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The impact of growth in manufactured imports from China on employment in Australia*

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Abstract

We examine how rapid growth in imports of manufactured goods from China affected employment in Australia from 1991 to 2006. Alternative sources of variation in Chinese import exposure – industry-level and between local labour markets – are used to identify the effect on employment. Growth in imports from China is estimated to have reduced manufacturing employment by around 75,000 workers, representing 7 per cent of that workforce in 1991. Largest impacts are found for manufacturing industries most exposed to import competition from China; and from 2001 to 2006 when import growth was strongest.

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1. Introduction

Australia's contact with the world economy rose steadily over the past 50 years.

International trade in goods and services to and from Australia grew from 25.2 to 41.0 per cent of GDP between 1971-72 and 2016-17.¹ Closely following that growth was concern about the impact on employment in trade-exposed industries (Tuhin, 2015; Leigh, 2017). From 1990 to 2018 import penetration of manufactured goods increased from 23 to 51 per cent, while the share of manufacturing in total employment fell from 14.4 to 7.4 per cent.²

Claims that international trade has been a major driver of developments in Australian labour market outcomes should, however, be treated with caution. No recent evidence exists on the causal impact of increased international trade. Existing Australian studies mainly examine periods ending in the late 1980s or early 1990s: see Borland and Foo (1996), Fahrner et al. (1994); Murtough et al. (1998) and Gaston (1998), and for a survey, see Borland (1999). Furthermore, other influences including technological change and reforms to labour market institutions have been proposed as explanations for trends in manufacturing employment.

Our main objective is to estimate the causal impact of recent growth in international trade on employment in Australia – for manufacturing industry and in aggregate. To identify a causal impact, we use the increase in imports of Chinese manufactured goods to Australia from 1991 to 2006. Increased imports from China – deriving from substantial productivity improvement in Chinese manufacturing industry following its transition to a market-based economy – arguably provide an ideal natural experiment for studying the effect of a rise in international trade.³ Figure 1 charts growth in imports of manufactured goods from China to Australia since the early 1990s. Between 1991 and 2006, manufacturing import penetration

¹ See <https://dfat.gov.au/trade/resources/trade-statistics/Pages/trade-time-series-data.aspx>; accessed 4/3/2020. Several factors explain this growth: liberalisation of trade policies by Australia and its trading partners; Australia's proximity to countries in Asia experiencing rapid economic growth; and shifts in manufacturing production from developed to newly industrialising countries (Pomfret, 2014).

² Import penetration was calculated from ABS, *Australian National Accounts: Input-Output Tables*, catalogue no. 5209.0.55.001. Imports are from the UN Comtrade Database, transformed from US into Australian dollars using the annual average exchange rate provided by the RBA. Employment shares are 4-quarter averages from ABS, *Labour Force Australia, Detailed*, Table 04.

³ 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 (see Campbell, 2017).

from China increased by 5.3 percentage points, accounting for about one-third of the total increase in import penetration to Australia during that period.

Our approach to identifying the effect of international trade and estimation method follow closely recent analyses for the United States by Autor et al. (2013) and Acemoglu et al. (2016). At the same time, an understanding of how increased exposure to Chinese manufactured imports has affected employment in Australia can only come from analysis of that experience. First, the situation of manufacturing employment was very different between Australia and the United States at the time when growth in Chinese imports commenced. By the early 1990s, manufacturing employment in Australia had already been decreasing for two decades, whereas in the United States it remained steady over that period. As well, the distribution of employment by industry – and hence the potential impact of import competition – differed between the countries. For example, food processing, relatively protected from trade with China, accounted for 18.4 per cent of manufacturing employment in Australia but only 8.1 per cent in the United States; whereas the trade-exposed industries of electronic and computer equipment and electric machinery were 14.4 per cent of manufacturing employment in the United States compared to 6.1 per cent in Australia (see Online Appendix Table 4.1 and Figure 4.1). Second, the impact of shocks to labour demand is mediated through labour market institutions which also differ between Australia and the United States. Research for several other countries has found that the size of impacts on employment from growth in Chinese imports has varied substantially between countries, providing further motivation for undertaking analysis for Australia (for example, Germany - Dauth et al., 2014; Norway - Balsvik et al., 2015; Spain - Donoso et al., 2015).

More generally, establishing the causes of the decline in manufacturing employment is important for several reasons. First, in most developed countries, manufacturing 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’, has given the industry an iconic status. Second, the uneven geographic distribution of manufacturing within countries means that its demise can bring significant regional adjustment issues and have important political implications (Autor et al., 2017). Third, the decline in manufacturing 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 (Charles et al., 2019; Barany and Siegel, 2018). Fourth, the decrease in manufacturing employment has had significant consequences

for social outcomes including health and marriage rates (Charles et al., 2018; Autor et al., 2019; Pierce and Schott, 2020; and for a survey see Autor et al., 2016).

We investigate how growth in Chinese manufactured imports has affected employment in Australia from 1991 to 2006. Two main approaches are used to identify that effect. The first uses industry-level variation in changes in exposure to imports from China. The second uses variation between local labour markets in changes to exposure. With both approaches, to identify a causal impact, we use Chinese imports to other high-income countries as an instrument intended to capture that part of the increase in imports attributable to productivity improvement in Chinese manufacturing, a plausibly exogenous source of variation.

The industry-level approach incorporates two channels through which effects of Chinese imports on employment could occur: (i) direct effects on industry-level employment due to increased imports of the same goods produced by an industry; and (ii) indirect spill-over effects that occur via input-output linkages. An illustration of the first channel is where an increase in imports of knitted products from China decreases demand for knitted products from Australian suppliers, and hence employment in that industry in Australia. The second channel exists where, for example, the increase in knitted product imports decreases demand by Australian knitted products producers for output from Australian suppliers in other industries, such as transport equipment, decreasing employment in those industries.

The local labour market approach encompasses the direct and spill-over channels as well as: (iii) effects from reallocation of labour towards expanding industries and away from import-competing manufacturing; and (iv) aggregate demand effects, where the negative effects from increased imports on employment are spread more broadly via decreases in consumption and investment. The third channel would occur, for example, if workers displaced from the knitted products industry are able to move to an expanding industry such as food processing. Effects on employment due to displaced workers from the knitted products industry having lower incomes and hence reducing their spending on items such as entertainment and personal services would represent the fourth channel.

Both approaches seek to incorporate economy-wide impacts that go beyond the direct effect of import competition. But the estimates cannot be regarded as necessarily equal to the overall effect of Chinese imports on employment in Australia. The industry-level approach cannot capture reallocation; and because identification is from inter-industry differences in

changes to import exposure, it cannot capture aggregate demand effects common to all industries. Similarly, while the local labour market approach does incorporate reallocation and aggregate demand effects, it can only capture those effects within regions. Effects (including spill-overs) that extend to other regions will be missed (Acemoglu et al., 2016).

Using the industry-level approach, we find that increased exposure to Chinese imports between 1991 and 2006 had a statistically significant negative impact on manufacturing employment in Australia. The direct effect of a 1 percentage point increase in import penetration from China is a 0.9 per cent decrease in manufacturing employment.⁴ Taking account of indirect spill-overs increases the magnitude of the negative effect slightly to 1 per cent. These impacts translate into estimated job losses in manufacturing of around 75,000 workers – representing 7 per cent of manufacturing employment in Australia in 1991.

The negative effect of growth in Chinese imports on employment differed over time, between industries and across different types of workers. We find stronger effects on employment from 2001 to 2006 when import growth was most rapid. Larger negative effects on employment occurred in industries most exposed to import competition such as textiles, clothing and footwear. Workers who were more likely to be employed in industries most affected – females and part-time workers – experienced the largest employment losses.

Our industry-level results are robust to an extensive set of sensitivity analyses. This includes using different high-income countries to construct the instrument variable, including controls for industry employment and using an alternative measure of import exposure. We also demonstrate that the impact of imports from China is not in part (or wholly) proxying for the effects of growth in imports from other low-income countries to Australia.

Using the local labour market approach, we estimate that increased exposure to Chinese imports reduced total employment by approximately 461,100. This comprises an estimated decrease in employment of 159,000 in *exposed tradeable* industries (proxying for direct and spill-over effects) and of 354,200 in *nontradeable* industries (proxying for an aggregate

⁴ Tuhin (2015) also finds a significant negative effect of import growth on manufacturing employment in Australia (late 1960s to early 2010s). Our analysis uses more disaggregated industries, incorporates general equilibrium spill-over effects within and outside manufacturing and arguably a more plausible basis for exogeneity in the measure of growth in international trade.

demand effect); offset only partially by an increase in employment of 52,100 in *non-exposed tradeable* industries (proxying for a reallocation effect).

We provide several important new findings about the effects of import competition on employment in Australia. First, the negative direct effect in Australia is found to be smaller than for the United States, likely due to Australian manufacturing being more insulated from Chinese imports. A shift within manufacturing away from labour-intensive and more trade-exposed industries such as clothing and footwear had already commenced in Australia prior to the growth in Chinese imports. Second, growth in Chinese imports had a stronger negative impact on manufacturing employment in Australia than imports from other low-income and Asian countries – because Chinese imports were more likely to be competing directly with Australian production. Third, the direct negative effect on employment at the local level due to increased imports that compete with Australian producers was exacerbated by decreased local aggregate demand due to job loss. This has implications for the types of policies needed to deal with the consequences of growth in international trade.

The rest of the paper is organised as follows. Section 2 describes the industry-level empirical method. 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 the industry-level analysis of direct and indirect spill-over effects. Section 7 describes the local labour market empirical method and section 8 presents the results using that method. Section 9 presents counter-factual predictions of the impact of increased Chinese imports on employment in Australia. Concluding comments and discussion are in section 10.

2. Industry-level estimation method

In this section we present the method used to estimate the direct effect of growth in imports from China on employment and the indirect spill-over effects from input-output linkages.

The **direct effect** is the effect on employment in a manufacturing industry in Australia due to increases in imports from China of goods from the same industry. For example, increases in imports of knitted products from China affect employment of workers producing knitted goods in Australia. Where Chinese imports compete with Australian production as a direct substitute, this will have a negative impact on employment.

Indirect effects on employment arise where Chinese imports of manufactured goods 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.⁵

An **upstream impact** occurs where employment in an industry is affected because it is a supplier to a manufacturing industry experiencing an increase in competition from Chinese imports. An example is where growth in imports of knitted products from China negatively affects the demand for transport equipment, and hence Australian employment in that industry. Any upstream effect would be expected to be negative unless Chinese producers are sourcing inputs from the same Australian suppliers.

A **downstream impact** occurs where employment in an industry is affected because it purchases inputs from another industry competing directly with Chinese imports. An example may be where growth in imports of computer and electronic equipment from China reduces prices of those inputs for producers of professional and technical services in Australia, allowing them to expand output and employment. The downstream effect could be positive or negative. In the example just given, the effect would be positive. However, it is possible that disruption to networks used by Australian producers to source inputs, due to imports from China crowding out local production, may cause reduced output and employment.

Direct effect

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

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

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

Manufacturing is disaggregated into 38 separate industries. Estimates are weighted by industry-level employment at the start of the sample period. Standard errors are clustered at the industry level to allow for arbitrary error correlations over time within industries.

⁵ The definitions of upstream and downstream are taken from Acemoglu et al. (2016) and are used in most studies. Some studies, however, do use reverse definitions of these terms.

We specify 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 t and $(t+1)$; and $Y_{j92-93} - E_{j92-93}$ is total domestic supply minus exports in 1992-93. Hence this measure scales the change in imports from China to Australia within a manufacturing industry against 1992-93 absorption in Australia for that industry.⁶

The coefficient of interest in equation (1) is β_1 . It can be interpreted as 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 OLS estimation may suffer from endogeneity bias. Growth in Chinese imports 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 demand by Australian consumers; or third, decreased supply by Australian producers. If the only source of the growth in imports 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 ε_{jt} may be correlated with growth in imports from China, ΔIP_{jt} , causing the estimate of β_1 to be biased (Autor et al., 2016).

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 again follow Acemoglu et al. (2016) by instrumenting for ΔIP_{jt} in (1) with ΔIPO_{jt} :

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

where ΔM_{jt}^{OC} is the change in the value of Chinese imports in industry j to other high-income countries between t and $(t+1)$; and the denominator is now defined as absorption in 1988-89.⁷

⁶ An alternative would be to update the absorption denominator over time. Broxterman and Larson (2019) discuss the trade-offs involved in this choice.

⁷ Input-output data for Australia are first available for 1988-89 and then again in 1992-93. We construct ΔIP_{jt} using 1992-93 data (around the start of our sample period) and use the earlier 1988-89 data to construct ΔIPO_{jt} to avoid mechanical correlation between the variable and its instrument.

The motivation for the instrumental variable (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, the increase in Chinese competitiveness must have created similar growth in imports to other high-income countries as Australia, and that growth must be uncorrelated with demand or supply shocks to manufacturing industries in Australia.

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 in Australia and the United States or New Zealand may be correlated. Hence, as robustness check we use countries where we believe correlated demand shocks are less likely: the group of EU-15 countries (used by Donoso et al., 2015): Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom. Note that removing the United Kingdom from this group does not affect our results.

Our main approach is to estimate effects from 1991 to 2006 as a stacked model with three 5-year intervals: 1991-1996, 1996-2001 and 2001-2006. We use this sample period and the 5-year intervals for several reasons. First, the start of 1991 is chosen to coincide with the beginning of the rise in Chinese imports to Australia. Second, the time intervals match with the Australian Census, the source of employment data used in the local labour market analysis. Third, we are concerned that going beyond 2006 would include the post-GFC period, reducing the plausibility of the assumption required for our IV: that demand shocks in Australia are uncorrelated with changes to imports to other high-income countries.

We apply several approaches to control for other influences on employment that might be correlated with increases in imports from China to Australia. First, we include indicators for 12 industry divisions, allowing for differential trends in employment across 2-digit industries. Second, we 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. Potential trade-related influences on

employment are also controlled for: the change in average tariff rate by industry as a proxy for the impact of trade liberalisation; and interactions of the 12 2-digit industry fixed effects with the change in the Australian Trade Weighted Exchange Index (TWI) to capture exchange rate effects that may differ by industry. Third, we control for the impact of pre-existing secular trends in employment by including the trend in industry-level employment from 1984 to 1991 (the period for which data are available prior to our estimation period). Fourth, we include indicators for each of the 38 industries in our sample.

An extensive range of robustness analysis is also undertaken. First, we examine whether the impact of Chinese imports might be proxying for growth in imports from other low-income and newly industrialised countries. Second, we conduct sensitivity checks: using Census employment data; changing the weighting method; 2-digit clustering of standard errors; and excluding outliers. Third, we use an alternative measure of Chinese import penetration.

Indirect effects via input-output linkages

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

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

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 from trade-induced impacts on its immediate buyers or suppliers, and the higher-order (full) spill-over effects from the full chain of linked buyers or suppliers. Both spill-overs between manufacturing industries and from manufacturing industries to non-manufacturing industries are investigated.

The first-order upstream effect is represented as:

$$\Delta IP_{jt}^U = \sum_g w_{gj}^U \Delta IP_{gt} \quad (5)$$

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 :

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

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 . The summation in the denominator runs over all industries (including non-manufacturing) and includes final demand by consumers and overseas customers, thus equalling total industry sales.

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. The denominator is still defined as the total of industry j ’s sales, so 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 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. 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:

$$\Delta IPO_{jt}^U = \sum_g w_{gj}^U \Delta IPO_{gt} \quad (7)$$

3. Data

Imports

Data on imports are from the UN Comtrade database which provides bilateral imports (and exports) expressed in USD values for 6-digit Harmonized Commodity Description and Coding System products (HS). To concord this HS data to our industry classification we apply 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.⁸ The concordance is carried out in three steps. In the first step, the HTISC codes are aligned to the HS codes by

⁸ 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.

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.⁹ Finally, all HS products assigned to the same 3-digit ANZSIC (2006) code are aggregated.

In our main analysis, all imports are measured in constant 2006 USD prices (using the US Personal Consumption Expenditure deflator).¹⁰ Using USD prices to express trade values allows us to measure import penetration in the way that best reflects changes in the volume of imports, and hence the potential scope for those imports to substitute for labour in Australia. The main alternative would be to express imports in Australian dollars. The problem with doing this is that over our sample period there were large changes in the AUD/USD exchange rate. Measures of imports from China to Australia therefore vary quite substantially for reasons unrelated to volume changes if converted to AUD. By contrast, during our sample period the US/China exchange rate was virtually unchanged. We test whether our findings are sensitive to measuring Chinese import penetration in AUD and deflating using an Australian manufactured good import price deflator. We provide a more detailed explanation for why we express imports in US dollars in Online Appendix 1.

Input-output measures

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. 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 USD using Comtrade conversion factors. 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 in using the input-output data is that classification of industries 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 ANZSIC (2006) system required aggregating some of the 55 3-digit manufacturing industries, resulting in 38 separate

⁹ Where HTISC codes mapped to more than one industry, imports were split evenly between them.

¹⁰ US Bureau of Economic Analysis Personal Consumption Expenditure Price Index. Accessible at: <https://www.bea.gov/data/personal-consumption-expenditures-price-index>.

manufacturing industry categories. For the analysis which incorporates spill-overs, we also include 29 non-manufacturing industries. See Online Appendix 2 for concordance details.

Direct and indirect effects

Data on employment by industry are from the Australian Bureau of Statistics (ABS) Labour Force Survey (catalogue no. 6291.0.55.003). We use measures of total persons employed and hours worked in 3-digit ANZSIC (2006) industries; and disaggregated measures of persons employed by sex and full-time/part-time status.

Construction of the industry-level covariates draws on a variety of sources (see Online Appendix 3 for details). ABS establishment-level surveys are used to obtain data on wages and salaries per employee for 1991-92 and R&D as a share of turnover for 1990-91. Data on the share of production workers is from the 1987 ABS Census of Manufacturing Establishments. Data on average tariff rates by industry is constructed using the World Integrated Tariff Solutions (WITS). Data on pre-sample trends in employment are from the ABS Labour Force Survey. Exchange rate data were constructed from Reserve Bank of Australia (RBA) historical exchange rate series as the annual average of monthly figures.

Reallocation and aggregate effects

Data on total employment and employment by industry for disaggregated geographic regions was sourced from customized tables of counts from the 5-yearly Australian Censuses from 1991 to 2006 provided by the Australian Bureau of Statistics (see Coelli et al., 2020).

4. Descriptive statistics

Descriptive information on changes in imports of manufactured goods from China and changes in employment in manufacturing industries in Australia is presented in Table 1. Manufacturing employment in Australia decreased by 0.63 of a log point per year between 1991 and 2006.¹¹ Over the same period, the employment-weighted mean of industry-level Chinese import penetration increased by 0.65 of a percentage point per year. Growth in import penetration was more rapid in the first half of the 2000s than in the 1990s.

¹¹ 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.

Specialisation by China means that changes to import penetration – and hence the potential impact on employment – varied across the 38 manufacturing industries. Figure 2 presents industry-level information on changes in Chinese import penetration and employment from 1991 to 2006.¹² Most industries saw increased Chinese import penetration of between zero to 0.5 per cent per year and had changes in employment ranging from minus 2 to plus 2 per cent per year. Quite a few industries also had larger changes in import penetration and employment. 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. 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 relation between industry-level changes in employment and Chinese import penetration.

5. Direct effects

Estimates of the direct effect on employment of growth in Chinese import penetration for the basic model are presented in Table 2. Column (1) includes time indicators that reflect the employment-weighted mean annual change in employment over those intervals. Column (2) presents an OLS estimate of the impact of increases in Chinese import penetration. Column (3) reports estimated impacts using two-stage least squares (2SLS). Columns (4) to (8) report 2SLS estimates for sub-periods. First-stage results for 2SLS models in the bottom rows of the table. In all models, 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 on manufacturing employment are similar in magnitude for the OLS and 2SLS methods and both are significant at the 5 per cent level. The 2SLS estimate for the whole sample period implies that a 1 percentage point increase in import penetration reduces employment by 0.89 per cent. This is smaller than the estimate of -1.30 for the United States reported by Acemoglu et al. (2016). There is substantial variation in the size of estimated effects over time. Indeed, only in the final sub-period (2001-06) is the effect statistically significant. This is likely to reflect increasing scope to identify the impact of changes to Chinese imports due to more rapid growth and greater variation in growth between industries in the final sub-period. The increased average size and

¹² The industry-level data underlying Figure 2 are provided in Online Appendix Table 4.2.

heterogeneity of industry-level changes in Chinese import penetration in 2001-06 compared to earlier periods can be observed in Online Appendix Figure 4.2.

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 (7) add various combinations of the control variables: 2-digit industry fixed effects; covariates to proxy for the industry-level rate of technological change and other international trade-related influences; and a pre-sample employment trend. Column (8) includes the 38 industry fixed effects.

Adding combinations of the control variables in most cases maintains or slightly increases the size and significance of the estimated effect of Chinese import penetration. The main exception is when we only add indicators for 2-digit industries in column (2). However, if these indicators are added together with other covariates (column 6), the estimated effect size is essentially the same and its precision improves. Adding the 38 industry fixed effects (column 8) marginally lowers the effect size but it remains significant. Altogether, both within and between-industry variation in Chinese import growth are found to be important sources of the overall estimated impact on employment.

Additional robustness exercises are reported in Table 4. Columns (1) to (4) show 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. In column (6) observations have been weighted by industry shares of employment at the beginning of each 5-year time interval and in column (7) observations are unweighted. Column (8) uses data from the ABS Census to construct the 5-year changes in industry-level employment. To do this check it was necessary to aggregate to 28 manufacturing industries. Column (9) 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 its significance are not sensitive to using alternative instruments or to changes in model specification. The estimates remain in a narrow range between -0.79 and -0.98. As with the base model, when extra controls are added to the model with the instrument constructed from the EU-15 countries,

the estimated direct effect is similar in size and more precisely estimated.¹³ The weighting method, clustering at the 2-digit industry level and adding the extra 5-year period have little impact on the estimate. Using ABS Census employment data does reduce the magnitude of the estimated effect but it remains significant. The difference is mainly due to the change in industry classification. Using LFS employment data and the same 28 industries the estimated impact of Chinese imports falls to -0.31 (se=0.17). Further checks reported in Online Appendix 5 (excluding outlier industries and a falsification analysis) also find that the estimated effect of Chinese imports is highly robust.

Table 5 shows estimated impacts disaggregated by gender and hours of work. The negative impact is much larger (and only significant) for females. There is also a larger negative effect on part-time than full-time employment. This may explain why the estimated impact on total hours worked is smaller and less significant than for employment. Impacts by gender and hours of work reflect the industry composition of the growth in Chinese imports – and especially the negative effect on textile, clothing and footwear industries, which had above-average shares of female workers and part-time jobs when compared with other industries.

Table 6 reports findings from models that include manufactured goods imports from extra countries to construct the import penetration variable. Column (2) adds imports from the 55 low-income countries as identified by the World Bank in 1989. Column (3) also adds imports from four “newly industrialising” Asian countries (Indonesia, Malaysia, the Philippines and Thailand). Column (4) adds imports from the four Asian tiger countries (Hong Kong, Singapore, South Korea and Taiwan).

Adding imports from the set of low-income countries and the newly industrialising countries to the import penetration variable does not affect the estimated impact on employment. When imports from the Asian tigers are also included, the effect becomes smaller and insignificant. Including other countries also does not affect the timing of the impact of import growth on employment in Australia. For example, using the import penetration variable for China and other low-income countries, the only significant effect is for the sub-period 2001-06 (see Online Appendix Table 4.5).

¹³ The results in Tables 2 and 3 are replicated using the EU-15 set of countries to construct the instrument variable in Online Appendix Tables 4.3 and 4.4.

That the main impact on employment in Australia due to import growth would come from China rather than these other countries can be understood in two ways. First, only small proportions of the increase in import penetration to Australia from 1991 to 2006 came from low-income countries, the Asian newly industrialising countries and the Asian tigers (see Online Appendix Figure 4.3). Instead, the growth in 1991-2001 came mainly from other developed countries; and in 2001-06 primarily from China. Second, increased imports from the other countries were predominantly in response to increasing Australian demand and from higher value-add industries. Hence, they had a smaller effect on Australian employment than the same value of imports of more labour-intensive products from China.

Measuring Chinese import penetration in AUD and deflating using an Australian manufactured good import price deflator does not substantially affect our findings (see Online Appendix Table 4.6). In the base 2SLS model, a 1 percentage point increase in import penetration is estimated to decrease employment by 0.75 per cent ($se=0.38$). Consistent negative effects are found in all sub-periods although only significant in 2001-06. The reason why the findings are not sensitive to the choice of prices is that AUD/USD exchange rate movements are mirrored in changes in the import price deflator, effectively cancelling each other out (and implying that Australia is essentially a price-taker on world markets for manufactured goods). Online Appendix 1 provides more detailed coverage of this point.

6. Indirect spill-over effects

Indirect spill-over effects are estimated for the three 5-year time intervals from 1991 to 2006 including 38 manufacturing and 29 non-manufacturing industries. Results are reported in Table 7 separately for first-order effects on an industry's immediate buyers or suppliers (Panel A) and higher-order effects from the full chain of trade-induced impacts on an industry's linked buyers or suppliers (Panel B). 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 results from a specification that combines the direct and upstream exposure for all industries. All models include time indicators.¹⁴

¹⁴ Descriptive statistics for variables used in the estimation are in Online Appendix Table 4.7.

Several main findings come from Table 7. First, upstream effects estimated for all industries are negative, consistent with our prediction. These effects are generally large in magnitude and significant for non-manufacturing but not manufacturing industries. Second, estimated downstream effects are small in magnitude and never significant, consistent with the existence of potentially off-setting drivers of the downstream effect. Third, pooling across all industries we find a large and significant combined impact of direct and upstream effects on employment. A 1 percentage point increase in Chinese import penetration causes a 2 per cent decrease in employment in Australia. Fourth, 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 effects 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 are agriculture and fishing; forestry; and oil and metal extraction.

7. Local general equilibrium effects estimation method

We now employ local labour market (LM) analysis to estimate employment effects of increased exposure to Chinese imports of manufactured goods. This approach uses variation in changes in import penetration between regions to estimate the effect on employment. The LM approach encompasses direct and indirect effects; and allows for general equilibrium effects on employment from reallocation and aggregate demand.

We begin by estimating a model for the effect of Chinese imports on total employment; and then seek to decompose that effect into separate impacts on exposed tradeable, nonexposed tradeable and nontradeable sectors. Roughly speaking, the effect on employment in the *exposed tradeable* sector can be thought of as corresponding mainly to the direct effect; the effect on employment in the *nonexposed tradeable* sector as a reallocation effect; and the effect on *nontradeable* industries as representing the aggregate demand (and possibly to some extent reallocation) effect.

The overall effect on employment is estimated from the model:

$$\Delta L_{it} = \gamma_t + \beta_1 \Delta IP_{it}^{LM} + \beta_2 X_{i0} + \varepsilon_{it} \quad (8)$$

where ΔL_{it} equals 100 times the annual change in the overall employment to working-age population ratio in LM i from period t to $(t+1)$; γ_t are time indicators; X_{i0} is a set of LM control variables detailed below; and ε_{it} is an error term.

The main variable of interest is ΔIP_{it}^{LM} , which measures the annual change in import exposure in LM i from t to $(t+1)$. It is constructed as follows:

$$\Delta IP_{it}^{LM} = \sum_j \frac{L_{ijt}}{L_{it}} \Delta IP_{jt} \quad (9)$$

where ΔIP_{jt} is the same industry j exposure measure in period t defined in equation (2); L_{ijt} is the start of period t employment in LM i in industry j ; and L_{it} is start of period t total employment in LM i . The variation in ΔIP_{it}^{LM} across LMs is driven solely by local industry employment shares at the start of each period.

We again estimate this model via IV regression, using imports from China to the eight developed countries to construct our instrument. To be specific, we construct our instrument ΔIPO_{it}^{LM} using the above equation after replacing ΔIP_{jt} with ΔIPO_{jt} (defined in equation (3)).

We define 124 LMs across Australia which were constructed such that 95 per cent of workers both live and work within those markets (see Coelli et al., 2020). These LMs are akin to the US commuting zones (CZs) analysed by Acemoglu et al. (2016) and Autor et al. (2013). Summary statistics describing our LM-level import exposure measures and changes in employment to population rates are provided in Online Appendix Table 4.8.

To estimate exposure effects separately by sector, we use the following equation:

$$\begin{aligned} \Delta L_{ikt} = & \gamma_{kt} + \beta_1 \Delta IP_{it}^{LM} \times 1\{exposed\ tradeable_k\} \\ & + \beta_2 \Delta IP_{it}^{LM} \times 1\{nonexposed\ tradeable_k\} \\ & + \beta_3 \Delta IP_{it}^{LM} \times 1\{nontradeable_k\} + \beta_4 X_{ik0} + \varepsilon_{ikt} \end{aligned} \quad (10)$$

where ΔL_{ikt} equals 100 times the annual change in the ratio of employment in sector k to working-age population in LM i in period t .

The first sector includes industries *exposed* to the Chinese import shock. In this sector, we include all manufacturing industries where predicted direct import exposure increased by at least 2 percentage points over 1991-2006. We also include industries where the predicted full upstream effect increased by at least 4 percentage points. This expands the set of *exposed*

tradeable industries by including one other manufacturing industry and one mining industry (non-metallic mineral mining and quarrying) that sell significant shares of their output to directly exposed industries. Overall, 31 of 38 manufacturing industries were identified as *exposed tradeable*, along with this one mining industry.

Our second broad sector, *nonexposed tradeable*, includes all agriculture, mining and manufacturing industries that were not identified as being exposed to increased Chinese imports. If there are reallocation effects at the local level, employment may well increase in this sector as workers move out of *exposed* industries. These industries can trade their output both internationally and with other LMs within Australia. The non-exposed manufacturing industries include several food product industries and petroleum and coal product. The final sector, *nontradeable*, includes all service industries. These service sector industries may contract in response to increased import exposure at the local level as employment and production declines in *exposed* industries.¹⁵

8. Local general equilibrium effects

Estimates based on equation (8) are presented in columns (1) to (3) of Table 8. The estimate in column (1) highlights a significant negative effect of increased exposure to Chinese imports on the LM employment rate. An increase in import exposure of 1 percentage point is related to a 2.3 percentage point lower LM employment rate among the working-age population. To provide some perspective on the economic size of this effect, compare the LM with increased exposure at the 25th percentile (0.292) with the LM at the 75th percentile (0.827). The second LM is estimated to have a 1.2 percentage point lower employment rate than the first due to the larger increase in Chinese import exposure between 1991 and 2006.

In column (2) of Table 8 we add controls for the initial manufacturing share of employment in a LM. This allows for differential trends in employment across manufacturing and non-manufacturing sectors. In column (3) we add state indicators which allow for differential employment trends across states. The main estimate is robust to these additional controls.

¹⁵ Overall, *exposed tradeable* industries were 12 per cent of 1991 employment, *nonexposed tradeable* industries comprise 8 per cent and *nontradeable* industries the remaining 80 per cent.

Estimates of equation (10) are presented in columns (4) to (6) of Table 8. Local employment in *exposed tradeable* industries falls considerably in response to increased Chinese import penetration. A 1 percentage point increase in LM import exposure is estimated to cause a 1.5 percentage point decline in the share of the working-age population working in *exposed* industries. Given that mean LM exposure increased by 1.2 percentage points between 1991-2006, this implies that increased import penetration from China lowered employment rates in exposed industries by 1.8 percentage points.

Consistent with re-allocation, employment increases in *nonexposed tradeable* industries, but not by enough to fully offset the decline in employment in *exposed* industries. It is important to keep in mind, however, that we do not capture indirect and re-allocation effects that extend outside a LM – such as where a displaced worker relocated to another LM to work in a nonexposed industry. There also appears to be a large negative local aggregate demand effect, with employment in *nontradeable* industries falling considerably in exposed LMs relative to less exposed LMs. Our findings differ from those reported by Acemoglu et al. (2016) for the United States, where no negative local aggregate demand effect on *nontradeable* industries was found.

9. Implied employment changes in manufacturing

Estimates 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:

$$\Delta L_t^{cf} = \sum_j L_{jt} (1 - e^{-\hat{\beta}_1 \Delta \hat{P}_{jt}}) \quad (11)$$

where $\hat{\beta}_1$ is the 2SLS estimate from (1) and $\Delta \hat{P}_{jt}$ is the increase in import penetration to Australia attributable to China's improving productivity between a base year and year t .¹⁶ 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.

¹⁶ Following Acemoglu et al. (2016) we estimate $\Delta \hat{P}_{jt}$ by multiplying the observed increase in import penetration by the partial R-squared (0.84) from the first-stage regression of (2) on (3). Where the instrument is valid, and in the absence of measurement error, $\Delta \hat{P}_{jt}$ is a consistent measure of the contribution of increases in imports from China to changes in import penetration.

Table 9 presents implied changes in employment in Australia due to growth in Chinese imports using estimated impacts from the industry-level and LM approaches. We begin with implied changes derived from the industry-level estimates. Two implied changes (rows (1) and (2)) are based on estimates of direct effects (with and without control variables) at the industry level. The next two are based on estimates of the sum of direct and upstream spill-over effects, again at the industry level. Changes estimated using first-order spill-over effects are in rows (3) to (5), and for higher-order effects in rows (6) to (8). We report changes in employment in aggregate, and separately for manufacturing and non-manufacturing.

Estimated total manufacturing job losses from 1991 to 2006 using the industry-level approach range from 53,200 (including only direct effects) to 78,900 (also incorporating first-order upstream effects). Compared to 1991 these effects would have implied decreases in manufacturing employment of between 5.3 and 7.5 per cent.¹⁷ The 95 per cent confidence intervals for the negative effect on employment range from around 5,000 to 150,000 persons.

Figure 3 shows the implied changes in employment by industry due to the estimated direct impact of growth in Chinese imports from 1991 to 2006. The main impression is of significant heterogeneity in the impact on employment. For one industry, knitted products, growth in Chinese imports is estimated to have decreased employment by over 100 per cent of its 1991 level.¹⁸ In several other industries the reduction in employment is estimated to be about 30 to 40 per cent. In general, industries that were most exposed to competition from imports in 1991 have the largest implied decreases in employment: 16 per cent for above-median exposure industries compared to 4 per cent for below-median exposure industries.¹⁹

Between 1991 and 2006 the actual decrease in manufacturing employment in Australia was 48,000 or 4.5 per cent. That this is smaller than the predicted change in employment reported in Table 9 might be taken to imply that the growth in Chinese import penetration more than accounts for the actual decline in manufacturing employment over this period. However, this would be to exaggerate the impact of Chinese imports. In a 'no change' scenario, where

¹⁷ Spill-over effects on employment in non-manufacturing industries are much smaller than for manufacturing employment. It is at most 0.3 per cent of non-manufacturing employment in 1991 (19,500 divided by 6,604,000).

¹⁸ Actual employment in this industry decreased from 9,500 in 1991 to 2,500 in 2006.

¹⁹ Fahrer and Pease's (1994) analysis of sources of changes in manufacturing employment from 1981/82 to 1991/92 also finds that the impact of import growth varied substantially by industry with largest impacts on textiles, clothing and footwear; chemicals; and other machinery and equipment.

employment in manufacturing grew at the same rate as in non-manufacturing 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. From this perspective, increased imports of manufactured goods from China explain at most one-fifth 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.

We now turn to use the LM estimates from column (6) of Table 8 to construct implied changes in aggregate employment due to increased import competition. These are shown in rows (9) to (12) of Table 9. To derive the predictions, we construct the total increase in exposure at the LM level over the 1991-2006 period, multiply it by the relevant estimated coefficient on the ΔIP_{it}^{LM} variable,²⁰ multiply that by LM working-age population in 2006, and then finally sum across LMs. Again, these predictions are constructed assuming all other factors affecting local employment remain unchanged and are based on variation across LMs only. They will not reflect any re-allocation of employment between LMs.

The overall estimated effect of increased exposure to Chinese imports is a reduction in employment of approximately 461,100. This overall effect includes a direct reduction of 159,000 jobs in *exposed* industries offset to some extent by an increase of 52,100 jobs in *nonexposed tradeable* industries. The aggregate demand effect, however, is a reduction of 354,200 jobs in *nontradeable* industries. The 95 per cent confidence interval for the negative effect on total employment ranges from about 300,000 to 600,000 persons.

10. Conclusion/Discussion

Substantial growth in imports from China to Australia occurred from the early 1990s onwards. This study examines 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 1 percentage point increase in import

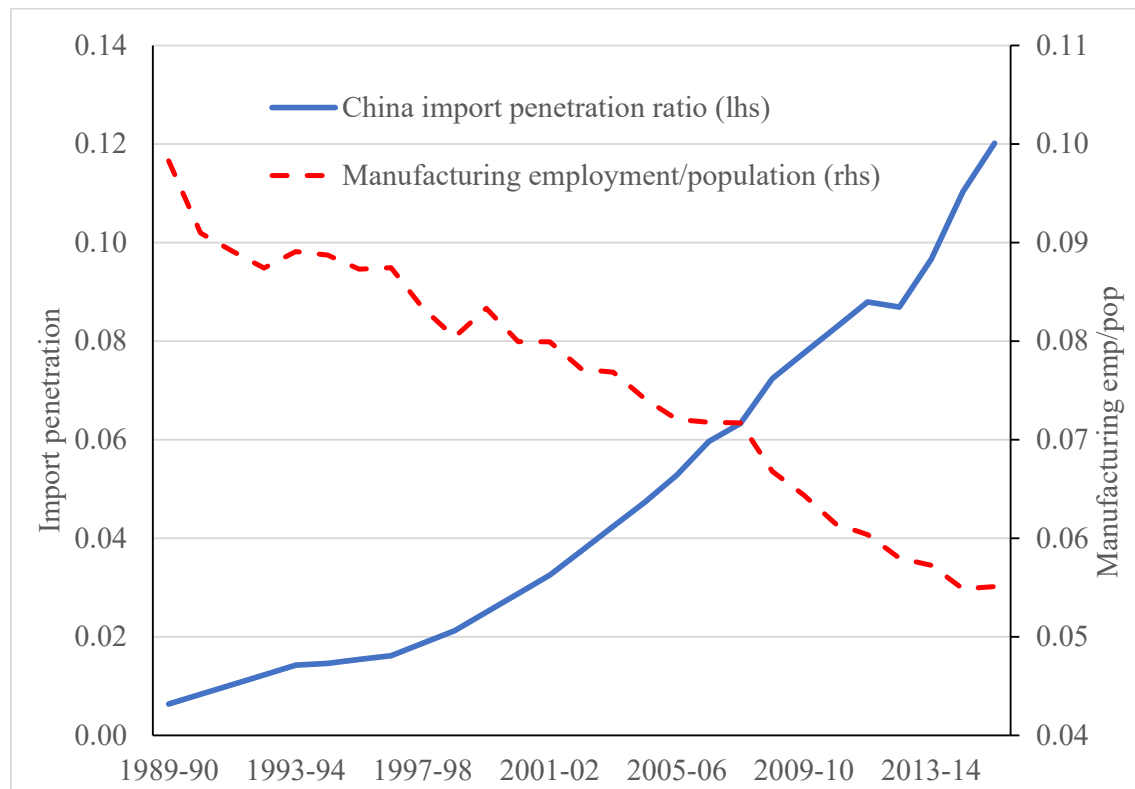
²⁰ We again multiply this coefficient by the first-stage partial R-squared value of 0.84 to ensure it is a consistent estimate of the predicted increase in exposure based on imports to our instrument countries.

penetration was a 0.9 per cent decrease in employment; and taking account of indirect spill-overs increases the negative effect to 1 per cent. These impacts translate into estimated job loss in manufacturing industry of between 53,200 and 78,900 workers – accounting for 5.3 to 7.5 per cent of manufacturing employment in Australia in 1991. The results are robust to an extensive set of sensitivity analyses.

Overall, the effect of growth in Chinese imports on employment in manufacturing in Australia from 1991 to 2006 can be described as sizeable; and may have accelerated slightly the 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 where the largest increases in Chinese imports have occurred, and where higher imports have the largest negative impact on employment, implied employment effects are substantial – with the most pronounced effects for textiles, clothing and footwear.

One obvious point that nevertheless deserves emphasis is that our 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 focusing on the impacts of growth in imports of Chinese manufactured goods on labour market outcomes, we are looking at just the ‘cost’ side of the ledger. We do not take account of the labour market ‘gain’ from the massive growth in Australian exports since the mid-1990s; nor of the benefits to households from decreased prices of manufactured goods due to increased competition (Kearns and Lowe, 2011).

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



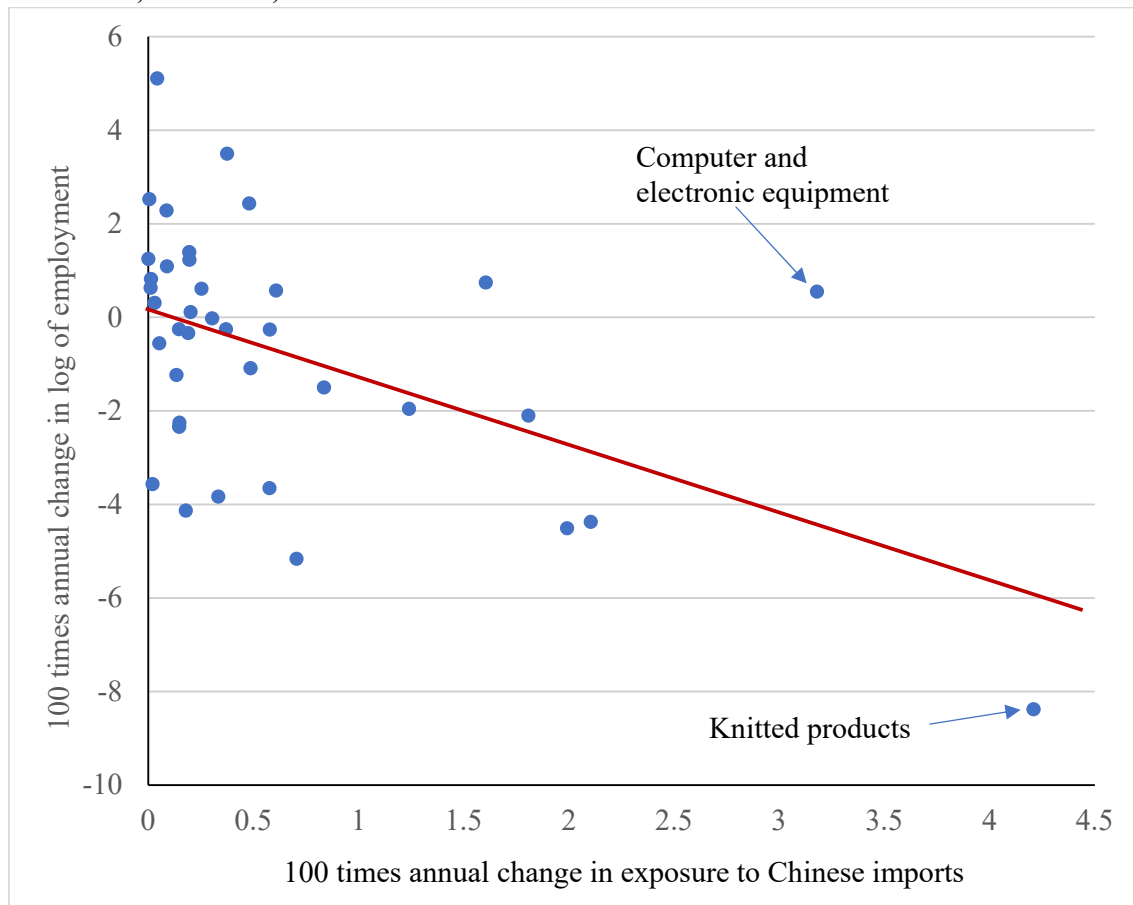
Notes: (i) Chinese import penetration to Australia equals (Manufacturing imports to Australia from China)/(Gross manufacturing output in Australia plus imports minus exports). Data for the denominator are from ABS, *Australian National Accounts: Input-Output Tables*, catalogue no.5209.0.55.001 for 1989-90, 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).

Table 1: Summary statistics

	1991-2006				1991-1996	1996-2001	2001-2006
	Mean (SD)	Median	Min	Max	Mean (SD)	Mean (SD)	Mean (SD)
100 x annual Δ in AUS exposure to Chinese imports	0.65 (1.16)	0.23	-0.02	8.34	0.22 (0.39)	0.37 (0.50)	1.35 (1.71)
Instrument for Δ in AUS exposure to Chinese imports	14.96 (26.67)	5.04	-4.66	231.87	7.99 (13.45)	10.18 (15.06)	26.70 (39.35)
100 x annual log Δ in employment in manufacturing industries	-0.63 (3.59)	-0.37	-21.19	27.74	0.01 (2.83)	-0.73 (3.46)	-1.17 (4.31)
100 x annual log Δ in total hours employed in manufacturing industries	-0.55 (3.88)	-0.68	-21.90	24.49	0.53 (2.93)	-1.17 (3.82)	-1.01 (4.57)
Number of observations	114	114	114	114	38	38	38
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)
Number of observations	87	87	87	87	29	29	29

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.

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



Sources: 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 Online Appendix 2 for a description of construction of 38 manufacturing industries. The solid line is the predicted relation between the change in employment and change in import penetration (observations weighted by initial employment), with a slope of -1.29 (se = 0.61).

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

	Whole sample 1991-2006			Sub-periods				
	(1)	(2)	(3)	1991-1996 (4)	1996-2001 (5)	2001-2006 (6)	1991-2001 (7)	1996-2006 (8)
100 x annual Δ in AUS exposure to Chinese imports		-1.04** (0.39)	-0.89** (0.41)	-2.01 (1.51)	0.45 (1.48)	-0.92** (0.38)	-0.71 (1.05)	-0.80* (0.42)
1{1991-1996}	0.01 (0.44)	0.24 (0.44)	0.21 (0.42)					
1{1996-2001}	-0.73 (0.58)	-0.34 (0.52)	-0.40 (0.52)				-0.64 (0.75)	
1{2001-2006}	-1.17 (0.77)	0.23 (0.87)	0.02 (0.89)					0.34 (0.93)
Constant				0.46 (0.45)	-0.90 (0.61)	0.06 (0.87)	0.17 (0.42)	-0.43 (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			0.85	0.93	0.58	0.89	0.71	0.85
1 st stage F-statistic			78.2	114.0	17.8	56.4	32.1	60.6

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 specifications 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)
100 x annual Δ in AUS exposure to Chinese imports	-0.89** (0.41)	-0.45* (0.25)	-1.27*** (0.32)	-0.75** (0.35)	-0.89** (0.42)	-0.77*** (0.27)	-0.79** (0.37)	-0.66** (0.29)
2-digit industry FEs	No	Yes	No	No	No	Yes	No	No
Covariates – Technological change	No	No	Yes	No	No	Yes	Yes	No
Covariates – Change in average tariff rates	No	No	No	Yes	No	Yes	Yes	No
Pre-sample employment trend	No	No	No	No	Yes	Yes	Yes	No
Δ TWI \times 2-digit industry FEs	No	No	No	No	No	No	Yes	No
38 industry FEs	No	No	No	No	No	No	No	Yes

Notes: All columns report results from stacking log employment changes and changes in AUS exposure to Chinese imports for five-year periods 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.

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

	Instrument countries:				2-digit clustering	Weighting		ABS Census employment data	Extended period 1991-2011
	US excluded	EU-15	EU-15 ex. UK	EU-15, plus controls		Varying	None		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
100 x annual Δ in AUS exposure to Chinese imports	-0.93** (0.44)	-0.98* (0.50)	-0.92* (0.48)	-0.85** (0.42)	-0.89** (0.40)	-0.82** (0.41)	-1.02** (0.52)	-0.37** (0.18)	-0.79** (0.40)
Number of observations	114	114	114	114	114	114	114	84	152
1 st stage Partial R-squared	0.77	0.79	0.76	0.70	0.85	0.88	0.84	0.95	0.75
1 st stage F-statistic	165.0	108.0	88.6	43.3	47.8	116.0	41.4	4472.0	241.0

Notes: Columns (1) to (7) 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 set of instrument countries. Columns (2) and (3) derive the instrument variable (import penetration) 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 includes the set of controls from column (6) in Table 3. Columns (5) to (9) report findings with the adapted version of the Acemoglu et al. (2016) set of instrument countries. In columns (1) to (4) and (6) to (9), 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), (8) and (9), observations are weighted by 1991 industry-level employment. In column (6) observations are weighted with industry-level employment at the start of each 5-year interval while in column (7), observations are unweighted. Column (8) 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 (9) reports results from expanding the sample period by adding the 5-year period from 2006-11.

Table 5: 2SLS Estimates of Chinese import penetration on log employment in manufacturing industry, Australia, 1991 to 2006
Disaggregated effects by gender, type of employment and using hours of employment

	Baseline	Males	Females	Full-time	Part-time	Hours
	(1)	(2)	(3)	(4)	(5)	(6)
100 x annual Δ in AUS exposure to Chinese imports	-0.89** (0.41)	-0.18 (0.53)	-1.30*** (0.34)	-0.69 (0.47)	-1.17*** (0.42)	-0.67 (0.45)
Number of observations	114	114	114	114	114	114
1 st stage Partial R-squared	0.85	0.82	0.84	0.85	0.85	0.85
1 st stage F-statistic	78.2	94.8	55.4	77.6	87.0	78.8

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 in the specific disaggregated sub-sample. Standard errors in parentheses are clustered at the level of the 38 industries. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6: 2SLS estimates of import penetration from country groups on log employment in manufacturing, Australia, 1991 to 2006

Imports from:	China	China + other Low- Income Countries (LICs)	China + LICs + Newly Industrialising Asian Countries (NICs)	China + LICs + NICs + Asian “Tiger” Countries
	(1)	(2)	(3)	(4)
100 x annual Δ in AUS exposure to imports from countries identified above	-0.89** (0.41)	-0.98** (0.39)	-0.80* (0.41)	-0.63 (0.40)
Number of observations	114	114	114	114
1 st stage Partial R-squared	0.85	0.90	0.76	0.51
1 st stage F-statistic	78.2	197.0	216.0	152.0

Notes: The adapted version of the Acemoglu et al. (2016) set of instrument countries is used to construct an average import penetration measure. All models include time indicators. In column (2), imports from the full set (including China) of 55 low-income countries as identified by the World Bank in 1989 are used to construct the exposure measure. This group was also analysed in Autor et al. (2013). In column (3), imports from four “newly industrialising” Asian countries are added to construct exposure: Indonesia, Malaysia, the Philippines and Thailand. In column (4) imports from four “Asian Tiger” countries are added to construct exposure: Hong Kong, Singapore, South Korea and Taiwan. In all specifications, observations are weighted by 1991 industry-level employment. Standard errors in parentheses are clustered at the level of the 38 industries. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Low income country list:

Afghanistan, Albania, Angola, Armenia, Azerbaijan, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Burma, Cambodia, Central African Republic, Chad, China, Comoros, Republic of the Congo, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Georgia, Ghana, Guinea, Guinea-Bissau, Guyana, Haiti, India, Kenya, Laos, Lesotho, Madagascar, Maldives, Mali, Malawi, Mauritania, Moldova, Mozambique, Nepal, Niger, Pakistan, Rwanda, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Sierra Leone, Somalia, Sri Lanka, Sudan, Togo, Uganda, Vietnam and Yemen.

Table 7: 2SLS estimates of import effects on employment incorporating input-output linkages

	Manufacturing industries			Non-manufacturing		All industries			
	N=38			N=29		N=67			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
A) First-order I/O linkages									
Direct import exposure	-0.83*	-0.80*	-0.47*			-0.89	-1.08*	-0.31	
	(0.44)	(0.47)	(0.24)			(0.65)	(0.61)	(0.53)	
Upstream import exposure	-1.06	-1.79	0.45	-14.61**	-42.46**	-8.72*	-6.67***	-5.56	
	(2.72)	(3.88)	(1.52)	(5.71)	(18.07)	(4.60)	(2.57)	(6.83)	
Downstream import exposure		0.35			1.61		-0.17		
		(2.01)			(1.10)		(0.40)		
Combined (direct + upstream) import exposure									-1.97***
									(0.69)
1 st stage Partial R-squared	0.86	0.86	0.82	0.54	0.91	0.89	0.89	0.82	0.54
1 st stage F-statistic	44.5	31.1	55.4	34.8	807.0	52.7	42.0	43.6	12.0
B) Full (Higher-order) I/O linkages									
Direct import exposure	-0.85**	-0.83*	-0.46*			-1.15	-1.20**	-0.46	
	(0.43)	(0.45)	(0.24)			(0.80)	(0.56)	(0.44)	
Upstream import exposure	-0.72	-1.01	0.20	-7.96	-14.80**	-5.36	-4.94***	-3.23	
	(2.23)	(2.03)	(1.26)	(6.89)	(7.11)	(5.89)	(1.91)	(5.17)	
Downstream import exposure		0.13			0.38		-0.03		
		(1.05)			(0.48)		(0.38)		

Combined (direct + upstream) import exposure									-2.15* (1.10)
1 st stage Partial R-squared	0.86	0.86	0.82	0.48	0.95	0.89	0.89	0.82	0.27
1 st stage F-statistic	45.3	30.6	55.8	15.0	843.0	57.1	49.8	43.8	4.55
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

Notes: 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.

Table 8: 2SLS estimates of import effects on local labour market employment to population ratios

	Overall employment rate			Sectoral employment rate		
	(1)	(2)	(3)	(4)	(5)	(6)
Local labour market import exposure	-2.33*** (0.77)	-3.83*** (0.95)	-3.41*** (0.58)			
Local labour market import exposure × 1 {exposed sector}				-1.52*** (0.12)	-1.34*** (0.179)	-1.18*** (0.17)
Local labour market import exposure × 1 {nonexposed tradeable sector}				0.55*** (0.16)	0.25 (0.20)	0.39** (0.20)
Local labour market import exposure × 1 {nontradeable sector}				-1.36* (0.70)	-2.74*** (0.88)	-2.62*** (0.64)
time effects (× sector)	Yes	Yes	Yes	Yes	Yes	Yes
Initial manufacturing share (× sector)	No	Yes	Yes	No	Yes	Yes
State indicators (× sector)	No	No	Yes	No	No	Yes
Observations	372	372	372	1,116	1,116	1,116
1 st stage F-statistic	1416	479.2	606.7			

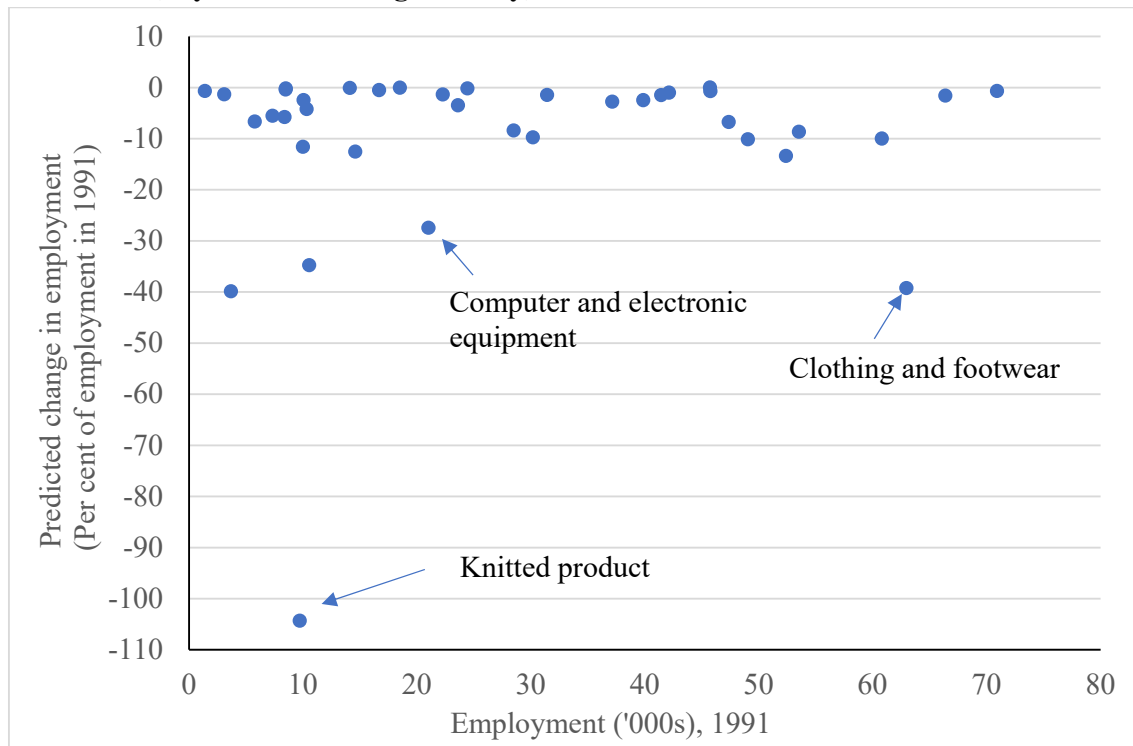
Notes: Columns (1) to (3) report results from models stacking changes in local labour market (LM) employment rates and changes in AUS exposure to Chinese imports for five-year intervals from 1991-2006 (124 LMs by three 5-year intervals). The dependent variable is 100 times the annual change in the ratio of total employment to working-age population in the 124 LMs by 3 periods. Columns (4) to (6) report results from models stacking changes in local labour market (LM) employment rates in 3 sectors, 3 time periods and 124 LMs. The dependent variable is 100 times the annual change in the ratio of sectoral employment to working-age population, with industries partitioned into three sectors: industries exposed to Chinese trade competition, nonexposed industries that produce tradable goods, and all remaining nonexposed industries. In these columns, the time indicators, initial manufacturing shares and state indicators are all interacted with the 3 sector indicators. Observations were weighted by 1991 LM working-age population. Standard errors in parentheses are clustered at the level of the 124 LMs. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9: Implied changes in employment due to exposure to imports from China, 1991 to 2006

	Model	Coverage	Difference (‘000s)	95% range	Percent of 1991 manufacturing employment
Table 2, column (3)	Direct impact – no controls	(1) Manufacturing	-68.7	-143.5 to -5.6	-6.8 (-14.2 to -0.6)
Table 3, column (6)	Direct impact – with industry-level controls	(2) Manufacturing	-53.2	-94.4 to -15.9	-5.3 (-9.3 to -1.6)
Table 7, Panel A, columns (1) and (4)	Direct impact + First-order upstream spillover effect	(3) Total	-98.4	-200.1 to -11.3	
		(4) Manufacturing	-78.9	-166.0 to -5.8	-7.5 (-15.7 to -0.6)
		(5) Non-manufacturing	-19.5	-34.1 to -5.5	
Table 7, Panel B, columns (1) and (4)	Direct impact + Higher-order upstream spillover effect	(6) Total	-85.1	-187.2 to +2.0	
		(7) Manufacturing	-75.0	-158.2 to -4.8	-7.1 (-14.9 to -0.5)
		(8) Non-manufacturing	-10.1	-29.0 to +6.8	
Table 8, Columns (3) and (6)	Local labour market effect	(9) Total	-461.1	-614.4 to -307.8	
		(10) Exposed	-159.0	-202.7 to -115.3	
		(11) Tradeable non-exposed	+52.1	+0.2 to +104.1	
		(12) Non-tradeable	-354.2	-523.4 to -185.0	

Notes: In the first four panels, 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. In the lowest panel, implied changes in employment are calculated starting with the total increase in exposure at the LM level over the 1991-2006 period, multiplying it by the relevant estimated coefficient on the ΔIP_{it}^{LM} variable (times the first-stage partial R-squared value of 0.84) and then multiplying that by LM working-age population in 2006 (from customised ABS tables) then summing across LMs.

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



Notes: 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 5, 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.

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