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Productivity Consequences of Product Market Liberalization: Micro-evidence from Indian Manufacturing Sector Reforms*

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Abstract

We use a new plant-level dataset to study the effect of two reforms aimed at increasing product market competition in India – liberalization of foreign direct investment (FDI) and reduction in tariff rates. First, we examine the effect of the liberalization policies on mean plant-level productivity in the liberalized industries. We find a 23% increase in productivity *level* following the FDI liberalization and a 33% increase following tariff liberalization (comparing mean value added log productivity levels in 1994-95 to the pre-reform 1987-90 period). We check the robustness of these results to: (a) using alternative measures of productivity; (b) using alternative definitions of the liberalization variable; and (c) inclusion of controls to address possible bias from the selection of industries into liberalization regimes. The tariff liberalization effect is generally robust; the FDI liberalization effect is 14%-16% when controlling for non-random selection. Next, we examine *aggregate* productivity *growth* in liberalized industries; we find a 16% (15.6%) increase following FDI (tariff) liberalization. This increase appears to be driven by improvement in intra-plant productivity growth, with a small role for re-allocation. Finally, we examine who benefitted from the productivity gains; we find that the major beneficiaries were wholesale consumers (in the form of relatively lower wholesale output prices in the liberalized sectors).

Keywords: Foreign Direct Investment, Trade Liberalization, Productivity, Reallocation, Industrial Policy.
JEL: F13, F14, F43

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I Introduction

In the last couple of decades, many countries have dramatically altered their regulatory regimes by abandoning "import substitution" policies and embracing pro-competitive, open-market policies (e.g., Chile in the late 1970s, Turkey in 1983, Mexico in 1985, India in 1991). Driven by multilateral agreements under the World Trade Organization, and by programs supported by international institutions such as the International Monetary Fund and the World Bank, policies reducing barriers to the flow of goods and capital continue to be adopted around the world. However, such policies have come under criticism from various quarters. Recent research (e.g., Easterly [2003]) has questioned the importance of such policies in explaining growth trends in developing countries. These policies have been critiqued in the context of crises in countries that had adopted these policies (e.g., in south-east Asia in the late 90s, and recently in Argentina and Bolivia). Capital and trade liberalization has also been the target of attacks by various 'anti-globalization' groups, with an important criticism being that the benefits from such liberalization have not been widely shared.[1]

Structural reform measures introduced in India in 1991 provide an excellent opportunity to use micro-data to evaluate the benefits from trade and investment liberalization policies. We use a previously unexplored, rich plant-level dataset, with annual data on about 40,000 plants covering the entire Indian (formal) manufacturing sector, to examine the impact on total factor productivity of two sets of reforms: (i) liberalization of foreign direct investment (FDI) into certain industries, and (ii) widespread reduction in tariff rates, with larger reductions in certain industries.[2]

The manner of implementation of the Indian reforms and the availability of rich micro-data provide a special opportunity to study these types of policy changes and contribute to the literature in many ways. One, FDI and tariff liberalization was applied selectively to certain industries. This quasi-experimental nature of the reforms allows us to use a difference-in-difference approach that controls for contemporaneous macroeconomic shocks. Hence, we are able to avoid a key weakness of early studies of trade liberalization (Pavcnik [2002]).[3] Two, the availability of a detailed and comprehensive plant-level dataset allows us to undertake industry-level analysis at a much finer level than for most other countries. Hence, unlike previous studies, we are able to directly address changes in aggregate productivity and investigate the role of reallocation of resources in reform-related aggregate productivity changes.[4] The data also allows us to investigate the question of who benefits from the post-

[1] One of the definitions of the term "globalization" is 'a process of removing government-imposed restrictions on movements between countries in order to create an "open", "borderless" world economy' (Scholte [2000], page 16). In this context, this study can be seen as an examination of the effects of the public policy underpinnings of globalization.

[2] See section II for our definitions of 'FDI liberalized' and 'tariff liberalized' industries.

[3] The policy changes are not ideal "natural experiments", since industries were not randomly selected for liberalization. We try to carefully address possible biases arising from the non-random selection of industries in Section B.4.

[4] As pointed out by (Nickell [1996]), by focussing solely on changes in mean intra-plant productivity we may miss the effect of re-allocation of resources on aggregate productivity. An important role for re-allocation has been highlighted in empirical studies of productivity in US manufacturing plants (Foster et al. [1998]) and in recent theoretical work on trade liberalization (e.g. Melitz [2003]). However no empirical studies of trade liberalization have addressed this question directly [Tybout 2001].

reform productivity gains, which has been seldom addressed in the productivity literature.

Our study is related to the literature addressing the effects of FDI on firm productivity, which have found mixed evidence on the effect of entry by foreign direct investors on domestic firms (see discussion in section III). We also contribute to the literature examining the effects of trade liberalization on productivity growth. While the early evidence on the effect of trade liberalization was somewhat mixed (Tybout 1992), recent surveys by Tybout (2000) and Epifani (2003) conclude that the empirical literature generally support a positive effect of trade liberalization on productivity. Notable recent works that have found evidence of a positive effect of trade liberalization on productivity have been Pavcnik (2002) for Chilean manufacturing firms, Fernandes (2003) for Columbian manufacturing firms and Muendler (2004) for Brazilian manufacturing firms.[5]

To analyze the effects of the reforms on productivity (defined in the base-case as the residual in a production function), we follow a two-stage approach. In the first stage we estimate a production function by adapting the recently proposed Levinsohn-Petrin (LP) structural estimation procedure (Levinsohn and Petrin [2003a]) to our repeated cross-section context. This methodology addresses the issue of simultaneity bias (potential correlation between inputs and the error term) and hence avoids a potential drawback of earlier studies of trade reforms (as highlighted by Pavcnik [2002]).

The second stage of our study has three parts, addressing three distinct questions about the effects of the FDI and tariff liberalization reforms: (i) What was the effect of the reforms on mean intra-plant productivity levels ?; (ii) How did the reforms affect aggregate productivity growth, and what were the roles of reallocation and intra-plant productivity on changes in aggregate productivity growth?; and (iii) How did changes in productivity affect potential beneficiaries (suppliers, blue and white collar workers, owners of capital and consumers), as reflected in changes to output and factor prices?

In the first part of our study, we examine the effects of FDI and tariff liberalization on *intra-plant* productivity levels by comparing plants in liberalized industries to those that

[5] Two recent papers have examined product market liberalization in India. Topalova (2004) uses a dataset of medium and large firms to carefully examine the effect of trade liberalization on Indian firms and finds a positive effect of tariff reductions on productivity. While Topalova's finding is consistent with this study, our study differs from and extends her study in the following ways. One, our study focusses significantly on the effect of foreign direct investment (FDI) liberalization, which is not examined in Topalova's study. Two, we use a comprehensive survey of all manufacturing plants, including a large number of non-publicly owned small plants that are not covered in the Prowess dataset used in the Topalova study. This allows us to obtain accurate estimates of industry aggregate productivity change, and decompose it to examine micro-economic sources of aggregate productivity change following FDI and trade liberalization. Three, our data includes figures on white and blue collar employment, whereas Prowess provides data only on labor expenditure. Our study avoids potential biases arising from using labor expenditure as a proxy for labor input (which arise if benefits from productivity are shared by workers). Four, our data extends from 1986-87 to 1994-95, while the Prowess dataset covers the 1989-2001 period. By looking further into the pre-reform period, we are able to avoid potential biases that could arise because of a temporary economic downturn prior to the reforms in 1991 (on the flip side, the lack of data for later years prevents us from examining the longer term consequences of the reforms). Finally, our data allows us to explore the question of who benefits from the observed productivity gains. A recent study by Aghion, Burgess, Redding and Zilibotti (2004) uses industry aggregate data to examine the impact of entry liberalization (de-licensing) on different industries in India. Consistent with their theoretical predictions, they find that entry liberalization had a greater positive impact on industries closer to the technology frontier and industries in states with more flexible labor regulations. They do not attempt to distinguish between the effects of de-licensing (a sweeping reform covering almost the entire manufacturing sector) from tariff or FDI liberalization; in our study we focus on separately identifying the effect of tariff and FDI liberalization on micro and aggregate productivity change.

faced neither reform. Our results suggest an increase in (value-added) log productivity levels over the long term (ie comparing mean log productivity levels in 1994-95 to levels in 1987-90), of about 23% for firms in FDI liberalized industries and of about 33% for firms in tariff liberalized industries. This translates to an increase of about 4.5% and 8% in log productivity in gross output terms following FDI and tariff liberalization respectively.[6]

We perform a three types of robustness checks on our results. First, to address the concern that our results may be driven by assumptions underlying the estimation of the production function, we check the sensitivity of the results to a range of alternative definitions of total factor productivity, and find our results to be remarkably robust.[7] Second, we check and find that our results are robust to alternative definitions of the FDI and the tariff liberalization measure.

Third, while our difference-in-difference approach controls for all industry fixed effects and macroeconomic shocks, the selective application of FDI and tariff liberalization could lead to bias due to other reasons. We try to control for four possible sources of bias, arising from the selective liberalization of: (a) industries with strong pre-reform growth in productivity that may simply be continuing on a pre-reform trend; (b) export-oriented industries that may have benefitted currency depreciation; (c) capital intensive sectors that may have benefitted from liberalization of capital imports; and (d) industries relatively farther away from the frontier that may have had a greater (or lower) scope for improvement. We address these four sources of bias in two ways. One, we redo our analysis conditioning out the effect of variables that proxy for each of these four sources of bias. Two, we check robustness to conditioning on the propensity of being selected for reform (following Rosenbaum and Rubin [1985]). The propensity score is derived from a selection model that includes proxies for the four sources of bias, factors highlighted in policy announcements, and variables drawn from the existing literature on the political economy of such reforms. We find that the tariff liberalization effect is robust to the inclusion of various controls; the FDI effect changes to about 16% when controlling for improvements in capital intensive sectors and to about 14% when conditioning on the propensity scores.

In the second part of this study, we evaluate how the FDI and tariff liberalizations affected *aggregate* output and productivity *growth*. We propose a decomposition of aggregate output growth into contribution from input growth, inter-industry reallocation, intra-plant

[6]Since value added is only a fraction of gross output, a gross-output augmenting productivity change is a much larger value-added augmenting productivity change. As shown by Rotemberg and Woodford [1995], log productivity change in value added terms ($d\omega^V$) is related to log productivity change in gross output terms ($d\omega$) as:

$$d\omega^V = \frac{d\omega}{1 - \gamma S_m}$$

where γ is returns to scale and S_m is the share of material in total revenue. In our case, assuming constant returns to scale and a material share of 0.75 (the mean material share in our sample), we get log productivity change in gross output terms to be the about one fourth of the value added log productivity change. This is confirmed by our results for the gross output production function in Table IV(a).

[7]A recent paper by Van Biesebroeck [2003] investigates alternative productivity estimation methodologies and finds that many interesting results on productivity change are robust to the choice of methodology. Together with our results, these findings suggest room for cautious optimism on the severity of the simultaneity bias problem for a range of common applications.

productivity growth and intra-industry reallocation. We find a difference-in-difference increase in mean industry-level aggregate productivity growth rate of 16% (15.6%) following FDI (tariff) liberalization (in the 1994-95 period compared to the pre-reform 1987-90 period). We find that the increase in the growth rate of intra-plant productivity was the single largest contributor to increase in aggregate productivity growth, contributing 11.6% in FDI liberalized industries and about 10.6% in tariff liberalized industries. This suggests that channels stressed in homogenous firm theories (such as better incentives to reduce slack or adopt new technologies), may have played a more important role in post-reform productivity improvements (relative to the predominant role for reallocation stressed in heterogeneous firm models such as Melitz [2003]).

Finally, in the third part of this study, we briefly examine who benefited from the productivity growth following FDI and tariff liberalization. We decompose changes in a Solow productivity index growth rate to changes in output and various factor prices. Our analysis indicates that the higher productivity (and lower input prices) following the reforms translated into lower output prices in the liberalized sectors. This implies that the biggest beneficiaries from the reforms were wholesale consumers, which suggests that the benefits from productivity gains were widely dispersed.

All our results need to be interpreted cautiously considering a number of caveats driven by the nature of the reforms and the limitations of our data (discussed in detail in section VIII). We believe our results are robust to many important concerns that arise for this type of policy evaluation studies; some factors (e.g., expectation that the reforms would be reversed or extended to other industries) suggest that our estimates potentially understate the true impact of the reforms.

The rest of this paper is organized as follows. In the next section, we describe the key Indian reforms, and define the key liberalization (dummy) variables. The third section briefly reviews related literature. We describe our data in section four. In section five, we analyze mean intra-plant productivity levels. Section six looks at aggregate output and productivity growth. Section seven examines who benefited from the reforms. Section eight discusses our results and section nine concludes.

II The Indian reforms

Significant reforms were introduced in 1991 that transitioned India from a closed, socialist economy to a more open, free-market oriented system. The proximate cause for the reforms was a severe balance of payments (BOP) crisis in 1991. The origin of the crisis was a rapid increase in India's external debt, which coupled with political uncertainty led international credit rating agencies to lower India's debt rating. This made borrowing in international markets difficult and triggered an outflow of foreign currency deposits by non-resident Indians. The collapse of the Soviet Union and other eastern bloc trading partners, and the spike in oil prices following the Gulf war, worsened the BOP situation. The Gulf war also led to a

reduction in repatriation from expatriate workers (an important source of foreign exchange at that time). These developments brought India to the brink of defaulting on its debt obligations. In June 1991 a new government came into power following mid-term elections; this government obtained funding from the international financial institutions (the IMF, the World Bank and The Asian Development Bank) and initiated a structural adjustment programme on the advice of these institutions. In terms of overall macroeconomic trends, the reforms coincided with a downturn in real output growth (see Figure I).

Underlying the policy shift was also a realization that the existing import-substitution and FDI unfriendly policies had resulted in a relatively inefficient manufacturing sector with limited ability to compete in international markets. Accordingly, the key stated goals of the trade and investment reforms were to: (1) put emphasis on modernization of plants plants and equipment through liberalized imports of capital goods and technology; (2) expose the Indian industry to competition by gradually reducing the import restrictions and tariffs; and (3) assign a greater role to multi-national enterprises in the promotion of manufactured exports.

In this paper, we focus on the following specific changes in foreign direct investment and trade policies initiated in July 1991:[8]

- **Foreign direct investment liberalization:** Prior to 1991, under the Foreign Exchange Regulation Act (1973), various constraints were imposed on foreign companies operating in India. Foreign ownership rates were restricted to below 40% in most industries. In addition, restrictions were placed on the use of foreign brand names, on remittances of dividends abroad and on the proportion of local content in output (under the Phased Manufacturing Program).

  In 1991, foreign direct investors were allowed up to 51% equity stakes in certain industries (listed in Annexure III of the Statement of Industrial Policy in 1991), under the "automatic approval route". Further, restrictions relating to use of foreign brands, remittances of dividend and local content were relaxed. Following these reforms, there was a significant increase in amount of foreign direct investment into India (see Figure II).

  To study the effect of lowered entry barriers to foreign investment, we focus on "Annexure III" industries where ownership of 51% was allowed under the automatic route. These were the sectors into which the government tried to channel foreign investment, and our analysis of aggregate sector-wise data on foreign investment proposals approved during August 1991 to December 1994 suggests that 80% of all approved foreign direct investment in the manufacturing sector in the period August 1991 to 1994 was in these Annexure III industries.[9] We define a dummy equal to one for 4 digit industries where

[8] For a more extensive discussion of these and other reforms initiated in 1991 and continued through the 90s, refer to Acharya [2002].

[9] The Annexure III industries evolved from a list that was originally Appendix 1 of the Industrial Licensing Policy of 1970.

FDI was allowed up to 51% (under the automatic approval route) to proxy for FDI liberalization. Hereafter, the terms 'FDI treated' or 'FDI liberalized' refer to firms (industries) where this dummy equals one. In section B.3, we check the sensitivity of our results to a more liberal definition of FDI liberalization.

- **Tariff liberalization:** Tariff rates were reduced across the board in the early 90s. The rates dropped from an (unweighted) average of about 85% in 1990 to about 60% in 1992. There was also a devaluation of the rupee by about 41% during the calender year 1991 (from about Rs 18.4/$ to about Rs 25.8/$), which counteracted the effect of the tariff reductions on import-competing industries, and gave a boost for firms in export-oriented industries.

  To study the impact of tariff liberalization, we define as 'tariff liberalized' (or 'tariff treated') those industries that experienced the steepest declines in tariff rates; specifically, we define a tariff liberalization dummy equal to one for industries that experienced a tariff drop (defined as $\left(\frac{\text{Tariff}_{92} - \text{Tariff}_{90}}{\text{Tariff}_{90}}\right)$) exceeding 33 per cent.

  We use a dummy variable instead of the actual tariff drops driven by the limitations of available tariff data. The data available are unweighted averages of tariff lines, and hence are crude measures of the tariff rates facing individual firms. We expect our dummy variable to capture broadly the segment of firms that faced the largest increase in competitive pressure from imports, adjusting for the devaluation in the currency. In Section B.3, we present the results from using an alternative measure of tariff liberalization.

In Table I, we list the largest (by number of plants) industries in each of the three regimes. About 28.5% of the firms belong to FDI liberalized industries, while around 41% of the firms belong to sectors we define as tariff liberalized. There is a little overlap between FDI and tariff liberalization dummies – about about 7.5% of the firms belong to industries that are both FDI and tariff liberalized under our definition. This low overlap is significant, as it suggests different industries were targeted for FDI and tariff liberalizations, and helps us to separately identify the effects of the two reforms. Even though the overlap is small, in order to separate out the effects of the two reforms, we shall focus on specifications where both FDI and tariff reform dummies are included.

In 1991 the government also initiated other widespread reforms. One big reform was the extensive liberalization of licensing requirements for establishing and expanding capacity, a cornerstone of the pre-91 industrial regulatory regime (which came to be called the "licence raj"). Other pro-market macroeconomic policies initiated in 1991 included moves to reduce the fiscal deficit, liberalization of technology and capital goods imports, devaluation

This Appendix 1 was a list of "Core Industries" introduced to limit the investment activity of large Indian companies and all foreign companies. This list was expanded under the Industrial Licensing Policy of 1973 and again in 1982.

of the local currency, transition to a market determined exchange rate and liberalization of capital markets. Since these reforms were pervasive and announced simultaneously, we adopt a difference-in-differences approach in order to identify the effects of the FDI and tariff liberalization reforms.

Our results may be biased if our key identifying assumption that de-licensing and other pervasive reforms had the same effect on the FDI and tariff liberalized industries as they had on the non-liberalized sectors, does not hold. Further, the non-random selection of industries for liberalization could lead to biased estimates of the effects of the reforms. In section B.4, we try to control for the possible differential impact of some of the concurrent reforms (such as devaluation and liberalization of capital goods imports) on particular industries, and for other potential biases introduced by non-random selection into liberalization regimes.

III Related literature

We briefly examine the literature relating FDI and trade liberalization to productivity change, and highlight the contributions of this study (see Tybout 2000, or Epifani 2003 for excellent surveys).

The literature examining the effect of FDI on productivity has generally focused on identifying the relative productivity of foreign firms and on evaluating whether there are spillovers from foreign firms to local firms. The evidence on spillovers is mixed, with some evidence of a negative effect of foreign presence on domestic firms in the same industry (Aitken and Harrison [1999]) while more recent studies find a positive effect (see survey in Keller [2004]). We focus here on the effect of FDI liberalization on all plants; irrespective of the sign of the spillover effect, liberalization of FDI regulations could affect productivity even without actual entry by foreign firms. The reduction in entry barriers to multi-national companies could force incumbents to cut slack or adopt newer technologies. The quasi-experimental nature of FDI liberalization in India permits us to try to identify the direct effect of a reduction in barriers to FDI.

As discussed in Tybout (2000) theoretical papers have argued for both a positive as well as negative impact of trade liberalization on productivity. Liberalization could improve productivity since trade protection allows inefficient firms to survive or entices inefficient producers to enter or survive (e.g., Krugman 1979, Melitz 2004), providing incentives (through increased competition) to cut slack (e.g., Schmidt 1997) or adopt new technologies (e.g. Aghion et al 1999), and providing new channels of knowledge transmission (e.g., Grossman and Helpman 1991) . Arguments for a positive effect of trade protection include providing greater incentives for marginal cost reductions (e.g. Rodrik 1992), providing incentives for high tech activities where learning-by-doing is important (e.g., Grossman and Helpman 1991), or providing better incentives (by reducing competition) to cut slack (Scharfstein 1988) or adopt new technologies (Aghion and Howitt 1992). Thus the net effect of trade liberalization is an empirical question.

We contribute to the empirical literature on trade liberalization and productivity by addressing some of the drawbacks the literature, highlighted in the survey by Tybout [2001]. Early studies attempted to identify the effect of trade openness by comparing more versus less protected industries using cross-sectional data. This is problematic as protection rates are endogenous in the long run. Other studies (e.g., Tybout and Westbrook [1995], Krishna and Mitra [1998]) try to identify the effects of trade by comparing the performance of plants before and after a trade liberalization. However, these studies are unable to separate the effects of trade reform from other macro-economic changes, which is especially problematic because many trade liberalizations are undertaken soon after an economic downturn (Epifani [2003]). Another problem with many of the earlier studies is that they did not address the issue of simultaneity bias (which arises because the choice of inputs may be correlated with the error term in the production function) while estimating production functions (Pavcnik 2002).[10]

Our study attempts to addresses all of these concerns. The nature of the Indian tariff and FDI liberalization allows us to adopt a difference-in-differences methodology that controls for the effect of concurrent macro-economic changes. Further, we adopt methodologies to address potential simultaneity bias while estimating the production function.[11]

Early studies of the 1991 Indian reforms generally focused on a few selected industries and come to contrasting conclusions of the effect of trade reform on productivity (e.g. Krishna and Mitra [1998] find a positive effect of trade liberalization, while Balakrishnan et al [2000] find a negative effect; see review by Epifani [2003]). These studies examine before-after effects that are potentially confounded by macro-economic shocks, and do not identify the effects of particular reforms. Two recent studies that carefully examine liberalization in India are Topalova's (2004) study of tariff liberalization and Aghion, Burgess, Redding and Zilibotti's (2005) study of entry liberalization. (Refer footnote 5 for a discussion of these works in relation to our study.)

Finally, to our knowledge, ours is the first study to examines the effect trade and FDI liberalization policies on aggregate productivity growth[12], and to address the question of who gains or loses from liberalization induced productivity changes.

[10] More recent studies, such as Pavcnik (2002), Topalova (2004) and Fernandes (2003) use methodologies to address these drawbacks in the earlier literature.

[11] A third potential bias highlighted by Pavcnik [2002] is caused because exiting plants are ignored in most studies. The nature of our data precludes us from identifying exiting plants, and hence we are unable to correct for this problem. To the extent that exiting firms are likely to be only a small fraction of the plants in our sample, the effect of ignoring these plants while estimating the production function may not be large. Ignoring plant exits is likely to bias the capital coefficient upward; we check the robustness of our results using different methodologies, which yield a broad range of coefficients on labor and capital, mitigating the concern that our results may be driven by a biased capital coefficient.

[12] This gap in the literature is highlighted by Tybout [2001]. While Pavcnik [2002] examines trends in aggregate productivity growth in Chile and documents a significant role for reallocation, she does not link the effect of trade liberalization to these aggregate variables.

IV Data

The primary data source for this study is the Annual Survey of Industries (ASI), undertaken by the Central Statistical Organization (CSO), a department in the Ministry of Statistics and Programme Implementation, Government of India.

The ASI covers all industrial units (called "Factories") registered under the Factories Act employing more than 20 persons. The ASI frame comprises all the factories registered with the Chief Inspector of Factories in each state. Manufacturing activity undertaken in the informal sector (households (own-account) and unregistered workshops) are not covered by the ASI. Like other low income countries, India had a large fraction of employment in the informal sector; according to estimates in Subrahmanya [2003], the employment share of the formal manufacturing sector was about 21.6% in 1989-90.

The ASI frame is classified into two sectors: the "census sector" and the "sample sector". Factories employing more than 100 workers constitute the census sector. Roughly one third of the units in the "sample sector" are enumerated every year (changed from a sampling rate of one-half in 1987-88). Since unit level data on electronic media has only recently become available to researchers, the unit-level ASI data has been used rarely used in empirical studies. Previous research using the ASI data has generally been confined to state or industry level aggregates (e.g., Besley and Burgess [2004]).

Certain limitations of the ASI data have been highlighted in the literature. Pradhan and Saluja [1998] conclude that the ASI provides " fairly reliable data" on organized manufacturing activity, but "with a considerable time-lag". Nagaraj (1999) highlights three other shortcomings of the ASI data: (i) incomplete coverage of factories, (ii) under-reporting of workers in factories covered, especially in small factories, and (iii) under-reporting of value added. He indicates that the underreporting may have increased over time. Fortunately, the questions we address and the difference-in-differences approach we use limit the effects of these shortcomings in the data. The lag in reporting the data does not affect us as we are looking at historical data. The under-reporting issues highlighted by Nagaraj do not bias our difference-in-difference estimates, under the reasonable assumption that the pattern of under-reporting does not change across the liberalized and non-liberalized groups. In addition to the ASI, we use various other sources of data on the Indian economy. Data on the sectors liberalized for FDI investment was obtained from the Handbook of Industrial Policy and Statistics issued by the Office of the Economic Advisor, Ministry of Industry, Government of India. Data on tariff rates were obtained from the World Bank Trade and Production database. Other data sources used include the annual Economic Surveys published by the Ministry of Finance, the annual Statistical Abstracts of India published by the CSO, and data from various government websites. The ASI dataset and the data collected from other sources were collated and cross-indexed using different concordance tables. Many variables in the ASI dataset had to be standardized for consistency across the years. A detailed data

appendix describing the ASI dataset and the various steps undertaken to clean the data is available on request from the author.

We obtained unit level ASI data for the nine-year period from 1986-87 to 1994-95 from the CSO. The data is reported on a financial year basis: e.g., the 1986-87 year refers to the period April 1, 1986 to March 31, 1987. (Hereafter we refer to year 1986-87 as 1987 and so on.) There are about 50,000 firms in every year, yielding about 450,000 firm-year observations for the full dataset. For our analysis, we restrict attention to industries strictly in the manufacturing sector.[13] We exclude extremely small firms (number of employees 5 or less), as the data on these firms appear to be noisy. This set of small firms constitutes about 3.75% of the manufacturing sector plants, but represents only 0.06% of total output (and 0.19% of employment and about 0.91% of total capital).

Further, observations for which real value added, real capital and the labor variables are less than or equal to zero are excluded from our analysis, because we use logged values of these variables. White collar labor is equal to zero for a very few cases (0.32% of the total). The constructed real capital variable is less than zero for 2.5% of the firms. There are larger number of cases where real value added is less than or equal to zero (14.4% of firms), with these firms contributing about 10.5% of capital and about 10% of employment. The distribution of excluded data over different industries and over time, suggests that our analysis is not severely affected on this account (see discussion in footnote 20 in section B.2).

Finally, since we wish to focus on difference-in-difference estimates, we drop observations corresponding to four digit NIC industries that appear only for a few years, either fully in the pre-reform period or wholly in the post reform period.[14]

The basic characteristics of the subset of the ASI dataset used for our analysis are summarized in Table II(a). As discussed earlier, different segments of the population are sampled using different sampling frequencies, reflected in the "multipliers" (inverse of sampling frequencies). About half the observations correspond to a multiplier of 3 (2 in year 1987) and about half belong to the census sector (multiplier of 1). There are on average approximately 37,500 plants in each year, corresponding to a population size of about 71,000 plants. Note that the sampling scheme changed in 1987, as reflected in the distribution of the multipliers. In all our analysis, we appropriately weight observations using the multiplier to adjust for the sampling frequencies.

The summary statistics our key variables are presented in Table II(b) (the definitions of these variables are discussed below). Most variables are highly skewed, leading to a large divergence between median and mean values. Since we use logged values or percentage changes in the variables in our analysis, our results are not significantly affected by the skewness in the distribution of these level variables. Nevertheless, we check the robustness

[13] The survey includes firms in some service sectors related to manufacturing, mainly general repair services, which we exclude. We also exclude the electricity generation and distribution sector. We include the repair of capital goods which is classified as a manufacturing activity.

[14] This eliminates only about 1.52% of the firms, but reduces the number of distinct 4 digit industry clusters from about 850 to about 475. Our results are largely unaffected by the exclusion of these plants.

of our results to dropping outlying observations.

Real value added is measured as the difference between real output and real values of intermediate inputs (including materials, fuels, and other intermediate inputs and services). Real output is obtained by deflating nominal output using the relevant wholesale price index (WPI). Intermediate input deflators were constructed for each industry using industry-wise WPI and the input-output table from the World Bank's Trade and Production database.

Labor is measured as the number of employees. Blue collar labor is all production workers, while white collar labor is measured as total number of employees less the number of production workers.

The dataset provides information on the opening and closing capital for each firm. However these are historical accounting numbers that are unlikely to conform to the economic notion of capital. We arrive at the real capital stock for each plant using a two-step procedure.[15] First, we start with the reported capital numbers for 1987, and use the reported nominal investment data to construct a real capital series at the industry (NIC 4 digit) level using the perpetual-inventory method. We get real capital stock $K_{j,t}$ for industry j in period t from the capital stock in the previous period $K_{j,t-1}$ and the real investment in the current period $I_{j,t}$, using: $K_{j,t} = (1-\delta)K_{j,t-1} + I_{j,t}$. We use a depreciation rate (δ) of 10% (based on rates used in the literature). The nominal investment values are deflated using the WPI for plant and machinery. Next, we form the capital stock deflator for each industry as the ratio of aggregate real capital stock to the aggregate nominal capital stock. The real capital stock for each firm is then obtained by deflating the nominal stock variable using the constructed capital stock deflator (as in Harrison [1994]). To capture productivity gains (losses) from decreases (increases) in inventory, we add real value of inventory to the real capital stock variable.

The definitions of liberalization variables used in our analysis are explained in Section II

V Effect of product market liberalization on intra-plant productivity

In this section, we analyze the effects of product market reforms (FDI and tariff liberalization), on intra-plant productivity levels. We first propose a methodology (based on recently proposed structural techniques) to identify the production function and estimate total factor productivity at the plant-level. We then use a difference-in-difference regression framework to identify the effects of different reforms on total factor productivity (which we define as the residual from the estimated production function).

A. Methodology

We assume the Cobb-Douglas production function:

$$v_{it}^j = \beta_l^j.l_{it} + \beta_n^j.n_{it} + \beta_k^j.k_{it} + e_{it}^j \tag{1}$$

[15] Since we have a repeated cross-section (survey) dataset, we cannot construct the capital series directly for each plant.

where v is the log real value added, l is the log of the number of production (blue collar) employees, n is the log of the number of non-production (white collar) employees and k is the log of the real capital employed. We allow the coefficients in the production function to vary by (2-digit NIC) industry (indexed by j), by estimating the production function separately for each industry. The index i stands for the firm and t stands for the year. We define total factor productivity as the residual e_{it} (as in e.g.Olley and Pakes [1996]).

We assume that the productivity residual has two components (we drop the industry index j from our notation to reduce clutter):

$$e_{it} = \omega_{it} + \eta_{it} \tag{2}$$

where ω_{it} is the component of the productivity shock that is known to the decision-maker before she makes the choice of inputs (k_{it}, l_{it} and n_{it}), but is unobserved by the econometrician. This "transmitted" component thus leads to a correlation between the input variables (regressors) and the productivity residual (error term), potentially biasing the coefficients estimated using the OLS methodology.[16] The component η_{it}, which is assumed to be orthogonal to the regressors, captures all other deviations from the hypothesized production function, arising from classical measurement error, optimizing errors, etc.

To address possible endogeneity of variable inputs, we adapt the structural technique proposed by Levinsohn and Petrin [2003a] (LP) for a panel dataset to our repeated cross-section setting. A detailed description of our modified LP approach is presented in Appendix 1 (essentially the LP approach uses information from an input choice equation to control for the endogenous productivity term). We find that, compared to the OLS estimates, the modified LP procedure yielded higher coefficients on the capital variable, and considerably lower coefficients on the labor variables, mirroring the findings reported by LP (in the "right direction" as per Griliches and Mairesse [1995, p19]). The returns to scale estimates are lower (and close to one) under the modified LP methodology.

The LP methodology solves the endogeneity issue at the cost of placing considerable structure on the problem. To ensure that our results are not driven by assumptions underlying the production function estimation methodology,[17] we cross-check our results using a range of alternative approaches for estimating total factor productivity (see section B.2).

To analyze the short-run and longer-term effects of various reforms on intra-firm productivity levels, we assume the following form for the productivity residual:

$$e_{it} = \alpha_t + \alpha_s + \beta_1 D_{st} + \beta_2 D_{lt} + \epsilon_{it} \tag{3}$$

where α_t captures year effects, α_s captures industry (4 digit NIC code) fixed effects, the dummy D_{st} takes on the value 1 if the firm belongs to a liberalized industry and the year is

[16] The transmitted component could arise from correlation in productivity shocks over time, or due to anticipated shocks to productivity. See Griliches and Mairesse [1995] for a comprehensive review of the literature addressing this problem.

[17] One concern could be the reasonableness of the key identifying assumption in equation 11 (see Appendix 1). Further, given the restrictive and changing regulatory conditions, it is possible that the assumption (implicit in the LP methodology) of common input and output prices across firms within an industry does not hold for some of the industries in our sample.

1992 or 1993 (short-run, post-reform), and D_{lt} takes on the value 1 if the firm belongs to a liberalized industry and the year is 1994 or 1995 (long-run, post-reform). The coefficient β_1 reflects the short-run difference-in-difference (DD) effect of the reform, while β_2 reflects the longer-term DD effect of the reform. The error term ϵ_{it} captures the remaining variation in productivity residual (including idiosyncratic shocks), and is assumed to be orthogonal to the liberalization dummies (see discussion in section B.4).

The effects of the various reforms could be analyzed using two alternative approaches. One, we could consolidate equations 1 and 3, or two, we could adopt a two-stage procedure: estimate equation 1 in the first stage and run equation 3 in the second stage (using the coefficients identified in the first stage to define the productivity residual). We find that the coefficients on the variables of interest are almost identical under the two approaches. Also, the latter procedure allows for modifying the specification without having to re-estimate the coefficients (which is extremely computationally intensive under the modified LP procedure). Hence we present all results using the latter approach.

As pointed out by , the standard errors of difference-in-difference estimators could be severely biased if we use variation within treatment groups without allowing for the errors to be correlated within each group. We code liberalization regimes at the 4-digit NIC level and hence allow for arbitrary correlation structure for the error terms within industries (by clustering on 4-digit NIC codes).

B. Effects of FDI and tariff liberalization

In this section, we evaluate the effect of FDI and tariff liberalization, on plant-level total factor productivity. To understand the broad trends in the liberalized and non-liberalized sectors, we plot the mean productivity levels for the different groups of industries in Figure III. The graph suggests that the difference in means between the liberalized and the non-liberalized groups increases after the reforms, especially towards the end of our panel period. The mean productivity level in the non-liberalized group shows no significant change in the post-reform period, while the productivity level in the FDI liberalized as well as the tariff liberalized group shows an upturn after the reforms.

In the next section B.1, we test for changes in productivity using a regression framework (based on equation 3). In section B.2, we check the robustness of our baseline results to alternative measures of productivity. In section B.4, we address the potential bias arising from the selection of certain industries for FDI and tariff liberalization. Finally, in section B.3, we check the robustness of our results to alternative definitions of the tariff and FDI liberalization measures.

B.1 Baseline results

Table III presents the regression results for FDI and tariff liberalizations. Our regression analysis confirms the significance of effects observed in Figure III.

Regressions 1 and 2 (3 and 4) compare FDI (tariff) liberalized sectors to non-liberalized sectors (based on equation 3 above). These regressions suggest a difference-in-differences improvement of 28% (35%) following FDI (tariff) liberalization in the short run, with small and statistically insignificant effects in the short term.

There is some overlap between tariff and FDI liberalization (7.5% of the firms); in regressions 1 through 4, the changes in the overlapping sectors get attributed completely to one of the reforms. In regressions 5 and 6, we look at both FDI and tariff liberalizations simultaneously. Here we find slightly smaller but still significant improvement in log productivity in the longer term for the liberalized industries; about 21% for FDI liberalization and about 33% for tariff liberalization. These regressions correctly attribute changes in overlapping sectors to the respective liberalization dummies.

We conclude that both FDI and tariff liberalizations resulted in significant improvements in mean intra-plant productivity levels in the liberalized industries. These improvements take a couple of years to be realized; we find little effect in the two years immediately following the reforms. We find the delayed effect reasonable since changes required for improving total factor productivity is likely to involve some lead time. Further, delays could also be due to concerns by firms about the permanence of the reforms (see discussion in section VIII).

B.2 Robustness to alternative measures of productivity

As discussed in section A., there may be reasons to worry that our results are driven by assumptions underlying the modified LP methodology used to derive the productivity residual in our base case (Table III). Accordingly, in this section we examine if our results are robust to various. alternative measurements of the productivity residual. The results are reported in Table IV(a). We generally find small and insignificant effects in the short run similar to the base case (Table III). Hence, for the sake of conciseness, we report only on the long-run effects of the reforms.

First, we use OLS (including industry fixed effects) to estimate the production function (equation 1). Second, we estimate the residual based on the methodology proposed by Olley and Pakes [1996], using investment to proxy for unobserved productivity disturbances (we do not control for exits since this is unidentifiable in our data). Third, we use an instrumental variables (IV) approach to identify the production function, using as instruments plant level blue and white collar wage rates (for blue and white collar labor), and debt level and interest rate as instruments for the capital variable.[18]

Fourth, considering the skewness in the key variables (see Table II(b)), in order to ensure that our results are not driven by a handful of extreme values, we redo our analysis after winsorizing the productivity variable by 2.5% on both tails of its distribution.

[18]Similar instruments have been used previously in the literature (e.g., Harrison [1994]), but have been critiqued (see Griliches and Mairesse [1995]). The key concern is that the useful variation in these instruments may be eliminated when we control for industry or year effects. We do not see this as a superior identification strategy, and use this merely as a cross-check on the robustness of our results.

Fifth, we use the commonly used Solow index definition of productivity (valid under the assumptions of constant returns to scale and perfect competition): $\log(\text{TFP}) = [v - s_l.l - s_n.n - (1 - s_l - s_n).k]$, where v is log real value added, l is log of the number of blue collar employees, n is log of the number of white collar employees, s_l is the share of blue collar wages in value added and s_n is the share of white collar wages in value added. We evaluate the shares (s_l and s_n) at the median level within each two digit industry.

Sixth, we use the residual from a gross output production function specification. Our base case production function specification defines real value added as a function of labor and capital inputs. This assumes a strong form of separability in intermediate inputs (Bruno [1978]). To check if our results are driven by the assumption of a value-added specification, we estimate productivity as the residual from a full production function, i.e. defining real output as a function of real intermediate inputs (including materials, fuels and other inputs), labor (blue and white collar) and capital. Given the remarkable consistency of results across the LP and OLS in the value added specification, for computational convenience we estimate the full production function using the OLS methodology (allowing the parameters to vary across 2-digit industries).

Finally, we use labor productivity (defined as log of value added per employee) as an alternative measure of productivity. While labor productivity has the drawback of confounding the effect of technology improvement and factor accumulation, it is commonly used as an alternative measure of productivity (especially when data on capital is unavailable). Further, examining this measure would be a check on whether the estimated total factor productivity improvements are driven solely by measurement error in capital.

We find our results remarkably robust to alternative measures of productivity. Note that productivity in gross output terms (row 7 of Table IV(a)) is expected to be much lower than the productivity in value added terms (first six rows of Table IV(a)), and a rough check suggests that the gross output results are broadly consistent with the value added results.[19]

In addition to the above, we checked the robustness of our results to using an alternative definition of capital, allowing production function coefficients to vary between the pre-reform and post-reform periods, and including other (size and location) fixed effects (results not reported). We found our results generally robust to these checks too.[20]

The remarkable robustness of our results across different definitions of productivity is

[19] Roughly, the ratio of gross output productivity to value added productivity is the same as the ratio of value added to gross output (refer footnote 6). Since the mean ratio of value added to output is about 25% in our sample, the gross output effect here is equivalent to (roughly) a 20% ($\simeq$ 4*0.049) increase in productivity following FDI liberalization and a 24% ($\simeq$ 4*0.059) increase in productivity following tariff liberalization, in value added terms.

[20] As noted in section IV, because we use logged variables, we exclude observations where real value added is non-positive. This leads to the exclusion of poorly performing firms, and potentially biases simple period means upwards. To understand the implications of this for our difference-in-difference estimates, we analyzed the patterns of non-positive real value added across the liberalized and non-liberalized samples and over time. We find that the proportion of firms with non-positive value added is generally higher for the non-liberalized industries and more so in the post-reform period, so that dropping these firms likely overestimates the productivity improvement in the non-liberalized industries. Thus dropping cases of non-positive value added is likely to cause an underestimation of the difference-in-difference effects of the FDI and tariff liberalizations. Further, as a crude check, we replaced the non-positive real value added figures with the minimum positive real value added figures for each year. We obtained larger but noisier (less significant) difference-in-differences effects.

consistent with the findings reported by Van Biesebroeck [2003]. As in Van Biesebroeck, we observe significant differences in coefficient estimates (and hence in returns to scale) across the OLS, LP, IV and index number methodologies, but our difference-in-difference estimates of the effect of reforms on productivity are largely unaffected by the particular methodology used. These findings provide room for cautious optimism about the severity of simultaneity bias problem on some common types of total factor productivity studies.

B.3 Alternative definitions of liberalization

In this section, we check whether the large and positive effects of FDI and tariff liberalization we estimated in Table III is robust to alternative definitions of the FDI and tariff liberalization variables. Our results are presented in Table IV(b).

First, we re-examine our definition of FDI reform. In section II, we defined the FDI reform equal to one for 4-digit NIC codes that corresponded to industries in the Annexure III list of the Statement of Industrial Policy, 1991. The cross-indexing of the Annexure III industries was done manually, and could lead to measurement error on the reform dummy. It is possible that the RBI or FIPB adopted a more liberal classification strategy allowing FDI into activities that were similar to those listed in Annexure III. Also, firms may have been able to classify their activities as within the automatic approval list even if they were reasonably close (even if they did not precisely match at the level of disaggregation we use). This could lead to a downward bias in our results in Table III (since we exclude some industries that were actually liberalized). To address this concern, we adopt a more liberal definition of FDI liberalization, classifying additionally all sub-sectors within a 3-digit NIC code as FDI liberalized if more than half the plants in the 3-digit industry had been classified as liberalized under the definition we used for Table III. This leads to about 5% additional plants being classified as FDI liberalized. Our results (row 2 of Table IV(b)) suggest that a more liberal definition of the FDI reform variable increases the reform effect from 21% to about 23% (the statistical significance also increases).

Next, as an alternative to the tariff reform dummy defined in section II, we define a variable equal to the normalized rank of the drop in tariffs (between 1990 and 1992) faced by each plant. For this measure, plants in the industries that faced the largest tariff drops would have a value equal to one, while plants in the industries with the lowest tariff drop would have a value close to zero (plants in industries with the median drop in tariffs would have a value equal to 0.5). The results of using this variable (row 3 of Table IV(b)) suggests a strong and highly statistically significant effect of both the FDI and tariff liberalizations. The coefficient magnitude (0.67) appears to be consistent with the results in Table III; as per the definitions used in Table III, the mean value of the rank variable is about 0.3 in the non-liberalized sectors and about 0.8 for tariff liberalized sectors, suggesting a productivity increase of about 34% (0.67 *(0.8-0.3)) as we move from the mean non-liberalized to the

mean tariff liberalized plant.[21]

The results are similar when we include both the liberal definition of FDI reform and the normalized rank variable definition of tariff liberalization in the same specification (row 4 of Table IV(b)).

B.4 Selection of Industries for FDI and Tariff Liberalization

By looking at difference-in-differences, our methodology controls for biases arising from the selection of certain industries for FDI and tariff liberalization, to the extent that the industry characteristics that led to the selection had a fixed effect on productivity levels. For example, pre-existing differences in productivity levels get absorbed by industry fixed effects in our specification. Further, we control for contemporaneous macro-economic shocks by comparing changes in the liberalized industries to changes in non-liberalized sectors. For example, economy wide effects of changes in tax rates or inflation are controlled for by time dummies.

However, our results could be still be driven by selection bias from two reasons. Firstly, if the choice of industries for liberalization was made on the basis of high pre-reform productivity *growth*, this could give rise to spurious differences in differences improvements in post-reform productivity *levels*. Secondly, it could be that industries with certain characteristics that were also selected for liberalization show improvements in productivity either due to other contemporaneous reforms, or because industries with these characteristics were poised for productivity improvement (even without the reforms), for some unknown reason.

We translate these two causes into four potential sources of bias for our baseline results: a) industries with strong pre-reform growth in productivity may have been selectively liberalized; (b) currency depreciation may have benefitted export-oriented industries who may have been selectively liberalized; (c) liberalization of capital imports may have benefitted capital intensive sectors, who may also have been selectively liberalized; and (d) industries relatively farther away from the frontier may have had a greater (or lower) scope for improvement, and they may have been selectively liberalized.

We try to address these sources of bias in two ways. One, we redo our analysis conditioning out the effect of variables that control for each of the four sources of bias. This allows us to identify if there are reform effects after controlling for the improvements experienced by all industries with the given characteristic. Second, we condition on the propensity score from a selection model that includes proxies for these sources of bias and additional variables influencing selection into different liberalization regimes (following Rosenbaum and Rubin (1985)). By conditioning on the propensity score, we test whether the selected industries

[21] We found our results robust to defining a tariff liberalization dummy equal to 1 for the 25 percentile and the 40 percentile of plants that experienced the largest drops in tariff between 1990 and 1992. We also attempted using the drop in tariff rates directly as the measure of tariff liberalization. While we found large effects consistent with other results, these were not statistically significant. Given the crudeness of available tariff data, we believe this is caused by the noise in the actual magnitudes of tariffs drops. As discussed earlier, the data we use are unweighted tariff line averages for 4 digit SIC codes (from the World Bank Trade and Production Database), which we then cross-index with the NIC codes. We believe that the relative ranks of industries would be a more informative (less noisy) measure of the relative degree of tariff liberalization faced by different industries.

show an improvement over-and-above the improvement exhibited by industries that had a high probability (based on our selection model) of being selected into liberalization treatment. We control for the effect of pre-reform trends by including an interaction of the growth rate of the mean productivity in each industry prior to 1991 ("PRE_GRW").[22] We control for the possible positive effect of contemporaneous events on export-oriented sectors by including an interaction of pre-reform total exports to industry output ratio ("EXP_INT"). Similarly, we control for the effect of the liberalization of capital imports on capital intensive sectors by including interactions of period dummies with the industry mean log of Capital per Employee ("CAP_EMP"). We control for the distance to frontier by including with period dummies interacted with the ratio of industry level labor productivity in Indonesia to that for the same industry in India ("DIS_FRON").[23]

Our results are presented in columns 1 to 4 of Table IV(c); we focus on the effects in years 1994 and 1995 as the short-run effects (years 1992-93) are insignificant and generally unaffected by the inclusion of these controls. In column one, we find that industries with high pre-reform productivity growth rate showed significant improvement in productivity post-reform, but this does not reduce the estimated effect of the FDI and tariff reforms. Similarly, in column two, export oriented industries show improvement in productivity post-reform, but this has no significant impact on estimated FDI and tariff reform effects. In column three we find significant improvement in capital intensive sectors after the 1991 reforms; this reduces the estimated effect of the FDI liberalization from 21% to about 16%, but does not materially affect the estimated tariff effect. Including the distance to frontier proxy in column four has no effect on the estimated reform effects. In column five, we include all four controls, and find that there is a small strengthening of the tariff liberalization effect, while the FDI liberalization falls by about 6% to 15.6%.

We find these results robust to using alternative measures for capital intensity (capital share of value added), trade orientation (import share of output) and distance to the frontier (labor productivity relative to Korea). We conclude that our estimated FDI and tariff liberalization effects are largely robust to the four sources of bias examined here, subject to the caveat that part of the FDI effect in Table III could be due to the widespread improvement in capital intensive sectors, which is possibly due to factors other than the liberalization of FDI.

In columns 6, 7 and 8, we try to control for the effect of selection into different liberalization regimes by estimating a selection model and controlling for the propensity score. Our selection model is discussed in Appendix 2. In addition to variables to control for the four sources of bias discussed above, the selection model includes controls drawn from the

[22] Another way to address the concern about pre-reform trends would be to look at difference-in-difference effect of the reforms on productivity *growth*. We do this type of analysis in sections VI and VII, and find robust positive effects on the productivity growth rates too.

[23] The idea here is similar to the "distance to frontier" concept used in other papers e.g., Acemoglu, Aghion and Zilibotti [2003]. We use the UNIDO data on value added (in dollars) and number of employees. Note that the value added figures here are not adjusted for industry specific PPP exchange rates, but use the official exchange rate. We also looked at output per unit labor cost and find very similar results.

literature on the political economy of trade liberalizations and factors discussed in policy announcements.[24]

The results from conditioning on the propensity score are presented in columns 6, 7 and 8 of Table IV(c). The propensity score for FDI liberalization ("FDI_PRED") and for tariff liberalization ("TAR_PRED") are derived from the selection models in column 5 and column 10 of Table A.I in Appendix 2. Conditioning on the FDI propensity score alone reduces the FDI effect from 21% to about 18%, while controlling for both the propensity scores reduces the FDI effect down to 14%. There is no effect on estimated tariff liberalization effect in these specifications. Again, these results suggest that a part of the effect of FDI estimated earlier (Tables III) is driven by the characteristics of the industries (possibly high capital intensity) selected for liberalization.

We conclude that a significant part of the FDI liberalization effect and almost all the tariff liberalization effect seems unlikely to be driven by non-random selection of industries for liberalization.[25] The results from this exercise must, however, be interpreted cautiously. Measurement error in the reform variable could bias coefficients on the liberalization variable downward. The definition of whether an industry is liberalized could be subject to interpretation by local regulatory authorities. For example, in the case of FDI liberalization, some of the industry with a high propensity score may have received approvals through the FIPB route (refer section II) more easily. In this case, if non-liberalized industries with a high propensity score show a large productivity increase, it may be because of these industries faced greater degree of FDI liberalization than is reflected in our reform measure; then our coefficient on FDI liberalization in Table IV(c) would be biased downward. On the other hand, our selection model could be misspecified, as there could be omitted or unobservable variables driving selection into FDI or tariff liberalization.[26] Hence, we are wary about completely ruling out bias arising from the selection of specific industries into the two liberalization regimes, but interpret the evidence as suggesting that estimated effects are not completely driven by selection bias.

[24] Our selection model suggests interesting political economy underpinnings for the liberalization process in India. A complete analysis of this topic is beyond the scope of this paper.

[25] Here we attempt to identify reform effects by controlling for potential omitted variables. An alternative identification strategy could be an instrumental variables approach. If we could identify variables that affected choice of industries into FDI and tariff liberalization but were uncorrelated with the potential for post-91 change in productivity, we could instrument for the policy liberalizations using these variables. However, all the variables we identify as affecting selection (see Appendix 2), such as labor productivity relative to international levels, export-share of output, etc are plausibly correlated with productivity change. Hence these variables would be poor instruments for the reform dummies, and therefore we try to control for these variables directly or through the propensity score. We examined other potential instruments (e.g., location of the industries relative to the political base of the ruling party), but these proved to be weak in the first stage regression (i.e. in explaining variation in the liberalization variable). The results using these weak instruments support a significant positive effect for both FDI and tariff liberalizations.

[26] Including additional predictors in the selection model may not improve the outcome; in the extreme case, if our model exactly predicted choice into a particular liberalization regime, we could have a collinearity problem, similar to the support problem highlighted by Heckman et al. (1997).

VI Analysis of aggregate output and productivity growth

The important role of re-allocation in improving aggregate productivity has been stressed in empirical studies of productivity in US manufacturing plants (Foster et al. [1998]) and in recent theoretical work on trade liberalization [e.g. Melitz [2003]. Nickell [1996] points out that focussing solely on changes in mean intra-plant productivity may be misleading, as the effect of increased competition could be to spur the re-allocation of resources from less to more efficient firms. However no empirical studies of trade liberalization have addressed this question directly [Tybout 2001], and we contribute here to plugging this gap in the literature.

We first propose a novel decomposition of changes in industry aggregate output growth into contribution from changes in inputs, reallocation across industries and changes in industry aggregate productivity growth. The change in industry aggregate productivity growth is further decomposed into a intra-plant component and a term capturing reallocation across plants within the industry (intra-industry reallocation). Then we estimate difference-in-difference effects of FDI and tariff liberalization on each component of this decomposition.

A. *Methodology*

Following from the Cobb-Douglas production function assumed in equation 1, indexing plants by i, we write aggregate output in an industry in period t as:

$$Y_t \equiv \sum_i Y_{it} \quad = \quad \sum_i e^{e_{it}} l_{it}^{\beta_l} n_{it}^{\beta_n} k_{it}^{\beta_k}$$

Then defining $\theta_{it} \equiv (e^{e_{it}})$ and $\psi_{it} \equiv \left(l_{it}^{\beta_l} n_{it}^{\beta_n} k_{it}^{\beta_k} \right)$ we get:

$$\begin{aligned} Y_t &\equiv \sum_i \theta_{it}\psi_{it} = \sum_i \left\{ \frac{\psi_{it}}{\sum_i \psi_{it}} \theta it \right\} \sum_i \psi_{it} \\ &= \sum_i \{s_{it}\theta_{it}\} \sum_i \psi_{it} \equiv \bar{\Theta}_t \bar{\Psi}_t \end{aligned} \tag{4}$$

Thus aggregate output can be viewed as the product of an aggregate input index $\bar{\Psi}$ and an aggregate productivity index $\bar{\Theta}$. Note that this aggregate productivity index, unlike those used earlier in the literature, can be directly related to the aggregate output.[27] We can then decompose changes in aggregate output into changes in the aggregate productivity index $\bar{\Theta}_t$ and changes in the aggregate input index $\bar{\Psi}_t$:

$$\frac{dY_t}{Y_t} = \frac{d\bar{\Theta}_t}{\bar{\Theta}_t} + \frac{d\bar{\Psi}_t}{\bar{\Psi}_t} \tag{5}$$

The aggregate productivity index $\bar{\Theta}_t$ can be further decomposed, as in Olley and Pakes

[27] This productivity index is incidentally similar to the one advocated by Levinsohn and Petrin (2003b). This paper discusses the shortcomings in productivity indices and decompositions used in the literature.

[1996], as follows:[28]

$$\bar{\Theta}_t = \bar{\theta}_t + \sum_i (s_{it} - \bar{s}_t)(\theta_{it} - \bar{\theta}_t) = \bar{\theta}_t + \rho_t$$

$$\Rightarrow \Delta\bar{\Theta}_t = \Delta\bar{\theta}_t + \Delta\rho_t \tag{6}$$

Combining equations 5 and 6, in the discrete time case we get the following decomposition of mean aggregate (industry) output growth:

$$\begin{aligned}\left[\frac{1}{k}\sum_{j=1}^{k}\frac{\Delta Y_{j,t}}{Y_{j,t}}\right] &= \left[\frac{1}{k}\sum_{j=1}^{k}\frac{\Delta\bar{\Psi}_{j,t}}{\bar{\Psi}_{j,t}}\right] + \left[\frac{1}{k}\sum_{j=1}^{k}\frac{\Delta\bar{\Theta}_{j,t}}{\bar{\Theta}_{j,t}}\frac{\Delta\bar{\Psi}_{j,t}}{\bar{\Psi}_{j,t}}\right] \\ &\quad + \left[\frac{1}{k}\sum_{j=1}^{k}\frac{\Delta\bar{\theta}_{j,t}}{\bar{\Theta}_{j,t}}\right] + \left[\frac{1}{k}\sum_{j=1}^{k}\frac{\Delta\rho_{j,t}}{\bar{\Theta}_{j,t}}\right]\end{aligned} \tag{7}$$

where j indexes the industry, and k is the total number of industries.

Thus, change in the average industry-level output growth comes from increases in the aggregate input index (term 1), or from covariance between changes in the industry aggregate input index and changes in the industry aggregate productivity index (term 2), or from change in the mean intra-plant productivity level (term 3), or finally from an increase in the covariance between intra-plant productivity levels and intra-industry input share (term 4). Term 4 is commonly interpreted in the literature as arising from (intra-industry) reallocation of inputs towards more productive plants. Analogously, term 2 can be interpreted as the component of output growth arising from the reallocation of inputs between industries (inter-industry reallocation).

We first estimate each component in Equation 7 separately for each 4-digit industry. We then analyze if the change in each component of output growth is significantly different for the industries where FDI and tariffs were liberalized, using a difference-in-difference regression framework similar to equation 3:

$$X_{jt} == \alpha_t + \alpha_s + \beta_1 D_{st} + \beta_2 D_{lt} + \epsilon_{jt} \tag{8}$$

where X_{jt} is one of the terms on the RHS of equation 7, the dummy D_{st}, captures the short run post-reform (1992 and 1993) effect, D_{lt} reflects the long-run, post-reform (1994 and 1995) effect, and ϵ_{jt} is the error term capturing omitted variables and other residuals.

Note that the terms in the above regression are industry-level (mean) *growth rates*, whereas the regression in the previous section looked at plant-level (log) productivity *levels*. Hence, these regressions give us difference-in-differences (DD) estimates of the changes in productivity *growth rates* in industries that were reformed. However, we must be cautious in interpreting these DD estimates as permanent changes in growth rates, since these are measured over relatively short periods and may not be distinguishable from one-time increases in productivity levels following the reforms (as pointed out by Tybout [2000]).

[28] This decomposition is critiqued in Levinsohn Petrin (2003b). While the alternative decomposition suggested by them in the panel context is more informative, we are unable to use that given the nature of our data (repeated cross-sections).

B. Results

To control for the effect of outliers on our regression analysis, in the baseline specification we truncate the sales growth variable by 2.5% on both sides of the distribution.[29] (We check the robustness of our results to using different truncation cut-offs, and to using a logged transformation of the dependent variable.)

The results under our baseline specification are summarized in Table V. In panel 1 we compare FDI liberalized industries to industries that faced neither FDI nor tariff liberalization. Following FDI liberalization, we find that there was a difference-in-difference (DD) increase in the growth of output of about 10.2% (not statistically significant) in the short run (1992-93) driven largely by input growth (4.6%) and by intra-industry reallocation (3.6%). In the longer term (1994-95), there was a 16.7 % increase in output growth, composed mainly of aggregate productivity growth (16%). Aggregate productivity growth was in turn dominated by intra-plant productivity growth (11.6%).

In panel 2 we do the same analysis as above for tariff liberalized industries. The results here are similar to those for FDI liberalization. There is a statistically insignificant 5.5% change in output growth in the short-run, contributed to mainly by changes in intra-plant productivity growth. In the longer term, we find a 12.9% (statistically insignificant) change in output growth for tariff liberalized industries, driven by mainly by aggregate productivity growth (15.6%, significant at 5 percent level). Changes in aggregate productivity growth is in turn driven largely by changes in intra-plant productivity growth (10.6%), and to a lesser extent by intra-industry reallocation (5.0%).

For both FDI liberalization and tariff liberalization, the statistically significant effects were changes in aggregate productivity growth, driven by changes in intra-plant productivity growth. Inter-industry reallocation plays only a minor role, in all the cases, while intra-industry reallocation plays a larger, but statistically insignificant role.

We cross-checked our results using different truncation cut-offs on the sales growth variable (1% and 5%); while the point estimates varied, the relative importance of the various components remained largely unchanged. We also examined a log transformation of each of the components (i.e. we looked at $log(1 + X_{jt})$ instead of X_{jt} in equation 8), which yields results more robust to dropping outliers. The results using the transformed variables were qualitatively similar to those under the baseline specification.

We interpret the above results as: (a) providing strong evidence of a positive effect of lowering entry barriers on aggregate productivity growth, and (b) suggesting that the aggregate longer-term (1994-1995) productivity growth was largely through channels stressed in representative agent theories (such as adoption of technology or reduction in slack). The reallocation channel stressed heterogenous firm theories (such as Melitz [2003]) plays an important role in the short-run, but these effects are small relative to the long-run gains from intra-plant productivity improvements. We note that the highly restrictive labor laws in

[29] That is, we drop observations for which sales growth is above 97.5 percentile or below 2.5 percentile.

India may have dampened the role of reallocations.

VII Beneficiaries from the reforms

A widely debated question in relation to opening markets to global competition (such as those analyzed here), is who obtains the benefits (if any) from the reforms. In the Indian context, there is an ongoing debate on the effect of the 1991 reforms on poverty (refer Datt and Ravallion [2002]). Studies on trade liberalizations in other countries have examined the impact of trade on labor market outcomes such as labor demand elasticity and wage inequality between skilled and unskilled workers (see Epifani [2003]). In this paper, we try to evaluate who benefited from the long-run improvement in productivity following FDI and tariff liberalization that we uncovered in the previous sections.

A. Methodology

To address this question, we evaluate a decomposition that relates total factor productivity change to changes in different price levels. We start with the accounting identity:

$$P_t^o.Q_t^o \equiv P_t^i.Q_t^i + W_t^l.L_t + W_t^n.N_t + R_t^k.K_t$$

where P_t^o is the output price at time t, Q_t^o is the real value of output, P_t^i is the input price at time t, Q_t^i is the real value of inputs used, L_t is the number of blue collar employees, W_t^l is the blue collar wage rate, N_t is the number of white collar employees, W_t^n is the white collar wage rate, R_t^k is the return to capital, and K_t is the capital employed. R_t^k is not directly observed; we define R_t^k as the residual, assuming the above identity holds.

Taking first differences and defining $s_i \equiv \frac{P^iQ^i}{P^oQ^o}, s_l \equiv \frac{W^lL}{P^oQ^o}, s_n \equiv \frac{W^nN}{P^oQ^o}, s_k \equiv \frac{R^kK}{P^oQ^o}$, some simple algebra yields:

$$\begin{aligned} \delta_p &\equiv \left(\frac{\Delta Q^o}{Q^o} - s_i\frac{\Delta Q^i}{Q^i} - s_l\frac{\Delta L}{L} - s_n\frac{\Delta N}{N} - s_k\frac{\Delta K}{K}\right) \\ &= \left(s_i\frac{\Delta P^i}{P^i}\right) + \left(s_l\frac{\Delta W^l}{W^l}\right) + \left(s_n\frac{\Delta W^n}{W^n}\right) + \left(s_k\frac{\Delta R^k}{R^k}\right) + \left(\frac{-\Delta P^o}{P^o}\right) \end{aligned} \tag{9}$$

In equation 9, the first line corresponds to the Solow index definition of productivity change. The five terms in the second row represent the decomposition of productivity growth to (share weighted) growth in input prices (term 1), blue collar wage growth (term 2), white collar wage growth (term 3), growth in return to capital (term 4) and changes in output prices (term 5). We interpret equation 9 as the decomposition of productivity gains into benefits to five groups of stake-holders: (input) suppliers, blue-collar workers, white-collar workers, owners of capital and consumers.

To operationalize the above decomposition, we aggregate output, employment, capital

and wages to the industry level.[30] For P_t^o, we use the wholesale price index, while P_t^i is obtained as a weighted average of the input wholesale price indices (with weights obtained from the input-output tables). Note that since we use the wholesale price index, price drops are more precisely interpreted as gains for wholesale rather than retail consumers. We then examine the effect of FDI and tariff liberalization on each component of the decomposition, adopting the same regression framework that we used in section VI.

B. Results

The results from the difference-in-difference analysis of each of the sub-components of equation 9 is presented in Table VI. As in section VI, we find that our point estimates are affected by outliers. Hence, for our baseline specification, we control for the effect of these outliers by truncating the data by 2.5% on the both tails of the productivity (δ_p) distribution.

In panel 1 of Table VI we examine the effect of FDI liberalization and in panel 2, we look at tariff liberalization. We obtain similar results for both FDI and tariff liberalizations. As in previous sections, we find no significant effects in the short run post-reform period (1992-93). There is a significant increase in industry level productivity growth (defined as per the Solow measure) in the longer-term (i.e. in the years 1994 and 1995): 5.2% for FDI liberalization and 5.1% for tariff liberalization.[31] As shown in equation 9, this change in productivity growth (column 1) can be decomposed into changes in various factor prices (columns 2 to 6). There is a statistically significant drop in input prices in the liberalized industries in the 1994-95 period (1% for FDI and 0.3% for tariff liberalization). This suggests a reduction in margins or reduced costs for suppliers of intermediate inputs. The relative increase in productivity and the drop in input prices appear to translate into relative drops in output prices (4.9% for FDI and 2.7% for tariff liberalization). The next largest component is gains to capital, but this is a smaller (and statistically insignificant) proportion of the long-run productivity improvement. There is almost zero relative change in the share-weighted wages for both blue and white collar workers in the liberalized industries. We see similar but smaller effects in the shorter run (1992-93) for both FDI and tariff liberalization.

We checked the sensitivity of our results to using different truncation cut-offs for productivity growth outliers (δ_p). Though point estimates vary, the qualitative conclusions remain the same: following the reforms, there is a long run increase in productivity growth and a fall in input prices, with the main effect being reduced consumer prices. There is no difference-in-difference impact on either blue or white collar wage rates. Our qualitative conclusions are also robust to using log transformations of our dependent variables.

Thus, we conclude that the main beneficiaries from the relative productivity improvement

[30] With panel data, we could implement the above decomposition at the firm level. Since we have a repeated cross-section (survey) dataset, we aggregate up to the industry level.

[31] Note that, as discussed in footnote 6, change in growth rate of 1% in real output terms translates into roughly 4% change in growth rate of value added (holding inputs constant). Hence the numbers here translate to a change in productivity growth of about 20% (20%) for FDI (tariff) liberalization in value added terms, which are somewhat higher than the values obtained for change in value-added aggregate productivity growth using the estimated coefficients in section VI.

in the reformed sectors were consumers. There is no evidence here of either a beneficial or detrimental impact of productivity improvements on either blue or white collar workers.[32] To the extent that wholesale consumers are not concentrated and/or that wholesale price drops translate to lower retail prices, these results assuage the concern of some critics that the benefits of from product market liberalizations may not be widely dispersed.

VIII Discussion of Findings

We draw three broad conclusions from our analysis: (i) there were significant gains in the mean level of intra-plant productivity, following the FDI and tariff liberalizations. This result survives tests for biases from measurement of productivity, selection into liberalization regimes and, measurement of the liberalization variable,; (ii) there was significant change in aggregate productivity growth in the liberalized industries, and the main channel for the aggregate productivity growth was intra-plant productivity growth; and (iii) the major beneficiaries from productivity growth appear to be wholesale consumers (in the form of lower prices).

A number of factors, based on the institutional peculiarities, the nature of the reforms and data limitations could affect our estimates or impact the interpretation our results. We discuss these in detail below.

The key issue in interpreting our estimated effects is the non-random selection of industries for FDI and tariff liberalization. Section B.4 addresses this issue; our analysis suggests that selection bias may lead to an overestimate of the effect of FDI reforms, while it does not affect our estimate of the effect of tariff liberalization. We are wary about interpreting this as conclusive evidence that the estimated effects are free of further biases induced by selection; for example there may have been selection on unobservables that we are unable to control for. However, we believe a conservative conclusion would be that both tariff and FDI liberalization had large, positive effects on total factor productivity levels in the liberalized sectors.

Our estimates could be affected if firms expected the reforms to be reversed. Some of the literature on the political economy of the Indian reforms suggests that the strength of the reforms were unusual given the weak position of the ruling party in the parliament. Also there had been a successful resistance and a political backlash to reform initiatives made by the earlier government, which could have lead to misgivings about the permanence of the 1991 reforms.[33] These concerns suggest that our estimates may be biased downward, and hence does not weaken the conclusions we draw from our analysis.

[32] These results are generally supported by our analysis of a range of other variables, including wage rates, labor share of output, return on assets and gross margins. We note that there was an increase in both blue and white collar wages, in the white collar to blue collar wage ratio, and in the white collar share of output and employment, across all sectors. This is not reflected in the above analysis, because it captures only relative differences between liberalized and non-liberalized industries.

[33] Generally, there has been a political consensus around the reforms, with governments formed by different parties furthering the reform agenda. There were no hikes in tariff rates until the Hindu nationalist Bharatiya Janata Party took office in 1997, and even these were partially rolled back. Thus a rational expectations model would have people expecting the reforms to be sustained. Refer to Echeverri-Gent [2003] for discussion of the political economy of the Indian reforms.

The expectation that the FDI and the tariff liberalization reforms would be extended to other industries could be another factor affecting our estimates. The list of industries where FDI was permitted above 50% was expanded considerably in 1997, and tariff rates continued to be reduced across all industries, through the mid to late 90s. This anticipation of reforms may have encouraged some firms in the non-liberalized industries to begin improving productivity (e.g., by adopting technologies or eliminating slack). Again, this concern suggests that our results understate the effect of the reforms.[34]

Our empirical strategy could be affected by two measurement issues – lack of information on capacity utilization and the use of deflated revenue as a measure of output. The former issue implies that some of the productivity improvements we measure may be a reflection of enhanced capacity utilization, possibly from demand shocks. To the extent that the demand shocks were similar in the control groups, we control for the changes arising from increased capacity utilization. Further, some of the pre-reform under-utilization of capacity may reflect the inefficiency and distortions of the over-regulated pre-reform regime. For example, anecdotal evidence suggests that large industrial houses used to obtain licences for capacity and leave them unutilized to prevent entry of new players (DeLong (2001)). Thus post-reform utilization of these (strategically) wasted resources may reflect genuine gains from the reforms.

Using deflated revenues as the measure of output could bias estimation of the production function, as highlighted by Klette and Griliches [1996]. Two features of the reforms we are studying mitigate the impact of this problem. One, since the reforms were implemented at an industry level, we are interested in industry level productivity (mean productivity of plants within industries as in section V, or industry aggregate productivity measures as in section VI and VII). While using industry level aggregate price deflators may overstate the output (and hence productivity) of plants that charge relatively higher prices and understate the output (and hence productivity) of plants that charge lower prices, the net impact on the mean industry productivity is likely to be low. Two, in the cases where our price data is more aggregated than the 4 digit industry level, if we assume that the reforms reduced the market power of firms in the liberalized industries, so that the price levels in these particular industries converged towards the mean (aggregated) price index, then output measures in the pre-reform period are overstated for these industries relative to post-reform. Then our difference-in- difference estimates of productivity improvements in these industries are biased downward. Our results on the fall in relative prices following the reforms (section VII) and results of previous studies suggest that this may be a reasonable assumption.[35]

The limited role of reallocation that we uncover in section VI should be viewed considering

[34] There is also the possibility that they continue to enjoy the perks of the protected environment for as long as possible. We feel this would be unlikely, as even owners/managers contemplating an exit may want to improve the potential sale proceeds by improving performance.

[35] A rough check we undertook suggest that margins either fell or remained the same in the liberalized industries, suggesting that the assumption of convergence of price levels toward the aggregate mean may not be unrealistic. Also Krishna and Mitra [1998] report a drop in margins post-reform.

the highly restrictive labor laws in India that limit the reallocation of inputs (Besley and Burgess, 2004). Also, it is possible that aggregate productivity changes due to reallocation may take longer to show up in the data. Finally, we note that we are unable here to fully analyze the role of exit, unlike studies such as Pavcnik [2002], which use plant-level census data-sets. This is because our survey dataset does not allow us to identify genuine exits.

Our analysis of the beneficiaries from the reforms needs to be qualified by the limitations of available data. The price data available is at an aggregated level (We have about 120 lines of price data, for about 450 different four digit industries.). However, since this analysis focuses on three broad categories of industries, we believe that our conclusions are likely to be robust to this measurement problem.

IX Conclusion

We interpret our results as a validation of the productivity enhancing effect of reforms that eliminate barriers to trade and foreign direct investment. Our finding that (wholesale) consumers were the major beneficiaries from the productivity improvements suggests that benefits from such reforms may be widely distributed.

The significant role we find for intra-plant productivity improvements in aggregate productivity (and output) growth suggests that channels stressed in homogenous firm models such as reduction of slack (e.g., Schmidt [1997]) or the adoption of new technologies (e.g., Aghion et al. [1999]) may have played a relatively important role, in contrast to the predominant role for reallocation suggested in some heterogeneous firm models (e.g., Melitz [2003]). An interesting extension of this work would be to use additional data to identify the contribution of different channels proposed by the theoretical literature (adoption of technology, reduction in slack, learning from contact with foreign goods/competitors) to the measured improvement in productivity in the liberalized sectors.

From a methodological viewpoint, the robustness of our results to alternative approaches to estimating the productivity parameter is reassuring. This result mirrors results in Van Biesebroeck [2003] and Pavcnik [2002], and suggests that the choice of methodology in estimating total factor productivity may not significantly impact many common types of investigations.

Appendix 1: Estimation algorithm in the L-P methodology

We assume that our value added production function $v = f(l, n, k, \omega)$, is part of a more general production function separable in all intermediate inputs $Y = g(f(l, n, k, \omega), h(\Gamma, \omega))$ where Γ is a vector of intermediate inputs. (Equation 1 is then a Cobb-Douglas parameterization of the function $v = f(l, n, k, \omega)$.)

Let ι be one intermediate input, which LP assume has a demand function of the form:$\iota_{it} = \iota_t(\omega_{it}, k_{it})$. Other possible state variables not explicitly included in the above input demand function include prices of inputs and output(s). We assume input and output prices are fixed across firms within the same industry, but allow for the common prices to change over time by indexing the input demand function by t.[36] Assuming monotonicity, i.e. input choice is strictly increasing in productivity for all relevant capital levels,[37] the input demand function can be inverted to yield an representation for the unobserved productivity: $\omega_{it} = \omega_t(\iota_{it}, k_{it})$.

Then, assuming the monotonicity condition holds, we can estimate the coefficients on the labor inputs by estimating the following regression:

$$v_{it} = \beta_l l_{it} + \beta_n n_{it} + \phi_t(\iota_{it}, k_{it}) + \eta_{it} \qquad \text{(Step 1)}$$

where:

$$\phi_t(\iota_{it}, k_{it}) = \beta_k k_{it} + \omega_t(\iota_{it}, k_{it})$$

We use quantity of electricity consumed ς_t as the input proxy ι_t. We specify $\omega_t(\iota_{it}, k_{it})$ as a polynomial function in its arguments (including the absorbed intercept term and dropping the firm index i for expositional convenience) as follows:

$$\begin{aligned}
\omega_t(\varsigma_t, k_t) = \quad & \alpha_{11}\varsigma_t + \alpha_{12}\varsigma_t^2 + \alpha_{13}\varsigma_t^3 + \alpha_{14}k_t + \alpha_{15}k_t\varsigma_t + \alpha_{16}k_t\varsigma_t^2 \\
& + \alpha_{17}k_t^2 + \alpha_{18}k_t^2\varsigma_t + \alpha_{19}k_t^3 \\
& + \alpha_{21}t_2\varsigma_t + \alpha_{22}t_2\varsigma_t^2 + \alpha_{23}t_2\varsigma_t^3 + \alpha_{24}t_2k_t + \alpha_{25}t_2k_t\varsigma_t + \alpha_{26}t_2k_t\varsigma_t^2 \\
& + \alpha_{27}t_2k_t^2 + \alpha_{28}t_2k_t^2\varsigma_t + \alpha_{29}t_2k_t^3 \\
& + \alpha_{31}t_3\varsigma_t + \alpha_{32}t_3\varsigma_t^2 + \alpha_{33}t_3\varsigma_t^3 + \alpha_{34}t_3k_t + \alpha_{35}t_3k_t\varsigma_t + \alpha_{36}t_3k_t\varsigma_t^2 \\
& + \alpha_{37}t_3k_t^2 + \alpha_{38}t_3k_t^2\varsigma_t + \alpha_{39}t_3k_t^3
\end{aligned}$$

where $t_2 = 1$ for years 1990, 1991 and 1992, and $t_3 = 1$ for years 1993, 1994 and 1995.

Identifying the coefficient on the capital variable requires additional assumptions and a second stage estimation procedure. The moment condition that LP propose uses panel information to identify the capital coefficient. LP assume that:

$$E[k_{i,t}.\ \{\omega_{i,t} - E[\omega_{i,t}|\omega_{i,t-1}]\}] = 0 \qquad (10)$$

[36] A sufficient condition for this to hold is perfect (or symmetric cournot) competition within an industry. This allows for symmetric markups (as assumed for example in Harrison [1994]).

[37] LP show that, given production technology $Y = f(K, L, \iota, \omega)$ then the five assumptions (i) f(.) is twice continuously differentiable in L and ι, (ii) investment does not respond to this period's productivity, (iii) capital is fixed, (iv) firms take input prices and output prices as given, (v) all cross derivatives exist, along with the condition that $f_{\iota L} f_{L\omega} > f_{LL} f_{\iota\omega}$ are sufficient to ensure that the input demand function $\iota(\omega : p_l, p_\iota, K)$ is strictly increasing in ω, i.e. for the monotonicity condition to hold.

This follows from a behavioral assumption that capital does not respond to "surprises" in productivity, or equivalently from assuming that $\{\omega_{i,t}\}_{i=1}^{\infty}$ follows a stochastic first order Markov process.

The LP methodology could be adapted to a repeated cross-section context by making the broader assumption that $\omega_{i,t}$ is uncorrelated with the choice of capital $k_{i,t}$ (which is arguably fixed in the short run). This moment condition is discussed by Griliches and Mairesse [1995], but they suggest this assumption may be too restrictive, as capital is likely to respond to any persistent component of ω_{it}. Instead we propose a less restrictive moment condition, which can be used in the repeated cross-section context. Instead of using last period's productivity for each firm (unobservable in our data), we use the average productivity in the previous period for a closely matched industry-location-size cell (observable in our data) as the predictor for this period firm productivity. This attempts to approximate the moment condition in equation 10 as closely as possible, given the limitations of our data.[38]

To implement this approach, we sub-divide the data into industry-location-size cells and estimate the average productivity for each cell in every period. Then our modified moment condition replacing equation 10 is given by:

$$k_{i,t}.\{\omega_{i,t} - E[\omega_{i,t}|\bar{\omega}_{i,t-1}]\} = 0 \tag{11}$$

where:

$$\bar{\omega}_{i,t-1} = \frac{1}{m_{j_i}} \sum_{s=1}^{m_{j_i}} \omega_{s,t-1} \tag{12}$$

where j_i indexes the industry-location-size cell to which firm i belongs, and m_{j_i} is the number of observations in cell j.

As in the LP methodology, we then identify the coefficient on the capital variable (β_k) by considering the second step regression:

$$v^*_{i,t} = \beta_k k_{i,t} + E[\omega_{i,t}|\bar{\omega}_{i,t-1}] + \eta^*_{i,t} \tag{Step 2}$$

where $v^*_{i,t} = v_{i,t} - (\beta_l l_{i,t} + \beta_n n_{i,t})$ and $\eta^*_{i,t} = \{\omega_{i,t} - E[\omega_{i,t}|\bar{\omega}_{i,t-1}]\} + \eta_{i,t}$.

The specific estimation algorithm to obtain the capital coefficient is as follows:

i. Start with a candidate estimate[39] of the capital coefficientβ_{k*}.

ii. From the results of the first stage regression, obtain:

$$\hat{\phi}_t = \hat{v}_t - \hat{\beta}_l l_t - \hat{\beta}_n n_t$$

[38]This is justified by the assumption that firm specific productivity ω_{it} is given by the cell specific productivity $\bar{\omega}_{i,t}$ plus a random mean-zero shock, along with the assumption that the cell specific productivity follows a stochastic first order Markov process. Then the best predictor for the current firm-specific productivity would be the last period cell specific productivity. One alternative is to assume that cell-specific fixed effects captures the transmitted component of productivity (ω_{it}). Our approach is more flexible in that it allows the cell specific mean productivity to vary over time.

[39]While we could use some clever starting point, since we expect the coefficient on capital to be within the range 0 to 0.6 (the OLS analysis yields capital coefficients in the range of 0.03 to 0.21), we simply search over this range. We cross-checked the final estimate to ensure that the estimated value is interior to this range.

iii. Then obtain:

$$\widehat{\omega}_t = \hat{\phi}_t - \beta_{k*} k_t$$

iv. Estimate the mean productivity for each industry -size-location cell using:

$$\widehat{\bar{\omega}_{t-1}} = \frac{1}{m_j} \sum_{s=1}^{m_j} \widehat{\omega_{s,t-1}}$$

where m_j is the number of observations in cell j.

v. Regress $\widehat{\omega}_t$ on $\widehat{\bar{\omega}_{t-1}}$ and $\widehat{\bar{\omega}^2_{t-1}}$ and use the predicted values to form $E[\widehat{\omega_t|\bar{\omega}_{t-1}}]$.

vi. Obtain $\hat{v^*_t} = v_t - \hat{\beta}_l l_t - \hat{\beta}_n n_t$.

vii. Form $\hat{\eta^*_t} = \hat{v^*_t} - \beta_{k*} k_t - E[\widehat{\omega_t|\bar{\omega}_{t-1}}]$.

vii. Estimate β_k by minimizing the sum (over all the firm-year observations) of the squared residuals in Step 2:

$$\underset{\beta_{k*}}{\text{Min}} \left\{ \sum_i \left(\hat{v^*_{it}} - \beta_{k*} k_{it} - E[\widehat{\omega_{it}|\bar{\omega}_{it-1}}] \right)^2 \right\}$$

As discussed in Levinsohn-Petrin [2003a], a bootstrapping procedure is used to estimate the standard errors.

Appendix 2: Models for selection into FDI and Tariff Liberalization

We specify a probit model for selection of industries into FDI and tariff liberalization regimes, based on observed industries characteristics in the pre-1991 period. As independent variables, we consider proxies for the four possible sources of bias discussed in Section B.4: (i) the pre-reform growth rate in mean productivity (PRE_GRW); (ii) the ratio of export to output (EXP_INT); (iii) log of capital per employee (CAP_EMP); and (iv) the ratio of the industry-level labor productivity in Indonesia (DIS_FRON) to that in India.

The main motivation for including these four variables in the selection model is to examine whether selection was indeed based on these characteristics, and to ensure that the propensity score reflects possible selection on these sources of bias. Information in policy announcements also suggest that these variables could be relevant in the selection model. The Statement of Industrial Policy (SIP), 1991 indicated that reforms were aimed at boosting exports and improving the balance of payments situation, suggesting that export orientation (EXP_INT) could be a relevant factor. Further, the SIP 1991 describes the industries targeted for FDI liberalization under the automatic route, as "high priority industries, requiring large investments and advanced technology", suggesting the relevance of capital intensity (CAP_EMP) in the selection model.

In the full specification, we add three additional variables: (i) the mean pre-reform productivity level, as an additional proxy for future growth potential; (ii) the five-firm concentration ratio (C5), motivated by Stigler-Peltzman theories of regulation suggest that producers in concentrated industries may be able to successfully lobby for protection; and (iii) the mean pre-1991 growth rate in wages to proxy for the overall health of the industry (from Lee and Swagel [1997] who suggest that weak/declining industries may be targeted for protection)

The results from estimating our selection model are summarized in Table A.I. Columns 1 to 5 examines FDI liberalization while columns 6 to 10 look at tariff liberalization (dependent variable reform dummies are as defined in section II. We find that pre-reform growth in productivity (PRE_GRW) is not significant, either singly (columns 1 and 6) or in the full specifications (columns 4 and 10). Effect of export intensity appears to be negative (significant singly in column 2) for choice into FDI reform, and positive (significant singly in column 7). This suggests that FDI reforms were targeted at import competing industries, while tariff reforms were targeted at export-oriented industries.

We find that capital intensity is not significant in our selection model specifications, and contrary to expectation, it appears with a negative sign on the FDI selection models. One variable that appears very strongly significant is the distance to frontier variable (columns 4, 5, 9 and 10); interestingly, FDI reforms appear to be targeted at industries farther away from the frontier while tariff reforms targeted industries closer to the frontier. We find high concentration to be a positive and significant factor in predicting tariff and FDI liberalization; this may reflect high degrees of protection for these industries prior to the reforms, consistent with the Stigler-Peltzman theories of regulation. We find that industries selected for FDI

(tariff) reform had low (high) rates of growth in blue collar wages. Interpreting along the lines of Lee and Swagel [1997], FDI (tariff) reform appears to be targeted towards (away from) declining industries. Finally, the pre-1991 productivity levels appear to have relatively high for industries selected for tariff liberalization (not significant in the FDI specification).

Our results here are robust to using Korea as a benchmark instead of Indonesia, capital share of output (instead of log capital per employee), import share (instead of export orientation), and the Herfindahl index (instead of the five-firm concentration ratio).

The propensity score for FDI and tariff liberalization (used in Table IV(c)) are obtained from specifications in column 5 and 10 respectively.

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FIGURE I

Trends in growth rate of total output (real value added) and total employment in the manufacturing sector

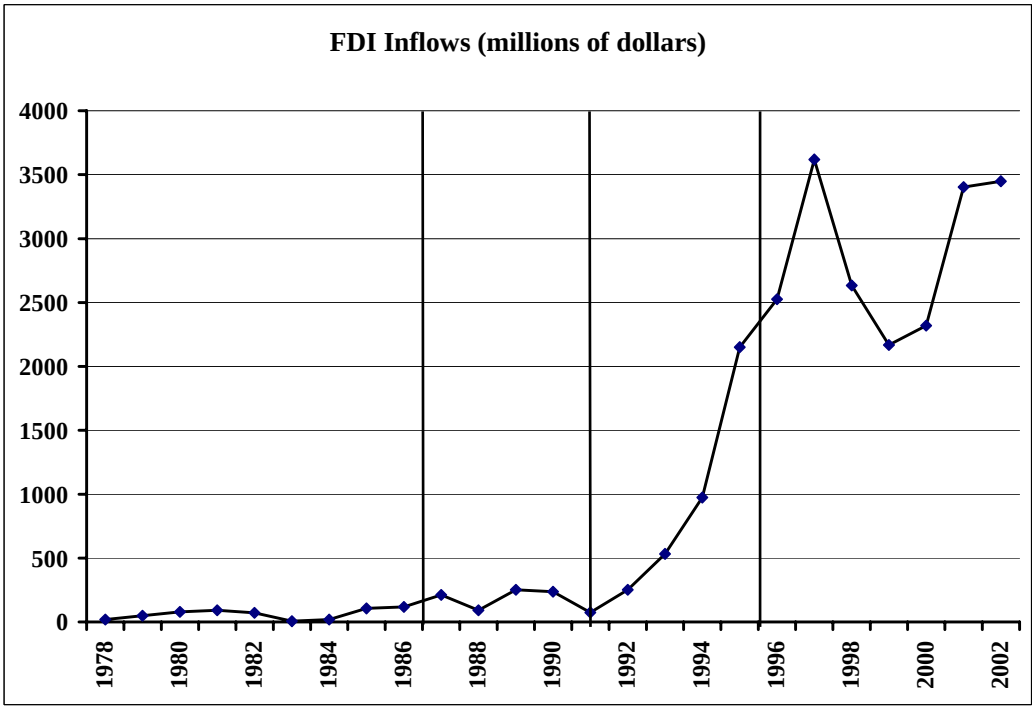

FIGURE II

Trends in Foreign Direct Investment into India
(The three vertical lines from left to right indicate the start of the panel period used in this study, the reform year, and the end of the panel period respectively)

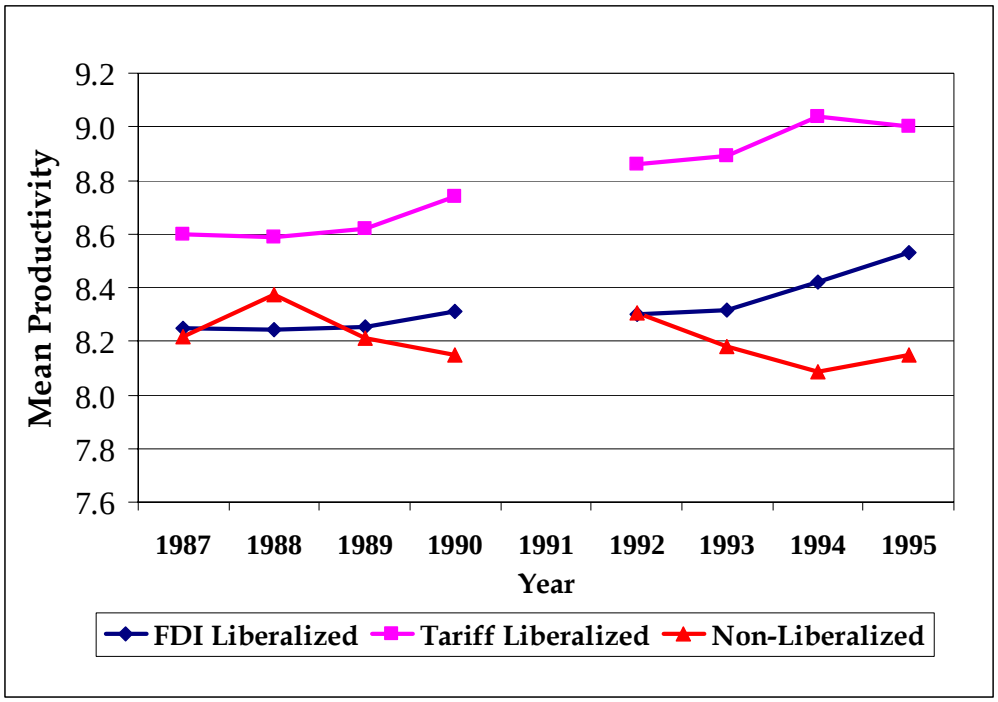

FIGURE III

Trends in mean productivity levels – liberalized sectors improve compared to non-liberalized

The year just preceding the reforms in July 1991 is omitted to illustrate the pre- and post-reform trends. `FDI Liberalized' represents firms in industries where foreign direct investment was liberalized. `Tariff Liberalized' represents firms in industries where tariff rates dropped by greater than 33%. `Non-Liberalized' represent firms in industries that where neither FDI nor tariffs were liberalized.

TABLE I

List of largest industries (by number of firms) and the fraction of firms in each regime

FDI Liberalized	Tariff liberalized	Non-Liberalized
List of 10 largest (by number of plants) industries in each regime		
• Electrical machinery	• Plastic products nec	• Grain mill products
• Industrials organic and inorganic chemicals	• Cotton ginning, cleaning and baling	• Structural clay products
• Industrial machinery (food and textile)	• Spinning and processing of man-made textiles fibers	• Drugs, medicines and allied products
• Industrial machinery (other than food and textile)	• Printing and allied activities nec	• Miscellaneous non-metallic mineral products n.e.c.
• Motor cars & other motor vehicles	• Raincoats, hats, etc.	• Structural stone goods, stoneware, stone dressing etc
• Special purpose machinery/equipment	• Weaving and finishing of cotton textiles in handlooms	• Sawing and planning of wood (other than plywood)
• Containers and boxes of paper or paper board	• Containers and boxes of paper or paper board	• Iron and steel in primary /semi-finished forms
• Machine tools, their parts and accessories	• Machine tools, their parts and accessories	• Indigenous, sugar, from sugar cane, palm juice, etc.
• General purpose non-electrical machinery	• Food products nec	• Hand tools and general hardware
• Pulp, paper and paper board, including news print	• Manufacture of knitted or crocheted textile products	• Metal cutlery, utensils and kitchenware
Fraction of plants in each regime (1991)		
28.6%	41.0%	37.3%

TABLE II (a)
DATA CHARACTERISTICS

Multiplier	1987	1988	1989	1990	1991	1992	1993	1994	1995	**Total**
1	19,984	18,571	17,741	18,426	16,575	17,478	16,306	16,956	18,144	**160,181**
(1, 2]	25,062	2	5	930	2,900	2,635	2,656	2,435	3,003	**39,628**
(2, 3)	-	-	-	939	1,583	1,800	1,393	1,498	1,660	**8,873**
3	-	13,923	14,725	15,695	15,685	15,588	16,503	17,407	18,896	**128,422**
Total	**45,046**	**32,496**	**32,471**	**35,990**	**36,743**	**37,501**	**36,858**	**38,296**	**41,703**	**337,104**

The multiplier is the inverse of the probability of sampling from within a state-industry stratum.

TABLE II (b)
DESCRIPTIVE STATISTICS

	FDI Liberalized		**Tariff Liberalized**		**Non-Liberalized**	
	Mean	**sd**	**Mean**	**sd**	**Mean**	**sd**
Real Value Added	8.02E+06	6.38E+07	4.60E+06	3.19E+07	5.72E+06	8.63E+07
Capital	2.28E+07	2.11E+08	1.34E+07	2.90E+08	2.10E+07	4.79E+08
Total Labor	93	447	100	498	73	560
Unskilled Labor	65	303	82	450	55	442
Skilled Labor	28	163	18	90	18	136

Quantities are in 1987 rupees. Labor is in number of employees. The statistics are adjusted for sampling weights.

TABLE III

EFFECTS OF FDI AND TARIFF LIBERALIZATION ON PRODUCTIVITY

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	LP_TFP	LP_TFP	LP_TFP	LP_TFP	LP_TFP	LP_TFP
Observations	215566	215566	266824	266824	337104	337104
R-squared	0.39	0.4	0.44	0.45	0.41	0.42
Adjrsq	0.387	0.397	0.435	0.446	0.411	0.422
FDI_LIB * I_(92-93)	-0.029	-0.032			-0.034	-0.037
	[0.090]	[0.090]			[0.083]	[0.083]
FDI_LIB * I_(94-95)	0.287	0.283			0.216	0.212
	[0.094]**	[0.094]**			[0.085]*	[0.085]*
TAR_LIB * I_(92-93)			0.053	0.054	0.071	0.073
			[0.118]	[0.119]	[0.107]	[0.107]
TAR_LIB * I_(94-95)			0.351	0.354	0.327	0.330
			[0.135]**	[0.134]**	[0.122]**	[0.121]**
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry (4 digit) fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes	No	Yes

Dependent variable `LP_TFP' is the total factor productivity estimated using the LP methodology. `FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991. . `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. `I_(92-93)' is a dummy for the years 1992 and 1993 and `I_(94-95)' is a dummy for the years 1994 and 1995. Standard errors are adjusted for clustering at 4 digit NIC level. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level.

TABLE IV(a)

ROBUSTNESS TESTS OF LONG-RUN EFFECTS OF FDI AND TARIFF LIBERALIZATIONS TO ALTERNATIVE MEASURES OF PRODUCTIVITY

	(1)	(2)
Description of alternative measure	FDI_LIB	TAR_LIB
Baseline specification (From Table III)	0.212	0.33
	[0.085]*	[0.121]**
OLS for estimating the production function	0.202	0.321
	[0.086]*	[0.124]**
Olley-Pakes methodology for estimating the production function	0.212	0.349
	[0.087]*	[0.131]**
Using IV for identifying the production function	0.196	0.323
	[0.090]*	[0.133]*
Winsorizing dependent variable by 2.5%	0.205	0.317
	[0.082]*	[0.117]**
Using a productivity index definition (Value Added)	0.256	0.375
	[0.085]**	[0.117]**
Using a gross output specification (OLS)	0.049	0.061
	[0.023]*	[0.036]+
Labour productivity [Log (Value added) – Log(Employment)]	0.185	0.319
	[0.090]*	[0.133]*

Reported numbers are the coefficient on a liberalization dummy interacted with I_(94-95) , a dummy for the years 1994 and 1995. All regressions include interactions of liberalization dummies with a dummy for years 1992 and 93 (I_(92-93), not reported for conciseness. All regressions also include industry, year and state fixed effects. `FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991. `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. Standard errors are adjusted for clustering at 4 digit NIC level. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level.

TABLE IV(b)

ROBUSTNESS TESTS OF LONG-RUN EFFECTS OF FDI AND TARIFF LIBERALIZATIONS TO ALTERNATIVE MEASURES OF FDI AND TARIFF LIBERALIZATION

	(1)	(2)	(3)	(4)
Description of robustness test	FDI_LIB	FDI_LIB	TAR_LIB	TAR_LIB
Baseline specification (From Table III)	0.216	0.212	0.327	0.33
	[0.085]*	[0.085]*	[0.122]**	[0.121]**
Liberal definition of FDI reform	0.23	0.226	0.334	0.338
	[0.084]**	[0.084]**	[0.121]**	[0.121]**
Normalized rank of tariff drop	0.223	0.218	0.671	0.672
	[0.085]**	[0.085]*	[0.235]**	[0.234]**
Liberal FDI definition and normalized rank of tariff drop	0.231	0.226	0.687	0.687
	[0.085]**	[0.085]**	[0.235]**	[0.234]**
Year effects	Yes	Yes	Yes	Yes
Industry (4 digit) fixed effects	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes

Dependent variable is `LP_TFP', the total factor productivity estimated using the L-P methodology. In the baseline specification, `FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991 and `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. Refer the text for the definitions of FDI_LIB and TAR_LIB in the other specifications. Standard errors are adjusted for clustering at 4 digit NIC level. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level.

TABLE IV(c)

ROBUSTNESS TESTS OF LONG-RUN EFFECTS OF FDI AND TARIFF LIBERALIZATIONS TO INCLUSION OF OTHER PERIOD SPECIFIC CONTROLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	LP_TFP	LP_TFP	LP_TFP	LP_TFP	LP_TFP	LP_TFP	LP_TFP	LP_TFP
FDI_LIB * I_(94-95)	0.207	0.215	0.162	0.213	0.156	0.181	0.211	0.143
	[0.081]*	[0.087]*	[0.083]+	[0.084]*	[0.078]*	[0.082]*	[0.086]*	[0.081]+
TAR_LIB * I_(94-95)	0.333	0.321	0.359	0.327	0.365	0.371	0.306	0.339
	[0.119]**	[0.129]*	[0.118]**	[0.112]**	[0.108]**	[0.121]**	[0.126]*	[0.122]**
PRE_GRW* I_(94-95)	0.766				0.743			
	[0.254]**				[0.278]**			
EXP_INT* I_(94-95)		0.048			0.037			
		[0.020]*			[0.026]			
CAP_EMP* I_(94-95)			0.929		0.872			
			[0.364]*		[0.357]*			
DIS_FRON* I_(94-95)				-0.017	0.034			
				[0.095]	[0.104]			
FDI_PRED* I_(94-95)						0.484		1.175
						[0.313]		[0.367]**
TAR_PRED* I_(94-95)							0.278	0.885
							[0.277]	[0.306]**
Observations	337037	332076	337104	330003	330003	329993	329993	329993
R-squared	0.43	0.41	0.42	0.42	0.42	0.41	0.41	0.41
Adjrsq	0.428	0.41	0.423	0.417	0.417	0.41	0.41	0.411

All regressions include interactions of variables with a dummy for years 1992 and 93 (I_(92-93), which is not reported for conciseness. All regressions include industry, year and state fixed effects. Dependent variable is `LP_TFP', the total factor productivity estimated using the L-P methodology. `FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991. `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. Refer text for definitions of other variables. Standard errors are adjusted for clustering at 4 digit NIC level. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level. a indicates significance at 15% level.

TABLE V

DIFFERENCE-IN-DIFFERENCE ESTIMATES OF THE COMPONENTS OF OUTPUT GROWTH

	(1)	(2)	(3)	(4)	(5)	(6)
	Output growth (2)+(3)+(4)	Input growth	Inter-industry reallocation	Aggregate productivity growth (5)+(6)	Intra-plant productivity growth	Intra-industry reallocation
Panel 1: FDI liberalization effect						
FDI_LIB* I_(92-93)	0.102	0.046	0.005	0.051	0.015	0.036
	[0.086]	[0.054]	[0.034]	[0.058]	[0.050]	[0.043]
FDI_LIB* I_(94-95)	0.167	-0.001	0.009	0.16	0.116	0.044
	[0.083]*	[0.055]	[0.037]	[0.057]**	[0.045]**	[0.044]
Observations	1819	1819	1819	1819	1819	1819
R-squared	0.12	0.15	0.22	0.07	0.06	0.13
Panel 2: Tariff liberalization effect						
TAR_LIB* I_(92-93)	0.055	0.000	0.002	0.054	0.049	0.004
	[0.099]	[0.062]	[0.041]	[0.060]	[0.054]	[0.043]
TAR_LIB* I_(94-95)	0.129	-0.033	0.005	0.156	0.106	0.05
	[0.102]	[0.063]	[0.043]	[0.063]*	[0.050]*	[0.043]
Observations	2007	2007	2007	2007	2007	2007
R-squared	0.22	0.23	0.34	0.14	0.11	0.2
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

`FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991. `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. `I_(92-93)' is a dummy for the years 1992 and 1993 and `I_(94-95)' is a dummy for the years 1994 and 1995. `Output growth' is the growth in industry aggregate value added. `Input Growth' is the growth in an industry aggregate input index Inter-industry reallocation is the covariance between growth in industry aggregate input index and the growth in industry aggregate productivity index. `Aggregate productivity growth' is the growth in industry aggregate productivity index. `Intra-plant productivity growth' is the growth in the industry aggregate productivity index resulting from change in mean firm level productivity. `Intra-industry reallocation' is the growth in the industry aggregate productivity index attributable to change in the covariance between intra-plant productivity and the plant level input index. Standard errors are adjusted for clustering at 4 digit NIC level. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level.

TABLE VI

DIFFERENCE-IN-DIFFERENCE ESTIMATES OF THE BENEFICIARIES OF PRODUCTIVITY GROWTH

	(1)	(2)	(3)	(4)	(5)	(6)
	Solow productivity growth (2)+(3)+(4)+(5)+(6)	Change in input prices	Change in blue collar wage	Change in white collar wage	Gain in return to capital	Drop in output prices
Panel 1: FDI liberalization Effect						
FDI_LIB* I_(92-93)	0.012	-0.008	0.001	-0.002	-0.003	0.025
	[0.019]	[0.002]**	[0.002]	[0.002]	[0.017]	[0.011]*
FDI_LIB* I_(94-95)	0.052	-0.01	-0.003	0.002	0.014	0.049
	[0.017]**	[0.001]**	[0.003]	[0.001]	[0.017]	[0.009]**
Observations	1941	1941	1941	1941	1941	1941
R-squared	0.10	0.55	0.13	0.11	0.09	0.21
Panel 2: Tariff liberalization Effect						
TAR_LIB* I_(92-93)	0.039	-0.009	0.002	-0.001	0.008	0.04
	[0.019]*	[0.002]**	[0.003]	[0.002]	[0.016]	[0.011]**
TAR_LIB* I_(94-95)	0.051	-0.003	-0.002	0.002	0.027	0.027
	[0.018]**	[0.002]*	[0.004]	[0.002]	[0.017]	[0.009]**
Observations	2059	2059	2059	2059	2059	2059
R-squared	0.13	0.53	0.20	0.16	0.13	0.18
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

`FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991. `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. `I_(92-93)' is a dummy for the years 1992 and 1993 and `I_(94-95)' is a dummy for the years 1994 and 1995. Standard errors are adjusted for clustering at 4 digit NIC level. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level.

Appendix

TABLE A.I
PROBIT MODELS OF SELECTION INTO FDI AND TARIFF LIBRERALIZATION REGIMES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	FDI_LIB	FDI_LIB	FDI_LIB	FDI_LIB	FDI_LIB	TAR_LIB	TAR_LIB	TAR_LIB	TAR_LIB	TAR_LIB
PRE_GRW (Pre-91 growth in mean productivity)	-0.189				-0.003	-0.08				-0.238
	[0.138]				[0.189]	[0.128]				[0.170]
EXP_INT (Export to output ratio)		-0.303			-0.204		0.29			0.196
		[0.166]+			[0.165]		[0.122]*			[0.138]
CAP_EMP (Log capital per employee)			-0.183		-0.252			0.232		-0.555
			[0.448]		[0.549]			[0.429]		[0.538]
DIS_FRON (Log Indonesian to Indian labor productivity)				0.484	0.445				-0.587	-0.619
				[0.099]**	[0.107]**				[0.101]**	[0.109]**
Pre-91 mean productivity					-0.115					0.191
					[0.077]					[0.072]**
Mean blue collar wage growth					-0.887					0.559
					[0.360]*					[0.291]+
Concentration ratio (C5)					0.683					0.949
					[0.296]*					[0.293]**
Constant	-0.345	-0.292	-0.131	-0.576	0.401	0.011	-0.041	-0.254	0.239	-1.297
	[0.060]**	[0.063]**	[0.575]	[0.077]**	[0.999]	[0.058]	[0.061]	[0.550]	[0.074]**	[0.964]
Observations	465	467	478	456	443	465	467	478	456	443
Log Likelihood	-303.79	-303.2	-311.62	-286.21	-270.65	-322.11	-318.68	-330.91	-298.08	-277.64

`FDI_LIB'==1 if automatic approval for FDI investment up to 51% was allowed in the industry in 1991. `TAR_LIB'==1 if the drop in tariff rates between 1990 and 1992 was greater than 33%. + indicates significance at 10% level, * indicates significance at 5% level and ** indicates significance at 1% level.