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Applied Economic & Social Research

Working Paper Series

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Working Paper No. 6/20
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* We are grateful for helpful discussions with David Autor, Bob Gregory, Phil McCalman and staff at a presentation at the Australian Treasury; and for assistance with data from Patrick Jomini. Research in this article has been funded by ARC Discovery Grant DP160102269.

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Abstract

We examine how the rapid growth in imports of manufactured goods from China affected industry-level employment in Australia from 1991 to 2006. Our analysis incorporates both the direct effect from increased import competition, and indirect spill-over effects from input-output linkages. We estimate that growth in imports from China caused a loss in total manufacturing employment of between 89,900 and 209,800 workers – accounting for 8.5 to 19.8 per cent of manufacturing employment in 1991. Such an effect seems best described as sizable, but not one that by itself spelled the end of manufacturing industry in Australia. The largest impacts from growth in Chinese imports are found for manufacturing industries most exposed to import competition; and for the sub-period from 2001 to 2006.

JEL classification: J23; F16

Keywords: employment, manufacturing, trade, China;

1. Introduction

Australia's contact with the world economy has risen steadily in the past 50 years. International trade in goods and services to and from Australia rose from 25.2 to 41.0 per cent of GDP from 1971-72 to 2016-17.[1] Several main factors explain why this growth has occurred: liberalisation of trade policies by Australia and its trading partners; Australia's proximity to countries in Asia experiencing rapid economic growth; and substantial shifts in the global distribution of production of manufactured goods (Pomfret, 2014).

Concerns about the labour market consequences of international trade have closely followed its growth.[2] First, increases in imports are likely to have reduced output and employment in domestic import-competing industries. Figure 1 shows how the declining share of employment in manufacturing industry in Australia from the early 1990s onwards has coincided with increased imports of manufactured goods from China. Second, demand for middle-skill workers may have decreased due to greater scope for off-shoring of services produced by workers performing routine tasks. Consistent with this concern, Coelli and Borland (2016) show that the period since the mid-1980s has seen job polarisation and associated increases in earnings inequality in Australia.

It would be incautious, however, to conclude that international trade has been the sole culprit for these developments in the Australian labour market. Trends such as the decline of manufacturing industry and job polarisation were happening prior to the current phase of growth in international trade. As well, influences including technological change and changes in labour market institutions have been proposed as alternative explanations for the same labour market trends. Making it even more difficult to assess the impact of growth in international trade is a dearth of recent empirical analysis on labour market consequences in Australia.[3]

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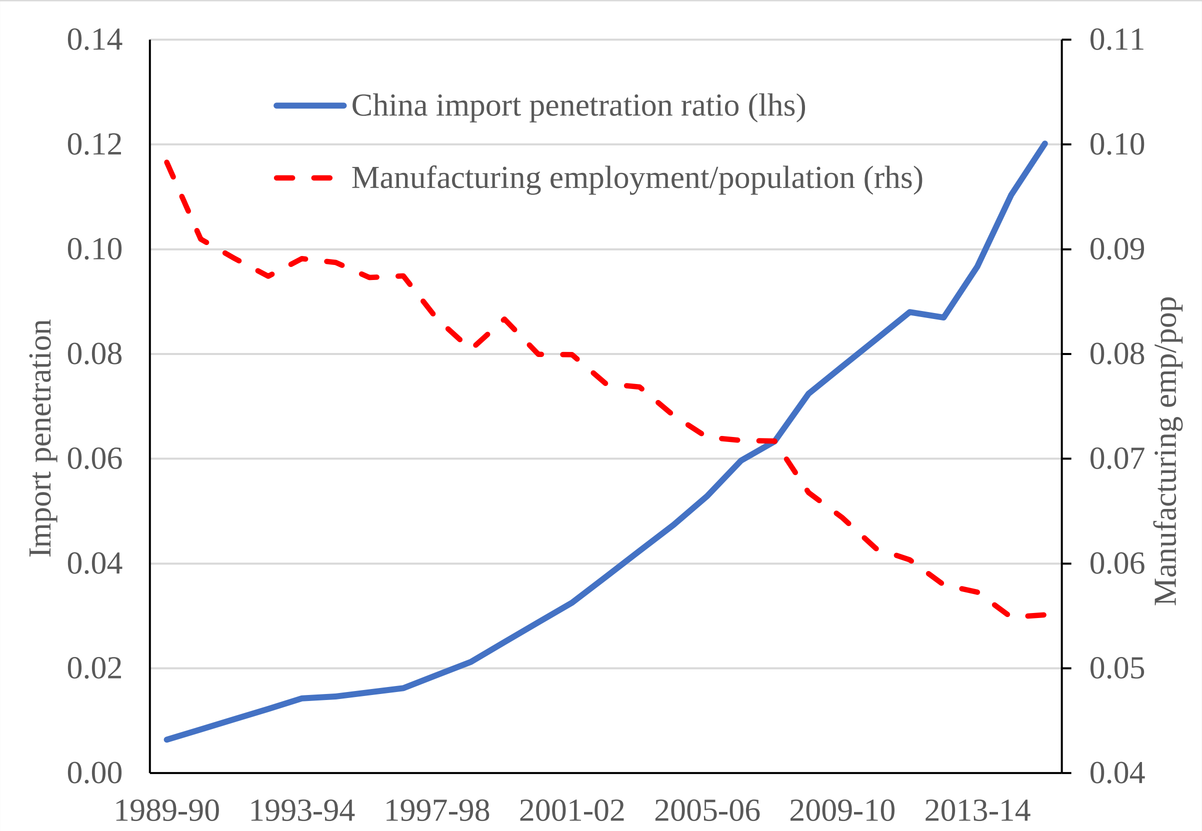
[1] See https://dfat.gov.au/trade/resources/trade-statistics/Pages/trade-time-series-data.aspx; accessed on 4/3/2020.

[2] See the examples cited in Tuhin (2015, footnotes 2 to 4) and Leigh (2017, chapter 1).

[3] Existing studies mainly examine time periods that finish in the late 1980s or early 1990s (for example, Borland and Foo, 1996; Fahrer et al., 1994; Murtough et al., 1998; Gaston, 1998; and for a survey, see Borland, 1999).

Figure 1: Manufacturing employment share and China manufacturing import penetration, Australia, 1989-90 to 2015-16



Notes: (i) Chinese import penetration to Australia equals (Manufacturing imports to Australia from China)/(Gross manufacturing output in Australia plus imports minus exports).
Data for the denominator are from ABS, *Australian National Accounts: Input-Output Tables*, catalogue no.5209.0.55.001 for 1989-90, 1992-93, 1993-94, 1994-95, 1996-97, 1998-99, 2001-02, 2004-05, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10, 2012-13, 2013-14, 2014-15 and 2015-16. Data for the numerator are from ABS, 5368.0 *International Trade in Goods and Services, Australia*, table 14b (sum over the year times 0.97, the average proportion of Chinese merchandise imports to Australia that are in manufacturing over the period according to author calculations using trade by product data from the UN Comtrade database https://comtrade.un.org/data/). Missing values are imputed using linear interpolation;
(ii) Share of manufacturing employment in working age population (15-64) is: for the numerator from ABS, *Labour Force, Australia, Detailed, Quarterly*, catalogue no. 6291.0.55.003, data cube EQ12 (average over year), for the denominator from ABS, *Australian Demographic Statistics*, catalogue no. 3101.0, table 59 (June estimate).

Our objective is to make a start on redressing the lack of evidence on this topic. We examine the labour market consequences of international trade in Australia using the episode of increases in imports of Chinese manufactured goods to Australia which occurred in the 1990s and 2000s. In taking this approach, we follow recent research for the United States by Acemoglu et al. (2016).[4] Increased imports from China in the 1990s and 2000s has been argued to provide an ideal natural experiment for studying the effect of a rise in international trade on labour market outcomes: being a large and unanticipated shock deriving from substantial productivity improvement in Chinese manufacturing industry as a result of its transition from communism to a more market-based economy (Autor et al., 2016, pp.6-7).

We investigate the impact of growth in Chinese imports on employment in 38 disaggregated manufacturing industries in Australia from 1991 to 2006. To identify the causal impact of growth in Chinese imports to Australia we apply the same instrumental variables (IV) approach as Autor et al. (2013) and Acemoglu et al. (2016): using Chinese imports from other high-income countries as the instrument – intended to capture that part of the increase in imports that can be attributed to productivity improvement in Chinese manufacturing industry. The analysis that we undertake incorporates estimates both of direct effects on industry-level employment due to increased imports of the same good produced by an industry; and indirect spill-over effects on employment that occur via input-output linkages, such as where an import-competing industry reduces its demand for inputs from Australian producers in other industries.[5] The industry-level analysis can be used to derive estimates of the economy-wide effects of growth in Chinese imports – which is done by applying the findings to make counter-factual predictions of the effect of growth in imports on aggregate employment.

[4] The other main approach to identifying the labour market impact of growth in international trade has been through studying episodes of trade policy liberalisation – see for example Pierce and Schott (2016) and Dix-Carneiro and Kovak (2017). A related literature examines the impact of real exchange rate appreciation on employment outcomes in manufacturing industry – see Campbell (2017) for a recent contribution and review of earlier literature.

[5] We do not examine the reallocation effect and aggregate demand effect that are part of the analysis in Acemoglu et al. (2016). In their study for the United States it is estimated that these effects account for about one-sixth of the overall impact of growth in Chinese imports on manufacturing employment in the United States. Acemoglu et al. (2016, p.S147) conclude that: '…we view our industry-level estimates of employment reduction as providing a conservative lower bound.'

Establishing the causes of the decline in manufacturing employment has become an important topic of research for several main reasons. First, in most developed countries, manufacturing industry was a major source of employment throughout much of the second half of the twentieth century. That, together with the idea that it is important for a country 'to make something', have given the industry an iconic status. Second, the uneven geographic distribution of manufacturing industry within countries means that its demise can bring significant regional adjustment issues and have important political implications (see for example Autor et al., 2017). Third, the decline in manufacturing industry has been associated with large changes in the relative demand for workers by skill level and has been argued to be a major cause of job polarisation (see for example Charles et al., 2019 and Barany and Siegel, 2018). Fourth, the decrease in manufacturing employment has had significant consequences for social outcomes including health and marriage rates (see Charles et al., 2018, Autor et al., 2019, Pierce and Schott, 2020; and for a survey see Autor et al., 2016).

Our main finding is that increased exposure to Chinese imports between 1991 and 2006 did have a statistically significant negative impact on industry-level manufacturing employment in Australia. The direct effect of a one percentage point increase in import penetration from China is a 1 per cent decrease in manufacturing employment; and taking account of indirect spill-overs increases the negative effect to 2.4 per cent. These impacts translate into estimated job loss in manufacturing industry of between 89,900 and 209,800 workers – accounting for 8.5 to 19.8 per cent of manufacturing employment in Australia in 1991. The negative effect of growth in Chinese imports on employment differed over time, and between industries and different types of workers. We find stronger effects on employment in the final sub-period from 2001 to 2006, larger effects on manufacturing industries which were most exposed to import competition, and larger effects for women and part-time workers. The results are highly robust to an extensive set of sensitivity analyses. This includes using a different set of high-income countries to construct the instrument variable, changes to the sample period and including extra controls for employment.

A recent study by Tuhin (2015) has done a similar analysis of the impact of changes to import intensity within nine manufacturing industries in Australia from the late 1960s to the early 2010s. Increases in imports have a significant negative effect on employment – with a 10 per cent increase in imports reducing employment by 2.8 per cent. This impact differs substantially between industries and seems to have become smaller from the 1990s onwards.

Compared to that study we make several extra important contributions. First, our analysis uses a more disaggregated set of industries that incorporates spill-over effects within and outside manufacturing industry. Second, our focus on China arguably constitutes a more plausible basis for exogeneity in the measure of growth in international trade.

While industry-level analysis reveals the most immediate employment impact of growth in Chinese imports, that impact then plays out in other ways – such as in changes to regional employment that depend on geographic specialisation in manufacturing production activities. Our study therefore complements other recent research which uses regional-level variation in exposure to Chinese imports to Australia to identify the impact of international trade on manufacturing employment and other labour market outcomes in Australia (Maccarrone et al., 2020; Coelli et al, 2020).[6] The main advantage of the industry-level approach in this study is that it allows inferences to be drawn on the national-level impact on employment of imports from China, a perspective which cannot be obtained from the regional-level analysis.[7]

One point which should be obvious, but nevertheless deserves emphasis, is that this study is not intended to be a holistic analysis of the impact of globalisation – or even growth in trade with China – on the Australian economy. By examining exclusively the impacts of growth in imports of Chinese manufactured goods on labour market outcomes, we are focusing on one component of the 'cost' side of the ledger. Our analysis does not take account of the labour market 'gain' from growth in Australian exports that occurred over the same period of the 1990s and 2000s; nor of the benefits to household consumption in Australia from decreased prices of manufactured goods due to increased import competition.[8]

The rest of the paper is organised as follows. Section 2 describes the empirical methodology in our study. Section 3 describes sources and construction of the data used in our study, and section 4 presents descriptive information. Sections 5 and 6 respectively present findings from analysis of direct and indirect spill-over effects on employment due to increases in

[6] These studies follow the methodology from Autor et al. (2013). Gregory and Hunter (1996) is an early analysis of the geographic distribution of changes to employment in manufacturing industry in Australia.
[7] For discussion of this issue, see Topalova, 2010; Beraja et al., 2019; and Muendler, 2017, pp.14-15.
[8] See for example, Kearns and Lowe (2011, pp.78-80).

manufactured imports from China. Section 7 presents counter-factual predictions of the impact on aggregate employment in Australia. Concluding comments and discussion are in section 8.

2. Methodology

In this section we present the methodology used to estimate the impact on employment in Australia due to of increases in imports of manufactured goods from China. Both the direct effect of the growth in imports from China on employment, and indirect effects from input-output linkages, are examined.

The **direct effect** is how employment in a manufacturing industry in Australia is affected by increases in imports from China of goods from the same manufacturing industry – for example, how increases in imports of textiles and clothing from China affect employment of workers producing those goods in Australia. Where imports of a good from China compete with and substitute for Australian production, that will have a negative impact on employment.

Indirect effects on employment can arise where Chinese imports of manufactured goods in an industry cause spill-overs on the demand for output from, or costs of inputs for, other manufacturing or non-manufacturing industries in Australia. Indirect effects on employment can be classified as upstream or downstream.[9]

An **upstream impact** occurs where employment in an industry is affected because it is a supplier to a manufacturing industry which has experienced an increase in competition from Chinese imports. An example would be where growth in imports of leather footwear from China negatively affects the demand for domestically-produced leather, and hence employment in that industry, in Australia. Any upstream effect of growth in Chinese imports

[9] The definitions of the upstream and downstream variables are taken from Acemoglu et al. (2016, pp. S169-70); and are the terminology used in most studies. Some studies, however, do use reverse definitions of the terms.

on employment would be expected to be negative wherever Australian producers of import-competing goods source inputs from local suppliers.[10]

A **downstream impact** occurs where employment in an industry is affected because it purchases inputs from a manufacturing industry where an increase in imports from China has occurred. An example would be where growth in imports of machinery and equipment from China results in a fall in the price of that input for producers of mining output in Australia, which allows them to expand output and employment.[11] The downstream effect of growth in imports from China could be positive or negative. In the example just given, the effect would be positive. However, it is also possible that disruption to networks used by Australian producers to source inputs, due to growth in imports from China crowding out local production of that input, may cause it to contract its output and employment.[12]

Direct effect

The direct effect of changes to imports from China is estimated in the model:

$$\Delta L_{jt} = \gamma_t + \beta_1 \Delta IP_{jt} + \beta_2 X_{j0} + \varepsilon_{jt} \tag{1}$$

where ΔL_{jt} is 100 times the annual log change in employment in manufacturing industry *j* in Australia between periods *t* and (*t+1*); ΔIP_{jt} is 100 times the annual change in import penetration from China in manufacturing industry *j* between periods *t* and *(t+1)*; γ_t is a dummy variable for the interval from period *t* to period (*t+1*); and X_{j0} is a vector of industry-specific controls from the initial time period.

Manufacturing industry is disaggregated into 38 separate industries, the construction of which is explained below in section 3. All regression models are weighted by industry-level employment at the start of the sample period. Standard errors are clustered at the level of the

[10] Assuming also that Chinese import producers are not sourcing their inputs from the same Australian suppliers.
[11] See for example, Wang et al. (2011).
[12] See also the discussion in Acemoglu et al. (2016, footnote 6).

38 industries to allow for arbitrary error correlations over time within those industry categories.

We follow Acemoglu et al. (2016) in specifying the change in import penetration from China for manufacturing industry j as:

$$\Delta IP_{jt} = \Delta M_{jt}^{AC}/(Y_{j92-93} - E_{j92-93}) \quad (2)$$

where ΔM_{jt}^{AC} is the change in the value of imports in industry *j* to Australia from China between time periods *t* and (*t+1*); and $Y_{j92-93} - E_{j92-93}$ is total supply (Y_{j92-93})[13] minus industry exports (E_{j92-93}) in industry *j* in 1992-93.[14] Hence this measure scales the change in imports from China to Australia within a manufacturing industry against initial absorption in Australia for that industry in 1992-93.[15]

The key coefficient of interest in equation (1) is β_1. It can be interpreted as showing the effect of a 1 percentage point rise in industry-level import penetration from China on employment in that industry in Australia. The major issue in estimating (1) is that an OLS estimate of the impact of ΔIP_{jt} on manufacturing employment, β_1, can suffer from an endogeneity bias. Growth in imports of manufactured goods from China to Australia could have occurred for several reasons: first, an increase in productivity due to large-scale economic reform in China and consequent decreases in prices of imported manufactured goods, together with the re-integration of China into the global economy; second, increased

[13] What we refer to as Y (total supply) is equivalent to Acemoglu et al.'s (2016) measure of shipments (local production) plus imports.

[14] Following the approach of Acemoglu et al. (2016) we construct ΔIP_{jt} using input-output data from around the start of our sample period, and then use data from an earlier date to construct an instrument ΔIPO_{jt} (see equation (3)). Input-output data for Australia are available for 1988-89 and 1992-93 and hence we choose these two time periods to construct ΔIPO_{jt} and ΔIP_{jt} respectively.

[15] In constructing the measure of change in import penetration across the time intervals it must be decided whether industry output from the initial time period will be used as the denominator for all time intervals or updating of the industry output should be done. There is a trade-off in making this choice (Broxterman and Larson, 2019). Import penetration in any time period will be a function of import growth in previous periods – hence updating may cause serial correlation in the measure of change in import penetration. However, not updating may mean that the measure of change in import penetration becomes less relevant for later time intervals. Our base approach – of not updating – follows Acemoglu et al. (2016).

demand by Australian consumers; or third, decreased supply by Australian producers. If the only source of the growth in Chinese imports to Australia is from productivity improvement in Chinese manufacturing, it is possible to treat ΔIP_{jt} as exogenous. However, where the increase in imports is due to changes in demand and/or supply conditions in Australia, the unobservable component in equation (1), ε_{jt} , will be correlated with growth in imports from China, ΔIP_{jt} . That correlation would cause the estimate of β_1 to be biased (Autor et al., 2016, p.17).

To seek to identify the impact on labour market outcomes of the component of the increase in Chinese imports to Australia due to supply conditions in China, we follow Acemoglu et al. (2016) by instrumenting for ΔIP_{jt} in (1) with ΔIPO_{jt} , which is constructed using changes in Chinese imports to other high-income countries:

$$\Delta IPO_{jt} = \Delta M_{jt}^{OC}/(Y_{j88-89} - E_{j88-89}) \qquad (3)$$

where ΔM_{jt}^{OC} is the change in the value of imports in industry *j* to other high-income countries from China between time periods *t* and (*t+1*); and the denominator is now defined as initial absorption in 1988-89.[16]

The motivation for the IV approach is that if the rise in productivity in manufacturing industry in China has caused increased import penetration to all high-income countries, using import flows from China to those other countries as an instrument should identify the impact of increasing Chinese competitiveness on labour market outcomes in Australia. For this to be the case it is necessary that the increase in Chinese competitiveness has indeed created similar growth in imports to other high-income countries as Australia, and that the increase in imports to the other high-income countries is uncorrelated with demand or supply shocks to manufacturing industries in Australia.

The interpretation of the IV estimator is as a local average treatment effect (see Muendler, 2017, pp.20-21). The effect represents the impact on employment due to that part of the growth in Chinese imports of manufactured goods to Australia attributable to increasing

[16] This is done to mitigate simultaneity bias.

Chinese competitiveness. It is a weighted average across industries which are affected by the increase in Chinese imports.

We adopt two approaches to construct ΔIPO_{jt} . The first 'base' approach is to use the same set of high-income countries as Acemoglu et al (2016) (but replacing Australia with the US): Denmark, Finland, Germany, Japan, New Zealand, Spain, Switzerland and the United States. A potential criticism of this set of countries is that demand shocks between Australia and the United States or New Zealand may be correlated.[17] Hence, as a robustness check we use a second approach with a set of countries where we believe correlated demand shocks are less likely to occur - the group of EU-15 countries (previously used by Donoso et al., 2015): Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.[18]

Our main approach is to estimate the impact of imports from China on employment for a sample period from 1991 to 2006. This is done as a stacked model with three 5-year intervals: 1991-1996, 1996-2001 and 2001-2006. We use this overall sample period and the 5-year intervals for several reasons. First, the start of the sample period is chosen to coincide with the beginning of the rise in Chinese imports to Australia. Second, we are concerned that going beyond 2006 would include the post-GFC period. Including the post-GFC period means that the assumption required for IV - that demand shocks in Australia are uncorrelated with changes to imports to other high-income countries - becomes less plausible. Third, using this sample period and time intervals allows us to make direct comparisons with a companion paper which undertakes regional-level analysis of the effect of the growth in Chinese imports to Australia (Maccarrone et al., 2020).

We also undertake a variety of extensions to the sample period as robustness analysis. First, we estimate the model over 1991-2011 (with four stacked 5-year intervals) to examine how the results are affected by including the post-GFC period. Second, we consider longer time

[17] Similarities in stages of development and average incomes, demographic profiles and cultural backgrounds are likely to cause some correlation in patterns of demand. In addition, New Zealand is Australia's closest neighbour (although it accounts for such a small share of total imports from China to the group of high-income countries that correlation in demand is unlikely to cause major problems).
[18] We also undertake sensitivity analysis by removing the United Kingdom from the group of EU-15 countries. This does not affect our results.

intervals by estimating the model over two 10-year intervals between 1991-2011 and two 8-year intervals between 1991-2007. This also allows some analysis of the dynamics of adjustment of the Australian labour market to growth in Chinese imports.

A variety of approaches to control for other influences on employment that might be correlated with increases in imports from China to Australia are applied. First, we include controls for 12 industry divisions. This allows for differential trends in employment across one-digit industries. The impact of imports from China then is identified by variation within the one-digit industries or by variation over time within one-digit industries that deviates from a linear trend. Second, we seek to control for specific influences on employment. Several industry-level variables are included to control for the potential impact on employment of technological change – log average wages and salaries per worker; the share of production workers; and expenditure on research and development as a share of turnover. In addition, the change in average tariff rate by industry is included to control for the impact of trade liberalisation on employment.[19] Third, we follow Acemoglu et al. (2016, p.S163) in seeking to control for the impact of pre-existing secular trends in employment by including the trend in industry-level employment from 1984 to 1991 (the time period for which data are available prior to our estimation period). Fourth, we include industry fixed effects for each of the 38 industries in our sample. In this case, the impact of imports from China is only identified by variation over time within the 38 industries that deviates from a linear trend.

Indirect effects via input-output linkages

To incorporate indirect effects, we estimate an expanded version of equation (1):

$$\Delta L_{jt} = \gamma_t \beta_1 \Delta IP_{jt} + \beta_2 U_{jt} + \beta_3 D_{jt} + \beta_4 X_{j0} + \varepsilon_{jt} \qquad (4)$$

[19] The set of variables representing technological change are measured at a single point of time in the late 1980s and included in levels form. This specification is based on an interpretation that it is the level of the variables that reflects the likely rate of technological change and hence the impact on changes in employment; and data availability. The tariff variable is measured as the average rate and included as the change for each time interval. This is based on the hypothesis that it is changes in tariff rates that are likely to be related to changes in employment.

where U_{jt} is the upstream effect – the exposure to import competition for an industry that comes from its buyers; and D_{jt} is the downstream effect – the exposure to import competition for an industry that comes from its suppliers.

Each effect, U_{jt} and D_{jt}, consists of a first-order spill-over effect on an industry from trade-induced impacts on its immediate buyers or suppliers, and the higher-order (full) spill-over effects on an industry from the full chain of linked buyers or suppliers.[20] Both spill-overs between manufacturing industries and from manufacturing industries to non-manufacturing industries are investigated.

The first-order upstream effect is represented as:

$$\Delta IP_{jt}^{U} = \sum_{g} w_{gj}^{U} \, \Delta IP_{gt} \tag{5}$$

which is equal to the weighted average change in import penetration between periods *t* and (*t+1*) across all industries, represented by g, that purchase from industry *j*. The weights are defined to represent the share of industry *j*'s total sales that are used as inputs by industry *g*:

$$w_{gj}^{U} = \mu_{gj}^{U} / \sum_{g'} \mu_{g'j}^{U} \tag{6}$$

where μ_{gj}^{U} is the 'use' value from an input-output matrix for the value of industry *j*'s output purchased by industry g.[21]

The first-order downstream effect, ΔIP_{jt}^{D} is defined analogously to (5) except that the weight term is defined as $w_{gj}^{D} = \mu_{jg}^{D} / \sum_{g'} \mu_{g'j}^{D}$. The first-order downstream effect is equal to the weighted average change in import penetration between periods *t* and (*t+1*) across all industries, represented by *g*, that industry *j* purchases from.[22]

[20] Acemoglu et al. (2016) derive measures of upstream and downstream effects from a multi-industry economy where each industry has a Cobb-Douglas production function and uses with different intensities the outputs of other industries as inputs.
[21] The summation in the denominator runs over all industries including non-manufacturing industries and includes final demand by consumers and overseas customers, and thus equals total industry sales.
[22] The denominator is still defined as the total of industry j's sales. Hence these weights will sum to less than one.

Estimates of the higher-order (full) spill-over effects of increases in Chinese imports capture both the first-order effect and further effects that result from, for example, impacts on an industry which is a buyer from an industry which is in turn a buyer from an industry directly affected by growth in Chinese imports. The full set of linked downstream and upstream impacts are represented as the full chain of implied responses from the input-output matrix, given by the Leontief inverse of the matrix of upstream and downstream linkages (Acemoglu et al., 2012).

We continue to instrument for these additional import exposure variables. The instruments for the upstream and downstream effects are constructed using contemporaneous changes in imports from China to other high-income countries to calculate the predicted upstream and downstream exposures for each industry. For example, the upstream instrument is:

$$\Delta IPO^{U}_{jt} = \sum_{g} w^{U}_{gj} \, \Delta IPO_{gt} \tag{7}$$

3. Data

Data are required for the 38 manufacturing industries on: (1) Employment in Australia; (2) Imports from China to Australia and the other high-income countries; (3) Measures of initial absorption in Australia; (4) Measures of upstream and downstream linkages in Australia; and (5) Other covariates used in the regression analysis.

Data on employment by industry are from the Australian Bureau of Statistics (ABS) Labour Force Survey.[23] We use measures of total persons employed in 3-digit ANZSIC (2006) manufacturing industry sectors; and disaggregated measures of persons employed by sex and full-time/part-time status.[24]

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[23] ABS, Labour Force Survey, Detailed, Quarterly, catalogue no.6291.0.55.003, EQ06 – Employed persons by industry of main job (ANZSIC), Sex, State and Territory. Available quarterly from November 1984 onwards.

[24] There are 55 3-digit manufacturing industry sectors plus a category for ‘not further defined’ (nfd) in the employment data. We assign the nfd category to the 55 industry sectors in proportion to their shares of total manufacturing industry employment. It is important to make some assignment of the nfd category as its share of manufacturing industry employment has varied considerably over time.

Data on imports are from the UN Comtrade database which provides bilateral imports (and exports) expressed in US dollar values for 6-digit Harmonized Commodity Description and Coding System products (HS). To concord data from Comtrade to our industry classification we use an algorithm that applies an ABS concordance table linking Harmonized Tariff Item Statistical Codes (HTISC) at the 10-digit level to ANZSIC (2006) codes at the 3-digit level.[25] The concordance is carried out in three steps.[26] In the first step, the HTISC codes are aligned to the HS codes by identifying the first six digits of the HTISC codes as HS codes. The second step uses the ABS concordance table to link each HS product to a 3-digit ANZSIC (2006) industry.[27] In the final step, all HS products assigned to the same 3-digit ANZSIC (2006) code are aggregated. Using historical US consumer price data, trade values are then expressed in constant 2006 US prices.[28]

Industry input-output tables from the ABS for 1988-89 and 1992-93 are used to calculate initial absorption and upstream and downstream industry linkages.[29] The tables contain information for each industry on total domestic supply (shipments plus imports) and total exports. Initial absorption for each industry is equal to the difference between these measures, converted to 2006 US dollars.[30] The time periods are selected as they mostly predate the growth in imports from China to Australia. The 1992-93 tables are used to calculate variables based on imports to Australia and 1988-89 tables to calculate the instruments using imports to other high-income countries.

A difficulty which arises in using the input-output data is that classification of industries in official data has changed over time in Australia. The 1988-89 tables used the ASIC classification system and the 1992-93 tables used the ANZSIC (1993) classification system. Matching both these classifications exactly to the employment and trade data based on the

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[25] The concordance from HTSIC to ANZSIC 2006 codes is in Appendix 6.2 of ABS, International Merchandise Trade, Australia, Concepts, Sources and Methods, catalogue no.5489.0, 2015.
[26] The algorithm is available on request from the authors.
[27] In the case that import codes map one-to-many industries, imports are split evenly between industries. For HS to ANZSIC 2006, by value of imports, the percentages dealt with in this way are: 1991-5.7%; 1996-9.1%; 2001-11.9%; 2006-10.5%; and 2011;11.2%.
[28] US Bureau of Labor Statistics, series: ID: CUUR0000SA0. CPI – All Urban Consumers (Dec. 2018); accessed at: www.bls.gov/cpi/tables/home.htm.
[29] ABS, Australian National Accounts: Input-Output Tables, catalogue no.5209.0.
[30] This is done using the currency conversion in the Comtrade database. See https://comtrade.un.org/db/mr/daExpNotebyRepYear.aspx

ANZSIC (2006) system required aggregating some of the 55 3-digit manufacturing industries. After doing the concordance we are left with 38 separate manufacturing industry categories.[31]

In our analysis all import variables are measured in US dollars. Using US dollars allows us to construct the import penetration variables in the way that best reflects changes in the volume of imports from China, and hence the potential scope for those imports to substitute for labour in Australia. The main alternative would have been to express imports in Australian dollars – that is, to convert Comtrade import data from US dollars to Australian dollars to match with initial absorption from the IO tables. The problem with doing this is that over the sample period there were large changes in the AUS/US exchange rate. Converting to Australian dollars therefore means that measures of imports from China to Australia vary quite substantially for reasons that are unrelated to the volume of imports. Hence, we choose to express the import exposure variable in US dollars. During our sample period the US/China exchange rate was virtually unchanged. A detailed explanation of why we choose to express imports in $US is presented in Appendix 2.

Construction of the covariates draws on data from a variety of sources. ABS establishment-level surveys are used to obtain data on industry-level wages and salaries per employee for 1991-92 and R&D as a share of turnover for 1990-91.[32] Industry-level data on the share of production workers is from the 1987 ABS Census of Manufacturing Establishments.[33] Data on average tariff rates by industry for 1991, 1996, 2001 and 2006 is constructed using the

[31] See Appendix 1 for details of the concordance.
[32] Wages and salaries per employee is calculated from data on total wages and salary payments and employment by industry in ABS, Manufacturing Industry Australia, 1991-92, catalogue no.8221.0, Table 4. R&D as a share of turnover is calculated from data on R&D and turnover by industry in (respectively) ABS, Research and Experimental Development Business Enterprises Australia, 1990-91, catalogue no.8104.0, Table 7 and ABS, Manufacturing Industry Australia, 1991-92, catalogue no.8221.0, Table 4.
[33] This is the latest year for which data on the share of production workers are available – ABS, Manufacturing Establishments, Details of Operations by Industry Class, catalogue no.8203.0. For further details see Borland and Foo (1996, Appendix 1).

World Integrated Tariff Solutions (WITS).[34] Data on pre-sample trends in employment in manufacturing industries are from the ABS Labour Force Survey.[35]

4. Descriptive statistics

Descriptive information on changes in imports of manufactured goods from China and changes in employment in manufacturing industry in Australia is provided in Table 1. Manufacturing employment in Australia decreased by -0.63 log point per year between 1991 and 2006.[36] Over the same period, the employment-weighted mean of industry-level Chinese import penetration increased by 0.59 percentage points per year. Growth in import penetration was more rapid in the first half of the 2000s than in the 1990s.

Specialisation by China within manufacturing means that changes to import penetration – and hence the potential impact on employment - varied across the 38 industry categories.[37] Figure 2 presents industry-level information on changes in Chinese import penetration and employment from 1991 to 2006.[38] Most manufacturing industries saw increased Chinese import penetration between zero to 0.5 per cent per year and had changes in employment that ranged from minus 2 to plus 2 log per cent per year. But quite a few industries also had larger changes in import penetration and employment. Industries producing textiles, clothing and footwear, computers and electronic equipment, domestic appliances and furniture had increases in Chinese import penetration above 1.5 per cent per year. And industries producing textiles, clothing and footwear, ceramic products, metal containers and sheet metal had average employment losses of above 4 per cent per year. Overall there is a clear negative

[34] See https://wits.worldbank.org/tariff/trains/en/country/AUS). Data on average tariff rates at the HS6 level have been aggregate to 3-digit ANZSIC level using the same concordance as used for data on import volumes, weighted using total imports to Australia by HS6 commodity at the start of each period.

[35] ABS, Labour Force, Australia, Detailed, Quarterly, catalogue no.6291.0.55.003, Table 06.

[36] Large minimum and maximum employment changes are reported in Table 1. These changes were both for the oil and fat manufacturing industry where employment is recorded as falling from 2,100 to 700 between 1996 and 2001 and increasing from 700 to 2,700 between 2001 and 2006.

[37] For further discussion of Chinese patterns of specialisation in manufacturing industry, see Autor et al. (2013, p.10)

[38] The industry-level data used to construct Figure 2 are provided in Appendix Table 3.1.

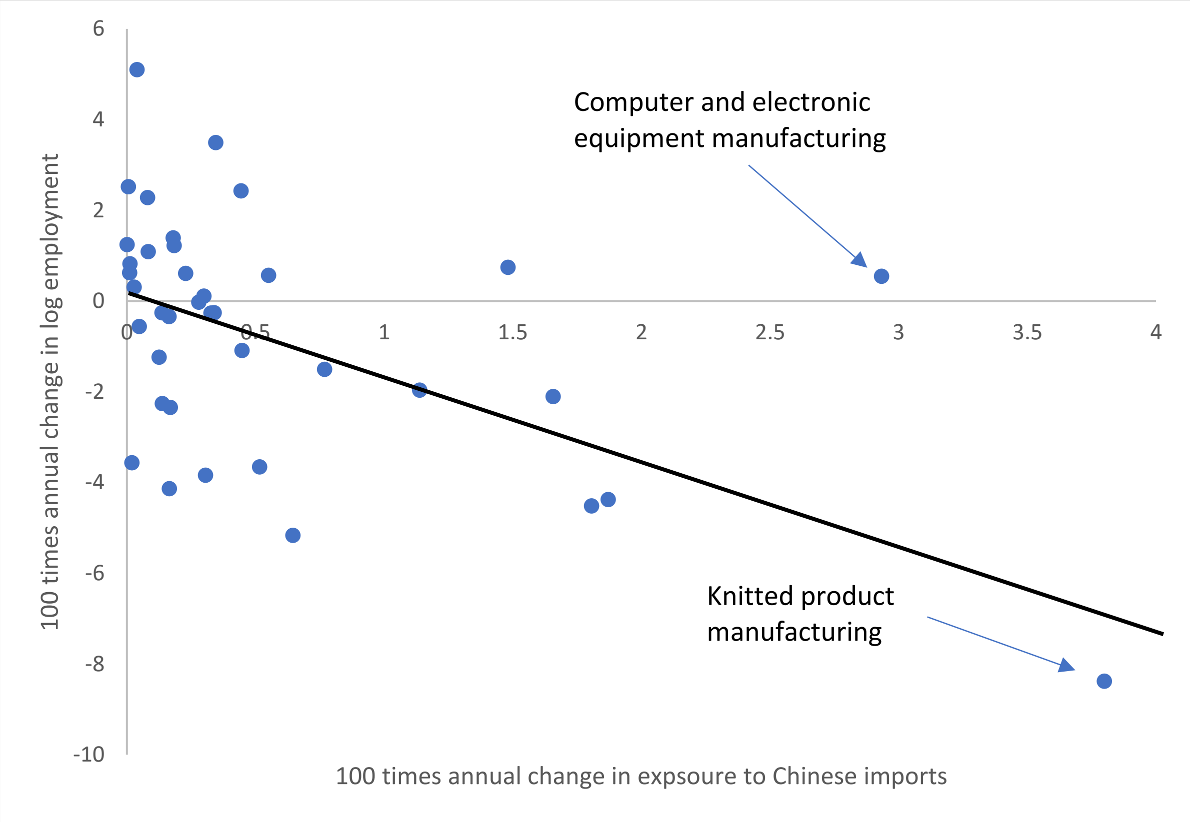
Table 1: Summary statistics

	1991-2006				**1991-1996**	**1996-2001**	**2001-2006**	**1991-2001**	**1996-2006**
	Mean/SD	**Median**	**Min**	**Max**	**Mean/SD**	**Mean/SD**	**Mean/SD**	**Mean/SD**	**Mean/SD**
100 x annual Δ in AUS exposure to Chinese imports	0.59 (1.06)	0.20	-0.02	7.58	0.21 (0.37)	0.32 (0.43)	1.23 (1.56)	0.27 (0.41)	0.78 (1.22)
Instrument for Δ in AUS exposure to Chinese imports (Ave. AADHP)	1.70 (2.98)	0.58	-0.58	26.06	0.95 (1.56)	1.10 (1.63)	3.06 (4.38)	1.02 (1.59)	2.08 (3.43)
Instrument for Δ in AUS exposure to Chinese imports (Total AADHP)	13.62 (23.84)	4.63	-4.61	208.44	7.59 (12.50)	8.78 (13.07)	24.49 (35.01)	8.18 (12.72)	16.63 (27.41)
100 x annual log Δ in employment in manufacturing industries	-0.63 (3.59)	-0.32	-21.19	27.74	0.00 (2.83)	-0.73 (3.46)	-1.17 (4.31)	-0.36 (3.16)	-0.95 (3.89)
Number of observations	114	114	114	114	38	38	38	76	76
100 x annual log Δ in employment in non-manufacturing industries	1.91 (2.43)	1.97	-10.40	41.36	1.63 (2.26)	1.74 (2.33)	2.36 (2.70)	1.68 (2.27)	2.05 (2.51)
Number of observations	87	87	87	87	29	29	29	58	58

Notes: The change in Australian exposure to Chinese imports is equal to 100 times the annualized change in the value of imports from China to Australia over the indicated period divided by total supply minus exports by industry in Australia in 1992-93. The instrument for the change in Australian exposure to Chinese imports is equal to 100 times the annualized change in imports from China to the AADHP set of countries (Denmark, Finland, Germany, Japan, New Zealand, Spain, Switzerland and the United States) divided by total supply minus exports by industry in Australia in 1989-90. Observations are weighted using 1991 industry-level employment shares as weights.

relation between industry-level changes to employment and Chinese import penetration, represented by the solid line.[39]

Figure 2: Changes in Chinese import penetration and employment, 38 manufacturing industries, Australia, 1991 to 2006



Source: Employment: ABS, Labour Force Australia, Detailed, Quarterly, catalogue no.6291.0.55.003, Table 04; Imports: See description of construction of import penetration measure in section 3. See Appendix 1 for description of construction of 38 manufacturing industries. The solid line is the predicted relation between the change in employment and change in import penetration: y = 0.211(se=0.46)– x*1.593(se=0.46).

5. Direct effects

Estimates of the direct effect on employment of growth in Chinese import penetration for the basic model (using the Acemoglu et al. (2016) set of high-income countries to construct the instrument) are presented in Table 2. Column (1) includes time interval dummies that reflect the employment-weighted mean annual change in employment in those intervals. Column

[39] Appendix Figure 3.1 presents descriptive information on industry-level changes in Chinese import penetration and employment for the three 5-year sub periods.

(2) presents OLS estimate of the impact of increases in Chinese import penetration. Column (3) reports the same estimated impact using 2SLS. Columns (4) to (8) report 2SLS estimates for sub-periods. For all 2SLS models results from the first-stage are provided in the bottom rows of the table. In all cases, changes in Chinese import penetration in other high-income countries are strongly related to changes in Australia and presents as a strong instrument.

The effect of changes to Chinese import penetration in manufacturing employment are similar in magnitude for the OLS and 2SLS methods and both are significant at the 5 per cent level.[40] The 2SLS result for the whole sample period implies that a 1 percentage point increase in import penetration reduces employment by 0.96 per cent. Looking at the sub-periods, there is substantial variation in the magnitude of estimated effects. Indeed, only in the final sub-period (2001-06) is the estimated effect significant. This pattern is likely to reflect increasing scope to identify the impact of changes to Chinese imports due to more rapid growth in imports and greater inter-industry heterogeneity in the final sub-period.[41]

Estimated direct effects from changes to Chinese import penetration that control for other potential determinants of manufacturing employment are presented in Table 3. All estimates are from 2SLS models for the whole sample period. Column (1) repeats the base model from Table 2. Columns (2) to (9) add various combinations of the four sets of control variables – 2-digit industry fixed effects; covariates for the industry-level rate of technological change and changes to average tariff rates; a pre-sample employment trend; and 38 industry fixed effects. Including any combinations of the first three sets of controls in most cases slightly increases the size and significance of the estimated effect of Chinese import penetration. The main exception is where only the control for changes in average tariff rates is included (column (4)). Adding the 38 industry fixed effects marginally lowers the effect size but it remains significant. Altogether, both within and between-industry variation in Chinese

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[40] Results from OLS and 2SLS specification are also similar when the EU-15 group of countries is used to construct the instrument. This may suggest that the impact of demand-side shocks on identification of productivity effects from Chinese imports to Australia is not a major concern. By contrast, Acemoglu et al. (2016, Table 2) estimate the effect of a one per cent increase in exposure to Chinese imports to the US to be -0.81 (se = 0.16) in an OLS model and -1.30 (se = .41) in a 2SLS model.

[41] The increased average size and heterogeneity of industry-level changes in Chinese import penetration in 2001-06 compared to the earlier 5-year intervals can be observed in Appendix Figure 3.1.

Table 2: Effect of Chinese import penetration on log employment in manufacturing industry, OLS and 2SLS, Australia, 1991 to 2006

		Whole sample		**Sub-periods**				
		1991-2006		**1991-1996**	**1996-2001**	**2001-2006**	**1991-2001**	**1996-2006**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
100 x annual Δ in AUS exposure to Chinese imports		-1.13** (0.42)	-0.96** (0.45)	-2.11 (1.59)	0.97 (1.58)	-1.01** (0.43)	-0.62 (1.18)	-0.86* (0.45)
1{1991-1996}	0.00 (0.44)	0.24 (0.44)	0.20 (0.42)					
1{1996-2001}	-0.73 (0.58)	-0.36 (0.53)	-0.42 (0.53)				-0.66 (0.75)	
1{2001-2006}	-1.17 (0.77)	0.22 (0.87)	-0.00 (0.89)					0.34 (0.93)
Constant				0.45 (0.45)	-1.04 (0.64)	-0.07 (0.88)	0.13 (0.42)	-0.45 (0.52)
Number of observations	114	114	114	38	38	38	76	76
Estimation method	OLS	OLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
1^{st} stage Partial R-squared			0.84	0.93	0.54	0.89	0.70	0.85
1^{st} stage F-statistic			82.5	112.0	20.0	56.5	35.9	62.0

Notes: Columns (1)-(3) report results from stacking log employment changes and changes in AUS exposure to Chinese imports for five-year intervals from 1991-2006 (N = 114; 38 manufacturing industries by three 5-year intervals). Columns (4)-(8) report results for the sub-periods indicated. In the 2SLS specification the adapted version of the Acemoglu et al. (2016) set of instrument countries is used to construct an average import penetration measure. In all specifications observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** p <0.01, ** p < 0.05, * p <0.1.

Table 3: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, With industry controls, Australia, 1991 to 2006

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
100 x annual Δ in AUS exposure to Chinese imports	-0.96** (0.45)	-1.02** (0.44)	-1.38*** (0.35)	-0.80** (0.38)	-0.97** (0.46)	-1.23*** (0.32)	-1.02** (0.45)	-1.22*** (0.32)	-0.72** (0.34)
2-digit industry FEs	No	Yes	No	No	No	Yes	No	No	No
Covariates – Technological change	No	No	Yes	No	No	Yes	No	Yes	No
Covariates – Change in average tariff rates	No	No	No	Yes	No	Yes	No	Yes	No
Pre-sample employment trend	No	No	No	No	Yes	No	Yes	Yes	No
38 industry FEs	No	No	No	No	No	No	Yes	No	Yes

Notes: All columns report results from stacking log employment changes and changes in AUS exposure to Chinese imports for five-year intervals from 1991-2006 (N = 114; 38 manufacturing industries by three 5-year intervals). The adapted version of the Acemoglu et al. (2016) set of instrument countries is used to construct an average import penetration measure. In all specifications observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** p <0.01, ** p < 0.05, * p <0.1.

import growth are found to be important sources of the overall estimated impact on employment.

Results from models that introduce further robustness checks are reported in Table 4. Columns (1) to (4) show the results when different sets of high-income countries are used to construct the instrument. Column (5) clusters standard errors at the 2-digit industry level. For column (6) observations have been weighted by industry shares of employment at the beginning of each 5-year time interval. Column (7) uses data from the ABS Census to construct the measure of 5-year changes in industry-level employment. To do this check it is necessary to aggregate to 28 manufacturing industries. Column (8) reports the estimated direct effect with the 5-year interval from 2006-11 added to the sample period.

The main message from Table 4 is that the estimated direct effect and the significance level are not sensitive to using alternative instruments or to changes in model specification. The estimated direct effect from most models are in a narrow range between -0.87 and -1.08. Similar to the basic model, when extra controls are added to the model with the instrument constructed from the EU-15 countries, the estimated direct effect is larger in size and more significant.[42] Using ABS Census employment data reduces the estimated magnitude of impact of Chinese imports, but the effect remains significant.[43]

Estimated direct effects from changes to Chinese imports for alternative time periods are presented in Table 5. The models estimated are designed to test whether results are sensitive to the length of the overall sample period or to varying the time intervals within the overall sample period. Considering different lengths of time intervals can also provide insights into the timing of labour market adjustment to growth in Chinese imports. To the extent that adjustment is not encompassed within the 5-year time intervals, estimates of direct effects would be expected to differ as the length of the time intervals changes. Panel A shows

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[42] The results in Tables 2 and 3 are replicated using the EU-15 set of countries to construct the instrument variable in Appendix Tables 3.2 and 3.3. For every regression model the estimated impact and significance level using the EU-15 set of countries to construct the instrument variable are at least as large as when the adapted Acemoglu et al. (2016) set of countries are used.

[43] The decrease in the estimated effect of Chinese imports seems mainly due to the change in industry classification. Using employment data from the LFS and the same 28 industry categories the estimated impact of Chinese imports falls to -0.31 (se=0.17).

Table 4: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, Australia - Extra robustness checks

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
	Instrument: United States excluded	**Instrument: EU-15**	**Instrument: EU-15 excluding UK**	**Instrument: EU-15 with 2-digit industry FEs, covariates, pre-trend employment**	**2-digit clustering**	**Varying start of period employment weights**	**ABS Census employment data**	**Extend sample period to 1991-2011**
100 x annual Δ in AUS exposure to Chinese imports	-1.00** (0.49)	-1.08* (0.56)	-1.01* (0.53)	-1.51*** (0.44)	-0.96** (0.44)	-0.88** (0.45)	-0.41** (0.19)	-0.87* (0.45)
Number of observations	114	114	114	114	114	114	84	152
1st stage Partial R-squared	0.75	0.79	0.75	0.75	0.84	0.87	0.95	0.75
1st stage F-statistic	196.0	112.0	94.0	59.6	52.4	123.0	573.1	261.0

Notes: Columns (1) to (6) report results from stacking log employment changes and changes in AUS exposure to Chinese imports for five-year intervals from 1991-2006 (N = 114; 38 manufacturing industries by three 5-year intervals). Column (1) excludes the US from the adapted version of the Acemoglu et al. (2016) set of instrument countries. Columns (2) and (3) derive the instrument variable (average import penetration measure) respectively using the EU-15 and EU-15 excluding UK sets of countries. Column (4) uses the EU-15 set of countries to construct the instrument variable, and the set of controls from column (8) in Table 3. Columns (5) to (7) reports findings with the adapted version of the Acemoglu et al. (2016) set of instrument countries. In columns (1) to (4) and (6) to (7), standard errors in parentheses are clustered at the level of the 38 industries. In column (5) clustering is at the 2-digit level. In columns (1) to (5), (7) and (8) observations are weighted by 1991 industry-level employment. In column (6) weighting is done with industry-level employment at the start of each 5-year interval. Column (7) reports results from a model which uses ABS Census data to construct the employment measure for 28 manufacturing industries (an aggregation of the 38 industries used for the LFS employment data). Column (8) reports results from expanding the same period with the extra 5-year interval from 2006-11. *** p <0.01, ** p < 0.05, * p <0.1. Appendix Tables 3.2 and 3.3 replicate Tables 2 and 3 with the instrument variable constructing using the EU-15 set of countries.

Table 5: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, Australia - Alternative time periods

	A] 1991-2007			**B] 1991-2011**				
	Stacked	**1991-99**	**1999-2007**	**Stacked**	**1991-2001 Single period**	**2001-11 Single period**	**Stacked 1991-2001**	**Stacked 2001-11**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
100 x annual Δ in AUS exposure to Chinese imports	-1.02 (0.81)	-2.48*** (0.96)	-0.78 (0.84)	-0.87* (0.45)	-1.46* (0.84)	-0.69* (0.37)	-0.62 (1.18)	-0.90** (0.40)
1{1991-1999}	-0.40 (0.39)							
1{1999-2007}	-0.63 (0.95)							
1{1996-2001}				-0.63 (0.74)			-0.66 (0.75)	
1{2001-2006}				-0.29 (0.94)				
1{2006-2011}				-1.42 (1.02)				-2.54** (1.05)
Constant		-0.04 (0.41)	0.40 (1.00)	0.11 (0.31)	0.11 (0.31)	-0.82 (0.69)	0.08 (0.86)	-0.07 (0.87)
Observations	76	38	38	152	38	38	76	76
Estimation method	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
1st stage Partial R-squared	0.87	0.73	0.92	0.75	0.79	0.95	0.87	0.78
1st stage F-statistic	107.0	15.5	92.7	261.0	25.4	459.0	36.0	215.0

Notes: The adapted version of the Acemoglu et al. (2016) set of instrument countries is used to construct an average import penetration measure. In all specifications observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** p <0.01, ** p < 0.05, * p <0.1.

estimates for various time intervals from 1991 to 2007 (ending just prior to GFC). Panel B shows estimates for time intervals from 1991 to 2011.

Three main findings come from considering alternative time periods. First, increasing the length of the overall sample period (to finish in 2007 – column (1); or 2011 – column (4)) does not affect the size of the estimated impact, although the significance is attenuated. Second, lengthening the time interval (to 8 or 10 years) does not have a consistent effect of increasing on the size of the estimated impact of Chinese imports. Hence, there is not immediate evidence that using 5-year time intervals is causing a large part of the adjustment of employment to changes in import penetration to be missed.[44] Third, changing the time intervals within the overall sample period does cause some variability in timing of the estimated impact, especially for the 8-year sub-periods from 1991 to 2007.[45]

Direct effects on employment by type of worker and by sub-groups of manufacturing industries are reported respectively in Tables 6 and 7. A larger and more significant negative effect is found on employment for females than males. There is also a larger negative effect on part-time employment than full-time employment. Important differences also exist between industries according to the intensity of import competition they face. For industries with above-median import penetration rates in 1991 there is a negative effect on employment that is almost three times larger than for industries with below-median import penetration rates (-1.74 per cent compared to -0.64 per cent). Excluding two industries which experienced growth in import penetration far above average (knitted product manufacturing

[44] To further investigate adjustment and dynamics we estimate models with the contemporaneous and once lagged instrumented change in Chinese import penetration as explanatory variables. Results are reported in Appendix Table 3.4. Estimation using 5-year intervals for 1996-2006 does find a large significant impact of the lagged change in Chinese import penetration. But that effect disappears when the overall sample period is lengthened to 1996-2011. This finding differs from Acemoglu et al. (2016, p.S184) who find stronger evidence of lagged effects of import growth on manufacturing employment in the post-GFC period.

[45] When the period from 1996-2001 is broken into sub-periods for 1996-99 and 1999-2001 it is found that there is relatively strong negative growth in employment in the former period and positive growth in employment in the latter period with the rate of change in Chinese import penetration being similar between the periods. As well, at the industry-level employment and import growth are negatively correlated in the former period and almost uncorrelated in the latter period. These aspects appear to explain why adding 1996-99 to the first 5-year sub-period generates a relatively large negative effect of imports on employment; whereas adding 1999-2001 to the final 5-year period attenuates the impact of imports on employment.

Table 6: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, Australia, 1991 to 2006 Disaggregated impacts by gender/type of employment

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	Baseline	**Males**	**Females**	**Full-time**	**Part-time**
100 x annual Δ in AUS exposure to Chinese imports	-0.96** (0.45)	-0.79 (0.53)	-1.37*** (0.32)	-0.97* (0.50)	-1.48** (0.62)
Number of observations	114	114	114	114	114

Notes: The adapted version of the Acemoglu et al. (2016) set of instrument countries is used to construct an average import penetration measure. In all specifications observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, Australia, 1991 to 2006 Disaggregated impacts by industry

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
	Baseline	**High Import Exposure**	**Low Import Exposure**	**Exclude ANZSIC 134**	**Exclude ANZSIC 134 & 242**
100 x annual Δ in AUS exposure to Chinese imports	-0.96** (0.45)	-1.74*** (0.37)	-0.64* (0.37)	-0.90* (0.48)	-1.63*** (0.50)
1{1991-1996}	0.20 (0.42)	0.22 (0.71)	0.32 (0.54)	0.33 (0.40)	0.45 (0.41)
1{1996-2001}	-0.42 (0.53)	-1.10 (1.02)	0.12 (0.56)	-0.42 (0.53)	-0.33 (0.52)
1{2001-2006}	0.00 (0.89)	-0.39 (1.24)	0.57 (0.97)	-0.09 (0.90)	0.59 (0.90)
Number of observations	114	57	57	111	108
1st stage Partial R-squared	0.84	0.86	0.91	0.87	0.83
1st stage F-statistic	82.5	59.9	166.0	133.0	68.2

Notes: The adapted version of the Acemoglu et al. (2016) set of instrument countries is used to construct an average import penetration measure. In all specifications observations are weighted by 1991 industry-level employment. High import exposure industries are the 19 industries with above-median rates of import penetration (from all countries) in 1991; and low import exposure industries are the 19 industries with below-median rates of import penetration. Standard errors in parentheses are clustered at the level of the 38 industries. *** p <0.01, ** p < 0.05, * p <0.1.

and computer and electronic equipment manufacturing) causes the estimated impact to either remain unchanged or increase in size.

Finally, we evaluate the robustness of our estimates with a falsification test. In this test, instrumented changes in import penetration are regressed on contemporaneous and lagged changes in employment. Our identification strategy is compromised if past changes in employment in manufacturing industry in Australia can explain the changes in Chinese import penetration which are supposed to reflect improvements in Chinese productivity. The results are shown in Table 8 – Panel A without the set of 2-digit industry controls and Panel B with those controls. The results are presented for varying lag lengths of changes in employment. For example, k=0 shows the relation between instrumented changes in import penetration and contemporaneous changes in employment for the four 5-year intervals from 1986-1991 to 2001-2006; and k = 3 shows the relation between instrumented changes in import penetration in 1986-1991 and changes in employment in 2001-06. There is no significant relation between any length of lag in the change in employment and the instrumented change in Chinese import penetration. Hence, it seems that growth in Chinese import penetration is not simply reflecting some longer-term trend in manufacturing employment in Australia.

6. Indirect spill-over effects

Indirect spill-over effects are estimated for three 5-year time intervals from 1991 to 2006 including 38 manufacturing and 29 non-manufacturing industries.[46] The results are shown in Table 9. Results are reported separately for first-order effects (from trade-induced impacts on an industry's immediate buyers or suppliers) and high-order effects (from the full chain of trade-induced impacts on an industry's linked buyers or suppliers). Panel A shows impacts based on first-order linkages, and Panel B shows impacts when the higher-order (full) input-output linkages are incorporated. Columns (1) to (3) show impacts for manufacturing industries, columns (4) and (5) for non-manufacturing industries, and columns (6) to (9) for the pooled set of industries. Columns (1) to (8) report different combinations of direct, upstream and downstream effects and different sets of fixed effects. Column (9) presents

[46] The concordance to link industry classifications in the 1988-89 and 1992-93 IO Tables to the ANZSIC 2006 classification for non-manufacturing industries is shown in Appendix 1.

Table 8: Falsification test

	A] Excluding 2-digit controls				**B] Including 2-digit controls**			
Employment in period (t-k)	**k=0**	**k=1**	**k=2**	**k=3**	**k=0**	**k=1**	**k=2**	**k=3**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
100 x annual Δ in AUS exposure to Chinese imports	-1.00*** (0.38)	-0.25 (0.52)	0.01 (0.31)	-0.03 (0.24)	-1.04*** (0.37)	-0.29 (0.51)	-0.01 (0.34)	-0.09 (0.24)
Constant	-0.16 (0.30)	-0.32 (0.31)	-0.29 (0.41)	-0.54 (0.57)	-1.18 (1.27)	-1.14 (1.28)	-0.48 (1.40)	-1.85 (1.85)
	152	114	76	38	152	114	76	38

Note: Results are from regressions of instrumented changes in import penetration on contemporaneous and lagged changes in employment in Australia. Panel A without the set of 2-digit industry controls and Panel B with those controls. The adapted version of the Acemoglu et al. (2016) set of countries is used to construct the instrument variable. *** p <0.01, ** p < 0.05, * p <0.1.

results from a specification that estimates the total impact for all industries. All models include indicators for time intervals.[47]

Several main findings come from Table 9. First, estimated upstream effects are negative throughout, which is consistent with our prediction. These effects are large in magnitude; and are significant for non-manufacturing but not for manufacturing industries. Second, estimated downstream effects are small in magnitude and never significant. This result is consistent with the existence of potentially off-setting drivers of the downstream effect. Third, pooling across all industries we find there is a large and significant combined impact of direct and spill-over effects on employment. A one percentage point increase in Chinese import penetration causes a 2.4 per cent decrease in employment in Australia. Fourth, the estimated impacts on employment are larger when only first-order input-output linkages are considered than when higher-order linkages are also incorporated. As Acemoglu et al. (2016, p.S173) note, this does not imply a smaller predicted effect on employment, since higher-order (full) changes in import exposure are larger than first-order changes. Fifth, the results for Australia are qualitatively similar to those for the United States reported in Acemoglu et al. (2016). For example, both studies find significant negative upstream effects but no evidence of significant downstream effects; and estimate larger upstream impacts for non-manufacturing than manufacturing industries. Upstream effects estimated for Australia are, however, much larger than for the United States. Non-manufacturing industries in Australia that have large upstream exposures to manufacturing industries are agriculture and fishing; forestry; and oil and metal extraction.[48]

In other research, we have also considered how our results on indirect effects are affected by the refinements to methodology proposed by Wang et al. (2018) – that is, calculating the downstream effect by separating intermediate from final goods and using input-output information on the use of Chinese imports to allocate them between industries. In their application of this method to the United States, Wang et al. (2018) find that growth in Chinese manufactured imports causes a positive downstream effect on employment in local labour markets that is large enough to outweigh negative direct and upstream effects.

[47] Descriptive statistics for variables used in the estimation are presented in Appendix Table 3.5.
[48] Average upstream exposure among non-manufacturing industries is, however, much smaller than among manufacturing industries.

Table 9: 2SLS estimates of import effects on employment incorporating input-output linkages

	M/facturing N=38			**Non-m/facturing N=29**		**All industries N=67**			
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
A] First-order I/O linkages									
Direct import exposure	-0.90* (0.48)	-0.85* (0.50)	-0.97** (0.47)			-0.94 (0.71)	-1.13* (0.66)	-0.41 (0.53)	
Upstream import exposure	-1.05 (3.04)	-2.36 (3.97)	-0.88 (2.98)	-16.35** (6.22)	-49.48** (20.52)	-9.79* (5.08)	-7.75*** (2.89)	-10.25** (4.99)	
Downstream import exposure		0.65 (2.17)			1.91 (1.23)		-0.26 (0.43)		
Combined (direct + indirect) import exposure									-2.17*** (0.76)
1st stage Partial R-squared	0.85	0.85	0.85	0.54	0.90	0.88	0.88	0.88	0.53
1st stage F-statistics	48.9	32.9	49.1	33.6	73.7	53.7	43.9	43.9	11.6
B] Full (Higher-order) I/O linkages									
Direct import exposure	-0.92** (0.47)	-0.89* (0.48)	-0.99** (0.46)			-1.25 (0.89)	-1.20** (0.62)	-0.63 (0.61)	
Upstream import exposure	-0.68 (2.54)	-1.29 (2.14)	-0.58 (2.45)	-8.89 (7.58)	-17.43** (8.22)	-5.98 (6.55)	-5.76*** (2.18)	-6.92 (5.87)	
Downstream import exposure		0.28 (1.16)			0.47 (0.54)		-0.01 (0.41)		

Combined (direct + indirect) import exposure									-2.37** (1.23)
1st stage Partial R-squared	0.85	0.85	0.85	0.47	0.95	0.88	0.88	0.87	0.27
1st stage F-statistics	47.4	32.8	48.5	14.9	69.6	57.7	50.5	51.7	4.44
Observations	114	114	114	87	87	201	201	201	201
Period FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ANZSIC 2-digit Fes	No	No	Yes	No	No	No	No	Yes	No

Note: The sample consists of stacked log employment changes and changes in AUS exposure to Chinese imports for five-year intervals from 1991-2006. The adapted version of the Acemoglu et al. (2016) set of countries is used to construct the instrument variable. In all specifications observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** p <0.01, ** p < 0.05, * p <0.1.

However, our replication of the refined methodology to Australia at the industry-level finds only weak evidence of positive downstream effects on employment (and then through manufacturing rather than non-manufacturing); and certainly not large enough to alter the overall result of a negative impact on employment in Australia (Coelli et al., 2020).

7. Implied employment changes in manufacturing

Estimates of impacts from the regression analysis can be applied to construct implied changes in manufacturing employment in Australia due to increases in Chinese imports. From equation (1) the difference between actual and counter-factual employment in manufacturing in year *t* can be expressed as:

$$\Delta L_t^{cf} = \sum_j L_{jt} \left(1 - e^{-\hat{\beta}_1 \Delta \widehat{IP}_{jt}}\right) \qquad (9)$$

where $\hat{\beta}_1$ is the 2SLS estimate from (1) and $\Delta\widehat{IP}_{jt}$ is the increase in import penetration to Australia from China that is attributable to China's improving productivity between a base year and year *t*.[49] In estimating the counter-factual change in employment it is assumed that all other factors would be unchanged by the hypothetical increase in import penetration from China.[50]

Table 10 presents implied changes in manufacturing employment in Australia due to growth in imports of manufactured goods from China for four regression models. Two implied changes (rows (1) and (2)) are based on estimates of direct effects (with and without control variables). The other two implied changes are based on estimates of the sum of direct and upstream spill-over effects. Changes estimated using first-order spill-over effects are in rows

[49] Following Acemoglu et al. (2016, p.S160) we estimate $\Delta\widehat{IP}_{jt}$ by multiplying the observed increase in import penetration, $\Delta\widehat{IP}_{jt}$, with the partial R-squared from the first-stage regression of (2) on (3). For example, the partial R-squared from our baseline specification is 0.84 (Table 2, column (3)). Where the instrument is valid, and in the absence of measurement error, $\Delta\widehat{IP}_{jt}$ is a consistent measure of the contribution of increases in imports from China to changes in import penetration in manufacturing industries in Australia.

[50] Although the counter-factual estimates do take account of time interval and covariates, in the calculations it is assumed they are unchanged.

(3) to (5), and for higher-order effects in rows (6) to (8) – in aggregate and separately for manufacturing and non-manufacturing industries.

Table 10: Implied changes in employment due to exposure to imports from China, 1991 to 2006

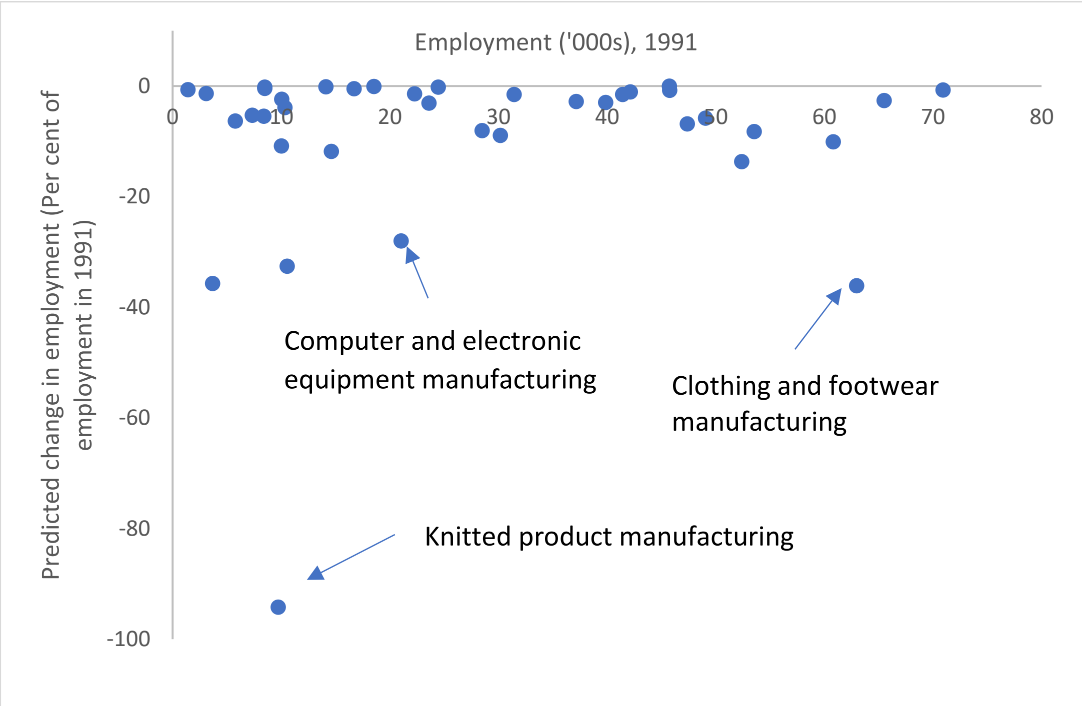
	Model	**Coverage**	**Difference ('000s)**	**Percent of manufacturing employment – 1991 (%)**
Table 2, Column (3)	Direct impact – No controls	Manufacturing	-89.9	-8.5
Table 3, Column (8)	Direct impact - With all industry-level controls	Manufacturing	-117.7	-11.1
Table 9, Panel A, Columns (2) and (4)	Direct impact + First-order upstream spillover effect	Total	-251.9	
		Manufacturing	-209.8	-19.8
		Non-manufacturing	-42.1	
Table 9, Panel B, Columns (2) and (4)	Direct impact + Higher-order upstream spillover effect	Total	-211.6	
		Manufacturing	-191.9	18.1
		Non-manufacturing	-19.7	

Note: Implied changes in employment are calculated using equation (9) applying instrumented changes in Chinese import exposure in the designated models. Manufacturing employment in 1991 (average across four quarters) was 1057.5 (Original series) – ABS, Labour Force – Australia – Detailed – Quarterly, catalogue 6291.0.55.003, Table 04.

Estimated total manufacturing job losses from 1991 to 2006 range from 89,900 (including only direct effects) to 209,800 (also incorporating first-order upstream effects). Compared to manufacturing employment in 1991 (average across four quarters), these effects would have implied decreases of between 8.5 and 19.8 per cent. Predicted effects on employment in some manufacturing industries are even more substantial. Figure 3 shows the implied industry-level changes in employment due to the estimated direct impact of growth in Chinese imports from 1991 to 2006. For one industry, knitted product manufacturing, growth in Chinese imports is estimated to have caused employment to decrease by 95 per cent of its

1991 level.[51] In several other industries the reduction in employment is estimated to be about 30 per cent. In general, industries that were most exposed to competition from Chinese imports in 1991 have the largest implied decreases in employment: -14.0 per cent for above-median exposure industries compared to -4.2 per cent for below-median exposure industries.[52]

Figure 3: Implied changes in employment due to direct impact of exposure to imports from China, By manufacturing industry, 1991 to 2006



Note: Implied changes in employment are calculated using equation (9) and applying: (i) industry-level changes in Chinese import penetration from 1991 to 2006; and (ii) estimated direct effects for above-median exposure and below-median exposure industries – Table 7, columns (2) and (3). Manufacturing employment in 1991 (average across four quarters) is from ABS, Labour Force – Australia – Detailed – Quarterly, catalogue 6291.0.55.003, Table 04.

[51] Employment in knitted product manufacturing decreased from 9,500 in 1991 to 2,500 in 2006 (average across four quarters) (ABS, Labour Force Australia, Detailed, Quarterly, no.6291.0.55.003, EQ06).

[52] Fahrer and Pease's (1994) analysis of sources of changes in manufacturing employment from 1981/82 to 1991/92 similarly finds that the impact of growth in imports varied substantially by industry – with largest impacts on textiles, clothing and footwear; chemicals; and other machinery and equipment.

Between 1991 and 2006 the actual decrease in manufacturing employment in Australia was 48,000 or 4.5 per cent.[53] This might be interpreted to imply that the growth in Chinese import penetration more than accounts for the actual decline in manufacturing employment from 1991 to 2006.[54] However, this would be to exaggerate the impact of Chinese imports. In a 'no change' scenario, where employment in manufacturing industry grew at the same rate as non-manufacturing industries from 1991 to 2006, it would have increased by 396,100. Therefore, the total loss in manufacturing employment over this period, compared to the 'no change' scenario, is equal to 444,100.[55] From this perspective, increased imports of manufactured goods from China explain from one-fifth to at most one-half of the decrease in manufacturing employment from 1991 to 2006. Hence, it seems reasonable to describe the impact of Chinese imports as sizeable, but not spelling the end of manufacturing employment in Australia. The growth in Chinese imports may have accelerated the downward trend in the share of manufacturing employment from the mid-1990s to mid-2000s; but other factors were already driving that decline.

Spill-over effects on employment in non-manufacturing industries in Australia due to growth in manufactured imports from China from 1991 to 2006 are much smaller than for manufacturing employment. As a proportion of total employment this impact is miniscule, accounting for at most only 0.6 per cent of non-manufacturing employment in 1991.[56]

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[53] Manufacturing employment in 1991 averaged across the four quarters was 1057.5 and in 2006 was 1009.5 (Original series) – ABS, Labour Force – Australia – Detailed – Quarterly, catalogue 6291.0.55.003, Table 04.

[54] This is quite different to the United States where there were substantial decreases in manufacturing employment in the 1990s and 2000s, so estimated impacts of growth in Chinese imports, while quantitatively large, only account for a small proportion of that decline. Acemoglu et al. (2016, p.S160) estimate that growth in Chinese imports from 1991 to 2011 would have caused at least 837,000 lost manufacturing compared to the actual decrease in employment of 5.6 million.

[55] The rate of growth in employment in non-manufacturing industries from 1991 to 2006 is calculated using the average of employment across the four quarters in those years (see ABS, Labour Force – Australia – Detailed – Quarterly, catalogue 6291.0.55.003, Table 04). The decline in employment in manufacturing industry compared to the 'no change' scenario is calculated as the sum of the amount by which manufacturing employment would have increased (396,100) plus the decrease in employment which actually occurred (48,000).

[56] Calculated as 42.1 (non-manufacturing spill-over effect) divided by 6604 (non-manufacturing employment – average across four quarters in 1991). See ABS, Labour Force – Australia – Detailed – Quarterly, catalogue 6291.0.55.003, Table 04.

8. Conclusion/Discussion

Massive growth in imports from China to Australia occurred from the early 1990s onwards. This study uses the same approach as Acemoglu et al. (2016) to examine the impact of that growth on employment in Australia from 1991 to 2006. Increased exposure to Chinese imports had a significant negative impact on industry-level employment. The direct effect of a one percentage point increase in import penetration from China was a 0.96 per cent decrease in manufacturing employment; and taking account of indirect spill-overs increased the negative effect to 2.4 per cent. These impacts translate into estimated job loss in manufacturing industry of between 89,900 and 209,800 workers – accounting for 8.5 to 19.8 per cent of manufacturing employment in Australia in 1991. The results are highly robust to an extensive set of sensitivity analyses – including, for example, using a different set of high-income countries to construct the instrument variable, changes to the sample period and including extra controls for employment.

Overall, the effect of growth in Chinese imports on employment in manufacturing industry in Australia from 1991 to 2006 can be described as sizeable; and may have accelerated slightly downward trend in the share of manufacturing employment from the mid-1990s to mid-2000s. However, the influence of other factors – such as technological change – is necessary to explain the declining share of manufacturing employment in the 1970s and 1980s; and to explain year-to-year variation in employment in the 1990s and 2000s that cannot be attributed to the growth in Chinese imports. Having said that, it is important also to recognise variation in the impact of Chinese imports between manufacturing industries. For those industries most exposed to import competition and where the largest increases in Chinese imports have occurred, implied employment effects are substantial – with the most pronounced effects for textiles, clothing and footwear.

In considering the impact for Australia of increasing trade with China, this study is limited by its focus on manufactured imports and labour market consequences. First, during some of the period considered in our study (and in later years), Australia had large growth in its exports to China which is likely to have caused extra employment growth. In other work in progress we are exploring in more detail how the impact of increases in imports from China on employment may have been offset by higher levels of exports from Australia to China.[57] Second, considering only labour market consequences of import growth ignores the substantial benefit to consumers from that growth via lower prices of manufactured goods.

[57] Other extensions to our analysis would be to consider worker-level and firm-level adjustment in response to growth in trade with China – See for example Utar (2018) and Traiberman (2019); and Asquith et al. (2019).

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Appendices

Appendix 1: Industry concordance

Appendix 2: Measurement of imports in $US

Appendix 3: Extra results

Appendix 1: Concordance of ANZSIC (2006) to match with industry classifications in IO tables in 1988-89 (ASIC) and 1992-93 (ANZSIC (1993))

The industry classification systems used for the 1989-90 and 1992-93 input-output tables need to be matched with the ANZSIC (2006) industry classification. This was done in three steps. First, the industry classification used in the 1989-90 input-output tables was concorded with the ASIC classification, and the industry classification used in the 1992-93 input-output tables was concorded with the ANZSIC (1993) classification. In each case, this was done to preserve the highest level of disaggregation in industries as possible. Second, the ASIC and ANZSIC (1993) classifications were concorded to the current ANZSIC (2006) classification – again in the way that preserved the highest level of disaggregation possible. Third, the two classifications were compared, and where necessary aggregated so that both input-output tables can be concorded to the same industry classification. Following the concordance there were 38 manufacturing and 29 non-manufacturing industries. The classifications of manufacturing and non-manufacturing industries used in the study are shown below.

Details of ANZSIC (2006) codes are in ABS, Australian and New Zealand Standard Industrial Classification, catalogue no.1292.0, chapter 6. The concordance between ANZSIC (2006) and ANZSIC (1993) is described in ABS, Australian and New Zealand Standard Industrial Classification, catalogue no.1292.0, chapter 10. The concordance between ANZSIC (2006) and ASIC is described in ABS, Australian and New Zealand Standard Industrial Classification (ANZSIC) 1993, catalogue no.1292.0. The concordance between industry classifications used in the 1989-90 input-output tables and ASIC is presented in ABS, Australian National Accounts, Input-Output Tables, catalogue no.5209.0, Appendix B. The concordance between industry classifications used in the 1992-93 input-output tables and ANZSIC (1993) is presented in ABS, Australian National Accounts, Input-Output Tables, catalogue no.5209.0, Appendix B.

Concordance of manufacturing industries
Concordance of manufacturing industries

ANZSIC 2006	IO 1992-93	IO 1989-90
111	2101	2101
112, 118, 119	2107, 2108	2107, 2108
113	2102	2102
114	2103	2103
115	2104	2104
116	2105	2105
117	2106	2106
121	2109, 2110, 2111	2109, 2110, 2111
122	2112	2201
131, 133	2201, 2202, 2203	2301, 2302, 2303, 2304, 2305, 2306
132	2207	3401
134	2204	2401

135	2205, 2206	2402, 2403
141	2301	2501
149	2302, 2303	2502, 2503
151	2304	2601
152, 161, 162, 541, 552	2305, 2306, 2401, 2402	2602, 2603, 2604, 2605
170	2501	2708
181, 182	2503	2702
183, 184	2502, 2505, 2905	2701, 2704
185	2506, 2507	2705, 2706
189, 191, 192	2508, 2510, 2542,2509	2703, 2707, 3402, 3403
201	2601	2801
202	2602	2802
203	2603, 2604, 2605	2803, 2804, 2805
209	2606	2806
211, 212, 221	2701	2901
213, 214	2702	2902
222	2703, 2901	3101
223, 224	2704	3102
229	2705	3103
231	2801	3201
239	2802, 2803, 2804	3202, 3203, 3204
241, 243, 259	2805, 2808, 2903	3301, 3304, 3404, 3405
242	2806	3302
244	2807	3303
245, 246, 249	2809, 2810, 2811	3305, 3306, 3307
251	2902	2504

Concordance of non-manufacturing industries

ANZSIC 2006	**IO 1992-93**	**IO 1989-90**
011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 041, 042, 052	0101, 0102, 0103, 0104, 0105, 0106, 0107, 0200, 0400	0101, 0102, 0103, 0104, 0105, 0106, 0200, 0400
030, 051	0300	0300
060, 070	1100	1200
080	1301, 1302	1101, 1102
091, 099	1400	1400
101, 109	1500	1600
261, 262, 263, 264	3601	3601
270	3602	3602
281	3701	3701
301, 302, 310, 321, 322, 323, 324, 329	4101, 4102	4101, 4102
331, 332, 333, 341, 349, 350, 360, 371, 372, 373, 380, 391, 392, 400, 411, 412, 421, 422, 423, 424, 425, 426, 427, 431, 432, 941, 942, 949	4501, 5101, 5401, 5402	4701, 4801, 4901, 4902

440, 451, 452, 453	5701	9201
461, 462	6101	5101
471, 472, 502	6201	5201
481, 482	6301	5301
490, 501, 521, 522, 529, 530, 722	6401	5401
	(Allocate 6601 proportionately between {461,462} {471,472,502} {481,482} {490,501,521,522, 529, 530})	(Allocate 5701 proportionately between {461,462} {471,472,502} {481,482} {490,501,521,522, 529, 530})
510, 542, 551, 552, 561, 562, 570, 580, 591, 592, 602	7101, 9101	5900
621, 622, 623	7301, 7302	6101
624	7303	6102
631, 632, 633	7401	6104
641, 642	7501	6103
661, 662, 663, 664, 671, 672, 691, 692, 693, 694, 695, 696, 699, 700, 721, 729, 731, 732, 771, 772	7702, 7801, 7802, 7803	6105
697, 840, 851, 852, 853, 859, 860, 871, 879	8601, 8701	8101
751, 752, 753, 754, 755	8101	7101
760	8201	7201
801, 802, 810, 821, 822, 601, 891, 892, 900	8401, 9201	8201
911, 912, 913, 920	9301	9101
951, 952, 953, 291, 292, 960	9501	9301
954, 955	9601	8301

Appendix 2: Why we express imports in US dollars

Our starting point is that the measure of changes in Chinese import penetration, ΔIP_{jt}, is intended to represent the potential impact of growth in imports from China on employment in Australia. The impact on employment will depend on changes in the quantity of imports. For example, suppose that imports from China perfectly substitute for output produced in Australia. If a worker in Australia can make 1000 T-shirts each year and imports of T-shirts from China increase by 10,000, then other things equal, that would reduce by ten the number of workers employed in making T-shirts in Australia. An ideal measure of the change in Chinese import penetration therefore should reflect changes in the quantity of imports from China - and should not reflect variation in other aspects such as the price index used to construct the measure.

The measure ΔIP_{jt} is the ratio of the change in a manufacturing industry's imports from China to the value of consumption in that industry. The input-output data on the value of consumption is expressed in $Aus. The Comtrade imports data are expressed in $US. Hence, there are two possible approaches to calculate ΔIP_{jt}. The first approach is to convert the imports data into $Aus and divide by the consumption data. The second approach is to convert the consumption data into $US and express as a ratio of the change in imports. It is important to recall that the numerator, the change in imports, is measured across time; whereas the denominator, consumption, is fixed at a base year. Hence variation over time in ΔIP_{jt} is due to the numerator, changes in imports.

A problem with using the first approach is that the measure of changes in imports will reflect both changes in the volume of imports and changes in the Aus/US exchange rate over the sample period. During the sample period there was substantial variation in the Aus/US exchange rate. This is shown in Appendix Figure 2.1. The exchange rate decreased from 1996 to 2001 and increased thereafter to 2006. Hence, exchange rate variation will have exerted a substantial upward influence on the measure of change in Chinese import penetration to Australia from 1996 to 2001, and a downward influence from 2001 to 2006.

Figure 2.1: Aus/US Exchange Rate, 1991 to 2006 (Monthly)

Source: Reserve Bank of Australia, https://www.rba.gov.au/statistics/historical-data.html#exchange-rates

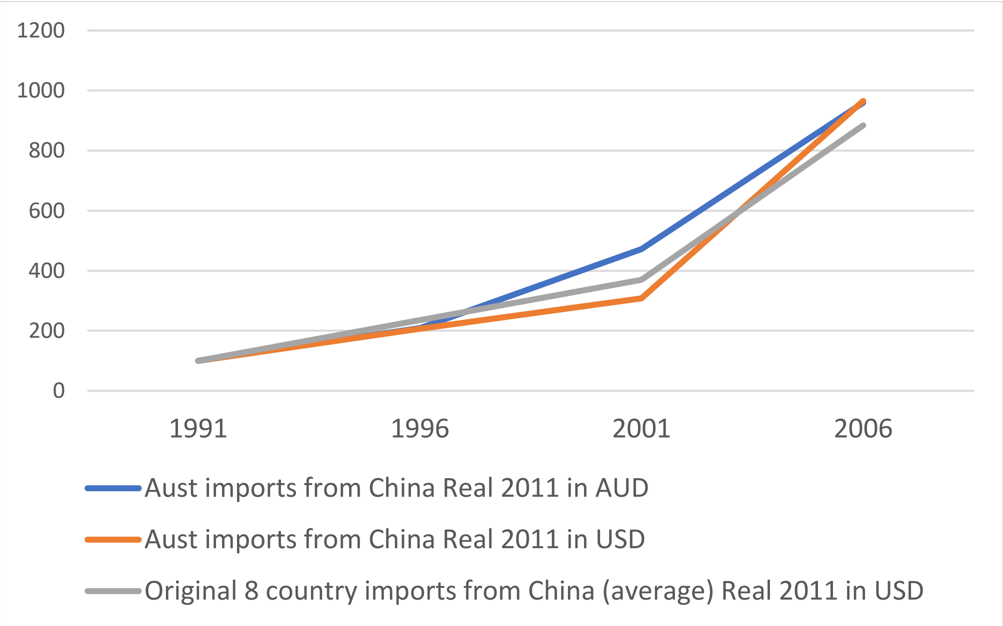
Furthermore, it seems accepted that the explanation for the depreciation in exchange rate from 1996 to 2001 was the 'tech boom' in the United States (see Macfarlane, 2000); and the explanation for the appreciation in the exchange rate from 2001 to 2006 was increase in the terms of trade as the mining boom commenced. Ex-Reserve Bank Governor, Glenn Stevens (2013), has suggested:

'Some trends did seem less explicable, such as when the exchange rate fell below 49 US cents in March 2001 and lingered at very low levels for a while. This was in the wake of a slowdown in the Australian economy, but was also the era of excitement over America's so-called 'new economy', and the sense that Australia was an 'old economy'. The 'old economy' elements like mining would come into their own only a few years later. In 2001, the terms of trade were already rising, and a powerful upswing ensued over the next decade. Even those who were prescient enough to understand the importance of the rise of China have, I suspect, been surprised by the extent of increase in Australia's terms of trade and its longevity. And, of course, this trend has carried Australia's currency to historically high levels – back, in fact, to about where the floating journey began thirty years ago.'

In summary, using the first approach would mean that changes over time in ΔIP_{jt} will reflect more than just the impact of changes in the volume of imports of manufactured goods from China to Australia – specifically, it will also reflect changes in the Aus/US exchange rate. By comparison, using the second approach, the only currency conversion is for the starting time period, so that the problem of the varying exchange rate does not arise.

As a final note, it is possible to show the impact of using the alternative approaches on the estimated value of imports of manufactured goods from China to Australia. This is done in Appendix Figure 2.2 for the sample period from 1991 to 2006. In order to make comparison easier, all series are indexed to 100 in 1991. As suggested above, converting imports into $Aus results in there being a faster rate of growth in imports from 1991 to 2001 than when import values are kept in $US, and then a slower rate of growth from 2001 to 2006. The magnitudes of the differences are large. For example, using the first approach of converting to $Aus, imports of manufactured goods from China to Australia are calculated to increase by a factor of four and a half between 1991 and 2001; whereas using the second approach of keeping import values in $US there is only a three-fold increase in imports. It is also notable that the timing of growth in imports of manufactured goods from China to Australia matches much more closely to the timing of import growth in the eight high-income countries used to construct the instrument when the approach of keeping import values in $US is applied.

Figure 2.2: Real value of imports of manufactured goods from China, 1991 to 2006 (Indexed to 100 in 1991; 2011)



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Macfarlane, Ian (2000), 'Recent influences on the exchange rate', *Reserve Bank Bulletin*, December.

Stevens, Glenn (2013), 'The Australian dollar: Thirty years of floating', Speech to the Australian Business Economists' Annual Dinner, 21 November; https://www.rba.gov.au/speeches/2013/sp-gov-211113.html

Appendix 3: Extra results

Appendix Table 3.1: Summary statistics by industry

Industries	**Average change in Chinese import penetration**	**Average change in log employment**	**Industries**	**Average change to Chinese import penetration**	**Average change in log employment**
Meat and meat product manufacturing	0	1.25	Fertiliser and pesticide manufacturing; Pharmaceutical and medicinal product manufacturing	0.16	-0.34
Seafood processing; Sugar and confectionary manufacturing; Other food product manufacturing	0.17	-2.34	Cleaning compound and toiletry preparation manufacturing	0.28	-0.02
Dairy product manufacturing	0.01	0.63	Other basic chemical product manufacturing; Polymer product manufacturing; Natural rubber manufacturing	0.45	-1.09
Fruit and vegetable processing	0.23	0.61	Glass and glass product manufacturing	0.55	0.57
Oil and fat manufacturing	0.04	5.11	Ceramic product manufacturing	0.65	-5.17
Grain mill and cereal product manufacturing	0.05	-0.56	Cement, lime, plaster and concrete product manufacturing	0.02	-3.57
Bakery product manufacturing	0.08	2.28	Other non-metallic mineral product manufacturing	0.35	3.50
Beverage manufacturing	0.01	2.52	Basic ferrous metal manufacturing; Iron and steel forging	0.18	1.39
Cigarette and tobacco product manufacturing	0.14	-2.26	Basic ferrous non-metal manufacturing; Basic ferrous metal product manufacturing;	0.44	2.43

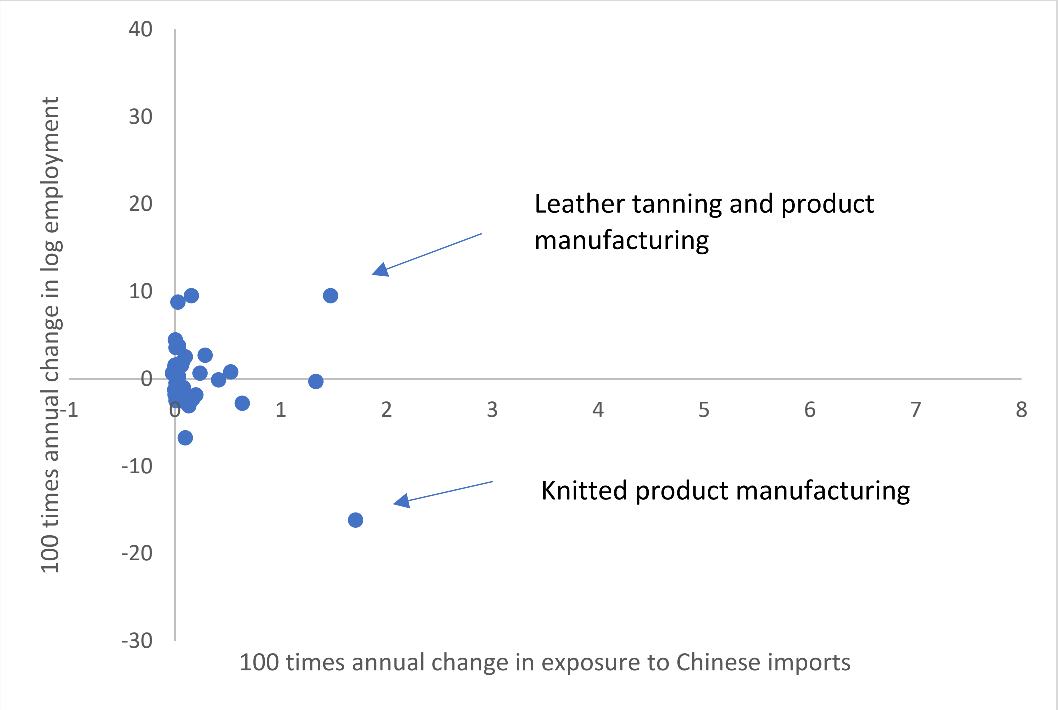
			Basic ferrous non-metal product manufacturing		
Textile manufacturing; Textile product manufacturing	0.52	-3.65	Structural metal product manufacturing	0.12	-1.23
Leather tanning, fur processing and leather product manufacturing	1.87	-4.38	Metal container manufacturing; Sheet metal product manufacturing	0.17	-4.13
Knitted product manufacturing	3.80	-8.38	Other fabricated metal product manufacturing	0.77	-1.51
Clothing and footwear manufacturing	1.81	-4.51	Motor vehicle and motor vehicle part manufacturing	0.08	1.09
Log sawmilling and timber processing	0.03	0.31	Other transport equipment manufacturing	0.34	-0.26
Other wood product manufacturing	0.18	1.23	Professional and scientific equipment manufacturing; Electrical equipment manufacturing; Reproduction of recorded media; Other manufacturing	1.14	-1.96
Pulp, paper and paperboard manufacturing	0.14	-0.26	Computer and electronic equipment manufacturing	2.93	0.55
Converted paper product manufacturing; Printing and printing support services	0.30	0.11	Domestic appliance manufacturing	1.66	-2.10
Petroleum and coal product manufacturing	0.01	0.82	Pump, compressor, heating and ventilation equipment manufacturing; Specialised equipment manufacturing; Other machinery and equipment manufacturing	0.33	-0.26

Basic chemical manufacturing; Basic polymer manufacturing	0.31	-3.83	Furniture manufacturing	1.48	0.74

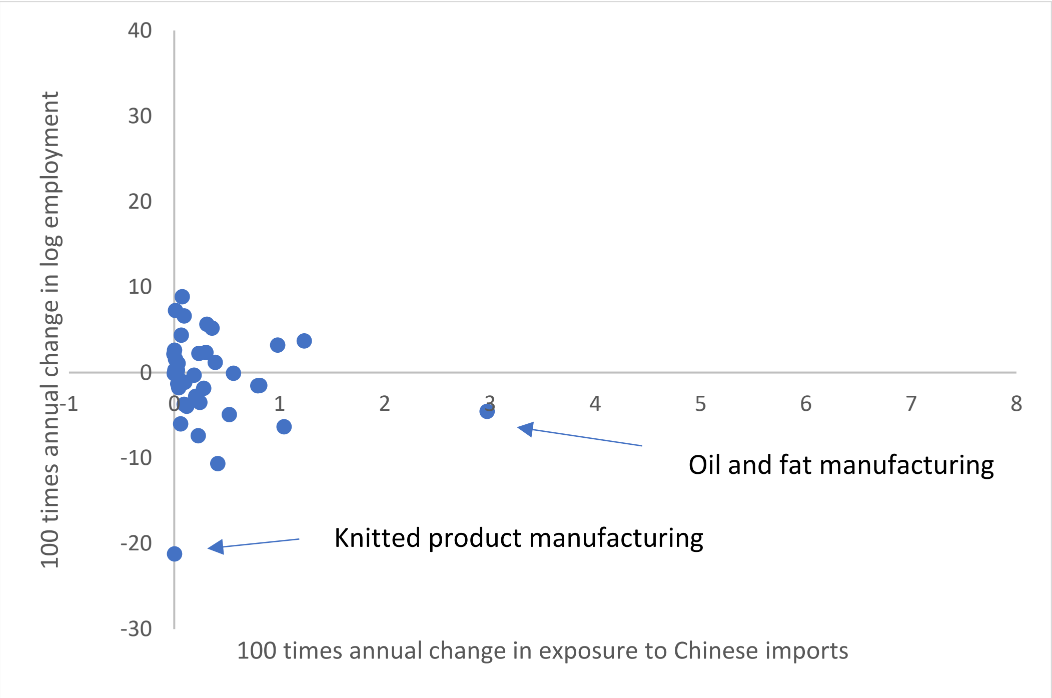
Notes: 1] Average change in Chinese import penetration: Equal to 100 times the average annual increase in the value of imports from China to Australia from 1991 to 2006 divided by total supply minus exports in Australia in 1992-93. ; 2] Average change in log employment: Equal to 100 times the average annual log change in employment from 1991 to 2006 - ABS, Labour Force Australia, Detailed Quarterly, catalogue no.6291.0.55.003, EQ06.

Appendix Figures 3.1: Changes in Chinese import penetration and employment, 38 manufacturing industries, 5-year periods

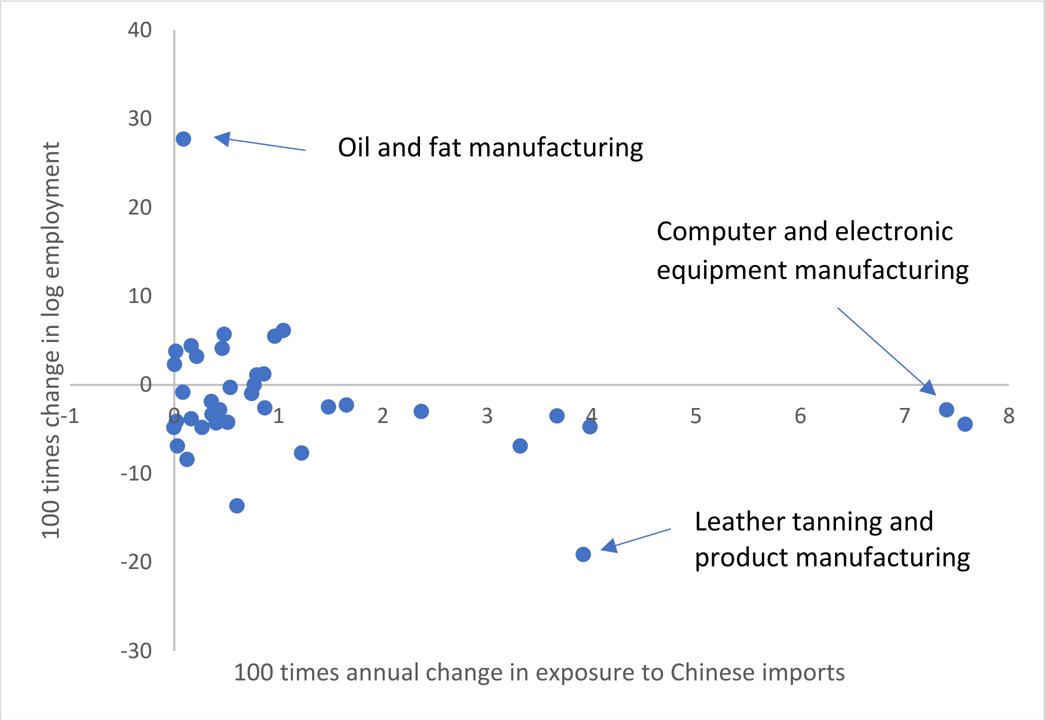
Panel A: 1991-96



Panel B: 1996-2001



Panel C: 2001-06



Notes: 1] 100 times annual change in exposure to Chinese imports: Equals 100 times the annualized increase in the value of imports from China to Australia over the indicated period divided by total supply minus exports by industry in Australia in 1992-93; 2] 100 times change in log employment: Equals 100 times log change in employment over the indicated period - ABS, Labour Force Australia, Detailed Quarterly, catalogue no.6291.0.55.003, EQ06.

Appendix Table 3.2: Effect of Chinese import penetration on log employment in manufacturing industry, OLS and 2SLS, Australia, 1991 to 2006 – Instrument constructed using EU-15 countries

		Whole sample		**Sub-periods**				
		1991-2006		**1991-1996**	**1996-2001**	**2001-2006**	**1991-2001**	**1996-2006**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
100 x annual Δ in AUS exposure to Chinese imports		-1.13*** (0.42)	-1.08* (0.56)	-2.89 (3.50)	-0.26 (1.71)	-1.13** (0.50)	-0.44 (1.62)	-1.08** (0.56)
1{1991-1996}	0.00 (0.44)	0.24 (0.44)	0.23 (0.44)					
1{1996-2001}	-0.73 (0.58)	-0.36 (0.53)	-0.38 (0.52)				-0.68 (0.73)	
1{2001-2006}	-1.17 (0.77)	0.22 (0.87)	0.16 (0.92)					0.53 (0.96)
Constant				0.61 (0.84)	-0.64 (0.66)	0.22 (0.88)	0.09 (0.52)	-0.38 (0.52)
Number of observations	114	114	114	38	38	38	76	76
Estimation method	OLS	OLS	2SLS	2SLS	2SLS	2SLS	2SLS	2SLS
1^{st} stage Partial R-squared			0.79	0.13	0.50	0.86	0.32	0.82
1^{st} stage F-statistic			112.0	4.79	12.3	116.0	14.7	114.0

Note: See Table 2.

Appendix Table 3.3: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, With industry controls, Australia, 1991 to 2006 – Instrument constructed using EU-15 countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
100 x annual Δ in AUS exposure to Chinese imports	-1.08** (0.56)	-1.13** (0.55)	-1.53*** (0.47)	-1.00* (0.52)	-1.07** (0.54)	-1.42*** (0.45)	-1.12** (0.54)	-1.41*** (0.44)	-0.89* (0.51)
2-digit industry FEs	No	Yes	No	No	No	Yes	No	Yes	No
Covariates – Technological change	No	No	Yes	No	No	Yes	No	Yes	No
Covariates – Change in average tariff rates	No	No	No	Yes	No	Yes	No	Yes	No
Pre-sample employment trend	No	No	No	No	Yes	No	Yes	Yes	No
38 industry FEs	No	No	No	No	Yes	No	Yes	No	Yes

Notes: See Table 3.

Appendix Table 3.4: Dynamic effects of Chinese imports

	1996-2006	**1991-2011**	**1991-2007**
	(1)	(2)	(3)
100 x annual Δ in AUS exposure to Chinese imports	0.12 (0.49)	-0.93 (0.58)	0.13 (1.00)
100 x annual Δ in AUS exposure to Chinese imports – lagged 5 years	-3.87*** (1.19)	0.31 (0.66)	
100 x annual Δ in AUS exposure to Chinese imports – lagged 8 years			-4.00 (3.27)
1{2001-2006}	-0.12 (0.91)	0.36 (0.99)	
1{2006-2011}		-2.46** (1.14)	
Constant	-0.05 (0.54)	-0.49 (0.55)	0.46 (0.90)
Number of observations	76	114	38
Estimation method	2SLS	2SLS	2SLS
1st stage Partial R-squared	0.85	0.87	0.93
1st stage F-statistic	34.1	165.0	74.9

Note: The sample consists of stacked log employment changes and changes in AUS exposure to Chinese imports for specified intervals from 1991-2011. The adapted version of the Acemoglu et al. (2016) set of countries is used to construct the instrument variable. In all specifications observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** p <0.01, ** p < 0.05, * p <0.1.

Appendix Table 3.5: Descriptive statistics for direct, upstream and downstream exposure to Chinese imports, 1991 to 2006

	Manufacturing				**Non-manufacturing**			
	Mean (SD)	**Median**	**Minimum**	**Maximum**	**Mean (SD)**	**Median**	**Minimum**	**Maximum**
Direct import exposure								
Direct exposure	0.59 (1.06)	0.20	-0.02	7.58				
Instrument for direct exposure	1.70 (2.98)	0.58	-0.58	26.06				
First-order indirect exposure								
Upstream exposure	0.13 (0.20)	0.05	0.00	1.31	0.03 (0.04)	0.02	-0.03	0.28
Instrument for upstream exposure	0.52 (0.77)	0.19	-0.07	4.94	0.79 (1.22)	0.22	-0.02	4.53
Downstream exposure	0.19 (0.34)	0.07	0.00	2.45	0.29 (0.47)	0.09	0.00	1.75
Instrument for downstream exposure	0.37 (0.51)	0.16	0.00	3.20	0.09 (0.11)	0.06	-0.18	0.89
Full (higher order) indirect exposure								
Upstream exposure	0.17 (0.27)	0.07	0.00	1.64	0.06 (0.08)	0.03	0.00	0.52

Instrument for upstream exposure	0.78 (1.04)	0.41	-0.06	6.24	1.64 (2.25)	0.56	0.00	7.56
Downstream exposure	0.29 (0.46)	0.11	0.00	3.08	0.60 (0.91)	0.23	0.00	3.02
Instrument for downstream exposure	0.49 (0.67)	0.24	0.00	3.77	0.18 (0.20)	0.13	-0.05	1.39

Notes: Direct exposure to Chinese imports is defined as 100 times the annualized increase in the value of imports from China to Australia over the indicated period divided by total supply minus exports by industry in Australia in 1992-93. The first-order indirect upstream (downstream) exposure measure is a weighted average of the direct import exposure experienced by its customers (suppliers). The full (higher-order) indirect upstream (downstream) measures are constructed using the Leontief inverse of the input-output matrix; see AADHP (2016, pp. S169-S171 for details). Instruments for the exposure measures are constructed in the same way, using changes in imports from China to the AADHP set of countries (Denmark, Finland, Germany, Japan, New Zealand, Spain, Switzerland and the United States). Observations are weighted using 1991 industry-level employment shares as weights.

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