# Empirical Econometrics I
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## Abstract

This paper is intended to be a review of the popular article by David Autor, David Dorn and Gordon Hanson: "The China Syndrome". In the following pages is performed a detailed review of the paper that, while emphasizing the results and the excellent methodology used by the authors, will also try to spot the potential critical points that may represent a threat to the thesis carried in the original. The decisive contribution given by Autor et al. is testified by the immense academic success that has followed this publication, added to the political implications that still carries on today. With the geopolitical world abandoning the neoliberal international system through tariffs and trade wars, a contemporary in-depth understanding of the theory and the empirical evidence presented along these pages is fundamental. Another valuable contribution provided by the examined paper is represented by its empirical design. As shown below, the original set up proposed by the author and its consequent econometric specification has inspired many and have been used as a baseline for future similar papers (see Acemoglu, Restrepo, 2020).

## Introduction

The China Syndrome was written in 2013 by David Autor, David Dorn and Gordon Hanson with the objective of measuring the impact on American labor markets of the increasing trade activities between China and US spanning from 1990 to 2007. Following a global trend that saw manufacturing imports from low-income country skyrocket, in less than two decades, Chinese imports increased from 0.6% to 4.6% of the US total spending. In 2007 they were accounting for 30% of the total imports in over 30 US manufacturing industries, increasing their share of imports by 1156% between 1990 and 2007. Meanwhile, during the same years, American manufacturing workers' population dropped by one-third, decreasing from 12.6% to 8.4%. In the following pages it will be shown that an increase in Chinese import competition causally implicate an American decline in manufacturing employment, an overall decrease in employment to population ratio, a decrease in wages and an increase in assistance transfer benefits demand.

Knowing the historical contexts in which such disruptive shocks happened is fundamental to account for all possible variables involved and to find a clean econometric specification that contains some degree of causality. In the China Syndrome case, there is a plethora of reasons and global issues that might have played a role in the contemporaneous increase in Chinese imports and the decrease in American manufacturing workers, understanding the context surely pave the way for a comprehensive acknowledgment and potential econometric control. Between the last decade of the twentieth century and the first one of the millennia, the world was entering into a delicate timeline. The post-war economic boom had vanished while newly created cooperative institutions (such as the EU or the WTO) decreased the distances between countries having both positive and long-standing negative effects. The paper discusses what is believed to be the most harmful damage that free international trade has on economies: worldwide competition. When starting to compete with the whole world, countries open to their consumers countless convenient possibilities: consumer prices often decrease while price quality increases, variety of products increment (Krugman 1979), and product availability follows. At the same time, companies must take into account a larger array of adversaries that inevitably hinder their conventional production strategies. Political leaders must consider both weights in taking decisions that could alter the overall economic equilibrium of a country. It can surely be said that it was not the case of Bill Clinton that, encouraging the entrance of China in the WTO in 2000, clearly underestimated the threat. The US president believed that such choice would have increased American exports in Chinese soil while improving the product variety of his citizens. The win-win scenario prefigured by Clinton became instead fuel for the salient process of import penetration that had been occurring in the previous ten years, and the impacts of this choice are still discussed today. With the imposition of tariffs and economic barriers for the first time in forty years, President Trump affirms that American manufacturing sector needs to reach previous levels of production for both citizens safeguarding and reasons of national security. The cited relationship between international trade and manufacturing sectors is exactly the causal relationship explored in the next sections.

## Data

The author mentions the sources from which data used for this study was retrieved. For global imports level between 1991 and 2007, the author used the publicly available UN Comtrade Databases. This database has a large set of available information related to international trade and the author uses imports at the six-digit Harmonized System (an international standard code created by the World Costums Organization that associate every product with a unique code useful for the identification of the good and the determination of taxes and import-export duties). The author later combines this data to show the increasing magnitude of the trade with China vis-à-vis other countries, both for the US and for eight developed countries, useful for future analysis. Information on manufacturing employment is derived from the County Business Patterns data, which includes information about employment on 397 manufacturing industries. Variables related to regional population, employment, wage structure by education, age and gender are built from the Census Integrated Public Use Micro Samples. The Bureau of Economic Analysis and Social Security provide to this paper the information related to state transfer payments.

Additional sources of data comprehend the Bureau of Labor Statics and Penn World Table (PWT 11.0), used in this review to gain accurate insights into the levels of productivity in US. Publicly available data retrieved from David Horn's personal site has been used in next sections to conduct exposure robust standard errors calculations.

## Theoretical Foundation and Empirical Approach

In building the empirical approach used to identify the causes behind the naïve positive correlation between the increase in Chinese exports and the decrease in manufacturing employment in US, the author assumes trade to have a "gravity" structure in which is possible to map changes in trade quantities into labor-market outcomes. The outcomes of interest are the changes in wages in area $i$, changes in employment in tradable goods and changes in employment in non-tradable goods in area $i$. Areas are defined as Commuting Zones (referred to as CZ onwards), logical geographic units for defining labor markets. They are exceptionally useful for the study because they cluster counties together, isolating labor markets. People living in the same county can work in two different ones by commuting. This limits the statistical power in making inference because import exposure in a county may affect employment in the neighboring one. Probabilities of working in the same CZ for people living in the same CZ are large (Tolbert and Sizer 1996) and they allow to neglect small deviations of people not doing so. The great degree of within-CZ similarity compared to the minimal between-CZ interaction allow to consider these areas as isolated bubbles where labor market outcomes can be perfectly associated with population changes. In this model, they are also functional for their accurate definition of sectoral employment, allowing for comparisons in labor market outcomes between CZs that are more manufacturing oriented (and thus more exposed to import competition) compared to others. The total number of CZ, according to the division used for this study is 741 (722 of which cover the entire mainland United States)

In the theoretical modelling performed by the author, the relevant factors influencing labor-market outcomes of interests are (i) the increase in Chinese export capability for industry $j$ and (ii) increases in Chinese demand for goods from industry $j$. According to this theoretical framework, wage and employment outcomes are given by the difference between the increase in Chinese demand for CZ $i$ exports and the decrease in demand for those same outputs of all other markets because of the CZ's competition with China. This difference is purely due to a superior productivity factor that China has and allows to isolate potential confounders of the demand. If China is able to provide the same goods more efficiently and at a lower price, the share of sales in that industry will shift towards China, decreasing the demand for US manufacturing products and thus its wages and employment. This increase in efficiency could be offset by a simultaneous increase in Chinese demand, case in which this difference would be larger than 0 and thus improve both wages and employment. This was the framework envisaged by Clinton who expected China to become the largest consumer market in the world, able to attract unprecedented demand for goods. In this scenario, even the increase in productivity and export capability that China went through would not compensate for its demand and thus benefit American manufactures. According to this model, the third variable of interest, employment in non-tradable goods sectors, always moves in the opposite direction of manufacturing wages and employment. The economic intuition behind this is relatively simple but it needs strong economic assumptions: in an unconstraint and efficient world economy, people losing their manufacturing job due to import competition will relocate to non-manufacturing jobs, while higher demand for exports will increase the productivity of the manufacturing sectors, leading to higher wages and more rational non-manufacturing workers entering in those industries. As it will be demonstrated by the findings, reassortments of this type are unlikely to happen because of the imperfect economic systems and trade asymmetry combined with irrational economic agents.

Having well defined the theoretical framework, the authors move to the empirical strategy used to capture the effect of Chinese increased import competition:

$$\Delta IPW_{uit} = \sum_j \frac{L_{ijt}}{L_{ujt}} \cdot \frac{\Delta M_{ucjt}}{L_{it}}$$

This equation explains how the author describes the degree of import penetration. The variable $\Delta IPW_{uit}$ is dependent on the change in US imports from China in the specific industry $j$ ($\Delta M_{ucjt}$), scaled by the share of workers in that industry compared to national average. Of course, a CZ that employs half of his worker in textiles will be more affected by Chinese imports compared to a region specialized in service provision, explaining the sense of the scaling factor $(L_{ijt}/L_{ujt})$. The results are expressed in decadal thousands of dollars import increases per worker, which justify the presence of the $L_{it}$ term, measuring initial overall employment in CZ $i$.

The model seems reasonable and theoretically well grounded; it represents a classic shift-share model where the scaled shift in imports is compared to a change in share of employed workers. Nevertheless, as the author recognizes, it can suffer from a variety of problems arising from local factors, reverse causality issues and common unexplained trends. The author intelligently accounts for them. The first issue is represented by local shocks within each commuting zone: if the demand shock is caused by specific CZ's factors, then the results may be biased due to omitted variable biases. Supposing for instance that a certain CZ experiences an exogenous positive growth pattern, then it will be likely to increase demand for imports, and at the same time benefit from higher employment and wages. In the main formulation, the OVB it will be defined by:

$$\Delta \mathrm{L}_{it} = \beta_0 + \beta_1 \Delta IPW_{uit} + \epsilon_{it}$$

$$\Delta \mathrm{L}_{it} = \beta_0 + \beta_1 \Delta IPW_{uit} + \beta_2 G_{it} + \epsilon_{it}$$

Where $\Delta \mathrm{L}_{it}$ is the share of employment and the difference between the long and the short form is given by $G_{it}$, representing the exogenous growth factor in that CZ. Then:

$$\hat{\beta}_1 = \frac{cov(\Delta L_{it}, \Delta IPW_{uit})}{var(\Delta IPW_{uit})} = \frac{cov(\beta_0 + \beta_1 \Delta IPW_{uit} + \beta_2 G_{it} + \epsilon_{it}, \Delta IPW_{uit})}{var(\Delta IPW_{uit})}$$

$$\hat{\beta}_1 = \beta_1 + \beta_2 \frac{cov(G_{it}, \Delta IPW_{uit})}{var(\Delta IPW_{uit})}$$

But in this case import penetration (also dependent on the demand for foreign goods $\Delta M_{ucjt}$) would be positively correlated with the growth factor $G_{it}$ and thus lead to an overestimation of the change in the share of employment. Without being able to account for potential confounding variables like this one, the results of the OLS estimation are biased, producing unreliable, unexpected effects. The estimation of the simple OLS model performed in the next section will further explain the direction of the OVB and provide solid grounds for this concern.

To account for the potential endogeneity of trade exposure, the author implements an instrumental variable. To eliminate shocks that are purely local, the author instruments the variable measuring import exposure ($\Delta IPW_{uit}$) with a variable measuring simultaneous Chinese exports in eight other developed countries: Australia, Denmark, Finland, Germany, Japan and New Zealand. Changes in import exposure of these countries due to Chinese improved export capability are relevant to import exposure in the US because they capture global trends, eliminating the endogenous part driven by domestic shocks. The author defines the instrumental variable as:

$$\Delta IPW_{oit} = \sum_{j} \frac{L_{ijt-1}}{L_{ojt-1}} \cdot \frac{\Delta M_{ocjt-1}}{L_{it-1}}$$

This new variable is simply the import exposure caused by China in the previously listed countries. The author now uses ten-year lagged employment levels to account for the potential simultaneous bias that can arise due to the anticipation effect. If developed countries expect China to increase exports by a large factor, then producers will be likely to shift the investment of resources away from manufacturing jobs even before the real import penetration happens. This will ultimately underestimate the effect of increase import competition because firms would have already adapted to future scenarios. Considering past employment levels enables the author to rule out this effect and capture the whole amount of the decrease in employment levels, having a more indicative instrument. A comparison of the regression using instrument's non-lagged employment levels with the author's preferred specification is completed in the next section.

The author can thus use a just-identified model to capture the exogenous variation of its initial variable. While the relevancy of the instrument is evaluated through multiple F-tests in the expanded version of the paper's Table 3, its validity must be qualitatively assessed. The first condition checks for potential effects that the instrument has directly on the dependent variable. Although not directly verifiable, it is not difficult to believe that international expansion of Chinese exports can induce changes in employment in local US economies only by revealing the Chinese global productivity improvement. Chinese trade penetration in Japan or Denmark should influence local levels of employment in the US only by showing the increased productivity of the Asian country, without any direct effect. The second validity condition imposes that there are no other endogenous variables that are correlated with the instrumental variable and that may have an effect on the dependent variable of interest. The author mentions this case suggesting that if shocks in demand were to be correlated across high income countries, then there could be a set of unobserved demand factors that could potentially contaminate IV and OLS regressors, making these coefficients appear smaller than they truly are. A global demand increase for a certain category of goods for example, would both affect the instrumental variable and the employment levels of specific CZs, even though they are not caused by Chinese competition. The author mentions the large underestimation of import competition in the sector of electronics: positive global demand is a benign factor for US manufacture and for Chinese export at the same time, which would then make the second one seemingly have a positive effect on the first one. The instrument in this case would not be able to "filter" only the effect determined by increased Chinese supply but would still capture demand specific patterns. To rule this out, Autor creates another model substituting the increase in US imports with the supply advantage that China has with respect to the US. This model uses fixed effects at the producer and importer level, eliminating time invariant characteristics. It is shown that the estimates of this model are fairly similar to those of the IV estimation suggesting that demand surges across the world are not significant in this model. The third and last condition of instrumental validity imposes no effect of the dependent variable on the instrument (reverse causality issue). This requirement is strongly credible given the unlikeliness of US regional employment to affect Chinese exports to high income countries.

Although the author does not mention or prove the first and the third validity conditions of the IV strategy, he focuses on two further threats that could potentially hinder the whole empirical strategy. The first one deals with American productivity. If the ongoing trend was due to American loss of productivity, then employment would shrink for that reason and increase in Chinese imports would follow as a natural consequence. Statistics presented in the paper show an exponential increase in total factor productivity in China (8.0% between 1998 and 2007), but data on American TFP between those same years suggest a smaller, yet relevant, increase in this measure for the US as well, which allows to rule out this conjecture. A subsequent hypothesis evaluated by the author suggests that the positive technology shocks happened in advanced economies have led to increases in import exposure and not the contrary. According to this conjecture, first-world economies moved toward automation in manufacturing (Acemoglu and Restrepo, 2020) leading to both decreases in employment and increases in the need for Chinese machinery and technologies. Author did not rule out completely this hypothesis but once again suggests that increases in Chinese exports are due to factors that are specific to China. I add to this discussion the hypothesis that another plausible cause behind Chinese import exposure is the inter-generational shift of first-world workers from manufacturing to non-manufacturing jobs. The increased level of education and the change in aspirational goals may have eventually led blue collar new generations to shift to office jobs. Usually better paid and less strenuous, they could have driven manufacturing jobs unsupplied, ultimately leading consumer market to be relatively unfed, and thus to a needed increase in foreign imports. Such choices (Moore et. al 2014), excluded by economic theory and by the paper's empirical approach, might be reasonable explainers of falling manufacturing employment over the twenty years of interests.

A further concern that is addressed in the paper is whether the decreasing trend in manufacturing employment and the simultaneous Chinese import increase are due to some long-run causally correlated elements. If that was the case the regression would only catch the correlation and not the causal link. To verify the plausibility of this hypothesis the author runs a falsification test by regressing past changes in manufacturing employment with future changes in import exposure. If the results show negative significant coefficients, then industries that are more exposed to import competition in the period of interest were already decreasing before the shock, i.e. the Chinese increased imports are simply a symptom of the decline, not the cause. This could also be an instance of reverse causality, where the regions more impacted have increased imports because of decreased employment and not the opposite. The falsification test ran by the author shows however that this is not the case (Table 2). CZs that suffered the highest burden between 1990 and 2007, were significantly increasing their manufacturing employment share by 0.43% between 1970 and 1980. The coefficient for the following period turns out to be insignificantly negative, and the stacked overall difference insignificant as well.

| Table 2: Pre-Period Placebo Test - Manufacturing Employment Changes<br>Dependent Variable: Change in Manufacturing Employment Share (Δ Mfg Empl/Pop) | | | |
|---|---|---|---|
| | 1990-2000 | 2000-2007 | Pooled |
| **Panel A: Main Period (1990-2007)** | -0.888*** | -0.718*** | -0.746*** |
| | (0.183) | (0.065) | (0.069) |
| N | 722 | 722 | 1444 |
| $R^2$ | -0.136 | 0.139 | 0.066 |
| **Panel B: Pre-Period Placebo (1970-1990)** | 0.431*** | -0.130 | 0.148 |
| | (0.151) | (0.127) | (0.096) |
| N | 722 | 722 | 1444 |
| $R^2$ | 0.043 | -0.009 | 0.181 |

Panel A shows the main period results (should be negative and significant). Panel B shows placebo tests using future import exposure on past employment changes (should be insignificant).
* p<0.1, ** p<0.05, *** p<0.01. Standard errors in parentheses, clustered at state level.

## Econometric Specification and Preliminary Results

As anticipated in the previous section, the econometric specification used by the author is:

$$\Delta \mathrm{L}_{it}^{m} = \gamma_t + \beta_1 \Delta IPW_{uit} + X_{it}'\beta_2 + e_{it}$$

where $\Delta \mathrm{L}_{it}^{m}$ is the decadal change in levels of manufacturing employment share in the working-age population of communting zone $i$, $\gamma_t$ represent time dummies for each decade, $\Delta IPW_{uit}$ is the change in import exposure (instrumented on $\Delta IPW_{oit}$) and $X_{it}'$ is a large set of controls for the demographic composition that might independently affect employment, our variable of interest.

The author used a first differencing estimation model by completing a stacked differencing of the two periods: 1990-2000 and 2000-2007. This means that every decade-specific model is equivalent to a fixed effect regression, while the three period first difference model resembles a three-period fixed effect model. How is that? Well, the same model can be run using fixed CZ specific fixed effects by estimating:

$$\mathrm{L}_{it}^{m} = \alpha_i + \gamma_t + \beta_1 IPW_{uit} + X_{it}'\beta_2 + e_{it}$$

where $\alpha_i$ represent CZ specific characteristics. The author, by looking for the impacts on decadal changes, represented by the Δ's, removes the entity specific characteristics through the difference:

$$\Delta \mathrm{L}_{it}^{m} = L_{it+10}^{m} - L_{it}^{m} = \gamma_t + \beta_1 \Delta IPW_{uit} + X_{it}'\beta_2 + \Delta e_{it}$$

But while computing first differencing between the two periods is algebraically equivalent of computing the FE (only one change per CZ), the stacked difference is similar to a three-period fixed effect regression only if loosening assumptions on the error term. The main assumption is related to the error's term serial correlation across periods for each CZ. Assuming the error term to be independent over time ($Cov(e_{it}, e_{it+1}) = 0$) it means that there is no persistence, and the fixed effect model estimator is efficient. If instead there exists some degree of persistence, i.e. $e_{it+1} = e_{it} + u_{it}$, then the error follows a random walk, and the first difference estimator would be more efficient. The usage of Newy-West standard errors clustered by state allows errors to be heteroskedastic and serially correlated within states. Therefore, even if one estimator is slightly more efficient under some assumption, the coefficient would still be unbiased in both cases as the robust standard errors used account for that. By adding a FE estimation on the author's preferred specification, I will conduct a direct comparison between the two models and provide inference over the true nature of the standard errors. The author further mentions that standard errors are clustered at the state level to avoid any spatial correlation between CZ that would bias the results of the IV regression. For least squares to work, residuals must be independent across observation, i.e. $Cov(e_{it}, e_{jt}) = 0$ and if clusters were made within each CZ, this was unlikely to hold. Commuting zones within each state might share common shocks or similar industrial composition due to specific statal policies, leading to correlation between residuals and thus biased results. By clustering at the state level, the author allows for correlation between residuals within each state but assumes independence of such residuals across states. A concluding robustness check will show how spatial correlation cannot hold even in instances of state clustering and will re-evaluate the results using an exposure-robust clustering technique.

Extended Table 3: Change in Manufacturing Employment Share (Δ Mfg Empl/Pop)

Dependent Variable: Ten-year Equivalent Change in Manufacturing Employment Share

| term | OLS | (1) | (2) | (3) | (4) | (5) | (6) | No Lag | FE model | CZ clusters | ER SE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Δ Chinese Import Exposure (per worker) | -0.397*** | -0.746*** | -0.610*** | -0.538*** | -0.508*** | -0.562*** | -0.596*** | -0.408*** | -0.327*** | -0.194*** | -0.596*** |
| | (0.058) | (0.069) | (0.095) | (0.092) | (0.082) | (0.097) | (0.100) | (0.127) | (0.064) | (0.047) | (0.124) |
| Manufacturing Share (lag) | | | -0.035 | -0.052** | -0.061*** | -0.056*** | -0.040*** | -0.062*** | -0.016 | -0.076*** | -0.040*** |
| | | | (0.022) | (0.020) | (0.017) | (0.017) | (0.013) | (0.021) | (0.045) | (0.010) | (0.013) |
| College Educated Share (lag) | | | | | -0.008 | | 0.013 | 0.010 | -0.035 | 0.010 | 0.013 |
| | | | | | (0.017) | | (0.012) | (0.011) | (0.053) | (0.011) | (0.047) |
| Foreign Born Share (lag) | | | | | -0.007 | | 0.030*** | 0.026** | 0.025 | 0.002 | 0.030** |
| | | | | | (0.008) | | (0.011) | (0.012) | (0.063) | (0.007) | (0.014) |
| Female Employment Share (lag) | | | | | -0.054** | | -0.006 | -0.009 | -0.311*** | -0.016 | -0.006 |
| | | | | | (0.025) | | (0.025) | (0.025) | (0.087) | (0.018) | (0.004) |
| Routine Occupation Share (lag) | | | | | | -0.230*** | -0.245*** | -0.227*** | 0.086 | -0.145*** | -0.245*** |
| | | | | | | (0.063) | (0.064) | (0.068) | (0.128) | (0.037) | (0.060) |
| Offshorability Index (lag) | | | | | | 0.244 | -0.059 | -0.132 | -0.451 | -0.312 | -0.059 |
| | | | | | | (0.255) | (0.239) | (0.247) | (0.802) | (0.260) | (0.166) |
| N | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 | 1444 |
| $R^2$ | 0.167 | 0.066 | 0.157 | 0.282 | 0.321 | 0.343 | 0.343 | 0.415 | 0.763 | 0.338 | 0.343 |
| First-stage F-statistic | / | 1147.0 | 650.1 | 592.5 | 555.2 | 552.2 | 533.3 | 415.4 | / | / | 533.3 |

Standard errors in parentheses, clustered at state level (except CZ clusters column, clustered at CZ level; and ER SE column using exposure-robust formula).

* p<0.1, ** p<0.05, *** p<0.01

The following table presents the results. It is based upon Table 3 of the paper which shows preliminary results of the econometric specification just described. I added to that: a first OLS estimates that does not use the instrumental variable (to check the direction of the OVB), a model of the author's preferred specification without accounting for lags in the instrument (to show the direction of the anticipation bias), a specification using FE rather than stacked first difference (for comparison), a stacked first differencing model such as the one of model (6) but using CZ clusters and the exact same estimation in model (6), but with exposure robust SE. I also added in the summary statistics the F-stat measuring the relevance of the instrument. The main finding of the paper is contained in first-row estimates. They indicate the percentage change in manufacturing employment per working age population when the CZ $i$ increases import exposure by $2,000 per worker over the 20 years.

Specifications (1) to (6) are the one chosen by the author and included in Table 3. Column (1) shows the instrumented 2SLS regression coefficient. It is statistically significant and of greater magnitude than the OLS estimate. The F-statistic I added shows the relevancy of the instrument in this specification as all others, providing sufficient ground to accept the relevance condition previously mentioned. From column (2) to (6) the author progressively adds controlling variables in order to test the robustness and eliminate potential confounders. In column (2) he takes into account the lagged share of manufacturing employment, i.e. those at the beginning of the period. This specification is used to check whether the Chinese import exposure estimate is capturing a long-term trend already happening in the US. The small difference in the import exposure estimates and the insignificant coefficient of the lagged share of manufacturing employment suggests that the hypothesis can be safely discarded. Column (3) adds nine census division dummies that are designed to absorb the regional effects of changes in manufacturing employment. Since the main coefficient remains significant it is possible to exclude that regional trends are the largest drivers of employment shifts in these industries. Since including these dummies, though, the lagged percentage of employment in manufacturing becomes significant. The reason behind may be that once eliminating those trends that occur over time and that are common to all entities, then the share of manufacturing employment before the period of interest becomes a significant indicator of future changes. Specification (4) checks whether including lagged variables that account for the share of the population that (i) has a college degree, (ii) is foreign born or (iii) is an employed working-age women, has some effect on the estimates and it turns out that these pre-period levels have virtually no influence on the magnitude of the main variable of interest. Model (5) introduces two variables created by the same authors in a previous work. They are an indicator of the lagged share of the population that (i) performs repetitive tasks that are more susceptible to computerization and (ii) is occupied in working positions that do not need proximity to specific work sites. The inclusion of them leaves the coefficient of interest untouched but the significance of the first one suggests that manufacturing employment decreases by an additional 0.23% for every additional percentage point of the population invested in repetitive tasks. This shows who are the workers most likely to lose their job when competition puts firms under pressure and, as one could expect, workers whose task is easier to replicate by computer lie in this category. One could argue that this is physiological, especially because levels prior to 1990 are compared to levels of 2007, thus in the peak of the rise of computerization. But including time variables in the regression, controls for the average factor of computer substitution that hit all industries at the same time. This estimate explains almost 30 percent of the overall decrease in manufacturing employment in regions where repetitive tasks are very common and might invalidate the justification brought by the author to exclude the concern of increased automaton. The offshoring estimate is instead insignificant suggesting that the decreased share of manufacturing workers is not due to an increase relocation of workers. Autor's preferred specification is (6), it includes all controls and the census division dummies. It indicates an extensive impact definable as a 0.596% decrease in manufacturing employment over the whole employed population following a $1,000 increase in import penetration per worker over 10 years. It will be clearer when computed in absolute terms.

The specifications that I have included work as controls and give important insights into the theoretical questions explored in the previous section. I wanted to include in the first column the un-instrumented OLS regression to check the empirical results of the statistical computation regarding omitted variable bias done before. Results show that the coefficient of the simple OLS estimate is the smallest of all specification used by the author and it suggests that the direction of the OVB is positive, as expected. As explained in the previous section, the OLS estimate suffers from local endogeneity of the demand. Without controlling for global trends able to capture the shift in productivity of Chinese industries, regional shocks would make manufacturing employment seem positively correlated with Chinese imports, leading to the inflation of such coefficients. The usage of the instrumental variable is thus motivated, and it avoids the downward bias toward zero (attenuation) caused by endogenous local variables. The model that eliminates the lagged values of the instrument is indicative as well. It reduces the estimate by one third and it measures the anticipation bias. If the instrument used for the identification of the exogenous change in the main variable of interest is not calibrated well, then the effect of import penetration is underestimated. This happens because it fails to exclude the anticipation bias. It measures the import penetration that took place in developed countries starting from 1990, when many firms had already reallocated investment and adjusted foreseeing future changes in trade competition. It tells that the adjustment response to a future Chinese productivity shock had an impact close 0,19%, which must not be neglected. These findings are aligned with the results discussed in the falsification test conducted before (Table 2). The negative, yet insignificant, results previously found are unlikely to provide evidence for reverse causality, but instead the rate of adjustment starting 1980's onwards, reflecting the neoliberal economic setting carried by the Reagan and Thatcher period. The new instrument loses some statistical power but remains still highly relevant in the correlation with the endogenous variable (F-stat=415). The Fixed Effect model provided in the next column performs quiet differently from what I expected. The inclusion of it was to test whether the stacked first differencing over two periods was similar to a fixed effect model of three periods, but this turn out not to be the case. The main coefficient of interest captures only half of the effect expressed by the first differencing model, coefficient that were significant ended to do so and some others became significant in the FE model. Apart from the first row, standard errors produced by the FE model are all bigger than the ones in FD Autor's preferred specification. It proves that residuals follow random walks rather than facing complete independence over time, which also has an appropriate economic explanation. Labor and supply shocks are likely to be persistent over time; residuals of a 10-year period are intuitively correlated with those of the previous one. FE models perform better with many and close time periods, and that the difference the author is looking for resembles more a first differencing model (rather than a de-meaning one). These reasons give abundant sense to the decision of using FD, and presumably motivate the distorted different results obtained. Second-last column presents the results of specification (6): lagged instrumental variable and full control FD regression, with standard errors clustered at the CZ level rather than at state level. Every SE of this column is smaller or equal than those clustered at the state level. There are different possible causes related to this difference, and they all support an overall theory of standard error underestimation when it comes to CZ clusters. As mentioned before, clustering at CZ level allows for correlation within that area but does not tolerate any form of correlation between different zones. This is unlikely to hold because, as said before, commuting zones within the same state can share statal policies, local shocks or industries regulation, thus being correlated with each other. A subsequent problem arises when looking at the difference in numbers between commuting zones and industries in the sample. According to the model proposed, industry shocks are the independent sources of variation, they account for the shifts. Effects on commuting zones are nothing more than average weighted effects for each CZ, based on the share of population working in those industries. Clustering standard errors by commuting zone means considering 741 independent variations that all pool their variation from a smaller sample of almost 400 industries considered. This would of course lead to smaller estimated standard errors: the variation caused by 400 observations is weighted on 741 observed clusters. Inference made on the state-level standard clustered errors is therefore more meaningful, yet not perfect. The problem linked to the clustering technique used by Autor is that CZs span over multiple states. They are made following the need of creating isolated labor economic bubbles and thus do not account for federal borders. If a large share of a specific county population work in the next county belonging to a different state, these counties will be included in the same zone, regardless of the state. Kansas City CZ for example, includes counties that are both in Kansas and Missouri and this does of course play a role in the error estimation. In principle, this clustering technique considers within CZ responses to shocks as uncorrelated, since belonging to different states, while they are instead perfectly correlated because defined within the same local labor market. To counter this problem, common to all shift-and-share models, exposure-robust or AKM standard errors must be used (Borusyak et al. 2022). This clustering technique involves a rewriting of the shift-share model as an equivalent shock level regression where the identification stems completely from the shocks. In this case the outcome variable is a weighted average of outcomes across regions. The variance of the estimator is computed based on the independent industry observations not on the regions, allowing for correlation between regions that are exposed to the same shocks. The number of regions vis-à-vis the number of industries becomes therefore irrelevant. As shown in the result table, the estimates of the coefficient should remain unchanged, while the standard errors adjustment is relevant. Uncertainty of the coefficients is now measured according to a different number of independent observations: industries rather than commuting zones or states. In principle, it would be plausible to expect their dimension to lie between the standard errors computed by clustering CZ and those clustered at the state level (the variance is scaled according to over 700 zones, 48 states and 400 industries). These scaling factors, however, are not comparable between each other because exposure shares across industries are re-weighted in the clustering procedure. Large industries with correlated shocks will dominate the uncertainty between the estimates, whereas small industries having peculiar shocks will contribute less. Aligned to the findings of Borusyak, I demonstrate that the number of industries driving the overall employment shock is smaller than the number of states, leading to a minor number of clusters that explain the same variance and thus higher SE.

## Consequent Results

Using the specification (6) with full controls, the author performs a comprehensive evaluation of the results, converting them into absolute levels and benchmarking to overall trends. The preferred model indicates that a $1,000 per worker increase in import exposure over a decade reduces the ratio between manufacturing employment to working age population by 0.596 percentage points. Since Chinese import exposure has risen by $1,140 per worker between 1990 and 2000, and by $1,839 per worker between 2000 and 2007, Autor's result should explain a 0.68 pp decrease in manufacturing employment in the first decade, and a subsequent reduction of 1.10 pp in the following seven years. Given that the overall US manufacturing industries decreased employment to working-age population by 2.07 pp between 1990 and 2000 and by 2.00 pp between 2000 and 2007, Chinese import exposure is believed to explain 33 percent of the US manufacturing employment decline between 1990 and 2000 and over 55 percent of the fall in the successive seven years. The author cleverly recognizes a possible source of overestimation in this conversion in absolute results. The friction arises from the different measurement used to account for the impact of Chinese supply improvement on exposure (represented by the 2SLS estimate) and the absolute increase in import levels. It is crucial for a correct interpretation of the results that these two elements are comparable, but they are not. While the first measure accounts for the expansion in Chinese manufacturing ability, the second does not. It is produced by a simple ratio between total increase in imports and number of workers, without the proper exclusion of demand factors. This discrepancy leads to a potential overestimation of the results, attributing to the Chinese supply shock some components that are outside of it. To see the real proportion of the effect given by the supply shock, the author compares the estimated coefficient when the instrumental variable is included to the simple OLS estimate. Through variance decomposition (Pasanen 2025), the author calculates that the supply-driven component accounts for about 48 percent of the total observed variation. The previously calculated absolute levels might be corrected by approximately one half. With a greater degree of certainty, the author thus establishes that supply-driven shock coming from China explained around 16 percent of US fall in manufacturing employment between 1990 and 2000 (548,000 workers ca.) and 26 percent of that trend between 2000 and 2007 (982,000 workers ca.).

The relevancy of these results, however, must subsequently assessed in a more comprehensive context. Basic economic theory supports the idea that changes in employment structure are natural and not worrying. Whenever an efficient market in perfect equilibrium welcomes a new producer, such in this case, market dynamics change the allocation of resources in a renovated efficient way that improves the welfare of both consumers and existing producers. In such an idealized world without frictions and constraints, the results of this paper would mirror nothing more than a simple reallocation of resources, not harming anyone and instead bolstering the overall welfare. Up to this point in fact, the author has provided evidence of a shift in employment, showing how the manufacturing share of the population have decreased across two decades. Such evidence would support an instance of perfect equilibrium in which workers simply relocate to more productive positions, either changing industry or location. To disproof such hypothesis, the author inspects the decadal change in commuting zones' overall population structure. In Table 4, Table 5 and Table 7 are reported the results that confirm the imperfect American labor market, unable to work as a zero-sum game when confronted with global shocks and pressures. Table 4 examine the population change between 1990 and 2007. Backing the idea of perfect market equilibrium, it would be reasonable to expect that commuting zones that are more harshly hit by import exposure suffer from a substantial decrease in population, particularly for blue collar workers. The results displayed in the table demonstrate the opposite. Once controlling for census dummies, all existing differences cease to be significant, proving a perpetual trend in population structure, both in absolute numbers and in its composition. Discarded the idea of geographical relocation, the perfect market equilibrium theory would still hold if employment levels and relevant labor statistics were unchanged. Table 5 provides evidence against this argument by displaying a far different scenario. Manufacturing employment decreased by 4.2 log points for every decadal $1,000 per worker increase in import exposure, with its share compared to working population falling by almost 0.6 percent, as shown before.

Table 5: Employment Status of Working-Age Population within CZs, 1990-2007

Dependent Variables: Ten-year Equivalent Changes (2SLS Estimates)

| | Mfg Emp | Non-Mfg Emp | Unemployed | Not in LF | SSDI Receipt |
|---|---|---|---|---|---|
| **Panel A: 100 × Log Change in Population Counts** | -4.231*** | -0.274 | 4.921*** | 2.058* | 1.466*** |
| | (1.058) | (0.658) | (1.140) | (1.091) | (0.562) |
| N | 1444 | 1444 | 1444 | 1444 | 1444 |
| $R^2$ | 0.308 | 0.345 | 0.415 | 0.458 | 0.320 |
| **Panel B: All Education Levels** | -0.596*** | -0.178 | 0.221*** | 0.553*** | 0.076*** |
| | (0.100) | (0.138) | (0.058) | (0.152) | (0.028) |
| N | 1444 | 1444 | 1444 | 1444 | 1444 |
| $R^2$ | 0.343 | 0.365 | 0.404 | 0.386 | 0.604 |
| **Panel C: College Education** | -0.592*** | 0.168 | 0.119*** | 0.304*** | — |
| | (0.126) | (0.123) | (0.039) | (0.114) | |
| N | 1444 | 1444 | 1444 | 1444 | |
| $R^2$ | 0.189 | 0.187 | 0.275 | 0.187 | |
| **Panel D: No College Education** | -0.581*** | -0.531*** | 0.282*** | 0.831*** | — |
| | (0.096) | (0.206) | (0.086) | (0.213) | |
| N | 1444 | 1444 | 1444 | 1444 | |
| $R^2$ | 0.361 | 0.440 | 0.427 | 0.490 | |

Δ Chinese Import Exposure (per worker). Robust standard errors in parentheses, clustered at state level.

* p<0.1, ** p<0.05, *** p<0.01

All models include full controls: manufacturing share, census regions, education share, foreign-born share, female employment share, routine occupation share, and offshorability index.

Non-manufacturing, albeit the insignificant coefficients, moves in a similar direction, decreasing both in shares to population and compared to previous levels. The most harshly hit portion of the population are individuals lacking college education, whose employment significantly fall in both manufacturing and non-manufacturing sectors. College graduates, instead, while suffering of a similar effect on manufacturing employment, are able to resist the impact on import exposure on their non-manufacturing activities. Such traumatic changes are absorbed by the rising changes in unemployment (which increases its ratio to working population by 0.22 log points for every $1,000 per worker increment in imports exposure) and by the "not in the labor force (NILF)" coefficient (raised by half percentage point by import expansion). Alterations of this kind explain a rather different story from what market equilibrium theories could predict. They offer instead some worrying insights on the impact of increased import exposure following international competition demonstrating the inability of the American labor market at reallocating its human resources in response to external pressure.

Knowing the effect that the Chinese supply driven shock had on population, I analyze the subsequent part of the paper related to wage effects. In this further specification the author uses the mean log weekly earning in commuting zones to grasp the effect that import exposure had on the wages. As mentioned by the author, the wages must be interpreted with caution. As basic economic theory suggests, decreases in employment are often associated with increases in wages. Companies suffering from a shock, and thus having to reduce absolute costs, will firstly dismiss the less productive workers and keep those whose productivity, and thus wage, is higher. Table 7 partially represent this outcome in the manufacturing sector by displaying an insignificant, yet positive, effect on weekly log wages. What really draws attention, however, is the strong and significant decrease in log wages (-0.761) for the non-manufacturing sector. Following an increment in the availability of workers, downward pressure on the wages is likely to be the predominant force behind such finding. Intuitively, workers that lose their job in the manufacturing sector will be likely to attempt a relocation in non-manufacturing industries. However, as testified by previous results in Table 5, non-manufacturing employment is not affected by the import exposure shock thus leading higher labor competition for the same number of positions to depress wages. This trend is furthermore supported by the highest coefficient presented in Panel D of the table: non-manufacturing wages for non-graduated segments of the population. Following increased import exposure in manufacturing industries, the non-manufacturing wage for less skilled workers becomes the most affected one with a sharp decrease of 0.822 log points on weekly salary. Given the whole labor market crisis, those workers without a college degree that manage to keep their position or to enter into non-manufacturing industries are forced to accept lower wages and suffer from the biggest burden.

Table 7: Comparing Manufacturing and Nonmanufacturing Employment and Wages, 1990-2007

Dependent Variables: Ten-year Equivalent Changes (2SLS Estimates)

| | Change in Average Log Weekly Wage | | |
|---|---|---|---|
| | Log Change in Number of Workers | | |
| | All Workers | College | Non-College |
| **Panel A: Manufacturing Sector** | -4.231*** | -3.992*** | -4.493*** |
| | (1.058) | (1.194) | (1.256) |
| N | 1444 | 1444 | 1444 |
| $R^2$ | 0.308 | 0.302 | 0.338 |
| **Panel B: Nonmanufacturing Sectors** | -0.274 | 0.291 | -1.037 |
| | (0.658) | (0.597) | (0.772) |
| N | 1444 | 1444 | 1444 |
| $R^2$ | 0.345 | 0.289 | 0.533 |
| **Panel C: Mfg Wages** | 0.151 | 0.458 | -0.101 |
| | (0.487) | (0.344) | (0.373) |
| N | 1444 | 1444 | 1444 |
| $R^2$ | 0.215 | 0.209 | 0.332 |
| **Panel D: Non-Mfg Wages** | -0.761*** | -0.743** | -0.822*** |
| | (0.263) | (0.301) | (0.249) |
| N | 1444 | 1444 | 1444 |
| $R^2$ | 0.599 | 0.540 | 0.508 |

Δ Chinese Import Exposure (per worker). Robust standard errors in parentheses, clustered at state level.

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

All models include full controls: manufacturing share, census regions, education share, foreign-born share, female employment share, routine occupation share, and offshorability index.

David Autor concludes the analysis on these subsequent results by evaluating the increase in the transfer benefits requested (already present in last column of Table 5) and by computing an average effect on household income. The results support the hypothesis constructed throughout this section, showing how transfer benefits requests sky-rocketed over this period and how did import exposure negatively affected average and median income of American households. The conclusion of the section provides a detailed and thoroughly computed estimation of the overall losses in American markets. The author acknowledges that even though import exposure and globalization trends adversely impacted manufacturing workers employment or average household income, they indeed carried many advantages. Increased product variety coming from abroad between 1972 and 2001 has brought welfare gain to American consumers equivalent to 2.6% of 2000's GDP (Broda et al. 2006). Availability of inputs at lower costs is fundamental for emerging companies (Goldberg et al. 2010) because it boosts their productivity and investment in innovation. Additionally, trade with low-wage countries like China is found to disproportionally benefit low-income consumers (Fajgelbaum et al. 2016), who benefit from the largest price drops in their basket of goods. I add that these households are plausibly the most likely that went through unemployment and reduction in average income through the years considered in the paper. Unlike a large array of other economic and social issues, this particular phenomenon has a double-faced impact on household wealth and thus requires prudence and cautiousness in global judgment. The author acknowledges this potential issue and thus limits his analysis to efficiency losses due to distributional programs and labor participation adjustment. He looks at potential losses using a state-level lens, rather than a consumer specific one, and concludes that efficiency costs due to redistribution through welfare transfers is approximately $33 dollar per capita. Such measure uses Gruber's estimate for the inefficiencies arising from the redistribution of the entire tax revenue. A confidence interval that delimits the loss between $22 and $44 per capita highlights the opportunity cost of funding welfare programs vis-à-vis other public projects at the disposal the whole American tax base. On the other hand, the author estimates that efficiency losses due to involuntary unemployment, thus not caused by rational choices after wage decreases, account between $87 to $137 per capita between 1990 and 2007.

## Conclusions

The paper written by Autor, Dorn and Hanson undoubtedly represent one of the classics in the literature of international, trade and labor economics. Its success depends on the nuanced empirical and econometric design, its important results and the central debate that it treats. The evidence that it brings have presumably influenced the international trade system as we know it today and have certainly raised awareness over the topic. The subject that is touches is contemporaneous today as it was ten years and in the timeframe of increasing trade barriers, economic tariffs and worldwide productivity competition is essential to understand the results produced by papers like this one. Meanwhile, the econometric specifications and the detailed empirical research confer to this masterpiece an outstanding level of internal and external validity. The robustness checks and the strategies used to counter potential sources of bias are intelligently designed, while the acknowledgments regularly expressed solidify the scientific ethical position of the authors. I designed this paper with the objective of broadening and explaining in detail the techniques and the choices that the authors made throughout the pages. The replication and the review using modern techniques were aimed at renovating a magnificent work, more than ten years after its first publication. The results I got are a further confirmation of the excellence of this academic research, able resists the most modern robustness checks and keep its relevancy.

Future research should aim at incorporating in a study of this kind a broader perspective. It should complete the work done by Autor, Dorn and Hanson by including research at the consumer level. The unique point of weakness one can attribute to the paper is the final verdict, which leaves much space for the multiple interpretations and disagreement. Research in the next years should look into the benefits and disadvantages that consumers and medium-sized firms retain in the aftermath of import increase or tariffs application (Amiti et al. 2018) and benchmark them to the results of this paper. Such discoveries could provide a deeper understanding of the consequences of import competition and thus equip policymakers with a solid and grounded evidence on which to base their decisions.

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