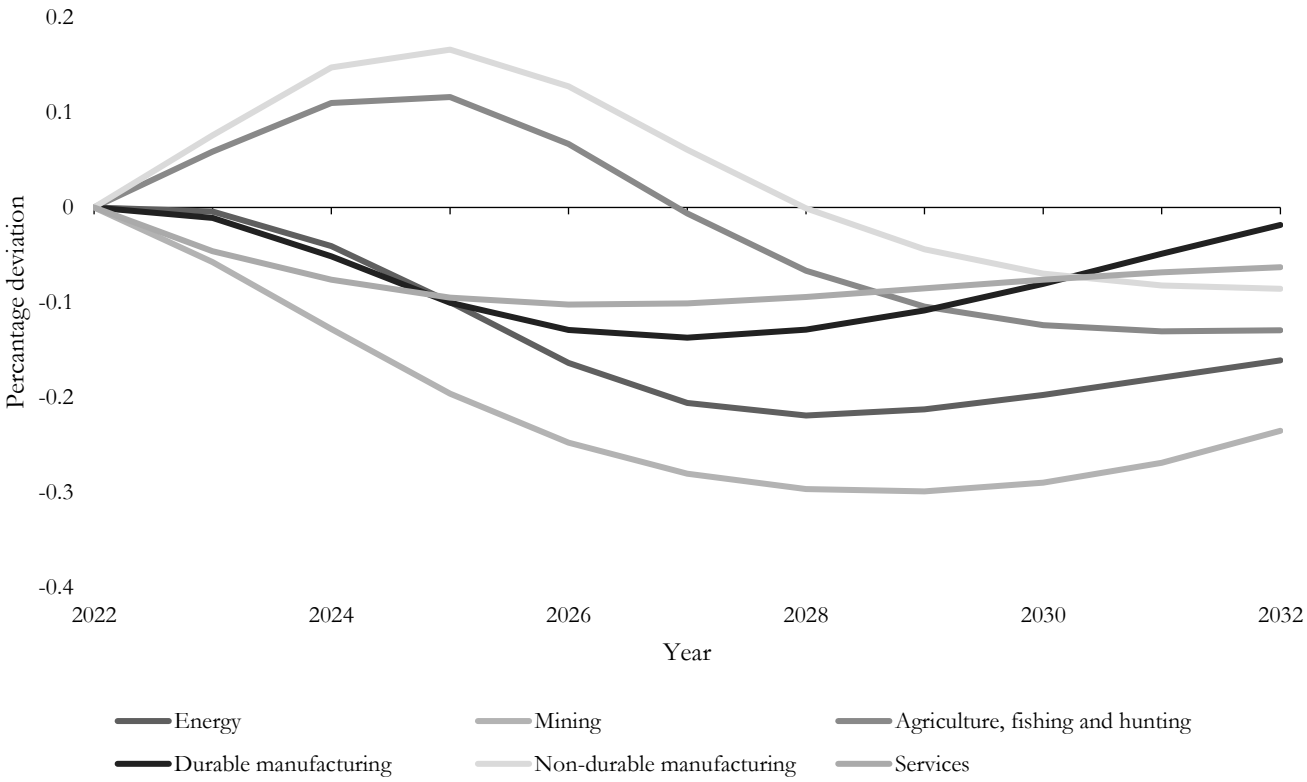

Figure 9. Percentage change in investment in Australian economic industries

Discussion / Policy Implications

The results of this study indicate that there are several important policy implications for agricultural productivity in both developed and developing nations. These include: the importance of ongoing productivity growth, agricultural productivity as a source of GDP growth, and international collaboration.

International collaboration

The paper highlights the importance of technology sharing and how such collaboration lifts all boats - benefiting both countries and benefiting different sectors within each country. This paper highlights the potential positive outcomes that result from government policies that support collaboration between countries and agricultural industries. The direct collaboration between Australian and Indonesian agriculture has a positive effect on output and investment in the sector across both countries.

This study highlights the positive contribution international collaboration can play in improving agricultural productivity. It also demonstrates the broader economic benefit that results from improving agricultural productivity in two countries through direct collaboration. This is evident in the paper's projected changes which show increased output in both countries agriculture sectors and broader Indonesian economic growth. At the same time, there is negligible impact on the Australian economy.

This paper demonstrates the role of people-to-people engagement and training as a clear method of increasing output and agricultural productivity. Technical and organisational change, brought about through research and development is a key enabler of productivity growth (Mallawaarachchi et al., 2009; Boult & Chancellor, 2020). Agriculture in both developed and developing nations, is highly dependent on foreign innovation and subsequent knowledge spill overs (OECD, 2012;

OECD, 2015a; OECD, 2015b). This paper demonstrates that a small number of farmers working on Australian farms and developing new skills and knowledge can facilitate knowledge spill overs from a country with higher productivity to one with lower productivity.

This occurs through different methods. First, the direct experience on Australian farms, provides an opportunity for Indonesian farmers to learn about and use different technologies that could then be adapted to Indonesia-specific conditions and would offer opportunities to share knowledge to respond to global challenges (OECD, 2012; OECD, 2015a; OECD, 2015b). It would also boost the efforts of existing channels of R&D and technology transfer, such as the Consultative Group for International Agricultural Research centres, and new mechanisms in the public and private sectors (OECD, 2015b). It would complement domestic reform efforts, which would be a critical to the transfer of technology and ways of working and the freeing up of markets within and between trading partners.

This collaboration will also lead to stronger ties between the countries and agricultural sectors moving forward. This will have additional benefit for both industries in the future. This benefit, which could include preferential purchasing, ongoing information sharing, collaborative research and development, is not captured in the results of this paper.

Increased focus on collaboration for human capital development

This paper demonstrates the need for countries to increase their focus on collaboration to underpin human capital development. Productivity is increased in both countries through a collaborative program that helps overcome existing labour shortages in Australia and provides an opportunity for Indonesian farmers to increase their skills and experience.

Australia and other developed countries currently use targeted programs to boost the capacity and productivity of agriculture in developing countries. These activities act as an arm of each country's development and aim programs. For example, the Australian Centre for International Agricultural Research invests in public and private research to improve the productivity and sustainability of agriculture across Asia, the Pacific and Africa.

The results of this paper highlight that to bolster the efficacy of these aid programs, governments should also extend their view of agricultural development support to in-country human capital development. Not only does the short-term experience in Australian support ongoing human capital development, but it also provides an opportunity for Indonesian farmers to increase their financial position through increased wages and remittances. This offers an increased opportunity to accelerate the uptake of new technologies and practices on-farm in Indonesia.

Importance of ongoing productivity growth

Although agriculture's share of GDP in Australia and Indonesia has declined with economic growth in the 20th century, it still plays an important role in promoting economic growth (OECD, 2012; OECD, 2015a; Global Harvest Institute, 2017). In this study, increasing agricultural productivity increased agricultural output and investment in both countries. Increasing agricultural productivity also increased broader macroeconomic conditions in Indonesia, with increases across GDP, domestic output, consumption, and terms of trade.

The results from this paper highlight the important role increasing agricultural productivity can play to support ongoing, long-term GDP growth in each country (OECD, 2015b). This is in line with economic theory where increased productivity contributes to economic growth (Solow, 1956; Swan, 1956; Solow 1957). It is also in line with the theory of structural adjustment where increased

agricultural productivity creates surplus labour that can be reallocated to industries with higher labour productivity (Lewis, 1954). As such, policymakers should focus on policies, programs and economy-wide structural reforms that that promote increased agricultural productivity in order to underpin economic development (OECD, 2015a).

Developed countries' existing policies

In this study, increased agricultural productivity results in increased agricultural output. This offers positive outcomes for food security in Indonesia which is a net-importer of key agricultural staples (Quincieu, 2015). However, it is likely to displace the existing market share of Australian agricultural exports. This presents a key challenge for producers and policy makers in developed countries as developing countries, as changes in relative competitiveness occur.

While these changes are positive for Indonesia, it presents a warning to Australian agriculture that it must adapt to changing market conditions. Future growth in global food demand is an opportunity for Australia as a competitive agricultural exporter. However, it cannot rely solely on increased global demand. Australia and other developed countries' ability to capture additional demand and maintain market share will depend on their ability to maintain and improve their competitiveness relative to trade competitors, especially in Southeast Asia (OECD, 2015b). To this end, Australia must focus on increasing the quality of produce to maintain high demand in premium markets both in Asia and globally or to enable resources to shift to more competitive activities through structural change domestically.

Conclusion

This paper examines the impacts of a specific policy of labour transfer between Australian and Indonesian agriculture. It uses existing data for the opportunity of a short-term labour program, similar to the existing Seasonal Worker Program, to increase labour productivity in Australia and increase the Total Factor Productivity of agriculture in Indonesia through increased human capital and technology transfer between the two countries. This paper demonstrates the broad, positive effects of this policy for both Australian and Indonesian agriculture and the broader Indonesian economy.

This paper outlines a key policy that governments and industry can use to fill existing labour shortages, improve agricultural productivity, and facilitate broader economic growth. It also provides a clear set out policy implications that underline the need for an ongoing focus on agricultural productivity growth as a means of increasing economic development.

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